Lebow Products

Honeywell

LOAD, FORCE, REACTION TORQUE,
ROTARY TORQUE, WIRELESS TELEMETRY TORQUE,
INSTRUMENTATION

Full Line Catalog
15th Edition, 2006

INDEX

A DYNAMIC FORCE IN MEASUREMENT SOLUTIONS

Lebow Products is a company whose beginning dates to 1955. Then it was Milton M. Lebow, professor of Mechanical Engineering, who began the legacy by serving the automotive industry. Over the years Lebow has undergone many changes, upgrading facilities and personnel, but the constant within is Lebow's driving energy in the pursuit of measurement solutions.

Now in its fifth decade, Lebow Products advances force and torque solutions with new products to satisfy the ever-evolving demands of technology. Lebow has expanded service capability, serving diverse markets including government and military, aerospace, education and research, agriculture, industrial and manufacturing.

Lebow's accumulated experience includes an 8,000-sensor design library and extensive line of torque and load cells, when combined with a reputation for rapid solutions, presents an innovative and reliable resource.

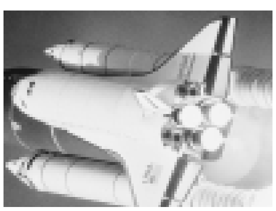
TRANSPORTATION

MANUFACTURING

AEROSPACE

MILITARY

EDUCATION



QUALITY CALIBRATION STANDARDS SPOKEN GLOBALLY

Globalization means greater need for standardization, and Lebow Products has certifications and accreditations to satisfy worldwide applications. Lebow products are tested and certified to meet published specifications using a calibration system conforming to A2LA certification number 1699.01 ISO guide 25 and ANSI/NCSL Z540 American National Standards for calibration from the American National Standards Institute. This calibration system ensures that all force measurement certification is traceable back to NIST.

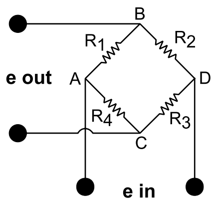
Lebow Products Inc.

FORCE MEASUREMENT

TRANSDUCTION

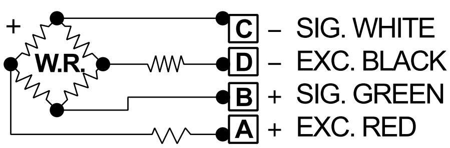
Lebow® Torque Sensors and Load Cells consist of specially designed structures which perform in a predictable and repeatable manner when a force is applied. This force is translated into a signal voltage by the resistance change of strain gages which are applied to the transducer structure. The change in resistance indicates the degree of deformation and, in turn, the load on the structure.

The strain gages are connected in a 4 arm (Wheatstone Bridge) configuration, which acts as an adding and subtracting electrical network and allows compensation for temperature effects as well as cancellation of signals caused by extraneous loading.



A fixed excitation voltage is applied between **A** and **D** of the bridge. A force applied to the structure unbalances the Wheatstone Bridge, causing an output voltage to appear between **B** and **C**. This voltage is proportional to the applied load. When the shaft of a torque sensor is rotating, means must be provided to transfer the signal voltage from the rotational element to a stationary surface. This can be accomplished through the use of slip rings and rotary transformers.

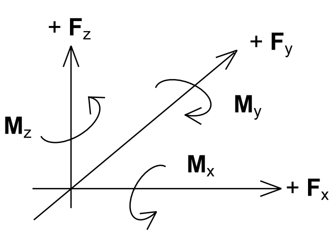
Lebow® products follow, where possible, the transducer wiring standard of Western Regional Strain Gage committee as revised May 1960. That code, for most Lebow load cells and torque sensors, is:



AXIS DEFINITION

Lebow® products comply with the Axis and Sense Definitions of NAS-938 (National Aerospace Standard-Machine Axis and Motion) nomenclature and recommendations of the Western Regional Strain Gage committee. For wheel sensors, ASTM specification F-376-73 has been adopted.

These axes are defined in terms of a "Right Handed" orthogonal coordinate system as shown below:

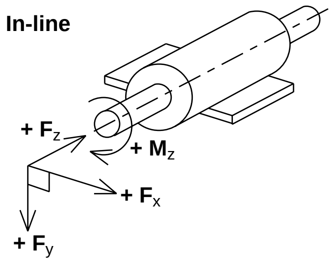


A + sign indicates force or torque direction which produces a + signal voltage and generally defines a tensile force direction or clockwise (CW) torque.

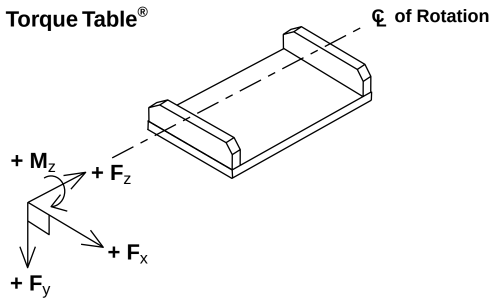
The principal axis of a transducer will normally be the **Z** axis. The **Z** axis will also normally be an axis of radial symmetry or axis of rotation. In the event there is no clearly defined axis, the following preference system will be used: **Z**, **X**, **Y**.

The following illustrations show the recommended axis and sense nomenclature for various transducers supplied by Lebow:

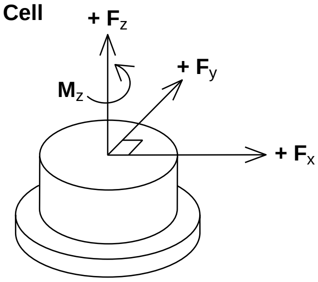
In-line



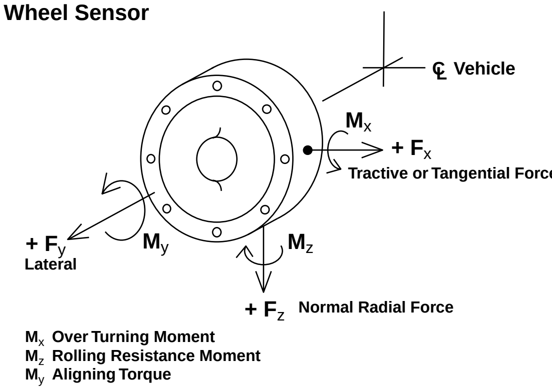
Torque Table®



Load Cell



Wheel Sensor



NOTE: Consider hub mounting surface as fixed, and wheel mounting surface as loading surface to determine polarity.

TRANSDUCER DESIGN

TORQUE SENSORS

STRUCTURES

Torque transducers with solid circular shafts and with gages at 45° to the centerline have been in use for years. Though well known, this structure is not generally used by Lebow where precision is important. The solid shaft is not recommended for capacities below 500 lb. in. as the shaft has inadequate bending strength and too much flexibility to provide good frequency response.

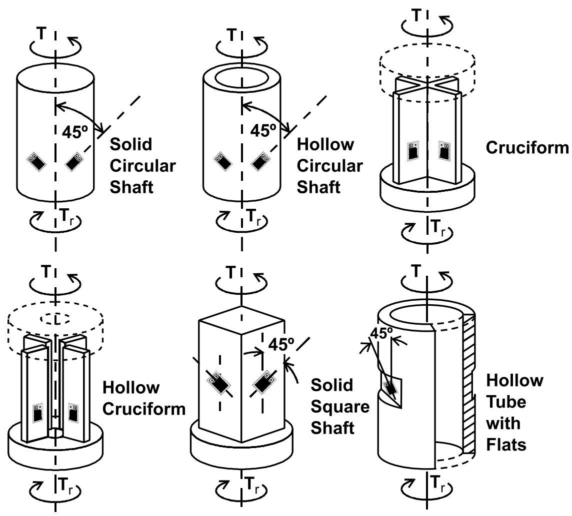
Hollow circular shaft construction permits increased bending strength; for example, a hollow shaft designed for 1,000 lb. in. will have a bending strength 50% higher than a solid bar with the same torsional level. However, the hollow circular shaft suffers some of the same drawbacks as the solid circular shaft and, therefore, is not in general use at Lebow®.

Another structure of interest is the cruciform which will produce high stress or strain values at low values of torque. The cruciform has good bending strength but is difficult to predict because of the fillet effect on torsional stress and stiffness.

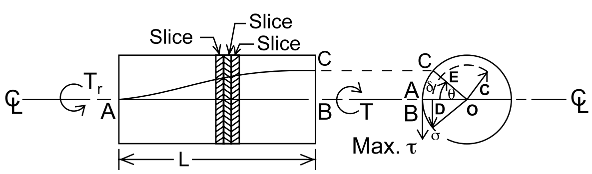
At Lebow®, the cruciform was modified by drilling a hole through its center section creating the *hollow cruciform* structure extensively used by Lebow® for low capacity torque transducers. The hollow cruciform eliminates the fillet effect of the cruciform and produces the 4 bar torsion frame. The bars in this case are subjected to a combination of torsion and bending when twisted. The stresses produced by a torque input can be accurately predicted, thus torsional sensitivity with good strength to external bending results.

The square section used by Lebow® for high-capacity transducers has several advantages over its circular counterpart for torque measurements. One of these is the ease with which gages can be placed on the shaft. Another is the increased bending strength when compared to a round shaft.

The following are drawings showing, in general, structures in use as torque transducers.



TORTIONAL SHEAR STRESS



Assume there is a shaft which consists of an infinite number of thin slices. Each slice is rigid and joined to its adjacent slice by an elastic fibre **AB**. As torque is applied, each slice will attempt to slip past its adjacent slice. The elastic fibre joining them becomes deformed enough to create a resisting torque **T**r, which balances the applied torque **T**. This deformation is transmitted over the length **L** of the shaft. The elastic fibre is thus twisted into a helix **AC** through an angle θ. As torque **T** is increased, the angle θ becomes larger.

Consider also a fibre internal to the shaft spanning distance **C** from the centerline ℄ of the shaft. As torque **T** is applied, the internal fibre will also be twisted into a helix. The length of the deformation δ is the length of arc **DE** with a radius **c** and which is subtended by the angle θ or

$$\delta = \widehat{DE} = c \cdot \theta$$

Unit deformation γ of the fibre is

$$\gamma = \frac{\delta}{L} = \frac{c\theta}{L}$$

From Hooke's Law, the shearing stress τ is

$$\tau = G\gamma = \left(\frac{G\theta}{L}\right) c$$

Where

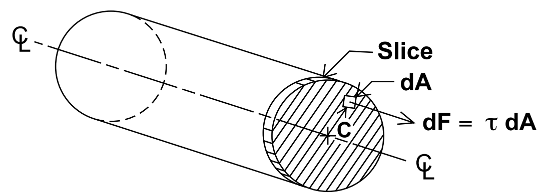
G = Shear Modulus of Elasticity (psi)

NOTE: The modulus of elasticity **E** of a material is related to the shear modulus **G** of the same material by the expression.

$$G = \frac{E}{2(1+\mu)}$$

where μ is Poisson's Ratio which is 0.25 to 0.30 for steel and approximately 0.33 for most other metals.

From the above, we may conclude that the stress distribution along any radius varies linearly with the distance from the axis or the centerline of the shaft. Also the maximum stress occurs at the surface of the shaft and denoted by Max. τ.



Separating the shaft at the face of two adjacent slices provides a free body diagram of the left hand portion. A differential area **dA** at a distance c carries a differential resisting load **dF** perpendicular to **c**.

Resisting torque **T**, is the sum of the individual resisting torques developed by all differential loads **dF**. To satisfy the condition of static equilibrium, the applied torque **T** must be equal the resisting torque **T**r. Therefore,

$$T = T_r = \int c \cdot dF = \int c\,(\tau \cdot dA)$$

By substitution

$$T = \frac{G\theta}{L} \int c^2 \cdot dA$$

By definition

$$\int c^2 \cdot dA = \text{Polar Moment of Inertia } I_p$$

Note: Although the above polar moment of inertia equation is mathematically correct, it is applicable for the calculation of stresses and deflections due to torsion only in closed circular sections. In the combined stresses section of this catalog, torsional shear stress and deflection equations will be given for square cross sections as well.

Therefore

$$T = \frac{G\theta}{L} \cdot I_p$$

Or more usually written as

$$\theta = \frac{TL}{GI_p} \text{ radians}$$

Where

T = lb. in.
L = in.
G = psi
For steel 12 x 10^6psi
For aluminum 4 x 10^6psi
Ip = in^4

By replacing the product $\frac{G\theta}{L}$ with its equivalent $\frac{T}{Ip}$ shearing stress τ becomes

$$\tau = \frac{Tc}{Ip}$$

Substituting the radius of the shaft **r** for **c**, we obtain the formula for the maximum shearing stress

$$\text{Max. } \tau = \frac{Tr}{Ip}$$

Since Hooke's Law was used to derive the above formula, Max. τ must not exceed the shearing proportional limit which is a function of the shaft material:

For steel	Max. τ = 36,000 psi
For aluminum	Max. τ = 21,000 psi

At Lebow®, the values for Max. τ used for torque transducers are different from those which appear above. These values are the result of experience, uniqueness of structures used in Lebow® torque transducers, modulus of the material used to fabricate the sensor structure, gage factor of the strain gage used as the transduction element, values of compensating elements and the need for reasonable sensitivity (signal) coupled with a conservative torque overload capability. These values for sensitivity of 2 mV/V are:

Material	Gage Factor (G.F.)	Max τ (psi)
17-4PH Stainless	2	24,788
17-4PH Stainless	4.5	11,017
K-Monel® Steel	2	22,613
K-Monel® Steel	4.5	10,050
4140 Steel	2	26,093
4140 Steel	4.5	11,597
2024 Aluminum	2	9,684
2024 Aluminum	4.5	4,304

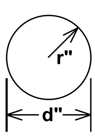
COMBINED STRESSES

Thus far, only the torsional loading of a shaft has been discussed. However, in practical applications, torsional loading can also include some combination of axial and flexural loading as well. Where a torque transducer has the potential of being subjected to extraneous loads, it is suggested that the application be discussed in detail with the manufacturer of the transducer, prior to its purchase or use.

Additional formulas must be utilized for this process; however, their use should be limited to those situations in which both bending moment **M** and torque **T** are known. Under any other condition, a more rigorous analysis is required. In addition, these equations or figures, have assumed a nonrotating torque sensor. Rotating torque sensors where bearings are involved is a special problem, and again it is recommended the factory be consulted.

With a knowledge of the shaft configuration and its relationship to **Ip**, we are now able to provide the equation for Max τ and θ in a more convenient form.

Solid Circular Shaft

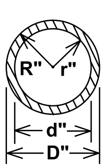


$$\text{Max. } \tau = \frac{2T}{\pi r^3} = \frac{16T}{\pi d^3}$$

$$\theta = \frac{2TL}{G\pi r^4} = \frac{32TL}{G\pi d^4}$$

$$\text{where } Ip = \frac{\pi r^4}{2} = \frac{\pi d^4}{32}$$

Hollow Circular Shaft

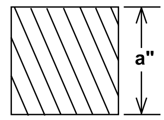


$$\text{Max. } \tau = \frac{2TR}{\pi(R^4 - r^4)} = \frac{16TD}{\pi(D^4 - d^4)}$$

$$\theta = \frac{2TL}{G\pi(R^4 - r^4)} = \frac{32TL}{G\pi(D^4 - d^4)}$$

$$\text{where } Ip = \frac{\pi}{2}(R^4 - r^4) = \frac{\pi}{32}(D^4 - d^4)$$

Solid Square Shaft



$$\text{Max. } \tau = 4.81 \bullet \frac{T}{a^3}$$

$$\theta = 7.11 \bullet \frac{TL}{Ga^4} \bullet$$

Note: the formula Max. $\tau = \frac{Tr}{Ip}$

is applicable to circular shafts only. The formulas for a square shaft are offered without proof.

Recall that for solid circular sections the relationship for shearing stress is as follows:

$$\tau = \frac{2T}{\pi r^3}$$

Without proof, the relationship of stress σ which results from flexural loading (bending) is as follows:

$$\sigma = \frac{4M}{\pi r^3}$$

The maximum shearing stress, Max. τ, the result of an element subjected to simultaneous flexural and torsional loading, is

$$\text{Max. } \tau = \sqrt{(1/2\ \sigma)^2 + \tau^2}$$

By substitution

$$\text{Max. } \tau = \sqrt{\left(\frac{2M}{\pi r^3}\right)^2 + \left(\frac{2T}{\pi r^3}\right)^2}$$

Which reduces to

$$\text{Max. } \tau = \frac{2}{\pi r^3}\sqrt{M^2 + T^2}$$

We now introduce the expression equivalent torque **T**e and define it as follows:

$$T_e = \sqrt{M^2 + T^2}$$

Thus

$$\text{Max. } \tau = \frac{2T_e}{\pi r^3}$$

In this application and from a study of Mohrs circle, we find that the maximum resultant normal stress, Max. σ, the result of an element subjected to simultaneous flexural and torsional loading, is

$$\text{Max. } \sigma = \frac{2}{\pi r^3}(M + T_e)$$

We have for the definition of equivalent moment **M**e that

$$M_e = 1/2\,(M + T_e)$$

Therefore

$$\text{Max. } \sigma = \frac{4M_e}{\pi r^3}$$

The expressions for **T**e and **M**e are important in the design of torque transducers. From these values and from the expressions for Max. τ and Max. σ, we are able to determine an optimum shaft radius where the torque capacity and bending moment are known. The shaft radius selected is usually the larger of the two values determined by solving for both Max. τ and Max. σ. Max. τ and Max. σ are usually established by the manufacturer.

The maximum stress values used by Lebow® will allow us to present the above formulas in a more convenient form.

TRANSDUCER DESIGN

CIRCULAR SHAFT

Material	Gage Factor	$r = \sqrt[3]{\frac{2T_e}{\pi r}}$	$T_e = \frac{\tau \pi r^3}{2}$
17-4PH Stainless	2	$0.030 \sqrt[3]{T_e}$	$38{,}937 \cdot r^3$
17-4PH Stainless	4.5	$0.039 \sqrt[3]{T_e}$	$17{,}305 \cdot r^3$
K-Monel® Steel	2	$0.030 \sqrt[3]{T_e}$	$35{,}520 \cdot r^3$
K-Monel® Steel	4.5	$0.040 \sqrt[3]{T_e}$	$15{,}786 \cdot r^3$
4140 Steel	2	$0.029 \sqrt[3]{T_e}$	$40{,}987 \cdot r^3$
4140 Steel	4.5	$0.038 \sqrt[3]{T_e}$	$18{,}216 \cdot r^3$
2024 Aluminum	2	$0.040 \sqrt[3]{T_e}$	$15{,}212 \cdot r^3$
2024 Aluminum	4.5	$0.053 \sqrt[3]{T_e}$	$6{,}761 \cdot r^3$

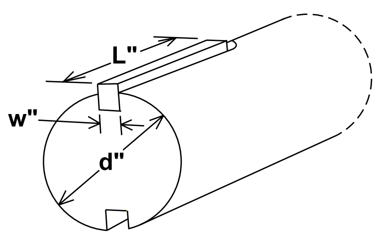
r = in. **T**e = lb. in. τ = psi

SQUARE SHAFT

Material	Gage Factor	$a = 1.7 \sqrt[3]{\frac{T_e}{\tau}}$	$T_e = .2\,\tau\,a^3$
17-4PH Stainless	2	$0.058 \sqrt[3]{T_e}$	$5{,}156 \cdot a^3$
17-4PH Stainless	4.5	$0.076 \sqrt[3]{T_e}$	$2{,}292 \cdot a^3$
K-Monel® Steel	2	$0.060 \sqrt[3]{T_e}$	$4{,}704 \cdot a^3$
K-Monel® Steel	4.5	$0.078 \sqrt[3]{T_e}$	$2{,}090 \cdot a^3$
4140 Steel	2	$0.057 \sqrt[3]{T_e}$	$5{,}427 \cdot a^3$
4140 Steel	4.5	$0.074 \sqrt[3]{T_e}$	$2{,}412 \cdot a^3$
2024 Aluminum	2	$0.079 \sqrt[3]{T_e}$	$2{,}014 \cdot a^3$
2024 Aluminum	4.5	$0.104 \sqrt[3]{T_e}$	$895 \cdot a^3$

a = in. **T**e = lb. in. τ = psi

EFFECTS OF KEYWAYS



Keyways cut into a shaft will reduce the load carrying ability, particularly where impact loads or stress reversals are involved. The general practice is to design circular shafts with keyways on the basis of a circular shaft not using more than 75 percent of the stress recommended for the solid shaft. At Lebow®, the practice is to design keyways based on accepted practices and attempt to keep shear stress on keys at a maximum of 10,000 psi at rated torque capacity (when the value is exceeded, it is recommended that heat treated keys be used). That is

$$\frac{2T}{ndLw} \leq 10{,}000 \text{ psi}$$

Where

- **n** = number of keyways
- **d** = diameter of shaft (in.)
- **L** = length of key (in.)
- **W** = width of key (in.)
- **T** = max. torque (lb. in.)

The above relation may also be applied to SAE splines where **d** is the mean shaft diameter.

LOAD CELLS

STRUCTURES

The most critical mechanical component in any load cell, as with any strain gage transducer, is the "Spring Element." In general terms, the spring element serves as the reaction to the applied load and focuses that load into a uniform, calculated strain path for precise measurement by the bonded strain gage.

Critical to this function is that the strain level in the gaged area of the spring element responds in a linear and repeatable manner to the applied load. The perfect load cell would repeatably produce a proportional relationship between the strain and the induced load. Achievement of this goal is made difficult by the presence of numerous application, economical and performance requirements which must be simultaneously satisfied. Compounding this difficulty is the great number of second and third order effects, such as natural frequency, and thermal sensitivity that become highly significant in the attainment of a precision force measuring device. The three basic load cell design classes are: bending beam, axial stress and shear.

Lebow® designs a multiplicity of load cells for use in applications ranging from dynamic fatigue testing, process control and precision weighing to general-purpose industrial use. Because of this broad range, a number of design elements must be utilized. Consideration in the design of the transducer is given to single piece structural design for maximum linearity and repeatability and minimal hysteresis. Other considerations such as overload protection, electric output sensitivity, and minimal strain levels with uniform strain distribution to the gage area, are all thoroughly investigated prior to the design of a new structure.

Bending Beam

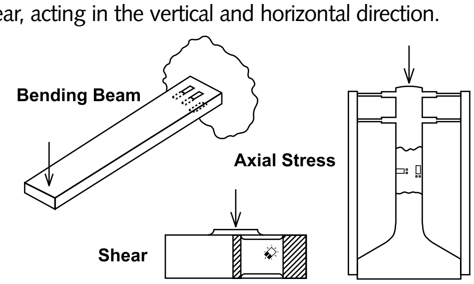
Load cell spring elements that employ the bending beam configuration are the most common of all contemporary commercial transducers. This is because the bending beam is typically a high-strain, low-force structural member that offers two equal and opposite surfaces for strain gage attachment.

Axial Stress

The column-type load cell is the earliest type of strain gage transducer. Although simple in its design concept, the column spring element requires a number of design stage considerations. The column should be long enough with respect to its cross section so that a uniform strain path will be applied at the strain gage. Also of prime importance is the second order effects a tall column can be subjected to, such as inadvertent off-axis loading. Proper diaphragm isolation can minimize this effect.

Shear

The principle of the shear-web load cell generally takes the form of a cantilever beam which has been designed with a cross section larger than normal with respect to the rated load to be carried in order to minimize deflection. Under this condition, the surface strain along the top of the beam would be too low to produce an adequate electrical output from the strain gage. However, if the strain gages are placed on the sides of the beam at the neutral axis, where the bending stress is zero, the state of stress on the beam side is one of pure shear, acting in the vertical and horizontal direction.



LOAD LIMITS

For more than four decades, Lebow® has maintained an industry-wide reputation for its ability to design and manufacture transducers which perform both accurately and reliably. While enjoying this reputation for performance and durability, we realize that many of our users require precise knowledge of the load limits for a particular cell to avoid overloading and possible damage. The following information provides the criteria to determine maximum load limits for Lebow® load cells, not only for normal axis loading, but also for all possible forces and moments which act on the load cell.

The allowable combined stress level (load limits) is a function of both the structure and the primary and extraneous forces applied. The following table specifies maximum allowable stress levels for static and fatigue loading of the basic fabrication materials, steel and aluminum.

Type of Loading	Sensor Material	Maximum Allowable Stress—PSI (σ max.)
Static	Steel	80,000
Fatigue	Steel	40,000
Static	Aluminum	25,000
Fatigue	Aluminum	10,000

MAXIMUM LOAD LIMITS

The combined stress level for any load cell should not exceed the maximum stress level, σ max.

The equation is:
$aF_x + bF_y + cF_z + dM_x + eM_y + fM_z = \sigma \leq \sigma$ max.

In which:
F_x F_y and F_z = absolute values of the forces along the X, Y and Z axis in pounds.

M_x M_y and M_z = absolute values of the bending moments relative to the X, Y and Z axis.

a through f = extraneous load coefficients (refer to page 110)

The equation parameters that must be established are:
F_z—The force applied along the axis of rotational symmetry of the load cell. If this force is not known, substitute the normal capacity of the sensor.

F_x, F_y—Enter the absolute values of F_x and F_y. If this value is not known, substitute the maximum shear force that is possible for this application for either F_x or F_y, and substitute 0 for the other shear force vector.

M_z—Enter the absolute value of the bending torque about the Z axis. This torque is usually a result of the technique used to load the sensor.

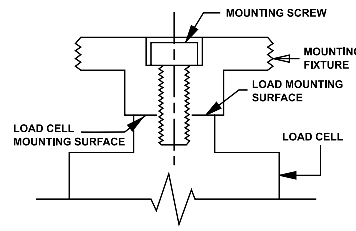
M_x, M_y—Enter the absolute value of the moment about the X and/or Y axis. These moments are usually a result of off-center loading.

NOTE: A "compression only" load cell, when loaded through a load button, normally will not be subjected to extraneous moments; therefore, M_x, M_y and M_z are 0.

After solving the equation, compare the answer to the maximum allowable stress. If the stress is to high, select another load cell, either with better extraneous load characteristics or a higher load capacity.

Values for static extraneous load limits as they appear in the specifications are calculated assuming that only one extraneous load (F_x or F_y or M_y or M_z) is applied simultaneously with half the nominal load limit capacity. It is also assumed that the load cell is properly mounted. Proper mounting is defined as follows:

1. Customer mounting surface is equal to or greater than load cell mounting surface.
2. Grade 8 or better mounting screws are used and tightened to 75% of their yield value for steel load cells, and 50% of their yield value for aluminum load cells.
3. Screws should be mounted such that the tightening torque does not enter the load cell internal surface. Use flats on the load cell structure to take the reaction tightening torque.



TRANSDUCER CONSIDERATIONS

DYNAMIC RESPONSE

The input and the resulting output, both as a function of time, of a load cell or a torque transducer are grouped into two categories: (1) the response of the strain gage bridge network and associated electronics approximates a first-order, non-oscillatory system; and (2) the transducer structure a second-order, slightly damped oscillatory system. These systems are complicated by the input types involved: sinusoidal, step-function, ramp, parabolic and impulse to name a few. In addition we may be concerned with velocity, acceleration, time derivative of acceleration ("jerk") or time integral of displacement ("excursion") response of the output. For a detailed analysis of dynamic response, textbooks on the subject should be consulted.

Since most load cells are excited by a steady-state DC voltage and because the response of associated electronics is assumed to be much greater than the mechanical response of the transducer, the first-order system is usually ignored. However, if system response is of concern, then the response of the electronics must be included in your analysis. Also, if the excitation is either pulsed DC or AC, then the first-order system response will be of concern.

When excited with a step input $\mathbf{V}_{step}$, the first order device will have a response of

$$\mathbf{V}_{out} = \mathbf{V}_{step}\,(\mathbf{l} - \mathbf{e}^{-1/\tau})$$

where τ is the time constant of the first-order system and **e** the base of the natural log and equal to 2.718. The time constant τ can be determined from the time required for the electronic network to respond to any given value of the input signal. The following table provides for various multiples of τ the value of $\mathbf{V}_{out}$ as a percentage of the value of $\mathbf{V}_{step}$.

t	$\mathbf{V}_{out}/\mathbf{V}_{step}$ • 100%
1τ	63.2
2τ	86.5
3τ	95.0
4τ	98.2
5τ	99.3
6τ	99.8
7τ	99.9

The mathematical considerations of dynamic response on a torque sensor and load cell, although similar in their mechanical accurancy, must be discussed separately.

For a Rotating Torque Sensor:
The equation for the response of a second-order system with a step function torque input **T** and output torque $\mathbf{T}_r$ is

$$\mathbf{T}_r = \mathbf{T}\left(\mathbf{1} - \frac{\mathbf{e}^{-\zeta\omega t}}{(\mathbf{1} - \zeta^2)^{1/2}}\ \mathbf{cos}\,[(\mathbf{1} - \zeta^2)^{1/2}\,\omega_n\mathbf{t} - \mathbf{sin}^{-1}\,\zeta]\right)$$

In the case of a torque transducer usually $\zeta << 0.1$ therefore we may rewrite the previous as

$$T_r = T\,(1 - e^{-\zeta\omega t}\cos[(1-\zeta^2)^{1/2}\,\omega_n t\,])$$

where ω_n is the undamped natural circular frequency, and ω the frequency of rotation. These will be discussed in another section. Damping ratio ζ is the ratio of the damping coefficient to the critical damping coefficient, the explanation of which we will leave to texts on the subject.

For a Rotating Torque Sensor or a Load Cell:
In the first-order system, we introduced the time constant τ which is inversely proportional to the natural frequency.

Rotating Torque Sensor First-Order System	Load Cell First-Order System
$\tau: \dfrac{1}{\omega_n}$	$\tau: \dfrac{1}{f_n}$

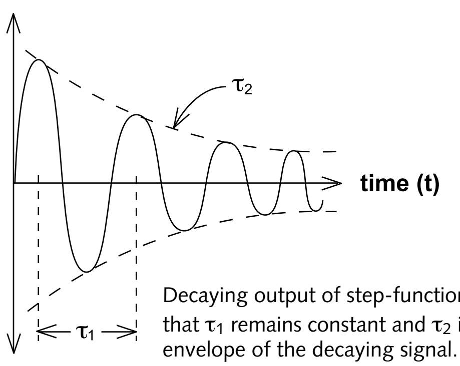
In the second-order system there occurs two time constants τ_1 and τ_2. Without proof, we have:

$$\tau_1: \frac{1}{\omega_n} \qquad \tau_1: \frac{1}{f_n}$$

and

$$\tau_2: \frac{2\zeta}{\omega_n} \qquad \tau_2: \frac{2\zeta}{f_n}$$

Amplitude (T)



Decaying output of step-function input showing that τ_1 remains constant and τ_2 is related to the envelope of the decaying signal.

Thus far we have discussed the dynamic responses of a torque transducer or load cell and its associated electronics. We have omitted a discussion of the effects of external devices such as couplings, bearings, the source of the forcing function, etc. We caution the reader to be aware that these external devices can alter the performance of a transducer and should be taken into consideration by the user.

NATURAL FREQUENCY

The differential equations of motion are based upon the idea that in any given structure or body disturbed in some manner by the application of an external force or by an impact that creates a sudden velocity change, the body will vibrate at a definite frequency known as the Natural Frequency. If no further excitation occurs, the vibration is said to be free, and the body will vibrate with decreasing amplitude until it comes to rest.

Ringing frequency differs from Natural Frequency only in that the ringing frequency of any Lebow® transducer is the unmounted free body natural frequency of the structure itself.

Under some conditions, the body or system may be subjected to a periodic excitation in the form of a force or motion. In such cases a forced vibration occurs. If the frequency of this forced vibration coincides with the natural frequency, a condition known as Resonance occurs.

One of the primary reasons for investigating undamped free vibrations is to find the frequency at which resonance may occur, and avoid it.

The natural torsional frequency ω_n of a rotating shaft is given by the general expression:

$$\omega_n = \sqrt{\frac{K_t}{J}}$$

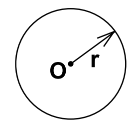
or

$$f_n = \frac{1}{2\pi}\sqrt{\frac{K_t}{J}}$$

where **K**t is the torsional spring constant or torsional stiffness of the shaft and **J** the shaft's mass moment of inertia or rotating inertia.

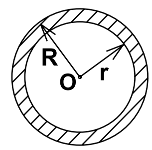
The equation for **J** for cross sections commonly found in shafts used in torque sensors of mass **m** and with axis of rotation through **O** are as follows:

Solid Circular Shaft



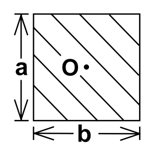
$$J = 1/2\ mr\ \text{lb. in. sec.}^2$$

Hollow Circular Shaft



$$J = 1/2\ m\,(R^2 - r^2)\ \text{lb. in. sec.}^2$$

Solid Rectangular Shaft



$$J = 1/12\ m\,(a^2 + b^2)\ \text{lb. in. sec.}^2$$

Torsional Stiffness **K**t is defined as follows:

$$K_t = \frac{GIp}{L}$$

where **G** is the shear modulus of elasticity, **Ip** the polar moment of inertia and **L** the length of the shaft being twisted. By substitution, we have that

$$\omega_n = \sqrt{\frac{GIp}{JL}}$$

or

$$f_n = \frac{1}{2\pi}\sqrt{\frac{GIp}{JL}}$$

The above appears to be the same relationship as for the case of a linear oscillation. However, in this case there are two moments of inertia, and the distinction between the two should be noted. The mass moment of inertia **J** arises from the **T** = **J** • α law stated elsewhere.

In another section, we will define the polar moment of inertia **Ip** as $\int c^2 dA$. This expression where **c** is the perpendicular distance from an area **dA** to the axis of inertia appears so frequently that it is commonly but inaccurately referred to as moment of inertia. A better term would be the second moment of area because each differential area **dA** is multiplied a second time by its moment arm **c**; the units being a fourth-dimensional term of length and not to be confused with the expression for **J** previously stated.

Additional confusion arises when we consider the formula for maximum flexure stress in a beam where

$$\text{Max. } \sigma_f = \frac{Mc}{I}$$

In this equation, **I** is referred to as the area moment of inertia. We will find use for this when we discuss critical speeds of rotating shafts. **I** in the above equation has the same units as the polar moment of inertia **Ip**. Depending upon which axis the summation of the product of the area and the square of its moment arm are taken, the designation for the area moment of inertia will be I_x or I_y. They are related to the polar moment of inertia as follows:

$$I_p = I_x + I_y$$

As with **Ip**, the area moment of inertia I_x or I_y should not be confused with the mass moment of inertia **J**. Where both occur, **J** is usually referred to as mass moment of inertia and, the other, area or polar moment of inertia.

If **Ip** is known for the area of a body of a constant cross section, the mass moment of inertia **J** may be calculated using the equation:

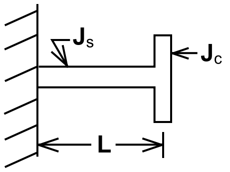
$$J = \frac{\rho L}{g} \cdot I_p \ \text{lb. in. sec.}^2$$

where

ρ = density of the material
L = length
g = gravitational constant

We now offer formulas to determine ω_n and f_n for various configurations:

1. Shaft of uniform cross section and mass moment of inertia J_s anchored at one end and carrying a disk or coupling with mass moment of inertia J_c at the opposite end:



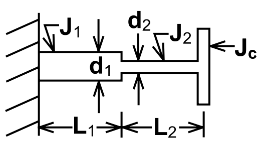
$$\omega_n = \sqrt{\frac{K}{J_c + {}^1\!/_3 J_s}}$$

or

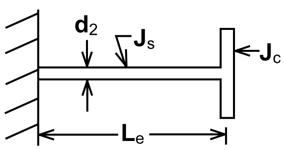
$$f_n = \frac{1}{2\pi}\sqrt{\frac{K}{J_c + {}^1\!/_3 J_s}}$$

Note: When computing J_c, assume a mass **m** of 1/ 2 the total coupling mass. If J_c is a prop immersed in water, J_c will be increased by approximately 20% or J_c (in water) = **1.2 •** J_c (in air).

2. Shaft with two (or more) diameters, anchored at one end and carrying a disk or coupling at the opposite end:



Original Shaft



Equivalent Shaft

$$L_e = L_1\left(\frac{d_2}{d_1}\right)^4 + L_2$$

$$K_e = \frac{\pi d_2^4 G}{32\, L_e}$$

$$J_s = \frac{1}{8} \cdot m_s \cdot d_2^2$$

and

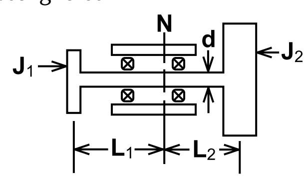
$$\omega_n = \sqrt{\frac{K_e}{J_c + {}^1\!/_3 J_s}}$$

or

$$f_n = \frac{1}{2\pi}\sqrt{\frac{K_e}{J_c + {}^1\!/_3 J_s}}$$

Note: When computing J_c, assume a mass **m** of 1/ 2 the total coupling mass.

3. A uniform shaft with couplings at each end of inertia J_1 and J_2, respectively, and rotating at constant RPM. Further, an external periodic force is applied, causing one end to advance with respect to the other which causes a torque in the shaft to retard the fast end and advance the slow end. The constant RPM may be ignored. For simplification, the mass moment of the inertia of the shaft is also ignored.



N = neutral axis of node which remains at rest

$$L = L_1 + L_2$$

$$L_1 = \frac{J_2}{J_1 + J_2} \cdot L$$

$$L_2 = \frac{J_1}{J_1 + J_2} \cdot L$$

$$K = \frac{\pi d^4 G}{32L} = \frac{GI_p}{L}$$

$$\omega_n = \sqrt{\frac{GI_p}{J_1 L_1}} = \sqrt{\frac{GI_p}{J_2 L_2}}$$

therefore

$$\omega_n = \sqrt{\frac{K(J_1 + J_2)}{J_1 J_2}}$$

and

$$f_n = \frac{1}{2\pi}\sqrt{\frac{K(J_1 + J_2)}{J_1 J_2}}$$

Note: When computing J_1 and J_2, assume a mass **m** of 1/ 2 the total coupling mass.

For products listed in this catalog, the engineering units for rotating inertia **J** and torsional stiffness K_t are

$$J = \text{lb. in. sec.}^2$$
$$K_t = \text{lb. in./radian}$$

Thus

$$\sqrt{\frac{K_t}{J}} \ \text{rad./sec.}$$

and

$$f_n = \frac{1}{2\pi}\sqrt{\frac{K_t}{J}} = .16\sqrt{\frac{K_t}{J}} \ \text{Hz}$$

The natural frequency f_n of a load cell is given by the general expression:

$$f_n = \frac{1}{2\pi}\sqrt{\frac{K}{m}}$$

where **K** is the spring constant of the sensor and m the support mass.

The above equation may be rewritten in terms of deflection Δ of the sensor for a given load:

$$f_n = \frac{1}{2\pi}\sqrt{\frac{g}{\Delta}} = 3.13\sqrt{\frac{1}{\Delta}}\ \text{Hz}$$

and

$$\Delta = \frac{W_{LC} + W_L}{L} \bullet \Delta_L$$

where

- $\mathbf{W_{LC}}$ = Weight of load cell sensor (lbs.) as seen by strain gage bridge. If this information is not available, use 1/ 2 the load cell weight.
- $\mathbf{W_L}$ = Load (lbs.)
- $\mathbf{L}$ = Load cell capacity (lbs.)
- Δ_L = Deflection of load cell at full-scale load (in.). See load cell specifications.
- $\mathbf{g}$ = Gravitational constant (386 in./sec.^{2})

The natural frequency or ringing frequency for load cell products listed in this catalog are for the unloaded condition $\mathbf{W_L} = 0$.

ERROR ANALYSIS

To establish a definition of error, there must exist a solid foundation from which this error is to be measured. We will assume the instrument used in conjunction with the sensor to be a linear device and not prone to introducing its own errors. In this case, a straight line superimposed upon the curve that represents the transfer function of the sensor can serve as the arbitrary basis of the error measurement relative to the sensor.

The primary mechanical input applied to, and measured by, a torque transducer or load cell may be of a steady-state (static or quasi-static) or of a dynamic (cyclic or transient) nature. For the errors that result we will, in this section, deal only with those that are a function of steady-state inputs. The dynamic errors have already been discussed.

Errors which reoccur in accompaniment with a specific set of conditions are defined as predictable. One example of this might be the *"bias"* that a certain operator introduces into the readings. Predictable errors can usually be isolated to a cause and can either be dealt with by eliminating the source or by applying a correction to measurements at an appropriate time.

Unfortunately, all errors are not predictable. When their magnitude and direction cannot be precisely determined but appear to remain within certain bounds, then the error is considered random and abides by the normal probability function:

$$f(x) = \frac{1}{\sqrt{2\pi}} \bullet e^{-\frac{1}{2}x^2}$$

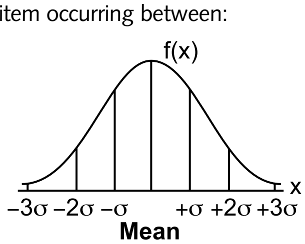
where:

- $\mathbf{x}$ = deviation measured from the mean
- $\mathbf{f(x)}$ = probability density
- $\mathbf{e}$ = base of the natural log and equal to 2.718

A graph of this function is drawn below. The origin is the mean or average of the sample. The distance measured from the origin along the x axis is referred to as the deviation from the average. The height of the curve at any point relates to the number of random samples at the specific deviation. Standard deviation σ (sigma) can be readily calculated by statistical techniques for a given random sample. The probability of a randomly sampled item occurring between:

- $-\sigma$ and $+\sigma$ is 68%
- -2σ and $+2\sigma$ is 94%
- -3σ and $+3\sigma$ is 99.7%

Normal Distibution



When an error is observed, practical considerations will either require that this error be expressed *as a percentage of full scale or a percentage of reading*.

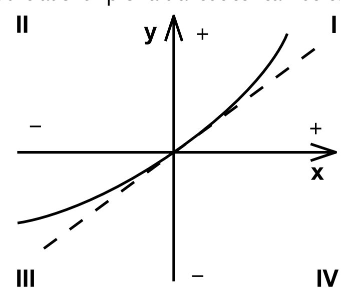
Since an error can be expressed either way, the choice will depend upon the particulars of the application. For example, a measurement taken within the low operating region of the sensor will be more influenced by a percentage of full-scale error, than a measurement taken at the upper operating region. Therefore, the percentage of reading is a more meaningful specification when operating the sensor in a derated mode.

On the other hand, for the sensor at full capacity, the lower operating region of the sensor produces readings of lower resolution, giving more value to the percentage of full-scale specification.

Imperfections inherent in the design and construction of a torque sensor and that which cause deviation from ideal elastic behavior in turn contribute to steady-state errors. They consist of:

NONLINEARITY

The input-output relationship of a transducer can be expressed as follows:



$$y = a_0x + a_1x^2 + a_3x^4 + \bullet\bullet\bullet$$

where $\mathbf{y}$ is the output quantity and $\mathbf{x}$ is the input quantity. The coefficients $\mathbf{a_0}$, $\mathbf{a_1}$, $\mathbf{a_3}$, • • • are the calibration factors. The above expression and graph may be used to define nonlinearity which is the maximum deviation of the calibration curve from a straight line drawn between the no-load and full-load outputs, expressed as a percentage of the rated output and measured on increasing load only. This error can be either systematic or random in nature.

HYSTERESIS

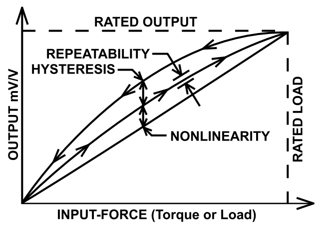
The concept of hysteresis covers a multitude of sins besides the inherent defects in the transducer structure. Such things as bearing friction, backlash, loose fit, fractured or corroded components, misalignment, bolting or just plain dirt manifest themselves as hysteresis, though, in fact, follow their own unpredictable laws and should not concern us here. Structural hysteresis of concern is a manifestation of the imperfect response of microscopic crystal grains, integrated over the macroscopic dimensions of the strained transducer element. The magnitude of the deformation depends upon the maximum stress applied, but is independent of frequency or time. The load-deformation is closed loop and analogous to a similar phenomenon found in magnetic and dielectric materials. The area within the curve represents energy dissipated into heat. We define hysteresis as the maximum difference between the sensor output readings for the same applied load; one reading obtained by increasing the load from zero and the other by decreasing the load from rated output. Hysteresis is usually measured at half rated output and expressed as a percent of rated output. Measurements should be taken as rapidly as possible to minimize the effects of creep. This error can be either systematic or random in nature.

REPEATABILITY

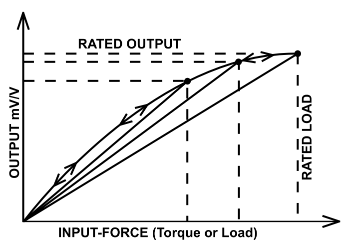
The single most important factor in any transducer measuring system is *repeatability*. Repeatability is a characteristic of a measuring system whereby repeated trials of identical inputs of the measured value produce the same indicated output from the system. Repeatability is the only characteristic error which cannot be calibrated out of the measuring system. Thus, repeatability becomes the limiting factor in the calibration process, thereby limiting the overall measurement accuracy. In effect, repeatability is the minimum uncertainty in the comparison between the unit under test and the reference. Repeatability is normally expressed as a percentage of rated output.

BEST FIT THROUGH ZERO

The generally accepted means of depicting nonlinearity, hysteresis and repeatability and their relationship to each other is as follows:

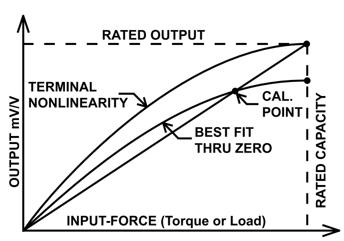


The ability to adjust instrument span and zero will allow variation in the positioning of the straight line relative to the sensor curve. This can often be used to the advantage of the user because it permits an adjustment that can minimize errors.



In the above drawing, assume the curve represents boundary maximums for the absolute value of errors produced by nonlinearity and hysteresis. If the output values of force are then scaled down so that the nonlinearity curve is reduced and at the same time maintain the position of the line, it is apparent that the maximum difference between the curve and the line is reduced. This process is implemented simply by adjusting the span control of the readout instrument.

In terms of mathematical convention when the curves are positioned so as to produce the minimum area between them, the line is termed to be a best fit through zero. At the intersection of the parabolic curve and the line representing true output for a given input, the values are the same, and this is therefore the desired calibration point.



Most manufacturers in the United States do not use this procedure. Instead the errors are not optimized and the line is referred to as terminally positioned. The same methods can be applied to derated full-scale outputs. Though not always included in the published specifications of most transducers, the following parameters should be considered when discussing potential sources of error.

CREEP

The main difference between hysteresis and creep is the fact that the latter depends on time. The effect is due to viscous flow in material. Its magnitude increases with increasing load and temperature. Creep is the change in transducer output occurring with time, while under load, and with all environmental conditions and other variables remaining constant. It's usually measured with rated load applied and expressed as a percent of rated output over a specific period of time. The error is either systematic or random in nature.

CREEP RECOVERY

Creep recovery is one of the elements of the broader topic known as elastic after-effect and which also involves such concepts as stress-relaxation and internal damping. When a load is applied and kept constant, there is still movement similar to creep which decreases with time; but in contrast to viscous flow as described above, there will also be a similar relaxation toward the original position when the load is removed. Creep recovery is defined as the change in no-load output occurring with time, after removal of a load which has been applied for a specific period of time. Creep recovery being little understood is usually ignored in error analysis.

NON-SYMMETRY

Similar to nonlinearity, non-symmetry is the maximum difference between sensor output readings for the same applied load but in the opposite direction. Non-symmetry is not generally expressed but implicit from calibration data. For example, a typical torque sensor may exhibit 1.95 mV/V full-scale output in the CW direction and 1.90 mV/V in the CCW direction. In the diagram from the input-output relationship of torque transducers above, non-symmetry is graphically represented by the curve in quadrant III. If a torque transducer is to be used in both CW and CCW directions, then instrument span and zero require readjustment to assure optimum performance.

There are other factors that should be included in any error analysis if optimum performance of the transducer is desired. They include:

TEMPERATURE EFFECT ON ZERO BALANCE

The change in zero balance due to a change in ambient temperature. This error is primarily of a random nature and usually expressed as a percentage of rated output per degree Fahrenheit change in temperature.

TEMPERATURE EFFECT ON OUTPUT

The change in output due to a change in ambient temperature. This error is primarily of a random nature and expressed as a percentage of reading per degree Fahrenheit change in temperature.

WINDAGE

The opposing torque applied to the torque sensor shaft in rotation due to air friction. This error is of a systematic type and can be directly correlated to rotational speed.

BEARING FRICTION

The opposing torque applied to the torque sensor shaft due to bearing friction. This error is of a systematic type and can be directly correlated to rotational speed.

TRANSDUCER CONSIDERATIONS

BRUSH FRICTION

The opposing torque applied to the torque sensor shaft as a result of the friction between the brush and the slip ring. This error may be eliminated if proper installation procedures are followed.

LOCKED-IN TORQUE

Refers to the torque applied to the shaft due to faulty mechanical alignment or bearing friction associated with the driver or driven element. This is a systematic error that can be eliminated by following installation and alignment procedures.

The intention of a set of specifications pertaining to a product is to forecast the worst case that can be expected and thus provide guidelines for the user who does not care to become concerned with the specific characteristics of the individual sensor or application.

If the user takes into account the specifics of the sensor, then randomness can be replaced by predictability. Predictable errors are correctable errors, and errors so corrected lead to greater precision. For example, with the knowledge that a torque sensor produces maximum nonlinearity at approximately 60% of rated output, it can be shown that a straight line that represents the desired output, relative to a best fit through zero, intersects the sensor's nonlinearity curve at approximately 80% of full scale. With the sensor's nonlinearity curve relocated for best fit through zero, this point represents true output for a given torque input. Therefore, the sensor's calibration network can be made to output the appropriate voltage to enable instrument span adjustment. This voltage can be determined during dead weight calibration.

To issue a generalized statement of accuracy pertaining to a family of sensors, we can use the methods of statistical operations applied to populations. Also, when there are several sources of error in each individual sensor randomly distributed throughout a family of sensors, we can use statistical methods to combine the effects of random errors. One method used to produce such a result is described by the following algorithm:

$$3\sigma_R = \sqrt{\frac{(3\sigma_1)^2 + (3\sigma_2)^2 + (3\sigma_3)^2 + \cdots + (3\sigma_n)^2}{n}}$$

where

$3\sigma 1$, etc. = 3σ error limit of a designated error source

$3\sigma R$ = 3σ error limit resulting from the combination of the individual error sources

The above is sometimes referred to as the RMS value.

OTHER CONSIDERATIONS

In the design of transducers, there are additional factors to be considered. These include, but are not limited to:

BEARING TEMPERATURES

When a rotating torque sensor is to be used for an extended period of time, it is recommended that the customer monitor the bearing temperatures. This may be accomplished by mounting thermocouples on the housing near bearing area. It would be unsafe to operate sensor above 200°F bearing temperature. We also recommend monitoring bearing temperature when application is such that if the torque sensor fails, it could cause personal injury and/or property damage.

FATIGUE LOADING

Sensors may be subjected to varying stresses caused by repeated loading and unloading. Such loading will frequently cause failure at a stress level or value much smaller than the maximum stress value for static tests. Failures of this type are known as fatigue failures. In the design of torque transducers, it is necessary to ascertain the stress that can be safely carried for the application intended. If this information is not available, it is recommended that a transducer not exceed 1/2 its rated capacity for fatigue level or value applications.

IMPACT OR DYNAMIC LOADING

Suddenly applied loads are of a magnitude greater than their static counterparts. The resultant greater deflection in the structure and consequently the stress which is directly proportional to it may cause premature failure or, at least, unreliable results. Kinetic energy, if the velocity of impact is high, will not be completely stored in a resisting element because deceleration of the moving body may be so rapid as to transform part of the kinetic energy into heat and local deformations. Even if the velocity is low, the resisting member may have sufficient stiffness to cause the same result. Also if the mass of the resisting member is large compared to the moving body, the inertia of the resisting member may also cause the same result.

STRESS CONCENTRATION

Undesirable stress concentrations, the result of poor or incorrectly designed structures, may cause premature fatigue failure. Proper transducer designs result from years of experience and the use of good engineering and design practices.

FAILURE ANALYSIS

Various theories of failure analysis exist, their purpose being to establish a point at which failure will occur under any type of loading. By failure, we mean yielding or actual fracture. Theory alone will not assure a successful product. Experience and intuition are also vital ingredients. Equally important is the desire by the manufacturer to improve any design subsequently found to be deficient.

TORQUE SENSORS: A DISCUSSION

TORQUE AND HORSEPOWER

A power-torque relationship is derived from the fact that power is simply defined as the rate of doing work. Work done by torque T in n revolutions is

$$\text{Work} = T\,(2\pi n)$$

Power P is the derivative of work with respect to time or

$$P = \frac{dW}{dt} = 2\pi T \cdot RPM$$

and

$$T = \frac{P}{2\pi \cdot RPM}$$

Horsepower HP, or the rate of doing work, is defined by:

$$1\ HP = 550\ lb.\ ft./sec. = 33{,}000\ lb.\ ft./min.$$

We therefore have the following convenient relations:

$$T = \frac{33{,}000 \cdot HP}{2\pi \cdot RPM}\ lb.\ ft.$$

$$T = \frac{5252 \cdot HP}{RPM}\ lb.\ ft.$$

$$T = \frac{63{,}025 \cdot HP}{RPM}\ lb.\ in.$$

Also

$$1\ Watt = 44.167\ lb.\ ft./min. = 530\ lb.\ in./min.$$

and

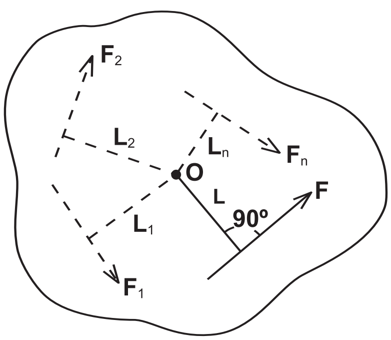
$$1\ Btu = 778\ lb.\ ft. = 9{,}336\ lb.\ in.$$

Therefore, we also have the relations that

$$T = \frac{84.36}{RPM}\ lb.\ in.$$

$$T = \frac{24.72\ Btu/hr.}{RPM}\ lb.\ in.$$

STATICS TORQUE, MOMENTS AND COUPLES



Consider a force of magnitude F lying in a fixed plane. Also consider an axis which is perpendicular to the plane and cutting the plane at O. The moment of the force is defined as the magnitude of the force F multiplied by the perpendicular distance L from the axis O to the line of action of the force. This moment is more commonly defined at the torque about O or To. Thus

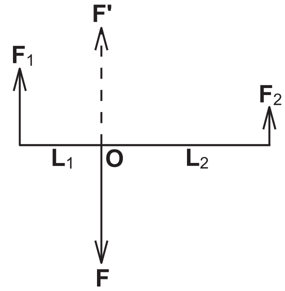
$$T_o = F \cdot L$$

Convention has defined a torque which tends to turn a body clockwise around a chosen axis as positive and that tending to turn a body counterclockwise as negative.

A body in equilibrium must have no resultant force acting upon it, and it is equally important that it have no resultant torque. Therefore, the sum of all torques acting upon a body in equilibrium measured about any axis must be zero. Referring to the above diagram, we may express this as:

$$F_1 \cdot L_1 + F_2 \cdot L_2 + \cdots + F_n \cdot L_n = 0$$

The concept of torque also enables us to deal with parallel forces. Assume a rigid rod as shown below, $L_1 + L_2$ in length and with two spring scales situated to measure forces F_1 and F_2.



Regardless of where a mass of magnitude F is suspended, we always find that

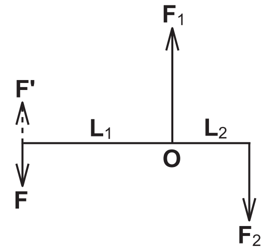
$$F = F_1 + F_2$$

and that by taking the moment about O, the resultant torque on the rod for equilibrium is zero or

$$F_1 \cdot L_1 = F_2 \cdot L_2$$

Also F is equal and opposite to F, and we may regard F_1 and F_2 as replaced by F. The imagined force F is said to be the resultant of $F_1 + F_2$. Also F is equal to the sum of F_1 and F_2 and has the same direction. Furthermore, F would produce the same turning effect on the rod as do the forces F_1 and F_2 jointly.

In the drawing which follows, if F_1 is parallel to F_2, of unequal magnitude and in the opposite direction, the forces are said to be unlike or antiparallel. In this case, the balancing force F no longer acts between the forces; it is outside and nearer the stronger force.



In this case

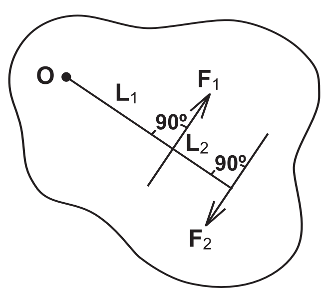
$$F = F_1 - F_2$$

and for equilibrium

$$F_1 \cdot L_1 = F_2\,(L_1 + L_2)$$

and the resultant F is equal and opposite to F.

But what is the resultant of two equal but opposite forces? In the drawing which follows, forces F_1 and F_2 are equal and parallel, but act in opposite directions. The resultant is zero and the forces are said to constitute a couple. A couple tends to produce rotation



and a measure of this tendency is the torque of the couple which is given as the product of one of the forces and the perpendicular distance between them. This can be demonstrated by considering the sum of the moments of the two forces where the magnitude of F_1 equals the magnitude of F_2 or $F_1 = F_2 = F$ and we have

$$T0 = F(L_1 + L_2) - F \cdot L_1 = F(L_1 + L_2 - L_1) = F \cdot L_2$$

TORQUE SENSORS: A DISCUSSION

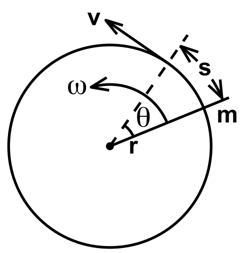
DYNAMICS

Thus far, we have dealt with forces acting upon bodies at rest with respect to the observer, or in uniform motion, that is, in equilibrium. We now turn our attention to the influence of unbalanced forces acting upon bodies relative to the measurement of torque. In simple terms, our previous study dealt with statistics. We will now deal with certain aspects of dynamics and rotation.

There is a parallel between linear and angular motion where angular displacement θ, angular velocity ω and angular acceleration α are commonly measured in radians, radians per second and radians per second^2, respectively. If we assume a shaft of radius **r**, we can relate linear velocity **v** and linear acceleration **a** to their angular counterparts as follows:

$$\mathbf{s} = \theta \bullet \mathbf{r}$$
$$\mathbf{v} = \omega \bullet \mathbf{r}$$
$$\mathbf{a} = \alpha \bullet \mathbf{r}$$

Consider a particle of mass **m** on the surface of a shaft with radius **r** as shown in the following drawing.



From textbooks on the subject, we can show that the kinetic energy **KE** of the particle of mass **m** is **1/2 mv**^{2}. If we have particles of $\mathbf{m}_1$, $\mathbf{m}_2$, $\mathbf{m}_3$, • • • with corresponding velocities $\mathbf{v}_1$, $\mathbf{v}_2$, $\mathbf{v}_3$, • • • the total energy of motion is $\mathbf{1/2\ m_1v_1^2} + \mathbf{1/2m_2v_2^2} + \mathbf{1/2m_3v_3^2}$ • • •, a most inconvenient quantity to calculate. Since $\mathbf{v}_1 = \omega\mathbf{r}_1$, $\mathbf{v}_2 = \omega\mathbf{r}_2$, $\mathbf{v}_3 = \omega\mathbf{r}_3$, etc. and $\mathbf{r}_1$, $\mathbf{r}_2$, $\mathbf{r}_3$, etc. the distances of $\mathbf{m}_1$, $\mathbf{m}_2$, $\mathbf{m}_3$, etc. from the axis of rotation, it follows that the kinetic energy **KE** is $\mathbf{1/2}\omega^2$ $(\mathbf{m}_1, \mathbf{r}_1^2 + \mathbf{m}_2\mathbf{r}_2^2 + \mathbf{m}_3\mathbf{r}_3^2 + \bullet\bullet\bullet)$ since ω, the angular velocity, is the same for all particles.

From Newton's Laws of Motion, inertia is the resistance offered by a body to a change of its state of rest or motion. In the rotation of a rigid body, not only the body's mass but the axis of rotation determines the change in angular velocity resulting from the action of a given torque for a given time. With units of mass multiplied by length^2 the quantity $\mathbf{m}_1\mathbf{r}_1^2 + \mathbf{m}_2\mathbf{r}_2^2 + \mathbf{m}_3\mathbf{r}_3^2$ • • • is known as the *mass moment of inertia* **J** where

$$\mathbf{J} = \sum (\mathbf{mr}^2) = \int \mathbf{r}^2\,\mathbf{dm}$$

and kinetic energy **KE** is expressed as

$$\mathbf{KE} = \mathbf{1/2 J} \bullet \omega^2$$

Using the same approach, we may also define the moment of momentum or, more commonly, angular momentum as

$$\text{Angular Momentum} = \mathbf{J} \bullet \omega$$

An important principle of dynamics is that mass **m** multiplied by acceleration **a**, in any direction, is equal to the resolved parts in that direction of all the forces **F** acting on the mass.

If it is possible to extend this principle to rotation and to state that the algebraic sum of the moments of the mass multiplied by acceleration is equal to the algebraic sum of the moments of the forces or

$$\sum \mathbf{F} \bullet \mathbf{r} = \sum \mathbf{ma} \bullet \mathbf{r}$$

Further, in the case of a large, rigid body free to rotate about any axis, the algebraic sum of the moments of the mass multiplied by acceleration equals the algebraic sum of the moments of the external forces, because the actions and reactions of internal forces cancel.

This means that **I** multiplied by **a** is equal to the sum of moments of all external forces where $\mathbf{a} = \alpha \bullet \mathbf{r}$ and

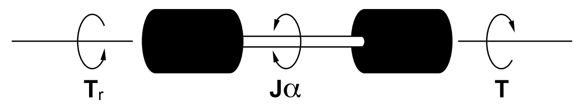
$$\sum \mathbf{F} \bullet \mathbf{r} = \sum \mathbf{mr}^2 \bullet \alpha$$

Since for a rigid body α is the same for all particles, then the sum of all the external torques $\mathbf{J} \bullet \alpha$ or

$$\mathbf{T} \pm \mathbf{T}_r = \mathbf{J} \bullet \alpha$$

If there are no external torques acting on the body $\mathbf{J} \bullet \alpha = \mathbf{0}$ and $\mathbf{J} \bullet \omega$ or angular momentum is a constant and we have the relationship for forces in equilibrium:

$$\mathbf{T} = \pm \mathbf{T}_r$$



As we have already shown, in any rotating system, the sums of all the external torques equal the product of the rotating inertia and the angular acceleration or

$$\mathbf{T} \pm \mathbf{T}_r = \mathbf{J} \bullet \alpha$$

Where

- $\mathbf{T}$ = Applied torque, or torque of device under test
- $\mathbf{T}_r$ = Load torque or resisting torque
- $\mathbf{J}$ = Inertia of all rotating components
- α = Angular acceleration

Rewriting the above:

$$\mathbf{T} = \mathbf{T}_r \pm \mathbf{J} \bullet \alpha$$

This equation points out that the torque of the test device and the load are equal only when the angular acceleration is zero. When the shaft is being accelerated, the torque of the test unit will be greater than that of the load; and the converse will occur during deceleration.

If measurements must be made under accelerating conditions, the device being tested can be mounted on a Torque Table®. Readings from the Torque Table® will be an accurate representation of the total torque developed by the device under test to overcome the load torque as well as the torque, the result of acceleration (or deceleration) of the shaft.

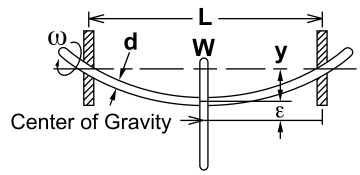
It is interesting to note that the Torque Table® can also be used to measure the torque due to bearing friction and windage losses. This is accomplished by allowing the motor under test to coast to a stop with the load free to rotate by inertia alone. In this manner the load, because of its large inertia, drives the device under test. As there is no power applied to the device under test, the output of the Torque Table® is a true representation of the torque caused by bearing friction and windage losses.

CRITICAL SPEED

At certain speeds and under various conditions of loading and support, a rotating shaft will become dynamically unstable. The resulting vibrations and deflections that occur can result in failure not only to the shaft but to the elements of which the shaft is part. The speeds at which such dynamic instability occurs are called the critical speeds; $\mathbf{N}_c$ of the shaft. Though there is more than one value for $\mathbf{N}_c$, we will concern ourselves with the first or lowest value.

For a rotating shaft, the rotational speed (RPM) is critical when synchronized with ω_n, the natural circular frequency of transverse vibration. Further, the critical speed of any arrangement of shafts is coincident with the natural frequency of the shaft system, vibrating laterally as a simple supported beam.

In this section, we will discuss *natural circular frequency* ω_n and its relationship to critical speed. In another section, we discussed the frequency of free vibration of a shaft, also referred to as the natural frequency ω_n. The two should not be confused.



Consider a uniform shaft of length **L**, diameter **d** as shown above, simply supported and with a disk weight **W** centrally located on the shaft.

We find from structural handbooks that the central static deflection Δ assuming the weight of the shaft as negligible is

$$\Delta = \frac{WL^3}{48EI_x}$$

where **E** is the modulus of elasticity and I_x its area moment of inertia. At any other deflection **y** there will be a spring force **f** tending to restore equilibrium where

$$F = \left(\frac{48EI_x}{L^3}\right) y = \left(\frac{W}{\Delta}\right) y = K \cdot y$$

and where **K** represents the shaft's spring constant. For the condition of dynamic equilibrium of the shaft at any instant and without proof, we may state that the lateral vibration frequency ω is

$$\omega = \sqrt{\frac{Kg}{W}} = \sqrt{\frac{48EI_x g}{WL^3}} \text{ radians/sec.}$$

Or we have that

$$f = \frac{1}{2\pi}\sqrt{\frac{48EI_x g}{WL^3}} \text{ cps}$$

By substitution, we may, therefore, show that

$$\omega = \sqrt{\frac{g}{\Delta}}$$

and that

$$f = \frac{1}{2\pi}\sqrt{\frac{g}{\Delta}}$$

But be sure there is no confusion. Δ is the static deflection due to the weight under gravity and not its amplitude of oscillation caused by deflection **y**. The amplitude of free harmonic oscillation depends only on the starting conditions. The frequency depends upon springs and masses. There is no relation between the two.

With this in mind, we now consider the same shaft rotating at a circular frequency ω. Due to machining errors, the center of gravity of the disk mounted on the shaft is slightly off the centerline by the eccentricity ϵ (exaggerated for purposes of clarity). As the shaft revolves, centrifugal force will tend to bend the shaft. This bending will be resisted by a restoring force, but the bending of the shaft increases the radius producing an even greater centrifugal force, thus producing more bending in the shaft.

Equilibrium will be reached when the shaft has bent an amount **y** and determined by the expression

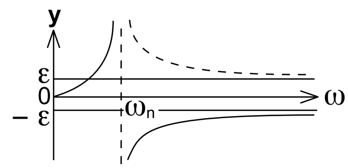
$$y = \frac{\varepsilon}{\left(\frac{\omega_n}{\omega}\right)^2 - 1}$$

Thus, if $\omega = \omega_n$, the deflection **y** appears mathematically infinite but at other values of ω, the value of **y** would be finite. The infinite value is beyond the limits of our hypothesis of the proportional elastic property of the shaft used to derive the above expression—the meaning is, therefore, that the shaft will be permanently strained and will probably fracture if run too long at this particular speed which is, therefore, called the critical speed ω_c; that is, if

$$\omega_c = \omega_n \text{ (radians/sec.)}$$

or where

$$N_c = \frac{60\,\omega_c}{2\pi} = \frac{60\,\omega_n}{2\pi} = \frac{60}{2\pi}\sqrt{\frac{g}{\Delta}} = \frac{187.6}{\sqrt{\Delta}} \text{ RPM}$$



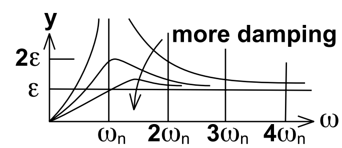
If the spinning shaft is undamped, then as ω increases from zero to ω_n, the deflection **y** increases from zero to infinity as shown in the graph above. For ω higher than ω_n, **y** has a negative sense relative to the sense of ϵ and decreases with increasing speed until at very high speeds **y** tends to the value $-\epsilon$. The dotted line in the higher speed range shows the absolute values of the shaft deflection. The change in the sign of the amplitude is referred to as a phase change approaching 180° as **y** approaches the absolute value of ϵ with a phase change of 90° at $\omega = \omega_n$.

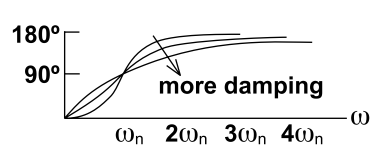
A more complete study of the above would include the effects of damping caused by windage, bearing friction, the spring rate of the bearings, viscosity of media in which the shaft is rotating, etc. Without proof, we can restate the equation for deflection **y** as

$$y = \frac{\varepsilon}{\sqrt{\left(\frac{\omega_n^2}{\omega^2} - 1\right)^2 + \upsilon^2}}$$

where ν is the damping force ratio.

The following graphs help to demonstrate this concept.





With large damping, the amplitudes of **y** can be held fairly low. However, the critical speed ω_n of the shaft remains unchanged and the phase change at ω_n is always 90° regardless of the amount of damping and approaches 180° well above ω_n.

As would be the case in practice bearings used to support the shaft discussed above. This would result in increased stiffness and, as in all vibration problems, increased stiffness will result in a higher natural frequency. Though the equation for N_c still holds, it has been found that Δ will vary depending upon the installation.

TORQUE SENSORS: A DISCUSSION

TORQUE SENSORS: A DISCUSSION

If the bearings are long and rigid, the shaft is considered fixed. In this case

$$\Delta = \frac{WL^3}{192EI_x}$$

If the bearings are self-aligning or very short, as with Lebow's rotating torque transducers, the value for Δ is somewhere between the value above and that previously stated. In practice, we recommend that the value used for Δ be as previously stated or

$$\Delta = \frac{WL^3}{48EI_x}$$

Assuming the shaft contains a number of disks which become infinite, the separate disks would merge to form a uniform shaft. Through the use of calculus and equating the potential energy stored to the work done in bending the shaft, we obtain an equation for N_c slightly different from that previously stated. Without proof, we have for a uniform shaft that

$$\omega^2 = \frac{\pi^4 EI_x g}{WL^3}$$

Converting this to RPM in terms of Δ, we have

$$N_c = \frac{211}{\sqrt{\Delta}} \text{ RPM}$$

where Δ is now defined as

$$\Delta = \frac{5\,WL^3}{EI_x g}$$

If the weight of the circular shaft is not known, it may be found from

$$W = \rho \bullet \frac{\pi d^2}{4} \bullet L$$

where ρ is the density of the shaft and 0.28 lb./in.^{3} for steel.

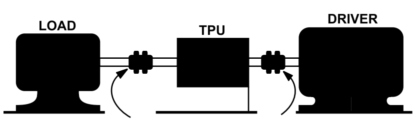
Applying the same techniques, we may also restate the equation for N_c in the case where the bearings are long and rigid and the shaft is considered fixed. We have without proof that

$$N_c = \frac{217}{\sqrt{\Delta}} \text{ RPM}$$

The decision as to which expression is proper in a given design is a matter for the discretion of the designer. All actual cases, except perhaps those of spherically seated ball bearings, lie somewhere between the two but experience shows that

$$N_c = \frac{211}{\sqrt{\Delta}}$$

is closer to the fact because of the effect of clearance between dimensions of any shaft and its journal for a running fit.



SINGLE FLEXIBLE COUPLING FLOATING SHAFT SENSOR

In the practical application where a torque shaft supports a housing through single flexible couplings (floating shaft) as shown above, the mathematical procedure for determining N_c becomes very tedious.

We have, however, an empirical formula (Dunkerley's Formula) which gives excellent results. It is:

$$\frac{1}{\omega_c^2} = \frac{1}{\omega_s^2} + \frac{1}{\omega_1^2} + \frac{1}{\omega_2^2} + \cdots$$

where

ω_s = circular frequency of the shaft due to its own mass only

ω_1 = circular frequency of the shaft regarded as stiff but massless carrying a weight W_1 (in this case the weight of the torque transducers housing)

ω_2 = circular frequency of the shaft carrying weight W_2 etc.

We have already shown that

$$\omega_s^2 = \frac{\pi^4 EI_x g}{W_s L^3}$$

and for the case of a shaft with a disk of weight **W**, we have that

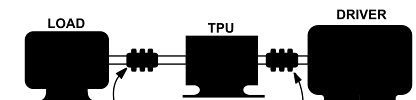
$$\omega_1^2 = \frac{48\,EI_x g}{W_1 L^3}$$

By substitution, we drive the useful relation for N_c of a floating steel circular shaft and housing:

$$N_c = \frac{2{,}230{,}726 \bullet d^2}{L\sqrt{L(W_s + 2W_1)}}$$

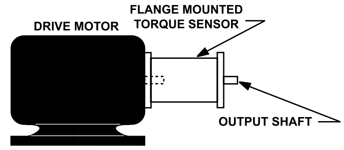
For a steel rotating torque transducer, floating with flanges of weight W_2 each end (e.g., Lebow Model 1228) with a shaft of weight W_s and diameter **d**, and a housing of weight W_1 we have that

$$N_c = \frac{2{,}230{,}726 \bullet d^2}{L\sqrt{L(W_s + 2W_1 + 4W_2)}}$$



DOUBLE FLEXIBLE COUPLING FOOT MOUNT SENSOR

Foot-mounted shaft: use double flex couplings to take the parallel and angular misalignment. Foot-mounting reduces net length of unsupported shaft and reduces possibility of low resonant frequencies. Good alignment of foot-mounted units is still necessary to reduce loads on the bearings.



Flange-mounting: use internal spline drive and follow careful alignment procedures.

For a steel rotating shaft torque transducer with housing foot or flange mounted as shown above, with a shaft of weight W_s and diameter **d**, and couplings each end of weight W_2 (when computing W_2, assume a weight of 1/ 2 the total coupling weight each end of the shaft)

$$N_c = \frac{2{,}230{,}726 \bullet d^2}{L\sqrt{L(W_s + 4W_2)}}$$

TORQUE SENSORS: A DISCUSSION

Tension or compression applied to a rotating shaft will also affect its natural frequency and, thus, its critical speed. As will be discussed in another section, this situation may result from improper use or selection of the shaft couplings. We have the relation and without proof that

$$N_c' = \sqrt{N_c^2 - \frac{36{,}380 \cdot P}{WL}}$$

where **N**c′ is the critical speed because of tension +**P** or compression -**P** and where **N**c is the critical speed of the shaft due to its mass only. For small values of **P**, the effect will be insignificant.

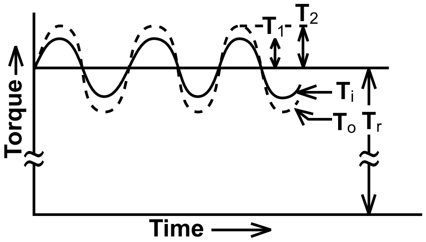
The formulas provided for determination of critical speeds are sufficiently accurate for general-purpose use. Investigations have shown, however, that the critical speed of a shaft can be decreased as torque is applied to a shaft. In fact, there exists critical torques which will reduce the corresponding critical speed of the shaft to zero. A detailed analysis of the effects of applied torques on critical speed may be found in a paper, *Critical Speeds of Uniform Shafts under Axial Torque*, by Golomb and Rosenberg presented at the First U.S. National Congress of Applied Mechanics in 1951.

In general, a rotating torque sensor may be operated safely 20–25% above or below **N**c.

TORSIONAL VIBRATION

It is not uncommon for a torque transducer to be used in applications where there are both static and periodic components of torque present. A good example is an engine dynamometer where the firing of each cylinder in sequence will impose a time varying component of torque upon the steady state value.

The degree to which a torque transducer will faithfully reproduce a time varying applied torque is a function of the frequency ω of the torsional vibration and the natural frequency ω_n of the torque transducer.



If a torsional vibration is applied to a shaft rotating at constant RPM, the torsional vibration torque **T**i has from simple harmonic motion the relation

$$T_i = T_1 \sin(\omega t)$$

Also the restoring torque function **T**o of the shaft due to the torsional vibration can be shown to be

$$T_o = T_2 \sin(\omega t)$$

And finally the torsional windup θ of the shaft resulting from the same torsional vibration is

$$\theta = \theta_1 \sin(\omega t)$$

In any rotating system we have already shown that the algebraic sum of all the torques must equal the product of the rotating inertia and angular acceleration. Therefore

$$T \pm T_r = J \cdot \ddot{\theta}$$

We may rewrite the above relation as follows

$$T_i \pm K\theta = J \cdot \ddot{\theta}$$

recalling that

$$T = \frac{GIp}{L} \cdot \theta$$

and that

$$K = \frac{GIp}{L}$$

and defining angular acceleration as the second derivative of θ or $\ddot{\theta}$. By substitution and during acceleration we have that

$$T_1 \sin(\omega t) - K\,\theta_1 \sin(\omega t) = J \cdot \ddot{\theta}$$

Without proof, we state that

$$\ddot{\theta} = -\,\omega^2\,\theta_1 \sin(\omega t)$$

Giving us the relation that

$$T_1 \sin(\omega t) - K\,\theta_1 \sin(\omega t) = -\,J\,\omega^2\,\theta_1 \sin(\omega t)$$

and therefore,

$$T_1 - K\,\theta_1 = -\,J\,\omega^2\,\theta_1$$

or

$$\theta_1 = \frac{T_1}{K - J\omega^2}$$

Since torque **T**2 is also a function of the torsional windup θ, we may show that

$$\theta_1 = \frac{T_2}{K_t}$$

By substitution, we may, therefore, write the following relationship

$$\frac{T_2}{K_t} = \frac{T_1}{K_t - J\omega^2}$$

or

$$\frac{T_2}{T_1} = \frac{1}{1 - \left(\frac{I}{K}\right)\omega^2} = \frac{1}{1 - \left(\frac{1}{K_t/J}\right)\omega^2}$$

We recall that

$$\omega_n = \sqrt{\frac{K_t}{J}}$$

Therefore, the maximum amplitude of the time varying restoring **T**2 is related as follows:

$$\frac{T_2}{T_1} = \frac{1}{1 - \left(\frac{\omega}{\omega_n}\right)^2}$$

If the amplitude **T**1 and the frequency ω of the torsional vibration are known, we may compute the value for **T**2 assuming **T**i and **T**o are in phase.

The error caused by torsional vibration in a torque measurement can be computed for various values of ω/ω_n and is tabulated below.

ω/ω_n	T_2/T_1	% ERROR
.00	1	0
.01	1.0001	1.00136 x 10-2
.02	1.0004	4.00543 x 10-2
.03	1.0009	9.01222 x 10-2
.04	1.0016	.160217
.05	1.00251	.250626
.06	1.00361	.361347
.07	1.00492	.492382
.08	1.00644	.644112
.09	1.00817	.816631
.10	1.0101	1.01013
.11	1.01225	1.2248
.12	1.01461	1.46103
.13	1.01719	1.71909
.14	1.01999	1.99919
.15	1.02302	2.30179
.16	1.02627	2.62728
.17	1.02976	2.97604
.18	1.03348	3.34845
.19	1.03745	3.74517
.20	1.04167	4.1667
.21	1.04613	4.6134
.22	1.05086	5.08614
.23	1.05585	5.58548
.24	1.06112	6.112
.25	1.06667	6.66666
.26	1.0725	7.25012
.27	1.07863	7.86324
.28	1.08507	8.50697
.29	1.09182	9.18217
.30	1.0989	9.89008
.31	1.10632	10.6317
.32	1.11408	11.4081
.33	1.12221	12.2209
.34	1.13071	13.071
.35	1.1396	13.9601
.36	1.1489	14.8897
.37	1.15861	15.8614
.38	1.16877	16.877
.39	1.17938	17.9384
.40	1.19048	19.0475
.41	1.20207	20.2067
.42	1.21418	21.4181
.43	1.22684	22.6843
.44	1.24008	24.0079
.45	1.25392	25.3918
.46	1.26839	26.8391
.47	1.28353	28.3532
.48	1.29938	29.9376
.49	1.31596	31.5962
.50	1.33333	33.3333

The % error listed in the above table relates to the periodic components only.

We can also show that the error as a percentage of full scale with the maximum torque amplitude of the applied torsional vibration being T_1 and the amplitude of the steady state torque T_r is as follows:

$$\text{\% error of full scale} = \frac{T_2 - T_1}{T_1 + T_r} \cdot 100$$

MECHANICAL CONSIDERATIONS

BEARING LIFE

Even if a bearing is properly mounted, adequately lubricated, protected from foreign matter and not subject to extreme operating conditions, it can ultimately fail. Under ideal conditions, the repeated stresses developed in the contact areas between the bearings and the raceway will eventually result in the fatigue of the material. Fatigue is considered to be a spalling or pitting of an area of 0.01 in^2 (6.5mm^2) in any of the bearing components.

In most applications, the fatigue life is the maximum useful life of a bearing. Manufacturers of bearings have developed a statistical relationship to establish a rated life, referred to as the L_{10} or $L_{B\text{-}10}$ for each type of bearing. The L_{10} life is defined as the number of operating revolutions that 90% of a given group of identical bearings will endure before the onset of "contact fatigue." $L_{B\text{-}10}$ has the same definition except the parameters are operating hours at a given RPM. L_{10} or $L_{B\text{-}10}$ ratings are based upon ideal operating conditions.

Fatigue life assumes the application of a constant, stationary radial load as established by the manufacturer. Since fatigue life is inversely proportional to the 10/3 power of the applied load, a reduction of the applied load by a factor of 2 will increase the statistical bearing life by a factor of 10. In most applications, the bearings will be subjected to loads less than the established rated loads, in which case extended bearing life should be expected.

Speed ratings of Lebow® rotating torque sensors, unless brush contact limited, are based upon an $L_{B\text{-}10}$ life of 15,000 hours. That is: the life of a bearing system used in Lebow® rotating torque sensors, on a statistical basis, should last at least 15,000 hours if operated at maximum speed. This rating is based on light bearing loads; light loads defined as not exceeding 33% of bearing load rating at speed of operation and under ideal conditions. The life of a bearing system at any lower RPM may be approximated by the relation

$$\text{Bearing life (Hrs.)}^* = 15{,}000 \left(\frac{\text{RPM for an } L_{B\text{-}10} \text{ life of 15,000 hrs.}}{\text{actual RPM}} \right)$$

* Not to exceed 30,000 hours.

The $L_{B\text{-}10}$ life rating of bearings is subject to being modified by the lubrication technique used. Most bearings supplied by Lebow® include a grease pack lubrication system; the bearings should not be operated for more than 200–300 hours continuous at rated speed. At 40% of rated speed, this increases to approximately 600 hours. An air-oil option available on most models should be used if the above values are exceeded, in which case the bearings should provide reasonable service up to 2,000 hours of continuous use at rated speed.

Because the parameters used by bearing manufacturers to establish bearing life or rated speed vary, it is impossible to provide a simple expression for the purpose of determining these values. If there are any questions, the factory should be consulted.

BRUSH LIFE

Under ideal operating conditions, total brush life has been determined from statistical analysis as well as empirical tests to be

$$\text{Brush Life (Hrs.)} = \frac{K}{dN}$$

Where

K = Brush Life Constant (in. hr. RPM)
d = Ring diameter (in.)
N = RPM

Two types of brushes are currently in use by Lebow. Values of **K** are

Type	K
A-10983-10,-11,-12	30.7×10^6
A-14417	6.2×10^6

For those products available from Lebow® with slip rings, a Brush Life Factor **LF** is provided. To determine the total usable brush life in hours under ideal operating conditions, divide **LF** by the RPM at which the transducer will be operated or

$$\textbf{Brush Life (Hrs.)} = \frac{\textbf{LF}}{\textbf{RPM}}$$

For elevated temperatures we have

$$\textbf{Brush Life (Hrs.)} = \frac{\textbf{0.1 LF}}{\textbf{RPM}}$$

The maximum speed at which a rotating slip ring system may be used is either limited by the bearings used or the surface speed of the brush to ring interface. In the latter case, some agree that the surface speed of a slip ring should not exceed 5,000 fpm. Others feel that 7,500 fpm is suitable. There are others who feel that under extremely good operating conditions and minimum temperature rise that 9,000 fpm is the limit. When operating at 9,000 fpm, it is recommended that slip rings be cleaned and the brushes be replaced every 15 minutes. In addition, the brushes should be lifted when not in use.

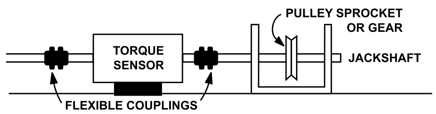
Lebow® makes no claim as to which of the above is correct. Though 5,000 fpm is in most cases the value used by Lebow®, there have been occasions when the higher values were used successfully. The ring diameters for the applicable products are provided in the specifications. To compute fpm where **d** is the ring diameter in inches, use the following expression

$$\textbf{fpm} = \textbf{.262d} \cdot \textbf{RPM}$$

BELT, CHAIN OR GEAR DRIVES

Precautions should be taken when Lebow® rotating shaft torque sensors are used for applications which require that they be driven or loaded directly by a belt, chain or gear power transfer system. The systems can induce high bending loads in the shaft and/or bearing failure.

Where these drive systems are required, the pulleys, sprockets or gears should be mounted on a jackshaft assembly which would be coupled to the shaft of the torque sensor with a flexible coupling. This will allow the bearings of the jackshaft assembly to carry all bending loads and transfer only torque loads to the shaft of the torque sensor.

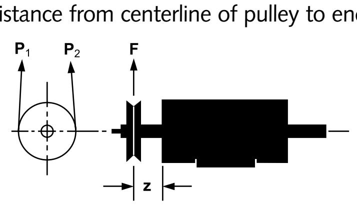


Belt drive or loading of the torque sensor shaft is permissible with 1100 series shaft torque sensors if belt tension can be carefully controlled.

To determine the belt tension limit, use the following formulas:

$\mathbf{F} \leqq \mathbf{T/4}$ Whichever is attained first
$\mathbf{FZ} \leq \mathbf{T/4}$

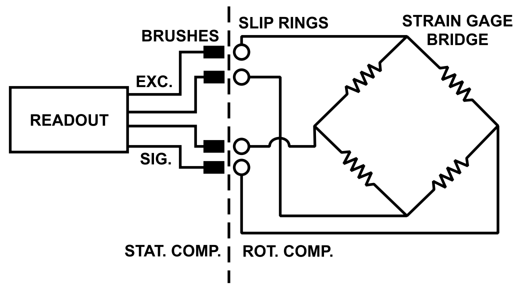
where
F = Total belt tension = $\mathbf{P}_1 + \mathbf{P}_2$ (pounds)
T = Rated capacity of sensor (in. lbs.)
Z = Distance from centerline of pulley to end of housing (inches)



IN-LINE ROTATING SHAFT TORQUE SENSORS

SLIP RINGS

The strain gage bridge is connected to four silver slip rings mounted on the rotating shaft. Silver graphite brushes rub on these slip rings and provide an electrical path for the incoming bridge excitation and the outgoing signal. It has the advantage that either AC or DC can be used to excite the strain gage bridge.



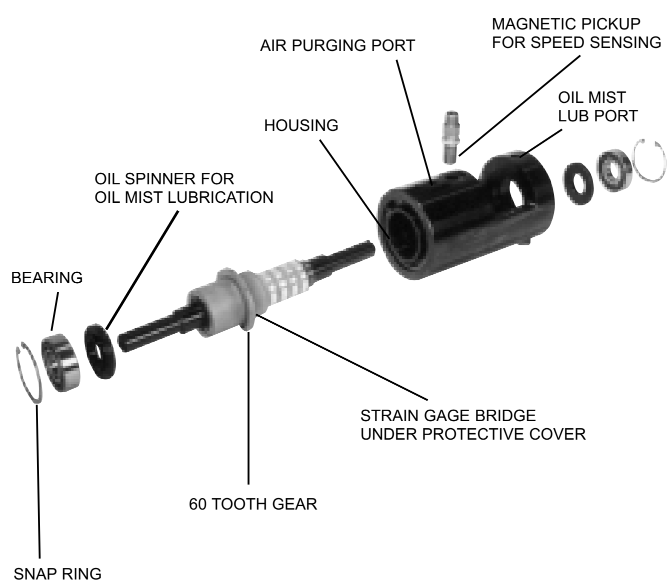
Slip ring rotating shaft torque measuring system

When rotating in a strong magnetic field, the slip ring system can generate small extraneous voltage. In this circumstance, AC excitation should be used.

Because of the low signal levels (millivolts) produced by a strain gage bridge, the rings and brushes should be periodically cleaned to maintain a satisfactory signal to noise ratio.

The brush carrier system utilized by Lebow® has been designed for easy maintenance. It is a single assembly that is readily changed by removing two screws on most models. Brushes themselves can be replaced with a screwdriver by removing the brush cap, pulling out the old brush and dropping in a new brush.

Where it is desired to lift brushes, a manual or air-operated lifter assembly can be provided as an option.

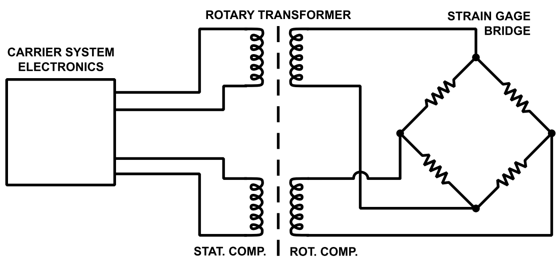


Disassembled view–typical rotating shaft torque sensor with slip rings

TORQUE SENSORS: A DISCUSSION

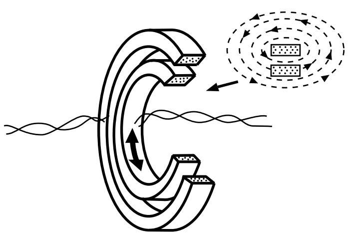
ROTARY TRANSFORMER

Rotating transformers differ from conventional transformers only in that either the primary or secondary winding is rotating. One transformer is used to transmit the AC excitation voltage to the strain gage bridge, and a second transformer to transfer the signal output to the non-rotating part of the transducer. Thus, two transformers replace four slip rings and no direct contact is required between the rotating and stationary elements of the transducer.



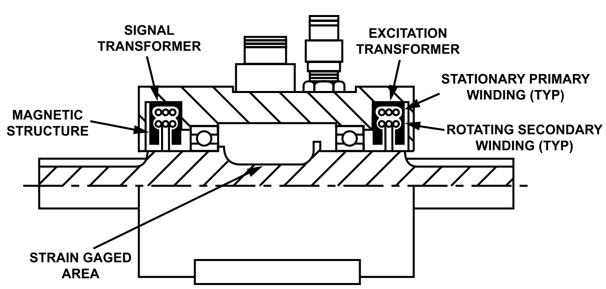
Rotary transformer rotating shaft torque measuring system

The transformers themselves are a pair of concentrically wound coils with one coil rotating within or beside the stationary coil. The magnetic flux lines are produced by applying a time varying voltage to one of these coils. A high permeability core is added to concentrate flux in a magnetic path and improve coupling between coils.



Basic principle of one coil rotating inside another

The diagram below illustrates the internal construction of this type of torque sensor.



The "gap" in the magnetic structure is to allow the passage of a support member for the inner rotating coil. This particular geometry (Lebow® Pat. No. 3,611,230) enables the transformer to exhibit high coefficient of coupling and, since there is no relative movement of any part of the magnetic path, to be free from "runout" effects.

Transmission of energy through any transformer requires that the current be alternating. A suitable carrier instrument providing excitation in the range of 3 KHz should be used. The Lebow® Model 7540 instrument contains features which assure optimum results when used with rotary transformer torque sensors.

REACTION TORQUE SENSORS

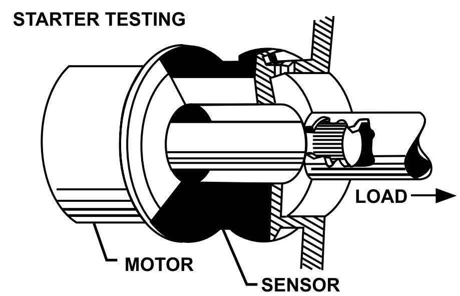
Reaction torque is the turning force (moment) which tends to produce rotation of the stationary portion of any device delivering or absorbing power by means of a rotating output (or input) shaft. For example, it is the moment required to keep the housing of an electric motor from rotating when its output shaft is loaded; or conversely, the force required to keep the housing of an electric generator from rotating when its input shaft is driven from a power source.

FLANGED REACTION TORQUE SENSORS

These units consist of a structure which supports the test device. The sensors wind up slightly (0.5 to 1 degree) when restraining the housing of the test device. Strain gages mounted on the sensor provide an electrical output proportional to torque.

This type of sensor has advantages in that they: (1) are not speed limited, (2) have no moving parts and therefore require no maintenance and (3) are easily calibrated by dead weight procedures.

The precautions to be taken in the application of flange-mounted reaction torque sensors are: (1) careful analysis of extraneous and tare loads to be carried and (2) care in connecting power cables, air or hydraulic lines, since these are parallel or parasitic torque paths which prevent the reaction torque sensor from carrying the full torque generated.



Flange-mounted torque sensor

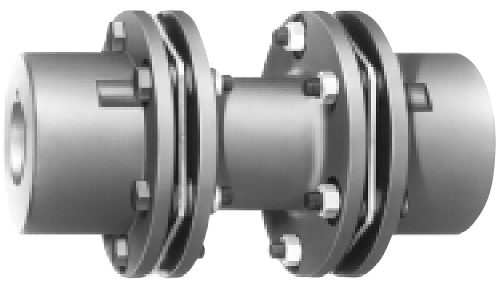
TORQUE SENSORS: A DISCUSSION

SELECTION OF COUPLINGS FOR ROTATING TORQUE SENSORS

FOR FOOT-MOUNTED SENSORS

DUAL FLEX TORSIONALLY STIFF DISC COUPLING

C-33700



FOR NON-FOOT-MOUNTED SENSORS

SINGLE FLEX TORSIONALLY STIFF DISC COUPLING

C-33701

Disc couplings are recommended for torsionally stiff applications when torque spikes need to be measured. Very low maintenance and high RPM ratings are advantages to selecting disc couplings.

DUAL FLEX DISC COUPLING MIXED SIZE HUBS

C-33702

SINGLE FLEX DISC COUPLING MIXED SIZE HUBS

C-33703

Mixed hubs offer a solution to the problem of shafts that have a large difference in diameter.

DUAL FLEX—TORSIONALLY SOFT "STEELFLEX"

C-33706

SINGLE FLEX—TORSIONALLY SOFT "STEELFLEX"

C-33707

"SteelFlex" couplings are recommended for non-stiff applications where torque spikes need to be smoothed out. "SteelFlex" is a registered trademark of the Falk Corporation.

Lebow Products can pre-install these couplings on torque sensors prior to shipment to minimize potential for damage to the torque sensor and facilitate installation on your site.

ROTARY

RATED CAPACITIES
(Capacities are Pound Inches unless otherwise noted)

MODEL PAGE CAPACITY

SLIP RING

SHAFT DRIVE

MODEL	PAGE	CAPACITY					
*1102	24	50	100	200	500	1K	
*1103	24	10	20				
1104	24	50	100	200	500	1K	2K
1105	24	2K	5K	10K			
1106	24	20K					
1107	24	50K	100K				
1108	24	120K	240K				
1109	24	360K	600K				
1118	24	840K	1200K	1800K			
1121	24	2400K	3000K				

SPECIAL PURPOSE

FLANGE DRIVE

MODEL	PAGE	CAPACITY		
1228	27	2K	5K	10K
1248	27	20K		

WHEEL

MODEL	PAGE	CAPACITY		
1246	28	20K	30K	36K
1256	28	100K	200K	300K

PULLEY

MODEL	PAGE	CAPACITY	
1388-102	29	500	1K

SQUARE DRIVE

MODEL	PAGE	CAPACITY						
1254	30	50	100	200	600	1.2K	3.6K	12K
1254E	30	50	100	200	600	1.2K	3.6K	12K

ROTARY TRANSFORMER

SHAFT DRIVE

MODEL	PAGE	CAPACITY					
*1602	32	50	100	200	500	1K	
1604	32	50	100	200	500	1K	2K
1605	32	2K	5K	10K			
1606	32	20K	30K				
1607	32	50K	100K				

FLANGE DRIVE

MODEL	PAGE	CAPACITY			
1641	35	20K	50K	100K	
1648	35	2K	5K	10K	20K

NON-CONTACT/AMPLIFIED OUTPUT

MODEL	PAGE	CAPACITY				
**1700	36	0.02	0.05			
**1701	36	0.10	0.20	0.50	1	2
**1702	36	5	10	20		
**1703	36	50	100	200	300	
**1706	36	500	1K	1.5K		

HIGH-ACCURACY ROTARY TRANSFORMER

SHAFT DRIVE: HIGH SPEED AND ACCURACY

MODEL	PAGE	CAPACITY				
1804	38	100	200	500	1K	2K
1805	38	2K	5K	10K		
1806	38	20K				
1807	38	50K	100K			

SPLINE DRIVE

MODEL	PAGE	CAPACITY							
1815A	40	50	100	200	500	1K			
1815K	40	50	100	200	500	1K	2K	5K	10K

SHORT FLANGE: DIGITAL TELEMETRY DYNAMOMETER

MODEL	PAGE	CAPACITY											
2000	42	1.2K	3K	6K	9K	12K	18K	24K	36K	48K	60K	72K	96K

*Rated Capacity Ounce Inches
**Rated Capacity N m

REACTION

RATED CAPACITIES
(Capacities are Pound Inches unless otherwise noted)

MODEL	PAGE	CAPACITY										
SHAFT MOUNT												
*2120	51	50	100	200	500	1K						
2121-2126	44	100	200	500	1K	2K	5K	10K	20K	50K	100K	500K
*2105	46	50	100	200	500	1K						
FLANGE MOUNT												
2102	46	50	100	200	500	1K						
2110	48	2K	5K									
2111	48	10K	20K	30K								
2112	48	50K	100K									
2113	48	200K										
2114	48	300K	500K									
2115	48	600K	750K									
2116	48	1200K	2400K									
SQUARE DRIVE												
***2133-300	30	10	20	50	100	250	600	1K				
HOLLOW FLANGE MOUNT												
2404	48	50	100	200	500	1K	2K	5K				
2320	48	12K	24K	36K								
REACTION TORQUE TABLES												
2514	52	10	25	50								
2520	52	50	100	200								
2528	52	100	200	500	750							
2540	52	500	750	1K	1.5K	2K						
STEERING EFFORT SENSOR												
1369	54	50	100	200								
TORQUE/THRUST												
6459	55	900/1.5K										
6467	55	5K/10K										
6468	55	25K/50K	25K/75K									
6469	55	50K/100K										
6470	55	100K/200K										
SLIP RING SHAFT ASSEMBLIES												
6105	56											
6109	56											
6116	56											
6118	56											
6121	56											
6129	56											

**Rated Capacity – Ounce Inches* ****Rated Capacity - Pound Feet*

TYPICAL APPLICATIONS OF IN-LINE ROTATING SHAFT SENSORS:

Testing of speedometer cables
Testing of blowers
Testing of small motors, pumps and fans
Evaluation of clutch and brake system
"4" square dynamometer
Testing hydraulic pumps
Engine dynamometer
Chassis dynamometer
Checking gear box efficiencies

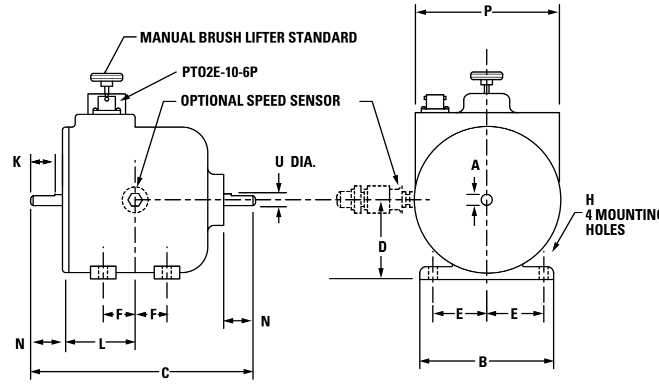
TYPICAL APPLICATIONS OF REACTION TORQUE SENSORS:

For viscosity measurements
Bearing friction measurements
Measurement of stepping switch torque
Small motor dynamometer
Hollow sensor controls bulk conveyor
High-speed alternator tests
Axle torsion test
Starter testing
Auto brake tests

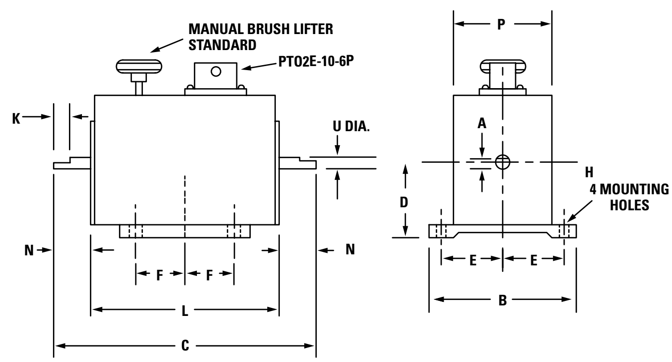
MODELS 1102/1103

Low capacity torque sensors

1102

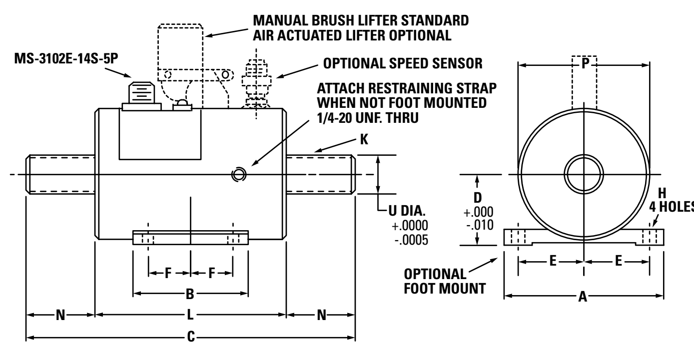


1103



MODELS 1104–1121

Standard rotating shaft torque sensor for general application



1104	IN.	CM.
C	10	25.40
L	5.81	14.76
N	2.09	5.32
P	4	10.16
U	*1.00	*2.54
K	*0.25 sq.	*0.64 sq.
A	4.75	12.07
B	3.50	8.89
D	2.13	5.40
E	2	5.08
F	1.38	3.49
H	0.28	0.71

1105	IN.	CM.
C	12.75	32.39
L	7.25	18.42
N	2.75	6.99
P	4.72	11.99
U	1.50	3.81
K	0.38 sq.	0.95 sq.
A	6.25	16.51
B	4	10.16
D	2.50	6.35
E	2.63	6.67
F	1.50	3.81
H	0.41	1.03

1106	IN.	CM.
C	14.63	37.15
L	6.88	17.46
N	3.88	9.84
P	5.50	13.47
U	2.25	5.72
K	0.50 sq.	1.27 sq.
A	7.25	18.42
B	5.25	13.34
D	3	7.62
E	3	7.62
F	2	5.08
H	0.53	1.35

1107	IN.	CM.
C	19	48.26
L	7.50	19.05
N	5.75	14.61
P	6.50	16.51
U	3.00	7.62
K	0.75 sq.	1.91 sq.
A	8.50	21.59
B	5.50	13.97
D	3.50	8.89
E	3.50	8.89
F	2	5.08
H	0.53	1.35

***100 & 200 lb. inch units; K=3/16" sq., U=3/4"**

1102	IN.	CM.
C	6.50	16.50
L	2.25	5.70
N	1.00	2.50
P	3.50	8.90
U	0.37	0.95
K	0.75 flat	1.90 flat
A	0.34	0.86
B	4.13	10.50
D	1.75	4.44
E	1.75	4.44
F	1.00	2.50
H	0.20	0.50

1103	IN.	CM.
C	4.00	10.16
L	2.88	7.30
N	0.56	1.43
P	1.50	3.81
U	0.12	0.32
K	0.25 flat	0.64 flat
A	0.09	0.24
B	2.25	5.70
D	1.00	2.50
E	0.94	2.38
F	0.75	1.90
H	0.14	0.37

1108	IN.	CM.
C	21	53.34
L	8.75	22.23
N	6.13	15.56
P	8.88	22.54
U	4.50	11.43
K	1 sq.	2.54 sq.
A	10	25.40
B	6	15.24
D	5	12.70
E	4.25	10.80
F	2.25	5.72
H	0.53	1.35

1109	IN.	CM.
C	28	71.12
L	11.25	28.58
N	8.38	21.27
P	10.25	26.04
U	5	12.70
K	1 sq.	2.54 sq.
A	11.5	29.21
B	6	15.24
D	5.75	14.61
E	5	12.70
F	2.25	5.72
H	0.53	1.35

1118	IN.	CM.
C	36	91.44
L	10	25.40
N	13	33.02
P	12	30.48
U	7.94	20.16
K	2 sq.	5.08 sq.
A	n/a	n/a
B	n/a	n/a
D	n/a	n/a
E	n/a	n/a
F	n/a	n/a
H	n/a	n/a

1121	IN.	CM.
C	42	106.68
L	10	25.40
N	16	40.64
P	13	33.02
U	8.94	22.70
K	2 sq.	5.08 sq.
A	n/a	n/a
B	n/a	n/a
D	n/a	n/a
E	n/a	n/a
F	n/a	n/a
H	n/a	n/a

FEATURES:

- Higher frequency response
- Lower cost for general "in-line" applications
- Can be used with almost all existing DC and AC signal conditioning instrumentation
- Accurate "in-line" torque measurements

Foot Mounting–foot mount plate and housing available for models 1104, 1105, 1106, 1107, 1108 and 1109.

Brush Lifters–recommended for protracted runs in which continuous readings are not taken. When released, brushes do not contact the rings.

Speed Sensor–a 60-tooth gear and a magnetic pickup provides an output of 60 pulses per shaft revolution. On models 1104 and 1105 for speeds less than 200 RPM, Zero Velocity Speed Sensors are recommended. On models 1106 and higher for speeds less than 100 RPM, Zero Velocity Speed Sensor is recommended. Zero Velocity Speed Sensor is not available on model 1102. No speed sensor is available on model 1103.

Safety Considerations: *"It would be unsafe to operate Lebow® Torque Sensors and Load Cells beyond Static Overload or Ultimate Extraneous Load Limits as defined in the Glossary of Terms or, when applicable, higher than maximum speed. When in doubt, consult the factory. Lebow® Products is not responsible for any property damage or personal injury which may result because of the misapplication of the Transducer."*

PERFORMANCE SPECS:

1102/1103 AND 1104–1121

SPECIFICATIONS	
Actual performance average:	
Nonlinearity:	0.026%
Hysteresis:	0.031%
Nonlinearity: *of rated output*	± 0.1%*
Hysteresis: *of rated output*	± 0.1%*
Output at rated capacity: *millivolts per volt, nominal*	2*
Repeatability: *of rated output*	± 0.05%
Zero balance: *of rated output*	± 1.0%
Bridge resistance: *ohms nominal*	350*
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-20 to +200
Temperature range, usable: *°C*	-29 to +93
Temperature effect on output: *of reading per °F*	± 0.002%
Temperature effect on output: *of reading per °C*	± 0.0036%
Temperature effect on zero: *of rated output per °F*	± 0.002%
Temperature effect on zero: *of rated output per °C*	± 0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges	1

*Model 1103 output at rated capacity is 0.95, nonlinearity is .05%, hysteresis is .05% and bridge resistance is 240 ohms.

SENSOR CHARACTERISTICS: 1102/1103 AND 1104–1121

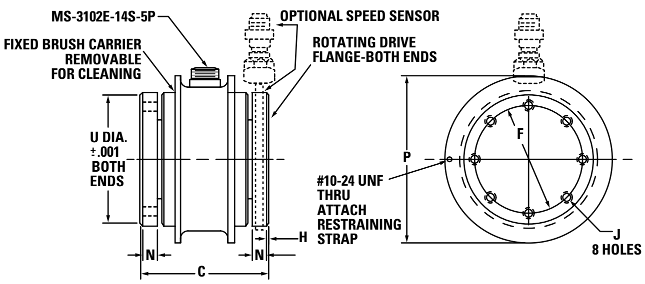
MODEL NUMBER	CAPACITY oz. in. (N • m)	MAX. SPEED RPM	PROTECTED FOR OVERLOADS TO oz. in. (N • m)	TORSIONAL STIFFNESS lb. in./rad. (N • m/rad.)	ROTATING INERTIA lb.-in. sec.^{2} (N • m sec.^{2})	WEIGHT lbs. (kg.)	BRUSH LIFE FACTOR x 10^6	RING DIAMETER in. (cm.)
1102-50	50 (0.35)	20,000	75 (0.53)	665 (75.13)	1.75 x 10^{-3} (2.00 x 10^{-4})	2 (0.90)	8.20	0.75 (1.91)
1102-100	100 (0.70)	20,000	150 (1.06)	1,070 (120.89)	1.75 x 10^{-3} (2.00 x 10^{-4})	2 (0.90)	8.20	0.75 (1.91)
1102-200	200 (1.50)	20,000	300 (2.12)	1,790 (202.24)	1.76 x 10^{-3} (2.00 x 10^{-4})	2 (0.90)	8.20	0.75 (1.91)
1102-500	500 (3.50)	20,000	750 (5.30)	3,480 (393.18)	1.77 x 10^{-3} (2.00 x 10^{-4})	2 (0.90)	8.20	0.75 (1.91)
1102-1K	1,000 (7.00)	20,000	1,500 (10.50)	4,850 (547.97)	1.78 x 10^{-3} (2.00 x 10^{-4})	2 (0.90)	8.20	0.75 (1.91)
1103-10	10 (0.07)	20,000	15 (0.11)	112 (12.65)	2.59 x 10^{-5} (3.00 x 10^{-6})	0.75 (0.34)	n/a	n/a -
1103-20	20 (0.15)	20,000	30 (0.21)	113 (12.76)	2.59 x 10^{-5} (3.00 x 10^{-6})	0.75 (0.34)	n/a	n/a -

MODEL NUMBER	CAPACITY lb. in. (N • m)	MAX. SPEED RPM	PROTECTED FOR OVERLOADS TO lb. in. (N • m)	TORSIONAL STIFFNESS lb. in./rad. (N • m/rad.)	ROTATING INERTIA lb.-in. sec.^{2} (N • m sec.^{2})	WEIGHT lbs. (kg.)	BRUSH LIFE FACTOR x 10^6	RING DIAMETER in. (cm.)
1104-100	100 (10)	9,000	150 (15)	6,430 (726)	3.93 x 10^{-3} (4.50 x 10^{-4})	11 (4.99)	15.40	2.00 (5.08)
1104-200	200 (20)	9,000	300 (30)	17,000 (1,920)	3.96 x 10^{-3} (4.50 x 10^{-4})	11 (4.99)	15.40	2.00 (5.08)
1104-500	500 (55)	9,000	750 (85)	45,200 (5,100)	4.11 x 10^{-3} (4.70 x 10^{-4})	11 (4.99)	15.40	2.00 (5.08)
1104-1K	1,000 (115)	9,000	1,500 (170)	103,000 (11,640)	4.11 x 10^{-3} (4.70 x 10^{-4})	11 (4.99)	15.40	2.00 (5.08)
1104-2K	2,000 (225)	9,000	3,000 (340)	182,500 (20,620)	4.14 x 10^{-3} (4.70 x 10^{-4})	11 (4.99)	15.40	2.00 (5.08)
1105-5K	5,000 (565)	8,500	7,500 (850)	475,000 (53,670)	9.29 x 10^{-3} (10.50 x 10^{-4})	28 (12.70)	14.00	2.19 (5.56)
1105-10K	10,000 (1,130)	8,500	15,000 (1,695)	750,000 (84,740)	1.06 x 10^{-2} (1.22 x 10^{-3})	28 (12.70)	14.00	2.19 (5.56)
1106-20K	20,000 (2,250)	4,500	30,000 (3,390)	2,610,000 (294,890)	3.93 x 10^{-2} (4.50 x 10^{-3})	42 (19)	10.20	3.00 (7.62)
1107-50K	50,000 (5,650)	4,000	75,000 (8,475)	7,220,000 (815,720)	0.14 (15.50 x 10^{-3})	74 (33.60)	7.20	4.25 (10.80)
1107-100K	100,000 (11,300)	4,000	150,000 (16,950)	12,450,000 (1,407,000)	0.15 (1.70 x 10^{-2})	74 (33.60)	7.20	4.25 (10.80)
1108-120K	120,000 (13,560)	2,400	180,000 (20,340)	15,400,000 (1,740,000)	0.69 (7.80 x 10^{-2})	162 (73.50)	5.30	5.75 (14.61)
1108-240K	240,000 (27,100)	2,400	360,000 (40,675)	23,300,000 (2,630,000)	0.74 (8.30 x 10^{-2})	162 (73.50)	5.30	5.75 (14.61)
1109-360K	360,000 (40,700)	2,100	540,000 (61,000)	28,000,000 (3,164,000)	1.04 (0.12)	240 (109)	4.40	7.00 (17.78)
1109-600K	600,000 (67,800)	2,100	900,000 (101,700)	40,000,000 (4,520,000)	1.49 (0.17)	240 (109)	4.40	7.00 (17.78)
1118-840K*	840,000 (94,900)	1,125	1,260,000 (142,360)	100,000,000 (11,298,000)	10.45 (1.18)	650 (295)	3.30	9.38 (23.81)
1118-1200K*	1,200,000 (135,600)	1,125	1,800,000 (203,375)	135,000,000 (15,253,000)	10.71 (1.21)	650 (295)	3.30	9.38 (23.81)
1118-1800K*	1,800,00 (203,400)	1,125	2,700,000 (305,000)	175,000,000 (197,723,000)	11.21 (1.26)	650 (295)	3.30	9.38 (23.81)
1121-2400K*	2,400,00 (270,000)	1,000	3,600,000 (406,800)	225,000,000 (25,422,000)	20.40 (2.30)	950 (430)	3.00	10.38 (26.35)
1121-3000K*	3,000,000 (340,000)	1,000	4,500,000 (508,400)	250,000,000 (28,246,000)	21.02 (2.40)	950 (430)	3.00	10.38 (26.35)

***Calibration performed to 600,000 lbs. in. Consult factory for higher calibrations.**

MODELS 1228/1248

Flange drive for use when short length is mandatory



1228	IN.	CM.
C	3.31	8.41
N	0.38	0.95
P	4.81	12.22
F	3.13	7.94
J	¼-28	-
U	3.50	8.89
H	0.13	0.32
A	-	-

1248	IN.	CM.
C	4.31	10.95
N	0.56	1.43
P	5.63	14.30
F	3.63	9.21
J	⅜-24	-
U	4.25	10.80
H	0.31	0.79
A	-	-

FEATURES:

- Special application flanges
- Short drive length
- High stiffness for increased frequency response
- An industry military standard for pump and driveline testing

PERFORMANCE SPECS:

1228/1248

SPECIFICATIONS

Actual performance average:	
Nonlinearity:	0.030%
Hysteresis:	0.031%
Nonlinearity: *of rated output*	±0.15%
Hysteresis: *of rated output*	±0.15%
Output at rated capacity: *millivolts per volt, nominal*	2
Repeatability: *of rated output*	±0.05%
Zero balance: *of rated output*	±1.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-20 to +200
Temperature range, usable: *°C*	-29 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges	1

*Prior to installation, consult instruction manual for maximum safe bending moments.

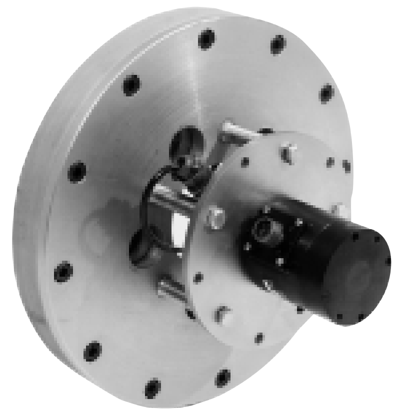
SENSOR CHARACTERISTICS: 1228/1248

MODEL NUMBER	CAPACITY lb. in. (N • m)	MAX. SPEED RPM	PROTECTED FOR OVERLOADS TO oz. in. (N • m)	TORSIONAL STIFFNESS lb. in./rad. (N • m/rad.)	ROTATING INERTIA lb.-in. sec.^{2} (N • m sec.^{2})	WEIGHT lbs. (kg.)	BRUSH LIFE FACTOR x 10^6	RING DIAMETER in. (cm.)
1228-2K	2,000 (225)	5,000	3,000 (340)	1,035,000 (117,000)	1.13×10^{-2} (1.30×10^{-3})	8 (3.60)	12.70	2.53 (6.43)
1228-5K	5,000 (565)	5,000	7,500 (850)	2,141,000 (241,890)	1.14×10^{-2} (1.30×10^{-3})	8 (3.60)	12.70	2.53 (6.43)
1228-10K	10,000 (1,130)	5,000	15,000 (1,695)	2,820,000 (318,000)	1.19×10^{-2} (1.30×10^{-3})	8 (3.60)	12.70	2.53 (6.43)
1248-20K	20,000 (2,250)	5,000	30,000 (3,390)	4,657,000 (526,000)	4.02×10^{-2} (4.60×10^{-3})	17 (7.70)	9.40	3.25 (8.26)

Model 1241-50K and 1241-100K available. Contact factory for details.

MODELS 1246/1256

Wheel torque sensors



FEATURES:

- "At the source" torque measurement
- Large selection of capacities available
- Wheel centerline offset correction available for cornering testing
- Special application versions available

The Automobile Wheel Torque Sensor is designed to be bolted to the brake drum or spindle of a car or truck in place of the regular wheel. The wheel is then bolted to the torque sensor. This moves the wheel outward approximately 1½ inches from its original location. A slip ring or rotary transformer assembly is provided to connect the torque sensor to an instrument in the vehicle.

Most torque sensors can be supplied with two sets of bolt holes so that it can fit two different bolt circle diameters, each with the same number of holes. The sensor is normally furnished with one adapter plate for one given stud pattern.

Some of the wheel torque sensors are designed to be used with special wheels which bring the tire rim back to its original location, thus maintaining the original tire track. Also, on some models, a DC tachometer or 60-tooth gear and magnetic pickup generator can be supplied which provides a signal proportional to wheel speed.

PERFORMANCE SPECS:

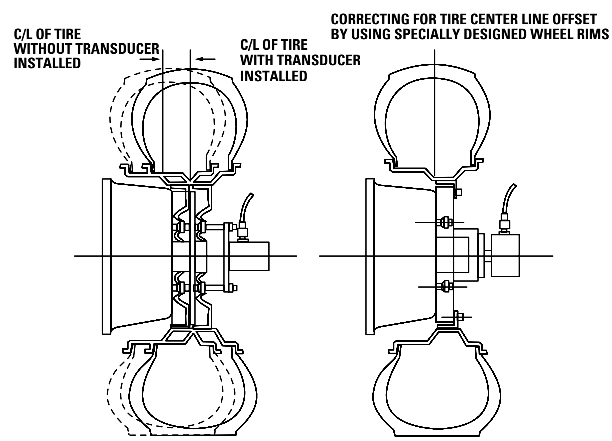
1246/1256*

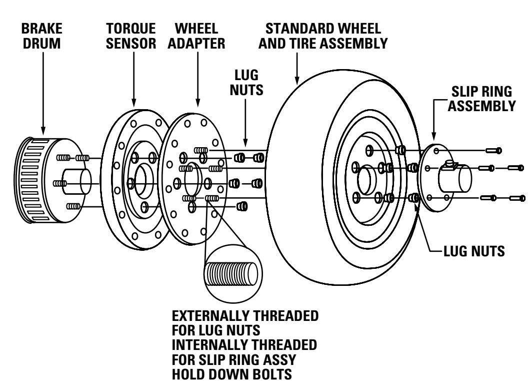
SPECIFICATIONS

Actual performance average: *Nonlinearity:* *Hysteresis:*	 0.080% 0.110%
Nonlinearity: *of rated output*	±0.25%
Hysteresis: *of rated output*	±0.25%
Static overload capacity: *of rated capacity, typical*	150%
Output at rated capacity: *millivolts per volt, nominal*	1.5
Repeatability: *of rated output*	±0.1%
Zero balance: *of rated output*	±5%
Bridge resistance: *ohms nominal*	700
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-65 to +200
Temperature range, usable: *°C*	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges: *single axis*	1

* Typical capacity: Model 1246: 20K, 30K, 36K lb. in. Model 1256: 100K, 200K, 300K lb. in. Consult factory for other capacity ranges and versions.

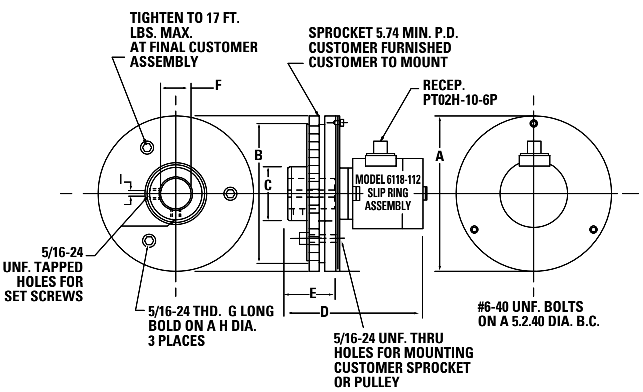
Non-contact with encoder models available. Consult factory.





MODELS 1388-102

Sprocket/Pulley torque sensor



Non-contact with encoder models available. Consult factory.

1388-102	IN.	CM.
A	5.78	14.67
B	5.185/5.186	13.170/13.172
C	2	5.08
D	5.13	13.02
E	1.75	4.45
F	1.125/1.127	2.858/2.863
G	1.50	2.54
H	3.75	9.53
I	0.25	0.64

FEATURES:

- High torsional stiffness
- Insensitivity to belt/chain tension loads on torque readings*
- Elimination of torque error due to bearing losses in jack-shaft assembly
- Measurements of torque "at the source"

Originally designed for a precision feedback control loop on textile machinery, the Lebow Model 1388 Sprocket/Pulley Torque Sensor is a low-cost, accurate method to measure processing torques. Coupled to any belt or chain driven stub shaft and monitored by a closed electrical circuit, machinery speeds and material feed rates can be precisely controlled. Consequently, this automation can increase productivity and decrease power consumption.

- Rotary transformer with encoder option available

PERFORMANCE SPECS:

1388-102

SPECIFICATIONS	
Actual performance average: *Nonlinearity:*	0.016%
Hysteresis:	0.023%
Nonlinearity: *of rated output*	±0.1%
Hysteresis: *of rated output*	±0.1%
Capacity: *in.-lbs.*	500 & 1000**
Output at rated capacity: *millivolts per volt, nominal*	2.0
Repeatability: *of rated output*	±0.15%
Overload: *of rated output*	150%
Zero balance: *of rated output*	≤1.0%
Bridge resistance: *ohms nominal*	360
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-65 to +200
Temperature range, usable: *°C*	-54 to +93
Temperature effect on output: *of reading per °F*	±0.004%
Temperature effect on output: *of reading per °C*	±0.0075%
Temperature effect on zero: *of rated output per °F*	±0.004%
Temperature effect on zero: *of rated output per °C*	±0.0075%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Speeding rating: *maximum RPM*	5000

*Not to exceed maximum overhung moment. Consult factory for values.
**Other capacities and designs available, consult factory.

MODEL 1254

FEATURES:

- Adaptable for portable usage
- No special adapter tools required
- Precision repeatable torque measurements
- Calibration reference for "hard usage" mechanical torque wrenches

The sensors are primarily used to measure the output torque of stall and clutch type nutrunners in production fastening operations (not recommended for mechanical impact wrenches). Units equipped with incremental encoders are available for applications where fastener's angle of rotation as well as torque data are required. These sensors are used to monitor operation of systems using the following fastening strategies:

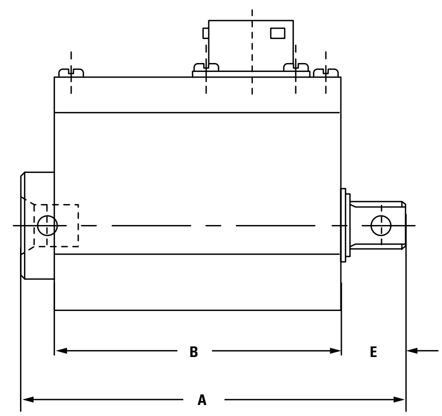
- Turn of the nut
- Yield control
- Tension control
- Torque rate

PERFORMANCE SPECS:

1254 AND 2133-300 SERIES

SPECIFICATIONS	1254	2133-300
Actual performance average:		
Nonlinearity:	0.019%	
Hysteresis:	0.015%	
Nonlinearity: *of rated output*	±0.15%	±0.25%
Hysteresis: *of rated output*	±0.15%	±0.20%
Output at rated capacity: *millivolts per volt*	2 ±0.25% FS	2 nominal
Repeatability: *of rated output*	±0.1%	
Zero balance: *of rated output*	±5% or better	
Bridge resistance: *ohms nominal*	350	
Temperature range, compensated: *°F*	+70 to +170	
Temperature range, usable: *°F*	-65 to +200*	
Temperature effect on output: *of reading per °F*	±0.002%	
Temperature effect on zero: *of rated output per °F*	±0.002%	
Excitation voltage, recommended: *volts DC or AC rms*	10	
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000	
Speed rating: *maximum RPM*	5000	n/a

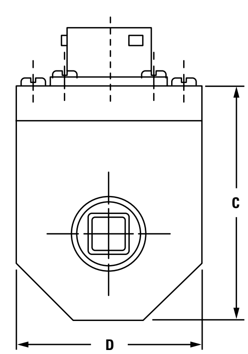
*w/encoder 185°F



SPECIFICATIONS - 1254 ENCODER

Pulses per revolution:	360
Output:	2 square wave signal 90 degrees phase difference flat over operating speed range
Output voltage:	High 5V, Low 0.5V**
Power required:	5 VDC @ 40 mA max.

**Output will drive two standard TTL loads.
Consult factory for hand-held computer floor routing system.



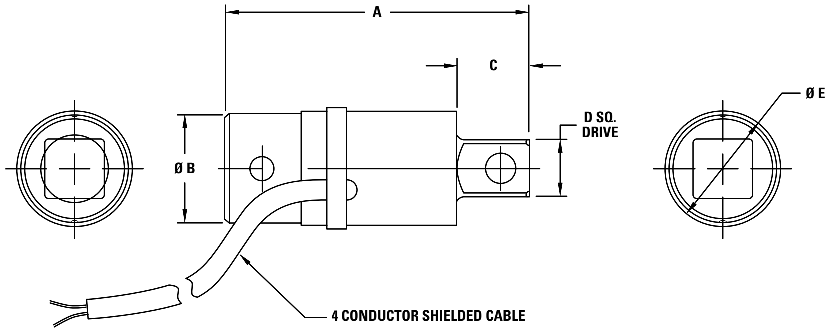
Receptacle: PTO2H-12-10P
Mating Connector: PTO6E-12-10S

SENSOR CHARACTERISTICS: 1254

MODEL NUMBER W/O ENCODER	MODEL NUMBER W/ENCODER	CAPACITY		OVERLOAD CAPACITY	DRIVE	SPEED (RPM)	DIMENSIONS A	B	C	D	E
1254-301	1254E-301	50 lb. in.	5.60 Nm	150%	¼ in. hex	5,000	3.25	2.53	1.94	1.62	0.46
1254-301	1254E-301	100 lb. in.	11.30 Nm	150%	¼ in. hex	5,000	3.25	2.53	1.94	1.62	0.46
1254-303	1254E-303	200 lb. in.	22.60 Nm	150%	⅜ in sq.	2,500	3.38	2.53	2.06	1.62	0.56
1254-305	1254E-305	50 lb. ft.	67.80 Nm	150%	½ in. sq.	2,500	3.54	2.53	2.06	1.62	0.68
1254-305	1254E-305	100 lb. ft.	135.60 Nm	150%	½ in. sq.	2,500	3.54	2.53	2.06	1.62	0.68
1254-307	1254E-307	300 lb. ft.	406.70 Nm	150%	¾ in. sq.	2,000	4.45	3.07	3.37	2.38	0.91
1254-309	1254E-309	1,000 lb. ft.	1356 Nm	125%	1 in. sq.	1,000	5.36	3.42	3.77	2.88	1.22

MODEL 2133-300 SERIES

Reaction socket torque sensor



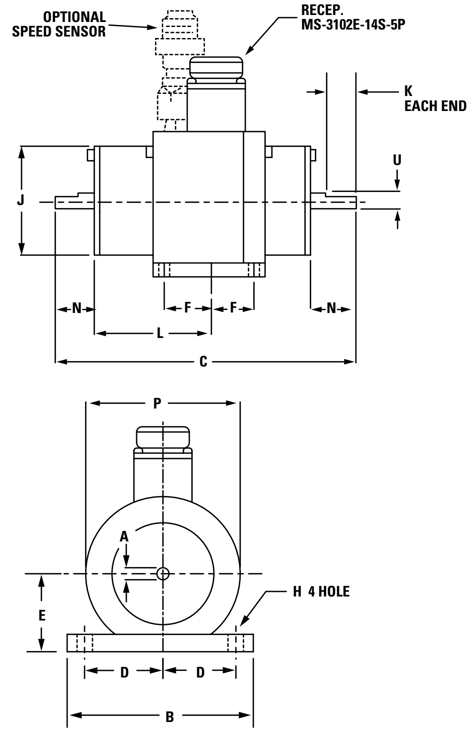
SENSOR CHARACTERISTICS: 2133-300 SERIES

MODEL NUMBER	CAPACITY lb. ft.	DIMENSIONS A	Ø B	C	D	Ø E
2133-301-10	10	1.75	0.60	0.38	¼	0.69
2133-301-20	20	1.75	0.60	0.38	¼	0.69
2133-302-50	50	2.50	0.94	0.50	⅜	1.00
2133-303-100	100	2.62	0.94	0.62	½	1.00
2133-304-250	250	3.50	1.69	0.69	⅝	1.75
2133-305-600	600	3.62	1.69	0.81	¾	1.75
2133-306-1K	1,000	4.75	1.94	1.09	1.00	2.00

Dimensions in inches.

MODELS 1602

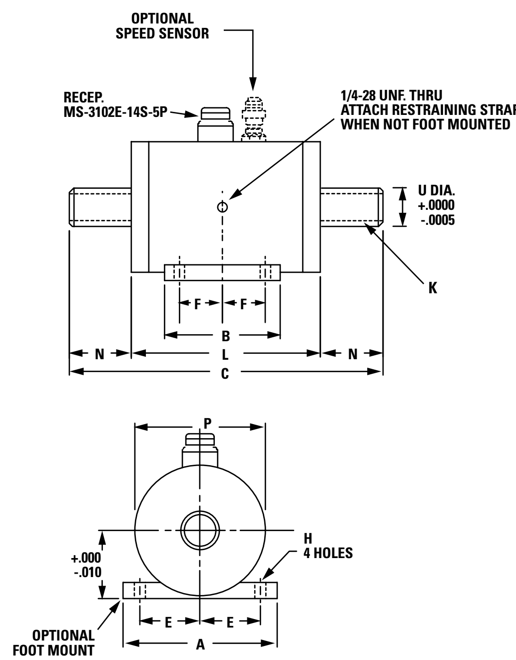
Low capacity torque sensors



MODELS 1604–1607

Standard rotating shaft torque sensor for general application

Model 7542 on-board amplifier option.
See page 107.



1602	IN.	CM.
C	6.50	16.50
L	2.25	5.71
N	1.00	2.50
P	3.50	8.89
U	0.37	0.95
K	0.75	1.90
A	0.34	0.86
B	4.00	10.16
D	1.75	4.44
E	1.75	4.44
F	1.00	2.50
H	0.20	0.50
J	2.38	6.03

1604	IN.	CM.
C	10	25.40
L	6	15.24
N	2	5.32
P	4	10.16
U	*1.00	2.54
K	*0.25 sq.	0.64
A	4.75	12.07
B	3.50	8.89
D	2.13	5.40
E	2	5.08
F	1.38	3.49
H	0.28	0.71

1605	IN.	CM.
C	12.75	32.39
L	7.25	18.42
N	2.75	6.99
P	4.75	11.99
U	1.50	3.81
K	0.38 sq.	0.95
A	6.25	16.51
B	4	10.16
D	2.50	6.35
E	2.63	6.67
F	1.50	3.81
H	0.41	1.03

1606	IN.	CM.
C	15.75	40.01
L	8.25	20.96
N	3.75	9.53
P	5.50	13.97
U	2.25	5.72
K	0.50 sq.	1.27
A	7	18.42
B	5.25	13.34
D	3	7.62
E	3	7.62
F	2	5.08
H	0.53	1.35

1607	IN.	CM.
C	19	48.26
L	8.75	22.23
N	5.13	13.02
P	6.50	16.51
U	3.00	7.62
K	0.75 sq.	1.91
A	8.50	24.59
B	5.50	13.97
D	3.50	8.89
E	3.50	8.89
F	2	5.08
H	0.53	1.35

***50, 100 & 200 lb. inch units; K=3⁄16" sq., U=3⁄4".**

FEATURES:

- High overload protection with high signal output (sensitivity)
- Extended speed range
- Minimal maintenance due to "bearings only" contact
- Carrier frequency excitation provides increased signal/noise immunity

Foot Mounting–foot mount adapter is available for models 1604, 1605, 1606 and 1607. Foot mount is standard on model 1602.

Speed Sensor–a 60-tooth gear and a magnetic pickup provides an output of 60 pulses per shaft revolution. On models 1604, 1605 and 1615 for speeds less than 200 RPM, Zero Velocity Speed Sensor is recommended. On models 1606, 1607, 1641 and 1648 for speeds less than 100 RPM, Zero Velocity Speed Sensor is recommended. Zero Velocity Speed Sensor is not available on model 1602.

Air/Oil Mist Bearings–standard grease pack bearings should not operate for more than 200–300 hours continuous at rated speed or more than 1,000 hours at 40% of rated speed. If exceeded request air/oil mist also provides approximately 40% higher speed ratings and for the exact rating consult the factory. Some air/oil mist units vary dimensionally–consult factory for information.

PERFORMANCE SPECS:
1602, 1604, 1605, 1606 AND 1607

SPECIFICATIONS

Actual performance average: *Nonlinearity:*	0.026%
Hysteresis:	0.024%
Nonlinearity: *of rated output*	±0.1%
Hysteresis: *of rated output*	±0.1%
Output at rated capacity: *millivolts per volt, nominal*	2
Repeatability: *of rated output*	±0.05%
Zero balance: *of rated output*	±1.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-20 to +200
Temperature range, usable: *°C*	-29 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, 10 VAC max. rms:	3.28 kHz optimum
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges	1

Higher accuracy versions available. Consult factory for details.

SENSOR CHARACTERISTICS: 1602 AND 1604-1607

MODEL NUMBER	CAPACITY oz. in. (N • m)	MAX. SPEED RPM	PROTECTED FOR OVERLOADS TO oz. in. (N • m)	TORSIONAL STIFFNESS lb. in./rad. (N • m/rad.)	ROTATING INERTIA lb.-in. sec.^{2} (N • m sec.^{2})	WEIGHT lbs. (kg.)
1602-50*	50 (0.35)	20,000	150 (1.05)	400 (45.20)	9.06 x 10^{-4} (1 x 10^{-4})	3.25 (1.48)
1602-100	100 (0.70)	20,000	300 (2.10)	1,000 (113)	9.06 x 10^{-4} (1 x 10^{-4})	3.25 (1.48)
1602-200	200 (1.50)	20,000	600 (4.50)	2,500 (282)	9.06 x 10^{-4} (1 x 10^{-4})	3.25 (1.48)
1602-500	500 (3.50)	20,000	1,500 (10.50)	5,500 (621)	9.06 x 10^{-4} (1 x 10^{-4})	3.25 (1.48)
1602-1K	1,000 (7.00)	20,000	1,500 (10.50)	8,000 (903)	9.06 x 10^{-4} (1 x 10^{-4})	3.25 (1.48)

***Output on this capacity only: 1 mV/V nominal.**

MODEL NUMBER	CAPACITY lb. in. (N • m)	MAX. SPEED RPM	PROTECTED FOR OVERLOADS TO lb. in. (N • m)	TORSIONAL STIFFNESS lb. in./rad. (N • m/rad.)	ROTATING INERTIA lb.-in. sec.^{2} (N • m sec.^{2})	WEIGHT lbs. (kg.)
1604-50	50 (5)	10,000	150 (15)	5,000 (565)	2.59 x 10^{-3} (3.00 x 10^{-4})	18 (8.20)
1604-100	100 (10)	10,000	300 (30)	13,500 (1,525)	2.59 x 10^{-3} (3.00 x 10^{-4})	18 (8.20)
1604-200	200 (20)	10,000	600 (60)	33,000 (3,728)	2.59 x 10^{-3} (3.00 x 10^{-4})	18 (8.20)
1604-500	500 (55)	10,000	1,500 (165)	85,000 (9,603)	2.59 x 10^{-3} (3.00 x 10^{-4})	18 (8.20)
1604-1K	1,000 (115)	10,000	3,000 (340)	150,000 (16,946)	2.59 x 10^{-3} (3.00 x 10^{-4})	18 (8.20)
1604-2K	2,000 (225)	10,000	3,000 (340)	225,000 (25,420)	2.59 x 10^{-3} (3.00 x 10^{-4})	18 (8.20)
1605-2K	2,000 (225)	10,000	6,000 (675)	700,000 (79,085)	8.41 x 10^{-3} (9.60 x 10^{-4})	28 (12.70)
1605-5K	5,000 (565)	10,000	15,000 (1,695)	950,000 (107,330)	8.41 x 10^{-3} (9.60 x 10^{-4})	28 (12.70)
1605-10K	10,000 (1,130)	10,000	20,000 (2,260)	1,000,000 (112,979)	8.41 x 10^{-3} (9.60 x 10^{-4})	28 (12.70)
1606-20K	20,000 (2,250)	6,700	60,000 (6,750)	4,080,000 (460,955)	3.62 x 10^{-2} (4 x 10^{-3})	40 (18.20)
1606-30K	30,000 (3,390)	6,700	60,000 (6,750)	4,080,000 (460,955)	3.62 x 10^{-2} (4 x 10^{-3})	40 (18.20)
1607-50K	50,000 (5,650)	6,000	150,000 (16,950)	11,800,000 (1,333,154)	0.15 (1.70 x 10^{-2})	75 (34.10)
1607-100K	100,000 (11,300)	6,000	150,000 (16,950)	19,950,000 (1,333,154)	0.47 (1.70 x 10^{-2})	75 (34.10)

Metric dimensions and specifications are purely mathematical calculations from standard English dimension control drawings. Request certified drawings before designing mountings or fixtures. Dimensions and specifications are subject to change without notice. Higher accuracy versions available. Contact factory for details.

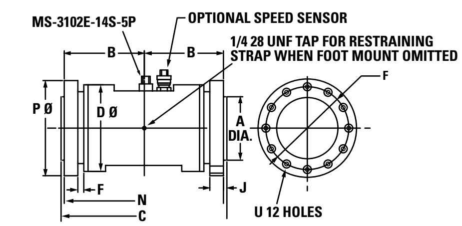
MODELS 1641/1648

Flange drive for use when short length is mandatory

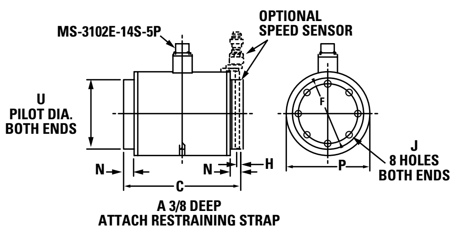
FEATURES:

- Shortened drive length
- Extended speed range
- Minimal maintenance due to “bearings only” contact
- High overall performance accuracy

Safety Considerations: *"It would be unsafe to operate Lebow® Torque Sensors and Load Cells beyond Static Overload or Ultimate Extraneous Load Limits as defined in the Glossary of Terms or, when applicable, higher than maximum speed. When in doubt, consult the factory. Lebow® Products is not responsible for any property damage or personal injury which may result because of the misapplication of the Transducer."*



1641	IN.	CM.
C	11.88	30.16
N	11.63	29.50
P	7.00	17.70
F	0.44	1.11
J	0.13	0.32
U	½-20	-
H	6.00	15.20
A	4.50	11.42
B	4.38	11.11
D	6.50	16.50
E	¼-28	-



1648	IN.	CM.
C	6.38	16.19
N	0.56	1.43
P	5.00	12.70
F	3.63	9.20
J	⅜-24	-
U	4.25	10.79
H	0.38	0.95
A	10-32	-
B	-	-
D	-	-
E	-	-

PERFORMANCE SPECS: 1641/1648

SPECIFICATIONS	
Actual performance average:	
Nonlinearity:	0.026%
Hysteresis:	0.031%
Nonlinearity: *of rated output*	±0.1%
Hysteresis: *of rated output*	±0.1%
Output at rated capacity: *millivolts per volt, nominal*	2
Repeatability: *of rated output*	±0.05%
Zero balance: *of rated output*	±1.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-20 to +200
Temperature range, usable: *°C*	-29 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, 10 VAC max. rms:	3.28 kHz optimum
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges	1

Higher accuracy versions available. Contact factory for details.

SENSOR CHARACTERISTICS: 1641/1648

MODEL NUMBER	CAPACITY lb. in. N • m	MAX. SPEED RPM	PROTECTED FOR OVERLOADS TO lb. in. N • m	TORSIONAL STIFFNESS lb. in./rad. N • m/rad.	ROTATING INERTIA lb. in. sec.² N • m/sec.²	WEIGHT lbs. kg.
1648-2K*	2,000 225	8,000**	3,000 330	742,000 83,830	5.95×10^{-2} 6.70×10^{-3}	23 10.50
1648-5K*	5,000 565	8,000**	7,500 845	1,811,000 204,605	5.95×10^{-2} 6.70×10^{-3}	23 10.50
1648-10K*	10,000 1,130	8,000**	15,000 1,695	2,248,000 253,977	5.95×10^{-2} 6.70×10^{-3}	23 10.50
1648-20K*	20,000 2,250	8,000**	30,000 3,390	3,507,000 396,218	6.08×10^{-2} 6.80×10^{-3}	23 10.50
1641-20K*	20,000 2,250	6,000	60,000 6,750	6,050,000 683,524	0.49 5.60×10^{-2}	85 38.50
1641-50K*	50,000 5,650	6,000	150,000 16,950	10,960,000 1,238,252	0.49 5.60×10^{-2}	85 38.50
1641-100K*	100,000 11,300	6,000	200,000 22,600	16,850,000 1,903,699	0.49 5.60×10^{-2}	85 38.50

***Prior to installation, consult user's Instruction Manual for maximum safe bending moments. **Optional speed rating of 10,000 RPM available.**

MODEL 1700 SERIES

Torque transducers

FEATURES:

- Built-in instrumentation amplifier (±10 V output)
- Contactless
- Single supply voltage
- Compact size
- Wide application range

OPTIONS:

- Speed sensing (S) option
- Angle encoder (E) option

These transducers are suitable for laboratory applications as well as industrial evironments because of their compact size and multiple mounting options. The contactless transmission of supply voltage and measuring signal enables continuous operation with low maintenance.

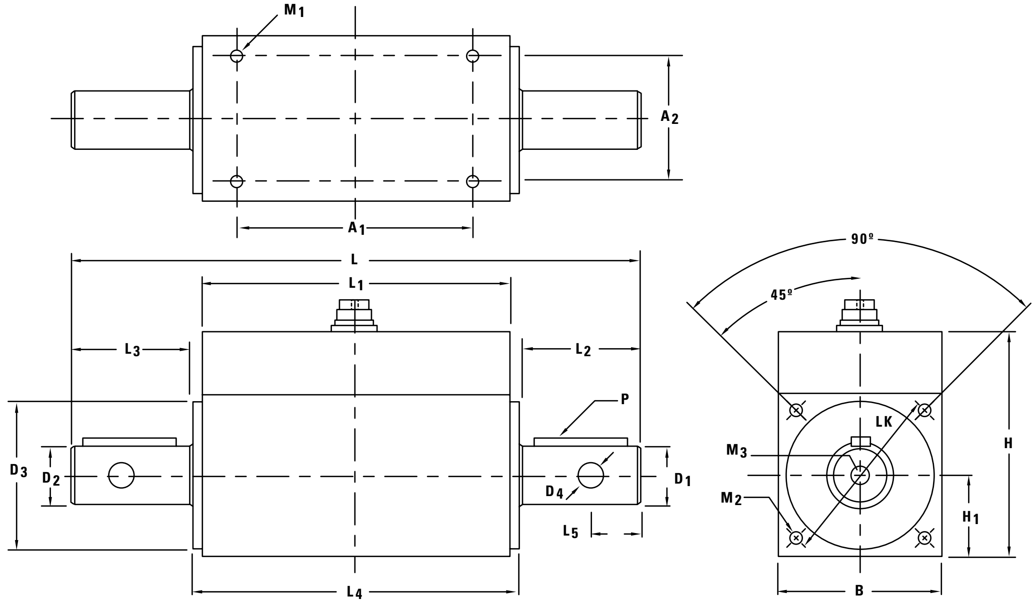
PERFORMANCE SPECS:

1700 SERIES

SPECIFICATIONS	1700	1701	1702	1703	1706
Capacity range:	0.02; 0.05 Nm	0.1; 0.2; 0.5; 1; 2 Nm	5; 10; 20 Nm	50; 100; 200; 300 Nm	500; 1,000, 1,500 Nm
Supply voltage:	12 VDC ±10%	12 VDC ±10%	12 VDC ±10%	12 VDC ±10%	12 VDC ±10%
Current consumption:	less than 200 mA	less than 200 mA	less than 200 mA	less than 200 mA	less than 200 mA
Rise time:	2 ms	2 ms	2 ms	2 ms	1 ms (1 Hz)
Limit frequency—3dB:	200 Hz	200 Hz	200 Hz	200 Hz	–
Voltage output:	0 to ±10 V	0 to ±10 V	0 to ±10 V	0 to ±10 V	0 to ±10 V
Internal resistance:	100 Ω	100 Ω	100 Ω	100 Ω	100 Ω
Ripple:	<100mVpp	<100mVpp	<100mVpp	<100mVpp	<100mVpp
Overall accuracy:	<0.25%	<0.25%	<0.25%	<0.25%	<0.25%
Operating temperature:	0-60°C	0-60°C	0-60°C	0-60°C	0-60°C
Compensated temperature range:	5-45°C	5-45°C	5-45°C	5-45°C	5-45°C
Temperature error:					
Zero point:	0.02%/K	0.02%/K	0.02%/K	0.02%/K	0.02%/K
Sensitivity:	0.01%/K	0.01%/K	0.01%/K	0.01%/K	0.01%/K
Mechanical overload: *of rated output*	200%	200%	200%	200%	200%
Weight:	approx. 200g	approx. 200g	approx. 600g	approx. 1300g	approx. 4500g
Max. sensor speed (RPM):	15,000	37,000	19,000	13,500	7,900

OPTIONS	
Speed sensing (RPM):	(S)
Speed max:	10,000 RPM
Output:	open collector
Internal pull up:	100kΩ (5V level)
External pull up:	24V max.
I max:	20mA
Pulses/rev.:	60
Angle:	(E)
Speed max:	3,000 RPM
Pulses/rev.:	360
Resolution:	1°
Phase shift:	Quadrature

RANGE	SPRING CONSTANT C (N • m/rad.)	MOMENT OF INERTIA I (kgm2)	ALLOWABLE AXIAL LOAD (N)	ALLOWABLE LOAD (N)
0...0.1 Nm	20	1×10^{-6}	2	2
0...0.2 Nm	20	1×10^{-6}	3	3
0...0.5 Nm	20	1×10^{-6}	3	3
0... 1 Nm	43	1×10^{-6}	4	4
0... 2 Nm	103	1×10^{-6}	5	5
0... 5 Nm	355	1×10^{-6}	5	5



SENSOR CHARACTERISTICS: 1700 SERIES

MODEL DIMENSIONS	**1700** 0.02/0.05 (N • m)	**1701** 0.1/0.2 0.5/1 (N • m)	2	**1702** 5/10/20 (N • m)	**1703** 50/100 200/300 (N • m)	**1706** 500/1000 1500 (N • m)
L (mm)	70	89	95	145	170	270
B (mm)	32	28		42	56	88
H (mm)	46	48,5		58	73	104
H_1 (mm)	14	14		21	28	44
D_1 g6 (mm)	Ø3	Ø5	Ø6	Ø15	Ø26	Ø45
D_2 g6 (mm)	Ø3	Ø8	Ø8	Ø15	Ø26	Ø45
D_3 -0,1 (mm)	Ø15	Ø27		Ø38	Ø54	Ø80
D_4 H7 (mm)	–	Ø2	Ø2.5	–	–	–
LK ±0,1 (mm)	*	Ø32		Ø46	Ø65	Ø98
L_1 (mm)	51	62		79	72	84
L_2 (mm)	7.5	10	14	30	45	85
L_3 (mm)	7.5	11	14	30	45	85
L_4 (mm)	55	66		83	78	90
L_5 -0,1 (mm)	–	4	5	–	–	–
A_1 (mm)	38	40		60	42	46
A_2 (mm)	24	22		32	40	70
M_1	M2.5 x 5 Deep	M3 x 5 Deep		M3 x 6 Deep	M4 x 8 Deep	M6 x 12 Deep
M_2	M2.5 x 5 Deep	M3 x 6 Deep		M3 x 6 Deep	M4 x 8 Deep	M6 x 12 Deep
M_3	–	–		–	M8 x 15 Deep	M10 x 20 Deep
P (DIN6885)	–	–		2 x A5 x 5 x 25	2 x A8 x 7 x 40	4 x A14 x 9 x 80

Dimensions are in mm.
***Consult factory.**

MODELS 1804–1807

High-accuracy rotating shaft torque sensor

FEATURES:

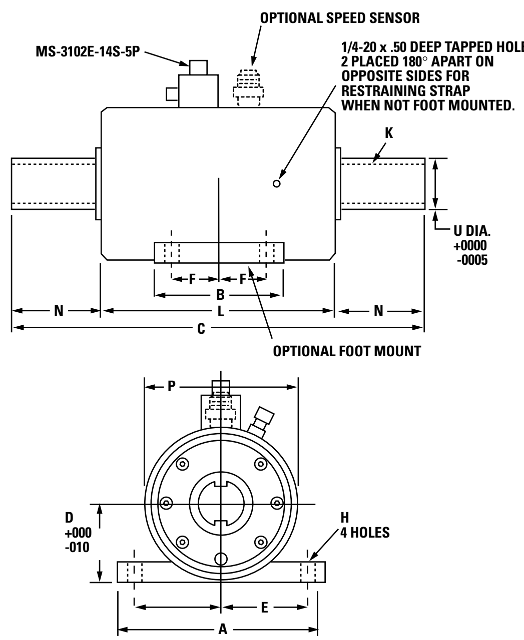
- High accuracy
- High overload protection with high signal output (sensitivity)
- Extended speed range
- Minimal maintenance due to "bearings only" contact
- Carrier frequency excitation provides increased signal/noise immunity
- 100 to 100,000 lb. in. capacities

Model 7927 shunt cal reference box included with each purchase of 1800 series.

PERFORMANCE SPECS: 1804–1807

SPECIFICATIONS

Actual performance average:	
Nonlinearity:	0.016%
Hysteresis:	0.012%
Nonlinearity: *of rated output*	±0.05%
Hysteresis: *of rated output*	±0.05%
Output at rated capacity: *millivolts per volt, nominal*	2
Repeatability: *of rated output*	±0.02%
Zero balance: *of rated output*	±1.0%
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-20 to +170
Temperature range, usable: *°C*	-30 to +77
Temperature effect on output: *of reading per °F*	±0.001%
Temperature effect on output: *of reading per °C*	±0.0018%
Temperature effect on zero: *of rated output per °F*	±0.001%
Temperature effect on zero: *of rated output per °C*	±0.0018%
Excitation voltage, 10 volts AC rms:	3.28 kHz optimum
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges	1



1804	IN.	CM.
C	10	25.40
L	6	14.76
N	2	5.32
P	4	10.16
U	*1.00	2.54
K	*0.25 sq.	0.64
A	4.75	12.07
B	3.50	8.89
D	2.13	5.40
E	2	5.08
F	1.38	3.49
H	0.28	0.71

1805	IN.	CM.
C	12.75	32.39
L	7.25	18.42
N	2.75	6.99
P	4.75	11.99
U	1.50	3.81
K	0.38	0.95
A	6.25	16.51
B	4	10.16
D	2.50	6.35
E	2.63	6.67
F	1.50	3.81
H	0.41	1.03

*100 & 200 in. lbs.; U= ¾", K= 3⁄16" sq.

SENSOR CHARACTERISTICS: 1804–1807

MODEL NUMBER	CAPACITY lb. in. (N • m)	MAX. SPEED RPM*	PROTECTED FOR OVERLOADS TO lb. in. (N • m)	TORSIONAL STIFFNESS lb. in./rad. (N • m/rad.)	ROTATING INERTIA lb.-in. $sec.^2$ (N • m $sec.^2$)	WEIGHT lbs. (kg.)
1804-100	100 (10)	27,000	300 (30)	13,500 (1,525)	2.59×10^{-3} (3.00×10^{-4})	18 (8.20)
1804-200	200 (20)	27,000	600 (60)	33,000 (3,728)	2.59×10^{-3} (3.00×10^{-4})	18 (8.20)
1804-500	500 (55)	27,000	1,500 (165)	85,000 (9,603)	2.59×10^{-3} (3.00×10^{-4})	18 (8.20)
1804-1K	1,000 (115)	27,000	3,000 (340)	150,000 (16,946)	2.59×10^{-3} (3.00×10^{-4})	18 (8.20)
1804-2K	2,000 (225)	27,000	3,000 (340)	225,000 (25,420)	2.59×10^{-3} (3.00×10^{-4})	18 (8.20)
1805-2K	2,000 (225)	22,000	6,000 (675)	700,000 (79,085)	8.41×10^{-3} (9.60×10^{-4})	29 (13.20)
1805-5K	5,000 (565)	22,000	15,000 (1,695)	950,000 (107,330)	8.41×10^{-3} (9.60×10^{-4})	29 (13.20)
1805-10K	10,000 (1,130)	22,000	20,000 (2,260)	1,000,000 (112,979)	8.41×10^{-3} (9.60×10^{-4})	29 (13.20)
1806-20K	20,000 (2,250)	12,000	30,000 (3,390)	$3.27 \text{ X } 10^{6}$ (369,475)	3.84×10^{-2} (4.40×10^{-4})	55.90
1807-50K	50,000 (5,650)	10,000	150,000 (16,950)	11.71×10^{6} (1.32×10^{6})	0.14 (1.61×10^{-2})	85.20
1807-100K	100,000 (11,300)	10,000	150,000 (16,950)	18.86×10^{6} (2.13×10^{6})	0.15 (1.68×10^{-2})	85.20

*Consult factory for higher speed ratings when used with air/oil mist bearings.

1806	IN.	CM.
C	15.75	40.01
L	8.25	20.96
N	3.75	9.53
P	5.50	13.97
U	2.25	5.72
K	0.50 sq.	1.27
A	7	18.42
B	5.25	13.34
D	3	7.62
E	3	7.62
F	2	5.08
H	0.53	1.35

1807	IN.	CM.
C	19	48.26
L	8.75	22.23
N	5.125	13.02
P	6.50	16.51
U	3.00	7.62
K	0.75 sq.	1.91
A	8.50	24.59
B	5.50	13.97
D	3.50	8.89
E	3.50	8.89
F	2	5.08
H	0.53	1.35

Consult factory for specials.

MODEL 1815

Flange housing mount with AND pads to match Army-Navy mountings standard. Spline drive.

Model 7927 shunt cal reference box included with each purchase of 1800 series.

FEATURES:

- Shortened drive length
- Extended speed range
- Minimal maintenance due to “bearings only” contact
- High overall performance accuracy

Safety Considerations: *“It would be unsafe to operate Lebow® Torque Sensors and Load Cells beyond Static Overload or Ultimate Extraneous Load Limits as defined in the Glossary of Terms or, when applicable, higher than maximum speed. When in doubt, consult the factory. Lebow® Products is not responsible for any property damage or personal injury which may result because of the misapplication of the Transducer.”*

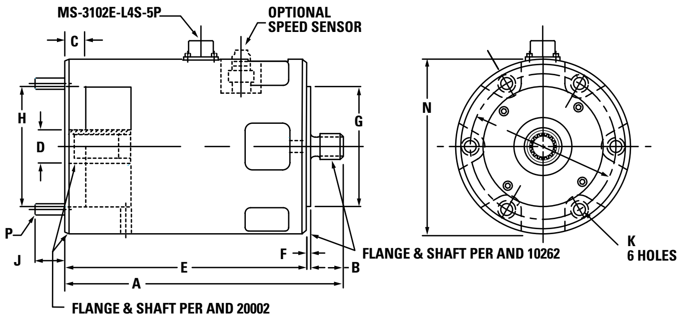
PERFORMANCE SPECS: 1815

SPECIFICATIONS	
Actual performance average:	
Nonlinearity:	0.026%
Hysteresis:	0.016%
Nonlinearity: *of rated output*	±0.05%
Hysteresis: *of rated output*	±0.05%
Output at rated capacity: *millivolts per volt, nominal*	2
Repeatability: *of rated output*	±.03%
Zero balance: *of rated output*	±1.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-20 to +200
Temperature range, usable: *°C*	-29 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, 10 VAC max. rms:	3.28 kHz optimum
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges	1

Other models available: 1115K, 1115A and 1615K.

SENSOR CHARACTERISTICS: 1815

MODEL NUMBER	CAPACITY lb. in. (N • m)	MAX. SPEED RPM	PROTECTED FOR OVERLOADS TO lb. in. (N • m)
1815A-50	50 (5)	25,000	150 (15)
1815A-100	100 (10)	25,000	300 (30)
1815A-200	200 (20)	25,000	600 (60)
1815A-500	500 (55)	25,000	1,500 (165)
1815A-1K	1,000 (115)	25,000	1,500 (165)
1815K-50	50 (5)	15,000	150 (15)
1815K-100	100 (10)	15,000	300 (30)
1815K-200	200 (20)	15,000	600 (60)
1815K-500	500 (55)	15,000	1,500 (165)
1815K-1K	1,000 (115)	15,000	3,000 (330)
1815K-2K	2,000 (225)	15,000	6,000 (675)
1815K-5K	5,000 (565)	15,000	15,000 (1,695)
1815K-10K	10,000 (1,130)	15,000	15,000 (1,695)



1815A	IN.	CM.
A	9.27	23.55
B	1.05	2.67
C	0.63	1.60
D	1.12	2.84
E	8.25	20.96
F	0.14	0.36
G	4.12	10.47
H	4.13	10.48
J	1.03	2.62
K	0.41	1.03
L	5.00	12.70
N	6.00	15.24
P	3/8-24	-

1815K	IN.	CM.
A	9.94	25.25
B	1.69	4.29
C	0.63	1.60
D	1.58	4.01
E	8.25	20.96
F	0.14	0.36
G	4.12	10.47
H	4.13	10.48
J	1.03	2.62
K	0.41	1.03
L	5.00	12.70
N	6.00	15.24
P	3/8-24	-

INTERNAL AND EXTERNAL SPLINE DATA

MODEL	PRESSURE ANGLE	PITCH DIA. in. (cm.)	PITCH	NO. OF TEETH
1815A	30°	0.80 (2.03)	20/30	16
1815K	30°	1.20 (3.05)	20/30	24

MODEL 1115A AND 1115K

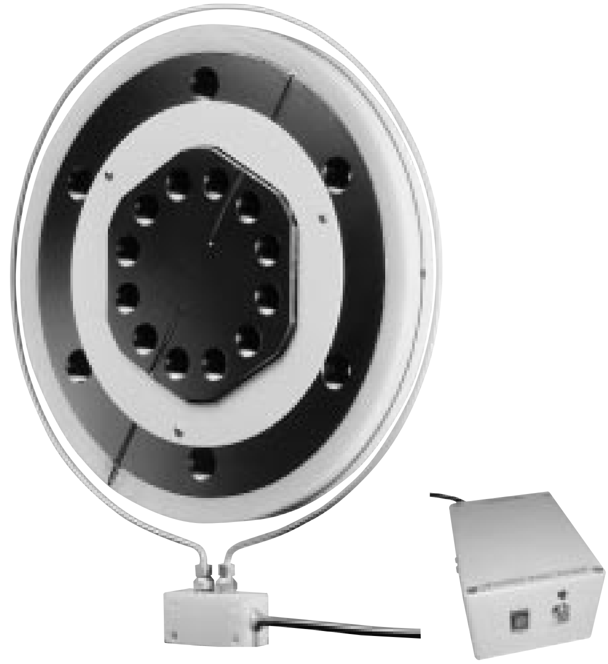
Other designs that conform to Army/Navy mounting standard. Please consult factory for details about 1115 and 1615 sensor designs.

MODEL 1615K

Consult factory for specials.

MODEL 2000

Short flange dynamometer sensor



FEATURES:

- High torsional stiffness
- Low rotating inertia
- Mates directly to commercially available couplings
- Digital telemetry

PERFORMANCE SPECS: 2000

SPECIFICATIONS	TOLERANCE
Rated capacities: *ft. lbs.*	From 100 to 60K
Output sensitivity: *at full scale load*	+/- 5 VDC
Overall accuracy:	≤0.25%
Temperature range, compensated: *°F*	+70 to +170
Temperature range, usable: *°F*	32 to +185
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on zero: *of rated output per °F*	±0.002%
Torque limit: *% of FS*	150
Breaking torque: *% of FS*	200
Axial float: *permissible, minimum*	±0.25"
Accel/Decel, maximum: *ft./sec²*	1800

ELECTRICAL VALUES	TOLERANCE
Output at receiver:	NEMA-12 Enclosure: 4-20mA, ±5 VDC bipolar or 0-2.5-5.0 VDC unipolar Benchtop Instrument: (Optional) 5 digit display with units scaling, ±5 VDC bipolar or 0-2.5-5.0 VDC unipolar, RS232, limit alarms
Power requirements: *AC:* *(Optional) DC:*	 120 VAC, 50/60Hz +10 to +18 VDC
Frequency response: *input sampling:* *amplifier bandwidth:*	 26,000 samples per second 2kHz @ 3db
Filtering:	6 pole low pass filter with 3db cutoff at 2kHz
Digital resolution:	12 bits
Cable length: *receiver to pickup*	24 ft. (other lengths optional)
Excitation voltage: *at bridge*	5 VDC, single ended
Shunt calibration (0.01%):	Shunt value supplied by factory for field setup

Request certified drawings before designing mountings or fixtures.
Dimensions and specifications are subject to change without notice.
Consult factory for higher accuracy and higher capacity versions.
Alternate mounting configuration designs available.

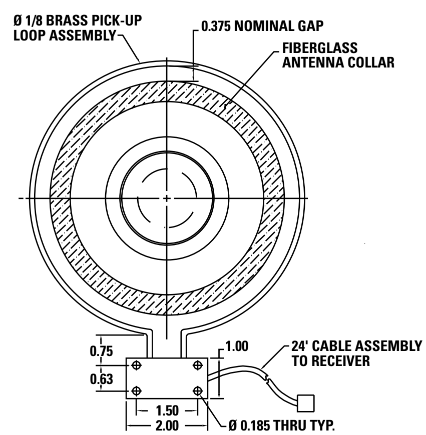
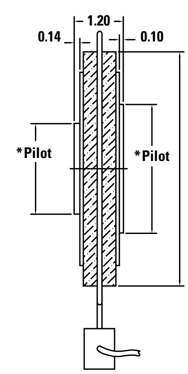


Illustration represents maximum values.



*Consult factory for dimensions.

DYNAMIC LOAD CHARACTERISTICS: 2000

MODEL NUMBER	RATED CAPACITY ft. lbs.	RATED CAPACITY in. lbs. (N • m)	SPEED, NOMINAL: RPM	TORSIONAL STIFFNESS x 10⁶ in. lbs./rad.	ROTATING INERTIA lb. in. sec.²	THRUST lbs.	SHEAR lbs.	BENDING LIMIT in. lbs.
2000-100	100	1.20K (136)	16,000	11	0.04	500	600	1,000
2000-100	250	3K (339)	16,000	74	0.04	2,000	1,500	4,000
2000-200	500	6K (678)	13,000	75	0.08	500	1,250	1,250
2000-200	750	9K (1,017)	13,000	112	0.08	1,500	2,000	3,000
2000-200	1K	12K (1,356)	13,000	149	0.08	2,500	2,500	5,000
2000-300	1.5K	18K (2,034)	11,000	186	0.17	1,000	1,800	2,000
2000-300	2K	24K (2,712)	11,000	248	0.17	1,800	2,400	3,500
2000-400	3K	36K (4,068)	9,000	986	0.34	3,000	2,500	6,500
2000-400	4K	48K (5,424)	9,000	1,315	0.35	5,500	3,500	11,500
2000-500	5K	60K (6,780)	8,000	985	0.51	4,500	7,000	9,000
2000-500	6K	72K (8,136)	8,000	1,182	0.51	6,500	9,000	13,000
2000-500	8K	96K (10,847)	8,000	1,576	0.51	10,000	11,000	20,000

Consult factory for larger capacities.

PHYSICAL CHARACTERISTICS: 2000

MODEL NUMBER	RATED CAPACITY ft. lbs.	RATED CAPACITY in. lbs. (N • m)	WEIGHT SENSOR ONLY LBS.	O.D. SENSOR in.	BOLT SIZE OUTER RING*†	NUMBER OF BOLTS, OUTER RING	B.C. DIAMETER, OUTER RING: in.	BOLT SIZE, INNER HUB†	NUMBER OF BOLTS, INNER HUB	B.C. DIAMETER, INNER HUB: in.
2000-100	100	1.20K (136)	5	5.74	¼-20	6	3.75	10-24	18	1.84
2000-100	250	3K (339)	5	5.74	¼-20	6	3.75	10-24	18	1.84
2000-200	500	6K (678)	6	7.00	⅜-24	8	4.81	½-20	8	2.25
2000-200	750	9K (1,017)	6	7.00	⅜-24	8	4.81	½-20	8	2.25
2000-200	1K	12K (1,356)	6	7.00	⅜-24	8	4.81	½-20	8	2.25
2000-300	1.5K	18K (2,034)	11	8.00	½-20	6	5.88	7/16-20	12	2.63
2000-300	2K	24K (2,712)	11	8.00	½-20	6	5.88	7/16-20	12	2.63
2000-400	3K	36K (4,068)	16	9.40	⅝-18	6	7.13	9/16-18	12	3.50
2000-400	4K	48K (5,424)	16	9.40	⅝-18	6	7.13	9/16-18	12	3.50
2000-500	5K	60K (6,780)	20	10.50	½-20	12	8.00	¾-16	8	4.00
2000-500	6K	72K (8,136)	20	10.50	½-20	12	8.00	¾-16	8	4.00
2000-500	8K	96K (10,847)	20	10.50	½-20	12	8.00	¾-16	8	4.00

***Optional bolt size through-holes available upon request.   † Bolt sizes available in metric.**
Consult factory for larger capacities.

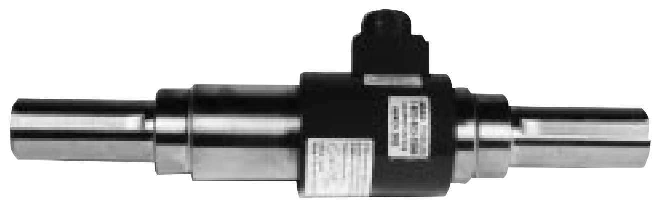
MODEL 2121–2126

Shaft reaction torque sensors

FEATURES:

- No maintenance of slip rings, bearings or brushes
- Minimal friction error
- Low end sensitivity
- Reaction measurements eliminate speed limitations

Safety Considerations: *"It would be unsafe to operate Lebow® Torque Sensors and Load Cells beyond Static Overload or Ultimate Extraneous Load Limits as defined in the Glossary of Terms or, when applicable, higher than maximum speed. When in doubt, consult the factory. Lebow® Products is not responsible for any property damage or personal injury which may result because of the misapplication of the Transducer."*



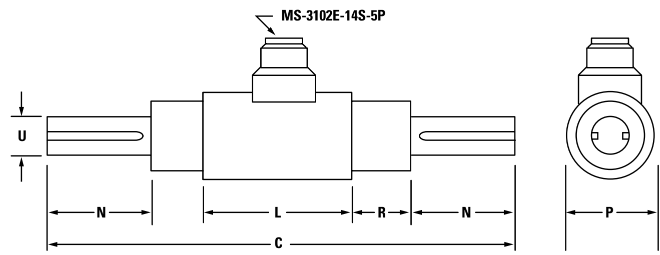
PERFORMANCE SPECS:

2121–2126

SPECIFICATIONS	
Actual performance average:	
Nonlinearity:	0.026%
Hysteresis:	0.031%
Nonlinearity: *of rated output*	±0.1%
Hysteresis: *of rated output*	±0.1%
Output at rated capacity: *millivolts per volt, nominal*	2*
Repeatability: *of rated output*	±0.05%
Zero balance: *of rated output*	±1.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-65 to +200
Temperature range, usable: *°C*	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges	1

***Model 2126-500K output at rated capacity is 2.7 mV/V nominal.**

Higher capacities available. Consult factory for details.



2121-100, 200	IN.	CM.
C	10	25.40
L	2.38	6.03
N	2.25	5.72
P	2	5.08
U*	0.75	1.91
R	0.56	14.29

2121-500, 1K, 2K	IN.	CM.
C	10	25.40
L	2.38	6.03
N	2.25	5.72
P	2	5.08
U*	1	2.54
R	0.56	14.29

2122-5K, 10K	IN.	CM.
C	12.75	32.40
L	3	7.62
N	2.97	7.54
P	2	5.08
U*	1.50	3.81
R	2.38	6.03

2124-20K	IN.	CM.
C	14.63	37.15
L	3.75	9.53
N	4	10.16
P	3	7.62
U*	2.25	5.72
R	2.06	5.24

2125-50K, 100K	IN.	CM.
C	19	48.26
L	5	12.70
N	6	15.24
P	5	12.70
U*	3	7.62
R	1	2.54

2126-200K, 500K**	IN.	CM.
C	21	53.34
L	5.75	14.61
N	6.50	16.51
P	5.50	13.97
U*	4.50	11.43
R	1.13	2.86

*Tolerance on shaft diameter +.0000–.0005

**Calibration performed to 300,000 lbs. in., consult factory for higher calibrations.

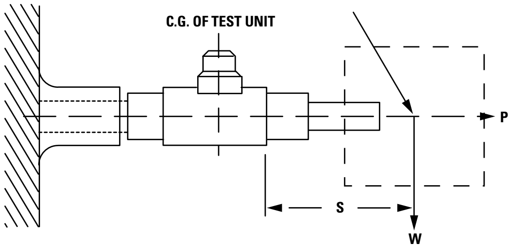
LOAD CARRYING CAPACITY

W = weight of test device

W x S = overhung moment

S = distance to center of gravity of test unit

Do not exceed moment (**W x S**) or shear (**W**), whichever value is attained first. **P** = thrust.



SENSOR CHARACTERISTICS: 2121–2126

MODEL NUMBER	CAPACITY lb. in. (N • m)	OVERLOAD lb. in. (N • m)	TORSIONAL STIFFNESS lb. in./rad. (N • m/rad.)	MAX. OVERHUNG MOMENT WxS lb. in. (N • m)	MAX. SHEAR W lbs. (N)	MAX. THRUST P lbs. (N)	KEY SIZE SQUARE in. (cm.)
2121-100	100	150	6,430	100	20	280	0.19
	(10)	(15)	(726)	(11.30)	(89)	(1,245)	(0.48)
2121-200	200	300	17,000	200	26	400	0.19
	(20)	(30)	(1,921)	(22.60)	(115)	(1,780)	(0.48)
2121-500	500	750	45,200	250	500	500	0.25
	(55)	(85)	(5,107)	(28.25)	(2,225)	(2,225)	(0.64)
2121-1K	1,000	1,500	103,000	500	1,000	660	0.25
	(115)	(170)	(11,637)	(56.50)	(4,450)	(2,935)	(0.64)
2121-2K	2,000	3,000	197,000	1,000	1,500	2,000	0.25
	(225)	(340)	(22,256)	(113.00)	(6,675)	(8,900)	(0.64)
2122-5K	5,000	7,500	379,000	2,000	2,100	3,000	0.38
	(565)	(850)	(42,819)	(225.00)	(9,340)	(13,350)	(0.95)
2122-10K	10,000	15,000	750,000	5,000	4,000	6,000	0.38
	(1,130)	(1,695)	(84,734)	(450.00)	(17,800)	(26,670)	(0.95)
2124-20K	20,000	30,000	2,610,000	10,000	6,500	10,000	0.50
	(2,250)	(3,390)	(294,875)	(1,130)	(28,900)	(44,480)	(1.27)
2125-50K	50,000	75,000	6,840,000	24,000	12,000	18,000	0.75
	(5,650)	(8,475)	(772,777)	(2,710)	(53,375)	(80,064)	(1.91)
2125-100K	100,000	150,000	12,200,000	50,000	20,000	30,000	0.75
	(11,300)	(16,950)	(1,378,346)	(5,650)	(89,000)	(133,440)	(1.91)
2126-200K	200,000	300,000	19,950,000	90,000	30,000	40,000	1
	(22,600)	(33,900)	(2,253,935)	(10,170)	(133,440)	(177,920)	(2.54)
2126-500K*	500,000	750,000	25,250,000	150,000	42,000	60,000	1
	(56,500)	(85,000)	(2,852,725)	(17,000)	(186,800)	(266,880)	(2.54)

***Calibration performed to 300,000 lbs. in. Consult factory for higher calibrations.**

Metric dimensions and specifications are purely mathematical calculations from standard English dimension control drawings. Request certified drawings before designing mountings or fixtures. Dimensions and specifications are subject to change without notice.

FEATURES:

- Reaction measurements eliminate speed limitations
- Minimal friction error
- No maintenance of slip rings, bearings or brushes
- Compact, "low mass" physical size

Safety Considerations: *"It would be unsafe to operate Lebow® Torque Sensors and Load Cells beyond Static Overload or Ultimate Extraneous Load Limits as defined in the Glossary of Terms or, when applicable, higher than maximum speed. When in doubt, consult the factory. Lebow® Products is not responsible for any property damage or personal injury which may result because of the misapplication of the Transducer."*

PERFORMANCE SPECS:

2105 AND 2102

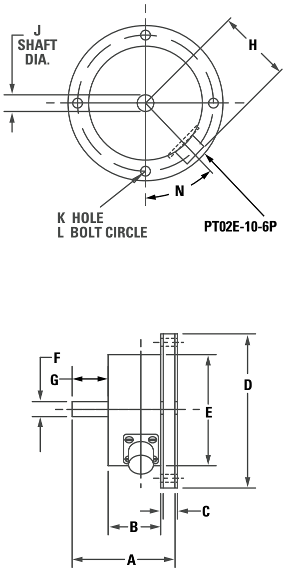
SPECIFICATIONS	
Actual performance average:	
Nonlinearity:	0.039%
Hysteresis:	0.028%
Nonlinearity: *of rated output*	±0.1%
Hysteresis: *of rated output*	±0.1%
Output at rated capacity: *millivolts per volt, nominal*	2.5
Repeatability: *of rated output*	±0.05%
Zero balance: *of rated output*	±1.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-65 to +200
Temperature range, usable: *°C*	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges	1

MODELS 2105

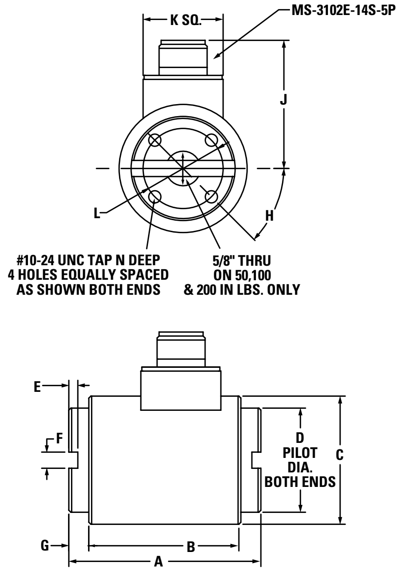
Low capacity torque sensor

MODELS 2102

Small flanged reaction torque sensor



2105	IN.	CM.
A	2.41	6.11
B	1.59	4.05
C	0.38	0.95
D	3.49	8.87
E	2.56	6.55
F	0.34	0.86
G	0.75	1.91
H	1.69	4.28
J	0.38	0.95
K	0.22	0.55
L	3.06	7.77
N	45°	45°



2102	IN.	CM.
A	3	7.62
B	2.38	6.03
C	2	5.08
D	1.63	4.13
E	0.14	0.36
F	0.25	0.64
G	0.31	0.79
H	45°	45°
J	2	5.08
K	1.25	3.18
L	1.25	3.18
N	0.38	0.95

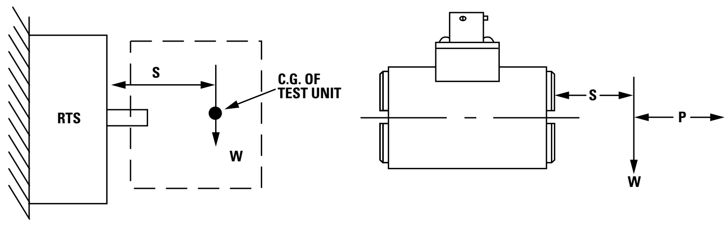
LOAD CARRYING CAPACITY

W = weight of test device

W x S = overhung moment

S = distance to center of gravity of test unit

Do not exceed moment (**W x S**) or shear (**W**), whichever value is attained first. **P** = thrust.



SENSOR CHARACTERISTICS: 2105 AND 2102

MODEL NUMBER	CAPACITY oz. in. N • m	OVERLOAD oz. in. N • m	TORSIONAL STIFFNESS oz. in./rad. N • m/rad.	MAX. OVERHUNG MOMENT WxS oz. in. N • m	MAX. SHEAR W oz. N	MAX. THRUST P oz. N
2105-50	50 0.35	75 0.53	12,900 91	100 0.72	160 44.50	320 89
2105-100	100 0.70	150 1.06	18,000 127	150 1.08	240 66.75	640 178
2105-200	200 1.50	300 2.25	51,500 364	200 1.44	320 89	960 267
2105-500	500 3.50	750 5.30	95,500 674	250 1.80	400 110	1,600 445
2105-1K	1,000 7.00	1,500 10.60	258,000 1,822	400 2.88	480 133	2,400 667

Torsional stiffness given for sensor less shaft extension(s).

MODEL NUMBER	CAPACITY lb. in. N • m	OVERLOAD lb. in. N • m	TORSIONAL STIFFNESS lb. in./rad. N • m/rad.	MAX. OVERHUNG MOMENT WxS lb. in. N • m	MAX. SHEAR W lbs. N	MAX. THRUST P lbs. N
2102-50	50 5	75 7.50	2,350 266	50 5.50	13 5.90	200 886
2102-100	100 10	150 20	6,725 760	100 11	20 9.09	280 1236
2102-200	200 20	300 30	18,800 2,124	200 22	26 11.80	400 1760
2102-500	500 55	750 85	73,600 8,315	250 27.50	500 227	500 2200
2102-1K	1,000 115	1,500 170	127,000 14,348	500 56	800 364	660 2900

FEATURES:

- High torsional stiffness
- Higher resistance to bending moments
- Minimal friction error
- Low end sensitivity due to absence of moving parts

Safety Considerations: *"It would be unsafe to operate Lebow® Torque Sensors and Load Cells beyond static overload or ultimate extraneous load limits as defined in the glossary of terms or, when applicable, higher than maximum speed. When in doubt, consult the factory. Lebow® Products is not responsible for any property damage or personal injury which may result because of the misapplication of the Transducer."*

PERFORMANCE SPECS: 2110–2116 AND 2320–2404

SPECIFICATIONS	
Actual performance average:	
Nonlinearity:	0.026%
Hysteresis:	0.029%
Nonlinearity: *of rated output*	±0.1%
Hysteresis: *of rated output*	±0.1%
Output at rated capacity:* *millivolts per volt, nominal*	2
Repeatability: *of rated output*	±0.05%
Zero balance: *of rated output*	±1.0%
Bridge resistance: *ohms nominal*	350*
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-65 to +200
Temperature range, usable: *°C*	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges	1

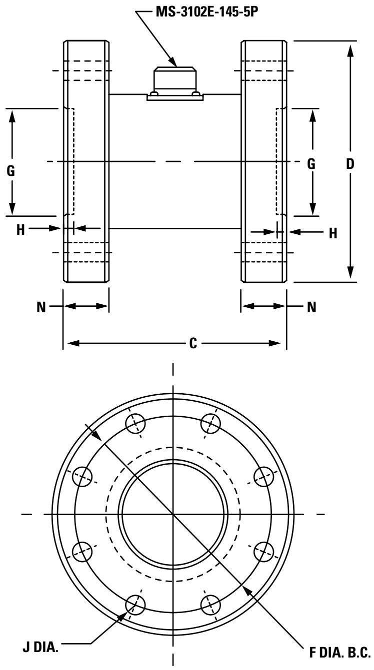
*Model 2404 output at rated capacity is 1.5 mV/V nominal and bridge resistance 700 ohms.

MODEL 2110–2116

Flanged reaction torque sensors

MODEL 2320 AND 2404

Hollow reaction torque sensors



2110-2K, 5K	IN.	CM.
C	3	7.62
D	4	10.16
F	3.25	8.26
G*	1.50	3.81
H	0.13	0.32
N	0.50	1.27
J†	0.33	0.83

2111-10K, 20K	IN.	CM.
C	3.50	8.89
D	5	12.70
F	4.25	10.80
G*	2.00	5.08
H	0.25	0.64
N	0.75	1.91
J†	0.39	0.99

2112-50K, 100K	IN.	CM.
C	7.38	18.73
D	8	20.32
F	6.50	16.51
G*	3.50	8.89
H	0.31	0.79
N	1.50	3.81
J†	0.65	1.63

2113-200K	IN.	CM.
C	8.50	21.59
D	9.75	24.77
F	8	20.32
G*	4	10.16
H	0.31	0.79
N	1.50	3.81
J†	0.77	1.94

2114-300K‡, 500K‡	IN.	CM.
C	10.50	26.67
D	14	35.56
F	11	27.94
G*	6	15.24
H	0.31	0.79
N	2	5.08
J†	1.02	2.59

2115-600K‡, 750K‡	IN.	CM.
C	10.50	26.67
D	15	38.10
F	12	30.48
G*	6	15.24
H	0.31	0.79
N	2	5.08
J†	1.52	3.85

2116-1200K‡, 2400K‡	IN.	CM.
C	16	40.64
D	20	50.80
F	16	40.64
G*	8	20.32
H	0.50	1.27
N	2	5.08
J††	1.52	3.86

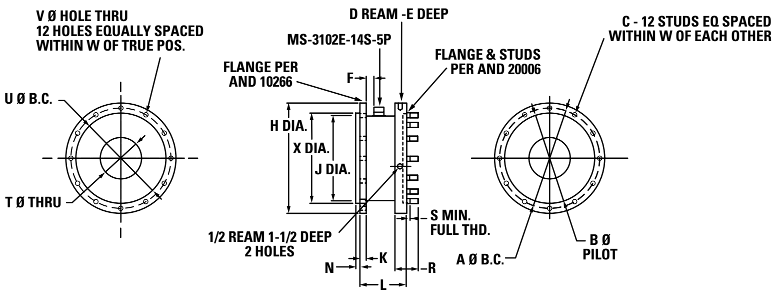
* Diameter tolerance +.002–.000.

† 8 equally spaced holes are located within .005 of true position.

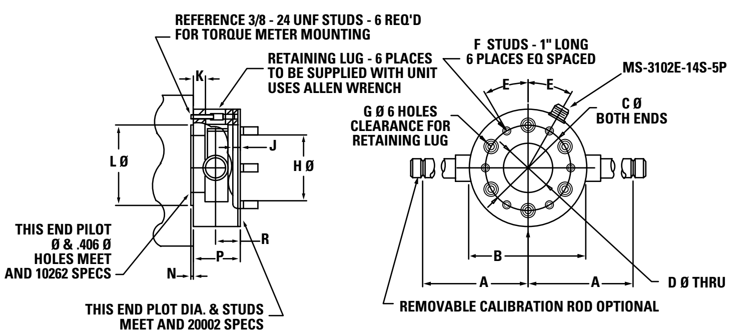
†† 16 equally spaced holes.

‡ Calibration performed to 300,000 lbs. in. maximum.

2320



2404



2320	IN.	CM.
A	10	25.40
B	9.00	22.86
C	⅜-24	-
D	0.38	0.94
E	0.38	0.94
F	1.25	3.15
G	0.25	0.64
H	11.00	27.94
J	8.50	21.59
K	0.63	1.58
L	4.25	10.79
N	0.22	0.56
P	1.13	2.85
R	1.13	2.85
S	0.81	2.06
T	4.13	10.47
U	10.00	25.40
V	0.41	1.03
W	0.01	0.02
X	8.99	22.83

2404	IN.	CM.
A	10	25.40
B	6.44	16.35
C	5.00	12.70
D	3.00	7.62
E	30º	30º
F	⅜-24	-
G	0.63	1.59
H	4.13	10.48
J	0.44	0.44
K	0.63	1.58
L	4.12	10.47
N	0.15	0.37
P	2.75	6.98
R	1.28	3.25
S	0.31	0.79
T	-	-
U	-	-
V	-	-
W	-	-
X	-	-

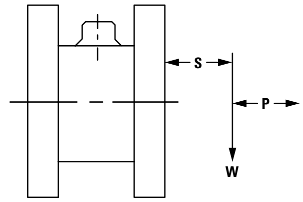
LOAD CARRYING CAPACITY

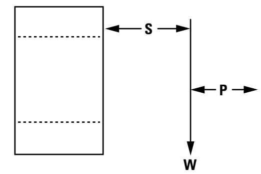
W = weight of test device

W x S = overhung moment

S = distance to center of gravity of test unit

Do not exceed moment (**W x S**) or shear (**W**), whichever value is attained first. **P** = thrust.





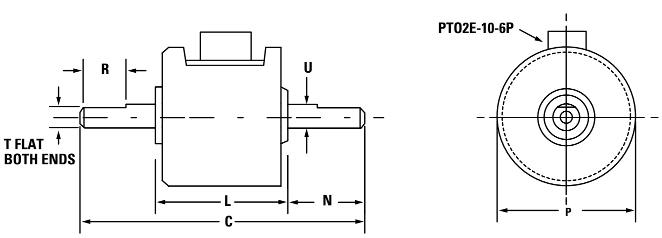
SENSOR CHARACTERISTICS: 2110-2116, 2320 AND 2404

MODEL NUMBER	CAPACITY lbs. in. (N • m)	OVERLOAD lbs. in. (N • m)	TORSIONAL STIFFNESS lbs. in./rad. (N • m/rad.)	MAX. OVERHUNG MOMENT WxS lbs. in. (N • m)	MAX. SHEAR W lbs. (N)	MAX. THRUST P lbs. (N)
2110-2K	2,000 (25)	3,000 (340)	384,000 (43,384)	1,000 (113)	1,500 (6,675)	2,000 (8,895)
2110-5K	5,000 (565)	7,500 (845)	920,000 (103,941)	2,000 (226)	2,000 (8,896)	3,000 (13,344)
2111-10K	10,000 (1,130)	15,000 (1,690)	2,680,000 (302,784)	5,000 (565)	4,000 (17,800)	6,000 (26,688)
2111-20K	20,000 (2,250)	30,000 (3,380)	5,750,000 (649,630)	10,000 (1,130)	6,500 (28,900)	10,000 (44,480)
2111-30K	30,000 (3,390)	45,000 (5,085)	10,000,000 (1,129,790)	15,000 (1,695)	8,500 (3,863)	13,000 (57,824)
2112-50K	50,000 (5,650)	75,000 (8,475)	8,000,000 (903,833)	24,000 (2,704)	12,000 (53,375)	18,000 (80,064)
2112-100K	100,000 (11,300)	150,000 (16,950)	20,000,000 (2,259,584)	50,000 (5,650)	20,000 (89,000)	30,000 (133,440)
2113-200K	200,000 (22,600)	300,000 (33,900)	33,400,000 (3,773,505)	90,000 (10,170)	30,000 (133,440)	40,000 (177,920)
2114-300K	300,000 (33,900)	450,000 (50,850)	60,000,000 (6,778,752)	150,000 (16,950)	42,000 (186,800)	60,000 (266,880)
2114-500K*	500,000 (56,500)	750,000 (84,750)	114,000,000 (12,879,628)	200,000 (22,600)	55,000 (244,640)	80,000 (355,840)
2115-600K*	600,000 (67,796)	900,000 (101,695)	160,000,000 (18,079,096)	200,000 (22,600)	95,000 (422,560)	90,000 (400,320)
2115-750K*	750,000 (84,745)	1,125,000 (127,119)	210,000,000 (23,728,814)	250,000 (28,250)	110,000 (489,280)	105,000 (467,040)
2116-1200K*	1,200,000 (135,593)	1,800,000 (203,375)	180,000,000 (20,338,983)	350,000 (39,550)	140,000 (622,720)	130,000 (578,240)
2116-2400K*	2,400,000 (271,186)	3,600,000 (406,800)	430,000,000 (48,587,570)	700,000 (79,096)	225,000 (1,000,800)	210,000 (934,080)
2404-50	50 (5)	250 (25)	17,000 (1,920)	200 (22)	50 (222)	200 (889)
2404-100	100 (10)	300 (30)	40,000 (4,519)	300 (34)	100 (445)	300 (1,334)
2404-200	200 (20)	500 (55)	100,00 (11,298)	400 (44)	150 (667)	400 (1,779)
2404-500	500 (55)	750 (85)	250,000 (28,245)	700 (77)	300 (1,334)	600 (2,668)
2404-1K	1,000 (115)	1,500 (170)	500,000 (56,490)	1,000 (113)	400 (1,779)	1,000 (4,448)
2404-2K	2,000 (225)	3,000 (340)	1,250,000 (141,224)	2,000 (226)	500 (2,224)	1,500 (6,672)
2404-5K	5,000 (565)	7,500 (850)	3,500,00 (395,427)	3,000 (338)	600 (2,669)	2,500 (11,120)
2320-12K	12,000 (1,350)	18,000 (2,030)	6,000,000 (677,875)	6,000 (676)	1,500 (6,672)	6,000 (26,688)
2320-36K	36,000 (4,050)	54,000 (6,085)	30,000,000 (3,389,376)	15,000 (1,694)	3,000 (13,344)	15,000 (66,720)

***Calibration performed to 300,000 lbs. in.; consult factory for higher calibrations.**

MODEL 2120

Shaft reaction torque sensor



2120	IN.	CM.
C	4.50	11.43
L	1.88	4.76
N	1.31	3.33
R	0.75	1.91
U	0.37	0.95
P	2.19	5.56
T	0.34	0.86

FEATURES:

- No maintenance of slip rings, bearings or brushes
- Minimal friction error
- Low end sensitivity
- Reaction measurements eliminate speed limitations

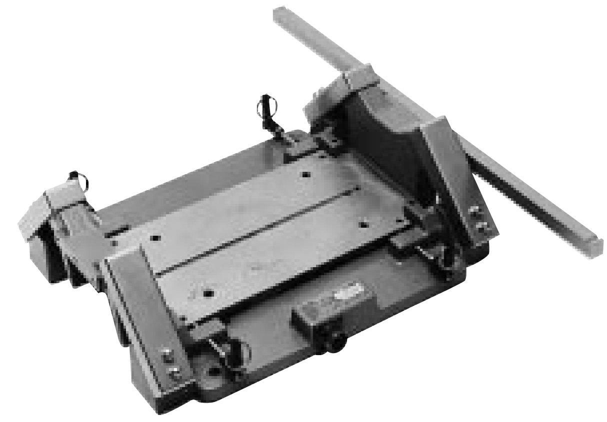
PERFORMANCE SPECS: 2120

SPECIFICATIONS	
Actual performance average:	
Nonlinearity:	0.021%
Hysteresis:	0.024%
Nonlinearity: *of rated output*	±0.1%
Hysteresis: *of rated output*	±0.1%
Output at rated capacity: *millivolts per volt, nominal*	2
Repeatability: *of rated output*	±0.05%
Zero balance: *of rated output*	±1.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-65 to +200
Temperature range, usable: *°C*	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges	1

SENSOR CHARACTERISTICS: 2120

MODEL NUMBER	CAPACITY oz. in. (N • m)	OVERLOAD oz. in. (N • m)	TORSIONAL STIFFNESS lb. in./rad. (N • m/rad.)	MAX. OVERHUNG MOMENT WxS lb. in. (N • m)	MAX. SHEAR W lbs. (N)	MAX. THRUST P lbs. (N)
2120-50	50 (0.35)	150 (1.06)	300 (34)	3.10 (0.35)	2.60 (11.57)	12 (53.40)
2120-100	100 (0.70)	300 (2.16)	890 (101)	6.25 (0.71)	3.60 (16.01)	35 (155)
2120-200	200 (1.50)	600 (4.32)	2,310 (261)	12.50 (1.41)	5.00 (22.24)	60 (265)
2120-500	500 (3.50)	1,000 (7.00)	2,560 (289)	31.25 (3.53)	10 (44.50)	120 (535)
2120-1K	1,000 (7.00)	1,500 (10.60)	5,130 (580)	62.50 (7.06)	16 (71.20)	140 (625)

MODEL 2514/2520 AND 2528/2540



FEATURES:

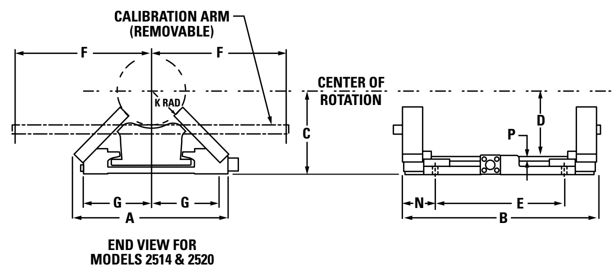
- Standard capacities from 160 ounce-inches to thousands of pound-inches
- No speed limitation
- Zero friction error
- Senses torque only—insensitive to force from other directions
- No slip rings or brushes
- Easily calibrated
- Four arm bonded strain gage sensor
- Positive overload protection
- A very small portion on the range can be expanded to full scale without loss of accuracy

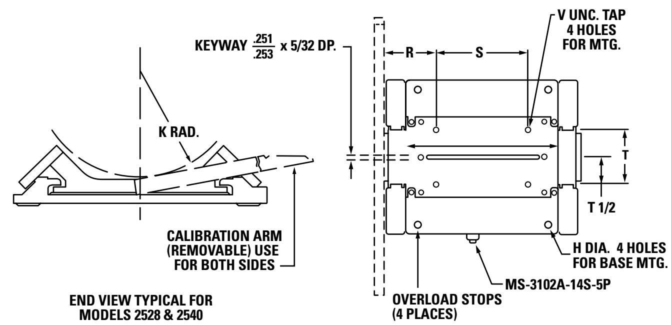
Safety Considerations: *"It would be unsafe to operate Lebow® Torque Sensors and Load Cells beyond static overload or ultimate extraneous load limits as defined in the glossary of terms or, when applicable, higher than maximum speed. When in doubt, consult the factory. Lebow® Products is not responsible for any property damage or personal injury which may result because of the misapplication of the Transducer."*

PERFORMANCE SPECS: 2514/2520 AND 2528/2540

SPECIFICATIONS

Actual performance average:	
Nonlinearity:	0.079%
Hysteresis:	0.045%
Nonlinearity: *of rated output*	±0.15%
Hysteresis: *of rated output*	±0.15%
Output at rated capacity: *millivolts per volt nominal*	±1.5
Repeatability: *of rated output*	±0.1%
Zero balance: *of rated output*	±5%
Bridge resistance: *ohms nominal*	700
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-65 to +200
Temperature range, usable: *°C*	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Static overload capacity: *of rated capacity*	200% *(positive overload stops set for approximately 120%)*
Torsional stiffness: *of rated capacity*	<0.5 *degrees twist*

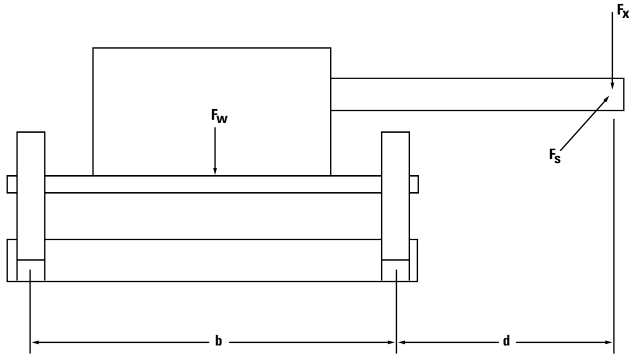




MODEL NUMBER	CAPACITY lb. in.	b inches	k
2514	10	12.00	25
	20	12.00	40
	25	12.00	50
	50	12.00	100
	100	12.00	200
2520	50	13.00	100
	100	13.00	150
	200	13.00	200
2528	100	15.00	150
	200	15.00	200
	300	15.00	225
	500	15.00	325
	750	15.00	400
	1,500	15.00	600
2540	500	20.00	275
	750	20.00	325
	1,000	20.00	375
	1,500	20.00	450
	2,000	20.00	550
	3,000	20.00	700
	3,600	20.00	800

TORQUE TABLE® EXTRANEOUS LOAD EQUATION

$$\left[\frac{F_W}{2} + F_X\left(1 + \frac{d}{b}\right) + F_S\left(1 + \frac{d}{b}\right)\right] \leq K$$



WHERE:

F_W = Customer's motor + mounting fixture weight–lbs.

F_X = Vertical force as shown–lbs.

F_S = Side force as shown–lbs.

d = Distance where F_X and/or F_S is applied as shown–inches

b = Torque Table length, given for each Torque Table–inches

K = Constant, given for each Torque Table

® Torque Table is a registered trademark of Lebow Products and is covered by U.S. Patent No. 3,213,679.

SENSOR CHARACTERISTICS: 2514/2520 AND 2528/2540

MODEL NUMBER	CAP. lb. in. (N • m)	VERT. LOAD CAP. lbs. (N)	A in. (cm.)	B in. (cm.)	C in. (cm.)	D in. (cm.)	E in. (cm.)	F in. (cm.)	G in. (cm.)	H in. (cm.)	K in. (cm.)	L in. (cm.)	M in. (cm.)	N in. (cm.)	P in. (cm.)	R in. (cm.)	S in. (cm.)	T in. (cm.)	DESIGN V in. (cm.)	AND USE
			DIMENSIONS																	
2514-10	10	50	9.00	13.38	4.50	3.50	10.38	10.00	3.75	0.44	0.88	11.13	6.00	1.50	0.38	3.19	7.00	4.00	¼-20	Adapts to NEMA Frames 42 & 48
	(1.30)	(222)	(22.86)	(33.97)	(11.43)	(8.89)	(26.35)	(25.40)	(9.53)	(1.11)	(2.22)	(28.86)	(15.24)	(3.81)	(0.95)	(8.09)	(17.78)	(10.16)	-	
2514-25	25	100	9.00	13.38	4.50	3.50	10.38	10.00	3.75	0.44	0.88	11.13	6.00	1.50	0.38	3.19	7.00	4.00	¼-20	
	(2.82)	(445)	(22.86)	(33.97)	(11.43)	(8.89)	(26.35)	(25.40)	(9.53)	(1.11)	(2.22)	(28.86)	(15.24)	(3.81)	(0.95)	(8.09)	(17.78)	(10.16)	-	
2514-50	50	200	9.00	13.38	4.50	3.50	10.38	10.00	3.75	0.44	0.88	11.13	6.00	1.50	0.38	3.19	7.00	4.00	¼-20	
	(5.65)	(890)	(22.86)	(33.97)	(11.43)	(8.89)	(26.35)	(25.40)	(9.53)	(1.11)	(2.22)	(28.86)	(15.24)	(3.81)	(0.95)	(8.09)	(17.78)	(10.16)	-	
2520-50	50	200	11.50	14.50	6.25	5.00	9.63	10.00	5.00	0.44	2.53	11.38	6.00	2.44	0.50	3.88	6.75	4.00	⅜-16	Adapts to NEMA Frames 56, 66, 140 & 180
	(5.65)	(890)	(29.21)	(36.83)	(15.88)	(12.70)	(24.45)	(25.40)	(12.70)	(1.11)	(6.43)	(28.89)	(15.24)	(6.19)	(1.27)	(9.84)	(17.15)	(10.16)	-	
2520-100	100	300	11.50	14.50	6.25	5.00	9.63	10.00	5.00	0.44	2.53	11.38	6.00	2.44	0.50	3.88	6.75	4.00	⅜-16	
	(11.30)	(1,335)	(29.21)	(36.83)	(15.88)	(12.70)	(24.45)	(25.40)	(12.70)	(1.11)	(6.43)	(28.89)	(15.24)	(6.19)	(1.27)	(9.84)	(17.15)	(10.16)	-	
2520-200	200	400	11.50	14.50	6.25	5.00	9.63	10.00	5.00	0.44	2.53	110.38	6.00	2.44	0.50	30.88	6.75	4.00	⅜-16	
	(22.60)	(1,780)	(29.21)	(36.83)	(15.88)	(12.70)	(24.45)	(25.40)	(12.70)	(1.11)	(6.43)	(28.89)	(15.24)	(6.19)	(1.27)	(9.84)	(17.15)	(10.16)	-	
2528-100	100	300	18.00	16.75	9.00	7.00	10.75	15.00	8.00	0.56	6.50	13.00	12.00	3.00	0.88	4.25	8.25	10.00	½-13	Adapts to NEMA Frames 210 & 250
	(11.30)	(1,335)	(45.72)	(42.55)	(22.86)	(17.78)	(27.31)	(38.10)	(20.32)	(1.43)	(16.51)	(33.02)	(30.48)	(7.62)	(2.22)	(10.80)	(20.96)	(25.40)	-	
2528-200	200	400	18.00	16.75	9.00	7.00	10.75	15.00	8.00	0.56	6.50	13.00	12.00	3.00	0.88	4.25	8.25	10.00	½-13	
	(22.60)	(1,780)	(45.72)	(42.55)	(22.86)	(17.78)	(27.31)	(38.10)	(20.32)	(1.43)	(16.51)	(33.02)	(30.48)	(7.62)	(2.22)	(10.80)	(20.96)	(25.40)	-	
2528-500	500	650	18.00	16.75	9.00	7.00	10.75	15.00	8.00	0.56	6.50	13.00	12.00	3.00	0.88	4.25	8.25	10.00	½-13	
	(56.50)	(2,890)	(45.72)	(42.55)	(22.86)	(17.78)	(27.31)	(38.10)	(20.32)	(1.43)	(16.51)	(33.02)	(30.48)	(7.62)	(2.22)	(10.80)	(20.96)	(25.40)	-	
2528-750	750	800	18.00	16.75	9.00	7.00	10.75	15.00	8.00	0.56	6.50	13.00	12.00	3.00	0.88	4.25	8.25	10.00	½-13	
	(84.80)	(3,560)	(45.72)	(42.55)	(22.86)	(17.78)	(27.31)	(38.10)	(20.32)	(1.43)	(16.51)	(33.02)	(30.48)	(7.62)	(2.22)	(10.80)	(20.96)	(25.40)	-	
2540-500	500	550	24.00	21.88	12.50	10.00	15.75	24.00	10.50	0.97	10.00	18.00	16.50	3.06	1.25	3.94	14.00	14.00	¾-10	Adapts to NEMA Frames 280, 320 & 360
	(56.50)	(2,450)	(60.96)	(55.56)	(31.75)	(25.40)	(40.01)	(60.96)	(26.67)	(2.46)	(25.40)	(45.72)	(41.91)	(7.77)	(3.18)	(10.00)	(35.56)	(35.56)	-	
2540-750	750	650	24.00	21.88	12.50	10.00	15.75	24.00	10.50	0.97	10.00	18.00	16.50	3.06	1.25	3.94	14.00	14.00	¾-10	
	(84.80)	(2,890)	(60.96)	(55.56)	(31.75)	(25.40)	(40.01)	(60.96)	(26.67)	(2.46)	(25.40)	(45.72)	(41.91)	(7.77)	(3.18)	(10.00)	(35.56)	(35.56)	-	
2540-1K	1,000	750	24.00	21.88	12.50	10.00	15.75	24.00	10.50	0.97	10.00	18.00	16.50	3.06	1.25	3.94	14.00	14.00	¾-10	
	(113)	(3,335)	(60.96)	(55.56)	(31.75)	(25.40)	(40.01)	(60.96)	(26.67)	(2.46)	(25.40)	(45.72)	(41.91)	(7.77)	(3.18)	(10.00)	(35.56)	(35.56)	-	
2540-1.5K	1,500	900	24.00	21.88	12.50	10.00	15.75	24.00	10.50	0.97	10.00	18.00	16.50	3.06	1.25	3.94	14.00	14.00	¾-10	
	(170)	(4,000)	(60.96)	(55.56)	(31.75)	(25.40)	(40.01)	(60.96)	(26.67)	(2.46)	(25.40)	(45.72)	(41.91)	(7.77)	(3.18)	(10.00)	(35.56)	(35.56)	-	
2540-2K	2,000	1,100	24.00	21.88	12.50	10.00	15.75	24.00	10.50	0.97	10.00	18.00	16.50	3.06	1.25	3.94	14.00	14.00	¾-10	
	(226)	(4,900)	(60.96)	(55.56)	(31.75)	(25.40)	(40.01)	(60.96)	(26.67)	(2.46)	(25.40)	(45.72)	(41.91)	(7.77)	(3.18)	(10.00)	(35.56)	(35.56)	-	

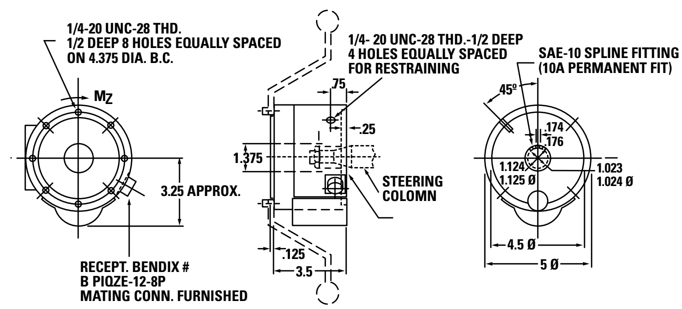
Many other configurations available. Consult factory.

MODEL 1369

Steering effort sensor

FEATURES:

- Direct to steering column attachment
- True steering torque–feedback for automobiles, trucks, buses and material handling equipment
- Torque to position capability



PERFORMANCE SPECS: 1369

SPECIFICATIONS

Actual performance average:	
Nonlinearity:	0.077%
Hysteresis:	0.083%
Nonlinearity: *of rated output*	≤0.50%
Hysteresis: *of rated output*	≤0.50%
Output at rated capacity: *millivolts per volt, nominal*	±2
Repeatability: *of rated output*	±0.35%
Zero balance: *of rated output*	±1.0%
Bridge resistance: *ohms nominal*	700
Temperature range, compensated: *°F*	+70 to +170
Temperature range, usable: *°F*	-20 to +200
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on zero: *of rated output per °F*	±0.002%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges	1
Static overload capacity: *of rated capacity*	150%
Speed: *RPM*	100

Other versions and custom designs available. Consult factory.

SENSOR CHARACTERISTICS: 1369

MODEL NUMBER	CAPACITY lb. in. N • m	PROTECTED FOR OVERLOADS TO lb. in. N • m
1369-50	50 5	75 7.50
1369-100	100 10	150 15
1369-200	200 20	300 30

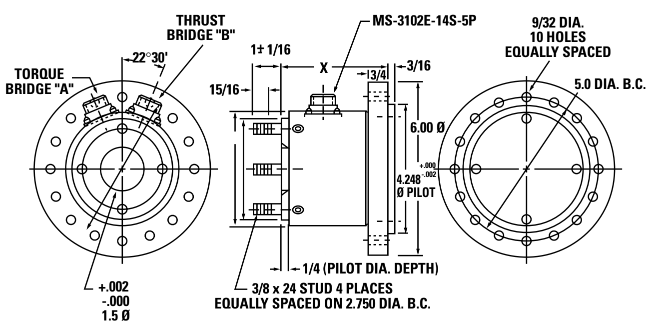
MODEL 6459 AND 6467–6470

Low capacity

6459

Larger capacities

6467



FEATURES:

- Minimal crosstalk
- Extraneous loading resistance
- Single piece construction
- Fatigue rated

Thrust/torque transducers are capable of sensing both torque and thrust force parameters simultaneously. Lebow® thrust/torque transducers are of one-piece construction and are designed specifically to provide the strength and rigidity required to withstand extraneous loads and bending moments. Unique construction provides both maximum structure life and minimum thrust/torque crosstalk.

PERFORMANCE SPECS: 6459 AND 6467–6470

SPECIFICATIONS	TORQUE	THRUST
Actual performance average:		
Nonlinearity:	0.042%	0.080%
Hysteresis:	0.057%	0.071%
Nonlinearity: *of rated output*	±0.15% *both components*	
Hysteresis: *of rated output*	±0.15% *both components*	
Output at rated capacity: *millivolts per volt, nominal*	±1.5 *both components*	
Repeatability: *of rated output*	±0.1% *both components*	
Zero balance: *of rated output*	±1%	
Bridge resistance: *ohms nominal*	700	
Temperature range, compensated: *°F*	+70 to +170	
Temperature range, compensated: *°C*	+21 to +77	
Temperature range, usable: *°F*	-65 to +200	
Temperature range, usable: *°C*	-54 to +93	
Temperature effect on output: *of reading per °F*	±0.002%	
Temperature effect on output: *of reading per °C*	±0.0036%	
Temperature effect on zero: *of rated output per °F*	±0.002%	
Temperature effect on zero: *of rated output per °C*	±0.0036%	
Excitation voltage, maximum: *volts DC or AC rms*	20	
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000	
Static overload capacity: *of rated capacity*	150%	

SENSOR CHARACTERISTICS: 6459 AND 6467–6470

MODEL NUMBER	FATIGUE TORQUE (Mz) CAP. lb. in. (N • m)	FATIGUE THRUST (Fz) CAP. lb. (metric ton)	A in. (cm.)	B in. (cm.)	C in. (cm.)	D in. (cm.)	E in. (cm.)	F in. (cm.)	G in. (cm.)	H in. (cm.)	L in. (cm.)	J in. (cm.)
6459	900 (102)	1500 (0.68)	6 (15.24)	3.75 (9.53)	4.246/4.248 (10.7848/10.7899)	0.75 (1.91)	n/a	n/a	⅜-24 Thd., 4 Places Eq. Sp. on 2.75 B.C. (6.99 B.C. 4 Holes Eq. Spaced)	3.50 (8.89)	1.500/1.502 (3.810/3.815)	0.28 Dia. on 5.00 B.C. 16 Holes Eq. Sp. (12.70 B.C. 16 Holes Eq. Spaced)
6467	5,000 (565)	10,000 (4.5)	7.38 (18.73)	5.25 (13.34)	5.246/5.248 (13.325/13.350)	1.75 (4.45)	5.88 (14.92)	7.13 (18.10)	½-13 Thd., 0.75 Dp. on 4.00 B.C. (10.16 B.C. 4 Holes Eq. Spaced)	5.44 (13.81)	2.500/2.502 (6.350/6.355)	0.42 Dia. on 6.50 B.C. (16.51 B.C. 16 Holes Eq. Spaced)
6468	25,000 (2,825)	50,000 (22.5)	10.75 (27.31)	8.50 (21.59)	7.996/7.998 (20.310/20.315)	2.25 (5.72)	8.69 (22.07)	10.31 (26.19)	⅝-11 Thd., 1.13 Dp. on 6.50 B.C. (16.51 B.C. 8 Holes Eq. Spaced)	8 (20.32)	4.002/4.004 (10.165/10.170)	0.69 dia. on 9.50 B.C. (24.13 B.C. 16 Holes Eq. Spaced)
6468	25,000 (2,825)	75,000 (34)	10.75 (27.31)	8.50 (21.59)	7.996/7.998 (20.310/20.315)	2.25 (5.72)	8.69 (22.07)	10.31 (26.19)	⅝-11 Thd., 1.13 Dp. on 6.50 B.C. (16.51 B.C. 8 Holes Eq. Spaced)	8 (20.32)	4.002/4.004 (10.165/10.170)	0.69 dia. on 9.50 B.C. (24.13 B.C. 16 Holes Eq. Spaced)
6469	50,000 (5,650)	100,000 (45)	10.75 (27.31)	10.00 (25.40)	7.996/7.998 (20.310/20.315)	3.00 (7.62)	8.56 (21.75)	10.44 (26.51)	⅞-9 Thd., 1.13 Dp. on 6.50 B.C. (16.51 B.C. 8 Holes Eq. Spaced)	8 (20.32)	4.002/4.004 (10.165/10.170)	0.84 Dia. on 9.50 B.C. (24.13 B.C. 16 Holes Eq. Spaced)
6470	100,000 (11,300)	200,000 (90)	16.50 (41.91)	11.00 (27.94)	12.496/12.498 (31.740/31.745)	3.75 (9.53)	13.00 (33.02)	15.50 (39.37)	1.0-8 Thd., 1.50 Dp. on 9.50 B.C. (24.13 B.C. 12 Holes Eq. Spaced)	12 (30.48)	5.002/5.004 (12.705/12.710)	1.13 Dia. on 14.25 B.C. (36.20 B.C. 16 Holes Eq. Spaced)

*Male pilot 3/16.

FEATURES:

- Heavy-duty construction
- Epoxy-embedded coin silver slip rings
- Silver graphite brushes
- Hollow shaft for easy mounting
- Low noise
- Designed for reuse
- Watertight covers and seals optionally available

Lebow® slip rings are self-contained units. The rings are molded on a hollow steel shaft. The brush assembly is supported through shielded ball bearings by the slip ring housing.

The entire assembly slides over the shaft of the test device and is held in place with locking screws. Leads are generally run through a hollow shaft in the test device.

PERFORMANCE SPECS:

6105, 6109, 6116, 6118, 6121 AND 6129

SPECIFICATIONS

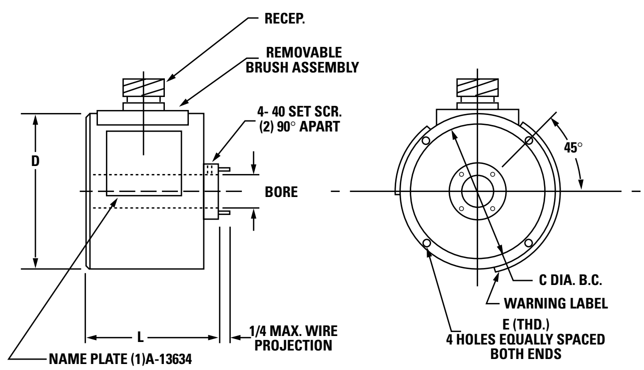
Rings: *Coin silver. Molded to shaft with high-temperature epoxy.*

Leads: *Silver wire. Silver soldered to ring and embedded in epoxy.*

Brushes: *Two brushes per ring. Silver graphite, positive wire connection, only screwdriver needed to replace brushes.*

Bearings: *Shielded ball bearings.*

MODEL 6118-8



MODEL 6109-8

SENSOR CHARACTERISTICS: 6105, 6109, 6116, 6118, 6121 AND 6129

MODEL NUMBER	BORE DIA. in. (cm.)	NO. OF RINGS	DIMENSIONS D in. (cm.)	L in. (cm.)	C in. (cm.)	E in. (cm.)	MAX. SPEED RPM	BRUSH LIFE FACTOR x 10^6	RING DIA. in.
6105-4	1.00 (2.54)	4	3.88 (9.84)	3.56 (9.04)	3.13 (7.94)	8-32	5,000	18.20	1.69
6105-8	1.00 (2.54)	8	3.88 (9.84)	5.06 (12.85)	3.13 (7.94)	8-32	5,000	18.20	1.69
6105-12	1.00 (2.54)	12	3.88 (9.84)	6.56 (16.66)	3.13 (7.94)	8-32	5,000	18.20	1.69
6109-4	4.50 (11.43)	4	8.06 (20.47)	7.13 (18.11)	n/a	n/a	2,000	6.20	5.75
6109-8	4.50 (11.43)	8	8.06 (20.47)	8.63 (21.92)	n/a	n/a	2,000	6.20	5.75
6109-12	4.50 (11.43)	12	8.06 (20.47)	10.13 (25.73)	n/a	n/a	2,000	6.20	5.75
6116-4	1.50 (3.81)	4	4.00 (10.16)	3.75 (9.53)	3.50 (8.89)	8-32	5,000	14.00	2.19
6116-8	1.50 (3.81)	8	4.00 (10.16)	5.25 (13.34)	3.50 (8.89)	8-32	5,000	14.00	2.19
6116-12	1.50 (3.81)	12	4.00 (10.16)	6.75 (17.15)	3.50 (8.89)	8-32	5,000	14.00	2.19
6118-4	0.50 (1.27)	4	2.38 (6.03)	2.13 (5.40)	2.13 (5.40)	4-40	8,000	6.20	1.00
6118-8	0.50 (1.27)	8	2.38 (6.03)	2.88 (7.30)	2.13 (5.40)	4-40	8,000	6.20	1.00
6118-12	0.50 (1.27)	12	2.38 (6.03)	3.63 (9.21)	2.13 (5.40)	4-40	8,000	6.20	1.00
6121-4	3.00 (7.62)	4	6.75 (17.15)	4.75 (12.07)	6.00 (15.24)	10-24	3,500	8.20	3.75
6121-8	3.00 (7.62)	8	6.75 (17.15)	6.25 (15.88)	6.00 (15.24)	10-24	3,500	8.20	3.75
6121-12	3.00 (7.62)	12	6.75 (17.15)	7.75 (19.69)	6.00 (15.25)	10-24	3,500	8.20	3.75
6129-4	2.00 (5.08)	4	5.00 (12.70)	4.59 (11.67)	4.38 (11.11)	10-24	4,500	11.40	2.69
6129-8	2.00 (5.08)	8	5.00 (12.70)	6.59 (16.75)	4.38 (11.11)	10-24	4,500	11.40	2.69
6129-12	2.00 (5.08)	12	5.00 (12.70)	8.59 (21.83)	4.38 (11.11)	10-24	4,500	11.40	2.69

Please contact factory for special requirements. Metric dimensions and specifications are purely mathematical calculations from standard English dimension control drawings. Request certified drawings before designing mountings or fixtures. Dimensions and specifications are subject to change without notice.

LOAD CELLS: A DISCUSSION

GENERAL-PURPOSE LOAD CELLS

General-purpose load cells can be divided up into several distinct categories. Designed to be utilitarian, the broad categories of general-purpose load cells are: precision weigh scale, universal and special application.

Precision weigh scale load cells must be designed in a rugged manner to withstand the normal abuses of daily operation in sometimes less than desirable situations, while maintaining a high degree of reliability and conformance to strict specifications. Normally, load cells falling into this category must adhere to performance criteria determined by the U.S. Weights and Measures and the OIML.

Universal load cells are the most common in industry, and can be found working in industrial environments ranging from the laboratory to harsh production line application. Universal load cells are designed to tolerate extremes of temperature, off-axis loading and "dirty" environments that often occur during the working lifetime of the transducer. Their force capacities range from a few pounds in the smallest to a few million pounds measuring force in the largest. As with any transducer, the most important criteria for proper usage and to guarantee the longest possible working life, proper attention must be given to working capacity and loading.

A good rule of practice to determine proper working capacity is to predetermine the maximum expected force that the load cell will be subjected to, including all vibration-induced "spikes" and keep that total force within the published working capacity of the load cell. Any electrical overload capacity of the load cell should be reserved as protection against those excess forces acting upon the load cell that were initially unforeseen.

Proper loading is important not only to the life of the load cell, but also to the integrity of the measurement. Structural crosstalk of varying degrees of severity is the normal result of improper loading. As with any mechanical arrangement, there should never be more or never less than 2 planes of axial freedom in measuring plane.

With load cells this is easily accomplished by the use of self-aligning swivel bearing for tension applications and load buttons or expansion plates in compression applications. Because of the relative stiffness a strain gage load cell has, consideration must also be made for inadvertent loading due to the thermal expansion of the surrounding loading fixtures. Once again, proper coupling procedure can eliminate this problem.

FATIGUE-RATED LOAD CELL

The fatigue-rated load cell is a special structure designed to withstand millions of cycles while maintaining its integrity and accuracy. The structural design typically consists of shear beam or columnar design.

A fatigue-rated load cell is also extremely resistant to extraneous bending and side-loading forces. These structures virtually eliminate bending strains at the strain gage, minimizing the primary cause of load cell failure.

A wide range of capacities can be handled by the fatigue-rated load cell family and have now become the standard in the high frequency load testing industry.

Since these load cells are often used in long-term fatigue tests, they also are available with dual bridges as a backup or used as a second primary bridge.

SELECTING THE PROPER LOAD CELL

A) To determine the proper capacity:
1) What is the maximum force value?
2) What are the dynamics of the system, i.e., frequency response?
3) What effect will placing the transducer in the force path have?
4) What are the maximum extraneous loads that load cell will see?

B) Evaluate the system in which the load cell is to be placed:
1) Will the load cell be in the primary load path or will the load cell see the forces indirectly?
2) Are there physical constraints that should be met for size and mounting?

C) What accuracy is required to meet the goals of the test?

D) What is the environment the load cell will be in and will this cause special problems?

Keeping in mind the above suggestions, choosing the proper load cell should be made easier.

All load cells are calibrated at Lebow® and are traceable to the National Bureau of Standards. This calibration is accomplished in two manners:
1) Deadweight—All deadweight calibrations are performed in English force units to 5,000 lbs.
2) Computer calibration—All computer calibrations are done in conjunction with a reference load cell. Most calibrations are done in English force units; however, metric ton calibrations are available on selected load cells upon request.

OUTPUT AT RATED CAPACITY CONSIDERATIONS

Load cell output is specified in millivolts per volt at rated capacity. A typical Lebow® load cell will have an output specification of 2 millivolts per volt nominal.

Certain model load cells have full-scale output trimmed to within a specified tolerance limit, for example: 2± 0.25% mV/V. This tolerance applies to the output in the primary direction of the load cell. For universal load cells listed in this catalog, tension will be considered the primary axis. A specified output tolerance in a non-primary direction can be met on individual request.

SAFETY CONSIDERATIONS

It would be unsafe to operate Lebow® torque sensors and load cells beyond static overload or ultimate extraneous load limits as defined in the Glossary of Terms or, when applicable, higher than maximum speed. When in doubt, consult the factory. Lebow Products is not responsible for any property damage or personal injury which may result because of the misapplication of the Lebow® transducers.

DIMENSIONS AND SPECIFICATIONS

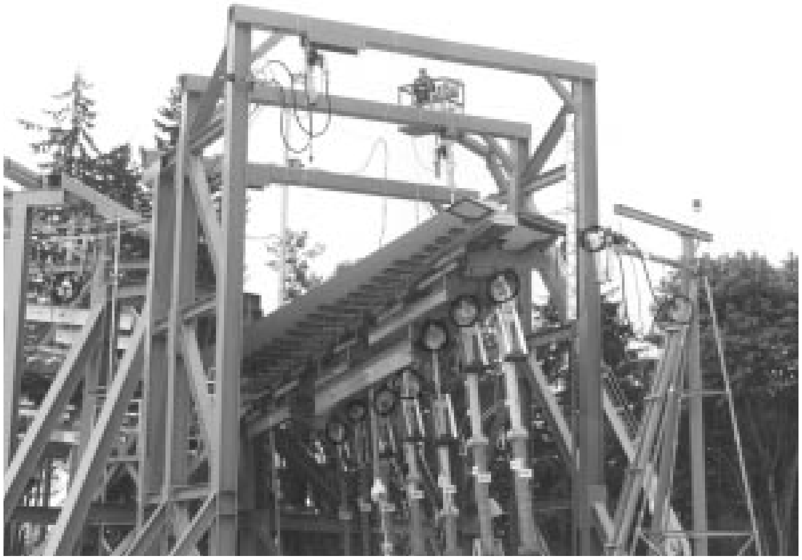
Metric dimensions and specifications are purely mathematical calculations from standard English dimension control drawings. Request certified drawings before designing mountings or fixtures. Dimensions and specifications are subject to change without notice.

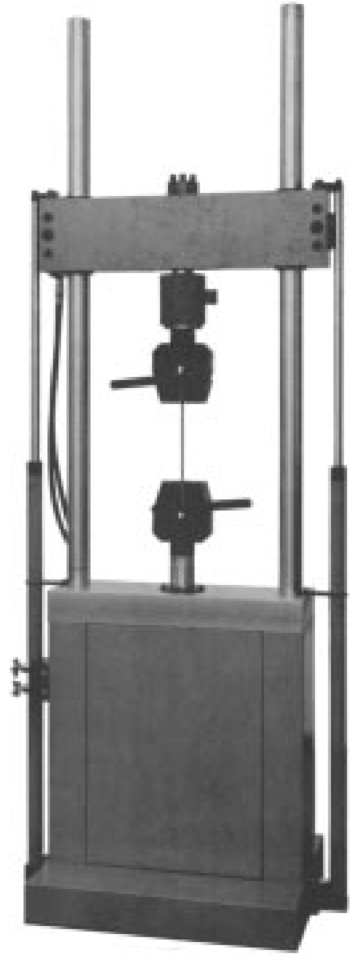
LOAD CELLS: A DISCUSSION

TYPES AND APPLICATIONS

FOR INDUSTRY

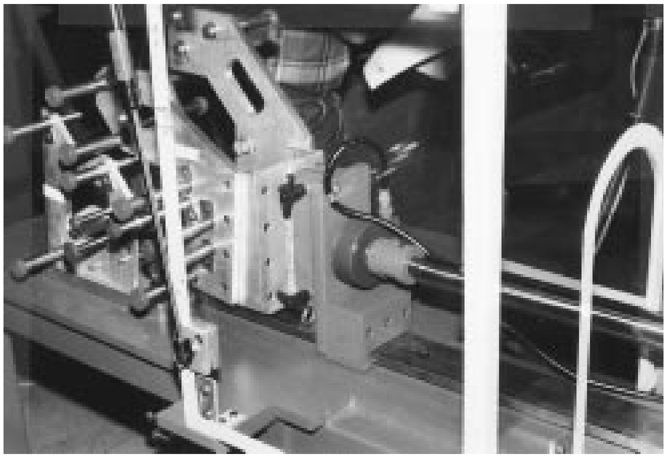
Fatigue testing material specimens in a precise, controlled manner is an often-cited application for load cells. The Lebow complete line of fatigue rated tranducers assures the integrity of the test information from the first cycle to the last. True fatigue application demands full tension/compression operation, thru zero, with full signal outputs and high reliability against costly breakage during the test cycle.





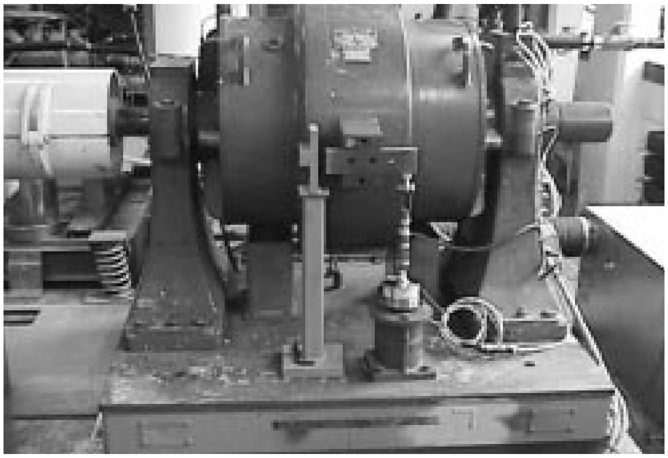
FOR COMPONENT TESTING

This machine, designed (for Chrysler) by Advanced Research in Lake Orion, uses a Model 3132-2K to test plastic dashboard components to verify the plastic welding process is achieving desired strength. After two parts are welded together, this machine is used to monitor the force required to break them apart.



FOR SPECIAL PURPOSE

Load cells mounted between ground and the casing of a trunnion bearing motoring/absorbing dynamometer have been a fundamental measurement technique for years. Lebow manufactures a complete line of general-purpose/fatigue load cells to suit the adverse conditions inherent in dyno lab testing. Most load cells can also be fitted with a patented overload protector for added safety and load cell over-ranging protection.



RATED CAPACITIES
(Capacities are Pound Inches unless otherwise noted)

MODEL	PAGE	CAPACITY					
GENERAL PURPOSE							
3108	62	5	10				
3167	62	25	50	100	200	300	
3397	62	25	50	100	200	300	
3132	64	500	1K	2K	3K	5K	
3169	65	500	1K	2K	3K		
3169-108	65	500	1K	2K	3K		
3143	67	500	1K	2K			
3144	67	5K	10K				
3145	67	25K	50K				
3146	67	100K					
GENERAL PURPOSE: CALIBRATION STANDARD							
3143-CS	69	300	500	1K	2K		
3144-CS	69	5K	10K				
3145-CS	69	25K	50K				
3146-CS	69	100K					
GENERAL PURPOSE: PRECISION							
3143-P	71	300	500	1K	2K		
3144-P	71	5K	10K				
3145-P	71	25K	50K				
3146-P	71	100K					
GENERAL PURPOSE: S-BEAM							
*3135	73	50	100				
*3136	73	150	200	300	500	750	1,000
*3137	73	2,000	5,000				
FATIGUE RESISTANT							
3156	75	25K	50K	100K	150K		
3129-112	76	150K	200K	300K			
3130	76	500K	800K	1,000K			
3127	76	2,000K					
3415-107	78	5K	10K				
3415-108	78	20K					
FATIGUE RESISTANT: LOW PROFILE							
3173	79	200	500	1K	2K	3K	
3174	81	5K	10K	20K			
3175	81	50K					
3176	81	100K					
COMPRESSION							
3691	83	1K	2K	5K	7.5K	10K	
3674	83	5K	10K	20K	50K		
3603	83	100K	200K	300K	500K		
3644	83	1,000K					
*3310	85	5,000	10,000	20,000	30,000		
HARSH ENVIRONMENT							
3272	87	100	200				
3273	87	500	1K	2K	5K		
3274	87	5K	10K	20K			
3275	87	50K					
3276	87	100K					
3277	87	200K					

**Rated Capacity – Kilograms*

RATED CAPACITIES
(Capacities are Pound Inches unless otherwise noted)

MODEL	PAGE	CAPACITY				
AUTOMOTIVE: SEAT BELT AND PEDAL EFFORT						
3419	89	3,500				
3663	90	50	100	200	300	
3663-111	90	300				
X-Y FORCE						
6443	91	500/1K				
6443-105	91	500/2K				
6443-106	91	500/1.5K				
HOLLOW						
3336	92	5K	10K	20K		
3632	92	25K	50K	100K		
BOLT FORCE SENSORS						
3711	94	No. 6-2"				
SMALL DIAMETER						
3124	96	5K	10K	15K	20K	25K
3161	96	2K	5K	10K	25K	
OVERLOAD PROTECTORS						
6214-111	98	100	200	300		
6214-121	98	100	200	300		
6214-112	98	500	1K	2K	3K	
6214-122	98	500	1K	2K	3K	
6214-131	98	500	1K	2K	3K	
6214-132	98	500	1K	2K	3K	

LOAD CELL ACCESSORIES (ROD ENDS AND LOAD BUTTONS) PAGE 98

JUNCTION BOXES (C18-1 THROUGH C20-1) PAGE 99

**Rated Capacity – Kilograms*

Consult factory for specials.

FEATURES:

- Low profile
- Calibration traceable to the National Bureau of Standards
- Low sensitivity to extraneous loads
- Low deflection
- Barometrically compensated construction (except 3108)
- Built-in temperature compensation
- Circuitry provides true temperature compensation

The load cells listed are precision general purpose designs, having exceptional structural capability to withstand extraneous loads, such as torque, bending moments and side loads.

Available in capacities from 5 lbs. to 300 lbs., they offer maximum performance and highest accuracy under changing environmental conditions.

Minimum deflection, no moving parts and compactness make Lebow® general-purpose load cells easy to install and use.

PERFORMANCE SPECS:

3108, 3167 AND 3397

SPECIFICATIONS	3108	3167	3397
Output at rated capacity: *millivolts per volt, nominal*	2±0.25%	2 nominal	2±0.25%
Nonlinearity: *of rated output*	±0.1%	±0.05%	±0.05%
Hysteresis: *of rated output*	±0.1%	±0.05%	±0.05%
Repeatability: *of rated output*	±0.05%	±0.02%	±0.02%
Zero balance: *of rated output*	±1.0%	±5.0%	±1.0%
Bridge resistance: *ohms nominal*	350	350	350
Temperature range, compensated: °F	+70 to +170	+70 to +170	+70 to +170
Temperature range, compensated: °C	+21 to +77	+21 to +77	+21 to +77
Temperature range, usable: °F	-65 to +200	-65 to +200	-65 to +200
Temperature range, usable: °C	-54 to +93	-54 to +93	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%	±0.002%	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%	±0.0036%	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%	±0.002%	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%	±0.0036%	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20	20	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000	>5,000	>5,000
Number of bridges:	1 or 2	1	1 or 2

MODELS 3397 AND 3108

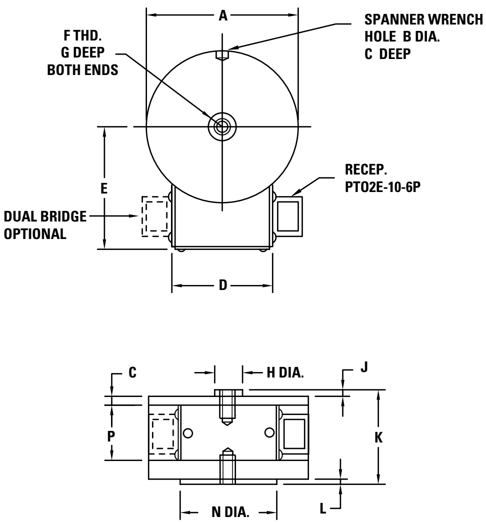
Tension and compression 5 lbs. to 300 lbs.

Model 3397 shown
3397—Capacities available 25 to 300 lbs.
3108—Capacities available 5 and 10 lbs.

MODEL 3167

Capacities available 25 to 300 lbs.

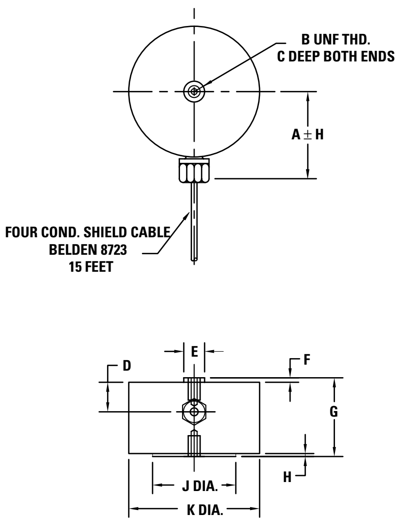
Consult factory for specials.



3397	IN.	CM.
A	2.75	6.98
B	0.22	0.55
C	0.13	0.32
D	1.75	4.44
E	2.22	5.60
F	¼-28	-
G	0.50	1.27
H	0.44	1.10
J	0.09	0.24
K	1.50	3.80
L	0.06	0.16
N	1.75	4.44
P	1	2.54

3108	IN.	CM.
A	2.75	6.98
B	0.22	0.55
C	0.13	0.32
D	1.75	4.44
E	2.22	5.60
F	¼-28	-
G	0.38	1.27
H	0.44	1.10
J	0.28	0.71
K	1.50	3.80
L	0.06	0.16
N	1.63	4.13
P	1	2.54

Note: The 3108 mounting configuration is similar to the 3397.



3167	IN.	CM.
A	2.25	5.72
B	¼-28	-
C	0.38	0.95
D	0.44	1.10
E	0.44	1.10
F	0.09	0.24
G	1.50	3.80
H	0.06	0.16
J	1.75	4.44
K	2.75	6.98

SENSOR CHARACTERISTICS: 3108, 3167 AND 3397

MODEL NUMBER	NOMINAL LOAD LIMIT CAPACITY F_Z LBS.	NOMINAL LOAD LIMIT CAPACITY F_Z NEWTONS	STATIC OVERLOAD CAPACITY % OF NOM. CAPACITY	STATIC EXTRANEOUS LOAD LIMITS: SHEAR F_X OR F_Y LBS.	STATIC EXTRANEOUS LOAD LIMITS: BENDING Mx OR M_Y LB. INCHES	STATIC EXTRANEOUS LOAD LIMITS: TORQUE Mz LB. INCHES	DEFLECTION AT NOM. LOAD LIMIT INCHES	RINGING FREQUENCY H_Z
3108	5	20	150	30	30	3	0.005	500
	10	50	150	40	40	4	0.005	900
3167	25	125	150	150	150	40	0.003	2,100
	50	200	150	150	150	40	0.003	2,800
	100	500	150	250	180	40	0.003	3,800
	200	1K	150	250	180	40	0.003	5,400
	300	1.5K	150	250	180	40	0.003	7,000
3397	25	125	150	150	150	40	0.003	2,100
	50	200	150	150	150	40	0.003	2,800
	100	500	150	250	180	40	0.003	3,800
	200	1K	150	250	180	40	0.003	5,400
	300	1.5K	150	250	180	40	0.003	7,000

MODEL 3132

Tension and compression 500 lbs. to 5,000 lbs.

Capacities available 500 lbs. to 5K lbs.

FEATURES:

- Low profile
- Calibration traceable to the National Bureau of Standards
- Low sensitivity to extraneous loads
- Low deflection
- Rugged welded construction
- Built-in temperature compensation
- Circuitry provides true temperature compensation

The load cell listed is a precision general purpose design, having exceptional structural capability to withstand extraneous loads, such as torque, bending moments and side loads.

Available in capacities from 500 lbs. to 5,000 lbs., it offers maximum performance and highest accuracy under changing environmental conditions.

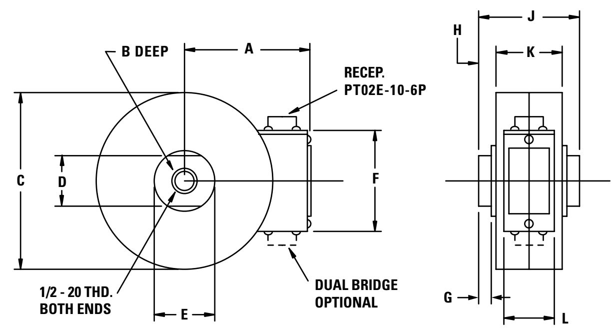
Minimum deflection, no moving parts and compactness make Lebow® general-purpose load cells easy to install and use.

PERFORMANCE SPECS:

3132

SPECIFICATIONS

Output at rated capacity: *millivolts per volt, nominal*	3 ±0.25%
Nonlinearity: *of rated output*	±0.1%
Hysteresis: *of rated output*	±0.1%
Repeatability: *of rated output*	±0.05%
Zero balance: *of rated output*	±1.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-65 to +200
Temperature range, usable: *°C*	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges:	1 or 2



3132	IN.	CM.
A	2.62	6.65
B	0.63	1.60
C	3.50	8.89
D	1	2.54
E	1.19	3.02
F	1.75	4.45
G	0.25	0.64
H	0.34	8.70
J	2	5.08
K	1.31	3.33
L	1	2.54

SENSOR CHARACTERISTICS: 3132

MODEL NUMBER	NOMINAL LOAD LIMIT CAPACITY F_Z LBS.	NEWTONS	STATIC OVERLOAD CAPACITY % OF NOM. CAPACITY	STATIC EXTRANEOUS LOAD LIMITS: SHEAR F_X OR F_Y LBS.	BENDING Mx OR M_Y LB. INCHES	TORQUE Mz LB. INCHES	DEFLECTION AT NOM. LOAD LIMIT INCHES	RINGING FREQUENCY H_Z
3132	500	2K	150	1,400	2,800	1,100	0.005	1,600
	1K	5K	150	2,000	3,900	1,100	0.005	2,000
	2K	10K	150	2,800	5,000	1,100	0.005	3,200
	3K	15K	150	3,400	5,500	1,100	0.005	4,100
	5K	20K	150	4,200	5,500	1,100	0.005	5,000

MODELS 3169 AND 3169-106

Tension and compression 500 lbs. to 3,000 lbs.

3169—English Thd.
3169-106—Metric Thd.

MODELS 3169-108 AND 3169-111

Tension and compression 500 lbs. to 3,000 lbs.

3169-108—English Thd.
3169-111—Metric Thd.

FEATURES:

- Stainless steel
- Hermetically sealed
- Barometrically compensated
- Low deflection
- Proven design and performance
- Tension and compression
- Low sensitivity to extraneous loads

The 3169 stainless steel load cell offers sealed, barometrically compensated construction. It is ideally suited for scales and other critical weighing applications. This compact load cell's temperature compensation circuit is located in close proximity to the strain gage bridge which provides more effective compensation where the internal and external load cell temperature can vary. Precision performance as well as the structural integrity required to withstand extraneous loads are also features of this rugged load cell.

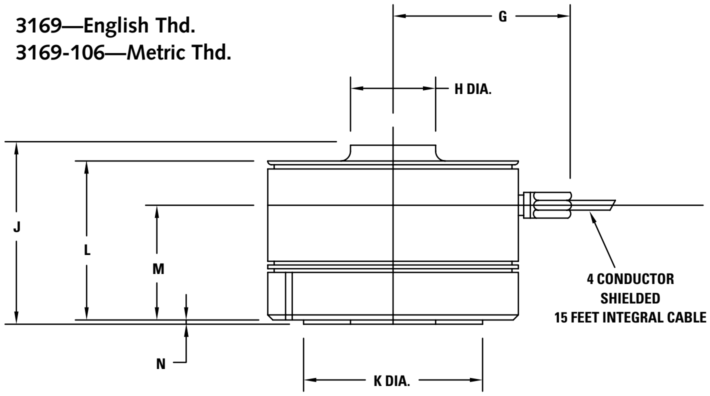
PERFORMANCE SPECS:

3169, 3169-106, 3169-108 AND 3169-111

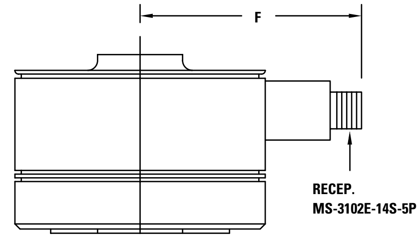
SPECIFICATIONS	
Output at rated capacity: *millivolts per volt, terminal*	2
Nonlinearity: *of rated output*	±0.05%*
Hysteresis: *of rated output*	±0.05%*
Repeatability: *of rated output*	±0.02%
Zero balance: *of rated output*	±5.0%
Creep: *in 20 minutes of rated output*	<±0.02%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: °F	+70 to +170
Temperature range, compensated: °C	+21 to +77
Temperature range, usable: °F	-65 to +200
Temperature range, usable: °C	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges:	1

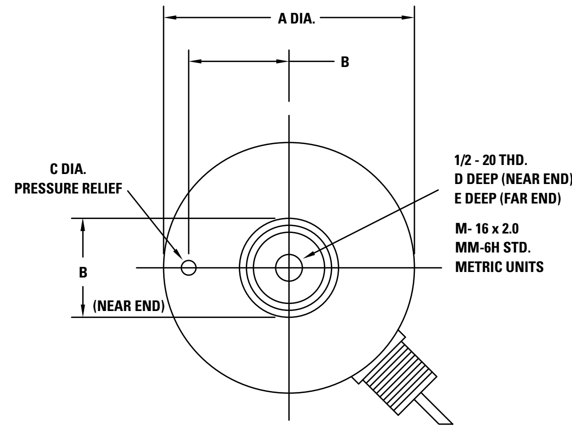
*Model 3169-106, -111: ±0.1%

3169—English Thd.
3169-106—Metric Thd.



3169-108—English Thd.
3169-111—Metric Thd.





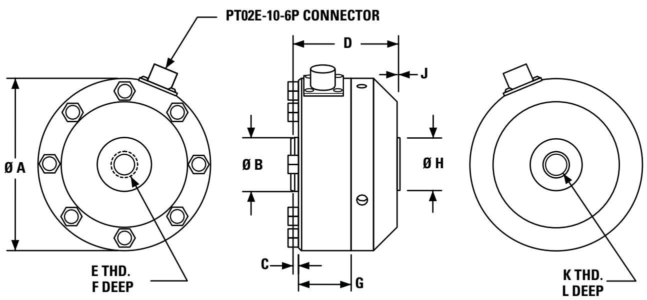
3169	IN.	CM.
A	3.50	8.89
B	1.38	3.51
C	0.13	0.33
D	0.75	1.91
E	0.69	1.75
F	3.31	8.41
G	2.50	6.35
H	1.19	3.02
J	2.50	6.35
K	2.50	6.35
L	2.22	5.64
M	1.53	3.89
N	0.06	0.15

SENSOR CHARACTERISTICS: 3169

MODEL NUMBER	NOMINAL LOAD LIMIT CAPACITY F_Z		STATIC OVERLOAD CAPACITY % OF NOM. CAPACITY	STATIC EXTRANEOUS LOAD LIMITS			DEFLECTION AT NOM. LOAD LIMIT INCHES	RINGING FREQUENCY H_Z
	LBS.	NEWTONS		SHEAR F_X OR F_Y LBS.	BENDING Mx OR M_Y LB. INCHES	TORQUE Mz LB. INCHES		
3169	500	2K	150	2,619	4,583	2,895	0.003	1,950
	1K	5K	150	2,619	4,583	2,895	0.003	2,440
	2K	10K	150	2,619	4,583	2,895	0.003	3,900
	3K	15K	150	2,619	4,583	2,895	0.003	5,000

MODEL 3140 SERIES

Tension and compression 500 lbs. to 100K lbs.



Consult factory for specials.

FEATURES:

- 500 lbs. through 100,000 lbs.
- Universal tension and compression loading
- High accuracy
- Low profile
- 150% FS safe overload capability
- Available in single or optional dual bridge configuration
- Metric sizes available

The Model 3140 load cell series has been designed for general-purpose use in demanding applications in automotive, aerospace and military markets. These new tension/compression load cells are direct replacements for other low profile models.

Some advantages of these new load cells are: compact size, high accuracy, low cost and availability.

PERFORMANCE SPECS: 3140 SERIES

SPECIFICATIONS	
Output at rated capacity (500 to 2K): *millivolts per volt, nominal*	2
Output at rated capacity (5K to 100K): *millivolts per volt, nominal*	4
Maximum nonlinearity error: *of full scale output*	± 0.06%
Maximum hysteresis error: *of full scale output*	± 0.06%
Maximum non-repeatability: *of full scale output*	± 0.01%
Zero balance: *of full scale output*	± 1.0%
Input resistance: *ohms*	350 +40/-3.5
Output resistance: *ohms*	350 ± 3.5
Temperature range, operating: *°F*	-65 to +200
Temperature range, compensated: *°F*	+70 to +170
Temperature effect on output: *of rated output per °F*	± 0.0015%
Temperature effect on zero: *of rated output per °F*	± 0.0015%
Static overload capacity: *of rated capacity*	150%

MODEL NUMBER	CAPACITY LBS.	ØA	ØB	C	D	E THD	F	G	ØH	J	K THD	L
3143-500	500	4.12	1.29	0.13	2.50	½-20 UNF 3B	1.12	1.25	1.25	0.03	½-20 UNF 3B	0.88
3143-1K	1,000	4.12	1.29	0.13	2.50	½-20 UNF 3B	1.12	1.25	1.25	0.03	½-20 UNF 3B	0.88
3143-2K	2,000	4.12	1.29	0.13	2.50	½-20 UNF 3B	1.12	1.25	1.25	0.03	½-20 UNF 3B	0.88
3144-5K	5,000	4.12	1.29	0.13	2.50	⅝-18 UNF 3B	1.12	1.25	1.25	0.03	⅝-18 UNF 3B	0.88
3144-10K	10,000	4.12	1.29	0.13	2.50	⅝-18 UNF 3B	1.12	1.25	1.25	0.03	⅝-18 UNF 3B	0.88
3145-25K	25,000	6.06	2.34	0.13	3.50	1¼-12 UNF 3B	1.50	1.63	1.25	0.03	1¼-12 UNF 3B	1.50
3145-50K	50,000	6.06	2.58	0.13	3.50	1¼-12 UNF 3B	1.50	1.63	2.25	0.03	1¼-12 UNF 3B	1.50
3146-100K	100,000	8.00	3.76	0.25	4.50	1¾-12 UNF 3B	2.25	2.25	3.00	0.03	1¾-12 UNF 3B	1.75

Dimensions are in inches.

SENSOR CHARACTERISTICS: 3140

MODEL NUMBER	NOMINAL LOAD LIMIT CAPACITY F_Z		STATIC OVERLOAD CAPACITY % OF NOM. CAPACITY	STATIC EXTRANEOUS LOAD LIMITS			DEFLECTION AT NOM. LOAD LIMIT INCHES	RINGING FREQUENCY H_Z
	LBS.	NEWTONS		SHEAR F_X OR F_Y LBS.	BENDING Mx OR M_Y LB. INCHES	TORQUE Mz LB. INCHES		
3143	500	2K	150	200	200	200	0.002	3,500
	1K	5K	150	400	400	400	0.002	4,900
	2K	10K	150	800	800	800	0.002	6,900
3144	5K	22K	150	2,000	2,000	2,000	0.004	4,500
	10K	45K	150	4,000	4,000	4,000	0.004	6,600
3145	25K	110K	150	10,000	10,000	10,000	0.004	4,500
	50K	200K	150	25,000	25,000	20,000	0.004	4,900
3146	100K	500K	150	50,000	50,000	40,000	0.006	4,100

MODEL 3140-CS CALIBRATION STANDARD

Consult factory for specials.

FEATURES:

- 300 lbs. through 100,000 lbs.
- Universal tension and compression loading
- High accuracy
- Low profile
- 150% FS safe overload capability
- Available in single or optional dual bridge configuration
- Metric sizes available
- Factory installed calibration adapters
- Eccentric load compensated
- High-precision base installed

The Model CS3140 load cell series has been designed as a reference standard for calibration labs in automotive, aerospace, military or industrial markets. These new tension/compression load cells can be used when accuracy is a high-priority requirement.

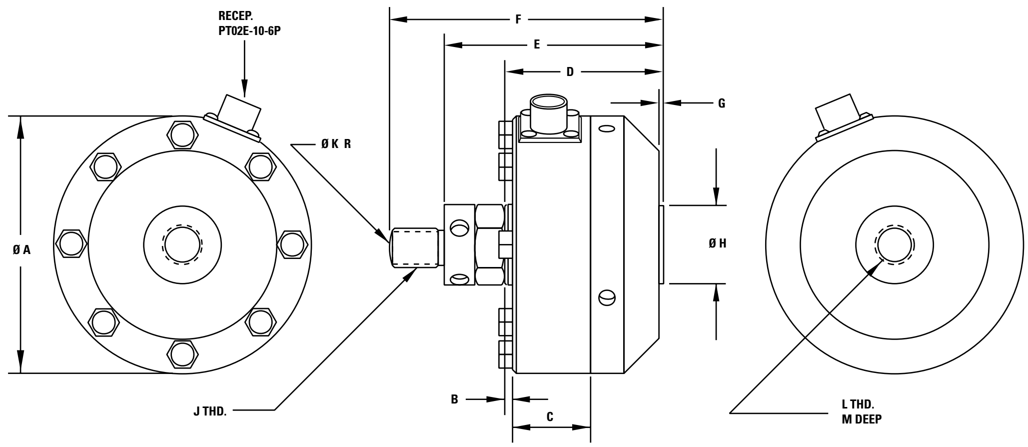
Some advantages of these new load cells are: compact size, high accuracy and availability.

PERFORMANCE SPECS:

3140-CS SERIES

SPECIFICATIONS

Rated capacity: *lbs.*	300 to 2K	5K to 10K	25K to 100K
Output at rated capacity: *millivolts per volt, nominal*	2.0	4.0	4.0
Maximum nonlinearity error: *of full scale output*	±0.02%	±0.04%	±0.04%
Maximum hysteresis error: *of full scale output*	±0.02%	±0.04%	±0.05%
Maximum non-repeatability: *of full scale output*	±0.005%	±0.005%	±0.005%
Zero balance: *of full scale output*	±1.0%	±1.0%	±1.0%
Input resistance: *ohms*	350 +40/-3.5	350 +40/-3.5	350 +40/-3.5
Output resistance: *ohms*	350 ±3.5	350 ±3.5	350 ±3.5
Excitation voltage, maximum: *volts DC*	10	10	10
Creep: *of reading in 20 minutes*	±0.01%	±0.01%	±0.01%
Off-center load sensitivity: */inch*	±0.10%	±0.25%	±0.25%
Side load sensitivity:	±0.10%	±0.25%	±0.25%
Temperature range, operating: *°F*	-65 to +200	-65 to +200	-65 to +200
Temperature range, compensated: *°F*	+15 to +115	+15 to +115	+15 to +115
Maximum temperature effect on output: *of reading/100°F*	0.08%	0.08%	0.08%
Maximum temperature effect on zero: *of rated output/100°F*	0.08%	0.08%	0.08%
Static overload capacity: *of rated output*	150%	150%	150%
Insulation resistance, bridge/case: *megohms*	>5,000	>5,000	>5,000



MODEL NUMBER	CAPACITY LBS.	ØA	B	C	D	E	F	G	ØH	J THD	ØK RADIUS	L THD	M
3143-CS-300	300	4.12	0.13	1.25	2.50	3.44	4.18	0.03	1.25	½-20 UNF 3A	6.00	½-20 UNF 3B	0.88
3143-CS-500	500	4.12	0.13	1.25	2.50	3.44	4.18	0.03	1.25	½-20 UNF 3A	6.00	½-20 UNF 3B	0.88
3143-CS-1K	1,000	4.12	0.13	1.25	2.50	3.44	4.18	0.03	1.25	½-20 UNF 3A	6.00	½-20 UNF 3B	0.88
3143-CS-2K	2,000	4.12	0.13	1.25	2.50	3.44	4.18	0.03	1.25	½-20 UNF 3A	6.00	½-20 UNF 3B	0.88
3144-CS-5K	5,000	4.12	0.13	1.25	2.50	3.44	4.19	0.03	1.25	⅝-18 UNF 3A	6.00	⅝-18 UNF 3B	0.88
3144-CS-10K	10,000	4.12	0.13	1.25	2.50	3.44	4.19	0.03	1.25	⅝-18 UNF 3A	6.00	⅝-18 UNF 3B	0.88
3145-CS-25K	25,000	6.06	0.13	1.63	3.50	4.94	6.44	0.03	1.25	1¼-12 UNF 3A	6.00	1¼-12 UNF 3B	1.50
3145-CS-50K	50,000	6.06	0.13	1.63	3.50	4.94	6.44	0.03	2.25	1¼-12 UNF 3A	6.00	1¼-12 UNF 3B	1.50
3146-CS-100K	100,000	8.00	0.25	2.25	4.50	6.13	7.88	0.03	3.00	1¾-12 UNF 3A	12.00	1¾-12 UNF 3B	1.75

Dimensions are in inches.

MODELS 3140-P SERIES

Ultra-precision load cell

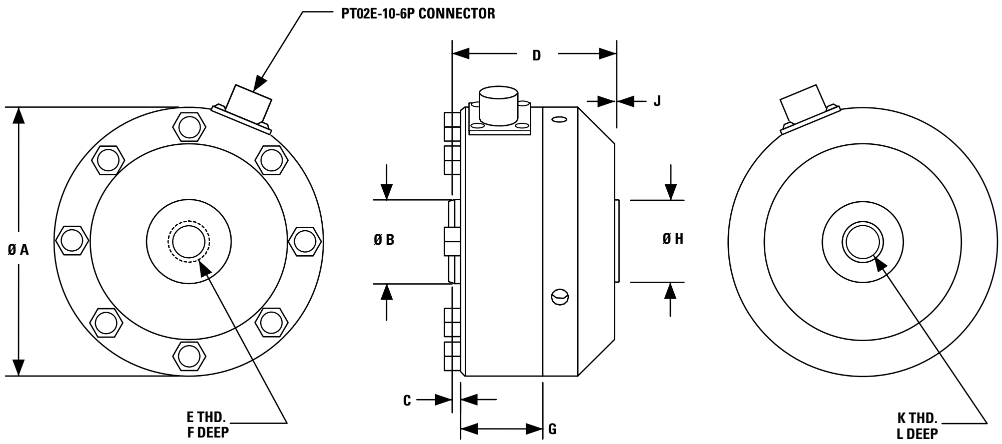
FEATURES:

- High-accuracy version of standard 3140 Series
- Low height
- Smaller guaranteed maximum off-center load and moment error than standard 3140 Series
- Static error band 0.02–0.04%
- Low creep
- Low sensitivity to magnetic fields
- Barometric pressure compensated
- Temperature compensated
- Output to 4 mV/V

PERFORMANCE SPECS:

3140-P SERIES

	3143-P	3144-P	3145-P	3146-P
		CAPACITY (lbf)		
SPECIFICATIONS	**300, 500, 1K, 2K**	**5K, 10K**	**25K, 50K**	**100K**
Accuracy:				
Zero balance: *of rated output*	±1.0%	±1.0%	±1.0%	±1.0 %
Non-linearity: *of rated output*	±0.03%	±0.03%	±0.03%	±0.03%
Hysteresis: *of rated output*	±0.02%	±0.04%	±0.04%	±0.04%
Non-repeatability: *of rated output*	±0.01%	±0.01%	±0.01%	±0.01%
Static error band: *of rated output*	±0.02%	±0.03%	±0.04%	±0.04%
Creep: *reading in 20 minutes*	±0.03%	±0.03%	±0.03%	±0.03%
Off-center load sensitivity: *inch*	±0.10%	±0.10%	±0.10%	±0.10%
Side load sensitivity:	±0.10%	±0.10%	±0.10%	±0.10%
Temperature:				
Range, compensated: *°F*	+15 to +115	+15 to +115	+15 to +115	+15 to +115
Range, operating: *°F*	-65 to +200	-65 to +200	-65 to +200	-65 to +200
Effect on sensitivity: *Rdg/100 °F*	0.08%	0.08%	0.08%	0.08%
Effect on zero: *of rated output/100 °F*	0.08%	0.08%	0.08%	0.08%
Electrical:				
Excitation voltage: *recommended VDC*	10	10	10	10
Input resistance: *ohms*	350 +40/-3.5	350 +40/-3.5	350 +40/-3.5	350 +40/-3.5
Output resistance: *ohms*	350 ±3.5	350 ±3.5	350 ±3.5	350 ±3.5
Sensitivity: *of rated output, mV/V, nominal*	2	4	4	4
Insulation resistance, bridge/case: *megohms*	>5000 @ 50VDC	>5000 @ 50VDC	>5000 @ 50VDC	>5000 @ 50VDC
Mechanical:				
Safe overload range: *of rated output*	150%	150%	150%	150%
Weight: *lbs.*	1.0	2.9	9.1	23.5
Weight w/base: *lbs.*	2.5	6.5	21.5	52.5
Flexure material:	Aluminum	Steel	Steel	Steel



MODEL NUMBER	CAPACITY LBS.	ØA	ØB	C	D	E THD	F	G	ØH	J	K THD	L
3143-P-300	300	4.12	1.29	0.13	2.50	½-20 UNF 3B	1.12	1.25	1.25	0.03	½-20 UNF 3B	0.88
3143-P-500	500	4.12	1.29	0.13	2.50	½-20 UNF 3B	1.12	1.25	1.25	0.03	½-20 UNF 3B	0.88
3143-P-1K	1,000	4.12	1.29	0.13	2.50	½-20 UNF 3B	1.12	1.25	1.25	0.03	½-20 UNF 3B	0.88
3143-P-2K	2,000	4.12	1.29	0.13	2.50	½-20 UNF 3B	1.12	1.25	1.25	0.03	½-20 UNF 3B	0.88
3144-P-5K	5,000	4.12	1.29	0.13	2.50	⅝-18 UNF 3B	1.12	1.25	1.25	0.03	⅝-18 UNF 3B	0.88
3144-P-10K	10,000	4.12	1.29	0.13	2.50	⅝-18 UNF 3B	1.12	1.25	1.25	0.03	⅝-18 UNF 3B	0.88
3145-P-25K	25,000	6.06	2.34	0.13	3.50	1¼-12 UNF 3B	1.50	1.63	1.25	0.03	1¼-12 UNF 3B	1.50
3145-P-50K	50,000	6.06	2.58	0.13	3.50	1¼-12 UNF 3B	1.50	1.63	2.25	0.03	1¼-12 UNF 3B	1.50
3146-P-100K	100,000	8.00	3.76	0.25	4.50	1¾-12 UNF 3B	2.25	2.25	3.00	0.03	1¾-12 UNF 3B	1.75

MODEL S-BEAM SERIES

MODEL 3137

MODEL 3136

MODEL 3135

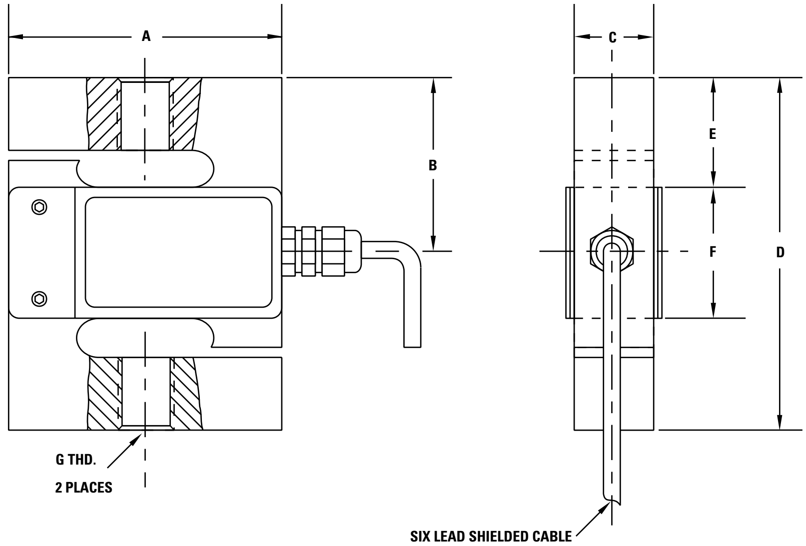
FEATURES:

The S-Beam series is designed for tension and compression weight/force measurement. It features the proven bending beam construction and integral loading threads. These combined features form an extremely rugged, compact axial force transducer. Where good performance and low price are requirements, the S-Beam series is an excellent choice.

PERFORMANCE SPECS:

3135, 3136 AND 3137

SPECIFICATIONS	3135	3136	3137
Rated capacity: *±10% millivolts per volt*	2.0	2.0	2.0
Total error: *of applied load*	±0.05%	±0.05%	±0.075%
Zero return after 30 min.: *of applied load*	±0.05%	±0.05%	±0.065%
Temperature effect: *on output of applied load/°F*	±0.0017%	±0.0017%	±0.0039%
Temperature effect: *on zero of applied load/°F*	±0.004%	±0.006%	±0.0083%
Zero balance: *of rated output*	±5%	±10%	±5%
Temperature range, operating: *°F*	-22 to +158	-22 to +158	-22 to +176
Temperature range, compensated: *°F*	+14 to +122	+14 to +113	+14 to +104
Safe overload: *of rated capacity*	150%	150%	150%
Ultimate overload: *of rated capacity*	300%	300%	300%
Excitation: *recommended volts AC or DC*	10	10	10
Excitation: *maximum volts AC or DC*	15	15	15
Input impedance: *±15 ohms*	415	385	400
Output impedance: *±3 ohms*	350	350	350
Insulation impedance: *megohms*	>1,000	>2,000	>1,000
Deflection: *at rated capacity, inches*	<0.016	<0.016	<0.016
Environmental protection:	IP65	IP66	IP68

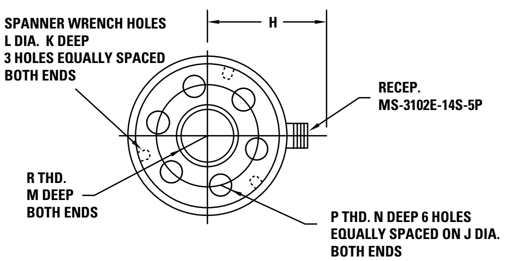


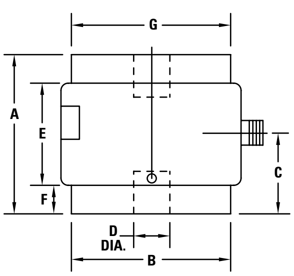
MODEL NUMBER	CAPACITY Kg	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	F (mm)	G THD
3135-50Kg	50	2.44 (62.10)	1.57 (40.00)	0.71 (18.00)	3.15 (80.00)	0.99 (25.10)	1.17 (29.80)	½-20 UNF 3B
3135-100Kg	100	2.44 (62.10)	1.57 (40.00)	0.71 (18.00)	3.15 (80.00)	0.99 (25.10)	1.17 (29.80)	½-20 UNF 3B
3136-150Kg	150	2.44 (62.10)	1.57 (40.00)	0.71 (18.00)	3.15 (80.00)	0.99 (25.10)	1.17 (29.80)	½-20 UNF 3B
3136-200Kg	200	2.44 (62.10)	1.57 (40.00)	0.71 (18.00)	3.15 (80.00)	0.99 (25.10)	1.17 (29.80)	½-20 UNF 3B
3136-300Kg	300	2.44 (62.10)	1.57 (40.00)	0.71 (18.00)	3.15 (80.00)	0.99 (25.10)	1.17 (29.80)	½-20 UNF 3B
3136-500Kg	500	2.44 (62.10)	1.57 (40.00)	0.71 (18.00)	3.15 (80.00)	0.99 (25.10)	1.17 (29.80)	½-20 UNF 3B
3136-750Kg	750	2.44 (62.10)	1.57 (40.00)	0.71 (18.00)	3.15 (80.00)	0.99 (25.10)	1.17 (29.80)	½-20 UNF 3B
3136-1,000Kg	1,000	2.44 (62.10)	1.57 (40.00)	0.71 (18.00)	3.15 (80.00)	0.99 (25.10)	1.17 (29.80)	½-20 UNF 3B
3137-2,000Kg	2,000	2.76 (70.00)	1.77 (45.00)	1.26 (32.00)	3.54 (90.00)	n/a	n/a	⅝-18 UNF 3B
3137-5,000Kg	5,000	3.94 (100.00)	2.36 (60.00)	1.77 (45.00)	4.72 (120.00)	n/a	n/a	1-12 UNF 3B

MODEL 3156

Tension and compression 25,000 lbs. to 150,000 lbs.

3156 (English)—Capacities available 25K to 150K lbs.
3156-133 (Metric)—Capacities available 100K to 750K Newtons
Optional dual bridge not shown





	3156 IN.	3156-133 CM.
A	7	17.78
B	5.50	13.97
C	3.50	8.89
D	2.13	5.41
E	4.75	12.07
F	1.13	2.87
G	5.45	13.84
H	3.59	9.12
J	3.50	8.89
K	0.31	0.79
L	0.38	0.95
M	2	5.08
N	1.25	3.18
P	¾-10	M20 x 2.5
R	2-12	M52 x 2

FEATURES:

- Resists fatigue failure
- Minimized bending strains
- Dual bridges available on all models
- Standard of the industry
- Special structure design
- High resistance to side loads and bending moments

Lebow® fatigue-resistant load cells are the result of many years of design development. You will note from the specifications that these load cells are extremely resistant to extraneous bending and side loading forces. The structure virtually eliminates bending strains at the strain gage, minimizing the primary cause of load cell failure.

PERFORMANCE SPECS: 3156

SPECIFICATIONS

Output at rated capacity: *millivolts per volt, nominal*	±2
Nonlinearity: *of rated output*	±0.2%
Hysteresis: *of rated output*	±0.2%
Repeatability: *of rated output*	±0.05%
Zero balance: *of rated output*	±1.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: °F	+70 to +170
Temperature range, compensated: °C	+21 to +77
Temperature range, usable: °F	-65 to +200
Temperature range, usable: °C	-54 to +93
Temperature effect on output: *of reading per °F*	±0.003%
Temperature effect on output: *of reading per °C*	±0.0054%
Temperature effect on zero: *of rated output per °F*	±0.003%
Temperature effect on zero: *of rated output per °C*	±0.0054%
Excitation voltage, maximum: *volts DC or AC rms*	30
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Number of bridges:	1 or 2
Fatigue life: *0 to full fatigue load (cycles x 10^6)*	100
Fatigue life: *full fatigue tension to full fatigue compression (cycles x 10^6)*	50

Note: Calibration results are based on applied load being carried by center thread. Consult factory for alternative loading methods.

SENSOR CHARACTERISTICS: 3156

MODEL NUMBER	NOMINAL LOAD LIMIT CAPACITY F_Z LBS.	NOMINAL LOAD LIMIT CAPACITY F_Z NEWTONS	STATIC OVERLOAD CAPACITY % OF NOM. CAPACITY	FATIGUE CAPACITY % OF NOM. CAPACITY	STATIC EXTRANEOUS LOAD LIMITS: SHEAR F_X OR F_Y LBS.	STATIC EXTRANEOUS LOAD LIMITS: BENDING Mx OR M_Y LB. INCHES	STATIC EXTRANEOUS LOAD LIMITS: TORQUE Mz LB. INCHES	DEFLECTION AT NOM. LOAD LIMIT INCHES	RINGING FREQUENCY H_Z
3156	25K	100K	150	100	2K	68K	10K	0.003	2,100
	50K	200K	150	100	6K	130K	20K	0.003	3,000
	100K	500K	150	100	10K	220K	85K	0.003	4,200
	150K	750K	150	100	20K	220K	85K	0.003	4,800

FEATURES:

- Resists fatigue failure
- Low failure rate
- Special structure designs
- Capacities to 2,000,000 lbs.
- Bending moment resistance up to 7,500,000 lb. inches
- Up to 450,000 lbs. of shear resistance

Lebow® fatigue-resistant load cells are the result of many years of design development. You will note from the specifications that these load cells are extremely resistant to extraneous bending and side loading forces. The structure virtually eliminates bending strains at the strain gage, minimizing the primary cause of load cell failure.

PERFORMANCE SPECS:

3127, 3129 AND 3130

SPECIFICATIONS	3127	3129	3130
Output at rated capacity: *millivolts per volt, nominal*	±2	±2	±2
Nonlinearity: *of rated output*	±0.2%	±0.2%	±0.2%
Hysteresis: *of rated output*	±0.2%	±0.2%	±0.2%
Repeatability: *of rated output*	±0.05%	±0.05%	±0.05%
Zero balance: *of rated output*	±1.0%	±1.0%	±1.0%
Bridge resistance: *ohms nominal*	700	350	700
Temperature range, compensated: °F	+70 to +170	+70 to +170	+70 to +170
Temperature range, compensated: °C	+21 to +77	+21 to +77	+21 to +77
Temperature range, usable: °F	-65 to +200	-65 to +200	-65 to +200
Temperature range, usable: °C	-54 to +93	-54 to +93	-54 to +93
Temperature effect on output: *of reading per °F*	±0.003%	±0.003%	±0.003%
Temperature effect on output: *of reading per °C*	±0.0054%	±0.0054%	±0.0054%
Temperature effect on zero: *of rated output per °F*	±0.003%	±0.003%	±0.003%
Temperature effect on zero: *of rated output per °C*	±0.0054%	±0.0054%	±0.0054%
Excitation voltage, maximum: *volts DC or AC rms*	20	20	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000	>5,000	>5,000
Number of bridges:	1 or 2	1 or 2	1 or 2
Fatigue life: *0 to full fatigue load (cycles x 10^6)*	100	100	100
Fatigue life: *full fatigue tension to full fatigue compression (cycles x 10^6)*	50	50	50

Note: Calibration results are based on applied load being carried by center thread. Consult factory for alternative loading methods.

MODEL 3129

3129-112 (English)—Capacities available 150K, 200K and 300K lbs.

3129-121 (Metric)—Capacities available 750K, 1M and 1.5M Newtons

MODEL 3130

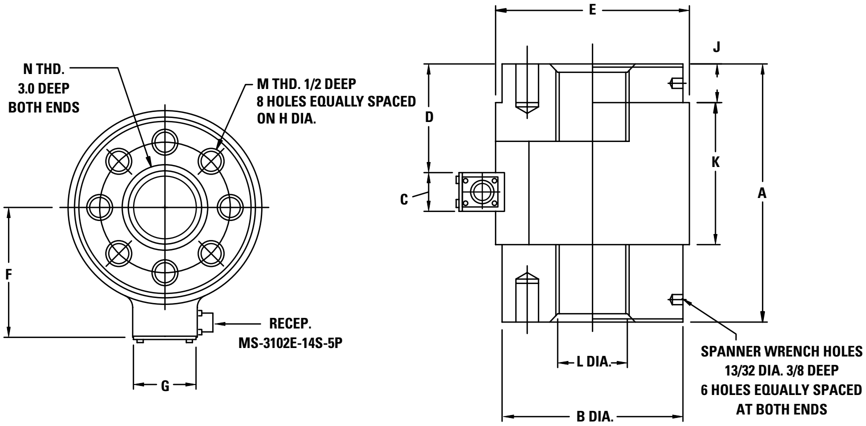
3130 (English)—Capacities available 500K, 800K and 1,000K lbs.

3130-131 (Metric)—Capacities available 2M, 3.5M and 5M Newtons
Optional dual bridge not shown

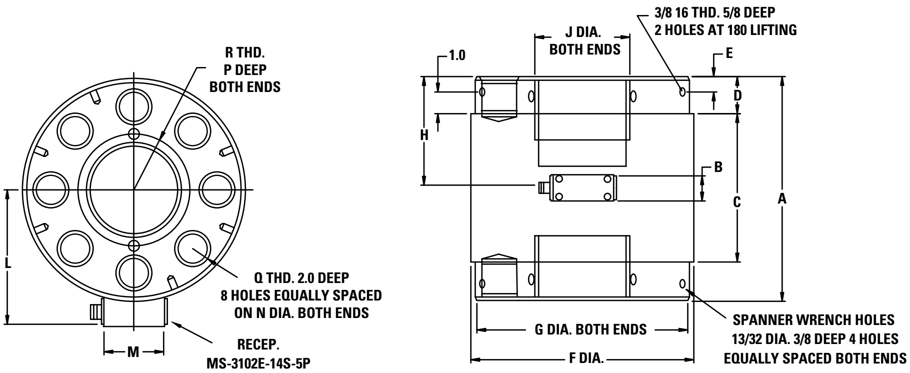
MODEL 3127

3127 (English)—Capacities available 2,000K lbs.

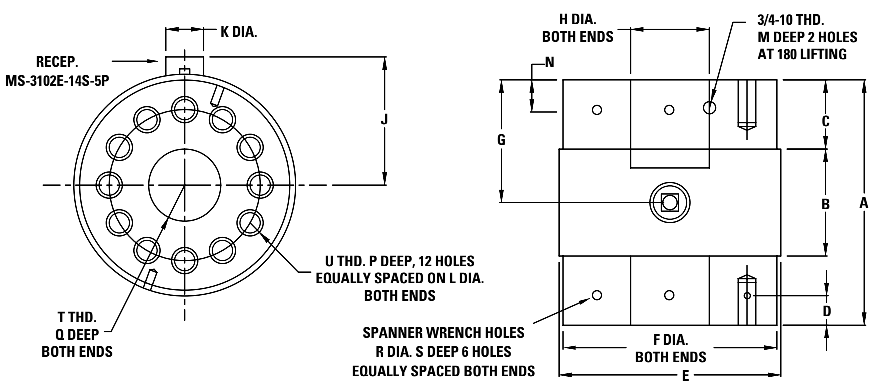
3127-118 (Metric)—Capacities available 10M Newtons
Optional dual bridge not shown



	3129-112 IN.	3129-121 CM.
A	10	25.4
B	7	17.78
C	1.50	3.81
D	4.25	10.80
E	7.50	19.05
F	5	12.70
G	2.50	6.35
H	5	12.70
J	1.50	3.81
K	5.50	13.97
L	3.31	8.41
M	1-8	M27-2
N	3-12	M76-2



	3130 IN.	3130-131 CM.
A	12.50	31.75
B	1.50	3.81
C	7	17.78
D	2	5.08
E	0.75	1.91
F	12.75	32.29
G	12.25	31.12
H	6.25	15.88
J	5.25	13.34
K	1	2.54
L	7.82	19.86
M	2.50	6.35
N	9.50	24.15
P	3.50	8.89
Q	1.75-12	M42-3
R	5-8	M125-4



	3127 IN.	3127-118 CM.
A	22.50	57.15
B	8	20.32
C	6.50	16.51
D	2.50	6.35
E	17.63	44.78
F	17	43.18
G	11.25	28.58
H	6.50	16.51
J	9.75	24.77
K	3	7.62
L	12	30.48
M	1.50	3.81
N	2.50	6.35
P	3.50	8.89
Q	8.25	20.96
R	0.41	1.03
S	0.50	1.27
T	6-8	M150-4
U	1.75-12	M42-3

SENSOR CHARACTERISTICS: 3129, 3130 AND 3127

MODEL NUMBER	NOMINAL LOAD LIMIT CAPACITY F_Z LBS.	NEWTONS	STATIC OVERLOAD CAPACITY % OF NOM. CAPACITY	FATIGUE CAPACITY % OF NOM. CAPACITY	STATIC EXTRANEOUS LOAD LIMITS SHEAR F_X OR F_Y LBS.	BENDING Mx OR M_Y LB. INCHES	TORQUE Mz LB. INCHES	DEFLECTION AT NOM. LOAD LIMIT INCHES	RINGING FREQUENCY H_Z
3129-112	150K	750K	150	75	40K	625K	150K	0.004	3,000
	200K	1M	150	75	55K	730K	260K	0.004	3,400
	300K	1.5M	150	75	65K	840K	236K	0.004	4,100
3130*	500K	2M	150	50	94K	4,530K	820K	0.006	2,500
	800K	3.5M	150	50	180K	5,450K	1,050K	0.006	3,100
	1,000K	5M	150	50	180K	6,110K	1,100K	0.006	3,600
3127*	2,000K	10M	100	50	450K	7,500K	1,500K	0.007	1,900

***Please note: Models 3130 and 3127 can be calibrated to 500,000 lbs. compression only. Consult factory for alternative calibrations.**

MODEL 3415

Tension and compression 5,000 lbs. to 20,000 lbs.

FEATURES:

The Model 3415 load cells provide a compact package that more easily integrates into test machines using hydraulic actuators for cyclical load applications such as those involved with vehicle dynamic simulation testing. Mounting threads are designed to attach directly to the actuator. The package size is optimally minimized to the smallest, most lightweight device with the longest possible life capable of measuring the forces inherent in vehicle test applications. These load cells are designed to measure loads in both tensile and compressive modes.

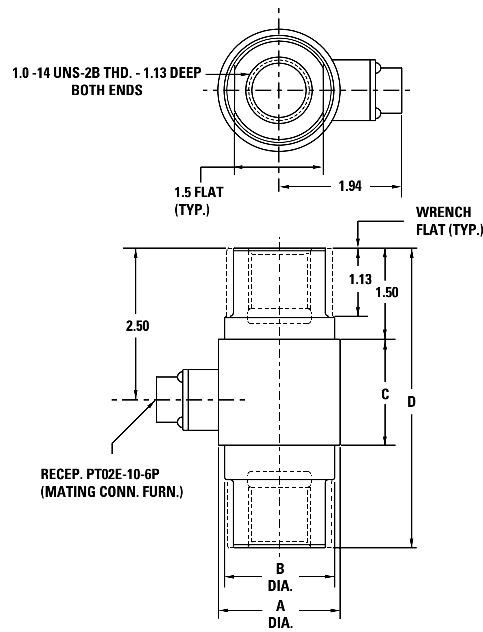
These sensors are machined from a single billet of high-strength steel. These quality sensors are specially designed to deliver an overall accuracy of ±0.15% when considering nonlinearity, hysteresis and repeatability. Standard load capacities are available in a range from 5,000 to 20,000 pounds. The sensors have a nominal bridge resistance of 350 ohms and can be powered by up to 20 volts DC. Nominal output sensitivity is 2 millivolts per volt. Sensors are protected for overloads up to 150% of rated capacity with no damage to the sensor. The sensor designs provide high resistance to side and bending moment loads and are rated to provide over 100 million load cycles in unidirectional loading applications.

PERFORMANCE SPECS:

3415

SPECIFICATIONS

Output at rated capacity: *millivolts per volt, nominal*	±2.0
Nonlinearity: *of rated output*	±0.10%
Hysteresis: *of rated output*	±0.10%
Repeatability: *of rated output*	±0.05%
Zero balance: *of rated output*	±1.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: *°F*	+70 to +170
Temperature range, usable: *°F*	-65 to +200
Temperature effect on output: *of reading per °F*	±0.01%
Temperature effect on zero: *of rated output per °F*	±0.005%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Static overload capacity: *of full scale*	150%



MODEL NUMBER	A	B	C	D
3415-107-5K	2.00	1.81	1.75	4.94
3415-107-10K	2.00	1.81	1.75	4.94
3415-108-20K	2.38	2.13	2.00	5.19

MODEL 3173

Tension and compression 200 lbs. to 3,000 lbs.

3173 WITH TENSION BASE

Consult factory for specials.

FEATURES:

- High accuracy
- Low deflection
- Proven fatigue resistant design and performance
- Low full-scale capacity
- Low profile
- Minimal sensitivity to extraneous loading

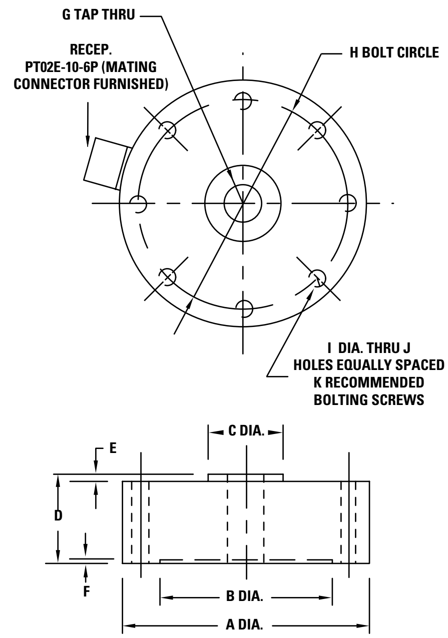
The Model 3173 is the newest member of a low profile tension and compression family of load cells. The Model 3173 covers the lower capacity ranges of 200 pounds force to 3,000 pounds force, while exhibiting the superior characteristics of stiffness and low profile. These load cells are well suited to materials testing machines and other applications requiring a rugged load sensor.

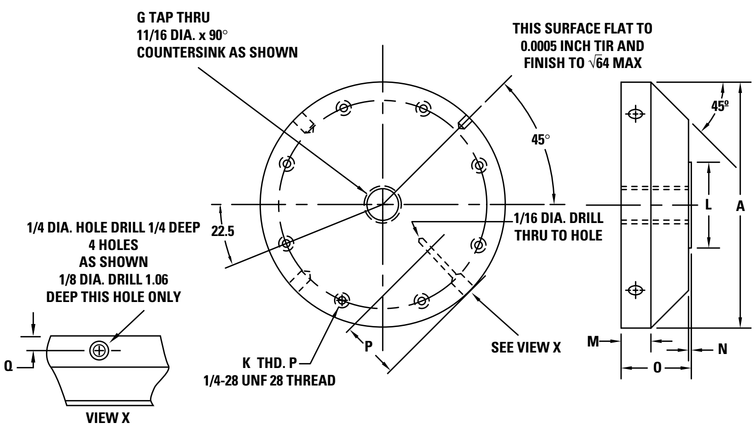
PERFORMANCE SPECS:

3173

SPECIFICATIONS	
Capacity: *lbs.*	200, 500, 1K, 2K, 3K
Output: *millivolts per volt, nominal*	1.50
Output: *millivolts per volt, nominal (2K and 3K units)*	2.00
Overload: *at rated capacity*	150%
Nonlinearity best fit: *of rated output*	≤ ±0.05%
Creep: *in 20 minutes of rated output*	≤ ±0.025%
Hysteresis: *of rated output*	≤ ±0.05%
Repeatability: *of rated output*	±0.02%
Input resistance: *nominal, ohms*	700
Output resistance: *nominal, ohms*	700
Excitation voltage: *maximum*	20V
Temperature range, compensated: *°F*	+70 to +170
Temperature range, usable: *°F*	-65 to +200
Temperature effect on output: *of reading per °F*	≤ 0.002%
Temperature effect on zero: *of rated output per °F*	≤ 0.002%
Fatigue life: *0 to full fatigue load (cycles x* 10^6*)*	≥ 100
Fatigue life: *full fatigue tension to full fatigue comp. (cycles x* 10^6*)*	≥ 50
Deflection: *at rated capacity (200-1K)*	.003 inch
Deflection: *at rated capacity (2K-3K)*	.001 inch

MODEL NUMBER	CAPACITY lbs. (N)	DIMENSIONS A in. (cm.)	B in. (cm.)	C in. (cm.)	D in. (cm.)	E in. (cm.)	F in. (cm.)	G English (Metric)	H in. (cm.)	I in. (cm.)	NO. OF HOLES J	BOLTING SCREWS K	DIMENSIONS L in. (cm.)	M in. (cm.)	N in. (cm.)	O in. (cm.)	P in. (cm.)	Q in. (cm.)
3173	200-3K	4.12	2.85	1.27	1.37	0.12	0.06	⅝-18 UNF-3B	3.50	0.28	8	¼-28 hexhead	1.25	0.50	0.03	1.13	0.87	0.25
3173-101	(900-13.5K)	(10.47)	(7.24)	(3.23)	(3.48)	(0.31)	(0.15)	(M16 x 15mm-6H)	(8.89)	(0.71)	8	1½ inches long Tighten to 200 in. lbs.	(3.18)	(1.27)	(0.08)	(2.87)	(2.21)	(0.64)





Tension bases are recommended for all model 3173 applications. When mounting without the tension base, attention must be given to the mating surface with regard to flatness, hardness and stiffness.

SENSOR CHARACTERISTICS: 3173

MODEL NUMBER	NOMINAL LOAD LIMIT CAPACITY F_Z LBS.	NEWTONS	STATIC OVERLOAD CAPACITY % OF NOM. CAPACITY	FATIGUE CAPACITY % OF NOM. CAPACITY	STATIC EXTRANEOUS LOAD LIMITS SHEAR F_X OR F_Y LBS.	BENDING Mx OR M_Y LB. INCHES	TORQUE Mz LB. INCHES	DEFLECTION AT NOM. LOAD LIMIT INCHES	RINGING FREQUENCY H_Z
3173	200	1K	150	100	4,471	185	3,477	0.003	1,500
	500	2K	150	100	15,625	466	5,208	0.003	2,440
	1K	5K	150	100	15,500	911	7,750	0.003	3,900
	2K	10K	150	100	4,000	2,133	1,523	0.001	5,500
	3K	15K	150	100	5,166	2,818	2,214	0.001	7,200

MODELS 3174, 3175 AND 3176

Tension and compression 5,000 lbs. to 150,000 lbs.

3174 WITH TENSION BASE

Consult factory for specials.

FEATURES:

- High accuracy
- Low deflection
- Proven fatigue-resistant design and performance
- Tension and compression
- Low sensitivity to extraneous loads
- Low profile

Models 3174, 3175 and 3176 are fatigue-resistant, low-profile tension and compression load cells that are well suited to materials testing machines and other applications requiring a rugged load sensor, with the superior characteristics of stiffness and low profile.

Models 3174, 3175 and 3176 are additions to the well-known Lebow® line of fatigue rated load cells which have been proven by more than 20 years' use in demanding applications.

Lebow® fatigue-resistant load cells are the result of many years of design development. You will note from the specifications that these load cells are extremely resistant to extraneous bending and side loading forces. The structure virtually eliminates bending strains at the strain gage, minimizing the primary cause of load cell failures.

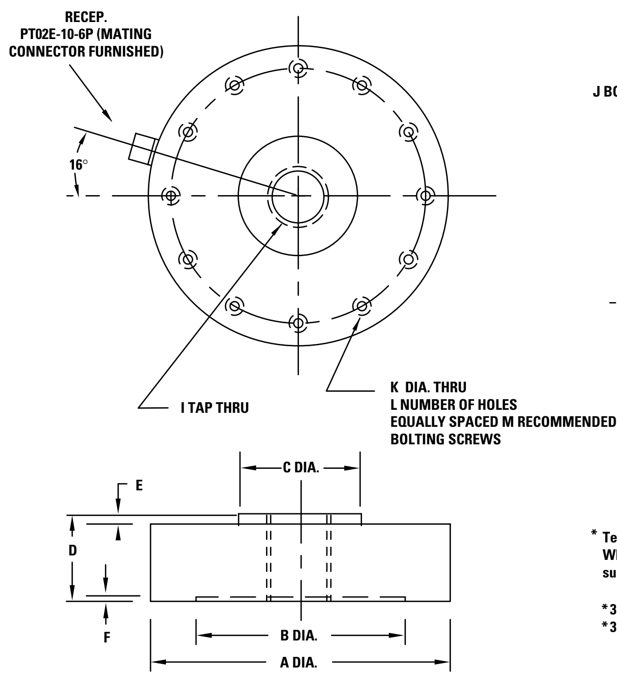
PERFORMANCE SPECS:

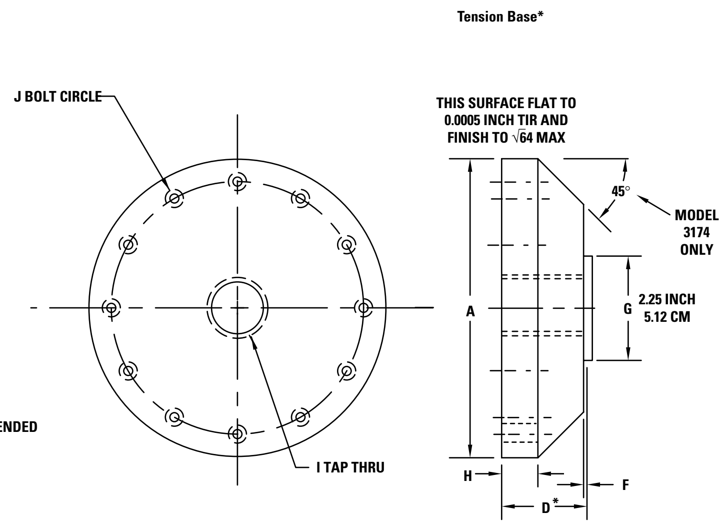
3174, 3175 AND 3176

SPECIFICATIONS	
Output at rated capacity: *millivolts per volt, nominal*	±2
Nonlinearity: *of rated output*	±0.05%*
Hysteresis: *of rated output*	±0.05%**
Repeatability: *of rated output*	±0.02%
Zero balance: *of rated output*	±1.0%
Creep: *in 20 minutes of rated output*	<±0.025%
Bridge resistance: *ohms nominal*	700
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-65 to +200
Temperature range, usable: *°C*	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5000
Number of bridges:	1
Fatigue life: *0 to full fatigue load (cycles x 10^6)*	100
Fatigue life: *full fatigue tension to full fatigue comp. (cycles x 10^6)*	50

*Model 3175 and 3176 Nonlinearity: of rated output is ±0.10%
**Model 3175 and 3176 Hysteresis: of rated output is ±0.10%
Higher capacity models available; consult factory.

MODEL NUMBER	CAPACITY lbs. (N)	A in. (cm.)	B in. (cm.)	C in. (cm.)	DIMENSIONS D in. (cm.)	E in. (cm.)	F in. (cm.)	G in. (cm.)	H in. (cm.)	TAP THRU I ENGLISH (METRIC)	J in. (cm.)	K in. (cm.)	NO. OF HOLES L	BOLTING M ENGLISH (METRIC)
3174	5K-20K (20K-100K)	6.06 (15.39)	4.33 (10.99)	2.42 (6.35)	1.75 (4.45)	0.12 (0.31)	0.05 (0.13)	2.25 (5.72)	0.81 (2.06)	1¼-12 UNF-3B (M30 x 2mm-6H)	5.13 (13.02)	13/32 (10.3)	12 12	⅜-24 hex head, 2¼ inches long. Tighten to 750 in. lbs. (M10 x 1.5mm hex head, 65mm long. Tighten to 90N•m)
3175	50K (200K)	8.00 (20.32)	5.18 (13.15)	3.14 (7.98)	2.50 (6.35)	0.12 (0.30)	0.03 (0.08)	3.14 (7.98)	- -	1¾-12 UN-3B (M48 x 2mm-6H)	6.50 (16.51)	17/32 (13.50)	16 16	½-20 hex head, 3⅜ inches long. Tighten to 120 ft. lbs. Grade 8 bolts
3176	100K (500K)	11.00 (27.94)	7.09 (18.02)	4.92 (12.50)	3.50 (8.89)	0.12 (0.30)	0.03 (0.08)	4.92 (12.50)	- -	2¾-8 UN-3B (M72 x 3mm-8H)	9.00	21/32 (16.70)	16 16	⅝-18 hex head, 4⅝ inches long. Tighten to 290 ft. lbs. Grade 8 bolts





* Tension bases are recommended for all model 3174, 3175 and 3176 applications. When mounting without the tension base, attention must be given to the mating surface with regard to flatness, hardness and stiffness.

*3175 base height 2.00 inches
*3176 base height 3.00 inches

SENSOR CHARACTERISTICS: 3174, 3175 AND 3176

MODEL NUMBER	NOMINAL LOAD LIMIT CAPACITY F_Z LBS.	NEWTONS	STATIC OVERLOAD CAPACITY % OF NOM. CAPACITY	FATIGUE CAPACITY % OF NOM. CAPACITY	STATIC EXTRANEOUS LOAD LIMITS: SHEAR F_X OR F_Y LBS.	BENDING Mx OR M_Y LB. INCHES	TORQUE Mz LB. INCHES	DEFLECTION AT NOM. LOAD LIMIT INCHES	RINGING FREQUENCY H_Z
3174	5K	20K	150	100	11K	9K	12K	0.001	6,500
	10K	50K	150	100	25K	27K	24K	0.001	7,200
	20K	100K	150	100	55K	58K	35K	0.001	8,600
3175	50K	200K	150	100	32K	33K	67K	0.001	12,000
3176	100K	500K	150	100	78K	147K	196K	0.001	15,000

Higher capacities available; consult factory.

MODEL 3691

Capacities available 1K to 10K lbs.

MODEL 3674

Capacities available 5K to 50K lbs.

MODEL 3603 AND 3644

Model 3603—Capacities available 100K to 500K lbs.
Model 3644—Capacity available 1,000K lbs.

FEATURES:

- Inexpensive
- Built-in load button
- Compact size
- Minimum deflection

The compression only load cells were developed by our engineers to deliver a high degree of performance at low cost and low deflection.

These designs handle a full range of compression loads including press calibration, weighing tube mills, extruding processes and rolling and reduction mills.

Consult factory for alternative compression button style load cells.

PERFORMANCE SPECS:

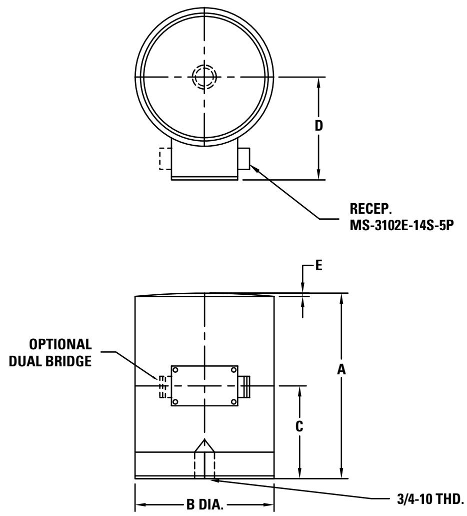
3603, 3644, 3674 AND 3691

SPECIFICATIONS	3603 & 3644	3674	3691
Output at rated capacity: *millivolts per volt, nominal*	2	2	1.8
Nonlinearity: *of rated output*	±0.15%	±0.15%	±1.0%
Hysteresis: *of rated output*	±0.15%	±0.10%	±1.0%
Repeatability: *of rated output*	±0.05%	±0.03%	±0.5%
Zero balance: *of rated output*	±2.0%	±2.0%	±0.5%
Bridge resistance: *ohms nominal*	350	350	350
Temperature range, compensated: °F	+70 to +170	+70 to +170	+70 to +170
Temperature range, compensated: °C	+21 to +77	+21 to +77	+21 to +77
Temperature range, usable: °F	-65 to +200	-65 to +200	-65 to +200
Temperature range, usable: °C	-54 to +93	-54 to +93	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%	±0.002%	±0.005%
Temperature effect on output: *of reading per °C*	±0.0036%	±0.0036%	±0.009%
Temperature effect on zero: *of rated output per °F*	±0.002%	±0.002%	±0.005%
Temperature effect on zero: *of rated output per °C*	±0.0036%	±0.0036%	±0.009%
Excitation voltage, maximum: *volts DC or AC rms*	20	20	15
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000	>5,000	>5,000
Number of bridges:	1 or 2	1 or 2	1

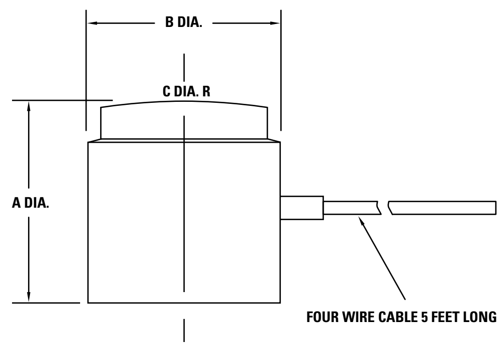
Consult factory for Model 3630 (1K-10K lbs. capacities) button cells.

3603	IN.	CM.
A	7	17.78
B	5.25	13.34
C	3.50	8.89
D	3.88	9.86
E	0.13	0.33

3644	IN.	CM.
A	11	27.94
B	7.50	19.05
C	5.50	13.97
D	5.12	13
E	0.13	0.33

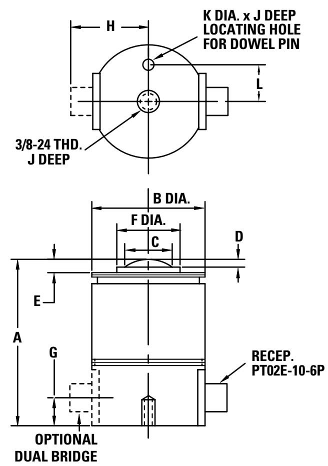


MODEL 3691



(See chart below)

3674	IN.	CM.
A	3.50	8.89
B	2.38	6.05
C	1	2.54
D	0.13	0.33
E	0.11	0.28
F	1.33	3.38
G	0.58	1.47
H	1.61	4.09
J	0.50	1.27
K	0.25	0.64
L	0.75	1.91



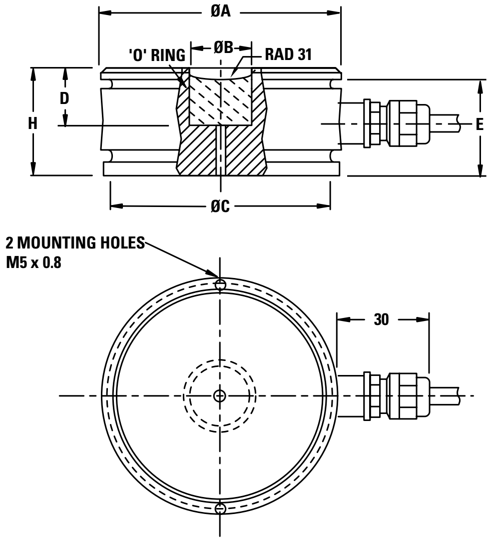
SENSOR CHARACTERISTICS: 3603, 3644, 3674 AND 3691

MODEL NUMBER	NOMINAL LOAD LIMIT CAPACITY F_z LBS.	NOMINAL LOAD LIMIT CAPACITY F_z NEWTONS	STATIC OVERLOAD CAPACITY % OF NOM. CAPACITY	DEFLECTION AT NOM. LOAD LIMIT INCHES	RINGING FREQUENCY H_z	A	B	C RADIUS
3691-1K	1K	5K	120	0.003	16,000	0.63	0.60	1.65
3691-2K	2K	10K	120	0.003	16,000	0.63	0.60	1.65
3691-5K	5K	20K	120	0.003	16,000	0.88	0.88	1.65
3691-7.5K	7.5K	35K	120	0.003	16,000	0.88	0.88	1.65
3691-10K	10K	50K	120	0.003	16,000	0.88	0.88	1.65
3674	5K	20K	150	0.003	5,000			
	10K	50K	150	0.003	7,000			
	20K	100K	150	0.003	9,000			
	50K	200K	150	0.003	11,000			
3603	100K	500K	150	0.008	3,800			
	200K	1M	150	0.008	5,800			
	300K	1.5M	150	0.008	6,000			
	500K	2M	150	0.008	7,000			
3644	1,000K	5M	150	0.011	10,000			

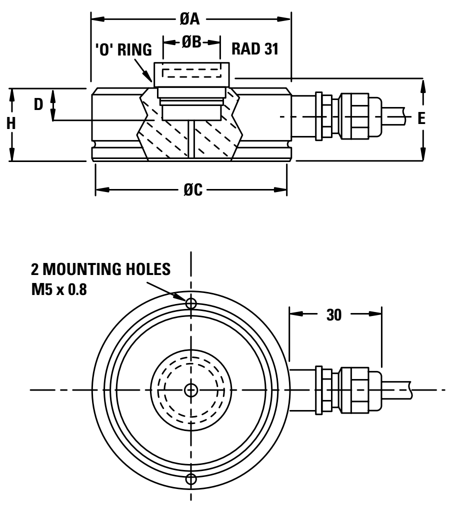
MODELS 3310

High accuracy compression load cells

20K & 30 K



5K & 10 K



CAPACITY	ØA	ØB	ØC	D	E	H
5,000	80	19	70	20	33.4	30
10,000	92	28	80	14.6	33.4	33
20,000	110	29	101.5	26.3	39	50
30,000	110	29	101.5	26.3	39	50

FEATURES:

- Capacities: 5,000, 10,000, 20,000 and 30,000 Kg
- Stainless steel construction
- Small size, low profile
- Current matched and rationalized
- Fully welded, providing IP68 protection

Model 3310 is a low-profile bending ring load cell designed for high-capacity weighing applications, including weigh-bridges, tanks, silos and high-capacity platform scales as well as force measurement.

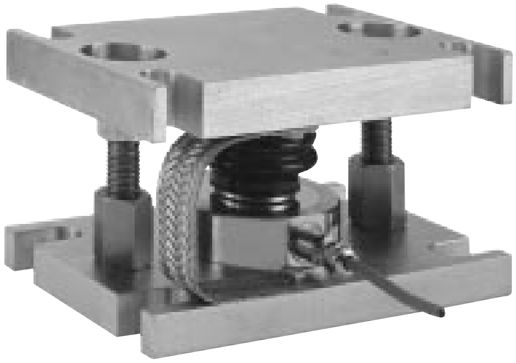
Its small physical size, combined with high accuracy and low cost, makes this load cell ideally suited for modern, low-profile designs in both approved applications and process weighing.

PERFORMANCE SPECS:

3310

SPECIFICATIONS	STANDARD
Rated capacity: *Kg*	5,000, 10,000, 20,000, 30,000
Rated output: *mV/V*	2.0 ± 10%
Total error: *of applied load*	0.050%
Zero return after 30 mins: *of applied load*	± 0.050%
Zero balance: *of rated output*	± 3.0%
Temperature effect on output: *of rated output/C°*	± 0.0040%
Temperature effect on zero: *of rated output/C°*	± 0.0028%
Temperature range, operating: °C	-30 to +70
Temperature range, compensated: °C	-10 to +40
Safe overload: *of rated capacity*	150%
Ultimate overload: *of rated capacity*	300%
Input impedance: *ohms*	1065 ±50
Output impedance: *ohms, nominal*	1,000
Insulation impedance: *megaohms*	>2000
Deflection at rated capacity: *mm*	<0.5
Weight: *Kg* *(including cable)*	1.10 (5K), 1.50 (10K) 3.25 (20K & 30K)
Construction:	Stainless steel
Environmental protection:	IP68

MODEL 3310 ACCESSORIES

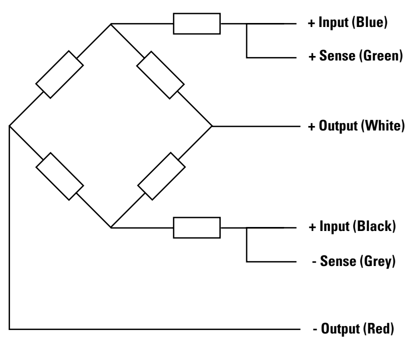


Silo Mount

Rocker Pin Mount

Summing junction boxes available; see page 99.

Wiring Schematic Diagram



MODEL 3270

Tension and compression 100 lbs. to 200,000 lbs.

Models 3272, 3273 and 3274
Capacities 100 lbs. to 20,000 lbs.

Models 3275, 3276 and 3277
Capacities 50,000 lbs. to 200,000 lbs.

Consult factory for specials.

FEATURES:

- 100 lbs. through 200,000 lbs. standard capacities
- Universal tension and compression loading
- Hermetically sealed, glass to metal military style connector IP67 rating
- Heat treated 17-4PH stainless steel
- 10^7 cycles extended life design, .001" to .003" FS deflection
- Compact package sizes
- 200% FS safe overload capability
- Superior resistance to extraneous loading
- Standardized output of 2mV/V +/-0.25% minimizes test setup
- Built-in wrench flat design provides easy installation
- Available in single, (optional) dual, or (optional) triple bridge configurations
- Metric sizes, special capacities and custom configurations available

The Model 3270 load cell series has been designed to work in harsh environments. These tension/compression load cells are made from 17-4PH stainless steel and are hermetically sealed to an IP67 rating.

The Model 3270 family is designed for demanding applications in automotive, aerospace, agricultural, chemical, military, and paper and pulp markets. The family consists of 12 different capacities from 100 lbs. to 200,000 lbs.

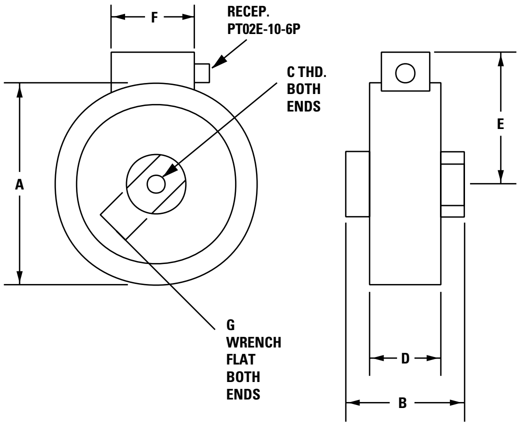
Some of the advantages of these load cells are: small size, high overload capacity, high frequency response, higher stiffness and extended life.

PERFORMANCE SPECS:

3270

SPECIFICATIONS	
Output at rated capacity: *millivolts per volt*	2 ±0.25%*
Maximum nonlinearity error: *of full scale output*	±0.10%
Maximum hysteresis error: *of full scale output*	±0.10%
Maximum non-repeatability: *of rated output*	±0.05%
Zero balance: *of rated output*	±1.00%
Bridge resistance: *ohms*	350 and 700**
Excitation voltage, maximum: *volts DC or AC rms*	20
Temperature range, operating: *°F*	-65 to +250
Temperature range, compensated: *°F*	0 to +150
Maximum temperature effect on output: *of reading per °F*	±0.002%
Maximum temperature effect on zero: *of rated output per °F*	±0.002%
Static overload capacity: *of rated capacity*	200%

*Model 3272-100 output 1.5mV/V ±0.25%.
**Models 3272 and 3273 are 350 ohms; models 3274, 3275, 3276 and 3277 are 700 ohms.



MODEL NUMBER	CAPACITY LBS.	DIMENSIONS A	B	C	D	E	F	G
3272	100-200	2.75	1.50	⅜-24	1.10	2.38	1.75	0.63
3273	500-5K	3.50	2.00	½-20	1.45	2.83	1.75	0.88
3274	5K, 10K, 20K	4.50	2.50	1-14	1.56	3.39	1.75	1.50
3275*	50K	6.25	4.25	1½-12	2.97	4.32	1.75	2.13
3276*	100K	7.75	5.00	1¾-12	3.52	4.96	1.75	2.50
3277*	200K	9.75	5.75	2¼-12	3.93	6.11	1.75	3.25

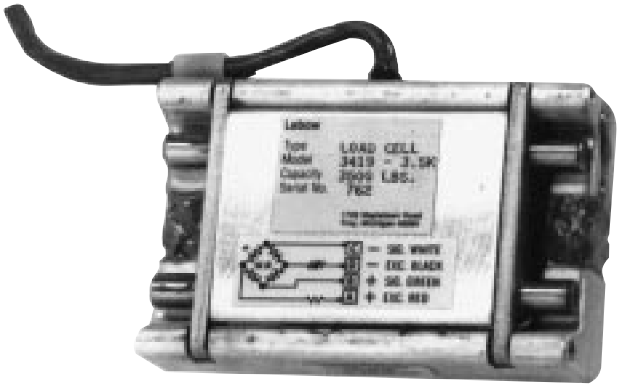
Dimensions are in inches.
***Has external tension base plate.**

SENSOR CHARACTERISTICS: 3270

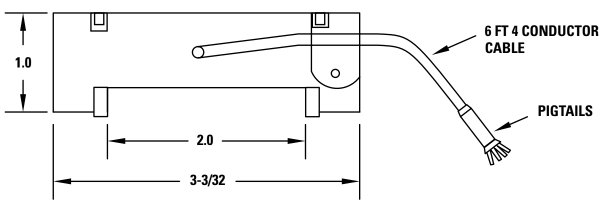
MODEL NUMBER	NOMINAL LOAD LIMIT CAPACITY F_Z		STATIC OVERLOAD CAPACITY % OF NOM. CAPACITY	STATIC EXTRANEOUS LOAD LIMITS			DEFLECTION AT NOM. LOAD LIMIT INCHES	RINGING FREQUENCY H_Z
	LBS.	NEWTONS		SHEAR F_X OR F_Y LBS.	BENDING Mx OR M_Y LB. INCHES	TORQUE Mz LB. INCHES		
3272	100	500	200	1,300	115	725	0.003	1,200
	200	1K	200	1,900	230	1,000	0.003	1,700
3273	500	2K	200	3,200	550	3,200	0.003	1,900
	1K	5K	200	4,500	1,100	4,500	0.003	2,700
	2K	10K	200	8,300	2,200	8,200	0.003	3,900
	5K	20K	200	13,000	2,700	10,900	0.003	6,100
3274	5K	20K	200	7,200	7,400	10,000	0.002	5,100
	10K	50K	200	14,500	14,800	18,400	0.002	7,200
	20K	100K	200	34,600	29,700	39,800	0.002	10,100
3275	50K	200K	200	39,000	39,000	54,000	0.001	11,700
3276	100K	500K	200	78,000	92,000	123,000	0.001	12,200
3277	200K	1M	200	118,000	222,000	296,000	0.001	12,700

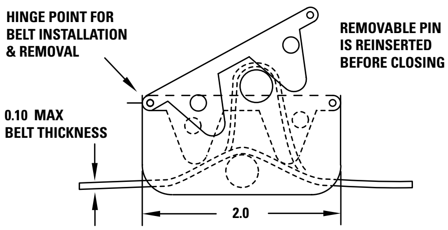
MODEL 3419

Seat belt load cell



Capacity available 3,500 lbs.*
**Please note: calibration will be performed to 2,500 lbs.*





FEATURES:

- Small size
- Installs without "threading"
- Low sensitivity to belt thickness change

The Lebow® seat belt sensor features improved accuracy. Calibration is essentially independent of belt thickness, which may change under load. It's so simple to install. Just remove the pin, lay the belt on the transducer and replace the pin.

It provides excellent repeatability without the need for the extensive belt wrap required on previous models.

PERFORMANCE SPECS:

3419

SPECIFICATIONS	
Output at rated capacity: *millivolts per volt, nominal*	2
Nonlinearity: *of rated output*	±2%
Hysteresis: *of rated output*	±4%
Repeatability: *of rated output*	±1.0%
Zero balance: *of rated output*	±2.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-65 to +200
Temperature range, usable: *°C*	-54 to +93
Temperature effect on output: *of reading per °F*	±0.003%
Temperature effect on output: *of reading per °C*	±0.0054%
Temperature effect on zero: *of rated output per °F*	±0.003%
Temperature effect on zero: *of rated output per °C*	±0.0054%
Overload rating, safe: *of rated capacity*	150%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Belt thickness: *(maximum) inches*	0.10
Belt width: *(maximum) inches*	2.00
Weight: *in ounces*	8
Available capacities: *pounds*	3,500

MODEL 3663

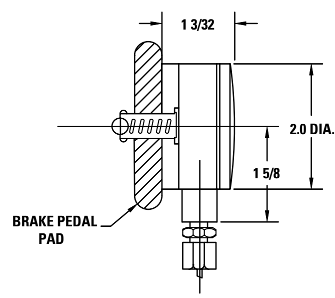
Pedal pressure load cell

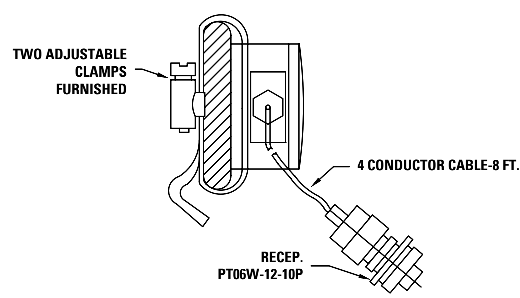
FEATURES:

- Low off center loading error
- Easy mounting
- Rugged load surface

The pedal pressure sensor mounts directly to the brake pedal with its own mounting clamp. Load applied up to 1/2 inch off center, produces less than a 0.5% error. Standard capacity is 300 lbs. This load cell, which is used for brake pedal force measurements by the automotive industry, finds many production applications. It adapts to any of the pedal or bar operated devices used in all production facilities.

English—Capacities available 50, 100, 200 and 300 lbs.
Metric—Capacities available 200, 500, 1K and 1.5K Newtons





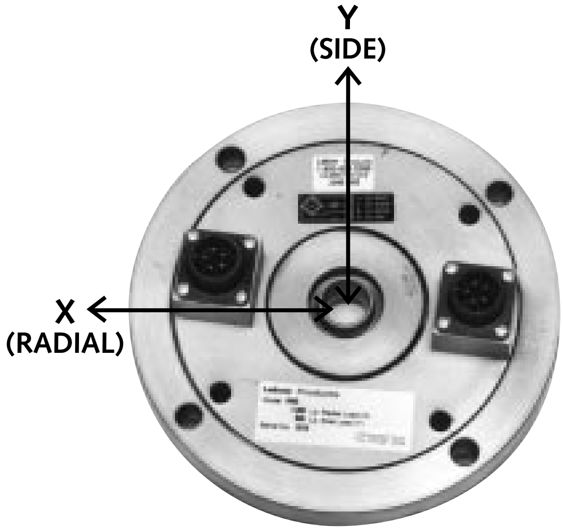
PERFORMANCE SPECS: 3663

SPECIFICATIONS	
Output at rated capacity: *millivolts per volt, nominal*	2
Nonlinearity: *of rated output*	±0.25%
Hysteresis: *of rated output*	±0.1%
Repeatability: *of rated output*	±0.1%
Zero balance: *of rated output*	±2.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-65 to +200
Temperature range, usable: *°C*	-54 to +93
Temperature effect on output: *of reading per °F*	±0.003%
Temperature effect on output: *of reading per °C*	±0.0054%
Temperature effect on zero: *of rated output per °F*	±0.003%
Temperature effect on zero: *of rated output per °C*	±0.0054%
Overload rating, safe: *of rated capacity*	150%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Available capacities: *pounds*	50, 100, 200 and 300

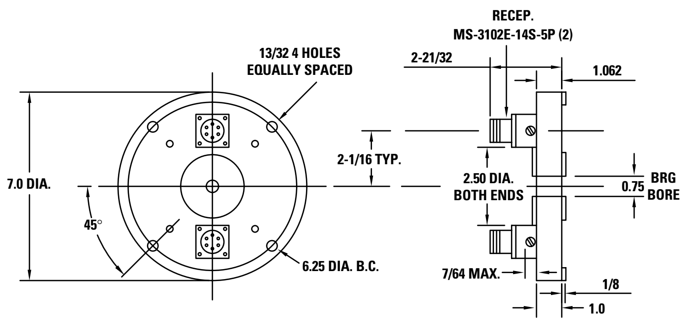
MODEL 3663-111

Contact factory for details.

MODEL X-Y FORCE



Model 6443



STANDARD MODELS AVAILABLE*

MODEL NUMBER	CAPACITY (lbs.) X (RADIAL)	Y (SIDE)	OUTPUT MV/V ±0.25%
6443	1,000	500	2.00
6443-105	2,000	500	2.00
6443-106	1,500	500	2.00

***Consult factory for other capacities, sizes or tri-axis versions.**

FEATURES:

- Measures engine mount force components
- Measures radial two-component bearing force loads
- Measures tire radial and side loads

The Lebow® X-Y force sensor is constructed of two strain gage bridges, mounted at 90°, isolated by a flexure system. The complete two-component system, including flexures, is machined from one specially prepared metal billet to provide unusual structure strength and to minimize crosstalk between the two transducers. This unique sensor has excellent linearity characteristics and maximum structure life.

PERFORMANCE SPECS:

X-Y FORCE

SPECIFICATIONS

Output at rated capacity: *millivolts per volt*	See table
Nonlinearity: *of rated output*	± 0.1%
Hysteresis: *of rated output*	± 0.1%
Repeatability: *of rated output*	± 0.05%
Zero balance: *of rated output*	± 1.0%
Bridge resistance: *ohms nominal*	350
Temperature range, compensated: *°F*	+70 to +170
Temperature range, compensated: *°C*	+21 to +77
Temperature range, usable: *°F*	-65 to +200
Temperature range, usable: *°C*	-54 to +93
Temperature effect on output: *of reading per °F*	± 0.002%
Temperature effect on output: *of reading per °C*	± 0.0036%
Temperature effect on zero: *of rated output per °F*	± 0.002%
Temperature effect on zero: *of rated output per °C*	± 0.0036%
Overload rating, safe: *of rated capacity*	150%
Excitation voltage, maximum: *volts DC or AC rms*	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000
Crosstalk: *of full scale*	≤1%

FEATURES:

- Measures press fit loads on bearings
- Fits in limited or tight spaces
- Measures rolling mill loads
- Measures tie rod loads

The hollow load cells are available for compression only loads in capacities of 25K, 50K and 100K lbs., and for tension-compression loads in capacities of 5K, 10K and 20K lbs.

The precision design and manufacture of this versatile transducer style is the result of our extensive experience in both metal working industry and automotive applications.

PERFORMANCE SPECS:

3336 AND 3632

SPECIFICATIONS	3336	3632
Output at rated capacity: *millivolts per volt, nominal*	±2	2
Nonlinearity: *of rated output*	±0.25%	±0.15%
Hysteresis: *of rated output*	±0.15%	±0.15%
Repeatability: *of rated output*	±0.15%	±0.15%
Zero balance: *of rated output*	±1.0%	±1.0%
Bridge resistance: *ohms nominal*	350* or 700**	480† or 240††
Temperature range, compensated: °F	+70 to +170	+70 to +170
Temperature range, compensated: °C	+21 to +77	+21 to +77
Temperature range, usable: °F	-65 to +200	-65 to +200
Temperature range, usable: °C	-54 to +93	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%	±0.002%
Temperature effect on output: *of reading per °C*	±0.0036%	±0.0036%
Temperature effect on zero: *of rated output per °F*	±0.002%	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000	>5,000
Number of bridges:	1 or 2	1

*5K **10K and 20K †25K and 50K ††100K

Other capacities and configurations available; consult factory.

MODEL 3336

Tension and compression

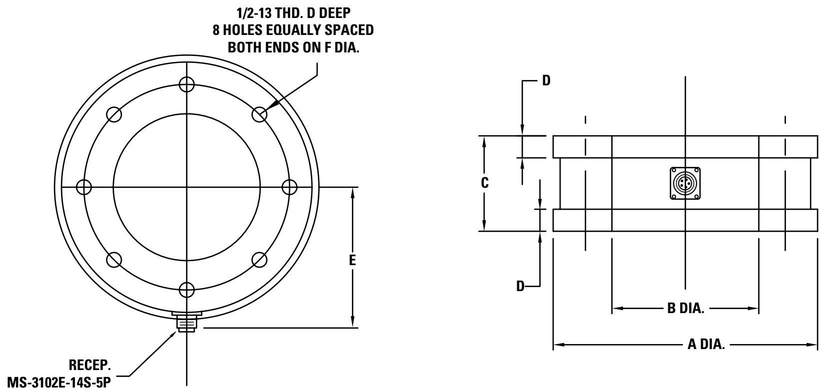
Capacities available 5K, 10K and 20K lbs.

MODEL 3632

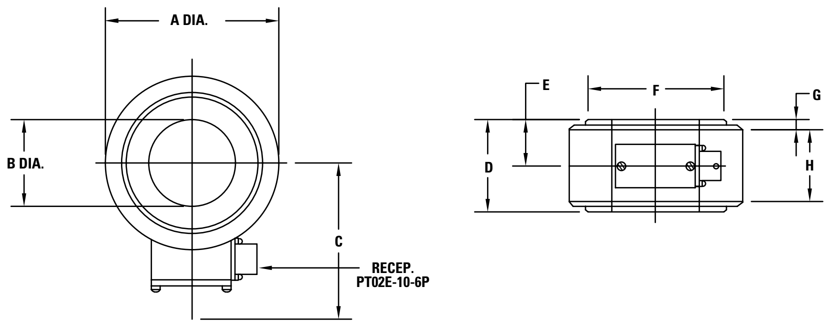
Capacities available 25K, 50K and 100K lbs.

Consult factory for specials.

3336	IN.	CM.
A	9	22.86
B	5	12.70
C	3.25	8.26
D	0.75	1.91
E	4.88	12.40
F	7	17.78



3632	IN.	CM.
A	4	10.16
B	2	5.08
C	3	7.62
D	2	5.08
E	1	2.54
F	3.25	8.26
G	0.06	0.15
H	1.88	4.78



SENSOR CHARACTERISTICS: 3336 AND 3632

MODEL NUMBER	NOMINAL LOAD LIMIT CAPACITY F_Z LBS.	NOMINAL LOAD LIMIT CAPACITY F_Z NEWTONS	STATIC OVERLOAD CAPACITY % OF NOM. CAPACITY	STATIC EXTRANEOUS LOAD LIMITS: SHEAR F_X OR F_Y LBS.	STATIC EXTRANEOUS LOAD LIMITS: BENDING Mx OR M_Y LB. INCHES	STATIC EXTRANEOUS LOAD LIMITS: TORQUE Mz LB. INCHES	DEFLECTION AT NOM. LOAD LIMIT INCHES	RINGING FREQUENCY H_Z
3336	5K	20K	150	550	12K	1,850	0.005	1,100
	10K	50K	150	1,400	31K	3,750	0.005	1,500
	20K	100K	150	2,650	62K	14K	0.005	2,200
3632	25K	125K	150	2,750	18K	3K	0.005	5,000
	50K	200K	150	5,500	36K	13K	0.005	7,000
	100K	500K	150	13K	91K	27K	0.005	10,000

FEATURES:

- Compact
- High output
- Standard models for bolts size no. 6 through 2" and up to 20mm
- Sensor and washers–carpenter 440C stainless steel, hardness R_C 58-60
- Sensitive to neither bolt or nut applied torque

The bolt force sensor is another unique transducer from Lebow® which is essentially a hollow-compression strain gage load cell. It is designed to be used with most strain gage indicators.

The bolt force sensor is a three-piece assembly consisting of:

1. A large hardened and ground flat washer with one side beveled.
2. The sensor
3. A small hardened and ground washer

NOTE: The use of both washers is mandatory. The three pieces are assembled for various applications as illustrated in figure 1. The large washer isolates the sensor from the force application tool. The beveled hole in this washer, which always faces away from the sensor, provides clearance for the bolt head radius. When a torque wrench is used, a torque vs. clamp force curve can be generated.

The 3711 bolt force sensor is designed for use in fastener testing where the compression loading of the sensor is induced by the tensile loading of the fastener. The bolt force sensor must be used with the size fastener for which it was designed.

The flat washers must be used to prevent damage to the sensor. If washers are substituted for those supplied with sensor, it is imperative that the factory be consulted prior to implementation.

Stress applied to the integral cable assembly will result in sensor damage. The installations illustrated are the recommended applications; other methods may result in reduced performance or damage to the sensor.

To implement correlation between calibration data supplied and the data obtained by the users, a calibration setup is described which illustrates a recommended testing method. Figure 2 partially illustrates a compression-tension testing machine setup which applies a compressive load to the bolt sensor. Note that the machine applies a tensile load to a test bolt and the inclusion of the factory-supplied large and small flat washers. The applied load is measured accurately by means of a hollow load cell which is loaded in compression.

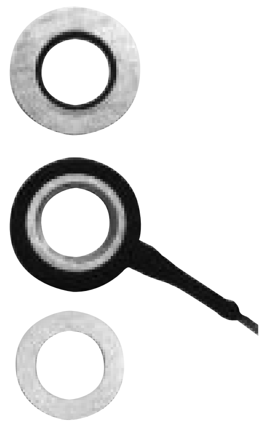
PERFORMANCE SPECS:

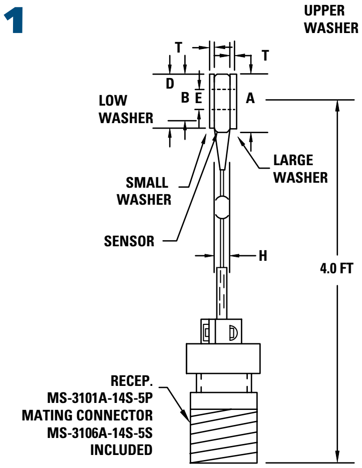
3711

SPECIFICATIONS

Sensor: *millivolts per volt, nominal*	4 arm strain gage bridge
Bridge resistance: *ohms nominal*	120
Bridge voltage: *volts maximum*	6
Output at rated capacity: *millivolts per volt, nominal depending on size*	2 to 5
Temperature range, usable: *°F*	-65 to +200
Effect of temperature on zero: *of full scale per °F*	±0.01%
Effect of temperature on output: *of reading per °F*	±0.02%
Accuracy-Typically: *of full range output*	5%

MODEL 3711





Consult factory for alternative models:
Model 3714—High Capacity
Model 3718—High Temperature
Model 3719—Auto ID/Higher Accuracy

WHEN NUT IS TURNED

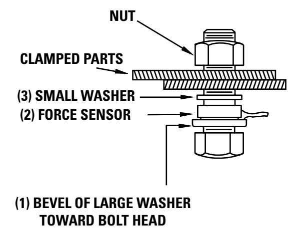
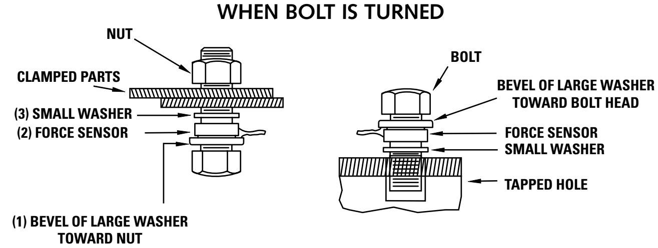


Figure 1

WHEN BOLT IS TURNED



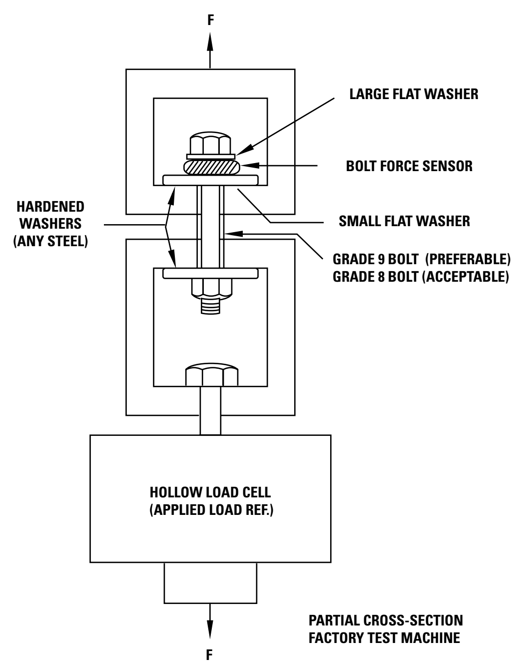


Figure 2

A pure compressive load applied equally across the large washer area will result in a different distribution of sensor internal stress, deflection and output signal. This is illustrated in Figure 3. Note particularly that a high degree of flatness and parallelism of the machine load faces does not improve the validity of the method. A similar conclusion is arrived at in the case of the application of uniform load across the area of the bolt head; the bolt head deflection is restrained and the sensor output may not correlate satisfactorily.

Although not recommended, it is possible to use a smaller size bolt than specified for a given sensor if the application permits an increase in height. Figure 4 illustrates an adapter which can be used to accommodate a smaller size bolt. It is important to note that the deflection of the adapter must be approximately equal to that obtained with the specified size bolt for the sensor. This is the limiting factor in terms of performance of the sensor. For example, for a 3711-750 (3/4"), the adapter deflection should be approximately equal to that of a 3/4" bolt head.

Nonlinearity and hysteresis specifications are not the same for all sizes of bolt force sensors. Each particular size has a characteristic curve which is not necessarily the same as for other sizes. Typically, nonlinearity may be 5% of full scale. A similar statement applies to the full-range output as well. Consult the factory for information on high-capacity (Model 3714) or high-temperature (Model 3718) models.

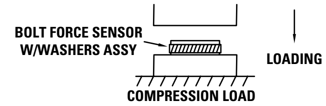


Figure 3

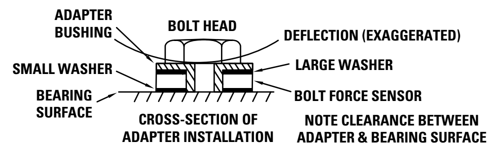


Figure 4

SENSOR CHARACTERISTICS: 3711

MODEL	BOLT SIZE in. (cm.)	CAPACITY lbs. N	DEFLECTION in. (cm.)	H in. (cm.)	BOLT FORCE SENSOR D in. (cm.)	BOLT FORCE SENSOR E in. (cm.)	LARGE & SMALL WASHERS A in. (cm.)	LARGE & SMALL WASHERS B in. (cm.)	LARGE & SMALL WASHERS T in. (cm.)
3711-138	No. 6	1,200	0.0012	0.15	0.44	0.14	0.44	0.28	0.04
3711-164	No.8	1,800	0.0012	0.15	0.44	0.17	0.44	0.28	0.04
3711-190	No. 10	2,400	0.0012	0.15	0.50	0.19	0.50	0.34	0.04
3711-250	1/4	4,000	0.0014	0.15	0.63	0.26	0.63	0.50	0.06
3711-312	5/16	7,000	0.0014	0.15	0.75	0.33	0.75	0.56	0.06
	(8MM)	(31,000)	(0.0014)	(0.38)	(1.91)	(0.83)	(1.91)	(1.43)	(0.16)
3711-375	3/8	10,000	0.0016	0.19	0.75	0.40	0.75	0.66	0.06
	(10MM)	(46,000)	(0.0016)	(0.48)	(1.91)	(1.01)	(1.91)	(1.66)	(0.16)
3711-437	7/16	14,000	0.0016	0.19	0.88	0.45	0.88	0.72	0.06
3711-500	1/2	20,000	0.0020	0.25	1.00	0.52	1.00	0.84	0.08
3711-562	9/16	25,000	0.0020	0.25	1.13	0.58	1.13	0.97	0.08
3711-625	5/8	30,000	0.0020	0.25	1.13	0.64	1.13	1.03	0.08
	(16MM)	(135,000)	(0.0020)	(0.64)	(2.85)	(1.64)	(2.85)	(2.62)	(0.20)
3711-750	3/4	45,000	0.0028	0.38	1.50	0.77	1.50	1.22	0.09
3711-875	7/8	60,000	0.0028	0.38	1.50	0.90	1.50	1.42	0.09
3711-1000	1	80,000	0.0034	0.50	1.75	1.02	1.75	1.61	0.09
3711-1125	1 1/8	80,000	0.0034	0.50	2.00	1.15	2.00	1.81	0.09
3711-1250	1 1/4	125,000	0.0053	0.63	2.25	1.28	2.25	2.13	0.13
3711-1500	1 1/2	190,000	0.0081	0.88	2.63	1.53	2.63	2.50	0.13
3711-1750	1 3/4	260,000	0.0111	1.13	3.00	1.79	3.00	2.88	0.13
3711-2000	2	300,000	0.0128	1.38	3.13	2.04	3.13	2.88	0.13
3711-6MM				0.15	0.63	0.24	0.63	0.44	0.06
	(6MM)	(16,000)	(0.0014)	(0.38)	(1.58)	(0.60)	(1.58)	(1.11)	(0.16)
3711-7MM				0.15	0.63	0.28	0.63	0.48	0.06
	(7MM)	(27,000)	(0.0014)	(0.38)	(1.58)	(0.71)	(1.58)	(1.23)	(0.16)
3711-9MM				0.15	0.75	0.36	0.75	0.59	0.06
	(9MM)	(36,000)	(0.0014)	(0.38)	(1.91)	(0.90)	(1.91)	(1.51)	(0.16)
3711-12MM				0.19	1.00	0.47	1.00	0.81	0.06
	(12MM)	(67,000)	(0.0016)	(0.48)	(2.54)	(1.20)	(2.54)	(2.06)	(0.16)
3711-14MM				0.25	1.13	0.55	1.13	0.94	0.08
	(14MM)	(102,000)	(0.0020)	(0.64)	(2.85)	(1.40)	(2.85)	(2.38)	(0.20)
3711-18MM				0.38	1.25	0.71	1.25	1.19	0.08
	(18MM)	(156,000)	(0.0027)	(0.95)	(3.17)	(1.81)	(3.17)	(3.01)	(0.20)
3711-20MM				0.38	1.50	0.79	1.50	1.25	0.09
	(20MM)	(230,000)	(0.0034)	(0.95)	(3.81)	(2.00)	(3.81)	(3.17)	(0.24)

FEATURES:

- Adapts directly to hydraulic cylinder
- Small diameter allows mounting in restricted areas
- High capacities vs. size
- Low deflection

The Lebow® small-diameter, low-cost load cells are designed to be used in applications that require an ability to mount in an existing system with restricted working area. They are commonly used in fluid power transfer systems. Their low cost and ease of mounting allow simultaneous testing of multi-element systems.

They may be directly attached to the piston rod of a hydraulic cylinder. Side-mounted cable connectors allow cable assemblies to be supported without affecting movement of the cell during tension or compression loading.

PERFORMANCE SPECS:

3124 AND 3161

SPECIFICATIONS	3124	3161
Output at rated capacity: *millivolts per volt, nominal*	±2	±2
Nonlinearity: *of rated output*	±0.25%	±0.15%
Hysteresis: *of rated output*	±0.15%	±0.1%
Repeatability: *of rated output*	±0.05%	±0.05%
Zero balance: *of rated output*	±1.0%	±1.0%
Bridge resistance: *ohms nominal*	350	350
Temperature range, compensated: *°F*	+70 to +170	+70 to +170
Temperature range, compensated: *°C*	+21 to +77	+21 to +77
Temperature range, usable: *°F*	-65 to +200	-65 to +200
Temperature range, usable: *°C*	-54 to +93	-54 to +93
Temperature effect on output: *of reading per °F*	±0.002%	±0.003%
Temperature effect on output: *of reading per °C*	±0.0036%	±0.0054%
Temperature effect on zero: *of rated output per °F*	±0.002%	±0.002%
Temperature effect on zero: *of rated output per °C*	±0.0036%	±0.0036%
Excitation voltage, maximum: *volts DC or AC rms*	20	20
Insulation resistance, bridge/case: *megohms at 50 VDC*	>5,000	>5,000
Number of bridges:	1 or 2	1 or 2

MODEL 3124

Capacity 5K lbs. to 25K lbs.

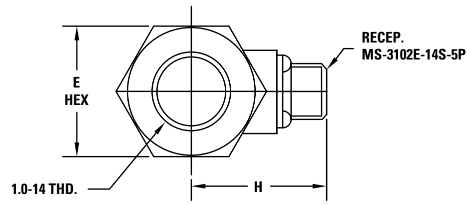
Optional dual bridge not shown

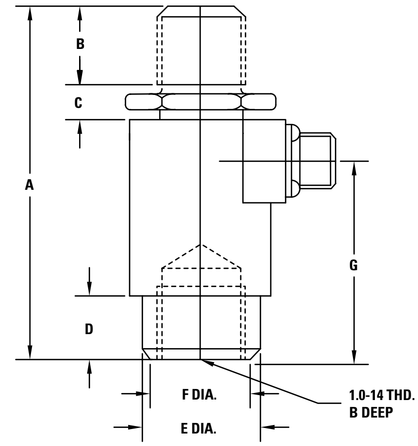
MODEL 3161

Fatigue resistant
Capacity 2K lbs. to 25K lbs.

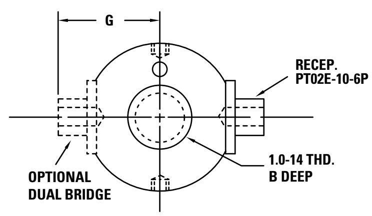
Fatigue Model 3415 also available, see page 78.

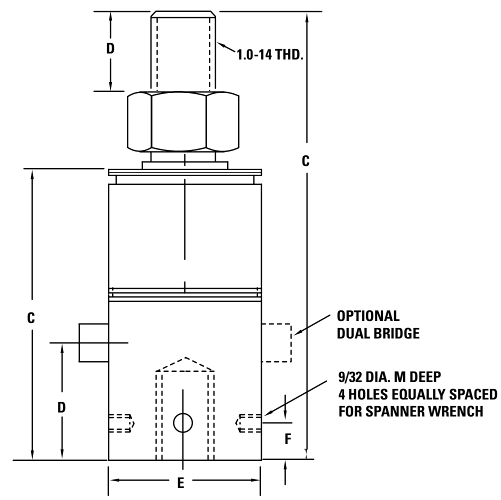
3124	IN.	CM.
A	4.50	11.43
B	1	2.54
C	0.38	0.97
D	0.81	2.06
E	1.50	3.81
F	1.38	3.51
G	2.44	6.20
H	1.72	4.37





3161	IN.	CM.
A	6.88	17.48
B	1	2.54
C	4.44	11.28
D	1.69	4.29
E	2.38	6.05
F	0.50	1.27
G	1.63	4.14
H	0.25	0.64





SENSOR CHARACTERISTICS: 3124 AND 3161

MODEL NUMBER	NOMINAL LOAD LIMIT CAPACITY F_Z		STATIC OVERLOAD CAPACITY % OF NOM. CAPACITY	FATIGUE CAPACITY % OF NOM. CAPACITY	STATIC EXTRANEOUS LOAD LIMITS			DEFLECTION AT NOM. LOAD LIMIT INCHES	RINGING FREQUENCY H_Z
	LBS.	NEWTONS			SHEAR F_X OR F_Y LBS.	BENDING Mx OR M_Y LB. INCHES	TORQUE Mz LB. INCHES		
3124	5K	20K	150	n/a	250	750	1,500	0.005	4,600
	10K	50K	150	n/a	250	700	1,100	0.005	6,400
	15K	75K	150	n/a	450	1,300	2,100	0.005	7,700
	20K	100K	150	n/a	650	2,000	3,000	0.005	8,800
	25K	125K	150	n/a	950	2,700	4,500	0.005	9,600
3161	2K	10K	150	100	850	3,800	3,500	0.003	5,000
	5K	20K	150	100	850	3,800	3,500	0.003	6,200
	10K	50K	150	100	850	3,800	3,500	0.003	7,100
	25K	125K	150	100	2,040	6,750	9,600	0.003	11,000

MODEL 6214

Load cell overload protectors

FEATURES:

The Lebow® overload protector is available in sizes that will accommodate load cells with capacities up to 3,000 lbs. and overloads to 15,000 lbs. in tension and 20,000 lbs. compression. It is available with an optional end plate assembly and rod ends. The overload protector eliminates downtime and replacement costs due to damaged strain gage load cells. The unit does not appreciably affect the cell's dynamic response.

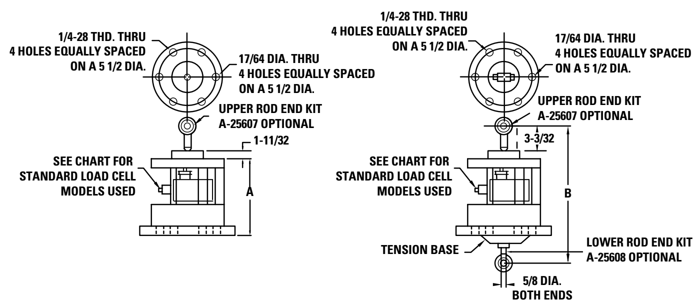
Up to its set point (usually 110%), the application of load results in linear deflection of the system. At 110% of rated load, the patented non-linear spring supporting the cell abruptly collapses, shunting the load in excess of 110% to the built-in mechanical stops.

When the load is removed, the springs automatically return to their original position. The low spring rate, above rated load, allows wide tolerances in mechanical stop settings.

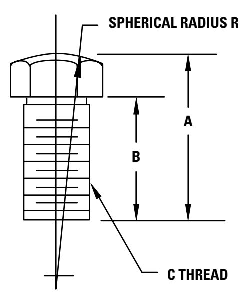
Alternative overload protectors are possible for other Lebow® load cells. Consult factory.

MODEL NUMBER	DESCRIPTION	DIMENSION A	DIMENSION B
6214-111	Protector incl. 3397-100 thru 300, per figure 1 (Rod Ends Opt.)	5.34	11.06
-121	Same as above, incl. tension base, per figure 2 (Rod Ends Opt.)		
-112	Protector incl. 3132-500 thru 3K, per figure 1 (Rod Ends Opt.)	5.84	11.56
-122	Same as above, incl. tension base, per figure 2 (Rod Ends Opt.)		
-131	Protector incl. 3169-108, per figure 1 (Rod Ends Opt.)	6.34	12.06
-132	Same as above, incl. tension base, per figure 2 (Rod Ends Opt.)		

Note: Protectors are sold only as assemblies which include the Lebow® load cell. Consult Lebow® Service Department for installation on existing Lebow® load cells.



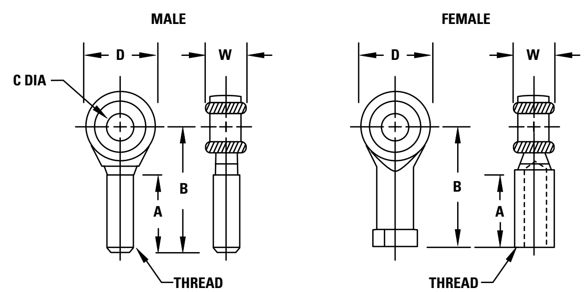
LOAD BUTTONS



PART NUMBER	A	B	THD. C	R
11277	0.47	0.31	¼-28	1.00
11748	0.75	0.38	½-20	2.00
18434	1.65	0.94	1-14	4.00
12311	3.50	2.38	2-12	8.00

Note: Protectors are sold only as assemblies which include the Lebow® load cell. Consult Lebow® Service Department for installation on existing Lebow® load cells.

ROD ENDS



PART NUMBER	A	B	C BORE	D	W	THREAD
26096	1	1.56	0.25	0.75	0.38	¼-28
26095	1.50	2.44	0.50	1.31	0.63	½-20
25607*	1.50	2.63	0.63	1.50	0.75	⅝-18
25608	1.50	2.50	0.63	1.50	0.75	⅝-18
30472	2.13	4.13	1.00	2.75	1.38	1-14

***Female**

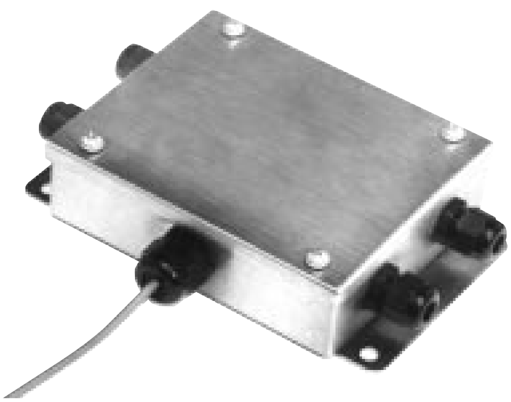
LOAD CELL SUMMING BOXES (C18-1, C19-1, C20-1) EXCITATION TRIM

SPECIFICATIONS

The Summing Card is 3" wide x 4" long. It has four 5-position terminal strips for load cell input and one 7-position terminal strip with internally jumped sense terminals for output to the instrument. The board will sum 2 to 4 load cells and can be daisy-chained to sum up to 8 load cells using 2 summing cards. Trimming is accomplished with four 25-turn trim pots with an operating temperature range of -55°C to +125°C. The board can be mounted with the four 11/64" mounting holes provided, with a spacing of 2½" x 3½" on center.

FEATURES

- 100 ohm trim pots
- Lever-operated cage-clamp spring terminal strips
- Stainless steel enclosure box



CALIBRATION

After all wiring is complete and the scale instrument is powered up, turn each of the four trim pots fully clockwise to obtain the highest possible output from each load cell. Before proceeding with the following adjustments, check the scale for repeatability and correct any problems.

I. SHIFT ADJUSTMENT

A. Place a test weight over each of the load cells and record the lowest reading and its location. This reading will be used as your target weight.

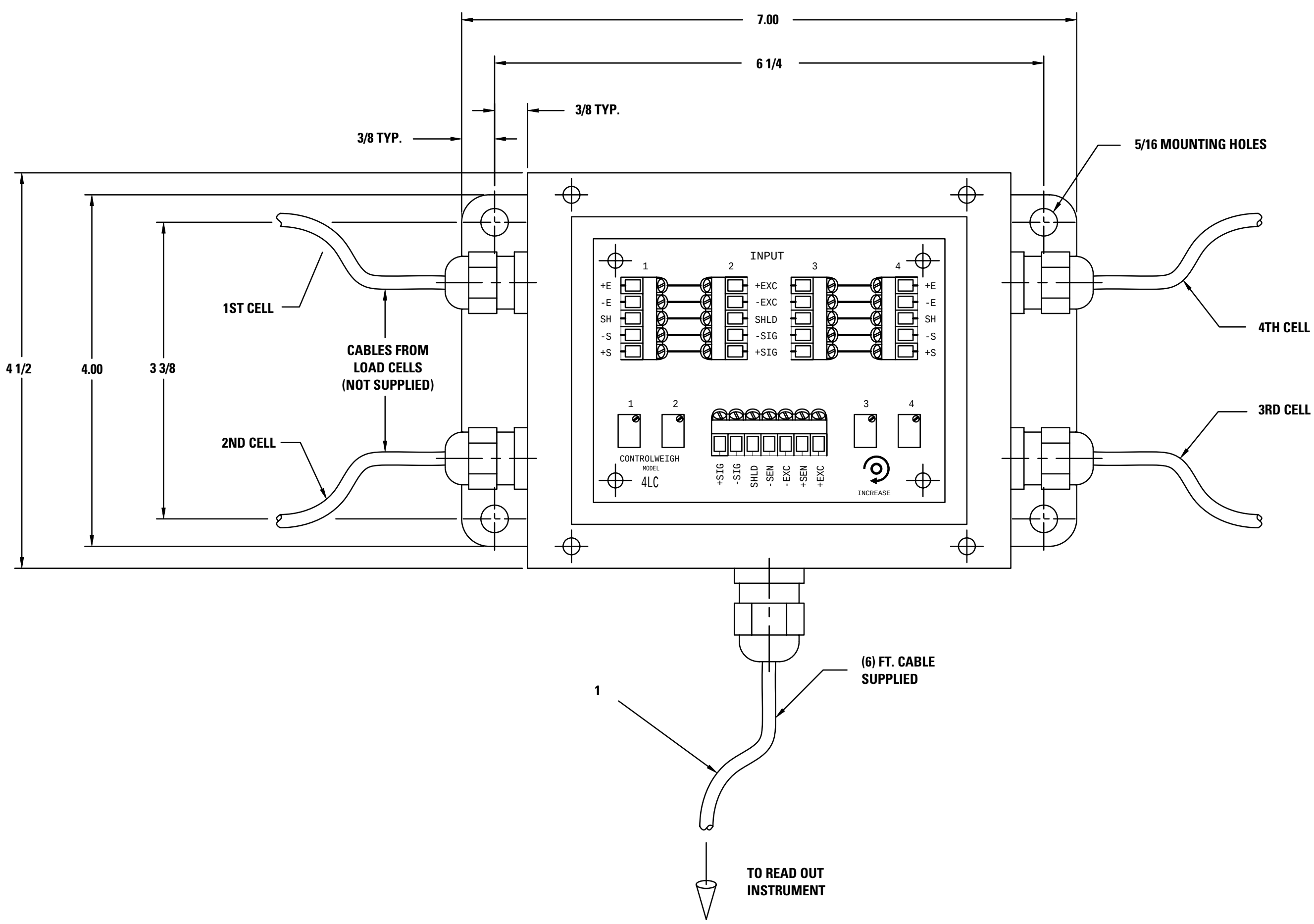
B. Place the test weight over each of the other load cells and, if necessary, adjust the corresponding trim pot to match the target weight.

C. Place the test weight over the cell located in step A. Record this weight as the new target weight and repeat steps B and C until all cells are matched to within the desired tolerance.

II. SPAN ADJUSTMENT

A. Calibrate the scale using the instrument calibration instructions supplied by its manufacturer.

C18-1	2 Cells
C19-1	3 Cells
C20-1	4 Cells



INSTRUMENTS

AC CARRIER STRAIN GAGE CONDITIONER INDICATOR

MODEL 7541-115

AC carrier

FEATURES:

- 3.28 kHz carrier excitation
- Reads, displays, processes and outputs
  - Shaft torque, speed, power
- Fast, rock-solid readings with high noise immunity
  - 2,000 samples/sec. for torque, head or drawbar force input
  - 1 millisecond response for speed
- 6-digit engineering unit display with legends and 0.01% resolution
- RS232, RS422 or RS485 serial communication
- Auto-scaled ±5 V and/or ±10 V analog outputs
- No pots, batteries, fans, maintenance or external power supplies

These advanced instruments provide engineering unit display of a strain gage (mV/V) input and a frequency input. They also compute power and perform 21 functions including limit checks, tare, hold and max/min capture. You needn't write code or add hardware to be up and running a productive test.

The alphanumeric readout can display measured and computed data, units of measure and test status. During setup, it guides you with English language prompts. There are **no manual adjustments.** To calibrate, enter the full scale value in engineering units and auto-cal takes over. Provides 0.01% resolution and ±5 V and/or ±10 V analog outputs at full scale. The keyboard accesses measured data, held data, max/min data, data spread, limit status and/or I/O status **without test disruption.** Password protection may be used if needed.

SPECIFICATIONS & FEATURES: 7541-115

Strain Gage Input . . . Any 80 Ω to 2 kΩ transducer, directly wired or transformer coupled. 4, 6 or 7 wire circuits are accommodated.
Transducer Excitation . . . 3 Vrms, 3.28 kHz ±0.01% sine wave. Regulated and short circuit protected.
Sensitivity . . . 0.5 to 5 mV/V with 50% overrange; automatically scaled.
Input Resistance . . . 100 MΩ in parallel with 33 pF.
Automatic Null . . . In Phase: ±10% of F.S. (with 50% overrange), ±60% of F.S. (with 0% overrange). Quadrature: ±1 mV/V.
Auto Calibration . . . Dual polarity shunt calibration with provision for CAL resistor feedback.
Spurious Signal Rejection . . . 60 Hz: 120 dB common mode, 100 dB normal mode. Carrier quadrature: 60 dB.
Antialias Filter . . . 200 Hz, 7 pole Bessel response filter.
Low Pass Filtering . . . 4 pole Bessel response digital filter with 11 cutoff frequencies from 0.1 to 200 Hz in 1-2-5 steps.
Signal-to-Noise Ratio[1] . . . With 1/10/100/200 Hz filters 86/76/66/62 dB @ 1 mV/V F.S. and 86/80/72/66 dB @ 5 mV/V F.S.
Resolution . . . 0.01% of F.S.
Overall Accuracy (at 77°/25°C) . . . 0.02% of F.S., worst case.
Temperature Effects . . . Zero: ±0.001% of F.S./F° (max); Span: ±0.001% of F.S./F° (max).
Frequency Input . . . Any unidirectional or bidirectional (quadrature) source including self-generating and zero velocity magnetic pickups, optical encoders, flowmeters, etc. When used with bidirectional sensors, the conditioner outputs both *direction* and *magnitude*.
Input Impedance and Configuration . . . Differential or single ended inputs. 100 kΩ differential, 50 kΩ single ended.
Input Threshold (keypad selectable) . . . 10, 20, 50, 100 or 200 mV pk-pk (between inputs) or TTL.
Maximum Voltage . . . ±130 VDC or 130 Vrms.
Input Signal Bandwidth . . . 0.001 to 200 kHz (10 to 200 mV pk-pk threshold). 0.001 to 400 kHz (TTL threshold).
Display Ranges and Resolution . . . Rangeless (use any F.S. Engineering Unit value) with 50% overrange. Resolution is 0.01% of F.S.
Low Pass Filter (keypad selectable) . . . 20 kHz (-3 dB) or none. This filter is not available for TTL inputs.
Response Time . . . Greater of: 1 ms, typical (2 ms worst case) or the input pulse length.
Common Mode Rejection . . . 80 dB (60 Hz), 55 dB (0 to 10 kHz).
Low Pass Filtering of Sampled Data . . . Unfiltered or 4 pole Bessel filter. Cutoff frequencies from 0.1 to 100 Hz in 1-2-5 steps.
Overall Accuracy . . . 0.01% of F.S. @ +77°F (+25°C), 0.015% of F.S. @ +41°F to +122°F (+5°C to +50°C).
Excitation Supplies . . . +12 V @ 125 mA[2] or +5 V @ 250 mA[2]. Short circuit (current limit and overvoltage (fuses) protected.
Maximum Transducer Cable Length . . . 500 ft. except 200 ft. for 100 Ω or lower strain gage transducers.
System Display . . . 2 line by 16 alphanumeric characters, each 0.2" wide by 0.3" high. Backlit LCD with adjustable contrast.
Views . . . Select either 2 Channels, 1 Channel with Limit Status or 1 Channel with I/O Status.
Data Displayed . . . Select from Current, Max, Min, Spread, Held data and Tare value.
Data Format . . . Engineering units with 6 digits (1-2-5 format) and 5 character, upper or lower case, user-entered legend/descriptor.
System Response (per channel)
Data Sampling and Max/Min Update Rates . . . 2,000 Hz (hardware channels), 50 Hz (CH3 calculation).
Limit Checking Rate . . . 1,000 Hz (hardware channels), 50 Hz (CH3 calculation).
Logic I/O Response Time . . . 1 ms (hardware channels), 20 ms (CH3 calculation).
Update Rate for Each Analog Output . . . 1,000 Hz.
System Control . . . All I/O functions can be OR'd in any combination. The pattern function adds ANDing capabilities.
Input Actions/Channel . . . Logic inputs, outputs and internal Matrix signals control following actions: Tare, Clear Tare, Hold, Clear Hold, Reset Max/Min, Clear Latched Limits, Check Limits, Do Max/Mins, Apply +CAL.
Output Events/Channel . . . The following events drive Logic outputs and internal Matrix signals: HI Limit, NOT HI Limit, IN Limit, NOT IN Limit, LO Limit, NOT LO Limit, At Max, NOT At Max, At Min, NOT At Min.
Three User-Defined Patterns . . . Patterns of Logic inputs, outputs and Matrix signals drive Logic outputs and internal Matrix signals.
Limit Checking . . . Each channel has a HI and LO limit which may be latched or unlatched, absolute or signed, and with or without hysteresis. Select either Current, Max, Min Spread or Held data for limit checking. Limit violations on any or all channels can be set to trigger backlight flashing in any of the display view modes.
Four Logic Inputs . . . Each with programmable destination, protected to ±130 VDC or 130 Vrms.
Type . . . TTL compatible, Scmitt Trigger, low-true with 47 kΩ pull-up. Input current is -100 µA @ 0 V.
Six Logic Outputs . . . Each with programmable source, short circuit (current and thermal limits) and overvoltage (fuse) protected.
Type . . . Open collector, low-true. Operating @ 24 V (max) and 0.3 A max sink current.
External +5VDC Power (on I/O connector) . . . 250 mA, short circuit (current limit) and overvoltage (fuse) protected.
Serial Communication Port . . . (selectable as RS232, RS422 or RS485) Supports 32 devices on RS485 port and 1 device on RS232/422.
Baud Rate . . . 300 to 38400. Maximum cable length: 4000 ft. (RS422/RS485), 50 ft. (RS232).
120 Ω Terminal Resistors (RS485) . . . User selectable for RXD and TXD.
RS422/485 Transceivers . . . Slew-rate limited, short circuit protected (current and thermal limits).
RS232 Drivers . . . Short circuit protected (current limit).
Serial I/Os . . . Use a 9 pin D connector. They are ±15 kV ESD protected and float (100 kΩ) with respect to Earth Ground.
Commands . . . Control of all modes, settings and measurements.
Non-Volatile Memory Storage for System Settings . . . EEPROM, batteries are not used.
Dual Analog Outputs . . . Each assignable to any of the 3 channels are short circuit (current limit) and overvoltage (fuse) protected.
Output Impedance/Minimum Load Resistance . . . < 1 Ω/10 kΩ.
Full Scale . . . ±5 V or ±10 V (user selectable). Resolution is 2 mV @ ±5 V F.S. or 4 mV @ ±10 V F.S.
Overrange . . . ±8.2 V @ ±5 V F.S. or ±13.5 V @ ±10 V F.S.
Nonlinearity . . . ±2 mV @ ±5 V F.S. or ±4 mV @ ±10 V F.S.
Overall Error (worst case, including temperature effects) . . . ±5 mV @ ±5 V F.S. or ±10 mV @ ±10 V F.S.
Filter . . . 100 Hz, 5 pole Bessel response low pass filter.
Size and Weight . . . 6.5" wide, 2.9" high, 8.7" deep. Weight is 3 pounds.
Operating Temperature . . . +41°F to +122°F (+5°C to +50°C).
Input Power . . . 90 VAC to 250 VAC, 50/60 Hz @ 25 VA, max. Two 2 A/250 V fuses, line filter and rear power switch.

Notes:
1. The ratio expressed in decibels (dB), of Full Scale (F.S.) to noise spread. Measurements are made for a one-minute interval using a 350 Ω bridge.
2. Both excitation voltages can be used simultaneously with the following restrictions: 4.8 x (12 V current) + (5 V current) ≤ 700 mA; 12 V current ≤ 125 mA; 5 V current ≤ 250 mA.
3. Applies to strain gage channel only. Frequency measurement is absolute with guaranteed accuracy and only requires user engineering unit scale.
4. Specification is subject to change without notice.

MODELS 7558

Panel Meter

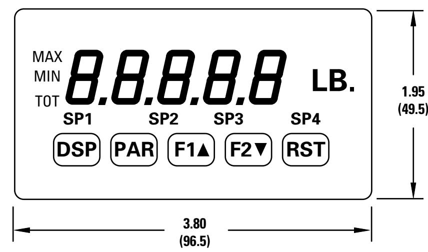
FEATURES:

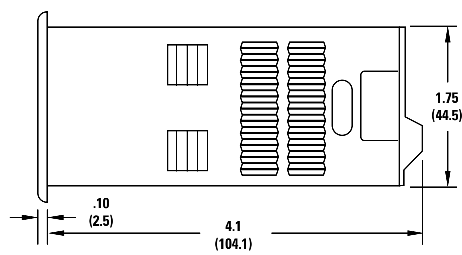
- 5-digit LED display
- ⅛ DIN size
- User selectable resolution
- NEMA 4X/IP65 construction
- Isolated analog output
- Min and max peak detection
- 16-point linearization
- CE approved

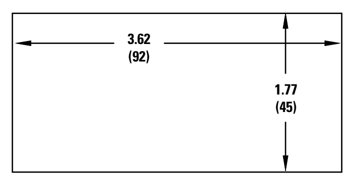
CE

The Model 7558 series of digital indicators provides high accuracy, ease of use and improved resolution of measurement. These low cost instruments provide a user selectable DC excitation voltage to drive strain gage based transducers.

These standard meters can be made more powerful through the selection of optional features that provide the capability to control external devices and offer digital communication with computers.







PERFORMANCE SPECS:

7558

SPECIFICATIONS

Display:
A/D converter: 16-bit resolution
Resolution: Selectable by 1, 2, 5 or 10 counts
Range: -19,999 to 19,999
Decimal point: Selectable position
A/D conversion rate: 20 readings/sec
Update rate: 1 to 20 updates/sec

Sensor input:
Range: ± 24 m VDC or ± 240 m VDC
Accuracy: ± 0.02% of reading
Impedance: 100 Mohm

Power supply:
AC supply voltage: 85-250 VAC, 50/60 Hz, 15 VA
DC supply voltage: 11 to 36 VDC, 11 W (optional model)

User configurable linearization:
User defined linearization function as a 16-point piece-wise linear approximation

Analog output:
Voltage: 0 to 10 VDC
Impedance: 500 ohm
Accuracy: +/- 0.17% FS (18 to 28°C)

Options: Dual limit relays, RS232 or RS485 isolated serial interface, DeviceNet interface and PC software for meter configuration

Dual limit relays:
Type: Two Form C relays
Isolation: 2,000 Vrms for one minute
Contact rating: Total current with both relays energized ≤ 5 amps

RS232 or RS485 serial output:
Data type: 7/8 bits
Voltage level: 50 V
Baud rate: 19200
Isolation: 500 Vrms
Address units: 99 max
Parity: No, odd or even

Product Specification Chart

7558 - X X X — **Basic Meter with Analog Output**

Communications
0 = None
1 = RS232/Software
2 = RS485/Software
3 = DeviceNet/Software
4 = ModBus

Relays
0 = None
1 = Dual Relays

Operating Power
0 = DC Power
1 = AC Power

MODEL 7554

Process monitor

FEATURES:

- Continuous process monitoring (tracking)
- 3 peak recording functions
- 2 record functions (with multiple sampling rates from 1 Hz to 10 kHz and storage for up to 8,000 data points)
- 3 process control output signals (for High, Low and Target occurances)
- RS232 output
- Storage capability for up to 8,000 peak readings
- 4 log operation functions (viewing, uploading, printing and erasing)
- Selectable engineering units
- Menu locking feature
- Automatic power-down (when sensor is not plugged in)
- Rechargeable Ni-Cad batteries
- Graphic User Interface software available (consult factory)
- Optional simultaneous angle or rpm measurements

The Model 7554 is a portable Process Monitor and Control Instrument designed to work with our Auto-ID transducers for Plug-and-Play operation. This versatile instrument is designed for:

- Measuring force, torque, pressure or displacement
- Capturing and storing multiple peaks
- High-speed recording of measurement profiles vs. time
- Optional simultaneous angle or rpm measurements available
- Control of remote devices

PERFORMANCE SPECS:

7554

SPECIFICATIONS	
Digits:	(5 w/no decimal)
Height of digits:	0.25"
Sampling rates:	
Track:	4 Hz
Peak:	5 kHz
Record:	selectable up to 10 kHz
Frequency response:	(-3 dB) at 1000 Hz
Accuracy:	max error = 0.05% of F.S.
Max input and F.S.:	± 4.5 mV/V
Polarity:	Bipolar
Bridge excitation:	7V supplied
Minimum bridge impedance:	120
Data output:	232 port ASCII, 9600 baud, 8-N-1
Control/limit outputs:	Open collector
Analog output:	0-2.4 VDC (1 VDC @ 2 mV/V)
Dimensions:	6.0" W x 8.0" D x 1.75" H
Power:	
AC (adapter supplied):	115 VAC
Batteries:	9.6V internal/rechargeable

MODEL NUMBER	
7554-100	Standard version
7554-101	Angle/rpm version

FEATURES:

Compact, single-channel signal conditioners with:
- High-level analog outputs
- Selectable low-pass active filtering
- Built-in regulated excitation with remote sensing

Options include:
- Local LED digital indication
- Dual limit monitoring with isolated logic sensing outputs
- Analog peak capture
- 4-20 mA output
- Dual galvanic isolated output
- Internal electromechanical or solid-state relays

INSTRUMENT SPECS:
DAYTRONIC 3000

SPECIFICATIONS

Required power: 105-135 VAC, 50-400 Hz; 5 W max (for Form 1 instruments), 8 W max (for Form 2 instruments), or 9 W max (for Form 3 instruments); 210-260 VAC optional (add suffix "F" to model number); any model not employing solid-state relay ("S") option may be powered by *battery* (11.5-15 VDC, 500 mA max; add suffix "B" to model number)

Analog voltage outputs:
Level: ±5.0 V with 50% overrange, 5.0 mA max
Active filtering: See "Outputs" in Specifications table, opposite[1]; in all cases, down 60 dB per decade above corner; full-scale slew time is 1.4/*ƒ* seconds, where *ƒ* is the corner frequency

Ripple and noise:
DC instruments: 0.02% of full scale (rms) on 2 Hz output; 0.15% of full scale (rms) on 200 Hz and 2000 Hz outputs
AC carrier instruments: 0.02% of full scale (rms) on 2 Hz output; 0.15% of full scale (rms) on 400 Hz output
Frequency-measuring instruments: less than 0.1% of full scale from 20% to 100% of selected input range, for both 2 Hz and 10 Hz outputs

Operating temperature range: 0°F to +130°F (-18°C to +55°C); assumes dry, noncondensing ambient atmosphere

Weight: **Instrument:** approx. 2.0 lb. (0.9 kg) max;
Shipping: approx. 3.5 lb (1.6 kg) max

Digital indication:
Display: Orange LEDs, six digits with polarity sign, 0.4" (1.0 cm) height; *Most Significant Digit* of display is either unlit or reads "1," and in either case contains polarity sign; *Least Significant Digit* is a dummy zero which may be lit or unlit, as desired
full-scale values of ±5000
counted by "1's" ±10000
counted by "2's" ±20000
counted by "5's" with selectable decimal-point locations (along with dummy zero) to give decade multiplier factors of 10, 1.0, 0.1, 0.01, 0.001 or 0.0001
Sampling rate: 3 samples per second

Limit logic outputs (Form 3 instruments only): Both true and complement available for each limit condition (LOW, OK, HIGH); TTL-compatible, wire-ORable; 10 mA sink, 0.5 mA source (max); normally non-latching, but *latching* outputs are also available

[1] For *temperature-measuring* instruments, low-pass filtering is omitted. For *frequency-measuring* instruments, appropriate filtering is provided for each input range.

DAYTRONIC 3000

FREQUENCY-MEASURING INSTRUMENTS (MODELS 3140A, 3240A)

- For measuring rpm, flow and other phenomena that can be sensed by frequency-generating devices like magnetic pickups or turbine flowmeters.
- A simple procedure, using an internal crystal reference oscillator and adjustable span controls, allows precise calibration in terms of frequency, rpm, gallons per hour or any other appropriate unit.
- Step-function response time of 99.9% of final full-scale value is 1.8 seconds for 100, 200 and 500 Hz ranges and 350 milli-seconds for all other ranges.

INSTRUMENTS FOR DC-EXCITED STRAIN GAGE TRANSDUCERS (MODELS 3170, 3270) AND FOR AC-EXCITED STRAIN GAGE TRANSDUCERS (MODELS 3178, 3278)

- For use with load cells, pressure sensors and other strain gage transducers employing a 4-arm bridge. Being phase-sensitive carrier-demodulator (rather than fully DC) instruments, the **Models 3178 and 3278** are intended for applications involving transformer coupling to the transducer bridge (as with rotary-transformer torque sensors). They can also be used where high sensitivity is required or where the electrical environment is especially noisy. Responding only to the modulated carrier frequency, the **Models 3178 and 3278** reject extraneous voltages that can cause errors in DC systems, particularly when there is a need to "blow up" a portion of the transducer range.
- Advanced circuit design overcomes many of the errors traditionally afflicting the strain gage measurement process, resulting in high-level, drift-free, noise-free analog outputs that cover nearly all mechanical measurement and control requirements.
- Remote sensing and regulation of bridge excitation eliminate errors from temperature effects on cable resistance.
- Seven-wire calibration circuitry. The internal shunt calibration resistor is applied at the transducer terminals, thereby eliminating significant calibration transfer error in long-cable installations.
- True differential input, with better than 80dB of common-mode rejection eliminates errors from common-mode pickup and possible "ground-loop" coupling.
- Input impedance in excess of 100MW to each input line preserves the validity of factory calibration, prevents conversion of common-mode to normal-mode signals and eliminates remaining errors attributable to cable resistance. Allowable cable length has virtually no practical limits.
- Both short-term and long-term drift are eliminated through an advanced solid-state chopper stabilization technique, while preserving the full frequency passband, free of chopper noise. The rated accuracy is obtained without "warm-up" period or periodic "tweaking" of controls.

MODEL-NUMBERING SYSTEM FOR THE 3000 SERIES

MODEL 3 X X X (X)

"3" is the "series" identifier, used with all units

Second digit identifies "form":
- "1" = Signal Conditioner only
- "2" = Signal Conditioner with Digital Indicator

Third and Fourth digits identify "type" of signal source:
- "40" = Frequency Source
- "70" = Strain Gage Transducer (DC-excited)
- "78" = Strain Gage Transducer (AC-excited)

Form 1 – Signal Conditioner Only
Form 2 – Signal Conditioner with Digital Indicator

THE ONLY ALLOWABLE OPTION COMBINATIONS ARE:
P and F; P and B; C and F; C and B; G and F; G and B; R and F; R and B; S and F.

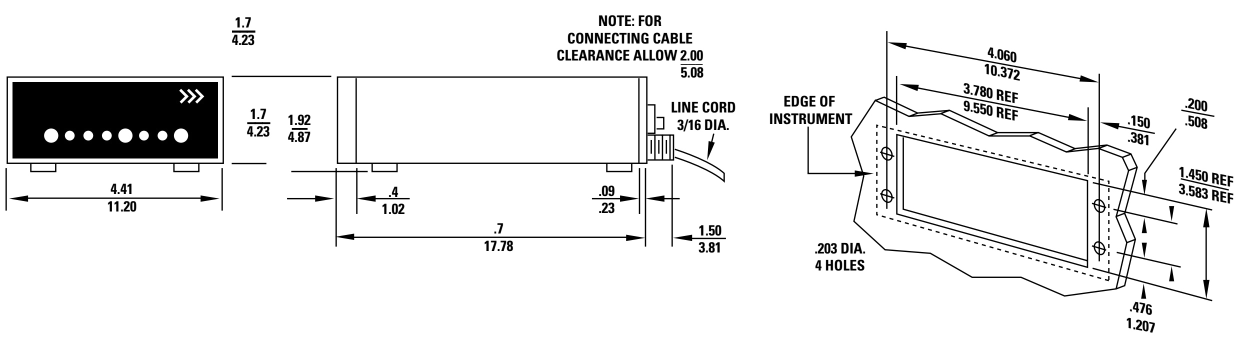
Suffix denotes optional feature(s)–see below:
- "P" = Analog Peak Capture (Form 2)
- "C" = 4-20 mA Current Output (all Forms)
- "G" = 0-10 VDC Dual Galvanic Isolated Outputs (Forms 1 and 2)
- "B" = 12 VDC Battery-Powered Operations (all Forms)
- "F" = Nominal 230 VAC Operation (all Forms)

3000 SERIES INSTRUMENT SPECIFICATIONS

MODEL NUMBER	INPUT TYPE	INPUT RANGES (FULL SCALE)	EXCITATION SUPPLIED	OUTPUTS	TYPICAL ACCURACY/ DISPLAY RESOLUTION
3140A 3240A	Any AC or unipolar pulse signal, floating or grounded, irrespective of waveform[1]	Switch-selectable 0 to 100, 200, 500, 1000 2,000, 5,000, 10,000, 20,000 or 50,000 Hz; full-scale sensitivity continuously adjustable from 0.1 to 200 V[2]	-9 VDC auxiliary supply available on rear connector	ONE 5 V output: low-pass corner frequency of 2 Hz for 100, 200 and 500 Hz ranges; 10 Hz for all other ranges	0.05% of full scale/ 0.02% of full scale
3170 3270	Conventional 4-arm strain gage bridge, nominal 90 to 2000 Ω	Nominal sensitivity 1 to 8 mV/V, full scale[3]	Regulated 5 to 10 VDC, user selectable[4]	THREE 5 V outputs: low-pass corner frequencies of 2 Hz, 200 Hz and 2 kHz	
3178 3278	Conventional 4-arm strain gage bridge, nominal 90 to 1000 Ω	Nominal sensitivity 0.5 to 5 mV/V, full scale[3]	2 VAC (rms) at 3.28 kHz	TWO 5 V outputs: low-pass corner frequencies of 2 Hz and 400 Hz	0.05% of full scale/ 0.02% of full scale[5]

[1] Input threshold level: automatic triggering at 75% and 25% of the input amplitude.
[2] Input sensitivity decreases above 10 kHz by 0.01 V/kHz (to 0.5 V at 50 kHz).
[3] Ten-turn coarse and fine front-panel controls with balance 1.5 mV/V initial unbalance and allow span adjustment over the stated full-scale sensitivity.
[4] Transducers with sensitivity from 4 to 8 mV/V, full scale, or with bridge resistance of 120 Ω or less, must use 5 V excitation.
[5] This specification includes the combined effects of nonlinearity, random noise, line-voltage variation between 105 and 130 volts, ambient temperature variation of ±20°F about starting value, and six months' drift of zero and span. Errors attributable to the transducer are not included.

SERIES BENCH-MOUNT DIMENSIONS



Mounting: Each unit is housed in a single piece of heavy-gauge aluminum; a simple reassembly procedure allows mounting in the user's precut panel (maximum panel thickness allowed is ⅛"); the optional **Model 3004 Adapter** permits secure mounting of up to four units in a standard 19-inch rack.

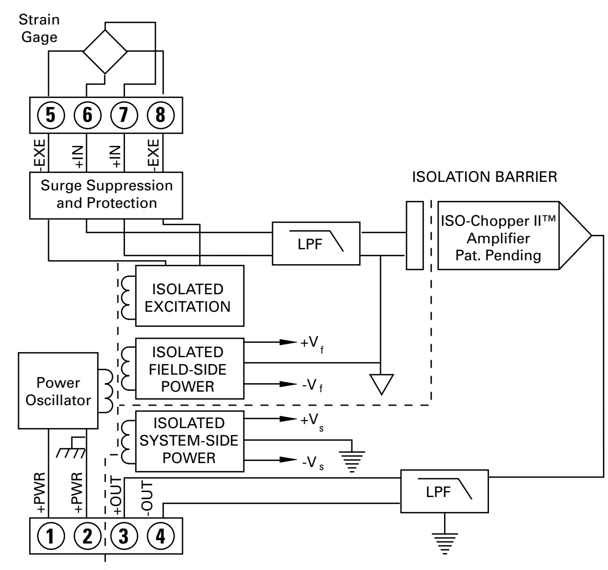
PERFORMANCE SPECS: 7527

MODEL 7527

SPECIFICATIONS

Input range:	±10 mV to ±100 mV (full bridge sensor)
Input bias current:	±0.5 nA
Input resistance:	
Normal:	50 MΩ
Power off:	65 kΩ
Overload:	65 kΩ
Signal input protection:	
Continuous:	240 Vrms max
Transient:	ANSI/IEEE C37.90.1-1989
Excitation:	
Output:	10 V ±0.03% or 3.3 V ±0.03%
Load resistance (10 V):	300 Ω to 10 kΩ
Load resistance (3.3 V):	100 Ω to 10 kΩ
Load regulation:	±5 ppm/mA
Stability:	±15 ppm/°C
Protection:	
Continuous:	240 Vrms max
Transient:	ANSI/IEEE C37.90.1-1989
Output range:	See ordering information
Load resistance:	600 Ω max
Current limit:	8 mA (V_{OUT}), 25 mA (I_{OUT})
Output protection:	
Short to ground:	Continuous
Transient:	ANSI/IEEE C37.90.1-1989
CMV, input to output, input to power:	
Continuous:	1500 Vrms max
Transient:	ANSI/IEEE C37.90.1-1989
CMV, output to power:	
Continuous:	50 VDC max
CMR (50 Hz or 60 Hz):	100 dB
Accuracy(1):	±0.08% span
Nonlinearity:	±0.01% span
Adjustability:	±5% zero and span
Stability:	
Input offset:	±1 μ V/°C
Output offset:	±20 ppm/°C
Gain:	±55 ppm/°C
Output noise, 100 kHz bandwidth:	750 μVrms (V_{OUT}), 3 μArms (I_{OUT}),
Bandwidth: *-3 dB:*	3 kHz
NMR:	100 dB/decade above 3 kHz
Response time, *90% span:*	165 μs
Power supply:	
Voltage:	19 V to 29 V
Current:	60 mA (V_{OUT}), 80 mA (I_{OUT})
Sensitivity:	±0.0002%
Protection:	
Reverse polarity:	Continuous
Transient:	ANSI/IEEE C37.90.1-1989
Environmental:	
Operating temp. range:	-40°C to +80°C
Storage temp. range:	-40°C to +80°C
Relative humidity:	0% to 90% noncondensing
Emissions:	EN50082-1, ISM Group 1, Class A (Radiated, Conducted)
Immunity:	EN50082-1, ISM Group 1, Class A (ESD, RF, EFT)
Mechanical dimensions:	2.95" H x 0.89" W x 4.13" D (75mm x 22.5mm x 105mm)
Mounting:	DIN EN 50022 -35 x 7.5 or -35 x 15 rail

NOTES: (1) Includes excitation error, nonlinearity, hysteresis and repeatability.

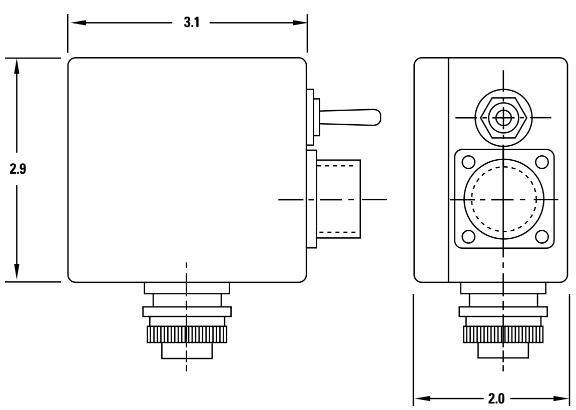


PART NUMBER	EXCITATION	OUTPUT RANGE	SENSITIVITY
7527-1	+10.0 V	-10 V to +10 V	3 mV/V
7527-2	+10.0 V	-10 V to +10 V	2 mV/V
7527-3	+3.333 V	-10 V to +10 V	10 mV/V

MODEL 7542

AC carrier amplifier module

Model 1604 with Model 7542 amplifier



FEATURES:

This single-channel conditioner module is of *phase-sensitive carrier-amplifier* design, and is intended primarily for Lebow® Model 1600 Series that employ transformer-coupling to the transducer bridge and will be calibrated with sensor. By means of the basic wiring configuration and special jumper settings, the 7542 can be set to produce either:

1. **two independent ±5 VDC analog outputs** (standard), with respective low-pass corner frequencies of 2 Hz and 600 Hz; or
2. **one analog current output** (optional) of either unipolar (4 to 20 mA) or bipolar (4 to 12 to 20 mA) form, and derived from either the 2 Hz ("slow") or the 600 Hz ("fast") voltage signal.

PERFORMANCE SPECS:

7542

SPECIFICATIONS

Size: 3.1" H x 2.0" W x 2.9" D

Required power: 12 to 15V-DC at 80 mA, nominal; the power input is protected against reversal of polarity

Operating temperature range: -25°F to 185°F (-32°C to 85°C)

Sensor input:
Type: Transformer-coupled resistive bridge
Bridge impedance: 300 to 400 Ω, nominal
Input impedance: Greater than 10 MΩ
Full-scale range: 0.75 to 4 mV/V

Analog outputs: Selectable by wiring for either
1. Two voltage outputs *(standard)*, ±5 VDC full scale with low-pass corner frequencies of 2 Hz and 600 Hz, respectively; or
2. One current output *(optional)*, selectable by internal jumpers for either unipolar (4 to 20 mA) or bipolar ("zero-center" 4 to 12 to 20 mA) form and for a low-pass corner frequency of either 2 Hz or 600 Hz

Output ripple and noise: 0.02% of full scale (rms) max for 2 Hz output; 0.03% of full scale (rms) max for 600 Hz output

Accuracy:
Linearity: 0.02% of full scale*
Stability *(zero and span)*: ±25 ppm/°C for an operating temperature between 0°C and 50°C; otherwise ±50 ppm/°C
Span/symmetry and zero adjustments:
Coarse control via internal pin interconnections; fine control via potentiometers to balance ±1.5% of full scale initial unbalance
Phase adjustment: via potentiometer to ±25°*
Shunt calibration control: Positive or negative selectable via nominal ±2.5 V "CAL" logic input

*With respect to a resistive bridge.

PERFORMANCE SPECS: 7905-103

SPECIFICATIONS

Connector:	Model 7905-103 color coded 5-way binding posts
Excitation: *maximum*	10 VDC or VAC rms
Input resistance:	350 ohms ±0.1%
Output resistance:	350 ohms ±0.1%
Output ratio:	0.25, 0.50, 1.00, 1.50, 2.00, 3.00 and 5.00 mV/V by push-button selector switch for range and polarity
Ratio accuracy:	±0.05% of full scale maximum at room temperature
Offset: *maximum*	±0.0005 mV/V at zero output and room temperature
Temperature coefficient: *maximum*	±12 ppm/°F
Net weight:	1 pound
Size:	6¼" W x 3¾" H x 2" D
Operating:	0°F to 120°F and 5% to 95% relative humidity, no warm-up time required

MODEL 7905-103

MODEL 7926

FEATURES:

The Model 7926 will test the following types of strain gage load cells:*

- Four-wire and six-wire (determined by the user)
- Input/output bridge resistance: up to 8K ohm
- Rate output: 1 mV/V–5 mV/V (determined by the user in 0.1 mV/V steps)

Main Features

- Input impedance (1 ohm resolution)
- Output impedance (1 ohm resolution)
- Sense to output impedance (with six wire load cell)
- Shielding to input/output impedance (up to 10M ohm)
- Ground to input/output impedance (up to 10M ohm)
- Load cell output in percentage from full scale

Performance Specifications

- Excitation voltage: 2.5 VDC
- Internal resolution: 12 bit
- Accommodate load cell type: four or six wires up to 8K ohm
- Total accuracy: 2%
- Accommodate load cell gain: 1 mV/V – 5 mV/V in 0.1 mV/V steps (default = 2 mV/V)

The Model 7926 is a stand-alone portable hand-held device that was especially designed to help technicians immediately analyze the condition of strain-gaged based load cells.

The Model 7926 provides the user with essential data needed regarding the conditions of the tested load cell, such as physical distortion or zero balance (possibly caused by overload, shock load or metal fatigue), and electrical conditions (bridge resistance, shielding and resistance to ground).

Allows the user to test the load cell whether it is installed or removed. The unit is fully computerized and battery operated. An alphanumeric LCD display guides the operator through all test stages and clearly displays the results. It is also equipped with a buzzer and LED, which alert the user to any suspicious result.

HARDWARE SPECS:

7926

SPECIFICATIONS	
Power source:	Four standard AA batteries
Connectors:	Eight pin screw type connector
Total connecting points:	Eight (two input, two output, two sense, one shielding, one ground)
Size:	100mm x 180mm x 44mm
Weight:	Approximately 250 grams

***Can also be used to check slip ring and reaction torque transducers.**

CAPACITY LBS.	A	B	C	D	E	F
MODEL NO. 3108*						
5	500	500	3,200	550	550	6,000
10	350	350	1,600	390	390	4,300
MODEL NO. 3124						
5K	220	220	10	70	70	35
10K	220	220	5	77	77	48
15K	120	120	3.3	42	42	26
20K	79	79	2.5	27	27	17
25K	56	56	2	20	20	12
MODEL NO. 3127						
2,000K	0.10	0.10	0.04	0.01	0.01	0.03
MODEL NO. 3129						
150K	1.70	1.70	0.15	0.11	0.11	0.36
200K	1.20	1.20	0.14	0.09	0.09	0.25
300K	0.90	0.90	0.14	0.07	0.07	0.25
MODEL NO. 3130						
400K	1.07	1.07	0.06	0.02	0.02	0.10
500K	0.72	0.72	0.05	0.02	0.02	0.08
600K	0.53	0.53	0.05	0.01	0.01	0.07
800K	0.32	0.32	0.05	0.01	0.01	0.06
1,000K	0.30	0.30	0.05	0.01	0.01	0.05
MODEL NO. 3132						
500	38	38	100	20	20	50
1K	27	27	50	14	14	50
2K	20	20	25	11	11	50
3K	16	16	17	10	10	50
5K	13	13	10	10	10	50
MODEL NO. 3156						
25K	35	36	0.96	1	1	7
50K	12	12	0.50	0.50	0.50	3
100K	6	6	0.30	0.25	0.25	0.80
150K	3	3	0.30	0.20	0.20	0.80
MODEL NO. 3167*						
25	100	100	670	100	100	400
50	100	100	335	100	100	400
100	65	65	168	90	90	400
200	65	65	84	90	90	400
300	65	65	56	90	90	400
MODEL NO. 3169						
500	21	21	100	12	12	19
750	21	21	70	12	12	19
1K	21	21	50	12	12	19
2K	21	21	25	12	12	19
2.5K	21	21	21	12	12	19
3K	21	21	17	12	12	19
MODEL NO. 3173						
200	7	7	87	169	169	9
500	2	2	35	67	67	6
1K	2	2	18	34	34	4
2K	8	8	8	15	15	21
3K	6	6	6	11	11	14
MODEL NO. 3174						
5K	3	3	3	3.6	3.6	6
10K	1.30	1.30	1.50	1.20	1.20	1
20K	0.60	0.60	0.70	0.60	0.60	0.40

CAPACITY LBS.	A	B	C	D	E	F
MODEL NO. 3175						
50K	0.69	0.69	0.69	0.66	0.66	0.33
MODEL NO. 3176						
100K	0.29	0.29	0.34	0.15	0.15	0.11
MODEL NO. 3336*						
1K	15	15	11	7	7	0.60
2K	8	8	5.50	4	4	0.60
5K	32	32	2.50	1.50	1.50	10
10K	13	13	1.25	0.60	0.60	5
20K	7	7	0.63	0.30	0.30	1.30
MODEL NO. 3397*						
25	100	100	670	100	100	400
50	100	100	335	100	100	400
100	65	65	168	90	90	400
200	65	65	84	90	90	400
300	65	65	56	90	90	400
MODEL NO. 3603						
100K	14.30	14.30	0.50	2.60	2.60	1.60
200K	4.80	4.80	0.25	0.88	0.88	0.55
300K	2.60	2.60	0.17	0.48	0.48	0.30
400K	1.70	1.70	0.13	0.32	0.32	0.20
500K	1.30	1.30	0.10	0.32	0.23	0.14
MODEL NO. 3663						
50	65	65	500	100	100	400
100	65	65	500	100	100	400
200	65	65	250	100	100	400
300	65	65	160	100	100	400
MODEL NO. 3674						
1K	40	40	50	N/A	N/A	N/A
2K	40	40	25	N/A	N/A	N/A
5K	40	40	10	N/A	N/A	N/A
10K	40	40	5	N/A	N/A	N/A
20K	40	40	2.50	N/A	N/A	N/A
50K	17	17	1	N/A	N/A	N/A
MODEL NO. 6467*						
5K/IN.	6.20	6.20	0.50	2	2	2
10K	9	9	1.25	1.70	1.70	1
MODEL NO. 6468**						
25K/IN.	2.48	2.48	0.17	0.42	0.42	0.42
75K	1.08	1.08	0.17	0.12	0.12	0.06
MODEL NO. 6468**						
25K/IN.	2.48	2.48	0.17	0.42	0.42	0.42
50K	1.63	1.63	0.26	0.17	0.17	0.09
MODEL NO. 6469**						
50K/IN.	1.52	1.52	0.12	0.24	0.24	0.24
100K	0.94	0.94	0.13	0.09	0.09	0.05
MODEL NO. 6470**						
100K/IN.	0.82	0.82	0.08	0.12	0.12	0.12
200K	0.36	0.36	0.07	0.30	0.03	0.02

NOTE: See page 7 for maximum load limit equations.
*Models 3108, 3167, 3336 and 3397 are aluminum.
See page 7 for illustration technique.
**Both equations must be satisfied simultaneously.

MOTOR TESTING GLOSSARY OF TERMS

ABSORBING DYNAMOMETER—A machine which provides an opposing load to a device under test where the device under test is providing an OUTPUT. The ABSORBING DYNAMOMETER is usually instrumented with either an electrical or mechanical means of measuring TORQUE.

AMBIENT TEMPERATURE—Temperature of the surrounding medium.

BREAKDOWN TORQUE—The maximum TORQUE developed by an A.C. motor (with rated voltage and frequency applied) without an abrupt drop in speed.

DYNAMOMETER—A device for measuring mechanical power.

EFFICIENCY—For a motor or generator, the ratio of the useful power delivered to the total power supplied and usually expressed in percentage.

FULL-LOAD SPEED—For a motor or generator, the RPM available to do work at rated TORQUE capacity.

FULL-LOAD TORQUE—The TORQUE of a motor necessary to produce its rated HORSEPOWER at FULL-LOAD SPEED.

HORSEPOWER—Unit of power equal to 550 foot pounds per second or 745.7 watts. Also equal to TORQUE (in foot pounds) times RPM divided by 5,252.

INDUCTION MOTOR—Machine which converts AC power delivered to the STATOR into mechanical power.

LOCKED-ROTOR CURRENT—The steady-state line current with the ROTOR locked and with rated voltage (and rated frequency in the case of AC motors) applied to the motor.

LOCKED-ROTOR TORQUE—The minimum TORQUE developed by a motor for all angular positions of the ROTOR locked, and with rated voltage applied (and rated frequency in the case of AC motors). Also known as STATIC TORQUE.

RATING—For a motor or generator, the rated OUTPUT, together with any other characteristics such as SPEED, voltage and current assigned to it by the manufacturer.

MOTORING DYNAMOMETER—A machine which provides an OUTPUT to a device under test where the device under test acts as the opposing load. The MOTORING DYNAMOMETER is usually instrumented with either an electrical or mechanical means of measuring TORQUE.

OUTPUT—For a motor, the product of the TORQUE available to do work times the rated RPM.

POWER FACTOR—The ratio of the average power to the apparent power.

PULL-IN TORQUE—In a SYNCHRONOUS MOTOR, the maximum constant TORQUE under which the motor will pull its connected inertia load into synchronism, at rated voltage and frequency. PULL-IN TORQUE cannot be determined without knowing the inertia of all rotating components as well as the TORQUE of the load. TORQUE input is equal to TORQUE output plus or minus the inertia times acceleration.

PULL-OUT TORQUE—In a SYNCHRONOUS MOTOR, the maximum sustained TORQUE which the motor will develop at SYNCHRONOUS SPEED with rated voltage applied at rated frequency and with normal DC excitation to the field circuit.

PULL-UP TORQUE—In an AC motor, the minimum TORQUE developed by the motor during the period of acceleration from rest to the speed at which BREAKDOWN TORQUE occurs. For motors which do not have a definite BREAKDOWN TORQUE, the PULL-UP TORQUE is the minimum TORQUE developed up to the rated SPEED.

ROTOR—The rotating member of an electric motor or generator.

SLIP HEAT—Heat generated when more HORSEPOWER is put into a brake or clutch than is taken out. SLIP HEAT is expressed in terms of slip watts.

SLIP SPEED—In an INDUCTION MOTOR, the difference between the SPEED of the ROTOR. Slip is the ratio of SLIP SPEED to SYNCHRONOUS SPEED and is usually expressed as a percentage.

STATOR—Portion of an electric motor or generator which contains the stationary parts of the magnetic circuit with their associated windings.

SPEED—The time rate of change of position of a body without regard to direction. In rotating devices, usually expressed in RPM.

SYNCHRONOUS SPEED—The SPEED at which the field of an INDUCTION MOTOR turns. It is equal to 120 times the frequency of the AC divided by the number of poles in the machine and expressed in RPM.

TORQUE—That force which tends to produce or prevent rotation, specifically the moment of tangential effort. TORQUE is equal to the product of length and tangential effort.

TORQUE RIPPLE—Pole to pole variations of TORQUE in electric motors and generators.

GLOSSARY OF TERMS

ACCURACY—Stated as a limit tolerance which defines the average deviation between the actual output versus theoretical output.

In practical transducer applications, the potential errors of nonlinearity, hysteresis, non-repeatability and temperature effects do not normally occur simultaneously, nor are they necessarily additive.

Therefore, accuracy is calculated based upon the RMS value of potential errors, assuming a temperature band of ± 10ºF, full rated load applied, and proper setup and calibration. Potential errors of the readout, crosstalk or creep effects are not included.

AMBIENT CONDITIONS—The conditions (humidity, pressure, temperature, etc.) of the medium surrounding the transducer.

AMBIENT TEMPERATURE—The temperature of the medium surrounding the transducer.

ANGULAR LOAD, CONCENTRIC—A load applied concentric with the PRIMARY AXIS at the point of application, and at some angle with respect to the PRIMARY AXIS.

ANGULAR LOAD, ECCENTRIC—A load applied eccentric with the PRIMARY AXIS at the point of application, and at some angle with respect to the PRIMARY AXIS.

AXIAL LOAD—A load applied along a line concentric with the PRIMARY AXIS.

CALIBRATION—The comparison of transducer outputs against standard test loads.

GLOSSARY OF TERMS

CALIBRATION CURVE—A record (graph) of the comparison of transducer outputs against standard test loads.

COMBINED ERROR (Nonlinearity and Hysteresis)—The maximum deviation from the straight line drawn between the original no-load and RATED LOAD outputs expressed as a percentage of the RATED OUTPUT and measured on both increasing and decreasing loads.

COMPENSATION—The utilization of supplementary devices, materials or processes to minimize known sources of error.

CREEP—The change in transducer output occurring with time, while under load and with all environmental conditions and other variables remaining constant.

Note: Usually measured with RATED LOAD applied and expressed as a percent of RATED OUTPUT over a specific period of time.

CREEP RECOVERY—The change in no-load output occurring with time, after removal of a load which has been applied for a specific period of time.

CROSSTALK—With one component loaded to capacity, and the other unloaded, the output of the unloaded component will not exceed the percentage specified of its full-scale capacity.

DEFLECTION—The change in length along the PRIMARY AXIS of the load cell between no-load and RATED LOAD conditions.

DRIFT—A random change in OUTPUT under constant LOAD conditions.

ECCENTRIC LOAD—Any load applied parallel to, but not concentric with, the PRIMARY AXIS.

ERROR—The algebraic difference between the indicated and true value of the load being measured.

EXCITATION, ELECTRICAL—The voltage or current applied to the input terminals of the transducer.

FATIGUE CAPACITY—Capacity as a percentage of the nominal load limit capacity, and based on 100×10^6 cycles (minimum) from zero to full fatigue capacity and 50×10^6 (minimum) from full fatigue capacity tension to full fatigue capacity compression load.

HYSTERESIS—The maximum difference between the transducer output readings for the same applied load; one reading obtained by increasing the load from zero and the other by decreasing the load from RATED LOAD.

Note: Usually measured at half RATED OUTPUT and expressed in percent of RATED OUTPUT. Measurements should be taken as rapidly as possible to minimize CREEP.

INSULATION RESISTANCE—The DC resistance measured between the transducer circuit and the transducer structure.

Note: Normally measured at 50 volts DC and under STANDARD TEST CONDITIONS.

LOAD—The weight, torque or force applied to the transducer.

LOAD CELL—A device, which produces an OUTPUT signal proportionate to the applied weight or force.

NATURAL FREQUENCY—The frequency of free oscillations under no-load conditions.

NOMINAL LOAD LIMIT CAPACITY—It is the designed normal maximum capacity of a transducer. Output sensitivity of transducer is based on this capacity unless specified.

NONLINEARITY—The maximum deviation of the CALIBRATION CURVE from a straight line drawn between the no-load and RATED LOAD outputs, expressed as a percentage of the RATED OUTPUT and measured on increasing load only.

OUTPUT—The signal (voltage, current, etc.) produced by the transducer.

Note: Where the output is directly proportional to excitation, the signal must be expressed in terms of volts per volt, volts per ampere, etc. of excitation.

OUTPUT, RATED—The algebraic difference between the OUTPUTS at no-load and at RATED LOAD.

OVERLOAD RATING—The maximum load in percent of RATED CAPACITY which can be applied without producing a permanent shift in performance characteristics beyond those specified.

OVERLOAD STATIC RATING, ULTIMATE EXTRANEOUS LIMIT—Only one ultimate static extraneous load limit (200% of static extraneous load limit F_x or F_y or M_x or M_y or M_z) can be applied simultaneously with 100% of the nominal load limit capacity without producing a structural failure.

PRIMARY AXIS—The axis along which the transducer is designed to be loaded; normally its geometric centerline.

RATED CAPACITY (RATED LOAD)—The maximum AXIAL LOAD that the transducer is designed to measure within its specifications.

REFERENCE STANDARD—A force measuring device whose characteristics are precisely known relative to a primary standard.

REPEATABILITY—The maximum difference between transducer output readings for repeated loading under identical loading and environmental conditions.

RESOLUTION—The smallest change in mechanical input which produces a detectable change in the output signal.

SENSITIVITY—The ratio of the change in OUTPUT to the change in mechanical input.

SHUNT CALIBRATION—Electrical simulation of transducer output by insertion of know shunt resistors between appropriate points within the circuitry.

SHUNT-TO-LOAD CORRELATION—The difference in output readings obtained through electrically simulated and actual applied loads.

STANDARD TEST CONDITIONS—The environmental conditions under which measurements should be made, when measurements under any other conditions may result in disagreement between various observers at different times and places. These conditions are as follows:

Temperature: 72°±3.6°F (23°±2°C)
Relative humidity: 90% or less
Barometric pressure: 28 to 32 inches Hg

GLOSSARY OF TERMS

STATIC EXTRANEOUS LOAD LIMITS (300% of the Nominal Load Capacity)—Static extraneous load limits are calculated such that only one extraneous load (F_x or F_y or M_x or M_y or M_z) can be applied simultaneously with 50% of the nominal load limit applied.

TEMPERATURE EFFECT ON OUTPUT—The change in OUTPUT due to a change in TRANSDUCER TEMPERATURE.

Note: Usually expressed as a percentage of load per degree Fahrenheit change in TEMPERATURE.

TEMPERATURE EFFECT ON ZERO BALANCE—The change in ZERO BALANCE due to a change in TRANSDUCER TEMPERATURE.

Note: Usually expressed as the change in ZERO BALANCE in percent of RATED OUTPUT per degrees Fahrenheit (change in temperature).

TEMPERATURE RANGE, COMPENSATED—The range of temperature over which the transducer is compensated to maintain RATED OUTPUT and ZERO BALANCE within specified limits.

TEMPERATURE RANGE, SAFE—The extremes of temperature within which the transducer will operate without permanent adverse change to any of its performance characteristics.

TERMINAL RESISTANCE—The resistance of the transducer circuit measured at specific adjacent bridge terminals, at standard temperature, with no-load applied, and with the excitation and output terminals open-circuited.

TERMINAL RESISTANCE, EXCITATION—The resistance of the transducer circuit measured at the excitation terminal, at standard temperature, with no-load applied, and with the output terminals open-circuited.

TERMINAL RESISTANCE, SIGNAL—The resistance of the transducer circuit measured at the output signal terminals, at standard temperature, with no-load applied, and with the excitation terminals open-circuited.

TRACEABILITY—The step-by-step transfer process by which the transducer calibration can be related to primary standards.

ZERO BALANCE—The output signal of the transducer with rated EXCITATION and with no-load applied, usually expressed in percent of RATED OUTPUT.

ZERO RETURN—The difference in ZERO BALANCE measured immediately before RATED LOAD application of specified duration and measured after removal of the load, and when the output has stabilized.

ZERO SHIFT, PERMANENT—A permanent change in the no-load output.

ZERO STABILITY—The degree to which the transducer maintains its ZERO BALANCE with all environmental conditions and other variables remaining constant.

ORDERING INFORMATION

Lebow Products offers the following forms of payment for its services: MasterCard, Visa, American Express, purchase orders, wire transfers and letters of credit (for overseas purchases). For new customers, a credit reference is required.

VISA, MASTERCARD AND AMERICAN EXPRESS

When purchasing by credit card, please provide the following information: name on card, number and expiration date.

PURCHASE ORDERS

When placing a purchase with a purchase order, please provide the following information: bill to, ship to, purchase order number, model and quantity, brief description, total amount, phone and fax number, and purchasing contact. If you are a new customer, please include a credit reference sheet. If you do not have an established form for credit references, we can supply one.

WIRE TRANSFERS AND LETTERS OF CREDIT

When purchasing items using this form of payment, contact the factory for specific details.

SERVICES

Lebow Products has a fully staffed service department to handle your transducer repairs or recalibration requirements. Service contracts are also available. Contact us at our toll-free number, 1-800-803-0386.

VERIFICATION SERVICES

Dimensions and specifications are subject to change without notice. Certified drawings are available upon request for your installation, mounting or fixture requirements.

TERMS AND CONDITIONS

1. Cancellation: Orders accepted by us cannot be countermanded or deliveries deferred except with our consent and upon terms that will indemnify us against all loss.

2. Modifying or conflicting conditions: Seller does not make or accept any terms, guarantees, conditions or warranties of sales other than those contained in this acknowledgement or in any existing written contract between Buyer and Seller covering this material.

3. Credit acceptance: Shipments and deliveries shall at all times be subject to the approval of the Seller's Credit Department. In case the Seller shall have any doubt as to Buyer's responsibility, the Seller may decline to make any further shipments hereunder, except upon receipt of satisfactory security or payment in advance.

In case of bankruptcy or insolvency, invoices bearing deferred terms shall be considered as matured on the date of such bankruptcy or insolvency.

4. Claims: Claim for errors, deficiencies or imperfections will not be considered unless made with reasonable promptness after receipt of material. Material found defective when in the hands of original purchaser, and when properly used for the purpose for which sold, will be replaced or credit will be allowed for the price thereof, at the Seller's option, upon its return prepaid, but the Seller shall not be liable for any claims for labor or consequential damages, and material must not be returned except by permission of Seller.

5. Tolerances: Materials furnished by Seller are to be within limits and of sizes published by Seller and subject to Seller's standard tolerances for variation.

6. Deliveries: While we shall endeavor to schedule your order for delivery as nearly in accordance with your instructions as possible and advise you accordingly, we do not guarantee nor assume liability for failure to meet any delivery date.

7. Inspection: If orders are placed subject to inspection by the purchaser, such inspection must be made before shipment is made from our plant.

8. Equipment: All patterns, dies, tools, jigs, etc. are designed especially for use on our machines; and our charge includes only a portion of the actual cost. Therefore, payment of amount quoted for equipment does not convey title or the right to remove such equipment from our plant. It will be kept in repair by us for future order, but in event of no reorder for a period of three years, we reserve the right to scrap such equipment without further notice.

9. Over or under shipments: Because of many operations in the production of these parts, it is impossible to always produce the exact quantity ordered, and unless otherwise agreed upon, we must reserve the privilege of over and under shipment, but not to exceed 10% of the order in any case.

10. Shipping: All items are shipped at Buyer's risk. The responsibility of Seller ceases upon delivery of merchandise in good order to the carrier. If the material is received in bad condition, the Buyer should require agent of transportation company to make notation of delivery on freight bill and immediately file a damage claim.

11. Patents: The Seller shall protect and indemnify the buyer from and against all claims, damages, judgments and loss arising from infringement or alleged infringement of any United States patent by any of the articles or materials delivered hereunder, provided that in the event of suit or threat of suit for patent infringement, the Seller shall promptly be notified and given full opportunity to negotiate a settlement. Seller does not warrant against infringement by reason of Buyer's design of the articles or the use thereof in combination with other materials or in the operation of any process. In the event of litigation, the Buyer agrees reasonably to cooperate with the Seller. All parties concerned shall be entitled, in connection with any proceeding under the provisions of this Article, to be represented by counsel at their expense.

12. Taxes: Any tax or other government charge now or hereafter levied upon the production, sale, use or shipment of goods ordered or sold may, at the Seller's option, be added to the purchase price.

13. Miscellaneous: Failure of the Seller to enforce any of these conditions or to exercise any right accruing through the default of the Buyer shall not affect or impair the Seller's rights in case such default continues or in case of any subsequent default of the Buyer and such failure shall constitute a waiver of other or future defaults of the Buyer.

MODEL NUMBER INDEX

Worldwide customer support

At Honeywell, products are based upon technology aimed at providing you with enhanced quality and reliability. When service is needed, our customer support engineers and service centers are strategically located around the world to provide efficient and responsive support.

Honeywell Sensing and Control designs, manufactures and markets one of the industry's most extensive line of sensing and control technologies available from a single switch or sensor manufacturer. Honeywell aims to develop the right products that are delivered on time and work right the first time.

Phone and Fax:

Tel: 614-850-5000
Fax: 614-850-1111

E-Mail: sales@sensotec.com

Internet: www.honeywell.com/sensotec

WARNING

MISUSE OF DOCUMENTATION

- The information presented in this catalog is for reference only, DO NOT USE this document as product installation information.
- Complete installation, operation and maintenance information is provided in the instructions supplied with each product.

Failure to comply with these instructions could result in death or serious injury.

WARNING

PERSONAL INJURY

DO NOT USE these products as safety or emergency stop devices or in any other application where failure of the product could result in personal injury.

Failure to comply with these instructions could result in death or serious injury.

Warranty/Remedy

Honeywell warrants goods of its manufacture as being free of defective materials and faulty workmanship. Honeywell's standard product warranty applies unless agreed to otherwise by Honeywell in writing; please refer to your order acknowledgement or consult your local sales office for specific warranty details. Honeywell warrants goods of its manufacture as being free of defective materials and faulty workmanship. If warranted goods are returned to Honeywell during the period of coverage, Honeywell will repair or replace, at its option, without charge those items it finds defective.

The foregoing is buyer's sole remedy and is in lieu of all warranties, expressed or implied, including those of merchantability and fitness for a particular purpose. In no event shall Honeywell be liable for consequential, special, or indirect damages.

While we provide application assistance personally, through our literature and the Honeywell web site, it is up to the customer to determine the suitability of the product in the application.

Specifications may change without notice. The information we supply is believed to be accurate and reliable as of this printing. However, we assume no responsibility for its use.

Sensing & Control
Lebow Products
Honeywell International Inc.
2080 Arlingate Lane
Columbus, Ohio 43228
www.honeywell.com

Honeywell

CAT010610.0
January 2006