INSTALLATION AND OPERATION GUIDE FOR HIMMELSTEIN
STRAIN GAGE REACTION TORQUEMETERS
INCLUDING HOLLOW* & SOLID FLANGED, SQUARE DRIVE & FLAT TYPES
WITH
MV/V AND 10 VOLT OUTPUTS
See separate manual for C-Face Reaction Torquemeters

Customer: . . . .

Model Number: . . . .   Serial Number: . . . .

Factory Reference Number: . . . .

Rated Torque (lbf-in): . . . .

Torque Overload Capacity (lbf-in): . . . .

Output: ( ) mV/V   ( ) ±10 Volt

Special Features: . . . .
                 . . . .
                 . . . .
                 . . . .
                 . . . .
                 . . . .
Readout/Power Supply Furnished: ( ) Yes   ( ) No
        If Yes, Readout Model Number: . . . .

Calibration Data is listed in the attached Calibration Certificate

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i. Introduction

Himmelstein Strain Gage Reaction Torque Sensors provide static and dynamic measurement of driver and load device torque. A variety of mechanical configurations are available including square drive, solid flanged, hollow flanged, flat and NEMA C-Face (see separate manual) types.

All measure torque whether the shaft is rotating or stationary. They have high safety margins and stiffness, have low deflection and are bidirectional, i.e., their output polarity follows the torque direction.

Millivolt/Volt (mV/V) and ±10 Volt outputs are offered. The mV/V output is available on all styles except the CF2700V Series. The ±10 Volt output is available on the larger solid flanged units and the hollow bore CF2700V.

Himmelsteins' Series 700 instruments provide power, engineering unit torque display, capture max/mins, evaluate limits, interface a PC and much more. When a speed sensor is provided, they can also display speed and computed shaft power.

A. Mechanical Installation

A.1 Reaction Torque Measurement Explained

Reaction torque measurements are based on Newton's third law of angular motion which states, "when a body exerts a torque upon another body, the second exerts an *equal torque* upon the first in the *opposite* direction and about the same axis of rotation".

To avoid extraneous load errors (see Sections A.3 & D.3), the reaction torque path must be through the torquemeter only. A correctly installed reaction sensor will accurately measure static and dynamic torque whether the test device rotates or is stationary.

Referring to Figure 1, using appropriate electronics, the test set-up can readily determine clutch applied torque and, when it slips, clutch peak or slip torque.
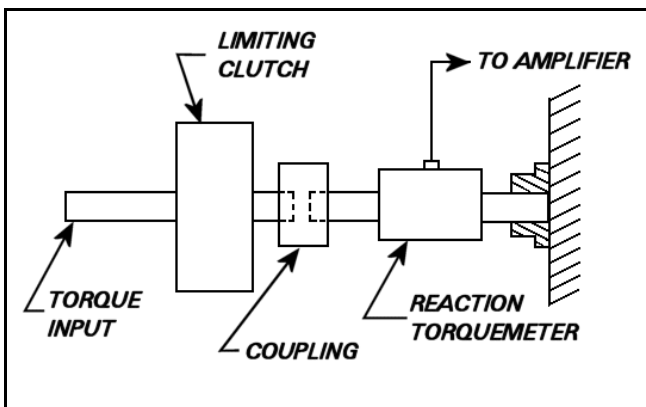

Figure 1. Measuring Clutch Slip Torque

Figure 2 shows a hollow reaction torquemeter measuring the output torque of an air tool. The torquemeter will accurately measure the instantaneous tool output torque even though it rises rapidly (in milliseconds) as the fastener seats. *However, all the reaction torque must pass through the torquemeter* - a rotating union (or equal) must be used at the air supply end to eliminate shunting part of the reaction torque through the air lines and thus producing a measurement error. Although it is possible to satisfy this requirement (no unwanted shunt torque paths) in an air tool application, many other applications can have significant, unavoidable shunt torque paths which, in turn, will limit the measurement accuracy. An in-line torque measurement should be used in such cases.
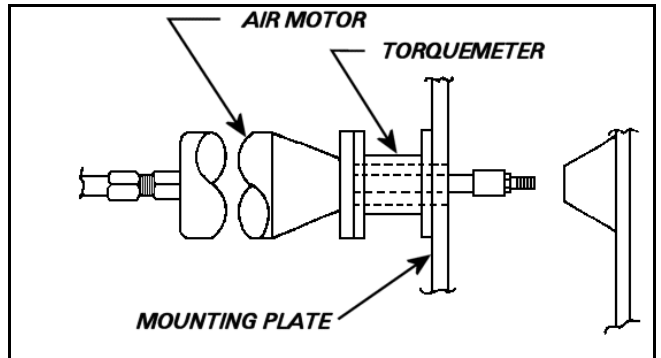

Figure 2. Air Tool Torque Measurement

Figure 3 shows a measurement similar to Figure 2, but *with a very important difference.* The torquemeter measures the reaction of the *power absorbing device* instead of the *power producing device.* Assuming no extraneous loads, the torquemeter sees the *total reaction torque of the absorber, but that torque is not necessarily equal to the motor output torque.*

During acceleration (or deceleration), the motor torque equals the sum of load inertia torques, total load windage torques, extraneous torques and the pumps work load torque. The inertia torques are the product of angular acceleration and all rotor inertias except the motors.
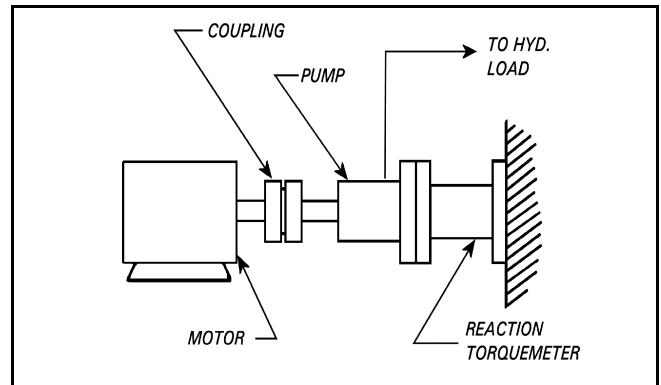

Figure 3. Measuring Absorber Torque

No reaction measurement can see, or measure, either the inertia or windage torques. As a result, in a setup like this, reaction torque measurements will be in error to the extent they, and extraneous load torques, exist. The acceleration error component disappears during constant speed conditions, but the windage error and extraneous load components are always present. Only in-line torque measurements are immune to these error sources.

When *angular motion is limited and test cycle rates are low enough to permit "cable windup"* without wire fatigue, reaction sensors are an economic torque measurement solution. Figure 4 illustrates such an application.
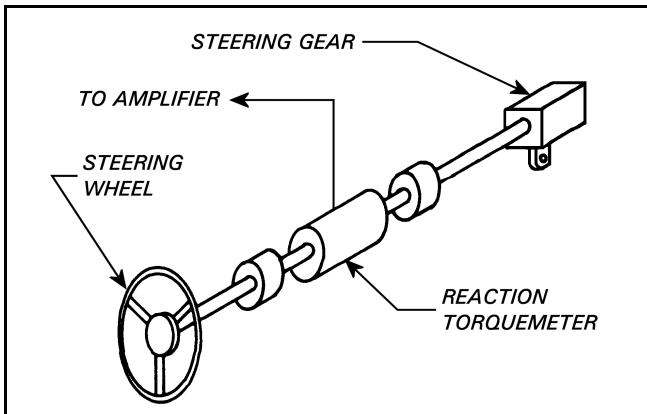

Figure 4. Shaft Torquemeter Senses Rotating Torque

A.2. Installation Discussion
To measure reaction torque, one end of the sensor must be mechanically grounded. The ground may be direct, as in Figures 1, 2 and 3, or it can be through the Load or Driver as in Figures 5 and 6. As noted on those figures, the sensor is installed on the device whose torque is to be measured and the ground is made via the other device.
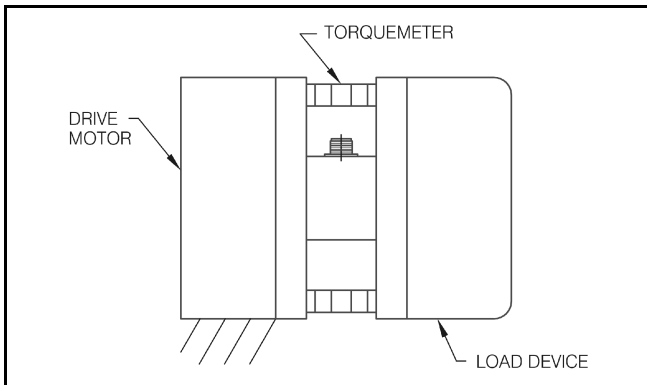

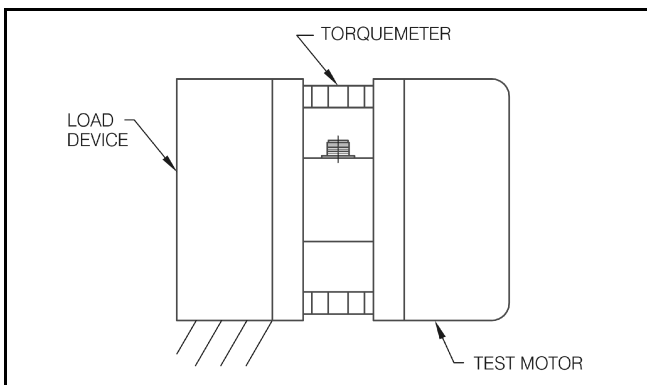Figure 5. C-Face Torquemeter Measures Load Torque

Figure 6. C-Face Torquemeter Measures Motor Torque

A.3. Extraneous Loads
Any force or moment sensor input, other than the reaction torque is an *extraneous load.* Depending on the installation (see Figures 7 and 8), these could include bending moments and axial thrust (tension or compression). The Bulletin describing your torquemeter lists the maximum safe *extraneous loads* that can be applied, assuming they act singly. Crosstalk errors from those loads are typically 1% to 2% and, assuming they are constant, can be electrically canceled.

$$W = \text{weight of test item}$$

$$F = \text{thrust force, if any}$$

$$d = \text{distance to test item center of gravity}$$
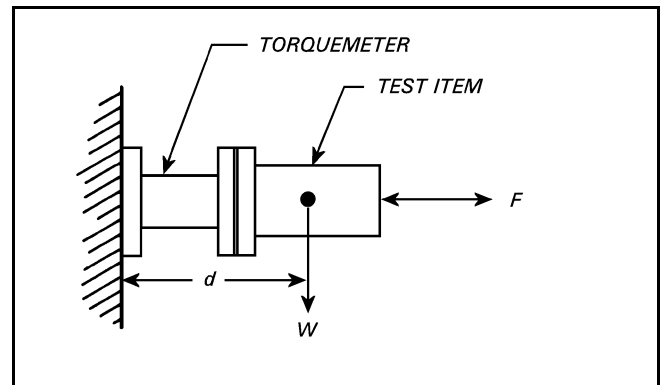
$$W{\times}d = \text{bending moment}$$

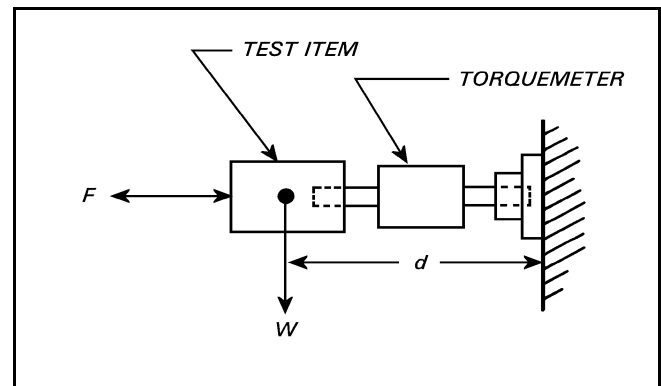Figure 7. Extraneous Load Definition for Flanged Sensor

Figure 8. Extraneous Load Definition for Shaft Sensor

B. Electrical Installation

B.1 Signal Polarity
B.1.1 Definition of Torque Direction
A clockwise (CW) torque is defined as one that will cause shaft rotation in the CW direction *when viewed from the driven end.* A counterclockwise (CCW) torque will cause CCW shaft rotation *when viewed from the driven end.*

B.1.2 Output Signal Polarity (Applies to all Models)
With CCW torque applied to the torquemeter, the output signal is positive. When CW torque is applied to the torquemeter, the output signal is negative.

B.2 Torquemeter Connections
B.2.1 ±10V Output (V Suffix) Torquemeters

Pin	Function
A	+Power Input (See Appendix 1)
B	Power Return (Do not use for Signal Return)
C	No Connection
D	Signal Common (Do not Use for Power Return)
E	Signal Out (0±10V Analog of Torque)
F	Remote Cal (Short to Pin D to Enable Cal)

A mating connector with strain relief and boot is furnished. Use P/N 320-1079 to order additional connectors.

Figure 9 shows recommended cabling. When using a Himmelstein Model 703, 733, or 723 Signal Conditioner, specify torque cable P/N 224-7696V-XX where XX is the cable length in feet, i.e., XX = 20 for 20 feet.

Refer to Section B.3 for a discussion of *valid earth grounds* and to Section B.4 for use with *IGBT-based Variable Frequency Drives (VFD's).*

B.2.2 mV/V Output (M Suffix & No Suffix) Torquemeters

Pin	Function
A	+ Excitation (See Appendix 1)
B	+ Excitation Sense
C	- Excitation Sense
D	- Excitation
E	- Signal
F	+ Signal

A mating connector with strain relief and boot is furnished. Figure 10 illustrates the cabling for 6 wire connections - they are preferred for accuracy. Use P/N 224-5360 to order additional cables, **except for the models listed in the following Table.**

Model	Mating Connector
2200, Solid Low Capacity	320-1280
1810 (current product)	320-1280
1810 (old style product)	320-1037

Figure 10 shows recommended cabling. When using a Himmelstein Model 701, 708, 711, 788, 721, or 728 Signal Conditioner, specify torque cable P/N 224-3642V-XX where XX is the cable length in feet, *except for the models tabulated below.*

Model	Mating Cable
2200, Solid Low Capacity	224-8147V-XX
1810 (current product)	224-8147V-XX
1810 (old style product)	224-3907V-XX

Refer to Section B.3 for a discussion of *valid earth grounds* and to Section B.4 for use with *IGBT-based Variable Frequency Drives (VFD's).*
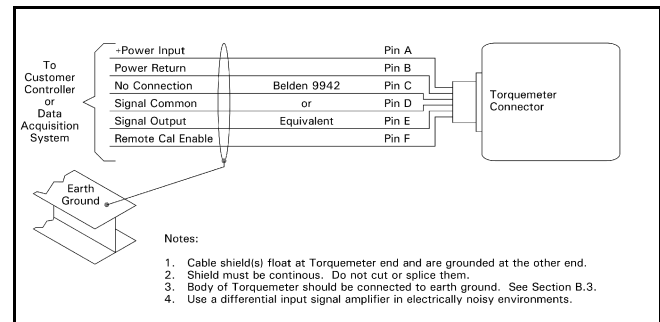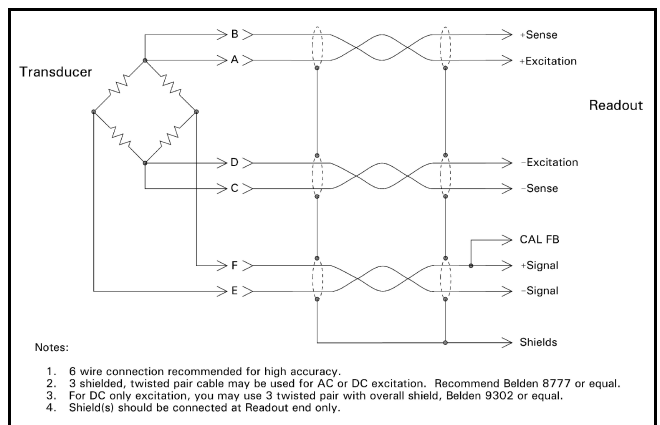

Figure 9. Cable Diagram for ±10V Output Torquemeters

Figure 10. Cable Diagrams for mV/V Torquemeters

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B.3 Valid Earth Ground Connection

Connect the <u>sensor body</u> directly to <u>earth ground</u> - *a buildings' steel frame or a 6' copper rod driven into the floor.* Run <u>separate grounds</u> *between it, the machine base, the sensor end* <u>closest to the drive motor</u>, *the data acquisition/computer/controller ground and the motor frame* <u>*end farthest from the sensor body*</u>*. See Figure 11 for details. Do not ground both torquemeter ends.*

The above directions are especially important when an electric drive is used. Grounding is normally not as critical when the drive is non-electric; i.e., is hydraulic or air.

B.4 CAUTION - When Using Variable Frequency Drives

If an IGBT-based variable frequency drive (VFD) is used, <u>follow its installation manual</u>. Improperly installed VFD's can cause reading errors from excessive noise, and premature motor and cable failures. VFD's should have shielded power and motor cables. Belden Types 29500 thru 29507cable are designed for VFD use. For a discussion of connection methods, see "Cable Alternatives for PWM AC Drive Applications" available at www.belden.com. Himmelstein recommends the connection shown in Figure 20 of that Belden document. <u>For best results, use a differential input amplifier in these electrically noisy environments.</u>
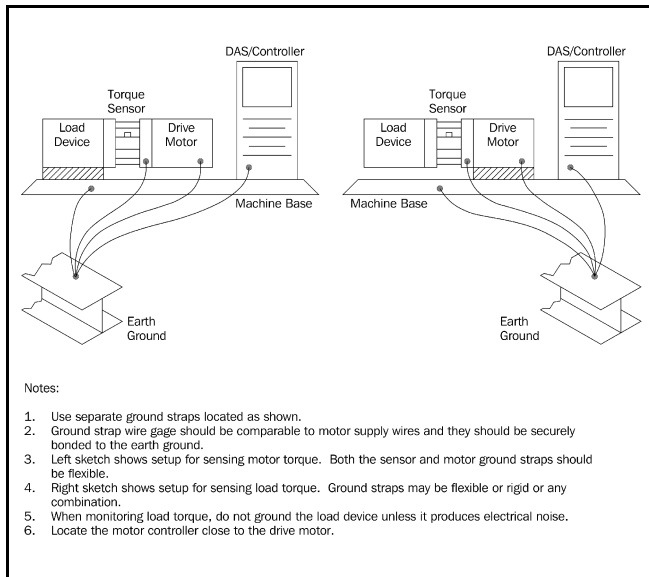

Notes:

1. Use separate ground straps located as shown.
2. Ground strap wire gage should be comparable to motor supply wires and they should be securely bonded to the earth ground.
3. Left sketch shows setup for sensing motor torque. Both the sensor and motor ground straps should be flexible.
4. Right sketch shows setup for sensing load torque. Ground straps may be flexible or rigid or any combination.
5. When monitoring load torque, do not ground the load device unless it produces electrical noise.
6. Locate the motor controller close to the drive motor.

Figure 11. Correct System Earth Grounding

B.5 ±10V Output Sensor DC Power Supply Caution

Do not connect the sensor to a power supply that also drives inductors or solenoids. Induced switching transients may cause damage or blow fuses. Some switching supplies create noise issues. Either use a quiet, low noise switcher or a linear power supply.

C. Operating Controls and Adjustments

C.1 mV/V Output Sensors

These sensors have direct connection to the strain gage bridge and do not have any onboard controls. Such controls and adjustments are part of the external, customer furnished, signal conditioner.

C.1.1 mV/V Output Sensor Calibration

The sensor was dead weight calibrated in Himmelsteins' accredited calibration laboratory (see Section C.3 for details). A Calibration Certificate documenting NIST traceability is attached. That Certificate includes the sensors full scale output.

mV/V Output Sensors have their output stated in mV/V for both CW and CCW torques. Also included are the equivalent torque and mV/V output of a shunt calibration resistor. The calibration resistor is shipped with the sensor. To duplicate the factory setup, it must be installed between +Signal and ±Excitation Sense in the users signal conditioner.

C.2 ±10V Output Sensors
C.2.1 Standard Output Signals

These sensors are factory calibrated to provide the following Output Signals.

Driveline Torque	Output Signal
Zero	0.00 Volts
CW[1] Full Scale	-10.00 Volts
CCW[1] Full Scale	+10.00 Volts

1. Torque direction is through the sensor.

The following Sections describe field adjustments.

C.2.2 Remote Calibration Feature

The sensor was dead weight calibrated in Himmelsteins' accredited calibration laboratory (see Section C.3 for details). A Calibration Certificate documenting NIST traceability is attached. That Certificate includes the Internal Calibration Torque Value determined during calibration and the output voltage it produces.

When Remote Calibration is enabled, by shorting connector Pin F to Pin D, the torquemeter will output the Calibration Torque and Output Voltage listed on the Calibration Certificate. Please note, **this procedure should be done with zero torque on the driveline. If calibration is done when the driveline torque is not zero, then the calibration signal will add algebraically with the driveline torque.**

CAUTION: **If you install a Calibration Enable switch, use a momentary type.** That will avoid inadvertent injection of the calibration signal and possible measurement errors.

C.2.3 Zero and Span Adjustment

These adjustments must be made with zero torque on the driveline. To achieve zero torque in installations that can "lock-in" friction torques (between gear drives, on a pump drive or other sealed shafts, etc.), break or disconnect one of the shaft couplings. User controls are located on the sensor housing. Proceed as follows:

1. Unscrew and remove the **Span/Zero Pot** covers.

2. Adjust the *Zero control* for zero torque output, i.e., 0.00 Volts.

3. *Activate and maintain the cal enable*, then adjust the **Span control** for the calibration torque voltage listed on the attached Calibration Certificate.

4. Release the *cal enable* and verify the output is 0.00 Volts. If necessary, re-adjust the **Zero control**. Then, repeat steps 2 and 3 until the output is 0.00 Volts when the torque is zero, and the calibration torque output matches the value listed on the Calibration Certificate.

5. Replace the **Span/Zero Pot** covers.

The torquemeter is now calibrated, its output will be 10.00 Volts when full scale torque is applied and 0.00 Volts at zero torque. For other torques, the output will vary linearly, i.e., at half scale it will be 5.00 Volts, at 20% of scale it will be 2.00 Volts, etc.

C.3 Factory NIST Traceable Dead Weight Calibration

All sensors are dead weight calibrated in our calibration laboratory. Calibrations are bidirectional with seven to ten steps (model dependent) in both the CW and CCW directions.

Data is reported in the attached Calibration Certificate which includes measurement uncertainty values as well as traceability evidence. During calibration the torque equivalent of the internal calibration network is determined and documented on the Certificate.

Unless you have accurate, accredited calibration facilities, do not substitute a field calibration for the factory calibration. Rather, use a field calibration as a rough check on normal operation and rely on the factory calibration for accurate results.

C.3.1 Calibration Laboratory Accreditation

Himmelsteins' Calibration Laboratory is accredited by NVLAP, an arm of the NIST (Lab Code 200487-0). To obtain more information on the accreditation visit our website at www.himmelstein.com or, follow the accreditation link at www.nist.gov.

C.3.2 Calibration Intervals

For continuous or intermittent service, make periodic Calibration Checks using the on board calibration networks or shunt calibration resistor described above, whichever is applicable to your sensor.

In applications requiring high accuracy, perform a **dead weight calibration in an accredited calibration torque laboratory at intervals specified by your QC procedures.** If you do not have an established procedure, then we recommend an initial one year interval.

If your Sensor is overloaded or operates abnormally, then calibrate/inspect it at once. Himmelstein offers certified dead weight calibration service, traceable to NIST, for all its products. Its calibration laboratory is accredited by NVLAP; see Section C.3.1.

D. Operating and Safety Considerations

D.1 Applicability

This Section applies to mV/V and ±10V Output devices.

D.2 Allowable Torque Loads
D.2.1 Overload Considerations

Himmelstein Reaction Senors have torque overload ratings between two (2) and five (5) times their full scale rating, model dependent. The overload rating of your sensor is listed on the cover sheet. The torque sensor will not yield (evidenced by a non-return to zero) if subjected to an *instantaneous peak torque* up to its overload value.

Full scale and overload ratings are based on the peak stress seen by the transducer. They are independent of stress duration, except for cyclical (or fatigue) loading. Virtually all rotary power producing and absorbing devices produce pulsating rather than smooth torque. Thus, in addition to its average torque value, the driveline torque usually includes a fundamental (driving) frequency and superimposed harmonics. Those torque perturbations can be multiplied when driveline resonance occurs. Additionally, in production and other real-world applications, accidental loads and other unforseen events can produce higher than expected torque levels.

For these reasons, reserve the region between the peak instantaneous torque and the sensor overload rating as a safety margin for unexpected loads. Do not knowingly operate in the overload region. When torques are expected to reach or exceed the full scale rating, change to a higher capacity sensor or one with a higher overload rating.

D.2.2 Fatigue Considerations

The sensor has infinite fatigue life with full torque reversals equal to or less than half the overload rating. If instantaneous peak torques exceed 50% of the overload rating, fatigue failure can occur.

When operating with peak torques greater than 50% of the overload, fatigue life is a function of several factors. They include the torque magnitude, the magnitude and type of extraneous loads simultaneously applied, the total number of loading cycles, the driveline damping, etc.
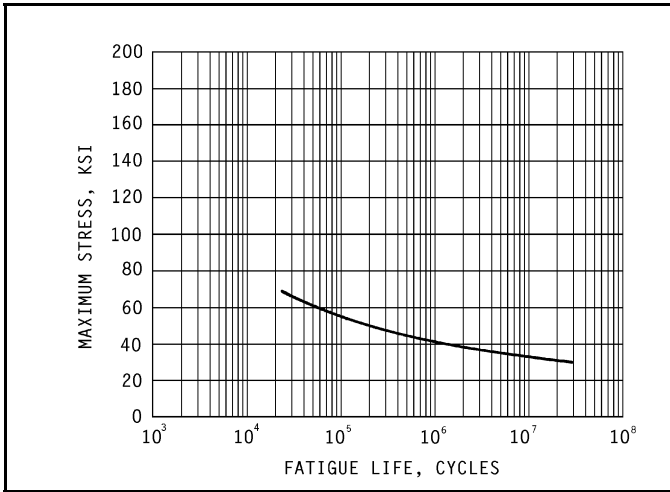

Figure 12. Typical Fatigue Life Characteristics

D.3 Allowable Extraneous Loads

Any force or moment the sensor sees, other than the reaction torque input, is an extraneous load. Depending on the installation, they can include bending moments and axial thrust; see Figures 7 and 8. Rated Torque can be simultaneously applied with rated bending or thrust loads without damage, provided the extraneous loads are applied singly. Typical extraneous load crosstalk is 1 to 2%. Crosstalk signals can be electrically canceled. Refer to Section A.3.

D.3.1 Bending Loads

Allowable bending loads are model dependent. Most range from half rated torque to eight times rated torque. Please refer to Model Specifications for complete ratings.

D.3.2 Thrust Loads

Allowable thrust loads are model dependent. Most range, in lbf, from rated torque, in lbf-in, to twenty times rated torque. Please refer to Model Specifications for complete ratings.

D.4 Contaminants

These devices should not be exposed to corrosive or electrically conductive fluids. They are not waterproof although they are water resistant. Pure water and hydrocarbon lubricants have no effect on operation. As a precaution, they should be shielded from direct liquid spraying.

D.5 Hazardous Environments

If used in a hazardous environment, the sensors must be connected via approved safety barriers. Safety barriers are sealed, passive networks installed in each wire that connects the hazardous and safe locations. They limit electrical energy passing between the two locations to a safe value.

Appendix 1.
Tabulation of Allowable Excitation Voltages

Model	Type	Output	Maximum Excitation Voltage
2010 thru 2092	Hollow Flange	mV/V	10V ac or dc
2137	Flat	mV/V	10V ac or dc
2200M	Miniature Solid Flange	mV/V	8V ac or dc
2201M	Low Range Solid Flange	mV/V	10V ac or dc
2202M thru 2207M	Solid Flange	mV/V	15V ac or dc
2208M and 2209M	Square Drive	mV/V	15V ac or dc
2202V thru 2205V	Solid Flange	±10V	13.5 to 24VDC
CF2756V thru CF2784V	NEMA Hollow C-Face	±10V	15 to 26 VDC

Power Supplies For ±10 Volt Output (V Suffix)Torquemeters

V Suffix torquemeters require a unipolar supply with an output voltage meeting the tabulated values. However, you should not connect these torquemeters to a power supply that also drives inductors or solenoids. Induced switching transients may cause damage or blow fuses. Use a Linear rather than a Switching power supply. Some Switching supplies can cause noise issues.