MCRT® mV/V TORQUEMETER

INSTALLATION, OPERATION

AND

TROUBLE SHOOTING GUIDE

REVISION F

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TABLE OF CONTENTS

* Includes discussion of shaft seals.

i. Introduction

When installed between a driver and load, MCRT® torquemeters measure static and dynamic shaft torque. Torque sensing employs field proven, strain gage technology. A corrosion resistant, one piece shaft is gaged with one or more bridges. The bridge measures torque and, in combination with the torsion element design, cancels signals from bending and thrust loads. Careful temperature compensation eliminates zero, span and calibration drift.

ii. Condensed MCRT® Torquemeter Specifications

The tabulation lists general specifications applicable to standard products. The full scale capacity of standard products range from 10 ozf-in to 4,000,000 lbf-in. See product literature for complete details. The *Enhanced Accuracy* option is available on most shaft-type torquemeters.

General Specifications*

	Standard Accuracy	Enhanced Accuracy
Nonlinearity** (% of F.S.)	±0.1	±0.05
Hysteresis (% of F.S.)	±0.1	±0.05
Nonrepeatability (% of F.S.)	±0.05	±0.02
Temperature Effects		
Zero (% of F.S./°F.)	±0.002	±0.001
Span (% of Rdg./°F.)	±0.002	±0.001
Compensated Range (°F.)	+75 to +175	
Maximum Usable Range (°F.)	- 65 to +225	
Nominal Output (mV/V)	1.5 or 4	
Zero Balance (% of F.S.)	±1.0	

* Subject to change without notice.
** End point method.

iii. Rotary Transformer, Non-contact Signal Coupling

Rotary transformers connect the rotating bridge to the stationary readout device. These proprietary devices offer superb signal transfer between rotating and stationary circuits. They exhibit extraordinary immunity to wear, noise, mechanical vibration, impact damage and fluid contamination. Additionally, the rotary transformer provides excellent shielding from external magnetic fields. All models (except MCRT® 28000TB) incorporate noise hardening to EMI from adjustable speed drives and enhanced magnetic field immunity.

The torquemeter housing is compact and includes integral bearings. Most torque ranges are available in several mechanical styles. A shaft style torquemeter is illustrated in Figure 1. Its rugged, non-ferrite construction is typical of MCRT® devices.

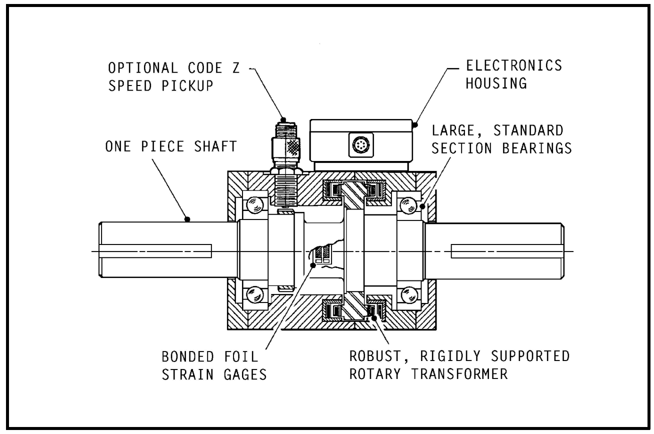


Figure 1. Typical Torquemeter Construction

iv. Readout Considerations

MCRT® mV/V torquemeters require a signal conditioner (carrier amplifier) with sinusoidal (a-c), not d-c, excitation. They operate with carrier frequencies between 2.4 and 6 Khz, but are *optimized for 3 Khz.*

Signal conditioners *must provide these essential functions:*

- 3 to 6 volts rms of 3 kHz sinusoidal drive,
- the ability to null any cabling unbalance,
- adjustable span capable of producing the desired signal output,
- phase sensitive demodulation,
- removal of the carrier frequency and its harmonics from the signal.

Appendix I lists additional, non-essential amplifier features. They are desirable because they *improve accuracy, noise immunity and operating convenience.*

A. Mechanical Installation

A.1 Applicability

This discussion is applicable to MCRT® shaft, and flanged torquemeters. Except for the coupling paragraphs, it also applies to splined torquemeters. Appendix IV contains installation data specific to splined units. Installation considerations for wheel and pulley types appear in their Technical Specifications.

A.2 Coupling Selection
The torquemeter installation method dictates the type of coupling needed. There are two installation methods, i.e., a *floating shaft* and a *foot mount.*

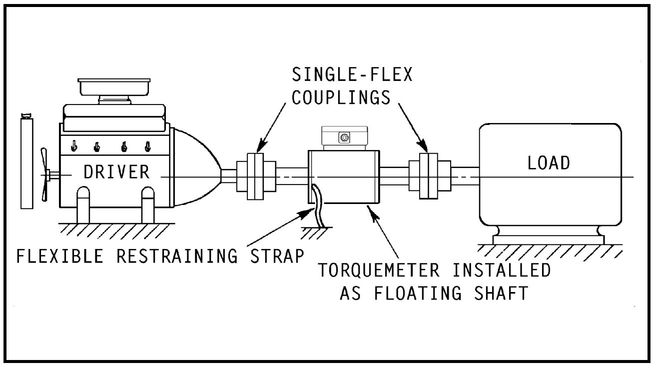


Figure 2. Floating Shaft Installation

Floating shaft installations are applicable to both shaft and flanged type torquemeters. A *single flex coupling* is installed at each shaft end. It takes out angular misalignment, and the torquemeter "tilts" to take out parallel misalignment. Use a *flexible strap* to prevent housing rotation and to strain relieve the torque cable.

Install a foot mounted torquemeter between *double flex couplings* as shown. The double flex couplings accommodate both parallel and angular misalignments.

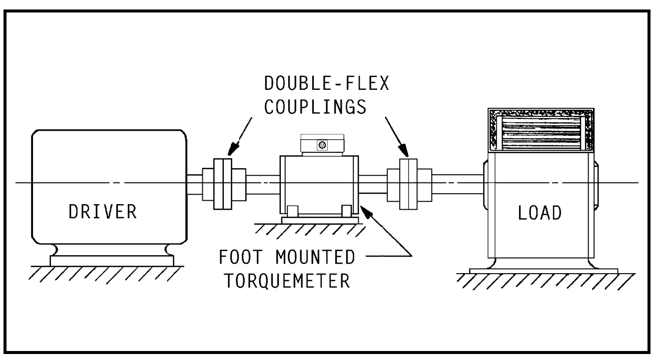


Figure 3. Foot Mounted Installation

Appendix II discusses the choice of a foot mounted or a floating shaft installation. It also contains additional comments on coupling selection. *For either installation method,* choose couplings that will handle the:

- expected shaft end float
- parallel and angular misalignments
- maximum expected shaft speed
- maximum expected shaft torque
- expected extraneous loading

A.3 Coupling Installation
Use a slight interference fit (0.0005 inches per inch of shaft diameter) and follow the coupling manufacturers' instructions. Before installation, lightly coat the torquemeter shaft with an anti-seizing compound suitable for use at 400°F. Next, heat the coupling hub, *not the torquemeter,* to approximately 400°F. Then, install the coupling.

The heated coupling hub should "slip" on the torquemeter shaft without significant resistance. That is, the coupling installation force shouldn't exceed 10% of the axial load tabulated in ¶C.3. Next, allow the assembly to cool to room temperature. Then, repeat the process for the second coupling.

If desired, use forced air to accelerate cooling. Air cooling avoids contaminating the torquemeter with anti-seizing compound. If cooling is speeded with water dampened rags, *orient the torquemeter to prevent entry of water mixed with anti-seizing compound.* Otherwise, internal damage can occur.

After coupling installation, verify that

- clearance exists between the coupling and torquemeter stator, and

- the shaft-to-coupling fit is snug enough to prevent vibration induced coupling motion.

To Avoid Damage Or Injury

- *Use fixturing to support the shaft.*
- *Use insulated gloves when handling hot parts.*
- *Stop the hub installation if the pressing force exceeds a few pounds. Remove the coupling. Cool all parts, and then inspect for burrs on the coupling bore, shaft, keys and keyways. If the parts are burr free, check the bore size and verify the coupling keyway squareness.*
- *Don't allow fluids to drip inside the torquemeter.*
- *Use protective guards over rotating components.*

A.4 End-to-End Orientation

A.4.1 Effect on Signal Polarity

MCRT® torquemeters are bidirectional. Their output polarity will reverse when the direction of transmitted torque reverses. A clockwise (CW) torque will produce a positive output with standard Himmelstein cables and readouts. A counterclockwise (CCW) torque produces a negative output. Himmelstein uses the following convention for torque direction.

CW Torque: shaft turns *CW, when viewed from the driven end*
CCW Torque: shaft turns *CCW, when viewed from the driven end*

Reversing a torquemeter end-for-end doesn't change the torque direction or magnitude. Therefore, it will have no effect on the torquemeter output signal. To reverse the signal polarity, order a reverse polarity cable. Alternatively, interchange the wires at pins E and F of the torque cable; make this change only at the torquemeter end of the cable.

A.4.2 Effect on Torquemeter Thrust Capacity

Orienting a foot mounted torquemeter per Figure 4 will provide increased unidirectional thrust capacity. Because dynamic thrust loading is usually bidirectional, it's safest to limit bearing axial (thrust) loads per ¶C.3. Orientation does not affect the thrust capacity of torquemeters installed as floating shafts.

When axial bearing loads are *unidirectional,* the orientation illustrated in Figure 4 increases the unidirectional thrust rating by a factor of four (4). The

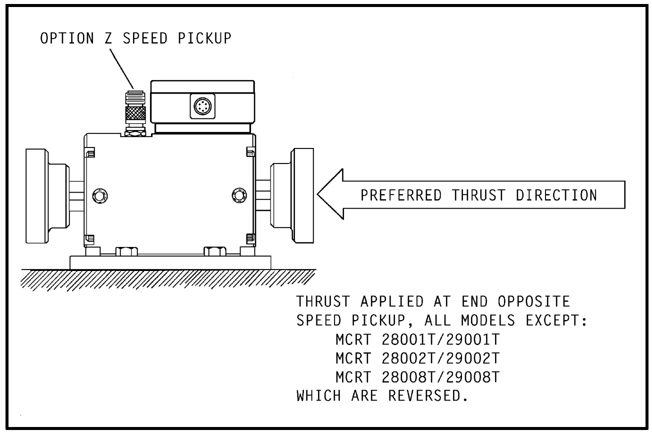


Figure 4. Preferred Thrust Path

MCRT® 3 Series torquemeters are an exception. Optimum orientation increases their unidirectional thrust rating by a factor of three (3). Remember, the *increased unidirectional rating applies to the optimum orientation only.*

A.5 Vertical Installations & Belt/Chain Drives

These installations require special mounting and coupling considerations. See Appendix III for vertical installations and Appendix XI for belt and chain drives.

A.6 Splined Torquemeter Installation

Refer to Appendix IV when installing a splined torquemeter.

B. Electrical Installation

B.1 Applicability

This section applies to all MCRT® mV/V Torquemeters except Series MCRT® 3120TA/31200T and MCRT® 27000T.

B.2 Torque Signal

B.2.1 Torque Connector Pinout

Pin designations shown in parentheses apply to the MCRT® 28000TB/29000TB models.

Pin	Function	Pin	Function
A (1)	+Excitation	D (4)	- Excitation
B (2)	+Excitation Sense	E (5)	- Signal
C (3)	- Excitation Sense	F (6)	+ Signal

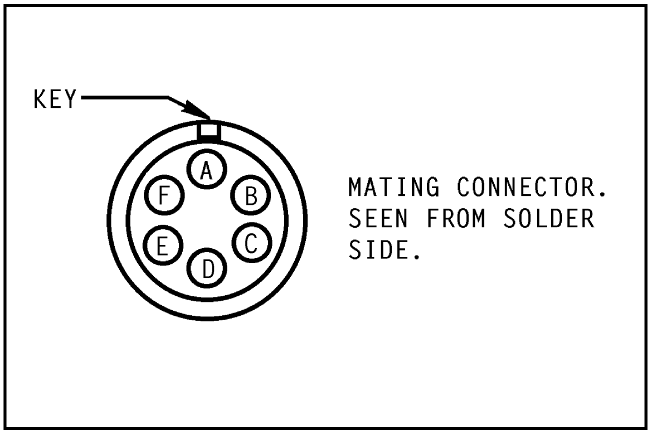


Figure 5. Torque Connector

Mating Connectors:

MS-3106A-14S-6S (SHC P/N 224-5360*) all models except MCRT® 3-08T/3L-08T & MCRT® 28000T/29000T which use Winchester SRM7C0300X (SHC P/N 320-1037). MCRT® 28000TA/29000TB use Conxall 6282-6SG-516 (SHC P/N 320-1280).

*SHC P/N includes cable clamp and boot assemblies.

B.2.2 Torque Cabling

For carrier amplifier connections, refer to the manufacturers' manual. Use stranded, *individually shielded, twisted wire-pair cables.* Recommended cable types are: Belden Type 8723 (or equal) for 4 wire connections, Belden Type 8777 (or equal) for 6 wire connections, and Belden Type 8778 (or equal) for 7 wire connections. Don't use unshielded or single shielded cables.

Six wire cables, combined with suitable carrier amplifiers, add an excitation sense function. The combination regulates the excitation *at the torquemeter* rather than *at the amplifier* as is the case for four wire cables. This action corrects for changes in the excitation lead resistance with temperature.

Seven wire cables add a calibration feedback connection. That refinement theoretically makes "shunt calibration circuits" immune to changes in cable length. This technique is valid in d-c circuits. In a-c circuits, other factors affect the accuracy of shunt calibrations.

As a result, Himmelstein engineers recommend 6-wire cables for use with MCRT® torquemeters. See Appendix V for more information.

Cable Diagrams for SHC Carrier Amplifiers

Connections shown are for the SHC Model ACUA carrier amplifiers and 700 Series Instruments. If you use another amplifier, refer to its operating manual.

B.2.3 Calibration Considerations

All MCRT® torquemeters are factory calibrated on dead *weight stands traceable to NIST/NBS*. The Himmelstein calibration laboratory is accredited by NVLAP (lab code 200487-0). A purchased system is calibrated as an entity. Transducers purchased without amplifier/readouts are calibrated with a factory owned Himmelstein readout and 20 foot 6-wire cable.

CW and CCW equivalent *shunt calibration torques are referenced to that dead weight calibration.* Complete measurement systems have the calibration resistor installed in the amplifier. Otherwise, calibration resistors are shipped separately. Torquemeter *millivolt/Volt (mV/V)* sensitivity is also determined and provided. The Torquemeter Calibration and Certification Sheet contain the shunt cal resistor value, equivalent shunt calibration torques, and *mV/V* sensitivity.

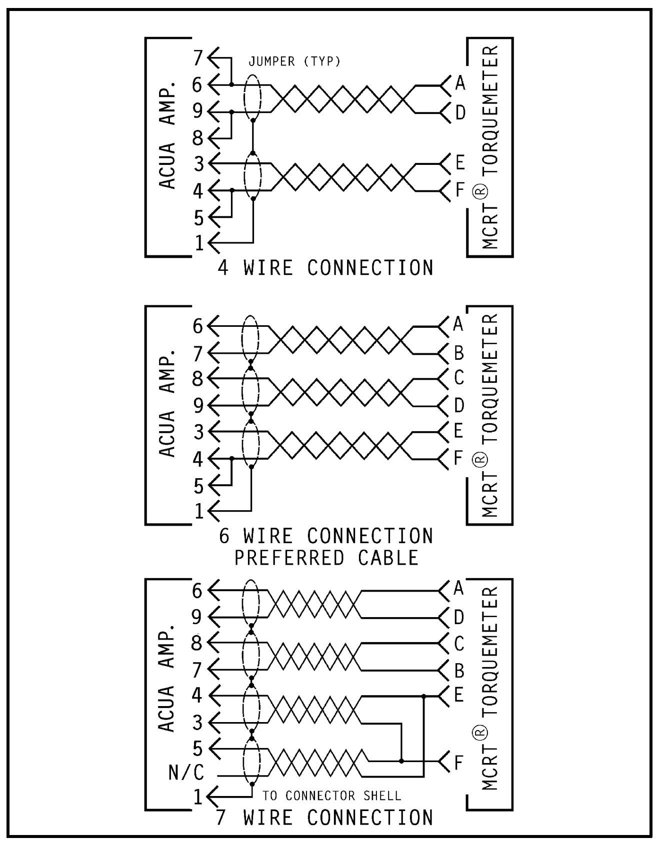


Figure 6. Four, Six and Seven Wire Cables

Himmelstein guarantees the accuracy and NIST/NBS traceability of systems calibrated with its amplifiers and cables. It also guarantees calibration transferability when substituting components bearing the same Himmelstein part numbers.

If a calibrated system isn't available then, to achieve the highest measurement accuracy, dead weight calibrate the instrument components as a system. Refer to Appendix V for a discussion of calibration transfer accuracy.

B.2.3.1 Shunt Calibration
When you buy a torquemeter only, install its calibration resistor in your readout. See the manufacturers' manual for instructions. The resistor is factory installed in Himmelstein readouts purchased with a torquemeter(s).

Operating the readout calibration switch, shunts the resistor across the torquemeter reference bridge and causes an unbalance. The unbalance is the equivalent shunt calibration torque listed on the Torquemeter Calibration and Certification Sheet. This arrangement yields a convenient, remote calibration method.

To shunt calibrate the system, *after installing the calibration resistor:*

- reduce the shaft torque to zero – if necessary break one of the shaft couplings,
- *NULL and ZERO* the readout in accordance with the manufacturers' instructions,
- while holding the *CAL* switch engaged, adjust the readout *SPAN* to produce the known *EQUIVALENT SHUNT CALIBRATION TORQUE,*
- release the *CAL* switch and verify the amplifier reads zero. If not, re-zero and then repeat the previous step.

Himmelstein shunt calibration resistors have a 0.025% tolerance and a very low temperature coefficient. If replaced, use a resistor of the same value and of equal or better quality. During the factory dead weight calibration, the resistor is shunted from *+SIGNAL to +EXCITATION SENSE* for a *CW* torque and from *+SIGNAL to – EXCITATION SENSE* for a *CCW* torque. Changing these connections will reduce the calibration accuracy. Refer to Appendix V for a discussion of calibration transfer accuracy.

B.2.3.2 Millivolt/Volt Calibrations
These calibrations simply state the torquemeter sensitivity (or output) in *mV/V at full scale torque.* The Transducer Section of this manual contains *CW* and *CCW* values.

A *mV/V calibration,* requires substituting a *calibrated mV/V source* for the torquemeter. To duplicate cable capacitance effects, its output impedance must be 350 ohms resistive. To calibrate, proceed as follows:

- compute the equivalent torque cal (Eqt) using the equation below, then
- adjust the amplifier SPAN to provide an amplifier output of Eqt with the *mV/V source* set to M. Re-zero the amplifier if needed – its output must be zero when the *mV/V* input is zero.

Eqt = [M/(mV/Vsen)]X[Full Scale Torque Range]

where:

Eqt = Equivalent Torque Value in same units as the torquemeter range

M = calibrated output of *mV/V source that is closest to* mV/Vsen

mV/Vsen = mV/V sensitivity for the torquemeter

For example, if the torquemeter full scale range is 4,000 lbf-in and its sensitivity (mV/Vsen) is 1.5189 mV/V, adjust the *mV/V source* for its closest available calibrated output (M). M is assumed to be 1.5000 mV/V for this example.

Substitute in the above equation, as follows:

Eqt = [1.5000/1.5189]X[4000] = 3950.2

With the 1.5000 mV/V source substituted for the torquemeter *at the cable input,* adjust the amplifier *span* to read 3950.2 lb-in at its output.

The *mV/V calibration* transfer validity is dependent on keeping system parameters constant. Refer to Appendix V for a discussion of calibration transfer accuracy.

B.2.3.3 Calibration Intervals

In applications requiring high accuracy, perform an annual dead weight calibration. If the torquemeter is overloaded or operates abnormally, then make an earlier calibration/inspection. For continuous service usage, *make monthly shunt calibration checks.* When used intermittently, perform either a *shunt* or a *mV/V calibration before each test series.*

Himmelstein offers dead weight calibration service, traceable to NIST/NBS, for all its products. Two levels of precision are available; 0.02% and 0.002%. To obtain the highest measurement accuracy, return the transducer, cables and readout *for a system calibration.*

B.3 Speed Signal

Both *standard passive and zero velocity speed pickups* are options on most MCRT® torquemeters. They are an integral (not optional) part of certain models. See ¶D.4.4.3 for an availability summary. Both pickup types produce exactly 60 pulses per shaft revolution. Hence, their output *frequency* in hertz equals the *shaft speed* in rpm.

A *standard passive speed pickup* requires no external power. Its output amplitude is approximately proportional to shaft speed. Thus, at speeds below 25 to 100 rpm (dependent on model), a *standard passive pickups'* amplitude may be too small to be useful. On the other hand, the output of a *zero velocity pickup* is independent of speed. Therefore, they are the choice for low speed measurements. *Zero velocity pickups are* also preferred in very noisy electrical environments, i.e., where SCR and Triac Motor Controllers and similar devices are present.

B.3.1 Standard Passive Speed Pickup Pinout

Pin	Function
A	Signal
B	Signal

Note: Both pins are isolated from the connector shell.

Mating Connector: MS 3106A-10SL-4S (SHC P/N 224-3897; includes cable clamp and boot assemblies)

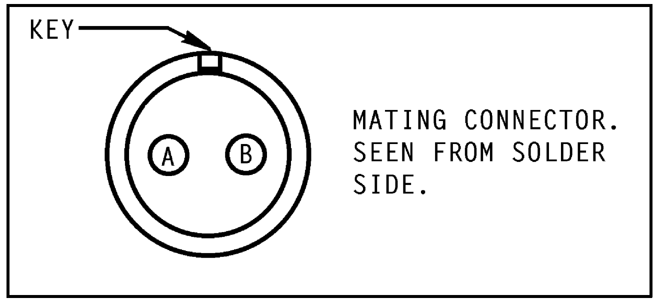


Figure 7. Passive Speed Pickup Connector

B.3.2 Standard Passive Speed Pickup Cabling

Refer to the manufacturers' manual for speed signal conditioner/readout connections. Use a cable with a single shielded twisted pair wire. Belden Type 8761 (or equal) is recommended.

Cable Diagram for SHC Speed Signal Conditioners

Figure 8 shows connections for SHC Models CTUA, UDCA and 700 Series Instruments. When using another readout, substitute its plug designations for those shown.

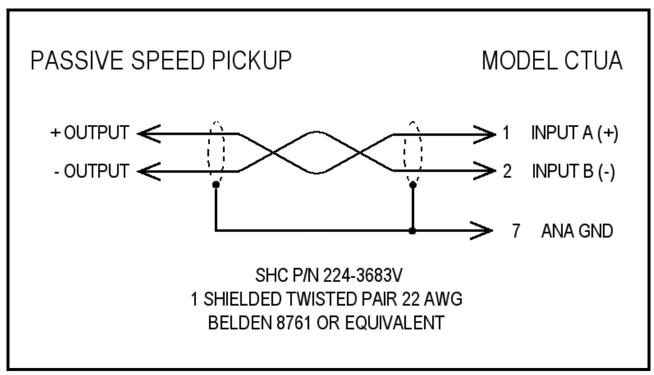


Figure 8. Passive Speed Pickup Cable

B.3.3 Zero Velocity Speed Pickup Pinout

Pin	Function
A	+ Supply (5 to 15 Volts DC)
B	Output Signal
C	Common

Note: All pins are isolated from the connector shell. Incorrect connections can damage the pickup.

Mating Connector: MS 3106A-10SL-3S (SHC P/N 224-5361; includes cable clamp and boot)

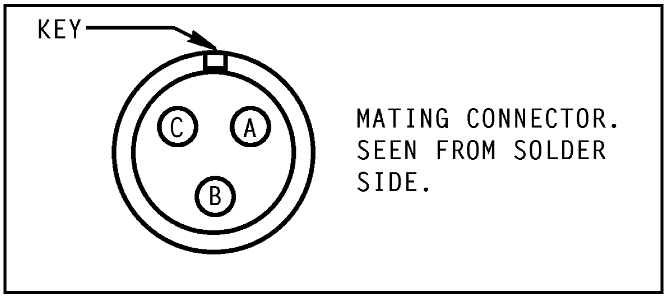


Figure 9. Zero Velocity Speed Pickup Connector

B.3.4 Zero Velocity Speed Pickup Cabling
Refer to the manufacturers' manual for speed signal conditioner/readout connections. Use cable with 2 shielded twisted pairs. Belden Type 8723 (or equal) is recommended.

Cable Diagram for SHC Speed Signal Conditioners
Figure 10 connections are for SHC Models CTUA, UDCA and 700 Series Instruments. If using a different readout, substitute its plug designations for those shown.

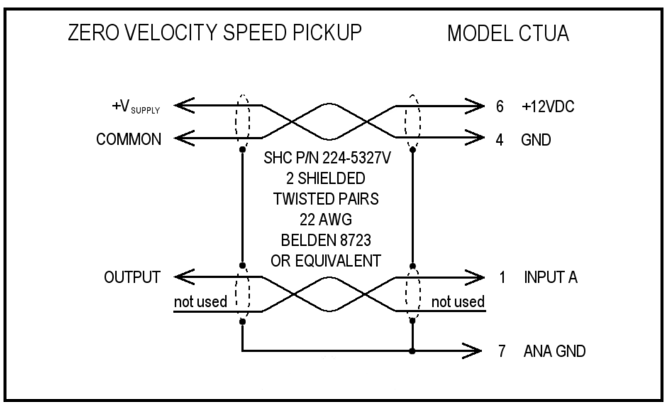


Figure 10. Zero Velocity Speed Pickup Cable

C. Operating & Safety Considerations

C.1 Applicability
The following Paragraphs apply to all MCRT® products.

C.2 Allowable Torque Loads
Operate an MCRT® torquemeter within the full scale rating listed in the *Operating and Technical Data Sheet.* That sheet appears in the Transducer Section of this manual.

C.2.1 Overload Considerations
All torquemeters have an overload rating higher than their full scale rating. Generally, it is at least 2 times full scale; see data for the serial number in use. A Himmelstein torquemeter will not yield (evidenced by a non-return to zero) or fail if subjected to a *peak torque* up to its overload value.

Both the 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 considerations; see ¶C.2.2.

Virtually all rotary power producing and absorbing devices – electric, hydraulic, pneumatic, internal combustion, etc. – produce pulsating rather than smooth torque and power. Furthermore, starting and stopping generates torque transients.

Thus, in addition to its average torque and speed values, the driveline torque usually includes a fundamental (driving) frequency and superimposed harmonics. It may also have transient torque pulses. The Figure 11 waveform is typical of what occurs in the real world. Torsional vibration magnitudes are difficult to estimate, and can be amplified by the driveline. See ¶E.4 for further information.

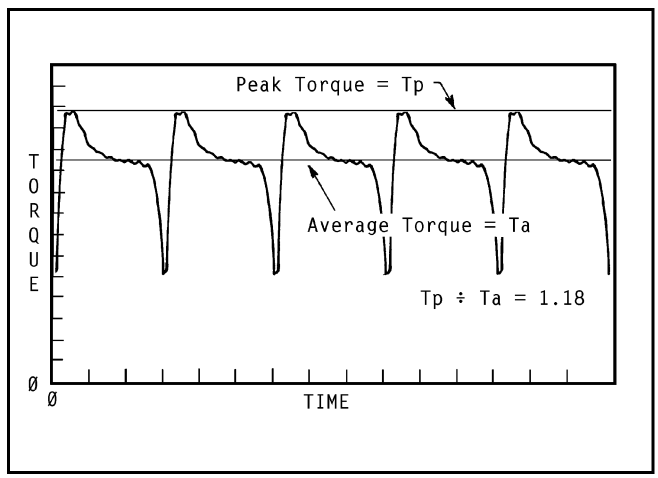


Figure 11. Reciprocating Machine Torque Profile

For these reasons, a conservative design approach dictates the *torquemeter overload region be used as a safety margin for unexpected loads. Do not knowingly operate in the overload region.* If you expect torques in the overload region, then change to a torquemeter with a higher rating.

CAUTION

*Some **amplifiers** saturate at their rated output. Therefore, if the torque exceeds their rated output, they produce erroneous (low) torque signals. The analog output of any standard Himmelstein amplifier is correct to at least 140% of its full scale rating. Some are correct at 200% of their full scale. Himmelstein digital indicators have an automatic overrange warning.*

C.2.2 Fatigue Considerations

If an MCRT® torquemeter sees peak-to-peak torques within its full scale rating, it can handle full torque reversals with infinite fatigue life. When peak torques are cyclical, and exceed the full scale rating, then fatigue failure can occur. Refer to Appendix VI for additional details.

C.2.3 Starting High Inertias with Electric Motors

When started across the line, *during the start,* a motors' developed torque can be several times its rated torque. Thus, a torquemeter sized to handle the motors' rated load torque, can be overloaded during starting. Drivelines are particularly vulnerable when oversized motors drive light duty, high inertia loads.

To avoid damage when starting high inertia loads, either use a torquemeter *rated for the starting torque or, limit the starting torque to a safe value.* Techniques to limit electric motor starting torques include:

- Use reduced voltage starting.
- Electronically limit the maximum motor current.
- Add inertia to the input side of the torquemeter (increasing J1). Before operating, verify the motor can safely start the increased load inertia.
- Use compliant, "shock absorbing" shaft couplings. Careful coupling selection and thorough analysis of the resultant driveline is essential. Under some conditions, such couplings can aggravate rather than improve the situation.

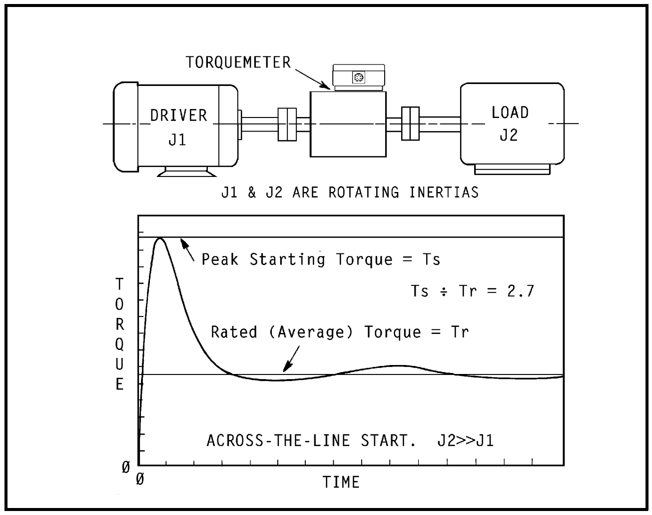


Figure 12. Motor Start Torque Profile

C.3 Allowable Bearing Loads

MCRT® torquemeter bearing design provides long life, smooth running, and avoids bearing torque measurement errors. These results are achieved, in part, by providing optimum bearing pre-load. A lower pre-load would degrade high speed performance. A higher pre-load would increase bearing friction torque, increase measurement error, and reduce bearing life.

In a floating shaft installation, the stator must be *flexibly restrained* so total loads, including the effects of stator restraint and shaft runout, don't exceed its bearing rating.

When the stator is foot mounted, the couplings *end float must be sufficient to take up axial shaft motions and hold the bearing loads within the limits specified in the following table.*

When using shaft and flanged torquemeters in belt/chain drives, pillow blocks are usually needed to isolate them from radial bearing and bending loads (see Appendix XI and ¶C.4). Consider pulley or wheel type torquemeters for such service. Their bearings are isolated from the belt loads, and they accept large radial and bending loads without damage or measurement errors.

MCRT® Torquemeter Type	Bidirectional** Bearing Load Axial (lbs)	Radial (lbs)
3-08T & 3L-08T	3	5
28000TB & 29000TB	3	5
28001T & 29001T	15	30
28002T & 29002T	30	80
28003/04T & 29003/04T	35	100
28006T & 29006T	55	150
28007T & 29007T	70	200
28008T & 29008T	80	220
28009T & 29009T	150	1,200
28010T & 29010T	200	2,100
28060/61T* & 29060/61T*	25	75
28070T* & 29070T*	50	150
28080T* & 29080T*	80	220
28090T* & 29090T	150	800
28091T* & 29091T*	200	1,400
28550/51T	30	100

* Flanged model – **must be mounted as floating shaft**. If used without flexible couplings, alignment must limit bearing loads to indicated values. Observe bending and thrust limits; see ¶C.4.

** See ¶A.4.2 for increased unidirectional axial load ratings.

C.4 Allowable Extraneous Loads
Any moment or force the torquemeter sees, other than the transmitted torque, is an extraneous load. Depending on the installation, these could include bending moments and axial thrust. Crosstalk errors from such loads, expressed in pound-inches, are typically 1% of the applied pound-inches of bending or, 1% of the applied pounds of thrust.

C.4.1 Allowable Bending Loads
When it is applied without thrust, unless specified otherwise, a standard MCRT® torquemeter can handle a shaft bending moment equal to one half its torque rating – see Figure 13. Such bending may be applied simultaneously with rated torque.

The allowable bending input to a foot mounted torquemeter is usually dictated by its bearing radial load ratings (see ¶C.3), and by the need to prevent coupling "lock-up". When a coupling locks-up, it no longer provides one or more needed degrees of freedom and, ultimately causes a driveline failure.

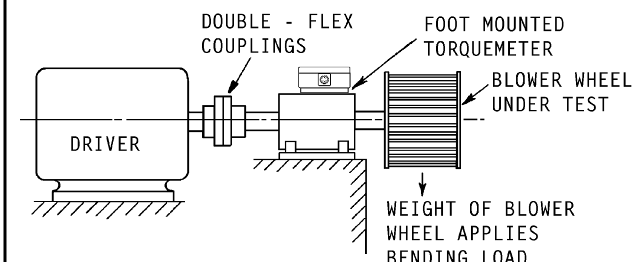


Figure 13. Torquemeter With Bending Load Applied

C.4.2 Allowable Thrust Loads
When applied without bending, a standard MCRT® torquemeter can handle a thrust load (tension or compression) in pounds, applied to its shaft (see Figure 14), equal to its torque rating in pound-inches. Some units may have different thrust capacities; refer to the Specification/Descriptive Bulletin. Such thrust may be applied simultaneously with rated torque.

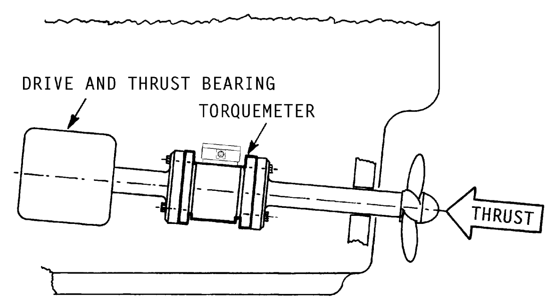


Figure 14. Torquemeter With Applied Thrust Load

Significant thrust loads are only allowable in floating shaft installations. Bearing axial load ratings limit the thrust capacity of foot mounted torquemeters; see ¶C.3 and ¶A.5.

C.5 Operating Speeds

Operate MCRT® torquemeters within the maximum speed rating published in the Operating and Technical Data Sheet for the Serial Number in use. That sheet appears in the Transducer Section of this manual. The ratings are bidirectional and, unless specified otherwise, do not require external lubrication.

CAUTION

*If a driveline part fails, dynamic balance is lost and the resultant forces can cause other part failures. Therefore, it is **an essential safety requirement** that guard covers, substantial enough to contain any separated mass, be installed.*

C.6 High Speed Operation

Refer to Appendix VII for information on H suffix, high speed torquemeter operation.

C.7 Lubrication

C.7.1 Standard MCRT® Torquemeters

The following data applies to all standard MCRT® torquemeters except those units which carry an H suffix and have provision for oil mist lubrication. Standard MCRT® products are permanently lubricated. Nonetheless, they should be re-lubricated periodically if operated at high speeds or, for long time intervals. Nye Lubricants (nyelubricants.com) synthetic oil 181RA (or equal) is recommended. Salient characteristics of 181RA oil are:

Density (lbs/gallon @ 77°F.)	6.926
Viscosity (cSt @ 104°F.)	49.9
(cSt @ 212°F.)	8.6
Viscosity Index	150
Pour Point (°F.)	-69
Flash Point (°F.)	464

To re-lubricate, remove the threaded closures at either end of the MCRT® device (see Figure 15). Then, add the correct quantity of lubricant per the accompanying table. Close the ports after re-lubrication. ***Caution****: Don't over lubricate. Too much lubricant causes excessive heating at high speeds.*

MCRT® Model	Lubrication Per Bearing
3-08T & 3L-08T	2 drops
2774T/TCC	8 drops
3102/03T	8 drops
3120TA/31200T	4 drops
27820/40T	8 drops
27830/35T	4 drops
27920/30T	4 cc
28000TB & 29000TB	2 drops
28001/02T & 29001/02T	10 drops
28003/04T & 29003/04T	15 drops
28006T & 29006T	4 cc
28007T & 29007T	5 cc
28008T & 29008T	7 cc
28009T & 29009T	25 cc
28010T & 29010T	32 cc
28060/61T & 29060/61T	8 drops
28070T & 29070T	4 cc
28080T & 29080T	7 cc
28090T & 29090T	25 cc
28091T & 29091T	32 cc
28550/51T	15 drops

* For maximum life, re-lubricate on a six month schedule.
1. See torquemeter data sheet for maximum speed rating.

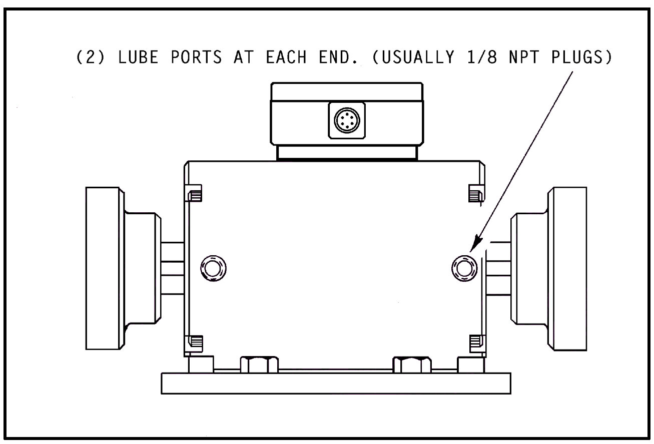


Figure 15. Torquemeter Lube Ports

C.7.2 Oil Mist For High Speed MCRT® Products

H suffix MCRT® devices must be oil mist lubricated. Refer to Appendix VIII for lubrication instructions.

C.8 Contaminants

Don't flood a torquemeters' internal volume with liquids. At higher operating speeds, viscous losses can cause excessive heating and possible damage.

MCRT® devices are immune to spray from mineral based oils and natural, hydrocarbon hydraulic fluids. When using synthetic fluids, verify they are compatible with plastics and electrical insulation. Protect the torquemeter from contact with fluids that attack insulation or plastics. Warranties are void for damage caused by such materials.

Airborne abrasive can cause premature bearing failure. When they are present, consider using an air purge to prevent invasion of such materials. See Appendix IX for additional information.

C.9 Hazardous Environments

Refer to Appendix IX when operating in hazardous environments.

D. Trouble Shooting

D.1 Scope

These discussions suggest procedures for identifying a defective system component. It is an aid for operating personnel. Special training and adequate inspection, test and assembly fixtures are needed for extensive repair work.

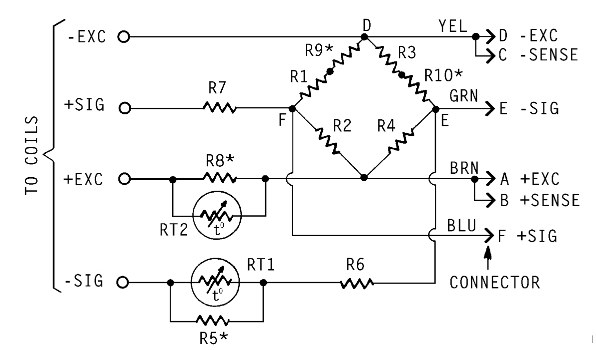
Possible trouble sources include the installation, the torquemeter, the cabling and the readout device. The best procedure is to isolate the problem part, then correct or replace it. Otherwise return the defective part to the factory.

D.2 Preliminary Inspection

D.2.1 Torquemeter

Inspect the torquemeter for physical damage. If the shaft is locked or a rub exists then, remove the speed pickup, if present, per instructions contained in ¶D.4.4. If the fault clears, reinstall the pickup following ¶D.4.4 instructions. Otherwise return the unit to the factory.

Your torquemeters' stator side resistance values appear in the Transducer Section of this manual. Verify the stator resistances are normal. If they are not, and a qualified electrical technician is available, then have the technician remove the stator connector housing and examine the wiring for *opens or shorts* – see Figure 16. Repair any wiring defects. Otherwise return the torquemeter for factory service.



NOTES:
1. RT1 & RT2 ARE PRECISION THERMISTORS USED FOR TEMPERATURE COMPENSATION.
2. * DENOTES TRIMMING COMPONENTS SELECTED DURING TEMPERATURE COMPENSATION.
3. R1 & R2, R3 & R4 ARE MATCHED PAIRS, TYPICALLY 5KΩ ± 0.01%.
4. RESISTOR VALUES CAN VARY WITH MODEL.

Figure 16. Torquemeter Stator Termination Network

D.2.2 Cabling

Make electrical checks for continuity and shorts; see Paragraphs B.2.2, and B.3 for connections. Verify the torque cable uses individually shielded, twisted wire-pairs per ¶B.2.2. Replace unshielded or single shielded cables with cable configured per ¶B.2.2. Examine the Torque and, where present, Speed cables for obvious damage. Replace damaged cables. Clean connectors with an approved contact cleaner.

D.2.3 Readout Instrument
Examine for physical damage, blown fuses and/or loose parts. Correct any defects; refer to the manufacturers' manual, as necessary.

D.3 Torque Subsystem Problems

D.3.1 No Output When Torque is Present
Check the readout instrument by replacing the torquemeter and cable with a star bridge (see Figure 17). If the combination of carrier amplifier and star bridge can be nulled, zeroed and shunt calibrated, the problem is in the torquemeter or cable.

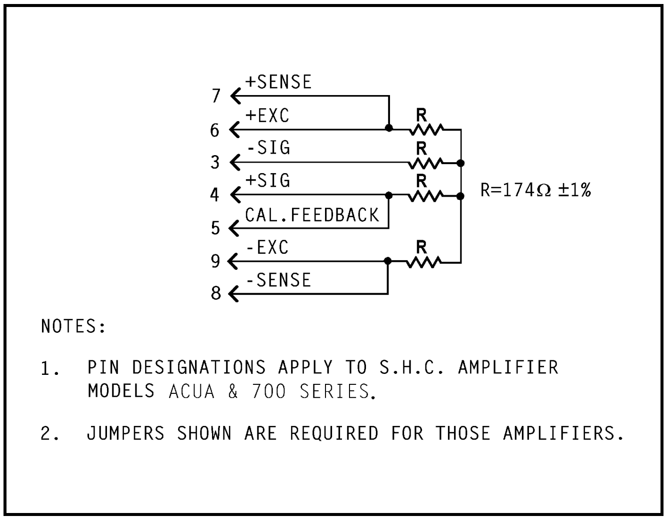


Figure 17. Star Bridge Circuit

If the amplifier is inoperative with a star bridge installed, it is at fault. Conventional troubleshooting procedures will locate the fault. Plug-in star bridge assemblies are available for Himmelstein amplifiers. For ACUA or 700 Series amplifiers use order number 7-001.

D.3.2 Constant Output Regardless of Shaft Torque
Install a star bridge per ¶D.3.1 above. If the amplifier can be nulled, zeroed and shunt calibrated, then the problem is in the torquemeter or cable. If stator resistance checks and the cable are normal, the problem is on the torquemeters' rotor. Return it for factory service.

D.3.3 Apparent Zero Drift

- **Check the Cabling.** See ¶D.2.2.

- **Check for Carrier Frequency Beats.** If the readout has more than one carrier amplifier, verify only one acts as *master* and all others are *slaved* to it. This avoids beats between oscillators. Such beats can resemble drift.

- **Check for a Drifting Amplifier.** Install a star bridge per ¶D.3.1 above. A star bridge cannot have *zero* drift; however, its *span* drift is a function of resistor stability. Do not change the span control settings from those used with the torquemeter. Re-null and re-zero the instrument. If the drift remains, it is in the readout instrument. Clean the input connector with an approved contact cleaner. If that does not clear the problem, the amplifier/readout is drifting. Analyze and correct it or, return it to the manufacturer for service.

- **Check for Driveline Torque Offsets.** Torquemeters installed in a drive which has hysteresis or friction torques, may *appear* to have long term drift when there is none. For example, when installed between a pump and a gear drive, the torque reading may not return to zero after the test because of locked in friction torque. The torquemeter sees and reads that locked in torque. Always zero a torquemeter with no torque on the driveline – in the case cited, with a coupling disassembled. At the end of the test, the shaft should be mechanically "shaken" or a coupling broken, to reduce the driveline torque to zero. Otherwise, the torquemeter will read locked in torque. A rub between any rotating and stationary part is a common cause of friction. Verify the shaft couplings and other rotating parts have clearance to the stator.

D.3.4 Signal Instability

- **Check for Amplifier Beats.** See ¶D.3.3, above.

- **Check for Amplifier Instability.** Install a star bridge per ¶D.3.1. If the amplifier output is stable, then the problem is in the torquemeter or cabling.

- **Check the Cabling**. See ¶D.2.2 above.

- **Check For Driveline Torque Variations.** The driveline may have a low frequency oscillation which the torquemeter reads (see ¶C.2.1). Engage the amplifiers' 0.1 hertz filter. That action will remove torque signals above 0.1 hertz. If the readings steady, then you may wish to identify the physical cause of the shaft torque variation or, remove it with mechanical filtering techniques; see ¶E.4. Oscillographic signal analysis is often helpful under these conditions.

D.3.5 System Cannot Be Nulled

- **Check the Cabling.** See ¶D.2.2 above.

- **Check the Amplifier.** Install a star bridge at the amplifier input. If it can be nulled and operation is normal, then the problem is in the cable or torquemeter. Otherwise the amplifier is at fault. Repair it or return it to the manufacturer.

- **Verify the Torque Input is Zero.** If the torquemeter is installed in a driveline, break or remove one of the couplings. If the system still cannot be nulled, then the problem is either the cable or the torquemeter. Verify cable integrity, configuration and connections and check the torquemeter per ¶D.2.1.

D.4 Speed Subsystem Problems

Speed measurement problems can originate in several components. They include the speed pickup, the readout instrument, and the interconnect cable. The best procedure is to isolate the defective element and then correct or replace that element.

D.4.1 No Signal Output When Shaft is Rotating

- Verify the Shaft Speed is Within the Measurement Range. Standard passive speed pickups have a practical lower operating speed range of 25 to 100 rpm, depending on the torquemeter and speed readout models. Run the shaft at a higher speed and verify the problem still exists. Zero velocity pickups will work down to zero speed. However, most Himmelstein speed readouts have a lower operating limit of 5 to 10 rpm.

- **Verify the Speed Pickup Signal is Normal.** Use an oscilloscope to measure the peak-to-peak output voltage at a constant speed. If no output exists, verify the cable is intact; replace defective cables. See ¶D.4.4 for pickup output data. If the signal amplitude is too low, then re-adjust the pickup location per ¶D.4.4. Misadjustment can cause marginal output from either a standard passive or zero velocity pickup.

- **Verify the Speed Readout is Operational.** Connect a known frequency to the readout input. It should be between 200 and 5,000 hertz, at 1 to 10 volts, rms. If no output is present, the readout is defective and must be corrected or replaced. Otherwise the problem is in the cable, or the pickup, or the operating speed is beyond the system measurement range.

D.4.2 Erratic Output at Constant Speed

- **Check for Cable Faults.** In addition to the usual checks, make certain the shield is in place and only grounded at the amplifier. Verify there is no connection between either signal and shield.

- **Check the Pickup for a Ground Fault.** There should be no connection between the signal pins (A & B) and the pickup shell.

- **Check the Speed Readout Operation.** Using the techniques described in ¶D.4.1, verify the amplifier output is stable.

- **Verify Pickup Operation.** Verify the pickup output is both normal and stable while the shaft is rotating at a constant speed above 600 rpm.

- **Verify Your Drive Speed is Stable.** Some drives have significant speed variations caused by control system instability, torsional vibrations, etc. To eliminate this possibility, use another drive source – preferably a direct drive motor running between 600 and 3,000 rpm. Alternately, observe the torque variations on an oscilloscope. If they track the speed variations and both signals are stable with the shaft stationary, then the drive is probably unstable and the instruments are correct.

D.4.3 Erratic Output When the Shaft is Stationary

- **Check the Cable, Speed Pickup and Speed Readout Operation** per ¶D.4.2 above. If a defect is found, correct it. Otherwise proceed to the next step.

- **Check for High Ambient Electrical Noise.** If the torquemeter is installed adjacent to large electrical machines, or the machinery is powered by Solid State Phase or Frequency Speed Controllers, significant noise interference can be present. Remove power from the machines and controls or, turn power to an adjacent machine on and off. If the readout stabilizes when power is off, use the techniques described below.

    1. **Isolate the instrument from the machine power** by powering it from a separate line transformer.

    2. **Reduce the noise** by providing one cable tray or conduit for the speed instrument cable and a separate tray for the machine power and control cables. If possible, use twisted and shielded wire pairs for the motor control cables.

    3. **Increase the speed signal level** by replacing the standard passive speed pickup with a zero velocity pickup (and cable). Then, adjust the speed amplifier to optimize the signal-to-noise ratio. Instructions for optimal adjustment of Himmelstein speed amplifiers can be obtained from the factory.

D.4.4 Speed Pickup Adjustment/Replacement

Most speed pickups are field changeable. They thread into the stator housing and are secured with a jam nut. Loosen the jam nut to remove or adjust the pickup. Both the standard passive and zero velocity types require radial location adjustment. These adjustments are described below.

D.4.4.1 Standard Passive Speed Pickup

The nominal outputs of standard passive pickups are tabulated below. Use an oscilloscope to measure open circuit voltages, while the shaft rotates at the indicated speed. The waveform is a distorted sine wave. Make the adjustment using the following procedure.

- Back out the pickup by turning it counterclockwise. Then re-insert it with one thread engaged.
- With the torquemeter shaft rotating at the reference speed, slowly turn the pickup clockwise until the output is within 15% of the tabulated value. *If a rub occurs, stop! Back off the pickup until the rub clears.*
- Stop the shaft and tighten the jam nut.
- Rotate the shaft by hand to verify no rub exists.
- Finally, verify the output is correct at the reference speed. Re-adjust if necessary.

The adjustments described take time and require test facilities. If neither is available, you may use the following less satisfactory procedure.

- *With shaft motion stopped,* turn the pickup in until it makes contact with the rotor assembly.
- Back off the pickup a quarter of a turn.
- Tighten the jam nut.
- Slowly rotate the shaft to verify no rub exists. If a rub exists, re-adjust the pickup.

MCRT® Torquemeter Model Number	Open Circuit Output (Volts pk-pk)	Reference Speed (rpm)
2774T/TCC	2.0	1,000
3102/03T & 3120T	2.0	5,000
27820/40T & 27920/30T	2.0	1,000
27830/35T	0.5	1,000
28001/02T & 29001/02T	3.0	5,000
28003/04T & 29003/04T	2.0	1,000
28006T & 29006T	1.5	1,000
28007T & 29007T	1.5	1,000
28008T & 29008T	2.0	1,000
28009T & 29009T	2.0	1,000
28010T & 29010T	2.0	1,000
28060/61T & 29060/61T	2.0	1,000
28070T & 29070T	2.0	1,000
28080T & 29080T	2.0	1,000
28090T & 29090T	2.0	1,000
28091T & 29091T	2.0	1,000
28550/51T	2.0	1,000

D.4.4.2 Zero Velocity Pickup

The output of a regular zero velocity pickup swings between approximately + 0.3 Volts and the supply voltage. When used with a Himmelstein readout, the pickup output will swing from +0.3 to about +11.7 volts. Certain specialized units have TTL (+0.3 and +5 Volt) outputs. To adjust the pickup, proceed as follows:

- *With shaft motion stopped,* turn the pickup in (clockwise) until it makes contact with the rotor assembly.
- Back off the pickup (counterclockwise) a quarter of a turn.
- Tighten the jam nut.
- Slowly rotate the shaft to verify no rub exists. If a rub exists, readjust the pickup until it is eliminated.

D.4.4.3 Replacement Part Numbers

D.4.4.3.1 Standard Passive Speed Pickups

Part Number 900-1001 is used for all torquemeters except:

MCRT® 28006/07/08/09/10T use P/N 900-1005

MCRT® 3-08T & 3L-08T are only available with Zero Velocity Pickups; P/N 900-1007

MCRT® 28000TB & 29000TB are only available with a 512 pulse/rev optical encoder

MCRT® 3102/03T, MCRT® 3120TA/31200T, MCRT® 27830/35T use P/N 900-1000 which requires soldering to remove and install.

D.4.4.3.2 Zero Velocity Speed Pickups

All torquemeter models use P/N 900-1007 except the MCRT® 3102/03T pulley torquemeters and MCRT® 27830/35T low profile wheel torquemeters which are only available with standard speed pickups; see ¶D.4.4.3.1.

MCRT® 28000TB and 29000TB low range torquemeters are only available with a 512 pulse/rev optical encoder; consult factory for special instructions.

E. Summary of References

The following paragraphs summarize references pertinent to torquemeter operation, installation and trouble shooting. Those references apply either to specific torquemeter models or model variations or, are too detailed and technical to be made a part of this document. The referenced material is available in the Transducer Data Section of the Manual.

E.1 Torquemeter Loads and Specifications

The Transducer Description Sheet contains specifications for the Serial Number in use. Special devices that contain design modifications are identified. If device modifications change performance specifications, the manual summarizes those changes.

The Models' Technical Bulletin contains complete specifications, and outline information. Pulley and wheel torquemeter documentation includes installation data.

E.2 Coupling Selection and Torquemeter Installation

Technical Memorandum 7850 contains useful information on coupling selection, mounting, measurement and operating considerations. It includes sketches of acceptable and unacceptable mounting arrangements. Addendum #1 to Technical Memorandum 7850 lists commercial sources of flexible couplings.

E.3 High Speed Operation

Technical Memorandum 7551 discusses the critical speed of installed torquemeters. It contains procedures for estimating shaft critical speeds, and related material.

E.4 Minimizing the Effects of Torsionals

Technical Memorandum 8150 discusses the estimation of torsional resonant frequencies, and describes how to avoid their destructive effects. It includes theoretical as well as practical help on the subject.

E.5 Selecting The Right Torquemeter

Bulletin 705 provides criteria for properly sizing a torquemeter. In addition to average drive torque and/or power requirements, the effect of the load and driver characteristics are explained. The bulletin provides a simple, easy to follow selection procedure and contains many useful examples.

Appendix I

Desirable Readout Characteristics

MCRT® torquemeters require a signal conditioner (carrier amplifier) with sinusoidal (a-c), not d-c, excitation. They operate with carrier frequencies between 2.4 and 6 kHz, but are *optimized for 3 kHz.*

Signal conditioners must provide these *essential functions:*

- 3 to 6 volts rms of 3 kHz sinusoidal drive,
- the ability to null any cabling unbalance,
- adjustable span capable of producing the desired signal output,
- phase sensitive demodulation,
- removal of the carrier frequency and its harmonics from the torque signal.

The following desirable amplifier *features improve accuracy, noise immunity and operating convenience:*

A bridge excitation source that:

- is balanced with respect to system ground,
- regulates the voltage at the transducer with respect to a reference shared with the analog-to-digital converter, i.e., provides *ratiometric operation,*
- has very good frequency stability,
- has provision for frequency synchronization.

An amplifier that has:

- immunity to noise voltages,
- very high quadrature signal rejection,
- selectable filter cut-off frequencies to eliminate vibratory signals and to optimize analysis,
- a 0.1 Hz filter to eliminate very large machinery vibrations,
- constant group delay Bessel filters to avoid signal waveform distortion,
- a substantial, error-free overload capacity,
- bi-directional shunt calibration circuitry,
- an independent negative span adjustment.

Himmelstein amplifiers have these features. They are available with compatible cables and NIST traceable system calibration.

Appendix II

Foot Mounted Versus Floating Shaft Installations

Floating shaft installations have two principal disadvantages. First, if the driving or driven machine is frequently changed, and the torquemeter is unsupported during the changeover, then pillow blocks must be added to handle this situation. Second, the *critical speed* of a foot mounted torquemeter is usually much higher than a floating shaft torquemeter.

If neither of these concerns are important, consider a floating shaft installation. They are less critical to align. Furthermore, because they don't directly transfer thrust loads to the torquemeter bearings, *floating shaft installations can usually handle much greater thrust loads than the foot mounted alternative.*

High speed applications should employ foot mountings; see Appendix VII for additional information.

For either installation method, choose couplings that will handle the:

- expected shaft end float
- installation parallel and angular misalignments
- maximum expected shaft speed
- maximum expected shaft torque
- expected extraneous loading

Where dynamic, once per revolution torque measurements are important, *use constant velocity couplings* that are torsionally rigid. If operated at high speed, dynamically balance the torquemeter and coupling assembly *after coupling installation.* Install the couplings in accordance with the manufacturers' instructions and ¶A.3.

Technical Memorandum 7850 has detailed installation discussions. Use only installations recommended in that memorandum. If in doubt, consult the factory. Addendum 7850-1 lists commercial coupling types. However, *coupling selection and mounting is the users' responsibility.*

Appendix III

Vertical Installations

In vertical installations, the torquemeter and couplings often carry the weight of suspended devices and frequently carry the live thrust of a pump impeller, mixer blade, etc. Even when those loads are absent, the upper shaft coupling must carry the weight of the torquemeter and coupling.

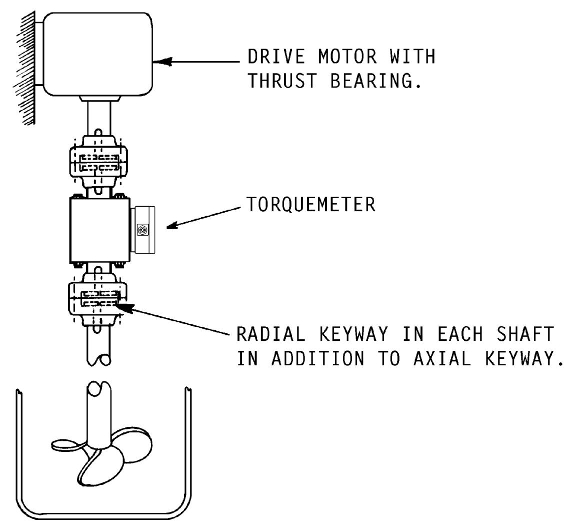


Figure 18. Vertical Torquemeter Installation

A flanged torquemeter with properly attached couplings can support substantial thrust loads. On the other hand, neither axial keys nor the friction of interference fits will carry significant thrust. On special order, we can supply shaft torquemeters with radial keyways to carry thrust and/or weight loads.

Vertical floating shaft installations don't transfer thrust to the torquemeter bearings. Thus, floating shaft installations are simpler and usually safer than foot mounted installations. See ¶C.4.2 for data on *shaft thrust ratings.*

Vertical, foot mounted installations must limit torquemeter bearing loads to those of ¶C.3.

Appendix IV

Splined Torquemeter Installation

When properly installed, the torquemeters splined configuration eliminates the need for *separate* flexible couplings. That is, it will transmit torque and handle residual misalignments without introducing excessive loads. A typical installation cantilevers the load device from the driver (see Figure 19) and uses stator pilots to accurately locate the shafts.

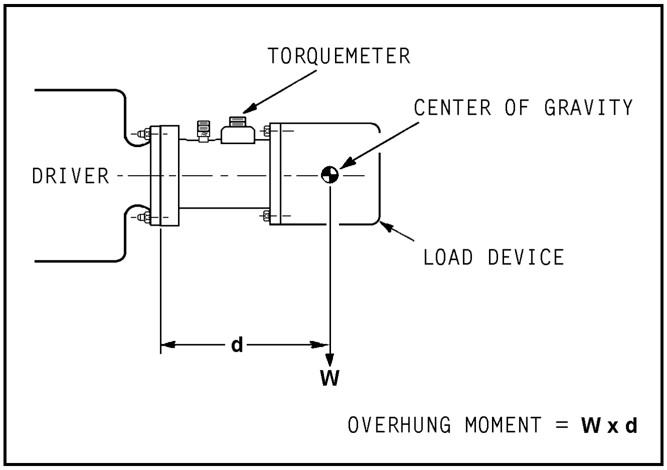


Figure 19. Typical Splined Torquemeter Installation

If all mating devices meet the spline standard specified for the torquemeter, the resultant clearances will provide the alignment needed. When installing the torquemeter, satisfy the following criteria:

- The dimensions of all devices must meet the spline standard.
- Mating splines should slide together without resistance.
- Splines should be lubricated for the intended service.
- Stator pilots, studs, and clearance holes should mate without being forced. That is, the bolts should *clamp the parts without forcing them into alignment*.
- The overhung stator moment should meet the limit specified for the torquemeter.
- The installation should have no (or low) vibration at all operating speeds.

Observe special caution if using adapters to mate a splined shaft with a different shaft end. Adapters can multiply concentricity and dimensional errors and produce spline lock-up. Lock-up can cause a failure. Adapters can also introduce additional degrees of freedom. That, in turn, may require a different mounting arrangement. Consult the factory if in doubt.

Appendix V

Calibration Transfer Accuracy

Figure 20 shows an MCRT® torquemeter shunt calibration network. It is compatible with standard amplifiers and provides a *switch actuated remote calibration.*

The ground reference circuit (Rr) is a Wheatstone Bridge rather than a Star Bridge. A Star Bridge (see Figure 17) constructed with common, low cost resistors won't have *zero drift* with temperature changes. However, that is its only advantage. Unless the Star Bridge employs very high quality resistors, its shunt cal output will exhibit temperature induced *drift.*

Furthermore, when it's shunt calibrated, a Star Bridges' output includes a component of common mode signal. That makes a Star Bridge calibration critically dependent on the amplifier common mode rejection (CMR) adjustment. A Wheatstone Bridge circuit doesn't generate a common mode signal when it's shunt calibrated. Therefore, its shunt calibration is independent of the amplifier CMR.

MCRT® torquemeters use Wheatstone Bridge ground reference circuitry because it provides superior performance.

The reference bridge resistor (Rr) match is 0.005%, they are within 0.01% of nominal value, and have a 0.6 PPM/°F. temperature coefficient. Himmelstein calibration resistors (Rc) are of similar, premium quality. Figure 20 illustrates a simplified torquemeter measurement and calibration network. Compensation components, reactances and shields have been omitted for clarity. Resistor values can vary with the model.

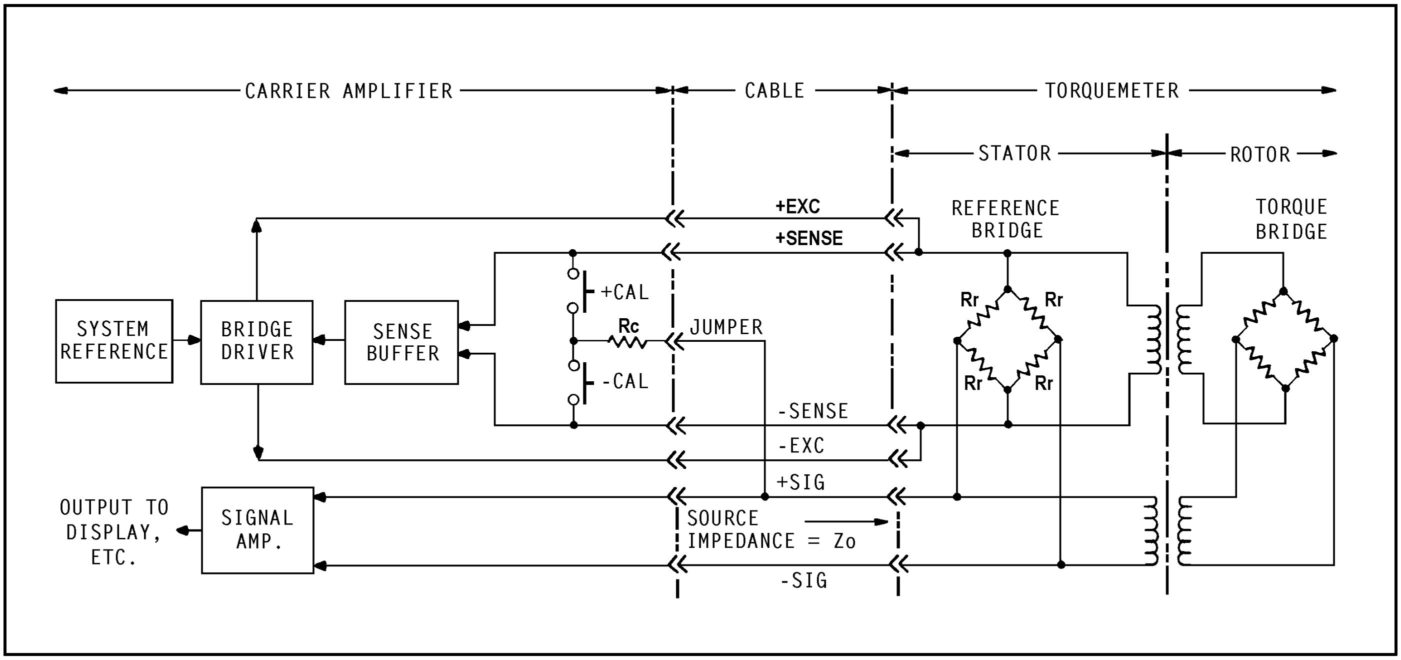


Figure 20. Simplified Shunt Calibration Network

When a switch closes, the calibration voltage at the amplifier input, ignoring cable reactance is:

[250Rr/(Rc + (Rr/2))][Zo/(Zo + Rr)] mV/Volt

With stable components, the shunt calibration voltage, the torque signal and their ratio are constant. Thus, the shunt calibration signal generates a constant and known torque equivalent. Adjusting the amplifier span so its output agrees with that signal, accurately transfers the dead weight calibration.

Differences between the system used during the *reference dead weight calibration* and that used during the *shunt calibration* affect shunt calibration transfer accuracy. Important parameters include cable capacitance, frequency, calibration phase shift, transducer phase shift, amplifier phase adjustment(s), etc.

When calibration and torque signals are *exactly in phase,* shunt calibrations are independent of amplifier phase adjustments. However, they are still dependent on other amplifier and the cable characteristics.

Any system component changes made after completing the reference dead weight calibration, will cause changes to the torque and calibration signal phases. That is, they will no longer be in phase. Nevertheless, it is possible to electrically shift the cal signal phase and thereby restore the original, in phase, relationship.

However, shifting a shunt cals' signal phase also changes its amplitude. Because that cal amplitude change occurs without *a corresponding change to the torque signal amplitude*, the procedure is invalid. Himmelstein engineers consider such adjustments an exercise in futility and *don't recommend them.*

The transfer accuracy of a *mV/V calibration* is also dependent on having stable system characteristics. Changing any significant parameter – frequency, cable capacity, amplifier phase adjustment, *mV/V source* impedance, etc. – reduce calibration transfer accuracy.

Safety barriers (see Appendix IX) attenuate electrical signals and change the effective value of calibration networks. If a system has safety barriers installed in the field, the complete system – torquemeter, cables and readout – *must be re-dead weight calibrated to obtain high accuracy.* Himmelstein can furnish NIST traceable systems, calibrated with factory installed safety barriers, when required.

Appendix VI

Fatigue Considerations

An MCRT® torquemeter can handle full scale torque reversals with infinite fatigue life. When peak torques are cyclical, and exceed the full scale rating, then fatigue failure can occur.

When operated at peak torques beyond its full scale torque rating, a torquemeters' 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 torquemeter configuration, etc.

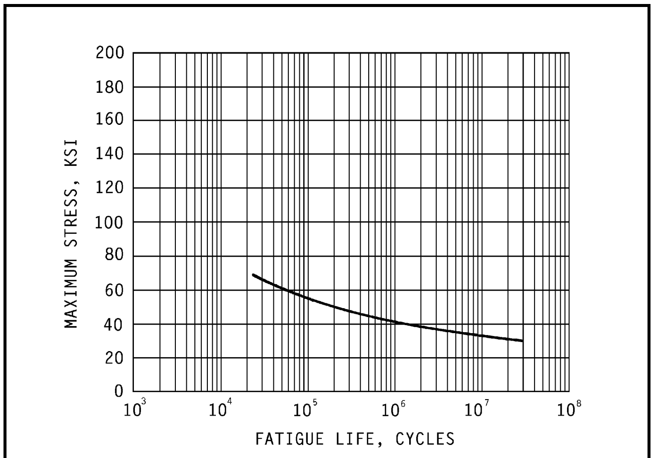


Figure 21. Typical Fatigue Life Characteristics

When large torsionals are present, the following steps will reduce the risk of fatigue failure:

- Reduce the magnitude of torsional inputs by using mechanical filtering (torsional dampers).
- Avoid torque magnification by eliminating torsional resonant frequencies in the operating range; see ¶E.4.
- Size the torquemeter so peak instantaneous torques are within its full scale rating.
- Check peak torque values, *over the range of operating conditions,* by observing the torque on an oscilloscope while the amplifier filter bandwidth is at 500 hertz.

If these guidelines are violated, shut down immediately or risk component damage.

Appendix VII

High Speed Operation

Special order, H suffix torquemeters operate at higher speeds than their standard counterparts. The Transducer Section of the device Manual lists the speed rating of your H suffix device. These products have strengthened rotor assemblies, revised bearings and provision for oil mist lubrication.

A successful high speed installation usually requires:

- Adequate bearing lubrication. Too little will result in bearing failure. Too much, produces excessive heating from viscous losses and can cause damage.
- A stable, usually foot mounted, vibration-free installation operating either well below or well above the first shaft system torsional resonant frequency (see ¶E.4). The operating speed should be below the first shaft critical (see ¶E.3).
- A dynamically balanced torquemeter/coupling assembly. Other driveline components must also be balanced.
- Taking all reasonable safety precautions including the installation of safety guards around rotating components.

Appendix VIII

Oil Mist Lubrication For High Speed Products

Use oil mist lubrication with H suffix MCRT® devices. These products contain structural modifications and oil mist ports that permit operation at higher speeds than their standard counterparts. See the Manual Transducer Section for the maximum speed rating of the torquemeter supplied. Typically, each end has two 1/8" NPT tapped lubrication ports. Use either port for *Inlet* and the other port for *Drain.* Make the port selection on the basis of installation convenience.

Available options include NPT body fittings, manifolding between bearings, and a lubricator with manifolding. When manifolding is furnished, the torquemeter has a single *Inlet* and a single *Drain.*

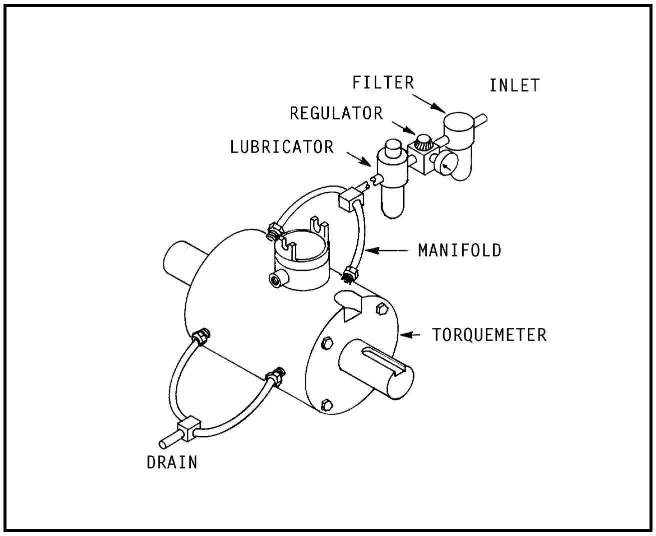


Figure 22. Typical Oil Mist Piping

Certain high speed torquemeters have multiple *Inlet* and *Drain* ports to enhance lubrication. When so furnished, the device manual will include special manifold information.

Before operating an externally lubricated torquemeter, verify the lube path is clear by confirming oil is recovered from *all Drains. Loss of lubrication will cause bearing failure. A blocked drain port will trap excess oil, cause overheating from viscous losses, and possible device damage.*

Recommended Lubricator:
Norgren Micro-Fog Lubricator Assembly consisting of:

Filter/Regulator:	P/N B73G ZAK-AD3-RMG
Lubricator:	P/N 10-015-002

SHC P/N 224-7139 is a complete assembly including filter, regulator, lubricator and oil reservoir.

Recommended Lubricant:
MIL-L-6085A. Salient characteristics of this lubricant are:

Viscosity (cSt @ 130°F.)	9.0
(cSt @ -65°F.)	11,740
Flash Point (°F.)	455
Pour Point (°F.)	-80
Rust/Corrosion Inhibited	Yes
Antiwear Properties	Yes

Recommended Lubricator Adjustments

MCRT® Model Number	B.I.[1]	Inlet Pressure (psig)	Manifold Pressure (in $H_2$0)	Air Flow* (scfm)
28/29001TH	1.5	6	15	1.1
28/29002TH	1.6	6	15	1.1
28/29003TH	3.2	6	15	1.1
28/29004TH	3.2	6	15	1.1
28/29006TH	5.5	6	15	1.1
28/29007TH	6.3	6	15	1.1
28/29008TH	9.5	15	15	2.2
28/29060TH	4	6	15	1.1
28/29061TH	4	6	15	1.1
28/29070TH	8	6	15	1.1
28/29080TH	9.5	15	15	2.2
28550TH	2.4	6	15	1.1
28551TH	3.2	6	15	1.1

* Values are total for both device bearings.
1. B.I. denotes bearing inches

Appendix IX
Hazardous Environments

When they are used in hazardous locations, *purge MCRT® torquemeters with air (or inert gas).* Properly used, an air purge will prevent explosive, flammable or corrosive fluid, or airborne abrasive, from entering the torquemeter. The user must interlock and monitor the gas supply in compliance with applicable safety codes. Two purge arrangements are available on most MCRT® torquemeters. One purges the torquemeter only. The other* includes a wire terminal/housing assembly that permits purging via the customers' threaded torque cable conduit.

Purging the torquemeter only requires the use of approved safety barriers to protect the torque excitation and output circuits. Safety barriers are sealed, passive networks installed in each wire that connects the hazardous and safe locations. They insure electrical energy passing between the two locations is limited to a safe value.

Explosion proof speed pickups can be supplied on most** torquemeters. They have provision for conduit connections and can be used without safety barriers. Alternately, you may use a ***zero velocity speed pickup*** *with wiring protected by safety barriers.*

* Except MCRT® 3-08T, 3L-08T, 28000TB, 29000TB, 3120TA/31200T and 3102/3T
** Except MCRT® 3-08T, 3L-08T, 28000TB, 29000TB, 3120TA/31200T and 3102/3T

Because barriers use nonlinear and other elements selected for protection against hazards rather than for stability, *their use compromises measurement accuracy. To obtain the most accurate measurements, use the alternative conduit arrangements described above.*

Safety barriers attenuate electrical signals and change the effective value of calibration networks. If a system has safety barriers installed in the field, the complete system – torquemeter, cables and readout – *must be re-dead weight calibrated to obtain high accuracy.* Himmelstein can furnish NIST/NBS traceable systems, calibrated with factory installed safety barriers, when required.

Shaft seals will prevent entry of certain contaminant solids or liquids; *not hazardous gases.* Although available on special order, only use seals in applications where air purging (see above) is not feasible. Shaft seal friction reduces accuracy, may reduce maximum speed, and seals have limited life.

CAUTION

Shaft seals are not suitable for use where hazardous gases are present.

Appendix X

Amplifier Phase Adjustment

Himmelstein amplifiers are optimized for input signals in phase with their excitation voltage. Proprietary techniques achieve a phase difference between excitation and reinserted carrier of 0.25°.

A typical torquemeters' output phase is within 5° of its excitation. Thus, the phase adjustment used may produce a small reduction in output signal when compared to aligning the amplifier and torquemeter signal phases. That reduction is 0.06% for torquemeters with 2° of phase shift, etc.

Nonetheless, *never adjust the amplifier in phase with the torquemeter signal.* Follow this rule because:

1. Any change in amplifier phase adjustment reduces calibration accuracy. Adjust a non-Himmelstein amplifier so its reinserted carrier is in phase with excitation.

2. Cable capacitance effects produce an unwanted crosstalk signal (Ec). *It is in phase quadrature with torquemeter excitation* (Ex). An amplifier, when correctly adjusted per this criteria, has negligible cable effect output, i.e., Ec*Cos(90°) = 0. This desirable result is also true *for cable changes* occurring after the amplifier is nulled. Thus, torque measurements are immune to such cable effects.*

   On the other hand, if the amplifier adjustment is Θ° out of phase with excitation, then the cable signals are not in phase quadrature with the excitation. As a result, the quadrature cable effects will not cancel, i.e., Ec*Cos(90° ± Θ°) <> 0. Under those conditions, the in phase cable effects* signal will appear as noise or drift in the system output; a very undesirable result.

Never re-adjust a Himmelstein amplifiers' phase, unless you can measure phase relationships with an accuracy of at least 0.5°.

*Cable capacitance effects change with aging, temperature, relative humidity, and mechanical abuse.

Appendix XI

Belt and Chain Drive Considerations

CAUTION

Do not install a pulley or sprocket on the torquemeter shaft unless the torquemeters' radial bearing load rating, from ¶C.3, is —

$\geq$ [Torque Rating] / [4*L]

and,

$\geq [T_1 + T_2]*[1 + L/H]$

The above criteria assure safe torquemeter bending and bearing loads. To simplify the analysis, assume $T_2 = 0$

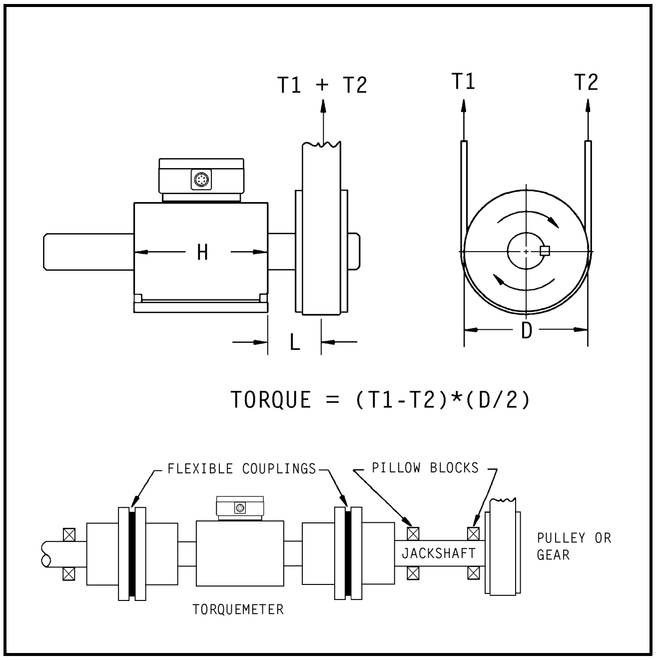


Figure 23. Installation Definitions

and calculate T_1 = [Torque Rating*2/D]. Then make $[T_1 + T_2]$ = 1.1 times the calculated value of T_1.

When the bearing load ratings do not meet the above criteria, use pillow blocks and a jack shaft to isolate the pulley/belt loads; see Figure 23 example. Alternatively, consider a pulley or wheel type torquemeter. Their bearings are isolated from the belt loads, and they accept large radial and bending loads without damage or measurement errors.

Appendix XII

WARRANTY STATEMENT AND SPECIMEN CALIBRATION AND COMPLIANCE CERTIFICATION

WARRANTY

Himmelstein hereby warrants, to their original purchaser, all its torque measurement products to be free of defects in materials and workmanship and to conform to the published specifications in effect at the time of order. The warranty period begins at the date of original shipment and extends for a period of one year thereafter.

Our liability under this warranty is limited to the obligation to repair or, at Himmelstein's option, replace without charge, F.O.B. our plant in Hoffman Estates, IL, any part found to be defective under normal use and service, provided:

1. The defect occurs within the warranty period.
2. Himmelstein is promptly notified in writing upon discovery of such defects.
3. The original parts are returned to Himmelstein, Hoffman Estates, IL, transportation charges prepaid.
4. Himmelsteins' examination shall disclose to its satisfaction that such defects have not been caused by abuse, accident, negligence or misuse after delivery.
5. No unauthorized modification has been made.

Equipment or merchandise not manufactured by Himmelstein is not warranted by Himmelstein but carries its manufacturers' warranty. Our performance warranties are stated in printed specifications for each standard product and in a written description included in system quotations. Himmelstein specifically disclaims any other performance warranties or implied warranties of fitness for a particular purpose. This warranty is expressly in lieu of all other warranties expressed or implied (except as to title) and constitutes all of Himmelsteins' liability in respect to equipment or merchandise sold by it.

CALIBRATION AND COMPLIANCE CERTIFICATION *(Specimen only. An executed document is attached.)*

Himmelstein certifies that, before shipment from its factory, this torquemeter was thoroughly tested and inspected and was found to meet or exceed its published specifications. The listed calibration values were obtained during this process.

It further certifies that its calibration measurements are traceable to the NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST).

Calibrated by: . . . . Date: . . . .

Certified by: . . . . . . Date: . . . .

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