MAGTROL

Micro Dyne System
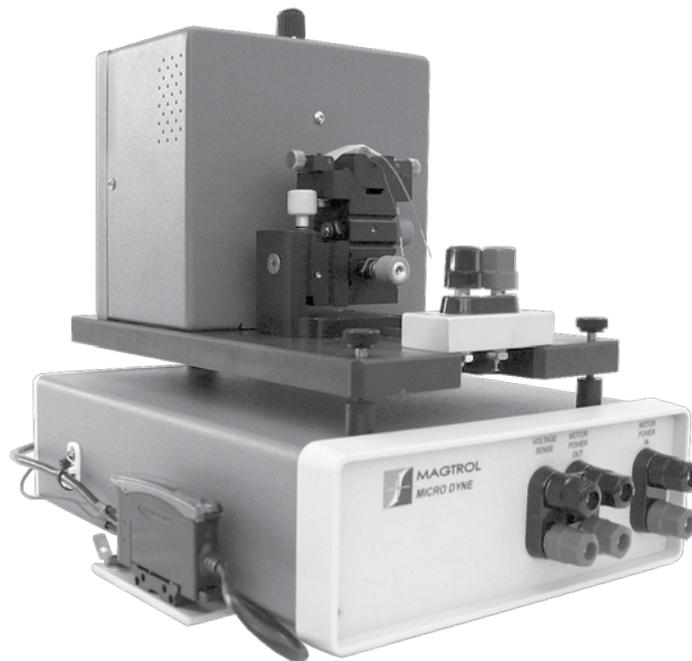
User's Manual

Purchase Record

Please record all model numbers and serial numbers of your Magtrol equipment, along with the general purchase information. The model number and serial number can be found on either a silver identification plate or white label affixed to each unit. Refer to these numbers whenever you communicate with a Magtrol representative about this equipment.

Model Number: _____

Serial Number: _____

Purchase Date: _____

Purchased From: _____

While every precaution has been exercised in the compilation of this document to ensure the accuracy of its contents, Magtrol assumes no responsibility for errors or omissions. Additionally, no liability is assumed for any damages that may result from the use of the information contained within this publication.

TRADEMARKS

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⧫MAGTROL

Safety Precautions

- Secure all grounding wires to the appropriate locations to reduce the chance of shock and damage to the equipment.
- Make sure all wiring and connections have been properly made.
- Always wear safety glasses when working around Micro Dyne equipment.
- Do not wear loose clothing or ties when operating the Micro Dyne equipment.
- Ensure motor under test is properly mounted to the motor fixture.

Revisions To This Manual

The contents of this manual are subject to change without prior notice. Should revisions be necessary, updates to all Magtrol User's Manuals can be found at Magtrol's web site at www.magtrol.com/support/manuals.htm.

Please compare the date of this manual with the revision date on the web site, then refer to the manual's Table of Revisions for any changes/updates that have been made since this edition.

REVISION DATE

First Edition, revision A – October 2007.

TABLE OF REVISIONS

Date	Edition	Change	Section(s)
10/21/07	1st Edition, rev. A	Added option to print calibration data results at end of calibration procedure.	6.3
06/13/07	1st Edition	Finalized version of preliminary manual	various

Table of Contents

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Preface

PURPOSE OF THIS MANUAL

This manual contains all the information required for the setup and general use of Magtrol's Micro Dyne System. To achieve maximum capability and ensure proper use of the system, please read this manual in its entirety before operating. Keep the manual in a safe place for quick reference whenever a question should arise.

WHO SHOULD USE THIS MANUAL

This manual is intended for bench test operators who are going to use the Micro Dyne System in order to determine the torque and power of a miniature/micro motor in relation to its speed. It is assumed that the user has sufficient knowledge in mechanics and electronics to be able to install/operate the dynamometer and its corresponding electronics unit without risk.

MANUAL ORGANIZATION

This section gives an overview of the structure of the manual and the information contained within it. Some information has been deliberately repeated in different sections of the document to minimize cross-referencing and to facilitate understanding through reiteration.

The structure of the manual is as follows:

Chapter 1:   INTRODUCTION – Contains the technical data sheet for Magtrol's Micro Dyne System which describes the system and all of its components, and provides detailed technical characteristics. A complete parts list, along with unpacking instructions, is also included in this section.

Chapter 2:   INSTALLATION/CONFIGURATION – Provides information needed for setup of the Micro Dyne System, primarily electrical connections and power configuration.

Chapter 3:   TESTING CONSIDERATIONS – Provides information on a number of factors that must be taken into consideration before running a test, including: safety, power dissipation, and influences that affect the apparent accuracy of the torque readout.

Chapter 4:   TEST SETUP – Provides instructions on how to set up a motor test, including dynamometer setup, motor mounting and software configuration

Chapter 5:   OPERATING PRINCIPLES – Information pertaining to the theory of operation including torque measurement, speed measurement and the PID control loop.

Chapter 6:   CALIBRATION – Step-by-step instructions for the calibration procedure.

Chapter 7:   TROUBLESHOOTING – Solutions to common problems encountered during setup, testing and calibration.

Appendix A: HARDWARE COMMANDS – Provides command reference tables for users who wish to write their own application.

Appendix B: SCHEMATICS – Contains a core block diagram, main schematic and wattmeter schematic.

Appendix C: CALIBRATION RECORD – Data record for tracking calibration results.

CONVENTIONS USED IN THIS MANUAL

The following symbols and type styles may be used in this manual to highlight certain parts of the text:

	Note:	This is intended to draw the operator's attention to complementary information or advice relating to the subject being treated. It introduces information enabling the correct and optimal function of the product.

	CAUTION:	THIS IS USED TO DRAW THE OPERATOR'S ATTENTION TO INFORMATION, DIRECTIVES, PROCEDURES, ETC. WHICH, IF IGNORED, MAY RESULT IN DAMAGE TO THE MATERIAL BEING USED. THE ASSOCIATED TEXT DESCRIBES THE NECESSARY PRECAUTIONS TO TAKE AND THE CONSEQUENCES THAT MAY ARISE IF THESE PRECAUTIONS ARE IGNORED.

	WARNING!	THIS INTRODUCES DIRECTIVES, PROCEDURES, PRECAUTIONARY MEASURES, ETC. WHICH MUST BE EXECUTED OR FOLLOWED WITH THE UTMOST CARE AND ATTENTION, OTHERWISE THE PERSONAL SAFETY OF THE OPERATOR OR THIRD PARTY MAY BE AT RISK. THE READER MUST ABSOLUTELY TAKE NOTE OF THE ACCOMPANYING TEXT, AND ACT UPON IT, BEFORE PROCEEDING FURTHER.

1.   Introduction

1.1   UNPACKING THE MICRO DYNE

1.1.1   PACKAGING

Your Micro Dyne System was shipped in its own hard-sided carrying case with shock-resistant packing foam. The packaging is designed to protect the instruments during normal handling.

Inspect the contents for any evidence of damage in shipping. In the event of shipping damage, immediately notify the carrier and Magtrol's Customer Service Department.

☞   Note: Save all shipping cartons and packaging material for reuse when returning the instrument for calibration or servicing.

1.1.2   PARTS LIST

Make sure the case contains all the following:
   A. Dynamometer with attached motor fixture
   B. Electronics unit

⚠   CAUTION: THE DYNAMOMETER AND ELECTRONICS UNIT ARE SHIPPED ALREADY CONNECTED TO ONE ANOTHER BY A SERIES OF CABLES (BUNDLED TOGETHER). USE CAUTION WHEN LIFTING OUT OF THE CASE.

   C. CD-ROMs
      1. M-TEST 5.0 CD-ROM
      2. Micro Dyne Supplemental Programs and Utilities CD-ROM
      3. Magtrol User Manual CD-ROM
   D. Bag of cables
      1. USB cable
      2. Three power supply cables with dual banana plugs on both ends
      3. Main IEC power cord
   E. A second bag of parts contains the following:
      1. Circular weight and fastening (hex key) screw for torque configuration
      2. Hardware for motor fixturing
         a. Two motor fixture adapters
         b. Small Allen wrench (hex key)
         c. Two small hex screws
      3. Three bags of rubber couplings
         a. Ten pieces of 0.5 mm inside diameter tubing, each 25 mm in length
         b. Ten pieces of 0.8 mm inside diameter tubing, each 25 mm in length
         c. Ten pieces of 1.6 mm inside diameter tubing, each 25 mm in length
      4. Two calibration weights, one 5 g and one 10 g, tagged and labeled.

5. Calibration documentation
    a. Calibration certificate for Micro Dyne
    b. Calibration test report for wattmeter
    c. Calibration test report for dynamometer
6. Accessory tools
    a. Tweezers
    b. Medium Allen wrench
    c. Large Allen wrench
    d. Five cable ties

1.2   DATA SHEET

Micro Dyne
Motor Testing System

FEATURES

- DESIGNED SPECIFICALLY for miniature and micro motors
- Torque: Easily convertible from 2.0 mN·m to 4.0 mN·m (0.28 oz·in to 0.57 oz·in)
- Speed: up to 100,000 rpm
- Power: 4 W
- Low inertia
- Sold as a complete, out-of-the-box motor testing system. Components include:
    - Hysteresis Dynamometer: provides precise torque loading independent of shaft speed
    - Motor Fixture: accommodates motors from 5 mm to 30 mm in diameter.
    - Dedicated Electronics: all-in-one dynamometer controller, DC wattmeter, power relay and USB interface
    - Comprehensive Motor Testing Software: new version of Magtrol's M-TEST 5.0, updated for the Micro Dyne
    - Easy-to-use calibration software
    - All necessary connection cables
    - Calibration weights: 5 g and 10 g

DESCRIPTION

With over 50 years' experience in dynamometer design and torque measurement, Magtrol has revolutionized the industry. Magtrol's NEW Micro Dyne, capable of measuring extremely low torques (2.0 mN·m can be resolved to 0.0004 mN·m), is designed EXCLUSIVELY for testing miniature and micro (low-torque) motors.

For the utmost convenience, the Micro Dyne is packaged as a COMPLETE MOTOR TESTING SYSTEM. Everything that is needed to accurately and efficiently test miniature motors and micro motors is included with the purchase of a Magtrol Micro Dyne. The only component that needs to be supplied by the customer is a laptop or desktop personal computer and motor power supply.

Motor Characteristics Measured/ Calculated:

- Torque
- Speed
- Amps
- Volts
- Horsepower
- Efficiency
- Input Watts
- Output Watts

APPLICATIONS

Magtrol motor test systems can be found in test labs, at inspection stations, and on the manufacturing floors of most of the world's leading motor manufacturers. The Micro Dyne system is used exclusively for closed-loop testing of miniature motors and micro motors used in low-torque/high-speed applications.

Motor sub-types include, but are not limited to, the following:

- Brushed and brushless DC motors
- Miniature stepper motors
- Gearmotors
- Brushless DC servomotors
- Vibrator motors
- Miniature air motors

These mini/micro motors are used in a diverse range of industries and products, including:

- Medical and laboratory equipment
- Robotics and automation
- Toys
- Handheld communication devices
- Audio/video equipment
- Optics and photonics
- Aerospace and defense
- Security and instrumentation
- Industrial machinery

System Configuration

Micro Dyne

SYSTEM MODEL

Dynamometer

shipping bolt knob

Electronic Unit
functions as a:
• Dynamometer Controller
• DC Wattmeter
• Power Relay
• USB Interface

dynamometer shaft

motor under test

motor power IN terminals

motor power OUT terminals

motor clamping strap (with knurled cam grip)

Motor Fixture

voltage sense terminals

motor fixture adjustment knobs (height, width and depth)

motor electrical connection

fiber optic speed pickup

leveling knobs

BLOCK DIAGRAM

```
Motor
Under          motor power
Test
  │
Slotted    speed signal (via fiber optic speed pickup)
Disc
  │
Brake          torque signal

               brake power
```

DSP

Firmware

USB cable

PC with M-TEST 5.0 and calibration software

Power Supply

Mains
(IEC 80 – 240 V AC,
60/50 Hz)

⚡ System Information

Micro Dyne

SYSTEM COMPONENTS

Dynamometer
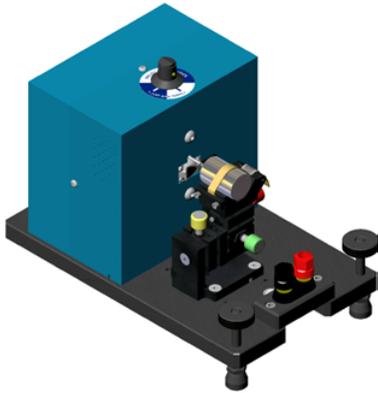
The Micro Dyne dynamometer absorbs power with Magtrol's unique Hysteresis Braking System. Because it does not require speed to create torque, the dynamometer can conduct a full motor ramp—from free-run to locked rotor.

In addition to a dedicated motor fixture, the dynamometer base plate also includes leveling knobs and motor power terminals. The housing of the dynamometer protects all the moving parts of the brake.

Electronic Unit

At the hub of the Micro Dyne system is a multifunctional electronic unit. The unit employs DSP technology for high-speed data acquisition and complete PC control of the dynamometer. A USB receptacle enables easy connection to a personal computer. An integrated DC wattmeter reads volts and amps, and calculates watts; and a built-in power relay controls motor power (on/off).

The front panel includes the terminals for motor power in/out and voltage sensing. LED power and communication indicators are located on the rear panel of the unit.

Motor Fixture

Attached to the dynamometer base plate is a motor fixture designed expressly for micro/miniature motors. The base of the fixture features an XYZ stage with 3-axis positioning for excellent adjustability and motor centering. With the included adapters, motors from 5 mm to 30 mm in diameter can be easily mounted. The fixture is keyed to help secure the motor under test and a rubber strap with knurled cam grip provides motor clamping.

Motor Testing Software
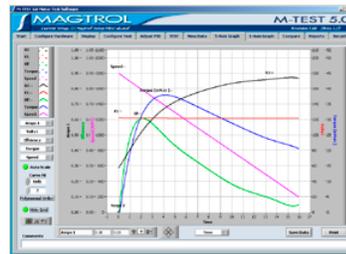
Magtrol's M-TEST 5.0 is a state-of-the-art comprehensive motor testing program designed for use with Windows® operating systems for PC-based data acquisition. The software measures and calculates a motor's performance characteristics by employing these user-configurable testing methods:

Ramp: Select from average ramp down/up or ramp down with inertia correction factor. Also allows extrapolation of free-run and locked-rotor data, plus interpolation of specific speed or torque data points.

Curve: Test speed, torque, amps, watts input, watts output and open loop parameters, and compares actual values to user-defined limits. Capable of adjusting sampling rate and using step or ramp from one load point to the next.

Pass/Fail: Checks amps, input watts, speed, torque and output watts against user-defined values.

The data generated can then be stored, displayed and printed in tabular or graphic formats, and is easily imported into a spreadsheet.

OPERATING PRINCIPLES

Speed Measurement

The Micro Dyne contains a reflective fiber optic speed pickup. Each rotor slot that passes by the sensing end of the fiber optic generates an electronic pulse, which is then converted to a speed reading (in rpm).

Torque Measurement

A hysteresis brake is used to develop a resistance to rotation of a mechanical shaft. A torsional force is produced by the test motor and applied to the brake's rotor-shaft assembly. Reaction torque is measured by the angle of the brake pendulum assembly and is interpreted by the Micro Dyne system software (M-TEST 5.0).

⚡ Specifications   **Micro Dyne**

DYNAMOMETER

The Micro Dyne offers two different torque configurations in one unit. Depending on the motor's maximum torque rating, the user can easily switch between the 2.0 mN·m and 4.0 mN·m torque settings via the dynamometer's rear access panel. The ratings are the same for either configuration.

Maximum Torque	Nominal Input Inertia	Maximum Kinetic Power		Maximum Speed	Accuracy	
		5 minute	continuous		Torque	Speed
mN·m	kg·cm²	W	W	rpm	Torque	Speed
4.0 or 2.0	5.43×10^{-4}	4	4	100,000	< 1% of full scale	< 0.02% of reading

Power Absorption Curve

Based on the maximum kinetic power ratings, the curve below represents the maximum power (heat) that the dynamometer can dissipate over time. The area under the curve equals the maximum speed/torque combinations for both a motor test of less than 5 minutes (intermittent duty), and a continuous-duty motor test.
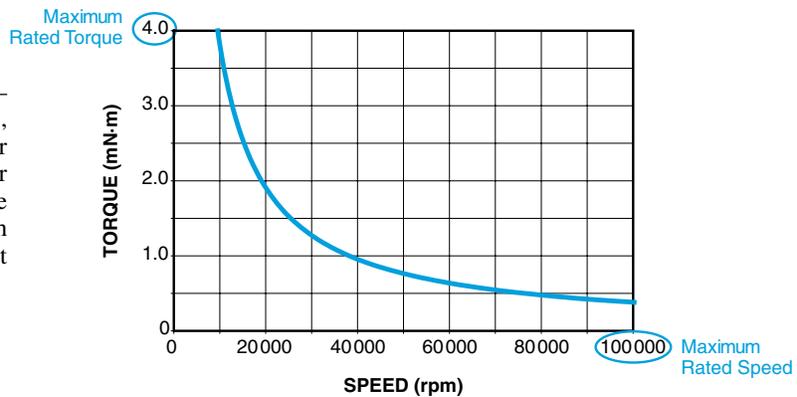
DYNAMOMETER ENVIRONMENTAL REQUIREMENTS	
Operating Temperature	0 °C to +70 °C
Relative Humidity	< 60% without condensation
EMC	In accordance with IEC 61326:2002

ELECTRONIC UNIT

GENERAL ELECTRICAL CHARACTERISTICS	
Fuse (5 × 20 mm)	IEC 315 mA 250 V T
Power Requirements	14 VA
Voltage Requirements	85 – 264 V AC, 60/50 Hz
ENVIRONMENT	
Operating Temperature	0 °C to +70 °C
Relative Humidity	< 60% without condensation

POWER MEASUREMENT (DC)	
Current Input (isolated)	±5 A
Voltage Input (isolated)	±30 V DC
Conversion Rate	15/second/input
Accuracy	Up to 0.02%
Isolation, to earth	50 V DC
Isolation, channel-to-channel	100 V DC

MOTOR FIXTURE

MOTOR ACCOMMODATION	
Motor Diameter	5 mm – 30 mm
Motor Length	5 mm – 50 mm
Motor Shaft Diameter	0.75 mm – 3 mm
Maximum Load	100 g

ADJUSTABILITY	
X/Y/Z Adjustable Range	±5 mm (all axes)
Controllable Motion	0.005 mm
Travel per Knob Revolution	0.318 mm

⊁ Dimensions (mm)   Micro Dyne

DYNAMOMETER

Weight	4.2 kg	9.3 lb
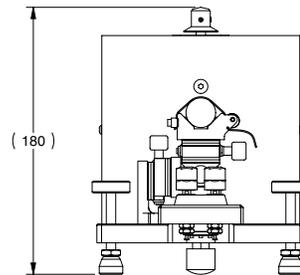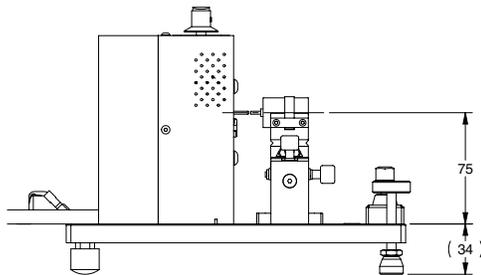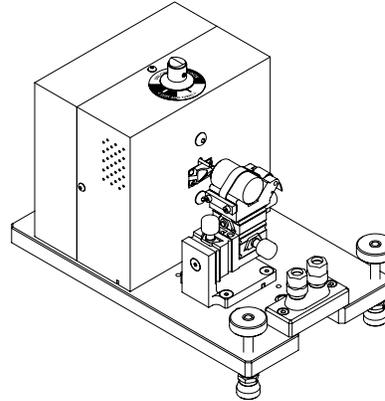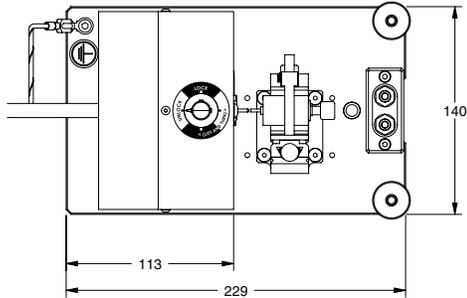
ELECTRONIC UNIT
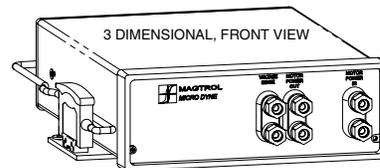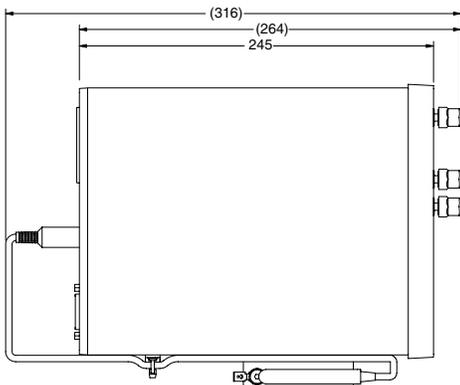
Weight	1.5 kg	3.2 lb
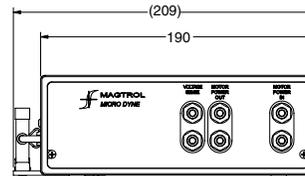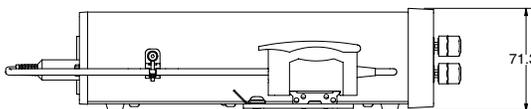
Due to the continual development of our products, we reserve the right to modify specifications without forewarning.

2. Installation/Configuration

2.1   DYNAMOMETER SETUP
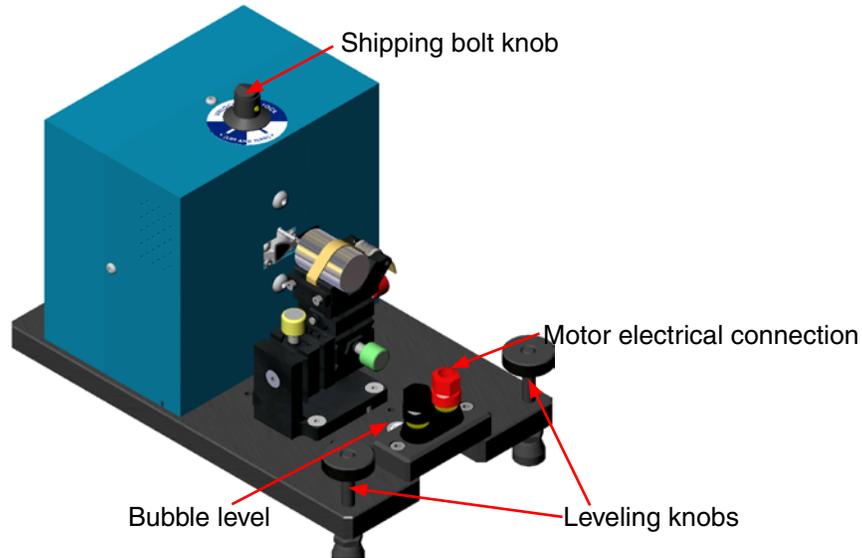
Figure 2–1 Micro Dyne Dynamometer

2.1.1   UNLOCKING THE SHIPPING/RESTRAINING BOLT

Before dynamometer operation, the shipping/restraining bolt must be unlocked. A knob attached to the bolt is located on the top of the dynamometer housing, as shown in *Figure 2–1*. To unlock, lift up on the knob and turn it clockwise 90° to the "Unlock" position.

2.1.2   DYNAMOMETER LEVELING

Simply level the dynamometer with the two leveling knobs at the front of the base plate, using the embedded bubble level as a guide.

2.2   ELECTRICAL CONNECTIONS

The Micro Dyne is shipped with the dynamometer and the electronics unit already connected to one another by a set of cables. These four cables are bundled together at the dynamometer end, and branch out into the following for connection to the electronics unit:

Connection Cable	Attaches To	Description
Earth ground	Mounting plate of speed pickup	Provides safety against electric shock.
Bifurcated fiber optic cable	Speed pickup	Reads speed measurement.
Dynamometer brake cable	BRAKE Output	Delivers power from electronics unit to dynamometer brake.
15-pin instrument cable	ENCODER Input	Quadrature encoder; reads torque measurement.

2.2.1   EARTH GROUND

For your safety, the dynamometer has been earth grounded and shipped with the ground strap already in place. This protective wire provides an alternate path to ground in case of short circuits or heavy electrical currents.

The dynamometer connection point is located on the rear of the base plate and is clearly marked with the earth ground symbol.

Ground lug   Ground strap
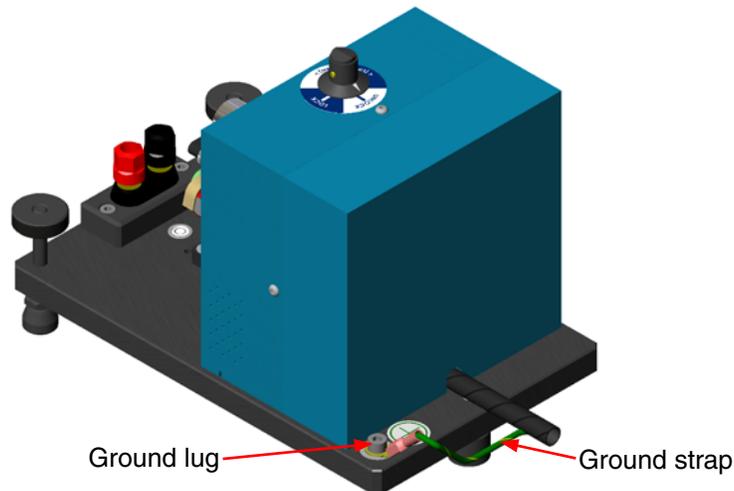
Figure 2–2 Dynamometer Earth Ground

The other end of the ground strap should be connected to the metal tab attached to the speed pickup mounting plate, located on the Micro Dyne Electronics Unit. See *Figure 2–3 Speed Pickup*.

The complete earth ground path is as follows:

Dynamometer —> Electronics unit —> Main power cord —> Earth

2.2.2   **SPEED PICKUP CONNECTION**

Plastic cover

Fiber connection mechanism
(shown in "up"/unlocked position)

Insert fiber optic
cable ends here

Organize
speed pickup
cables here

(Partial) side view of electronics unit

Earth ground
connection

SETUP
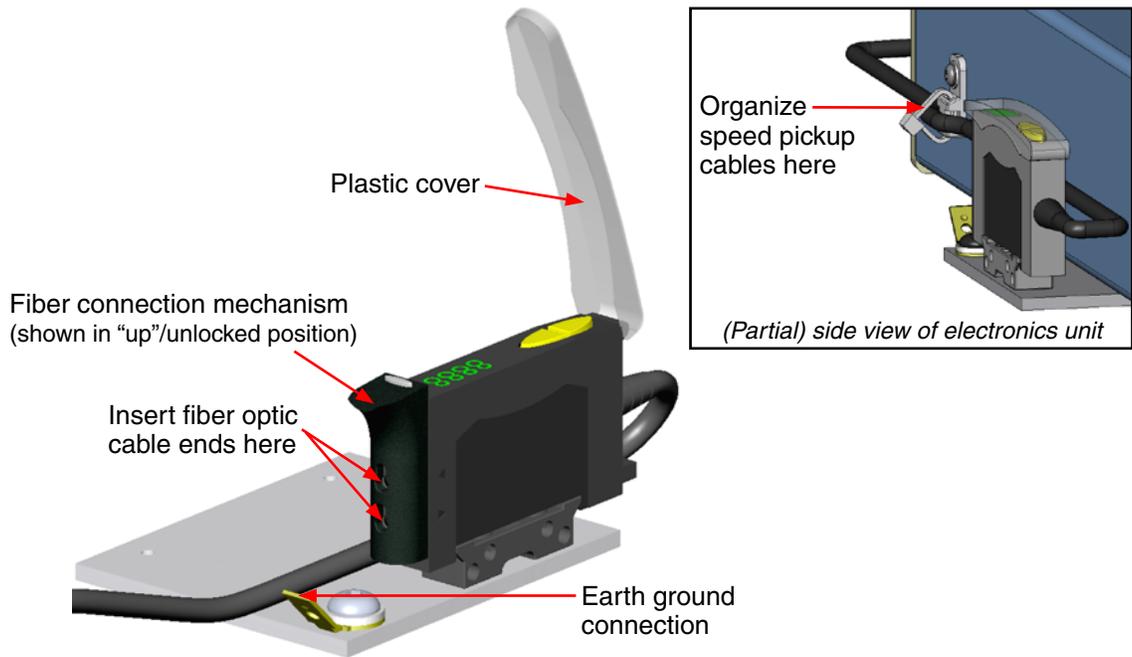
Figure 2–3 Speed Pickup

To connect the speed pickup to the dynamometer:

1. Lift up the plastic cover.
2. Slide the fiber connection mechanism up.
3. Locate the two openings in the sliding mechanism and insert the bifurcated ends of the fiber optic cable, inserting as far as the mechanism will allow.

☞   Note: It does not matter which fiber optic sensing end goes into which opening.

4. Slide the fiber connection mechanism down in order to lock.

2.2.3   **REAR PANEL CONNECTORS**
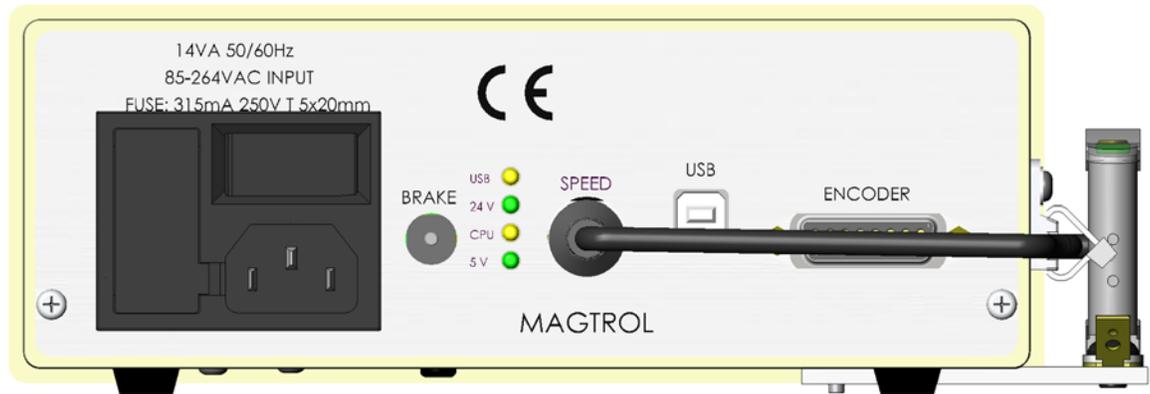
Figure 2–4 Electronics Unit Rear Panel

The rear panel connectors, from left to right, are:

Connector	Attaches To	Connection Cable
POWER Input	Power source	Main power cord
BRAKE Output	Dynamometer	Dynamometer brake cable
SPEED Output	External speed sensor	6-pin sensor cable
USB Port	Personal computer	USB cable
ENCODER Input	Dynamometer	15-pin instrument cable

Using the table above, make the necessary connections with the cables provided. As noted in *Section 2.2 – Electrical Connections*, some of the cables have been installed prior to shipping.

2.3   **MOTOR POWER**

☞   Note: For detailed instructions on motor mounting, refer to *Section 4.2*.

Using the three power supply cables provided, make the following basic connections. Other power configuration options are shown in *Section 2.2.1*.

⚠️   CAUTION: PAY ATTENTION TO WHICH PIN ON THE BANANA PLUG IS POSITIVE AND WHICH ONE IS NEGATIVE. CONNECT TO THE RED (+) AND BLACK (−) TERMINALS ACCORDINGLY.

Terminal on Electronics Unit	Connected To	Description
Motor Power In	User's power supply	Allows power measurement and on/off switching from electronics unit.
Motor Power Out	Motor connection point on dynamometer	Outputs power to the motor. Controlled by relay inside electronics unit which turns motor power on/off.
Voltage Sense	Motor connection point on dynamometer	Measures voltage directly from the motor, thus eliminating voltage drop. Results in increased power measurement accuracy and efficiency.

Figure 2–5 Electronics Unit Front Panel

Figure 2–6 illustrates the internal wattmeter and relay layout, showing the complete basic power circuit from power supply to motor.
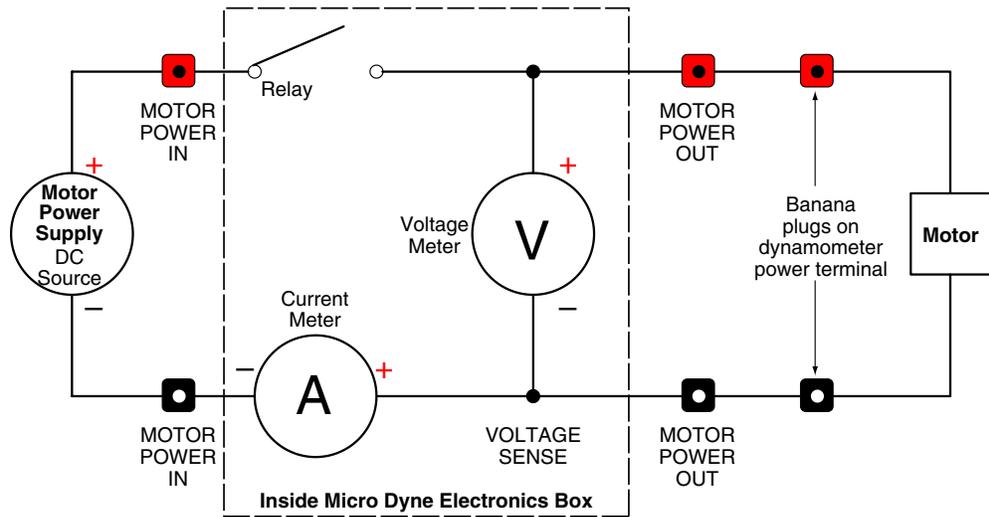
Figure 2–6 Basic Motor Power Circuit

2.3.1   POWER CONFIGURATION OPTIONS

2.3.1.1   Basic Configuration

This standard Micro Dyne setup shows a (customer-provided) motor power supply wired to the Micro Dyne Electronics Unit. This setup allows the Micro Dyne's electronics to control on/off power to the motor under test, and to monitor input power.
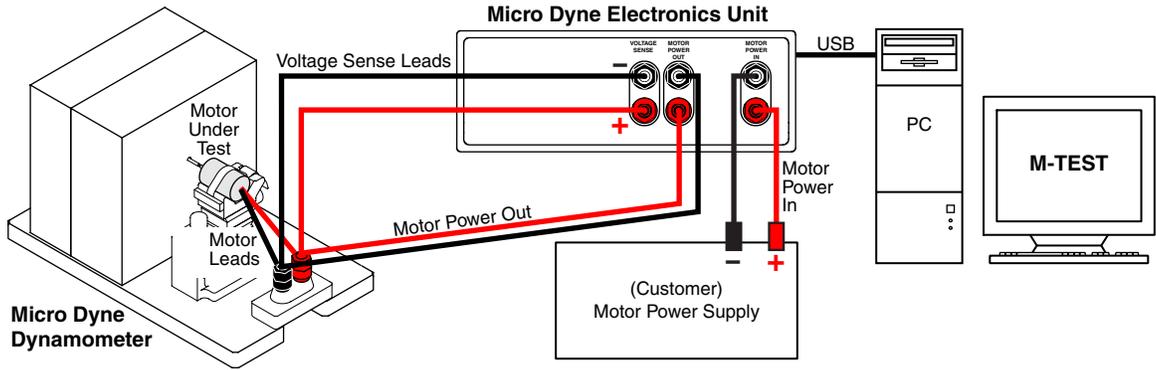
Figure 2–7 Basic System Configuration

2.3.1.2   Relay Configuration

To run a motor in both clockwise and counter-clockwise directions, without having to rewire during the middle of a test, a relay card is required. A National Instruments™ PCI relay card (available for purchase from Magtrol) allows for the automatic reversing of motor leads when the motor power supply is connected to the relay card. Like the basic system configuration, the Micro Dyne controls on/off power to the motor under test and monitors motor input power. For more information regarding motor reversal, refer to *Section 4.3.1.*
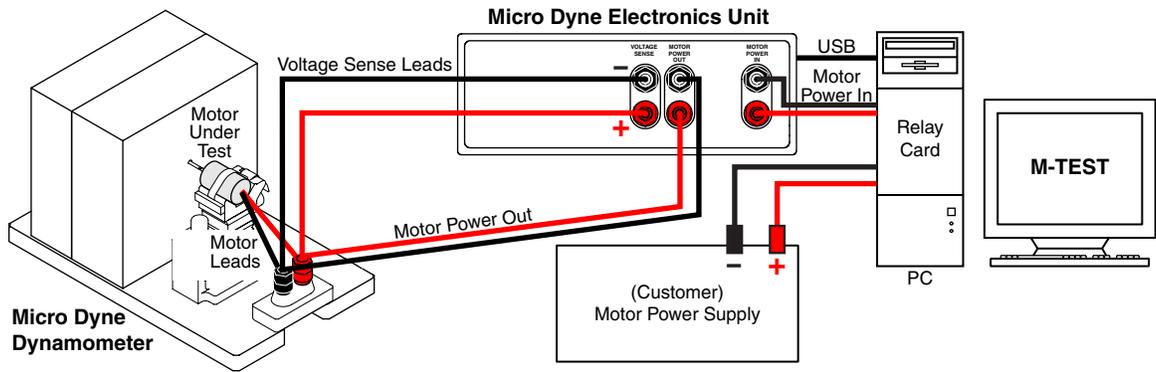
Figure 2–8 Relay Configuration

2.3.1.3   Motor Drive Configuration

This setup allows for the addition of a motor drive unit. The advantage to this is that the Micro Dyne is now measuring the drive/motor efficiencies, instead of the just the motor alone. This is especially beneficial when the motor is dependent on the motor drive for operation. With the power supply unit attached to the Micro Dyne relay, the power to the motor drive can be controlled through M-TEST.
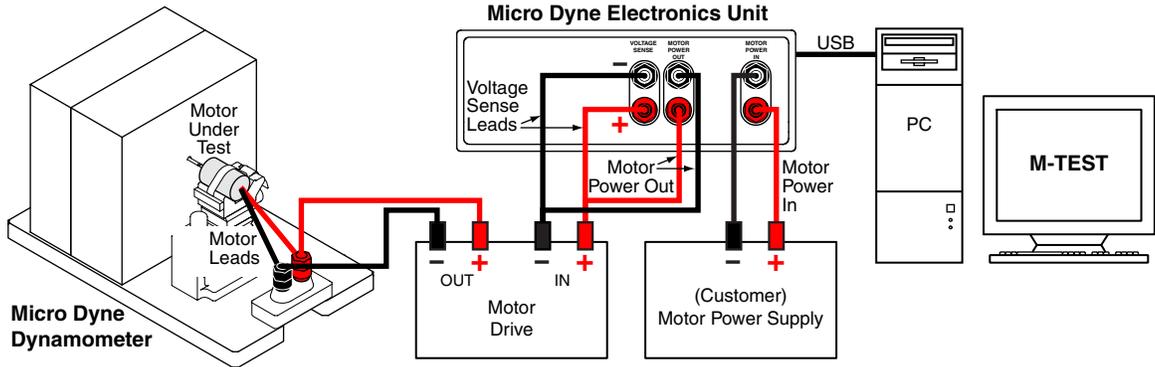
Figure 2–9 Motor Drive Configuration

2.4   MOTOR TESTING SOFTWARE

2.4.1   SOFTWARE INSTALLATION

For detailed installation instructions, refer to Magtrol's *M-TEST 5.0 User's Manual*.

2.4.2   M-TEST COMMUNICATION

In order to use M-TEST with the Micro Dyne, the COM port to which the USB interface is connected must first be determined.

1. Power up the Micro Dyne.
2. Find the COM port.

    For Windows 95/98/2000: Go to Start menu > Settings > Control Panel > System > Hardware > Device Manager > Ports. Look for the USB Serial Port and note the COM port number in parenthesis.

    For Windows XP: Go to Start menu > Control Panel > Switch to classic view > System > Hardware > Device Manager > Ports. Look for the USB Serial Port and note the COM port number in parenthesis.

☞   Note: To configure M-TEST for the Micro Dyne, refer to *Section 4.3 – Software Configuration*.

2.5   COMMUNICATION CHECK

When powering up the Micro Dyne, check to make sure that all four LEDs on the rear panel of the electronics unit (see *Figure 2–4*) are illuminated according to the table below.

LED	Color	Indicates
USB	Yellow	Flashing: USB communication is taking place.
24 V	Green	The 24 volt power is OK.
CPU	Yellow	The power-up sequence has been initiated.
5 V	Green	The 5 volt power is OK.

2.6   INITIAL CALIBRATION

After communication is verified, it is highly recommended to calibrate the dynamometer before performing any tests. Refer to *Chapter 6 – Calibration* for a detailed procedure.

SETUP

3. Testing Considerations

A number of factors must be taken into consideration before running a test, including: safety, power dissipation, and influences that affect the apparent accuracy of the torque readout (such as shaft alignment, windage, friction, vibration, dynamometer leveling, cogging, Eddy currents and temperature rise). The following sections describe these factors, and their effects, in further detail.

👉 Note: If you have not already done so, please take a moment to familiarize yourself with the Micro Dyne System's technical specifications. See *Section 1.2 – Data Sheet*.

3.1   SAFETY

🛑 **WARNING!   FOR GENERAL SAFETY CONSIDERATIONS, PLEASE FOLLOW THESE FEW COMMON-SENSE RULES:**

- Make sure all wiring and connections have been properly made.
- Secure all grounding wires to the appropriate locations to reduce the chance of shock and damage to the equipment.
- Always wear safety glasses when working around Micro Dyne equipment.
- Do not wear loose clothing or ties when operating the Micro Dyne equipment.
- Ensure motor under test is properly mounted to the motor fixture.

3.2   POWER DISSIPATION

All Magtrol dynamometers are power absorption instruments. As a dynamometer loads a test motor, it is absorbing power from the motor into the hysteresis brake. The brake is converting this mechanical energy into heat.

There are finite limits to the amount of energy and resulting temperature rise that any absorption brake can withstand. Excessive power over extended periods of time may result in more obscure damage including breakdown of bearing lubricants and degradation of magnetic coil insulation. Extreme temperatures due to inappropriate operation can not only warp the rotor and surrounding housings, but also alter the magnetic characteristics. Absolute best-case scenario under such circumstances would be a reduced torque output from the brake assembly, if complete dynamometer failure were not realized.

3.2.1   POWER ABSORPTION CURVE

Based on the maximum kinetic power ratings, the curve represented in *Figure 3–1* illustrates the maximum power (heat) that the dynamometer can dissipate over time. The area under the curve equals the maximum speed/torque combinations for both a motor test of less than 5 minutes (intermittent duty), and a continuous-duty motor test.

Conditional Environmental Parameters	
Maximum brake temperature	100 °C (212 °F)
Ambient temperature	25±5 °C (77±9 °F)
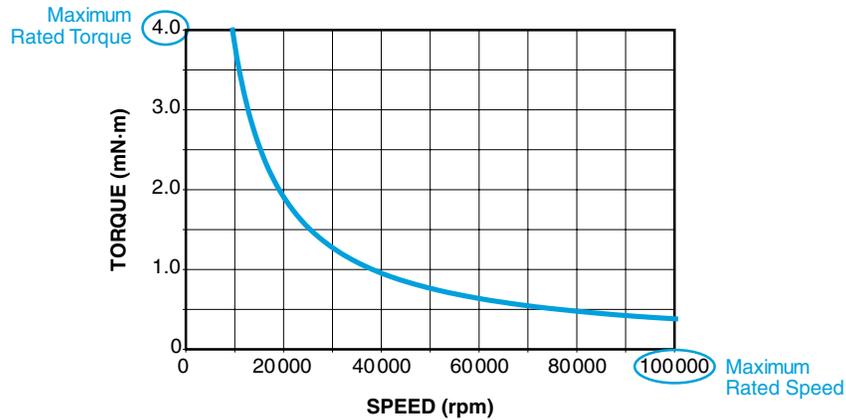
Figure 3–1 Micro Dyne Power Absorption Curve

OPERATION

3.3   SHAFT ALIGNMENT

In motor testing, shaft alignment is one of the most important factors to consider. An improper coupling and/or shaft alignment can lead to unwanted side loads and vibration, damaging both the test equipment and motor. To accommodate micro motor sizes, while preventing side loading on the dynamometer shaft, a coupling of small flexible rubber tubing should be used. The friction of the rubber tube on the shaft alone suffices as a clamping agent. Several pieces of rubber tubing, in various diameters, are included with the Micro Dyne for this purpose. Refer to *Section 4.2.1 – Shaft Coupling* for detailed coupling instructions.

3.4   WINDAGE

Windage is proportional to the square of speed. The air friction is tangential to the surface and impinges upon the stationary field assembly. This acts as viscous drag and becomes part of the motor load and torque reading. There is also a small amount of air dissipated as pumping loss. Since this appears as a load on the motor, not measured by the dynamometer, it becomes a source of error. Considering the size of the parts affected by windage in the Micro Dyne, this source of error will be less pronounced then if similar speeds were seen on larger dynamometers.

3.5   FRICTION

Friction of the carrier bearings is a measurable load. When correctly loaded and lubricated, the friction is insignificant. During actual motor testing there is usually enough system vibration to "settle" negating frictional effects. If excessive drag is present, mechanical realignment may be required. In the design of the Micro Dyne, careful attention was paid to carrier bearing friction for the proper operation of the pendulum assembly; mainly in ensuring the pendulum returned to the zero position within the published error bands.

☞   Note: Friction is the largest source of error in the Micro Dyne but it is relatively small in comparison to the overall range and accuracy (<1%) of the dynamometer.

3.6   VIBRATION

All rotating dynamometer assemblies are precision balanced. At high speeds, some vibration and noise are inevitable but not necessarily harmful. However, excessive resonant vibrations caused by bent shafts and poor alignment will produce data errors and are a safety hazard.

⚠   CAUTION: SEVERE VIBRATION LEFT UNATTENDED COULD ULTIMATELY LEAD TO PERMANENT DAMAGE TO THE TEST EQUIPMENT OR THE MOTOR UNDER TEST.

OPERATION

3.7   DYNAMOMETER LEVELING

An improperly leveled dynamometer will alter the torque calculations in proportion to the deviation from a true level surface. The base plate of the Micro Dyne is equipped with two leveling knobs and an embedded bubble level for easy leveling.

3.8   COGGING
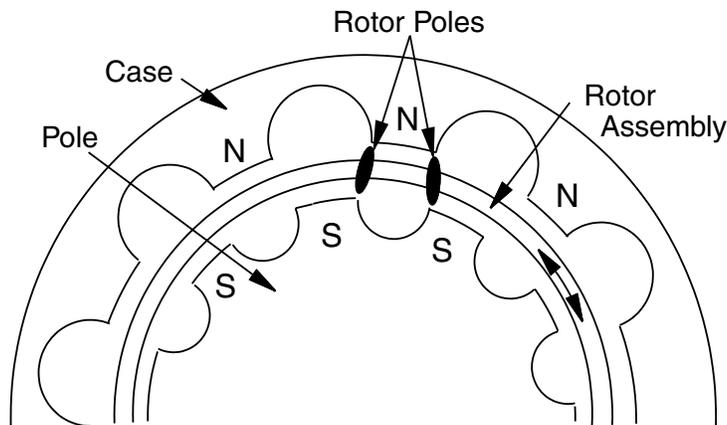
Figure 3–2 Hysteresis Brake Cross-Section

This cross-section shows (by one tooth) the magnetic relationship of the hysteresis brake elements. If the dynamometer shaft is at rest with the torque applied, and if the torque control is then reduced to zero, a magnetic salient pole will be temporarily imposed on the rotor of the brake.

If the shaft is then rotated slowly, the magnetic poles on the rotor will attempt to align with the adjacent case-pole tooth form. This is often referred to as "cogging". The action is sinusoidal. First it tries to resist rotation and then, as the rotor passes through the tooth form, it subsequently supports rotation.

The most obvious results of cogging are uncontrolled oscillations within the torque/speed curve. It will become difficult for the motor under test to tune in the PID loop, along with a possible increase in resonant noise from the dynamometer and motor.

3.8.1 AVOIDING COGGING

To avoid magnetic cogging, before the shaft comes to rest, slowly reduce the torque control to zero.

3.8.2 REMOVING COGGING

To most effectively remove cogging, once established, reapply current on the dynamometer. Then, slowly ramp the current to zero while maintaining a very low speed (only a few rpms). The current ramp to zero can be increased slightly in speed when the dynamometer rotation is sped up during this process.

3.9 EDDY CURRENTS

There is some Eddy current generation within the brake rotor. These magnetically-induced currents cause an increase in braking torque proportional to speed. While more pronounced in larger dynamometers (which exhibit higher rotor surface velocities), in a pure loading system it becomes a benefit of the dynamometer. Since the Eddy currents effect the rotor surface, this torque is measured by the torque pendulum and becomes another load source (and not a source of error).

3.10 TEMPERATURE RISE

Temperature rise has a more complex effect on hysteresis brake load torque and is difficult to quantify. As the temperature of the brake increases, differential expansions cause dimensional changes that tend to increase torque. Conversely, electrical resistance in the rotor increases with temperature, resulting in decreased Eddy current generation and load, all in a variable frame.

> CAUTION: UNDER NO CIRCUMSTANCES SHOULD THE MAXIMUM WATTAGE RATINGS FOR THE DYNAMOMETER BE EXCEEDED. THE RESULTING RISE IN TEMPERATURE CAN CAUSE PERMANENT DAMAGE TO THE ROTATING ASSEMBLY, INCLUDING ALTERING THE MAGNETIC PROPERTIES OF THE ROTOR ITSELF.

OPERATION

4. Test Setup

4.1   TORQUE CONFIGURATION

The Micro Dyne can be configured to either a 4 mN·m or 2 mN·m torque scale. The Micro Dyne is shipped with the 2 mN·m configuration. To convert it to 4 mN·m, follow the procedures below.

1. Remove the rear panel of the dynamometer as described in *Section 6.2.1 – Dynamometer Rear Panel Removal*.

2. Locate the small parts bag that contains a single circular weight and fastening screw.

3. Once the inside of the dynamometer is accessed, move the pendulum in either direction in order to expose the threaded hole located at the center of the pendulum.
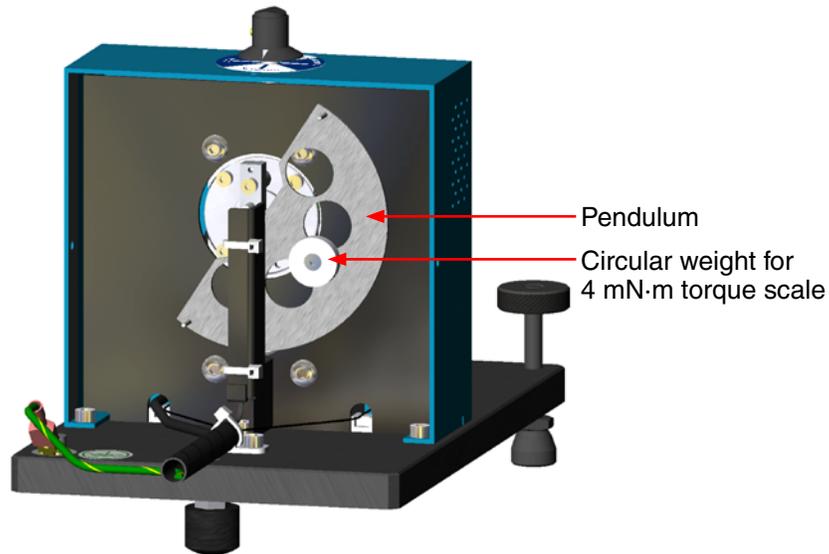
Figure 4–1 Dynamometer, Inside View

4. Attach the circular weight with the provided hex screw, using the smaller of the two Allen wrenches included in the accessory tool bag.

5. Calibrate the dynamometer with the 10 gram calibration weight. Refer to *Chapter 6* for complete calibration instructions.

☞ | Note: | Re-calibration is necessary after every conversion between the 2 mN·m and 4 mN·m torque configurations.

4.2   MOTOR MOUNTING
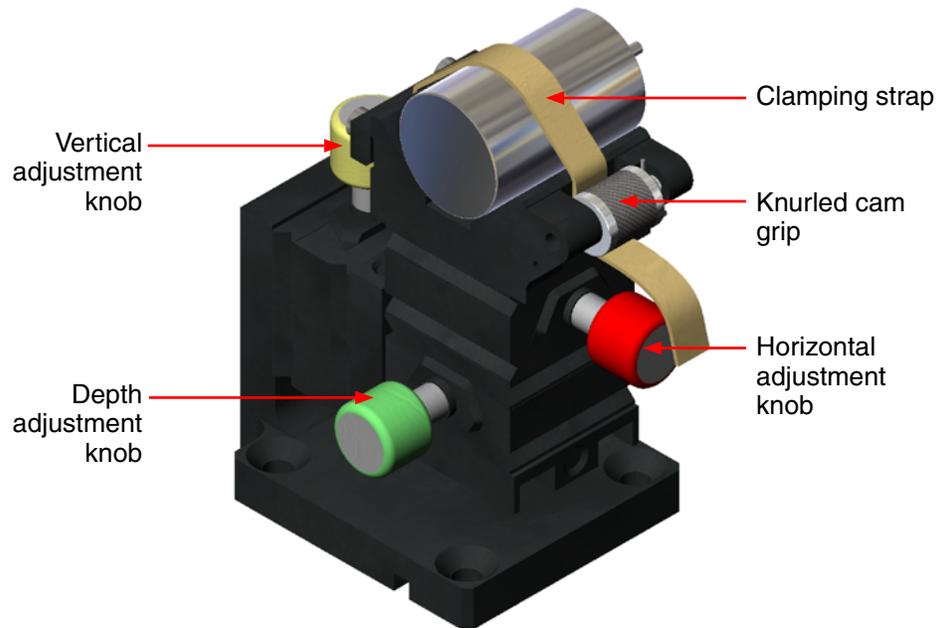
Figure 4–2 Micro Dyne Motor Fixture

4.2.1   SHAFT COUPLING

If the motor shaft diameter is 0.5 mm to 1.6 mm, it is highly recommended to use one of the provided rubber couplings to adapt the motor shaft to the 2.0 mm Micro Dyne Dynamometer shaft.

1. Trim the tubing to allow about 2 mm of tubing over the dynamometer shaft and 3 mm of tubing over the motor shaft.
2. Place the tubing snugly around the dynamometer shaft, being careful not to bend the shaft.
3. After the motor is mounted, as described in *Sections 4.2.2, 4.2.3* and *4.2.4*, place the other end of the rubber tubing around the motor shaft.

4.2.2   ADAPTERS

When testing motors with diameters less than 20 mm, the appropriately-sized adapter must be used.

Motor Diameter	Adapter
5 mm – 10 mm	V-Adapter I
10 mm – 20 mm	V-Adapter II
20 mm – 30 mm	No adapter necessary

Attach the adapters to the fixture using the provided hex screws and Allen wrench. The threaded holes are found in the groove of the V-adapters.

☞   Note: The adapter should be secured in place but be careful not to overtighten.

Motor Fixture
with
V-Adapter I

Motor Fixture
with
V-Adapter II

Motor Fixture
without
adapter
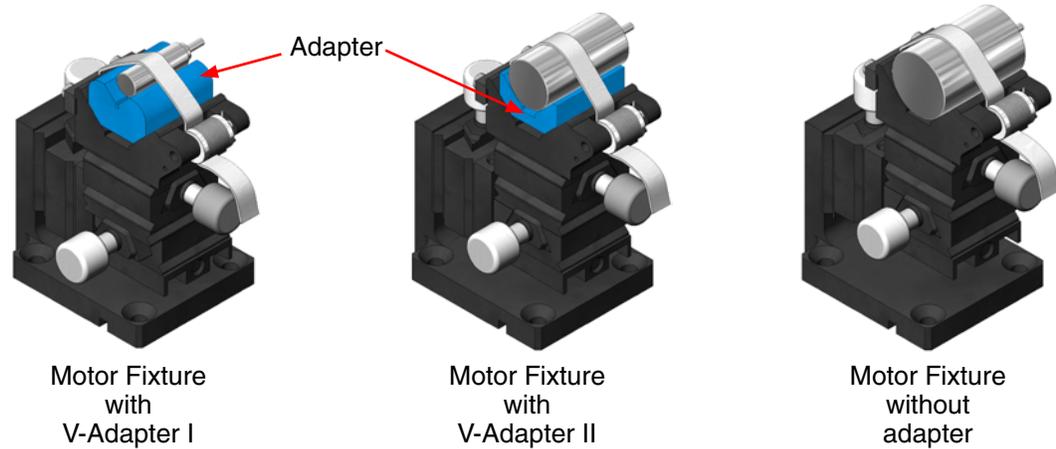
Figure 4–3 Motor Fixture Adapters

4.2.3   CLAMPING STRAP

1. Place the motor under the rubber strap.
2. Tighten by pulling on the strap. A knurled cam will lock the strap in place when the strap is let go.
3. To release the motor, rotate the cam upward and the strap will loosen.

☞   Note: Ideally, the clamping strap should be secured at the middle of the motor.

4.2.4   STAGE ADJUSTMENT

For precise motor alignment, the stage of the motor fixture may be axially adjusted using the three colored adjustment knobs.

Knob Color	Axis	Adjustment Direction
Red	X	Horizontal (side-to-side positioning)
Yellow	Y	Vertical (shaft height)
Green	Z	Depth (of motor to input shaft of dynamometer)

☞   Note: The entire motor fixture can also move (as one unit) along the length of the dynamometer base plate, in line with the bolt pattern. The fixture is locked in place by screwing into the tapped holes with the provide hex key screws.

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4.3   SOFTWARE CONFIGURATION

This section only provides very basic instructions for setting up M-TEST to run with the Micro Dyne. For detailed information about selecting, configuring and running a test, refer to Magtrol's *M-TEST 5.0 User's Manual*.

1. Power up the Micro Dyne.
2. Start M-TEST.
3. Open the Configure Hardware window.

Figure 4–4 M-TEST Configure Hardware Window

4. Enter the following settings:
    a. Under Dynamometer Controller, select "Micro Dyne" for the Model.
    b. For the Interface, select the COM port where the USB interface is connected (as determined in *Section 2.4.2 – M-TEST Communication*).
    c. Under Power Measurement, select "Micro Dyne" as the Device.

☞ Note: For increased power measurement capabilities, other power analyzers (such as Magtrol's 6510*e* or 6530) may be used in conjunction with the Micro Dyne. If applicable, the supplemental power analyzer should be selected as the "Device." If using a third-party measurement device not found on the list, by selecting "None", M-TEST will no longer be responsible for measuring the input power.

OPERATION

4.3.1   MOTOR REVERSAL

If it is desired to perform a motor test in both clockwise and counter-clockwise directions, a relay card is required. Motor direction is configured in M-TEST and requires a power supply supported by M-TEST. Supported power supplies are found in the Device text box, under the Power Supply options in the Configure Hardware window. See *Figure 4–5*.

4.3.1.1   Reversing Motor Direction Before Test is Run

To reverse the motor direction and keep the direction of rotation constant throughout the entire test, use the Configure Hardware window for motor reversal setup.

1. Open the Configure Hardware window.
2. Under Power Supply, click on the Device text box and scroll through for a list of supported power supplies.
3. After selecting a power supply, set the voltage and current output for that voltage supply. If a negative voltage is entered, M-TEST switches relays to change the polarity of the motor voltage and, in turn, reverses the direction of rotation (for a DC motor).
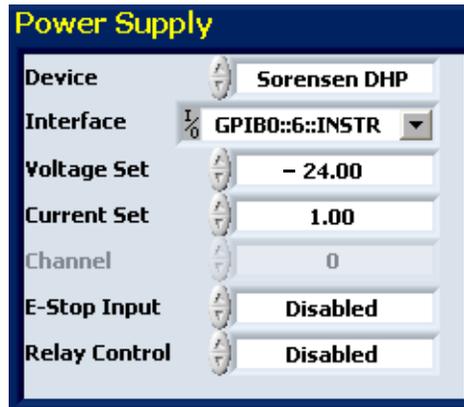
Figure 4–5 M-TEST Power Supply Configuration

4.3.1.2   Automatic Reversal of Motor Direction During Test

Curve tests and Pass/Fail tests allow for reversing the motor direction during a test.

> Note: Because Ramp tests do not allow motor voltage control, the motor must ramp up and down in the same direction for the entire test. To reverse the direction of rotation for a ramp test, after running the first test, enter a negative power supply voltage in the Configuration Hardware window (as described in *Section 4.3.1.1*) and then run the test a second time.

1. If not already done so, select a power supply supported by M-TEST in the Configure Hardware window.
2. Open the Configure Test window. If Curve Test or Pass/Fail Test is selected, an extra column in the Control Data table, under Test Parameters, labeled "Volts" should appear.
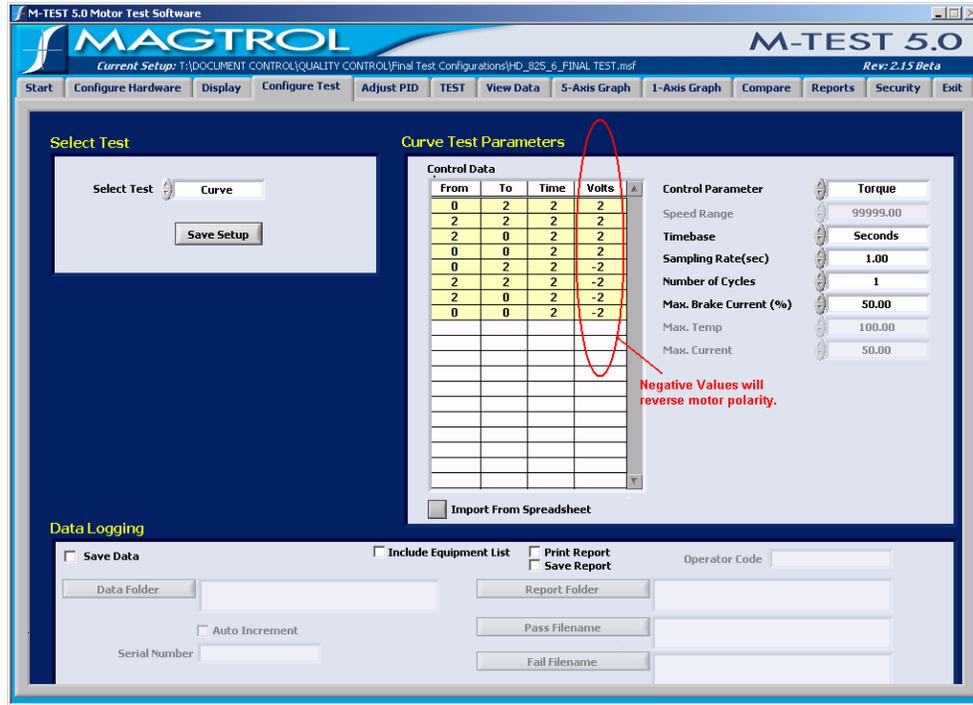
Figure 4–6 Curve Test Parameters with Motor Reversal

3.   To have the motor direction reversed during a test, simply enter a negative voltage, as shown in *Figure 4–6*.

OPERATION

5. Operating Principles

5.1   TORQUE MEASUREMENT

An innovative approach to measuring small torques is implemented in the Micro Dyne. The design employs a very small pendulum and brake assembly hung in a precision-machined carrier. The basic concept, a textbook physics problem, is described below.

$$\text{Torque} = L_{cm}\, mg \sin(\theta)$$
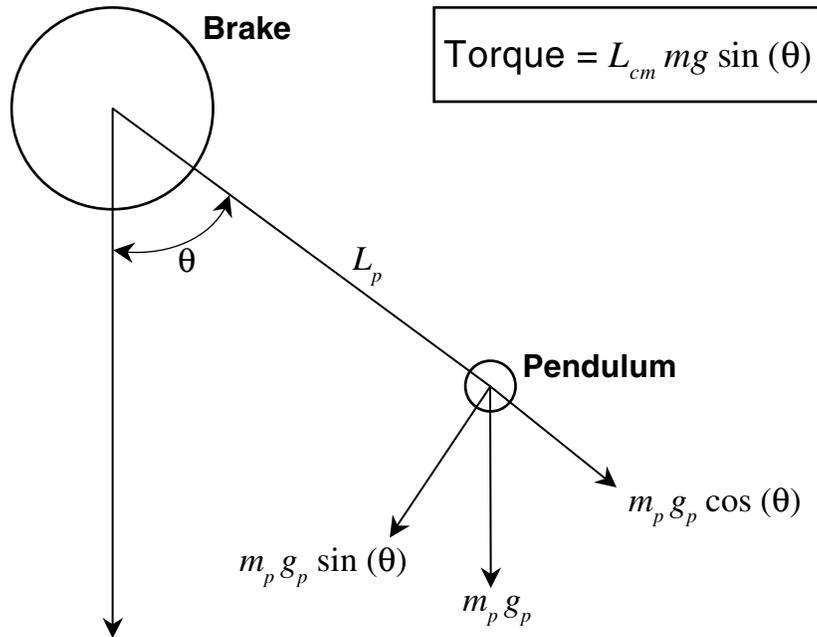
Symbol	Represents
L_p	the length to the center of mass of the pendulum
$m_p g_p$	the force applied by the mass and gravity
$m_p g_p \sin(\theta)$	the force in the radial direction

Figure 5–1 Illustrated Torque Principle

5.1.1   TORQUE CALCULATION

At calibration time, a known mass at a known distance is applied to the pendulum system and a precise calibration is accomplished.

$$L_p m_p g_p \sin(\theta) = L_c m_c g_c \cos(\theta)$$

Symbol	Represents
L_c	the length from the center to the calibration weight
$m_c g_c$	the force applied by the known mass and gravity

The coefficient $L_p m_p g_p$ is calculated and stored. Torque data is calculated using this coefficient, along with position data.

5.2   SPEED MEASUREMENT

The Micro Dyne contains a reflective fiber optic speed pickup. As each rotor slot passes by the sensing end of the fiber optic, an electronic pulse is generated, which is then converted to a speed reading (in rpm). The incoming pulses from the speed pickup can be resolved down to 5 Hz or 5 pulses per second. With 6 slots on the rotor, this results in a minimum speed setting of 50 rpm. (The speed reading will drop to zero at 50 rpm.)

☞   Note: The rotor/speed measuring mechanism of the Micro Dyne has been optimized for motors running from 10,000 rpm to 100,000 rpm.

Figure 5–2 Micro Dyne Rotor

5.3   CONTROLLER AND THE PID LOOP

The Micro Dyne has PID adjustment capability for both the speed and torque modes to provide the best system response. The PID Loop comprises the following three variables:
- P   =   proportional gain
- I   =   integral
- D   =   derivative

Other important variables include:
- • Set point - desired load or speed
- • Error - difference between the set point and the actual measurement
- • Additional scaling – used to broaden the range of the control loop

5.3.1   P (PROPORTIONAL GAIN)

With proportional gain, the controller output is proportional to the error or to a change in measurement. Deviation from the set point is usually present. Increasing the proportional gain will make the PID loop unstable. Increasing the integral value will eliminate this instability. For best loop control, set the proportional gain as high as possible without causing the loop to become unstable.

5.3.2   I (INTEGRAL)

With integral, the controller output is proportional to the amount of time the error is present. Increasing the integral value eliminates the offset from the set point. If the response becomes oscillatory, increase the derivative value.

5.3.3   D (DERIVATIVE)

With derivative, the controller output is proportional to the rate of change of measurement or error. Derivative can compensate for a changing measurement. Derivative takes action to inhibit more rapid changes of the measurement than proportional gain.

5.3.4   **ADDITIONAL SCALE FACTOR**

The Additional Scale Factor (PS, IS and DS) is a multiplier of the P, I or D term. Due to the fact there are so many different motor combinations, this multiplier is needed to extend the range of the PID. The letters represent the following values:

A = 0.001	D = 0.05	G = 1	* The default multipliers are G, G, and G
B = 0.005	E = 0.10	H = 5	
C = 0.010	F = 0.50	I = 10	

Using the multiplier, PID values from 0.001 (0.001 × 1%) to 990 (10.0 × 99%) may be inputted.

5.3.5   **HOW THE PID LOOP WORKS**

The following diagram demonstrates the correlation between the variables in the PID Loop.
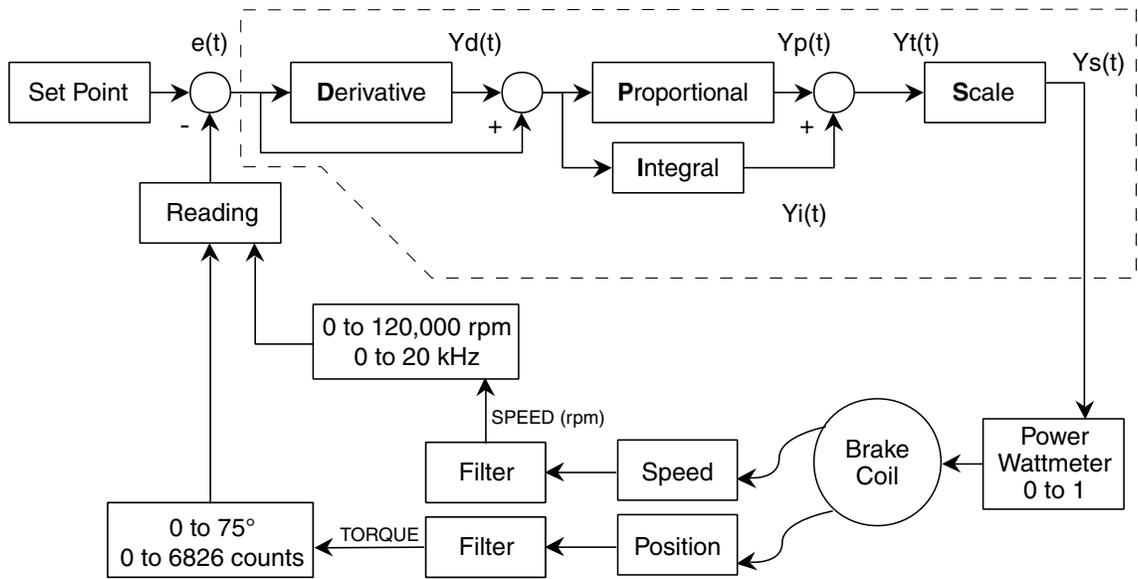
Figure 5–3 Control Loop and PID System Block Diagram

5.3.6   **PID EQUATIONS**

Where *Skp*, *Ski* and *Skd* are factory-determined system coefficients…

$Yd(t) = (e(t) - e(t-3) + 3 * [e(t-1) - e(t-2)]) * (10/Skd) * D\% * DS$

$Yp(t) = (e(t) + Yd(t)) * (10/Skp) * P\% * PS$

$Yi(t) = Yi(t-1) + [e(t) + Yd(t)] * (10/Ski) * I\% * IS$

$Yt(t) = Yp(t) + Yi(t)$

$Ys(t) = Scale * Yt(t)$

5.4   DC WATTMETER

The data acquisition stage in the hardware of this DC power measurement instrument is very simple. The input voltage is divided by an amplifier circuit and applied directly to a LTC2515 A/D converter. The input is differential and isolated from the amps circuitry. The input current is applied to a shunt resistor and the resulting voltage is amplified and applied directly to a LTC2515 A/D converter. The input is differential and isolated from the voltage circuitry. The wattage presented is a multiplication of the amps and voltage. See *Section B.3 – DC Wattmeter Schematic*.

OPERATING PRINCIPLES

6. Calibration

6.1 CALIBRATION SOFTWARE INSTALLATION

1. Insert the "Micro Dyne Supplemental Programs and Utilities CD" into your CD-ROM drive.
2. The USB Driver Utility will auto start. Just press EXIT.
3. Start Windows Explorer.
4. Locate the directory where M-TEST 5.0 is installed.
5. Copy the entire "Calibration Sequence rev 1.0" folder into the same folder as the M-TEST program. If the default directory was used, the location is C:\Program Files\M-Test 5.0\.
6. Once copied onto the hard drive, locate the **MD-CAL.exe** application file. This is the executable file for the Micro Dyne Calibration Software.

☞   Note: Create a shortcut to the calibration program by clicking the **MD-CAL.exe** file and dragging it to the desktop.

6.2 CALIBRATION PREPARATION

1. Disconnect motor.
2. Remove coupling.
3. Disconnect all wiring and power supply cables from motor connection point.
4. Remove the rear panel of the dynamometer as described in *Section 6.2.1*.
5. Level the dynamometer as described in *Section 2.1.2 – Dynamometer Leveling*.

6.2.1 DYNAMOMETER REAR PANEL REMOVAL

Rear panel screws
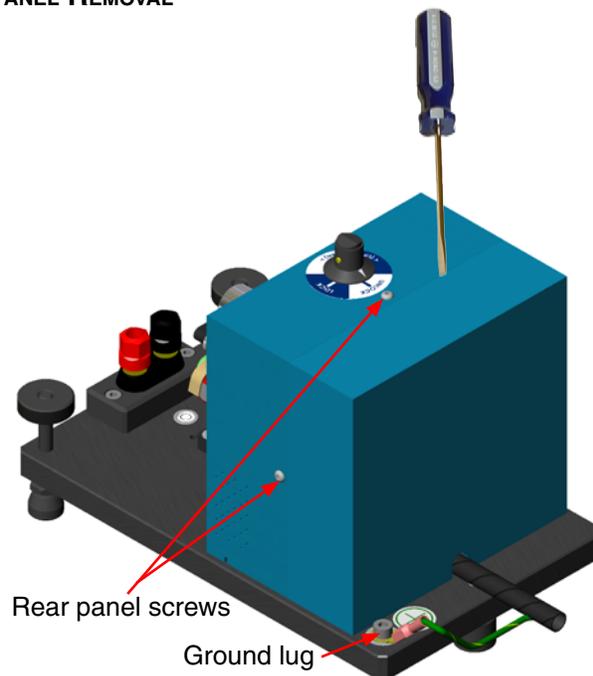
Ground lug

Figure 6–1 Dynamometer Rear Panel Removal

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1. Remove the three rear panel screws with the smaller of the two Allen wrenches provided in the accessory tool bag.
2. Remove the ground lug with the larger Allen wrench.
3. Using a small flathead screwdriver for leverage, **GENTLY** pry open the dynamometer rear panel and remove.

6.2.2   CALIBRATION WEIGHTS

Two calibration weights are included with the Micro Dyne System. They are tagged and labeled with their exact weight at time of manufacture. The 10 gram weight is used for the 4 mN·m torque configuration and the 5 gram weight is used for the 2 mN·m torque configuration.

6.3   CALIBRATION PROCEDURE

The Micro Dyne Calibration Software walks the user through every step in the calibration process. Simply follow the instructions and prompts that appear on the screen.

1. Start the Micro Dyne Calibration Software by opening the **MD-CAL.exe** application file mentioned in *Section 6.1*. The COM Port Selection dialog box will appear.
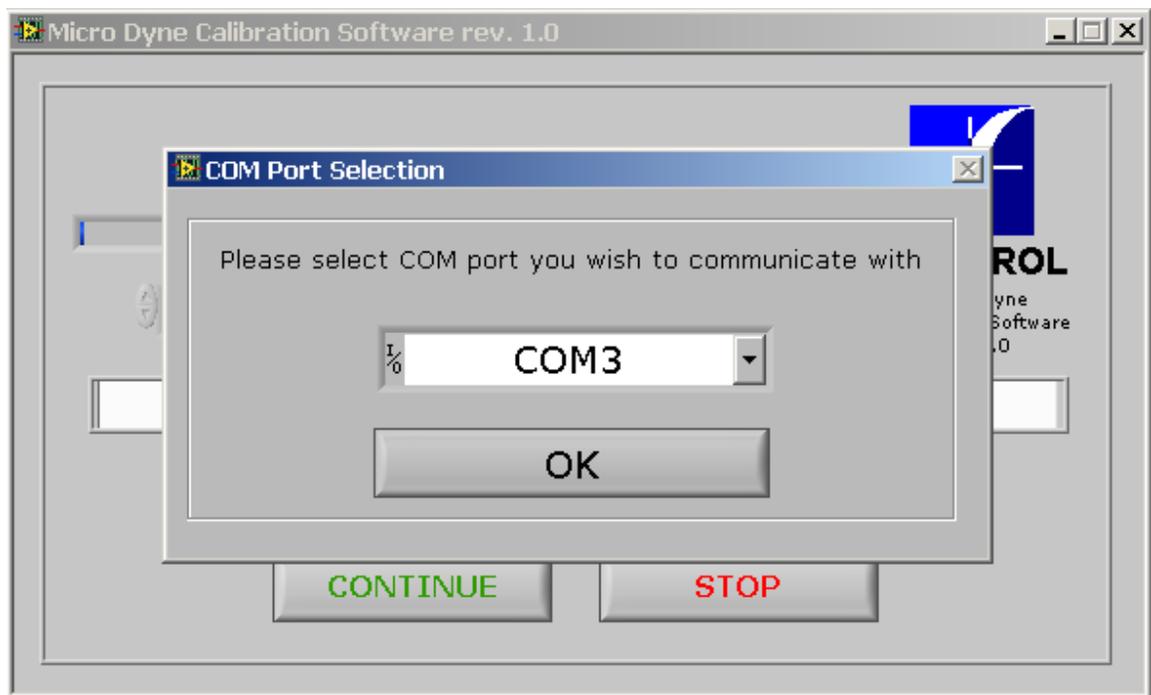
Figure 6–2 COM Port Selection

2. Select the COM port to which the USB interface is connected, as previously determined in *Section 2.5.2 – Verify Communication with M-TEST*, and click **OK**.
3. The main window of the Calibration Software will appear, displaying the version of your Micro Dyne System at the top.

MAINTENANCE
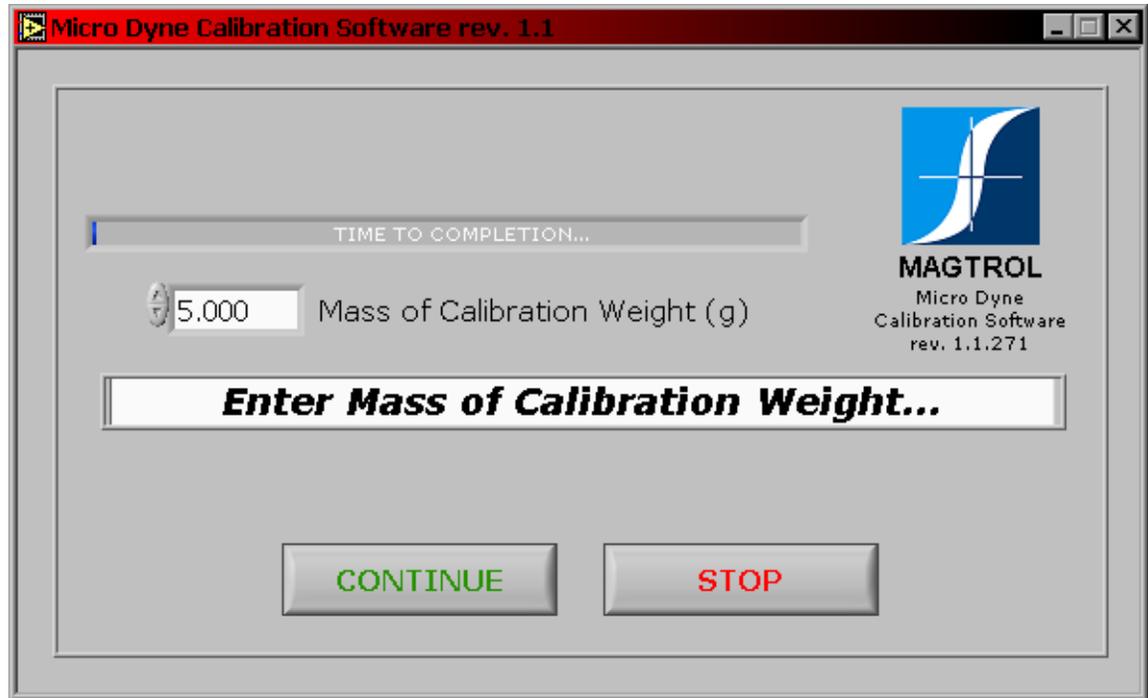
Figure 6–3 Enter Mass of Calibration Weight

4. Enter the exact weight as labeled on the weight's tag. Refer to *Section 6.2.2. – Calibration Weights* for more information.
5. Click **Continue**. The Reset ZERO dialog box will appear.
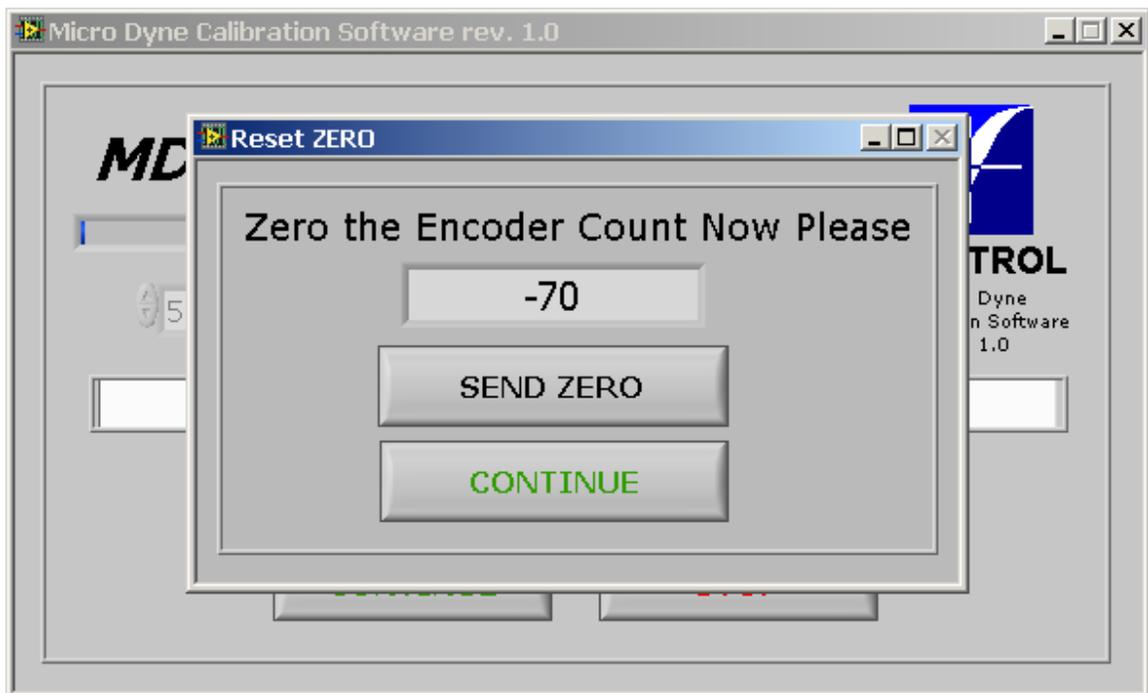
Figure 6–4 Reset ZERO

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6. To zero the pendulum at its current rest state (without weights), click **Send Zero**. After the dialog box displays a value of "0" consistently (for a few seconds), click **Continue**.

7. The next prompt asks the user to hang the calibration weight, starting with the right side. Carefully hang the appropriate calibration weight from the calibration peg, as show in *Figure 6–5*. Tweezers have been included in the accessory tool bag for your convenience.
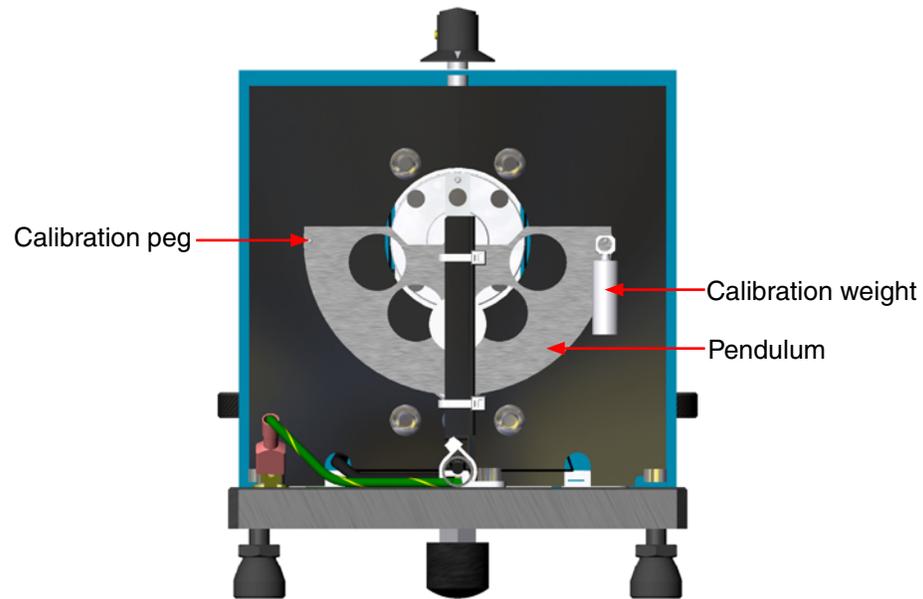
Figure 6–5 Dynamometer Calibration

8. Continue to follow the prompts on the screen, alternating between hanging the weight on opposite sides of the pendulum and removing the weight. This entire cycle will be performed a total of five times. After each cycle, the message/instruction bar will display the status of the calibration routine. The blue progress bar will also update.

☞   Note: After clicking **Continue**, the Continue button is grayed out purposely in order to prevent accidental double-button pressing which would result in a skipped step.

MAINTENANCE
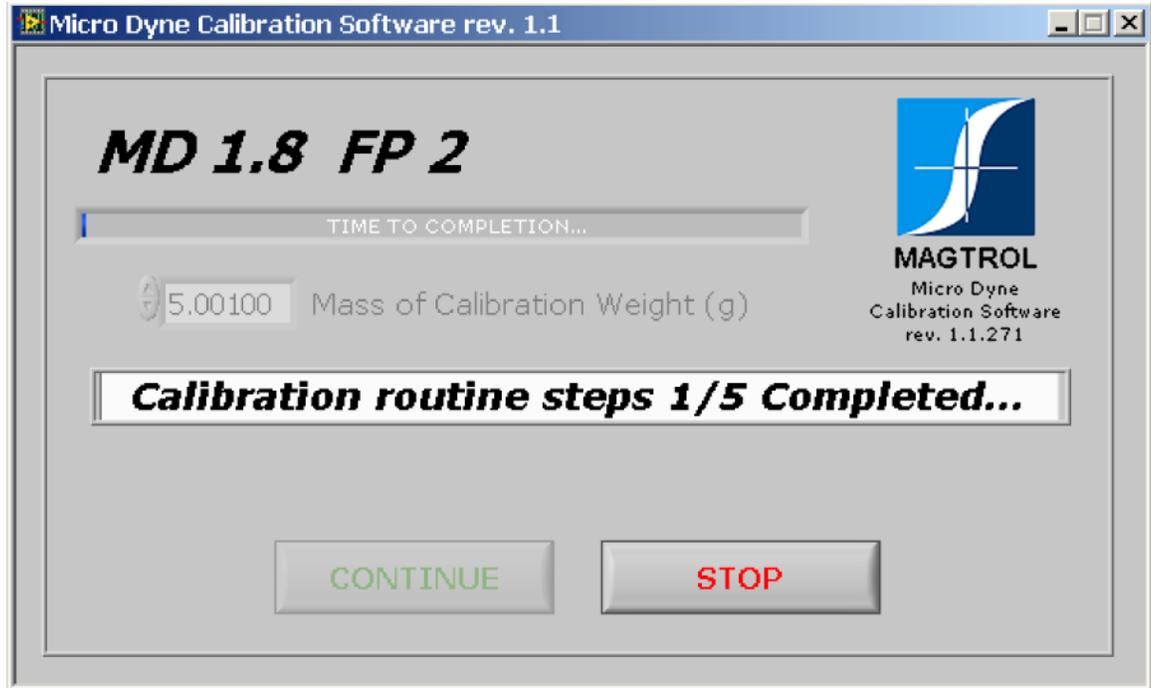
Figure 6–6 Calibration Routine Status

9. After the message/instruction bar displays "Calibration routine steps 5/5 Completed" one of two dialog boxes will appear, dependent upon whether or not the calibration was successful.
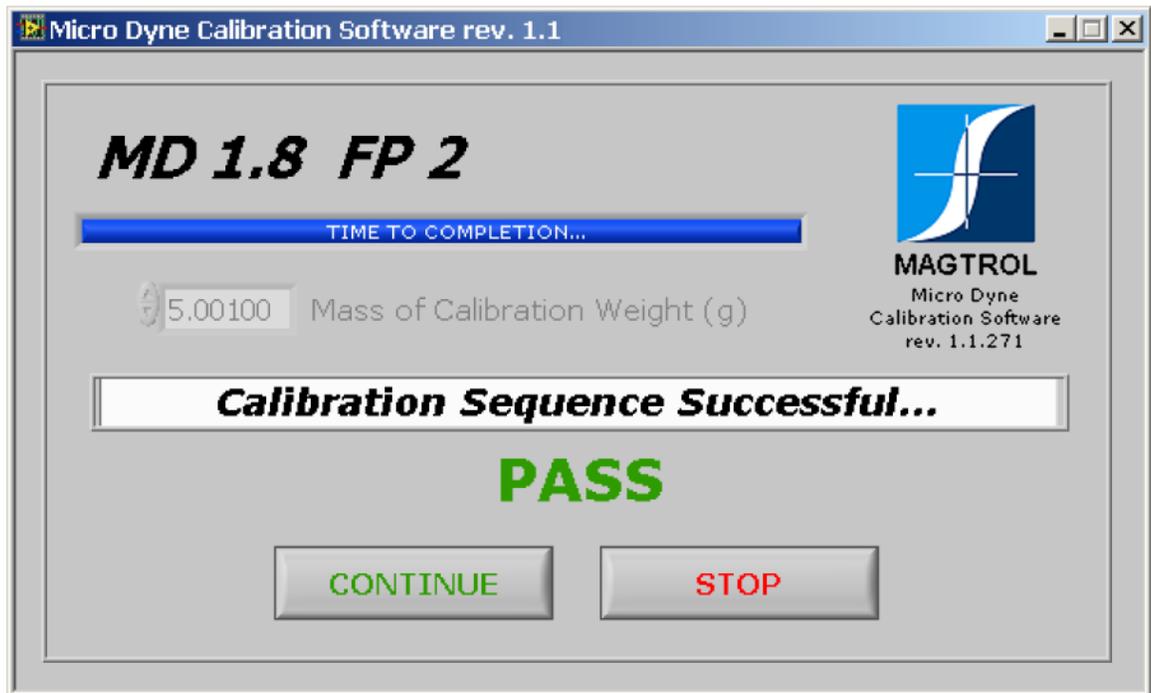
Figure 6–7 Calibration Sequence Successful
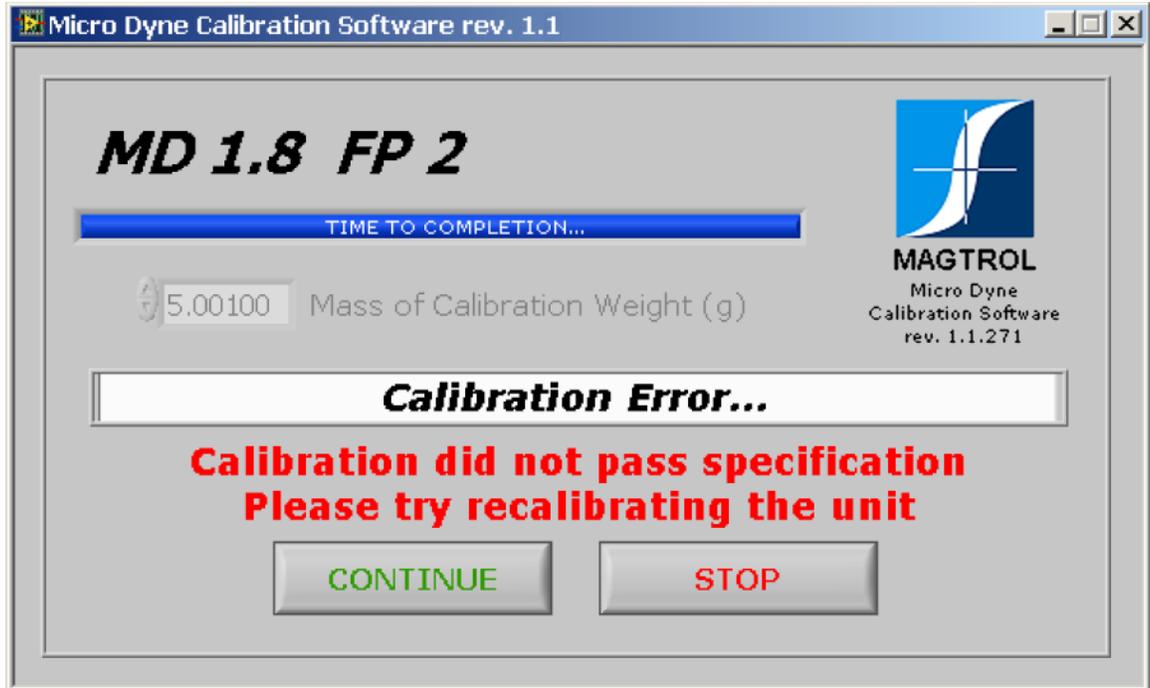
Figure 6–8 Calibration Error

10. If calibration was successful, click **Continue** and proceed to step 11.

    If a calibration error occurs, it is most likely due to the pendulum not fully returning to zero after the weight is removed. Make sure that the dynamometer is level and then click **Continue** to restart the calibration sequence. If the Calibration Error message is displayed after repeated calibrations, contact Magtrol Technical Support.

11. A dialog box will appear asking the user whether or not they would like to print a copy of the calibration data results.
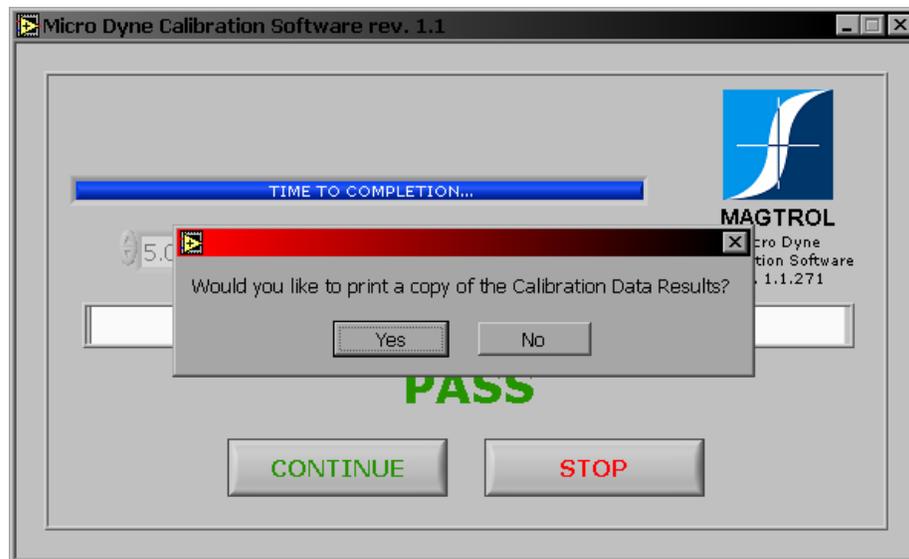
Figure 6–9 Calibration Data Results Prompt

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To print a calibration report, click **Yes** and proceed to step 12.
Click **No** to quit the Calibration Software without printing the results.

12. The Additional Report Information dialog box will appear.
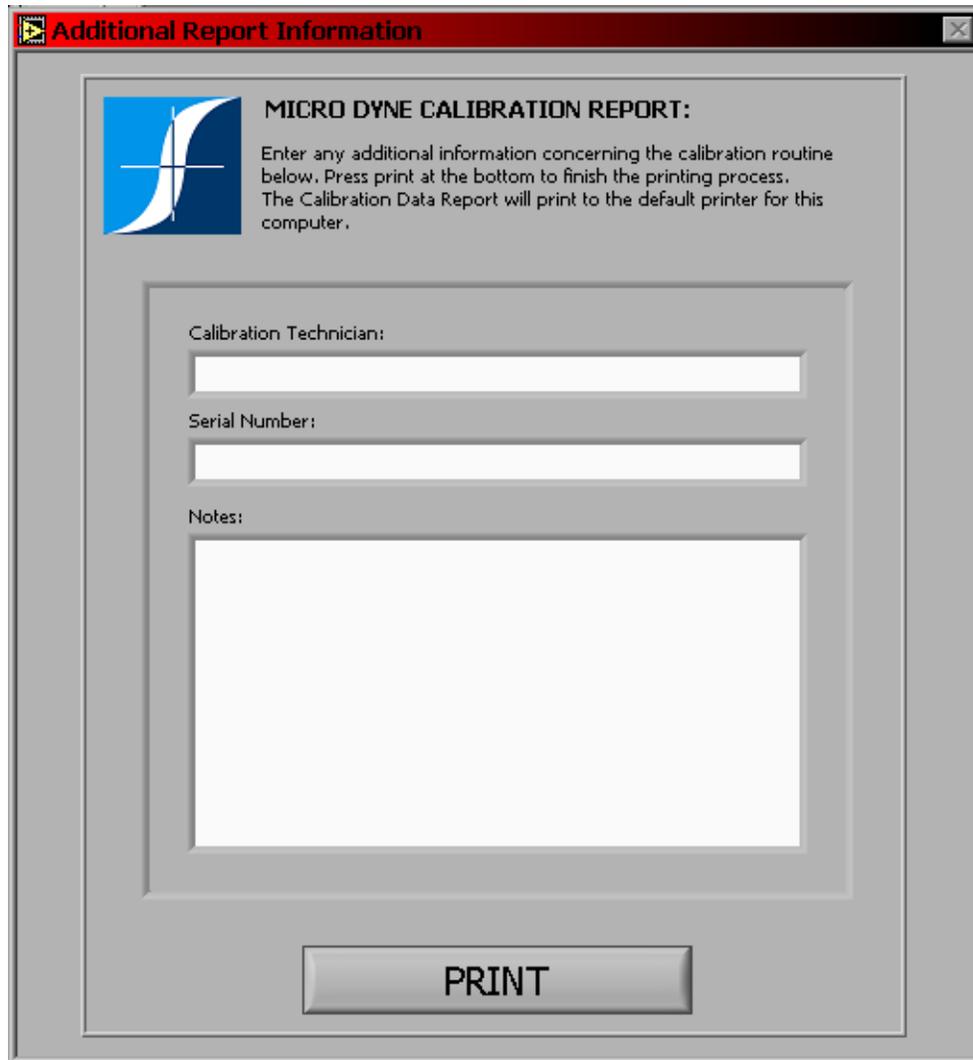
Figure 6–10 Additional Report Information

Enter any additional information concerning the calibration routine and click **Print**. The
Calibration Data Report will print to the default printer and the Calibration Software will
quit.

7. Troubleshooting

Problem	Reason	Solution
Speed Measurement		
Speed is eratic or there is no speed reading.	Speed pickup is in incorrect mode.	Switch speed pickup to SHS Mode.
Calibration		
Micro Dyne revision is not displayed in the calibration software window.	Lost communication with electronics unit.	Check USB connections.
Calibration Error message appears at completion of calibration procedure.	Pendulum not fully returning to zero after the weight is removed	Make sure the dynamometer is level and restart calibration procedure.

If you require additional assistance, please contact Magtrol Customer Service at 1-716-668-5555.

MAINTENANCE

Appendix A: Hardware Commands

Although most motor tests can be performed with M-TEST, the following command reference tables are included for users who wish to write their own application.

A.1   DATA FORMAT

Speed-torque data is a fixed-length string in ASCII format with a floating point decimal. Use the following string format:

<p align="center">SdddddTdddd.R(cr)(lf)</p>
<p align="center">Or</p>
<p align="center">SdddddTdddd.L(cr)(lf)</p>

Where…

- S = Speed in rpm. (No leading zeroes are used.)
- d = Decimal digit 0 through 9.
- T = Torque in mN·m. (The torque value always contains a decimal point.)
- L = Counterclockwise dynamometer shaft rotation (left).
- R = Clockwise dynamometer shaft rotation (right).
- . = Decimal point. (The decimal point location depends on the specific dynamometer and torque range in use.)

☞   Note: The (cr) and (lf) characters will not display.

EXAMPLE

If a motor is running at 1725 rpm clockwise, with the dynamometer loading the motor to 22.6 oz.in., the Micro Dyne will return:

<p align="center">S 1725T22.60R</p>

By manipulating the string, the speed-torque and shaft direction (if required) can be extracted. Then separate numerical variables can be assigned to them for data processing.

A.1.1   CODES FOR CR - LF

	BASIC	HEX	DEC
CR =	CHR$(13)	0D	13
LF =	CHR$(10)	0A	10

A.2   MICRO DYNE COMMAND SET

When entering a command code:

1. Type all characters in uppercase ASCII format.
2. End all commands with a CR-LF (hex 0D-0A).
3. Do not string multiple commands together in one line.

The character # represents a floating-point numerical value following the command. Leading zeroes are not required.

A.2.1   COMMUNICATION COMMANDS

Command Code	Function	Explanation
*IDN?	Returns Magtrol Identification and software revision.	Example: "MD 1.4 FP 2" Micro Dyne REV 1.4 and FPGA REV 2
B0	Brake Off.	---
B1	Brake On.	---

OD	Returns speed-torque value.	Output Data prompt to return data string with this format:
		       SxxxxxTxxxxxRcrlf
		       or
		       SxxxxxTxxxxxLcrlf
		R or L is the shaft direction indicator, as viewed looking at the dynamometer shaft where:
		 R = right; clockwise (CW)
		 L = left; counterclockwise (CCW)

A.2.2   RAMP COMMANDS

Command Code	Function	Explanation
DILXX.XX	Sets dynamic scale coefficient.	When using dynamic scaling, XX.XX is multiplied by the I term to give the end I value.
DPLXX.XX	Sets dynamic scale coefficient.	When using dynamic scaling, XX.XX is multiplied by the P term to give the end P value.
DS#	Enable or disables dynamic scaling.	Values for # are: 0 = disable 1 = enable
PD#	Program Down: Sets ramp down rate to #rpm per second and starts ramp.	Specify speed range (F#) AND a stop speed (S#) before using this command. This command programs a decreasing shaft speed at a rate of #rpm per second.
PR	• Resets ramp up or down. • Sets speed to maximum speed. • Turns brake off.	This command resets the ramp function, halting the ramp's progress, and returns the motor to free run.
PU#	Program Up: Sets ramp up rate to #rpm per second and starts ramp.	Specify speed range (F#) AND a start speed (S#) before using this command. This command increases the shaft speed at a rate of #rpm per second.
S#	Sets start or stop speed for ramp to #RPM.	When this command is used with the PD command, the controller will ramp down to this speed and halt. When this command is used with the PU command, the controller will load immediately to this speed and ramp up to free-run.

A.2.3   SETUP COMMANDS

Command Code	Function	Explanation
R	Resets as follows: • Brake OFF.	Use this command to cancel any previous commands.
RQ1	Resets quadrature counter.	Use this command to reset torque count to zero.

A.2.4   SPEED COMMANDS

Command Code	Function	Explanation
F#	Sets maximum speed to # rpm.	Sets a speed range for the controller. Must be specified before using the speed or ramp mode. Sets the range of the PID calculation.
N	• Resets speed point to maximum speed. • Sets speed mode OFF. • Sets brake OFF.	Use this command, sent alone, to reset any previous speed-stabilized setting to the maximum speed range.
N#	• Sets speed point to #. • Sets brake ON.	Use this command to load the motor under test to a specific speed value #. Issue a speed range command (F#) first for best dynamic response. The controller is functioning with the dynamometer as a closed loop system. Adjust the speed PID values to tune the response.
ND#	Sets speed derivative to #.	Derivative value (#) can be any number from 0 to 99.
NDS#	Sets scaling factor.	Values for # are: A (0.001) D (0.05) G (1) B (0.005) E (0.10) H (5) C (0.01) F (0.50) I (10)
NI#	Sets speed integral to #.	Integral value (#) can be any number from 0 to 99.
NIS#	Sets scaling factor.	Values for # are: A (0.001) D (0.05) G (1) B (0.005) E (0.10) H (5) C (0.01) F (0.50) I (10)
NP#	Sets speed proportional to # gain.	Proportional gain value (#) can be any number from 0 to 99.
NPS#	Sets scaling factor.	Values for # are: A (0.001) D (0.05) G (1) B (0.005) E (0.10) H (5) C (0.01) F (0.50) I (10)

APPENDICES

A.2.5   TORQUE COMMANDS

Command Code	Function	Explanation
Q	• Resets torque to 0.0. • Turns torque mode OFF. • Turns brake OFF.	Resets any previous torque-stabilized command, and returns the motor to free run.
Q#	• Sets torque point to #. • Turns brake ON.	Closed-loop command with its own set of PID parameters. Units are in mN·m.
QD#	Sets torque derivative to #.	Derivative value (#) can be any number from 0 to 99.
QDS#	Sets scaling factor.	Values for # are: A (0.001) D (0.05) G (1) B (0.005) E (0.10) H (5) C (0.01) F (0.50) I (10)
QI#	Sets torque integral to #.	Integral value (#) can be any number from 0 to 99.
QIS#	Sets scaling factor.	Values for # are: A (0.001) D (0.05) G (1) B (0.005) E (0.10) H (5) C (0.01) F (0.50) I (10)
QP#	Sets torque proportional gain to #.	Proportional gain value (#) can be any number from 0 to 99.
QPS#	Sets scaling factor.	Values for # are: A (0.001) D (0.05) G (1) B (0.005) E (0.10) H (5) C (0.01) F (0.50) I (10)

A.2.6   POWER ANALYZER AND RELAY COMMANDS

Command Code	Function	Explanation
OA1,0	Reads amps.	---
OV1,0	Reads volts.	---
OW1,0	Reads watts.	---
PWR0	Switches off the power relay.	---
PWR1	Switches on the power relay.	---

A.2.7   MISCELLANEOUS COMMANDS

Command Code	Function	Explanation
I#	Sets current output to #.	The Micro Dyne power supply outputs a fixed value of current. Use any value (#) between 0 and 99.99%. (99.99% = FS).
SAVE	Saves present configuration of unit to non-volatile memory.	---

APPENDICES

A.2.8   CALIBRATION COMMANDS

Command Code	Function	Explanation
CAL	Sets current output to #.	Displays "CALCOMPLETE"
FSA=X.XXX	Takes the full scale amps reading. X.XXX is the applied current.	Displays "FSA=X.XXX" prompting the user to apply zero full scale amps.
FSV=X.XXX	Takes the full scale volts reading. X.XXX is the applied voltage.	Displays "FSV=X.XXX" prompting the user to apply zero full scale volts.
ZERO	Takes zero reading for both volts and amps.	Displays "ZERO" prompting the user to apply zero volts and zero amps.
GL=xxxx	Sets average gain after calibration on left side.	Input, floating point
GR=xxxx	Sets average gain after calibration on right side.	Input, floating point
ZL=xxxx	Sets average of Zero calibration reading on left side.	Input, floating point
ZR=xxxx	Sets average of Zero calibration reading on right side.	Input, floating point

Appendix B: Schematics

B.1 CORE BLOCK DIAGRAM

CORE BLOCK

RS232
DRIVER

EEPROM
93C66A

JP1

RAM
128K x 24

GSI GS73024AB
3.3V

119 PBGA

FLASH
1M x 8
SST SST39LF080
3.3V

48 FBGA

JP2

RESET

XTAL
8 MEG

DSP

MOTOROLA DSP56303GC100
3.3V

196 PBGA

JTAG-1

FPGA

ACTEL APA075
2.5V

144 BGA

JTAG-2

2.5V REG

U1
78B212_CORE_DSP_REVB

B.2 MAIN SCHEMATIC

APPENDICES

B.3   DC WATTMETER

Appendix C: Calibration Record

| DATE	DYNAMOMETER MODEL/SERIAL #	APPLIED TORQUE	INDICATED TORQUE	ERROR	TESTER
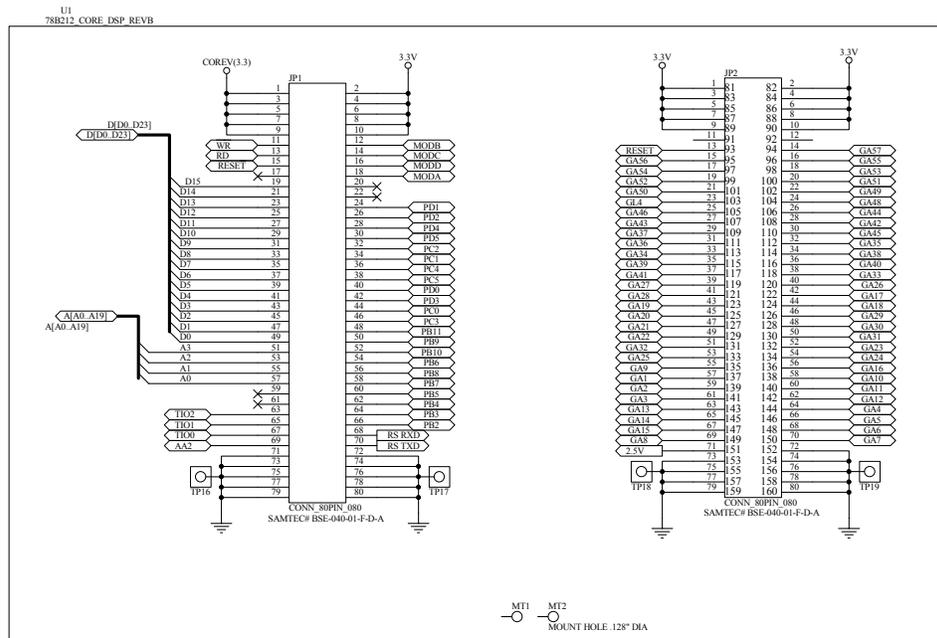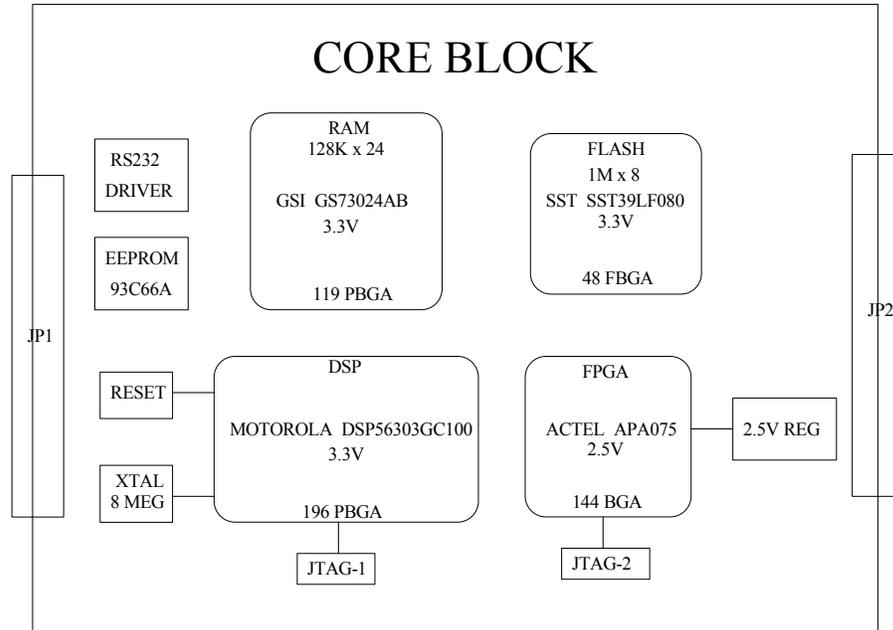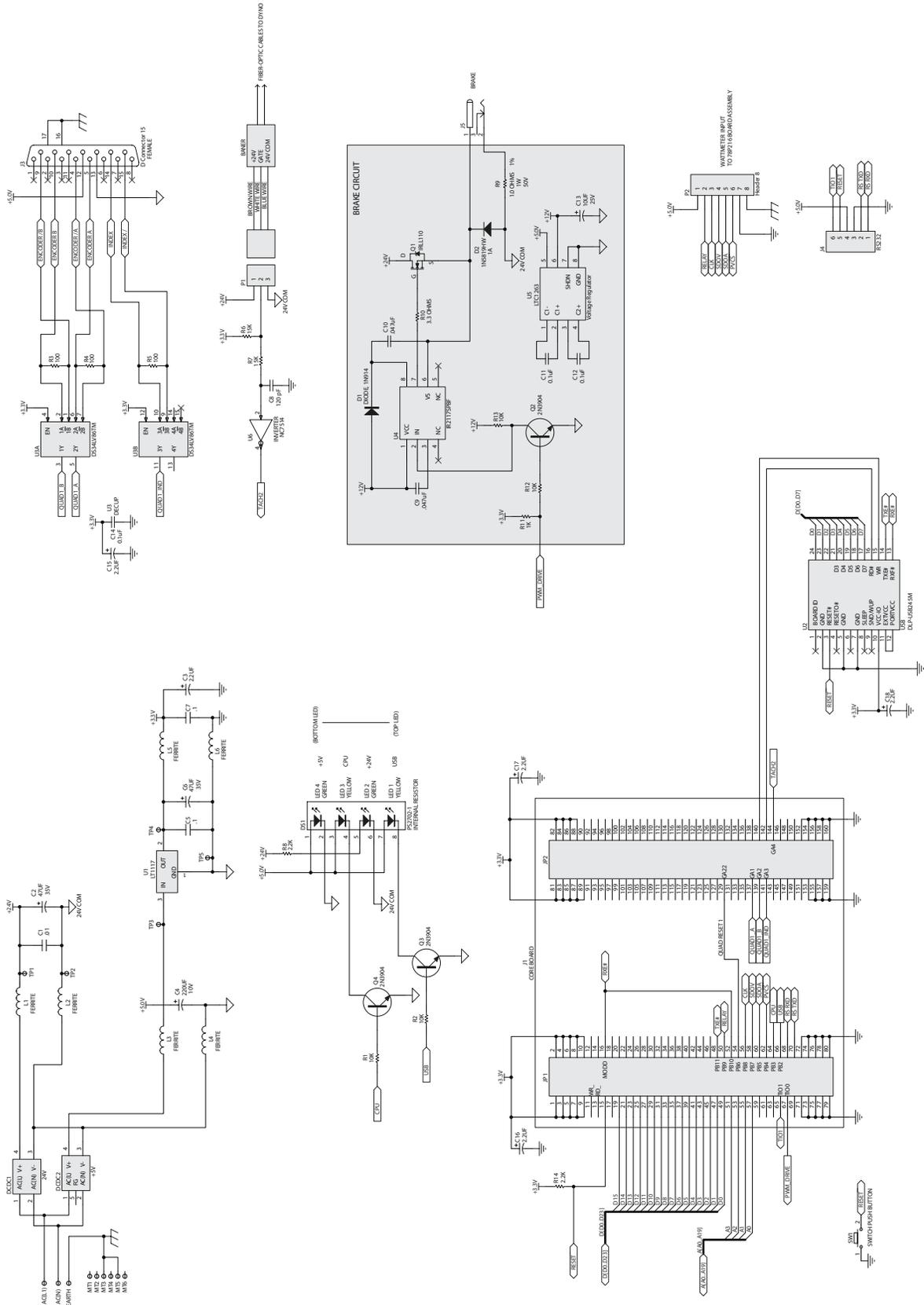
Magtrol Limited Warranty

Magtrol, Inc. warrants its products to be free from defects in material and workmanship under normal use and service for a period of twenty-four (24) months from the date of shipment. Software is warranted to operate in accordance with its programmed instructions on appropriate Magtrol instruments. This warranty extends only to the original purchaser and shall not apply to fuses, computer media, or any other product which, in Magtrol's sole opinion, has been subject to misuse, alteration, abuse or abnormal conditions of operation or shipping.

Magtrol's obligation under this warranty is limited to repair or replacement of a product which is returned to the factory within the warranty period and is determined, upon examination by Magtrol, to be defective. If Magtrol determines that the defect or malfunction has been caused by misuse, alteration, abuse or abnormal conditions of operation or shipping, Magtrol will repair the product and bill the purchaser for the reasonable cost of repair. If the product is not covered by this warranty, Magtrol will, if requested by purchaser, submit an estimate of the repair costs before work is started.

To obtain repair service under this warranty, purchaser must forward the product (transportation prepaid) and a description of the malfunction to the factory. The instrument shall be repaired at the factory and returned to purchaser, transportation prepaid. **MAGTROL ASSUMES NO RISK FOR IN-TRANSIT DAMAGE.**

THE FOREGOING WARRANTY IS PURCHASER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, OR FITNESS FOR ANY PARTICULAR PURPOSE OR USE. MAGTROL SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR LOSS WHETHER IN CONTRACT, TORT, OR OTHERWISE.

CLAIMS

Immediately upon arrival, purchaser shall check the packing container against the enclosed packing list and shall, within thirty (30) days of arrival, give Magtrol notice of shortages or any nonconformity with the terms of the order. If purchaser fails to give notice, the delivery shall be deemed to conform with the terms of the order.

The purchaser assumes all risk of loss or damage to products upon delivery by Magtrol to the carrier. If a product is damaged in transit, PURCHASER MUST FILE ALL CLAIMS FOR DAMAGE WITH THE CARRIER to obtain compensation. Upon request by purchaser, Magtrol will submit an estimate of the cost to repair shipment damage.

Service Information

RETURNING MAGTROL EQUIPMENT FOR REPAIR AND/OR CALIBRATION

Before returning equipment to Magtrol for repair and/or calibration, please visit Magtrol's Web site at http://www.magtrol.com/support/rma.htm to begin the Return Material Authorization (RMA) process. Depending on where the equipment is located and which unit(s) will be returned, you will be directed to either ship your equipment back to Magtrol, Inc. in the United States or Magtrol SA in Switzerland.

Returning Equipment to Magtrol, Inc. (United States)

When returning equipment to Magtrol, Inc.'s factory in the United States for repair and/or calibration, a completed Return Material Authorization (RMA) form is required.

1. Visit Magtrol's Web site at http://www.magtrol.com/support/rma.htm to begin the RMA process.
2. Complete the RMA form online and submit.
3. An RMA number will be issued to you via e-mail. Include this number on all return documentation.
4. Ship your equipment to: MAGTROL, INC.
                                    70 Gardenville Parkway
                                    Buffalo, NY 14224
                                    Attn: Repair Department
5. After Magtrol's Repair Department receives and analyzes your equipment, a quotation listing all the necessary parts and labor costs, if any, will be faxed or e-mailed to you.
6. After receiving your repair estimate, provide Magtrol with a P.O. number as soon as possible. A purchase order confirming the cost quoted is required before your equipment can be returned.

Returning Equipment to Magtrol SA (Switzerland)

If you are directed to ship your equipment to Switzerland, no RMA form/number is required. Just send your equipment directly to Magtrol SA in Switzerland and follow these shipment instructions:

1. Ship your equipment to: MAGTROL SA
                                    After Sales Service
                                    Centre technologique Montena
                                    1728 Rossens / Fribourg
                                    Switzerland
                                    VAT No: 485 572

2. Please use our forwarder : TNT • 1-800-558-5555 • Account No 154033
    Only ship ECONOMIC way (3 days max. within Europe)
3. Include the following documents with your equipment:
    • Delivery note with Magtrol SA's address (as listed above)
    • Three pro forma invoices with:
        • Your VAT number   • Value - for customs purposes only
        • Description of returned goods   • Origin of the goods (in general, Switzerland)
        • Noticed failures
4. A cost estimate for repair will be sent to you as soon as the goods have been analyzed. If the repair charges do not exceed 25% the price of a new unit, the repair or calibration will be completed without requiring prior customer authorization.