KURZ
INSTRUMENTS INC.

Series 7500 Mass Flow Control Systems
User's Guide

March 1989

Tables

About This Book

This book contains five sections and an appendix, each of which is briefly described below. The book also contains a Unit Description Sheet, and a Quick Set-Up Guide. The book is not designed to be read cover to cover; rather, it is designed to present information to the 7500 user in as accessible a manner as possible.

Organization

Unit Description Sheet

This sheet is found in the front of the book, immediately following the title page. It contains important identifying information about your 7500 Mass Flow Control System, including model numbers, serial numbers, Kurz order number, and customer purchase order number. It also lists any options you ordered with your 7500. Check the options listed against your original order and against the actual contents of the shipping carton. Report any discrepancies immediately to Kurz Instruments Incorporated at (408) 646-5911.

Quick Set-Up Guide

The Quick Set-Up Guide consists of an illustration that summarizes much of the information presented in the rest of the manual. You can use the illustration to refresh your memory after you read the relevant sections of the manual. Or, if you feel that you do not need the more detailed information presented in the rest of the manual, you can attempt to install your 7500 referring only to the Quick Set-Up chart. Kurz Instruments does **not**, however, recommend the latter approach.

Section 1: Product Overview

This section introduces you to the purpose, principles of operation, and features of the 7500 Mass Flow Control System. You can safely skip this section if you are already familiar with that information.

Section 2: Installation

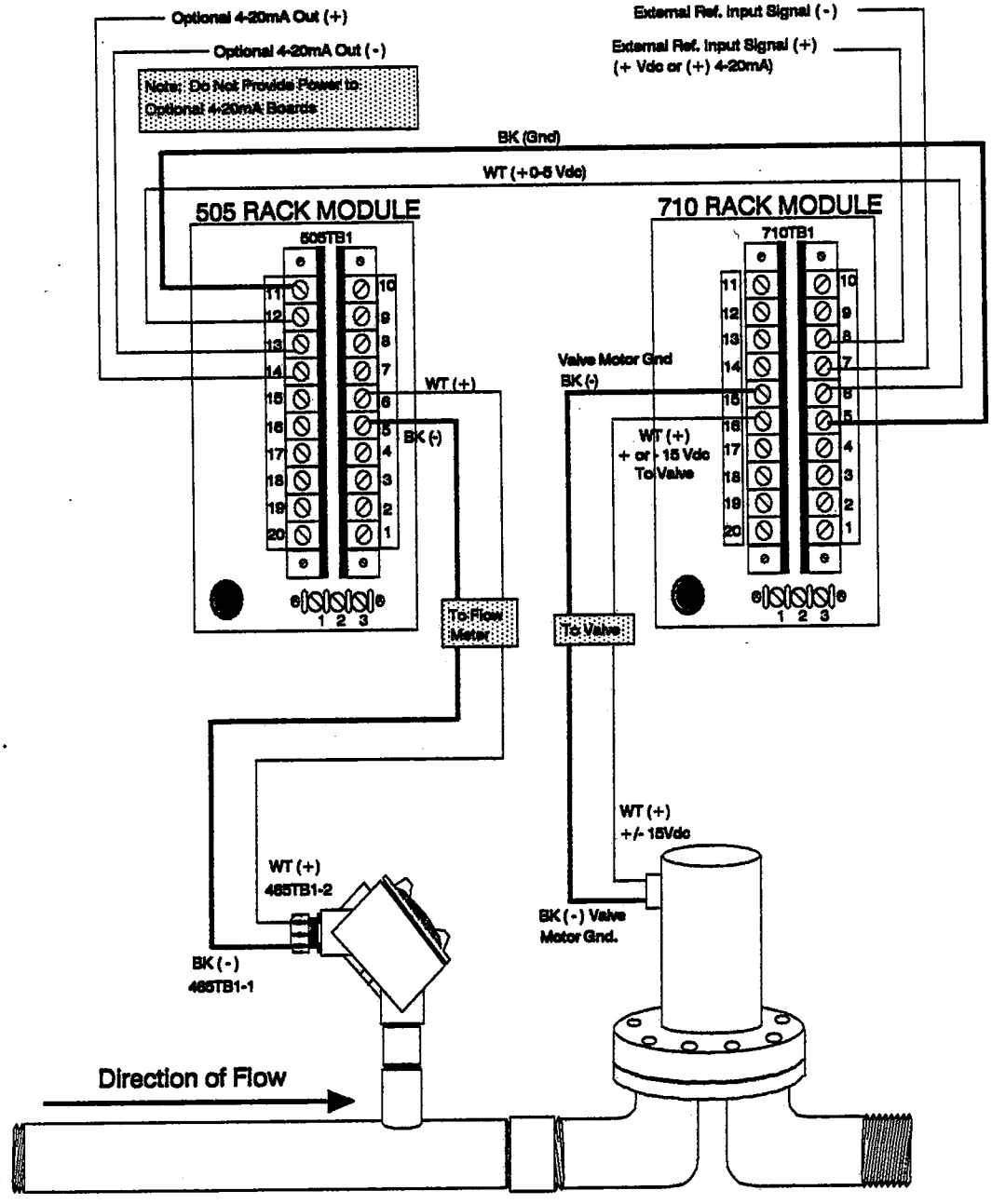
Section 2 explains, in necessarily general terms, how to install your 7500. This section explains how to determine the correct location for installation, as well as how to perform the physical installation. You should read thoroughly the parts of this section that apply to your installation before you install the 7500. **You may also want to read Section 5, "Testing," before you install the 7500.**

About the Art in This Book

The computer-generated art in the main sections of this book is intended to illustrate particular points under discussion. It includes only as much detail as is relevant to the discussion at hand. No attempt has been made to accurately scale these drawings or to include details not under discussion in the text that precedes and follows each drawing. If you need more detailed and precise visual information, refer to Appendix A, which contains reproductions of actual engineering drawings.

Quick Set-Up Guide

The quick set-up chart below summarizes much of the information presented in this manual. **They do not, however, contain all the information you may need for safe and satisfactory installation of your 7500. Kurz Instruments recommends that you read the manual before attempting installation.**



Section 1: Product Overview

This section contains a general description of the Series 7500 Mass Flow Control System. It explains how the flow controller works and lists its features and specifications.

1.1 Description

The Kurz Series 7500 Mass Flow Control Systems are state of the art mass flow controllers for use in the most demanding process requirements. The 7500 Mass Flow Control System can be used in applications requiring gas flow control in addition to flow metering. Our customers have used the 7500 to control anhydrous ammonia flows in a water treatment plant and to control argon gas flows in automated welding stations. The 7500 has also been integrated into gas monitoring systems built for nuclear power plants and for nuclear sampling systems.

The 7500 is composed of three basic subsystems:

- A fast response Model 505 Mass Flow Meter provides a 0-5 Vdc output signal linearly proportional to the measured flow. The 505 Mass Flow Meter consists of two assemblies. The first assembly is the flow meter (containing the mass flow sensor and current-transmitter board) mounted perpendicular on the flow body. The second assembly is the 505 rack module containing the power-supply/linearizer board.

- The Series 710 Electronic Valve Controller opens or closes the control valve after comparing the 505 flow meter's 0-5 Vdc output signal to a user-selectable internal or external setpoint value. The 710 also provides all the control and function switches to operate the 7500 system as well as an LDC digital display used in system operation.

- The Series 730 Electric Rotary Ramp Metering Valve provides precise flow control in conjunction with 710 controller.

Figure 1-1, on the following page, shows an illustration of the 7500 system components.

Each of these components is described in the following subsections.

1.2 The 505 Mass Flow Meter

The Model 505 Mass Flow Meters come with an attached flow body and are designed to be installed in lines carrying air or other gases. It is extremely rugged and resistant to contamination, and is therefore particularly suitable for hot, dirty, or corrosive industrial environments. Because of the 505's exceptionally energy-efficient design, pressure drops across the 505 are extremely low, typically about two inches of water, or 1/15 of one psi.

The 505 is available in many sizes to suit a wide range of applications. Table 1-1 lists the various 505 models and summarizes some of their characteristics.

Table 1-1. *505 Sizes and Specifications*

Maximum Flow/Units of Flow		Model Number	Inlet & Outlet Fitting Size	Maximum Pressure Drop (in inches of water) at Full Scale	Recommended Allowable Working Pressure (psi)
0-50	SCCM	505-1-00	1/4" MNPT x 6"	.05	1000
0-150	SCCM	505-2-00	1/4" MNPT x 6"	.05	1000
0-500	SCCM	505-3-00	1/4" MNPT x 6"	.05	1000
0-1500	SCCM	505-4-00	1/4" MNPT x 6"	.1	1000
0-5	SLPM	505-5-00	1/4" MNPT x 6"	.3	1000
0-15	SLPM	505-6-00	1/4" MNPT x 6"	.5	1000
0-50	SLPM	505-6-04	1/4" MNPT x 6"	5.0	1000
0-50		505-7-02	3/8" MNPT x 7"	.06	1000
0-1	SCFM	505-6-02	1/4" MNPT x 6"	2.0	1000
0-1		505-7-0	3/8" MNPT x 7"	.02	1000

Table 1-1 (continued). *505 Sizes and Specifications*

Maximum Flow/Units of Flow		Model Number	Inlet & Outlet Fitting Size	Maximum Pressure Drop (in inches of water) at Full Scale	Recommended Allowable Working Pressure (psi)
0-150	SCFM	505-9B-06	2" MNPT x 24"	.52	1000
0-150		505-10A-00	3" MNPT x 36"	2.6	900
0-175	SCFM	505-10-02	2 1/2" MNPT x 30"	8.0	1000
0-200	SCFM	505-10A-02	3" MNPT x 36"	4.6	900
0-200		505-11-00	4" MNPT x 48"	2.3	800
0-200		505-11-01	4" MNPT x 12"	2.3	800
0-300	SCFM	505-10-04	2 1/2" MNPT x 30"	10.5	1000
0-300		505-10A-04	3" MNPT x 36"	10.5	900
0-300		505-11-02	4" MNPT x 48"	5.1	800
0-300		505-11-03	4" MNPT x 12"	5.1	800
0-400	SCFM	505-10A-06	3" MNPT x 36"	7.0	900
0-400		505-11-04	4" MNPT x 48"	7.0	800
0-400		505-11-05	4" MNPT x 12"	7.0	800
0-500	SCFM	505-12-00	6" MNPT x 66"	2.0	300
0-500		505-12-01	6" MNPT x 18"	2.0	300
0-600	SCFM	505-11-06	4" MNPT x 48"	6.7	800
0-600		505-11-07	4" MNPT x 12"	6.7	800
0-750	SCFM	505-12-02	6" MNPT x 66"	4.5	300
0-750		505-12-03	6" MNPT x 18"	4.5	300

1.2.1 505 Basic Components

All the 505s consist of the same basic components:

- DuraFlo™ ceramic flow sensor (Models 505-1 through 505-6), Mini MetalClad™ all-metal sensor (Models 505-7 through 505-9), or MetalClad™ all-metal sensor (Models 505-10 through 505-13).

  NOTE: The sensor shipped with your 505 was specifically matched to your unit's electronics during factory calibration. Sensors are **not** interchangeable between different 505s.

- 316 stainless steel flow body with male National Pipe Thread fittings (MNPT)

- Two-wire current transmitter board housed in a weatherproof junction box attached to the flow body

- Power-supply/linearizer board unit housed in a rack module

All information is this guide applies equally to all 505 models unless specifically identified as applying only to a particular model or models.

Figure 1-2 shows the basic components of the 505.

Figure 1-2. *505 Basic Components:*

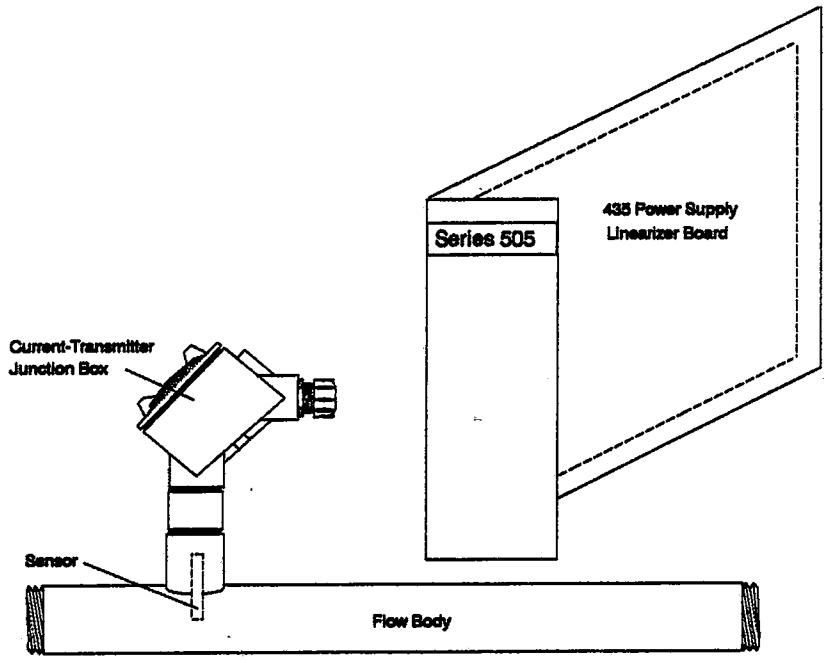
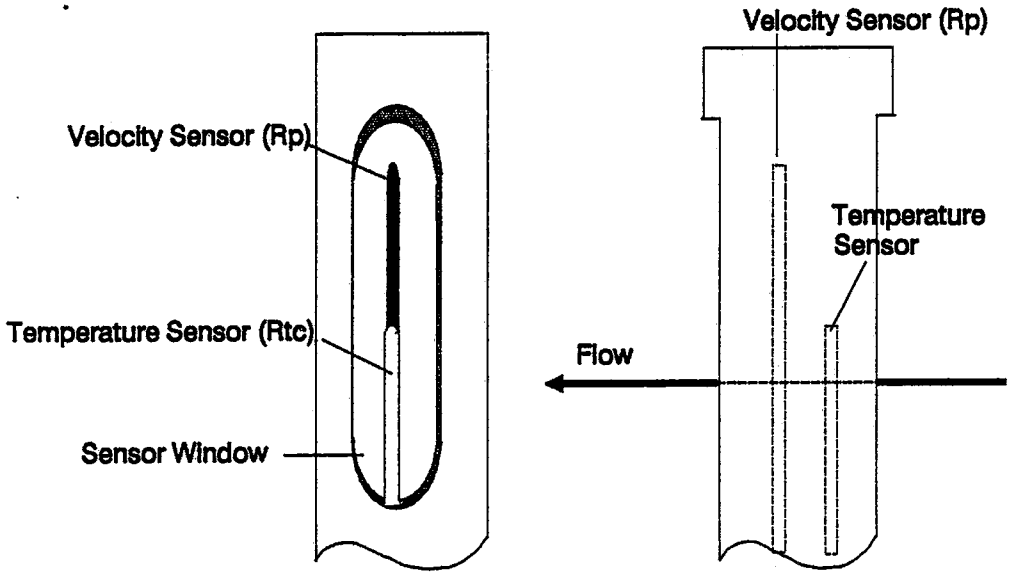


Figure 1-4. *The Mini MetalClad and MetalClad Sensor: Two Views*

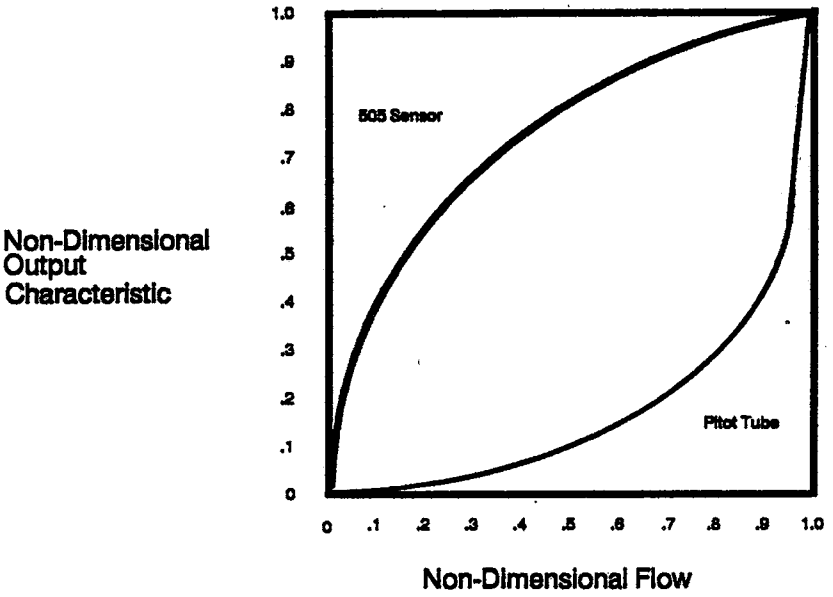


All Kurz sensors operate in the same manner. The temperature winding senses the ambient temperature of the flow. The velocity winding is then heated to approximately 75° to 100° F **above** the ambient temperature and is maintained at the same level of temperature differential (overheat) above the ambient temperature regardless of changes in ambient temperature.

CAUTION: The standard rating on the 505 sensor is for nonexplosive gases. If you plan to use it in flows of explosive gases, contact Kurz Instruments.

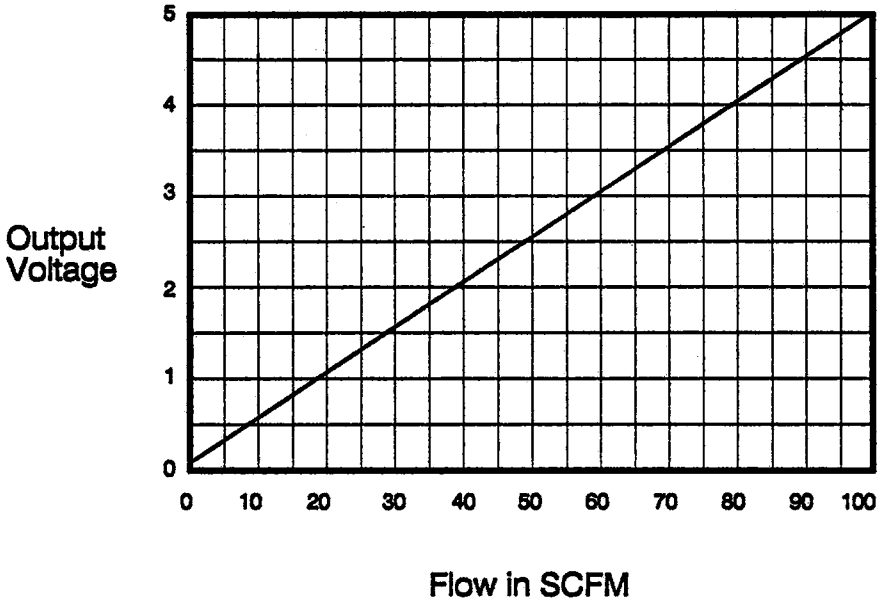
Because the temperature winding compensates for fluctuations in ambient temperature, the amount of electrical power needed to maintain the velocity winding's overheat is affected only by the flow of air or other gases over the sensor: The greater the flow, the greater its cooling effect on the sensor and the greater the electrical power needed to maintain the sensor's overheat. It is this power or current draw that is measured by the 505.

Figure 1-5. *Sensor Output vs Flow*



The linearizer converts the nonlinear draw into a linear voltage that is directly proportionate to flow: 0 Vdc indicates no flow, 5 Vdc indicates maximum measurable flow, and 2.5 Vdc indicates a flow exactly half of the maximum measurable flow, as shown in Figure 1-6.

Figure 1-6. *Linearized Output*



The 710 then applies this error signal to the 730 control valve to open or close the valve until the setpoint is reached. The +15 Vdc signal opens the valve and the -15 Vdc signal closes the valve. The valve stays in it's last position until it receives an error signal, and moves only while an error signal is present.

The setpoint reference signal that is compared to the 505's output signal can be generated by the 710 Controller or can be input externally to the 710 Controller. Using an external setpoint reference allows the setpoint (and therefore the flow rate) to vary according to computer control or respond to the state of other process variables. This also allows one flow control system to be slaved to another, to create a blending system for example.

The 710 controller board inside the 710 rack module includes a power supply that generates regulated +5 Vdc, +15 Vdc, and -15 Vdc supplies. The comparator circuit on the 710 board compares the 505's output signal to the setpoint reference signal and generates an error signal. Power transisitors on the 710 board drive the 730 valve motor with a +15 or -15 Vdc error signal.

The 710 controller is supplied in a standard 4.2"-wide rack module, which includes a 4 1/2-digit character LCD display, setpoint adjust potentiometer, switches for automatic or manual valve operation, and a provision for the external setpoint signal. Remote inputs (external set point signals) are usually of the same type and in the same units as the process variable input (with the exception of the 710-07-RMD). A typical 710 rack module is illustrated in Figure 1-7.

1.4 The 730 Electric Rotary Ramp Metering Valve

The Kurz Series 730 Electric Rotary Ramp Metering Valve provides the metering required for both isokinetic and constant flow control operations. The 730 is an electrical metering valve that combines the electric drive motor, the valve body, and limit switches into a well designed integrated package.

The standard valve incorporates a high torque DC gear motor designed to be operated by "error signals" (+ 15 or -15 Vdc signals) from the Series 710 Controller. The flow coefficient (C_v) of the 730 is linear over a wide range due to its nearly 300 degree rotation between a complete flow shutoff and full open. The standard full open to full close time is 30 seconds, unless an optional valve speed has been specified. In addition, the orifice size is unaffected by changes in system pressure and the valve remains in its last position during constant flow or during power shutoff.

Because the motor is used only when the valve must move to a new position during flow control, the motor operates only for brief periods and is usually idle. In this type of application the motor should enjoy an extremely long life and should not require replacement of the brushes.

The standard 730 valve is constructed of type 304 stainless steel and includes an O-Ring sealed motor cover with a 1/2" FNPT (female National Pipe Thread) conduit fitting. The Series 730 valves may be used with most fluids, including steam and liquids. Special materials of construction may be specified for hostile fluids or environments.

The cover of the valve can be removed for servicing or hookup by removing the 4 socket cap screws circumferentially mounted to the base of the valve motor cover housing. See Section 5 for information on servicing.

1.5 Specifications

The specifications for the system components included in the 7500 are summarized below.

1.5.1 505 Mass Flow Meter Specifications

Table 1-2. *505 Specifications*

Sensor Construction:	Reference-grade 385 platinum RTD-type windings around a high-purity ceramic core, sheathed in glass (Models 505-1 through 505-6) or stainless steel (Models 505-7 through 505-13).
Accuracy:	+/- (2% of reading + 1/2% of full scale)
Repeatability:	+/- 0.25%
Response Time:	1 second
Calibration:	Factory calibrated in NBS-traceable wind tunnel for air at 25° C and 760 mm Hg. Includes Calibration Certificate showing output voltage vs flow for 11 data points, including zero flow.

Table 1-2. *505 Specifications* (continued)

Operating Temperature Range of Electronics:	-20° C to +60° C Units with high temperature sensors (HT or HHT) use current-transmitter enclosure placed remote from the flow body via a 15-foot cable
Power Supply:	110VAC/60Hz Standard 220VAC/50-60Hz power supply optionally available
Output:	Linear 0-5 Vdc standard. Isolated and nonisolated 4-20 mA outputs optionally available. For other nonstandard outputs, consult factory.
Linearization:	11 breakpoint analog voltage offset type (11 amplifier stages) plus zero and span. Optional digital linearizer available, see Options section

Table 1-3. *710 Specifications* (continued)

Enclosure:	Standard: 4.2" wide by 7" high rack module Optional 7500 system packages are available that house all system components in one large NEMA enclosure.
Signal In:	Accepts 0-5 Vdc process variable input normally provided by 505 Mass Flow Meter. Alternatively accepts 0-5 Vdc process variable input provided externally. 710 controller modules that accept a 4-20 mA, 0-2 Vdc, or 1-5 Vdc process variable signal are also available. Consult factory regarding other external inputs.
Signal Out:	+15 Vdc or -15 Vdc signal drives the 730 valve over a two-wire hookup (2nd wire is ground)
Hookup:	Rear-mounted barrier screw terminal provided for hookup of signal in and valve control signal

Table 1-4. *730 Specifications* (continued)

Cycle Times:	Full CLOSE to full OPEN is normally approximately 35 to 40 seconds when the 2426:1 ratio gearmotor is used. Less pronounced gear ratios result in faster cycle times, but can result in loss of some precision in fine metering. Select other cycle times only where flow is rapidly changing. It is very simple and economical to swap out gearmotors in the field with only a screwdriver should you wish to change the valve cycle time.
Hookup:	Two-wire hookup. One wire is ground. The other wire carries the + 15 Vdc or -15 Vdc signal from the 710 controller that opens or closes the valve respectively.
Motor Cover:	The cover for the motor is constructed of the same material as the valve (e.g. 316 stainless steel covers are provided with 316 stainless steel valves). All motor covers include cable fitting which may be removed to run conduit into the 1/2" FNPT fitting provided.
Shutoff:	While a pressure assisted shutoff plug is a standard feature, the 730 valves are metering valves, not shutoff valves. For users requiring 100% confidence in total shutoff we recommend installation of a simple normally open closed solenoid valve downstream of the Kurz 730 valve.

Section 2: Installation

This section explains how to install your 7500 Mass Flow Controller. The instructions given in this section are necessarily general in nature; every installation is unique. If you need further assistance with your installation, contact Kurz Instruments, Inc. at (408) 646-5911.

2.1 Checking the Contents of the Shipping Carton

Normally no special precautions need to be observed during unpacking of your flow control system. Depending on the number of systems or system components, the electronics for the 7500 (710 Controller and 505 Power-Supply/Linearizer rack modules) may or may not be shipped in the same physical box as the 505 Flow Meter and 730 Valve.

Of course, any external damage to the package(s) should be reported to the carrier. Open the shipping carton(s) and remove the protective foam packaging material that covers the 7500 and any options shipped with it. Check to see that the shipping carton contains everything you ordered. If you ordered your 7500 without any options, the contents of the shipping carton should be as shown in Figure 1-1.

Any options you ordered should be specified on the Unit Description Sheet at the front of this manual. Available options are listed, described, and (where applicable) pictured in Section 4, "Options". If the options specified on the Unit Description Sheet do not match the options you ordered or the options actually shipped, contact Kurz immediately.

Usually the 505 Mass Flow Meter and the 730 Electric Rotary Ramp Metering Valve are already mated or piped together. In most cases the valve will be installed downstream from the 505 flow meter.

Make sure the NBS-traceable calibration certificate for the 505 Mass Flow Meter is included. Verify that the line size and pipe schedule shown on the calibration certificate are correct.

2.3 Installing the 505 Mass Flow Meter

2.3.1 Determining Flow Meter Location

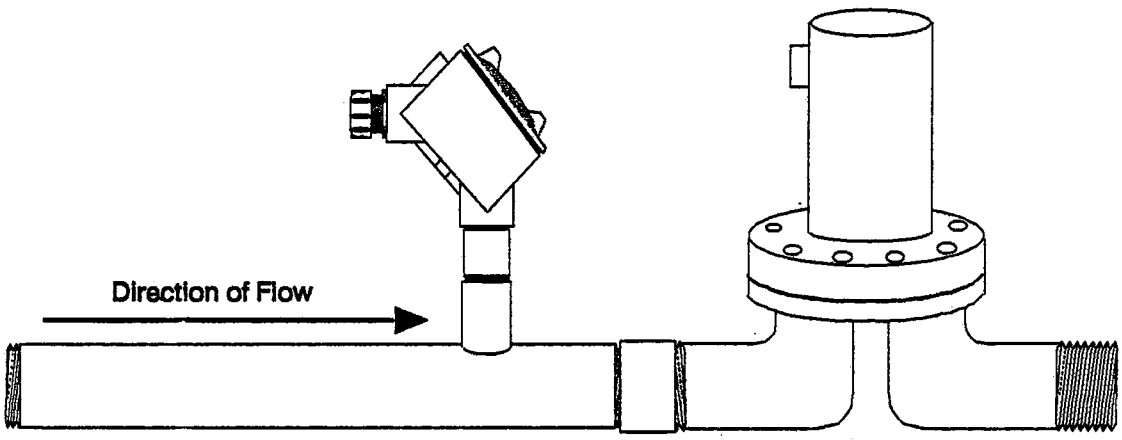
The flow body itself provides the required unobstructed runs upstream and downstream from the sensor. Even so, it is a good idea to install the 505 near the center of a long, straight pipe section, if possible.

Unless it has been specifically calibrated for another orientation, the flow meter must be installed in a horizontal run, with the junction box extending straight up. You must therefore choose a location where there is sufficient clearance for the junction box.

2.3.2 Orientation

Note that the flow body is not symmetrical—it has a long end and a short end (relative to the T connection for the junction box). You must install the 505 so that flow enters through the long end of the flow body and exits through the short end. Figure 2-1 illustrates the position of the flow meter is relation to the flow.

Figure 2-1. *Flow Meter's Position in Relation to Flow*



In consulting Table 2-1, there are two things you should bear in mind:

- Table 2-1 applies to stranded copper wire at 65° F. Resistance in other kinds of wire, or in stranded copper wire at different temperatures, will vary.
- American Wire Gauge (AWG) numbers are inversely proportionate to the size of wire they apply to. That is, the smallest AWG number specifies the **largest** wire and vice versa.

Table 2-1. *Approximate Loop Resistance in Current-Transmitter Wire*

AWG#	Ohms/Ft	Maximum Loop (Ft)	Maximum Run (Ft)
4	.0003	13,333	6,667
8	.0005	8,000	4,000
10	.0008	5,000	2,500
12	.002	2,000	1,000
14	.003	1,333	667
16	.005	800	400
18	.008	500	250
20	.012	333	167
22	.019	211	105
24	.030	133	67
28	.077	52	26

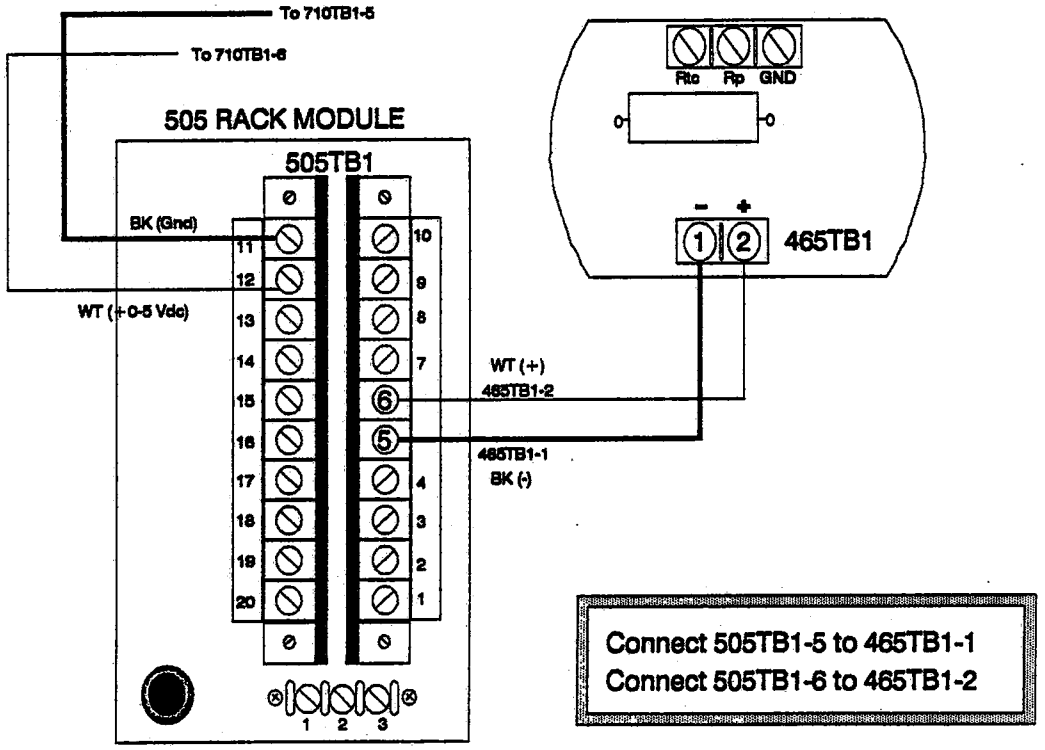
WARNING: Always unplug the power cords for the 710 and 505 rack modules before you make connections. Failure to unplug or disconnect the power cord will result in severe shock hazard and possible damage to the circuits and/or sensor.

2.4.1 Connecting the 465 Current-Transmitter to the 505 Rack Module

The two-wire current loop must be connected between the 465 Current-Transmitter Board in the 505 flow meter and the 505 rack module containing the 435R1 Power-Supply/Linearizer Board. The 7500 system is shipped with 15 feet of wire already connected to the current-transmitter terminals and exiting a conduit fitting on the junction box of the flow meter. You can either splice longer wires onto the existing wires or replace them with wires of your own. Make sure that the wire gauge and length do not cause the resistance in the current-loop to exceed 4 ohms.

The black wire attached to terminal 1 of 465TB1 is the return signal. You should connect this wire to terminal 5 on the back of the 505 rack module. The white wire attached to terminal 2 of 465TB1 is the +24 Vdc power supply. You should connect this wire to terminal 6 on the back of the 505 rack module. These connections are shown in Figure 2-3. Note that, because of the 505's reverse polarity protection, the connections between the 465 Current-Transmitter Board and the 505 rack module can be reversed without damaging the 505.

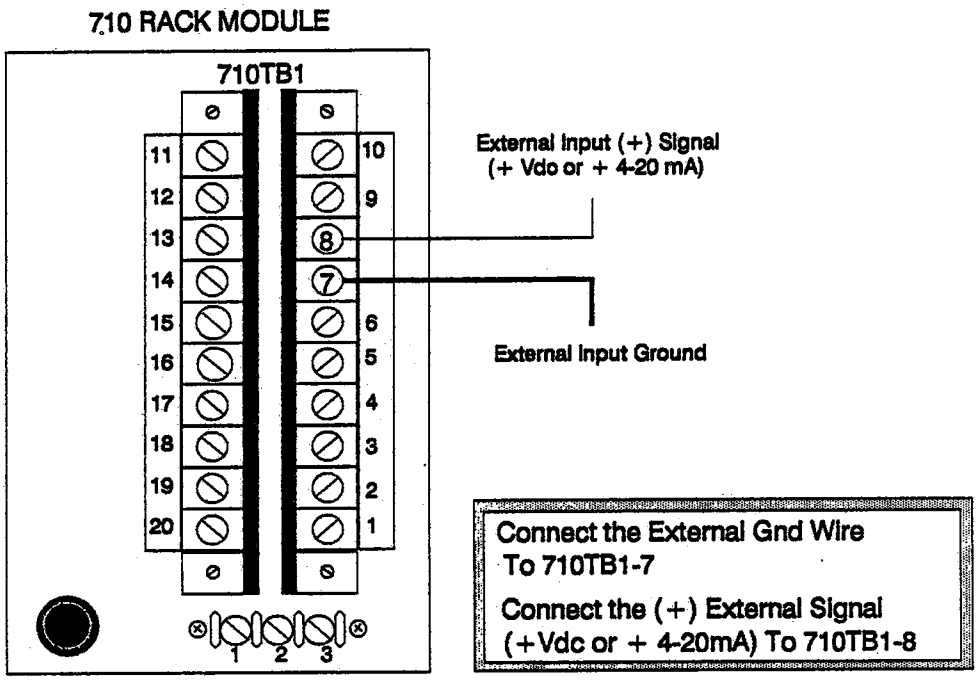
Figure 2-3. *Two-wire Current Loop Connections*



2.4.3 Connecting an External Setpoint Signal

If you are using an external setpoint reference signal to control the flow, connect the inputs to the 710 rack module as shown in Figure 2-5. These connections can be used to input either an external voltage or 4-20 mA reference signal.

Figure 2-5. *Connecting an External Setpoint Reference Signal to the 710*



Section 3: Operation and Maintenance

This section describes the operation and routine maintenance of the 7500 Mass Flow Control System.

3.1 Operation

As discussed in the previous sections, the 7500 system controls flow by comparing the 0-5 Vdc or optional 4-20 mA output signal generated by the 505 Mass Flow Meter to a setpoint reference voltage or 4-20 mA signal. When the actual rate of flow (as indicated by the output signal from the 505) is less than the setpoint flow rate (as indicated by a setpoint reference signal) the 710 outputs a + 15 Vdc error signal to open the valve thereby increasing flow. When the actual rate of flow (as indicated by the output signal from the 505) is greater than the setpoint flow rate (as indicated by a setpoint reference signal) the 710 outputs a -15 Vdc error signal to close the valve thereby decreasing flow.

The setpoint reference signal can be generated by the 710 Controller or can be input externally to the 710 Controller. The valve stays in it's last position until it receives an error signal, and moves only while an error signal is present.

The simplest way to explain the modes of operation for the 7500 is to explain the functions of the control switches. Typically the Series 505 Mass Flow Meter rack module will have an ON/OFF switch only. All the other controls for the standard 7500 are on the 710 Controller rack module. As shown in Figure 3-1 on the next page, these operator controls include:

ON/OFF Switch

DISPLAY Select Switch

FUNCTION Select Switch

MANUAL VALVE OPEN/CLOSE Switch

SET-POINT ADJ. Locking Potentiometer

3.1.1 The DISPLAY Select Switch

The DISPLAY select switch allows you to choose the type of reading that is displayed on the LCD display. The reading will be displayed in your particular control system's engineering units (typically a unit of flow or lbs.). Depending on the switch position, the LCD display indicates:

1.) the actual flow

2.) the 7500's internal setpoint flow

3.) the external setpoint flow (if used)

Normally the DISPLAY select will be set FLOW RATE. The reading displayed is the flow as measured by the 505 Mass Flow Meter. Because the flow meter is directly upstream of the flow control valve, the reading displayed is the actual current rate of flow control.

The other two positions on the DISPLAY select switch are used to display the setpoint flow rate in engineering units. When the DISPLAY switch is set to the SET-POINT position, the LCD display provides a flow reading derived from the 7500's internal setpoint reference voltage as set by the SET-POINT ADJ. locking potentiometer. This SET-POINT switch position should be selected when adjusting the SET-POINT ADJ. locking potentiometer to set or change the 7500's internal flow control setpoint.

You can select to use an external 0-5 Vdc or other external setpoint in place of the 7500's internal setpoint. The external setpoint is selected using the FUNCTION select switch described in the next subsection. When the DISPLAY select switch is set to EXTERNAL INPUT the display provides a flow reading derived from the external setpoint reference voltage or 4-20 mA reference input. This display is helpful when setting or changing the external setpoint signal used to control the flow.

3.1.4 The SET-POINT ADJ. Locking Potentiometer

This locking potentiometer allows you to adjust the 7500's internal setpoint reference signal. This 10-turn potentiometer trims the supplied 0-5 Vdc (or optional 4-20 mA) setpoint signal to the level by which the 505's signal output signal will be compared.

3.2 Calculating Actual Flow

For most air-flow monitoring applications, the **mass** of the flowing gas is the relevant variable. The 505's sensor was designed with this fact in mind. The sensor accurately registers mass flow at any temperature and pressure. Its output is therefore calibrated in standard units.

Those units are referenced to a standard temperature of 25° C (77° F) and standard atmospheric pressure of 760 mm (29.92 inches) of mercury. A flow reading obtained for air at a different temperature and/or pressure will not be the actual volumetric flow of that air.

Generally, standard flow is a much more useful measurement than actual flow. Sometimes, however, you may want to calculate the **actual** flow of an airflow whose temperature or pressure differs significantly from the standard temperature and pressure.

The formula for deriving actual flow from indicated flow is given below:

$$F_{act} = F_{ind} \frac{d_s}{d_a}$$

where:

d_s = Standard air density (25° C; 760 mm Hg).

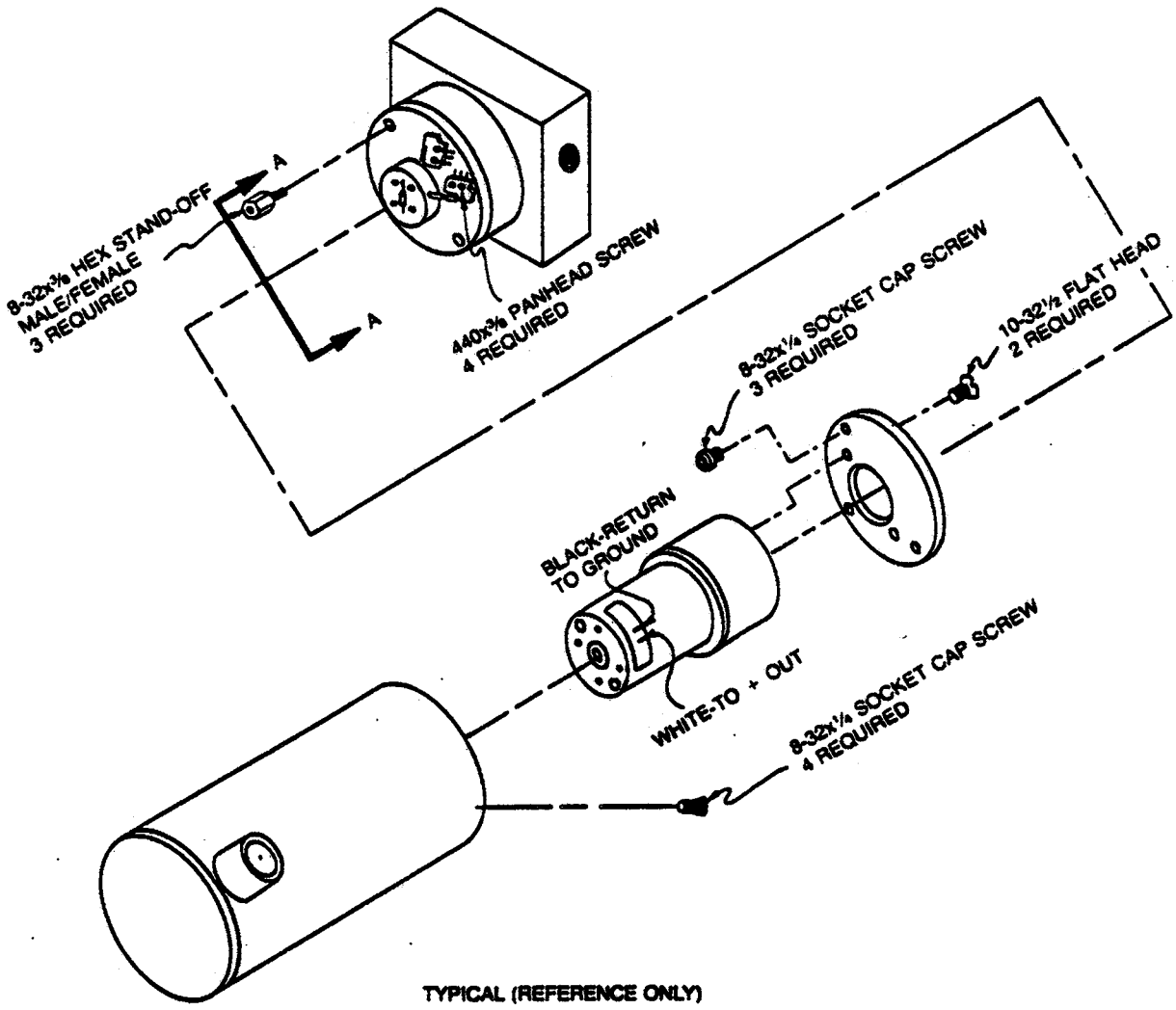
d_a = Actual air density at local temperature and barometric pressure.

F_{act} = Actual air flow in cubic feet per minute.

F_{ind} = Indicated flow in standard cubic feet per minute.

To disassemble smaller valves refer to Figure 3-2. First remove the motor cover housing by removing the 4 socket cap screws placed around the base of the valve's motor cover housing. Before you remove the motor you will need to remove the motor lead wires. It may be helpful to mark the leads with a + or - to indicate how the wires should be reinstalled.

Figure 3-2. *Motor Assembly*

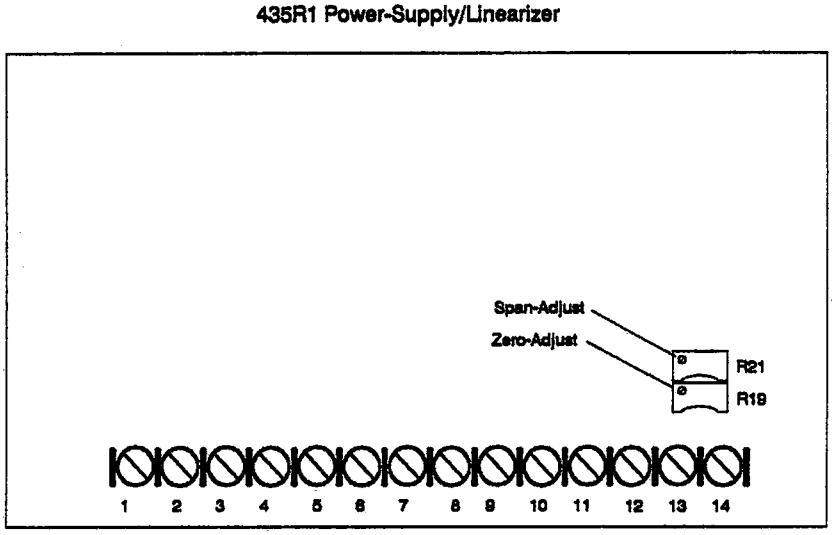


If you do recalibrate the 505 yourself, follow the procedure described below. You will need:

- a digital voltmeter accurate to +/-.001 Vdc
- a flat-bladed screwdriver with a narrow blade and a long shaft

The velocity calibration procedure consists of running a flow of known velocity through the 505 and adjusting the zero and span potentiometers on the 435R1 Power-Supply/Linearizer Board. Figure 3-3 shows their locations.

Figure 3-3. *Power-Supply/Linearizer Board: Zero and Span Potentiometers*



Step 1: Set the flow to 0.

Step 2: Check the voltage between Terminal Screw 2 (linear output) and Terminal Screw 3 (ground). If necessary, adjust the zero-control potentiometer up or down until you get a reading of zero volts.

NOTE: You should check for zero voltage either immediately after powering the 505 or after first running flow through the meter and then returning to zero flow. This is necessary because, after several minutes at zero flow, the heat produced by the velocity winding (R_p) begins to affect the ambient temperature winding (R_{tc}).