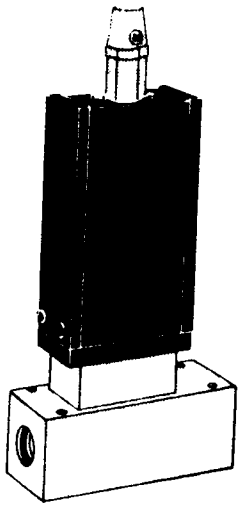
FMA-300, FMA-400 Series
Mass Flowmeter
FMA-500 Series
Air Mass Flow Transducers



OMEGA®
An OMEGA Technologies Company

Operator's Manual
M386/1292

MADE IN USA

WARRANTY

OMEGA warrants this unit to be free of defects in materials and workmanship and to give satisfactory service for a period of **13 months** from date of purchase. OMEGA Warranty adds an additional one (1) month grace period to the normal **one (1) year product warranty** to cover handling and shipping time. This ensures that our customers receive maximum coverage on each product. If the unit should malfunction, it must be returned to the factory for evaluation. Our Customer Service Department will issue an Authorized Return (AR) number immediately upon phone or written request. Upon examination by OMEGA, if the unit is found to be defective it will be repaired or replaced at no charge. However, this WARRANTY is VOID if the unit shows evidence of having been tampered with or shows evidence of being damaged as a result of excessive corrosion; or current, heat, moisture or vibration; improper specification; misapplication; misuse or other operating conditions outside of OMEGA's control. Components which wear or which are damaged by misuse are not warranted. These include contact points, fuses, and triacs.

We are glad to offer suggestions on the use of our various products. Nevertheless OMEGA only warrants that the parts manufactured by it will be as specified and free of defects.

OMEGA MAKES NO OTHER WARRANTIES OR REPRESENTATIONS OF ANY KIND WHATSOEVER, EXPRESSED OR IMPLIED, EXCEPT THAT OF TITLE AND ALL IMPLIED WARRANTIES INCLUDING ANY WARRANTY OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE ARE HEREBY DISCLAIMED.

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Every precaution for accuracy has been taken in the preparation of this manual, however, OMEGA ENGINEERING, INC. neither assumes responsibility for any omissions or errors that may appear nor assumes liability for any damages that result from the use of the products in accordance with the information contained in the manual.

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RETURN REQUESTS / INQUIRIES

BEFORE RETURNING ANY PRODUCT(S) TO OMEGA, YOU MUST OBTAIN AN AUTHORIZED RETURN (AR) NUMBER FROM OUR CUSTOMER SERVICE DEPARTMENT (IN ORDER TO AVOID PROCESSING DELAYS). The assigned AR number should then be marked on the outside of the return package and on any correspondence.

OMEGA's policy is to make running changes, not model changes, whenever an improvement is possible. That way our customers get the latest in technology and engineering.

OMEGA is a registered trademark of OMEGA ENGINEERING, INC.

TABLE OF CONTENTS
FMA-300, FMA-400 SERIES MASS FLOWMETERS AND FMA-500 SERIES AIR MASS FLOW TRANSDUCERS

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SECTION 1 INTRODUCTION

CAUTION

These units are for air and Nitrogen ONLY—not for oxygen service, nor any other gas.

Units with 4-20 mA output require a minimum 150 ohm loop impedance. If impedance is too low, the unit outputs more than 4 mA at zero flow.

1.1 GENERAL DESCRIPTION

This Operator's manual covers the OMEGA® FMA-300 and FMA-400 Series Mass Flowmeters, and the FMA-500 Series Air Mass Flow Transducers. These systems directly monitor the flow of gas molecules. Molecular flow is the quantity required for all processes involving chemical reactions, combustion, semi-conductor fabrication, and blending. Because they measure mass flow directly, these units do not require pneumatic hook-ups, square root extractors, or temperature and pressure corrections.

The FMA-300, FMA-400 and FMA-500 Series operate on +15 to +18 V dc power and deliver a 0-5 V dc or 4-20 mA linear output signal over a wide variety of ranges. Each model is complete with flow body, integral electronics in a compact enclosure, and electrical connector.

1.2 FEATURES

- For Air and Nitrogen
- Low pressure drop
- Mount in any direction
- Rugged construction
- Easy maintenance

SECTION 2 INSTALLATION

2.1 UNPACKING

Remove the packing list and verify that all equipment has been received. If there are any questions about the shipment, please call the OMEGA Customer Service Department at 1-800-622-2378 or (203) 359-1660.

Upon receipt of the shipment, inspect the container and equipment for any signs of damage. Take particular note of any evidence of rough handling in transit. Immediately report any damage to the shipping agent.

NOTE

The carrier will not honor any claims unless all shipping material is saved for their examination. After examining and removing contents, save packing material and carton in the event reshipment is necessary.

2.2 PLUMBING HOOK-UP

At least five pipe diameters of straight pipe should be installed before and after the flow body. In cases where it is impossible to have five pipe diameters, it may be a good idea to calibrate the unit in place to see if there are problems within the range of concern. Orient the flow body so the flow goes in the direction of the arrow on the flow meter body. Use a good quality Teflon tape sealant on all threaded connections to prevent leaks. On units where Swagelocks, VCO, or VCR fittings are used, check the condition of all seals before flow is applied. If the air flow is dirty, an in-line filter should be installed upstream for long-term measurements.

CAUTION

Do not tighten pipe fittings more than eight turns on flow bodies or damage to probe may result. Five turns is generally more than sufficient.

2.3 ELECTRICAL HOOK-UP (Refer to Table 2-1)

Before hooking up the unit, make sure all wire ends are separated to prevent shorting. Be sure to connect or disconnect the connector for the flow body with the power turned off. For multiple channel units, make sure that the proper flow meter is plugged into the corresponding jack.

After installation and hook-up of mass flowmeters, it is normal for a zero offset to occur in the meter reading. This is easily corrected by adjusting the zero offset in the readout meter.

WARNING

Do not attempt any adjustment of the flowmeter zero and span. This voids the warranty.

TABLE 2-1
WIRING

PLUG PIN NO.	WIRE COLOR	FUNCTION
1	BLK	SIGNAL GROUND/4-20 mA (–)
2	WHT	0-5V DC OUTPUT/4-20 mA (+)
3	RED	+ SUPPLY (PER STICKER)
4	BRN	HIGH ALARM*
5	GRN	LOW ALARM*
6	BLU or SIL or GRN	POWER GROUND

* Table 2-1 shows all possible connections. Note that your unit may not have alarms so connection is not necessary.

SECTION 3 OPERATION

3.1 THEORY OF OPERATION

The FMA-300, FMA-400 and FMA-500 Mass Flowmeters have two sensors immersed in the flow — a mass flow sensor and a temperature sensor that automatically corrects for flow temperature changes. Both are glass-coated platinum resistance temperature detectors (RTD's). The unexcelled stability and reproducibility of RTD's have made them the standard of NIST. The sensors are large, rugged, insensitive to dirt and easily cleaned, yet feature rapid response. The sensor resistances are opposite legs of a bridge circuit. The circuit heats the mass flow sensor at a constant temperature differential above ambient (approximately 60°F) and measures the cooling effect of the air or gas flow. The resulting output provides unsurpassed sensitivity and a rangeability up to 100:1.

The FMA-300, 400, and 500 series mass flowmeters are all individually calibrated versus primary or secondary NIST traceable mass flow standards. With the calibration sheet supplied with the flowmeter, the polynomial equation programmed into the linearizing microprocessor is listed. However, the analog output from the flowmeter is LINEAR with flowrate. The polynomial is not used by the end user.

3.2 CALCULATING VOLUMETRIC FLOW RATE

The flow sensor measures the mass flow of air, referenced to standard conditions of 25°C and 1 atmosphere. The units of measurement are either standard liters per minute (SLPM), standard cubic feet per minute (SCFM), or standard cubic centimeters per minute (SCCM). Air mass flow, the quantity required for most applications, is measured directly by the readout meter or the output voltage indication. In cases where the volumetric flow rate (at the actual temperature and pressure at the time of measurement) is desired, a simple correction is required. In this case, the volumetric flow rate is in units of liters per minute (LPM), cubic feet per minute (CFM), or cubic centimeters per minute (CCM). The required correction factor is given in the following equation:

$$Q = Q_s \left(\frac{\rho_s}{\rho}\right) = Q \left(\frac{P_s}{P}\right) \left(\frac{T}{T_s}\right), \qquad \text{Equation (1)}$$

where

Q = volumetric flow rate at "actual" conditions of P and T (LPM, CFM, or CCM),

Q_s = mass flow rate referenced to "standard" conditions of $_s$, P_s, and T_s (SLPM, SCFM, or SCCM),

ρ = air mass density at actual conditions, g/cc,

ρ_s = air mass density at standard conditions, = 1.189×10^{-3} g/cc,

T = absolute air temperature at actual conditions, °K,

T_s = standard air temperature = 298°K,

P = air pressure at actual conditions, atmospheres (or psia), and

P_s = standard air pressure = 1 atmosphere (14.7 psia).

Example Calculation

If the flowmeter indicates a reading of 20 SLPM and the actual air temperature is 50°C and the pressure −3 psig. From Equation (1), the volumetric flowrate is calculated as follows:

$$Q = 20 \left(\frac{14.7}{14.7-3}\right) \left(\frac{50 + 273}{298}\right) = 27.2 \text{ LPM.}$$

SECTION 4 SERVICE INFORMATION

4.1 MAINTENANCE

If inspection of the flow sensor reveals that the temperature or mass flow sensors are broken or damaged, it is advised that they be returned to OMEGA Engineering for gluing and recalibration. If you wish to glue the sensor yourself, a high quality five-minute epoxy should be used. After the unit is glued, it will require recalibration because of the greatly increased thermal mass.

4.2 CALIBRATION

If the flow meter has been damaged, or you simply want to recalibrate, contact OMEGA Engineering Customer Service Department at 1-800-622-2378 or (203) 359-1660. Having OMEGA do your calibration will prove to be the most cost-effective alternative. Refer to the following section if you wish to do your own calibration.

The FMA-300, 400, and 500 series mass flowmeters are all individually calibrated versus primary or secondary NIST traceable mass flow standards. With the calibration sheet supplied with the flowmeter, the polynomial equation programmed into the linearizing microprocessor is listed. However, the analog output from the flowmeter is LINEAR with flowrate. The polynomial is not used by the end user.

4.2.1 Field Calibration

To calibrate, you must generate a precisely known air mass flow over the range of interest. Connect a precision flow meter, preferably with an NBS calibration, in series with the flowmeter. Possible candidates for the calibration standard are: positive displacement flow transfer standards, standard ASME orifices, thermal mass flow meters, and turbine meters. Rotameters and other flow meters without a fundamental temperature and pressure dependence should be avoided. If the calibration standard is a true mass flow meter, no separate temperature and pressure measurements are required; if not (as with volumetric flow meters), the pressure and temperature in the calibration standard must be separately measured to convert the reading to mass flow. The air flow in the system can be generated with a pressured tank of dry air with a pressure regulator set below 100 psig or a suitable pump, such as a diaphragm pump. Pumps with carbon, oil, or other particles in their exhaust should be avoided. The relative humidity during calibration should be less than 50%.

R9 IS ZERO

The first adjustment required for calibration is the zero adjust. ~~Consult the schematic for the readout device for~~ location of the zero adjust potentiometer. Dead end the entire system and assume that absolutely no flow is present in the flowmeter. Wait 2 minutes for stabilization. Adjust the pot so that zero "volts" appears on the output device.

R15 SPAN

The second adjustment required for calibration is the span or range adjust. ~~Consult the schematic for the readout device for~~ location of the span adjust potentiometer. Generate the full scale flow or the flow of primary concern and allow 45 seconds for stabilization at this flow. Adjust the pot so that the desired "voltage" value appears on the output device.

4.3 TROUBLESHOOTING

Typical problems and solutions are given in the following table. If other problems arise, or if the suggested action does not solve the problem, contact OMEGA Engineering Customer Service Department.

DO NOT TOUCH R19, 24

TABLE 4-1
TROUBLESHOOTING GUIDE

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
1. Measurement seems low	Sensors are dirty	Clean sensors with water or ethanol and a small artist's brush; install in-line filter upstream
2. Measurement is erratic	Unsteady flow	Install at least 5 pipe diameters of straight pipe, an in-line filter, or a screen upstream
	Sensors are broken	Return flow body and meter to OMEGA for repair or replacement of sensor and recalibration
	Bridge amp is bad	Replace with same type IC or return to OMEGA for repair
	Flow body is not secured to a solid base	Secure to a non-vibrating solid mount

TABLE 4-1 (Cont'd)

SYMPTOM	PROBABLE CAUSE	CORRECTIVE ACTION
3. Meter needle pegs plus or minus	Flow body not plugged into meter	Plug in both connectors
	Sensors are broken	Return flow body and meter to factory for repair or replacement of sensor and recalibration
	Bridge amp is bad	Replace with same type IC or return to OMEGA for repair.
	Bridge drive transistor is shorted	Replace with same type transistor or return to OMEGA for repair
4. System won't zero	Mechanical zero off on analog meter	Adjust mechanical zero with power off
	Out of calibration	Return flow body and meter to OMEGA for recalibration
	Sensors are broken	Return flow body and meter to OMEGA for repair or replacement of sensor and recalibration.

SECTION 5 SPECIFICATIONS

5.1 FMA-300, 400 SERIES

RANGES*: 0-200, 0-500 SCCM; 0-1, 0-2, 0-5, 0-10, 0-20, 0-50 SLM
OUTPUT: Linear 0-5 V dc or 4-20 mA proportional to mass flow; into 2000 ohm min. load for 5 V models
RESPONSE TIME: 100 ms to within ±2% of final flow**
ACCURACY: ±(2% reading +0.5% full scale) including linearity over 0 to 40°C, 0 to 30 PSIG; add ±2% full scale for −20 to +180°C; add ±2% full scale for 1 to 100 PSIG.
REPEATABILITY: ±0.2% full scale
PRESSURE DROP: @ 1 ATM 0.05 PSID
GAS PRESSURE: 500 PSIG max.
TEMPERATURE: 0 to 100°C: SS model
AMBIENT TEMPERATURE RANGE: 0 to 50 °C
WETTED PARTS: Aluminum, or 304 SS; Buna-N O-rings, platinum, ceramic, glass coating, epoxy
CONNECTION: ¼" Female NPT
INPUT POWER: 15 to 18 Vdc; 250 mA max.
ACCESSORIES SUPPLIED: Mating connector
CABLE REQUIREMENTS: 4-wire, 22 AWG; 100 ft. max.
CURRENT LOOP RESISTANCE: 250 ohms max.
DIMENSIONS: 5.1" H x 3.13" W x 1.25" D
WEIGHT: 0.9 lb.

* Minimum measureable flow rate is 20 SCCM for all flow ranges.

** Standard units are electronically dampened to 1 sec. response time. Consult Flow department for modifications required to obtain the fastest response time.

5.2 FMA-500 SERIES

RANGES*: 0-500 SCCM; 0-1, 0-2, 0-5, 0-10, 0-20, 0-50 SLM**
OUTPUT: Linear, 0-5 V dc or 4-20 mA, proportional to air mass flow, into 2000 ohm min. load for 5 V models
RESPONSE TIME: 200 ms
ACCURACY: ±3% full scale linearity over 0 to 40°C, 7 to 30 PSIG; add ±2% full scale for 2 to 7 or 30 to 75 PSIG
REPEATABILITY: ±0.3% full scale
PRESSURE DROP: 0.1 PSID @ 1 ATM at full flow.
MAXIMUM PRESSURE: 75 PSIG max.
GAS TEMPERATURE: 0 to 40°C
AMBIENT TEMPERATURE RANGE: 0 to 40°C
WETTED PARTS: Plastic flow body; platinum resistance (RTD) mass flow and temperature sensors, on rugged aluminum oxide ceramic mandrils, varnish coated; 304 SS; epoxy; tin plating
INPUT POWER: 15 to 18 V dc, 200 mV p-p max. ripple, 250 mA max.
CABLE: 4-wire, 22 AWG; 100 ft. (30 m) max. length required.
DIMENSIONS: 5.7" H x 1.0" W x 2.0" D
WEIGHT: 0.5 lb.
ACCESSORIES INCLUDED: Mating connector
CURRENT LOOP RESISTANCE: 250 ohms max.

* Minimum measureable flow rate is 20 SCCM for all flow ranges.

** Standard units are electronically dampened to 1 sec. response time. Consult Flow department for modifications required to obtain the fastest response time.