Technical Data Sheet No. TD0701M Rev. C **Date of Issue:** September 2009

OPERATING MANUAL

XFM DIGITAL MASS FLOW METERS

TABLE OF CONTENTS

1. UNPACKING THE XFM MASS FLOW METER

1.1 Inspect Package for External Damage

Your XFM Mass Flow Meter was carefully packed in a sturdy cardboard carton, with anti-static cushioning materials to withstand shipping shock. Upon receipt, inspect the package for possible external damage. In case of external damage to the package contact the shipping company immediately.

1.2 Unpack the Mass Flow Meter

Open the carton carefully from the top and inspect for any sign of concealed shipping damage. In addition to contacting the shipping carrier please forward a copy of any damage report to your distributor or Aalborg® directly.

When unpacking the instrument please make sure that you have all the items indicated on the Packing List. Please report any shortages promptly.

1.3 Returning Merchandise for Repair

Please contact the customer service representative of your distributor or Aalborg® if you purchased your Mass Flow Meter directly, and request a **Return Authorization Number (RAN). Equipment returned without an RAN will not be accepted.** Aalborg® reserves the right to charge a fee to the customer for equipment returned under warranty claims if the instruments are tested to be free from warrantied defects.

Shipping charges are borne by the customer. Meters returned "collect" will not be accepted!

It is mandatory that any equipment returned for servicing be purged and neutralized of any dangerous contents including but not limited to toxic, bacterially infectious, corrosive or radioactive substances. No work shall be performed on a returned product unless the customer submits a fully executed, signed SAFETY CERTIFICATE. Please request form from the Service Manager.

2. INSTALLATION

2.1 Primary Gas Connections

Please note that the XFM Mass Flow Meter will not operate with liquids. Only clean gases are allowed to be introduced into the instrument. If gases are contaminated they must be filtered to prevent the introduction of impediments into the sensor.

CAUTION: XFM TRANSDUCERS SHOULD NOT BE USED FOR MONITORING OXYGEN GAS UNLESS SPECIFICALLY CLEANED AND PREPARED FOR SUCH APPLICATION.

For more information, contact your distributor or Aalborg®.

Attitude limit of the Mass Flow Meter is ±15° from calibration position (standard calibration is in horizontal position). This means that the gas flow path of the Flow Meter must be within this limit in order to maintain the original calibration accuracy. Should there be need for a different orientation of the meter, re-calibration may be necessary. It is also preferable to install the XFM transducer in a stable environment, free of frequent and sudden temperature changes, high moisture, and drafts.

Prior to connecting gas lines inspect all parts of the piping system including ferrules and fittings for dust or other contaminant's.

When connecting the gas system to be monitored, be sure to observe the direction of gas flow as indicated by the arrow on the front of the meter.

Insert tubing into the compression fittings until the ends of the properly sized tubing home flush against the shoulders of the fittings. Compression fittings are to be tightened to one and one quarter turns according to the manufacturer's instructions. Avoid over tightening which will seriously damage the Restrictor Flow Elements (RFE's)!

CAUTION: For XFM 17/37/47/57/67/77 models, the maximum pressure in the gas line should not exceed 500 PSIA (34.47 bars). Applying pressure above 500 PSIA (34.47 bars) will seriously damage the flow sensor.

XFM transducers are supplied with either standard 1/4 inch (XFM 17 and 37), 3/8 inch (XFM 47/57), ½ inch (GDFM 67), or optional 1/8 inch inlet and outlet compression fittings which should NOT be removed unless the meter is being cleaned or calibrated for a new flow range. XFM 77 transducers are supplied with ¾ inch FNPT fittings.

2.2 Electrical Connections

XFM is supplied with a 15 pin "D" connector. Pin diagram is presented in **Figure b-1**.

2.2.1 Power Supply Connections

The power supply requirements for XFM transducers are: 11 to 26 Vdc, (unipolar power supply)

DC Power (+) --------------- pin 7 of the 15 pin "D" connector
DC Power (-) --------------- pin 5 of the 15 pin "D" connector

> ⚠ **CAUTION: Do not apply power voltage above 26Vdc.**
> **Doing so will cause XFM damage or faulty operation.**

2.2.2 Output Signals Connections

> ⚠ **CAUTION: When connecting the load to the output terminals, do not exceed the rated values shown in the specifications. Failure to do so might cause damage to this device. Be sure to check if the wiring and the polarity of the power supply is correct before turning the power ON. Wiring error may cause damage or faulty operation.**

XFM series Mass Flow Meters are equipped with either calibrated 0-5 or calibrated 4-20 mA output signals (jumper selectable). This linear output signal represents 0-100% of the flow meter's full scale range.

> ⚠ **WARNING: The 4-20 mA current loop output is self-powered (non-isolated).**
> **Do NOT connect an external voltage source to the output signals.**

Flow 0-5 VDC or 4-20 mA output signal connection:

Plus (+) -------------------------- pin 2 of the 15 pin "D" connector
Minus (-)-------------------------- pin 1 of the 15 pin "D" connector

To eliminate the possibility of noise interference, use a separate cable entry for the DC power and signal lines.

2.2.3 Communication Parameters and Connections

The digital interface operates via RS485 (optional RS-232 or Profibus DP available) and provides access to applicable internal data including: flow, CPU temperature reading, auto zero, totalizer and alarm settings, gas table, conversion factors and engineering units selection, dynamic response compensation and linearization table adjustment.

Communication Settings for RS-485/RS-232 communication interface:

Baud rate:	**......................**	**9600 baud**
Stop bit:	**......................**	**1**
Data bits:	**......................**	**8**
Parity:	**......................**	**None**
Flow Control:	**......................**	**None**

RS-485 communication interface connection:

The RS485 converter/adapter must be configured for: multidrop, 2 wire, half duplex mode. The transmitter circuit must be enabled by TD or RTS (depending on which is available on the converter/adapter). Settings for the receiver circuit should follow the selection made for the transmitter circuit in order to eliminate echo.

RS-485 T(-) or R(-)	**......................**	**pin 8 of the 15 pin "D" connector (TX-)**
RS-485 T(+) or R(+)	**......................**	**pin 15 of the 15 pin "D" connector (RX+)**
RS-485 GND (if available)	**......................**	**pin 9 of the 15 pin "D" connector (GND)**

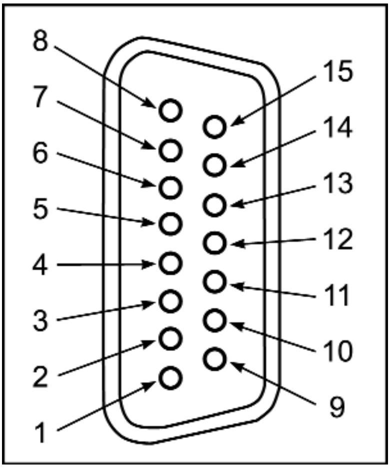
RS-232 communication interface connection:

Crossover connection has to be established:

RS-232 RX (pin 2 on the DB9 connector)	**.....**	**pin 8 of the 15 pin "D" connector (TX)**
RS-232 TX (pin 3 on the DB9 connector)	**.....**	**pin 15 of the 15 pin "D" connector (RX)**
RS-232 GND (pin 5 on the DB9 connector)	**.....**	**pin 9 of the 15 pin "D" connector (GND)**

Figure b-1 - XFM 15 PIN "D" CONNECTOR CONFIGURATION

PIN	XFM FUNCTION
1	Common, Signal Ground For Pin 2 (4-20 mA return)
2	0-5 Vdc or 4-20mA Flow Signal Output
3	Relay No. 2 - Normally Open Contact
4	Relay No. 2 - Common Contact
5	Common, Power Supply (- DC power for 11 to 26 Vdc)
6	Relay No. 1 - Common Contact
7	Plus Power Supply (+ DC power for 11 to 26 Vdc)
8	RS485 (-) (Optional RS232 TX)
9	RS232 Signal GND (RS-485 GND Optional)
10	Do not connect (Test/Maintenance terminal)
11	Relay No. 2 - Normally Closed Contact
12	Relay No. 1 - Normally Open Contact
13	Relay No. 1 - Normally Closed Contact
14	Do not connect (Test/Maintenance terminal)
15	RS485 (+) (Optional RS232 RX)
Shield	Chassis Ground



⚠ IMPORTANT NOTES:

Generally, "D" Connector numbering patterns are standardized. There are, however, some connectors with nonconforming patterns and the numbering sequence on your mating connector may or may not coincide with the numbering sequence shown in our pin configuration table above. It is imperative that you match the appropriate wires in accordance with the correct sequence regardless of the particular numbers displayed on the mating connector.

⚠ Make sure power is OFF when connecting or disconnecting any cables in the system.

The (+) and (-) power inputs are each protected by a 300mA M (medium time-lag) resettable fuse. If a shorting condition or polarity reversal occurs, the fuse will cut power to the flow transducer circuit. Disconnect the power to the unit, remove the faulty condition, and reconnect the power. The fuse will reset once the faulty condition has been removed. DC Power cable length may not exceed 9.5 feet (3 meters). Use of the XFM flow transducer in a manner other than that specified in this manual or in writing from Aalborg, may impair the protection provided by the equipment.

3. PRINCIPLE OF OPERATION

The stream of gas entering the Mass Flow transducer is split by shunting a small portion of the flow through a capillary stainless steel sensor tube. The remainder of the gas flows through the primary flow conduit. The geometry of the primary conduit and the sensor tube are designed to ensure laminar flow in each branch. According to principles of fluid dynamics the flow rates of a gas in the two laminar flow conduits are proportional to one another. Therefore, the flow rates measured in the sensor tube are directly proportional to the total flow through the transducer.

In order to sense the flow in the sensor tube, heat flux is introduced at two sections of the sensor tube by means of precision wound heater-sensor coils. Heat is transferred through the thin wall of the sensor tube to the gas flowing inside. As gas flow takes place heat is carried by the gas stream from the upstream coil to the downstream coil windings. The resultant temperature dependent resistance differential is detected by the electronic control circuit. The measured temperature gradient at the sensor windings is linearly proportional to the instantaneous rate of flow taking place.

An output signal is generated that is a function of the amount of heat carried by the gases to indicate mass-molecular based flow rates.

Additionally, the XFM model Mass Flow Meter incorporates a Precision Analog Microcontroller (ARM7TDMI® MCU) and non-volatile memory that stores all hardware specific variables and up to 10 different calibration tables. The flow rate can be displayed in 23 different volumetric or mass flow engineering units. Flow meter parameters and functions can be programmed remotely via the RS-232/RS-485 interface or optional Profibus DP interface. XFM flow meters support various functions including: programmable flow totalizer, low, high or range flow alarm, automatic zero adjustment (activated via local button or communication interface), 2 programmable SPDT relays output, 0-5 Vdc / 4-20 mA analog outputs (jumper selectable), self diagnostic alarm, 36 internal and user defined K-factor. Optional local 2x16 LCD readout with adjustable back light provides flow rate and total volume reading in currently selected engineering units and diagnostic events indication.

4. SPECIFICATIONS

FLOW MEDIUM: Please note that XFM Mass Flow Meters are designed to work only with clean gases. **Never** try to measure flow rates of liquids with any XFM.

CALIBRATIONS: Performed at standard conditions [14.7 psia (101.4 kPa) and 70°F (21.1°C)] unless otherwise requested or stated.

ENVIRONMENTAL (PER IEC 664): Installation Level II; Pollution Degree II.

FLOW ACCURACY (INCLUDING LINEARITY): ±1% of FS at calibration temperature and pressure.

REPEATABILITY: ±0.15% of full scale.

FLOW TEMPERATURE COEFFICIENT: 0.15% of full scale/ °C or better.

FLOW PRESSURE COEFFICIENT: 0.01% of full scale/psi (6.895 kPa) or better.

FLOW RESPONSE TIME: 1000ms time constant; approximately 2 seconds to within ±2% of set flow rate for 25% to 100% of full scale flow.

MAXIMUM GAS PRESSURE: 500 psig (3447 kPa gauge).

MAXIMUM PRESSURE DROP: 0.18 PSID (at 10 L/min flow). 8 psi (at 100 L/min flow). See Table IV for pressure drops associated with various models and flow rates.

GAS AND AMBIENT TEMPERATURE: 32 °F to 122 °F (0 °C to 50 °C). 14 °F to 122 °F (-10 °C to 50 °C) - Dry gases only.

RELATIVE GAS HUMIDITY: Up to 70%.

LEAK INTEGRITY: 1 x 10^{-9} sccs He maximum to the outside environment.

ATTITUDE SENSITIVITY: Incremental deviation of up to 1% from stated accuracy, after re-zeroing.

OUTPUT SIGNALS: Linear 0-5 Vdc (3000 ohms min load impedance);
Linear 4-20 mA (500 ohms maximum loop resistance).
Maximum noise 20mV peak to peak (for 0-5 Vdc output).

TRANSDUCER INPUT POWER: 11 to 26 Vdc, 100 mV maximum peak to peak output noise.

Power consumption: +12Vdc (200 mA maximum);
+24Vdc (100 mA maximum);
Circuit board have built-in polarity reversal protection, 300mA resettable fuse provide power input protection.

WETTED MATERIALS: Anodized aluminum, brass, 316 stainless steel, 416 stainless steel, VITON® O-rings; BUNA-N®, NEOPRENE® or KALREZ® O-rings are optional.

CAUTION: Aalborg makes no expressed or implied guarantees of corrosion resistance of mass flow meters as pertains to different flow media reacting with components of meters. It is the customers' sole responsibility to select the model suitable for a particular gas based on the fluid contacting (wetted) materials offered in the different models.

INLET AND OUTLET CONNECTIONS:

Model XFM 17/37 standard 1/4” compression fittings,
Model XFM 47/57 standard 3/8” compression fittings,
Model XFM 67 standard 1/2” compression fittings,
Model XFM 77 standard 3/4” FNPT fittings,

Optional 1/8” or 3/8” compression fittings and 1/4” VCR fittings are available.

DISPLAY: Optional local 2x16 characters LCD with adjustable backlight (2 lines of text).

CALIBRATION OPTIONS: Standard is one 10 points NIST calibration. Optional, up to 9 additional calibrations may be ordered at additional charge.

4.1 CE Compliance

EMC Compliance with 89/336/EEC as amended.
Emission Standard: EN 55011:1991, Group 1, Class A,
Immunity Standard: EN 55082-1:1992.

FLOW RANGES

TABLE I XFM 17 LOW FLOW MASS FLOW METER*

CODE	scc/min [N_2]	CODE	std liters/min [N_2]
00	0 to 5	07	0 to 1
01	0 to 10	08	0 to 2
02	0 to 20	09	0 to 5
03	0 to 50	10	0 to 10
04	0 to 100		
05	0 to 200		
06	0 to 500		

TABLE II XFM 37 MEDIUM FLOW MASS FLOW METER*

CODE	std liters/min [N_2]
30	20
31	30
32	40
33	50

TABLE III XFM XFM 47/57/67/77 HIGH FLOW MASS FLOW METERS*

CODE	std liters/min [N_2]
40	60
41	80
42	100
50	200
60	500
70	1000

*Flow rates are stated for Nitrogen at STP conditions [i.e. 70 °F (21.1 °C) at 1 atm].
For other gases use the K factor as a multiplier from APPENDIX 2.

TABLE IV PRESSURE DROPS

MODEL	FLOW RATE [std liters/min]	MAXIMUM PRESSURE DROP		
		[mm H_2O]	[psid]	[kPa]
XFM 17	up to 10	130	0.18	1.275
XFM 37	20	TBD	TBD	TBD
	30	TBD	TBD	TBD
	40	TBD	TBD	TBD
	50	TBD	TBD	TBD
XFM 47	60	TBD	TBD	TBD
	100	TBD	TBD	TBD
XFM 57	200	TBD	TBD	TBD
XFM 67	500	TBD	TBD	TBD
XFM 77	1000	TBD	TBD	TBD

TABLE V APPROXIMATE WEIGHTS

MODEL	WEIGHT	SHIPPING WEIGHT
XFM 17 transmitter	2.20 lbs. (1.00 kg)	3.70 lbs. (1.68 kg)
XFM 37/47 transmitter	2.95 lbs. (1.33 kg)	4.34 lbs. (1.97 kg)
XFM 57 transmitter	TBD	TBD
XFM 67 transmitter	TBD	TBD
XFM 77 transmitter	TBD	TBD

5. OPERATING INSTRUCTIONS

5.1 Preparation and Warm Up

It is assumed that the Mass Flow Meter has been correctly installed and thoroughly leak tested as described in section 2. Make sure the flow source is OFF. When applying power to a flow meter within the first two seconds, you will see on the LCD display: the product name, the software version, and revision of the EEPROM table (applicable for LCD option only).

AALBORG XFM 485

S: Ver1.4 Rev.A0

Figure b-2: XFM first Banner Screen

Within the next two seconds, the RS-485 network address, the analog output settings, and currently selected gas calibration table will be displayed (applicable for LCD option only).

Ad: 11 Out: 0-5Vdc

Gas# 1 AIR

Figure b-3: XFM second Banner Screen

Note: Actual content of the LCD screen may vary depending on the model and device configuration.

After two seconds, the LSD display switches to the main screen with the following information:

- Mass Flow reading in current engineering units (upper line).
- Totalizer Volume reading in current volume or mass based engineering units (lower line).

F: 50.0 L/min

T: 75660.5 Ltr

Figure b-4: XFM Main Screen

Note: Allow the Digital Mass Flow Meter to warm-up for a MINIMUM of 6 minutes.

During initial powering of the XFM transducer, the flow output signal will be indicating a higher than usual output. This is an indication that the XFM transducer has not yet attained its minimum operating temperature. This condition will automatically cancel within a few minutes and the transducer should eventually indicate zero.

Note: During the first 6 minutes of the initial powering of the XFM transducer, the status LED will emit CONSTANT UMBER light.

For the XFM transducer with LCD option: If the LCD diagnostic is activated, the second line of the LCD will display the time remaining until the end of the warm up period (Minutes:Seconds format) and will alternatively switch to Totalizer reading indication every 2 seconds.

F: 50.0 L/min

**** WarmUp 2:39 ****

Figure b-5: XFM Main Screen during Sensor Warm up period.

Note: After 6 minutes of the initial powering of the XFM transducer, the status LED will emit a constant GREEN light (normal operation, ready to measure). For XFM with LCD option, the screen will reflect flow and totalizer reading. (see **Figure b-4**).

5.2 Swamping Condition

If a flow of more than 10% above the maximum flow rate of the Mass Flow Meter is taking place, a condition known as "swamping" may occur. Readings of a "swamped" meter cannot be assumed to be either accurate or linear. Flow must be restored to below 110% of maximum meter range. Once flow rates are lowered to within calibrated range, the swamping condition will end. Operation of the meter above 110% of maximum calibrated flow may increase recovery time.

5.3 XFM Parameters Settings

5.3.1 Engineering Units Settings

The XFM Mass Flow Meter is capable of displaying flow rate with 23 different Engineering Units. Digital interface commands (see paragraph 8.3 ASCII Command Set "XFM SOFTWARE INTERFACE COMMANDS") are provided to:

- get currently active Engineering Units
- set desired Engineering Units.

The following Engineering Units are available:

TABLE VI UNITS OF MEASUREMENT

NUMBER	INDEX	FLOW RATE ENGINEERING UNITS	TOTALIZER ENGINEERING UNITS	DESCRIPTION
1	0	%	%s	Percent of full scale
2	1	mL/sec	mL	Milliliter per second
3	2	mL/min	mL	Milliliter per minute
4	3	mL/hr	mL	Milliliter per hour
5	4	L/sec	Ltr	Liter per second
6	5	L/ min	Ltr	Liter per minute
7	6	L/hr	Ltr	Liter per hour
8	7	m^3/sec	m^3	Cubic meter per second
9	8	m^3/ min	m^3	Cubic meter per minute
10	9	m^3/hr	m^3	Cubic meter per hour
11	10	f^3/sec	f^3	Cubic feet per second
12	11	f^3/min	f^3	Cubic feet per minute
13	12	f^3/hr	f^3	Cubic feet per hour
14	13	g/sec	g	Grams per second
15	14	g/min	g	Grams per minute
16	15	g/hr	g	Grams per hour
17	16	kg/sec	kg	Kilograms per second
18	17	kg/min	kg	Kilograms per minute
19	18	kg/hr	kg	Kilograms per hour
20	19	Lb/sec	Lb	Pounds per second
21	20	Lb/min	Lb	Pounds per minute
22	21	Lb/hr	Lb	Pounds per hour
23	22	User	UD	User defined

> **Note:** Once Flow Unit of Measure is changed, the Totalizer's Volume/Mass based Unit of Measure will be changed automatically.

5.3.2 Gas Table Settings.

The XFM Mass Flow Meter is capable of storing calibration data for up to 10 different gases. Digital interface commands are provided to:

- get currently active Gas Table number and Gas name
- set desired Gas Table.

> **Note:** By default the XFM is shipped with at least one valid calibration table (unless optional additional calibrations were ordered). If instead of the valid Gas name (for example NITROGEN), the LCD screen or digital interface displays Gas designator as "Uncalibrated", then the user has chosen the Gas Table which was not calibrated. Using an "Uncalibrated" Gas Table will result in erroneous reading.

5.3.3 Totalizer Settings.

The total volume of the gas is calculated by integrating the actual gas flow rate with respect to the time. Digital interface commands are provided to:

- reset the totalizer to ZERO
- start the totalizer at a preset flow
- assign action at a preset total volume
- start/stop (enable/disable) totalizing the flow
- read totalizer via digital interface

The Totalizer has several attributes which may be configured by the user. These attributes control the conditions which cause the Totalizer to start integrating the gas flow and also to specify actions to be taken when the Total Volume is outside the specified limit.

> **Note:** Before enabling the Totalizer, ensure that all totalizer settings are configured properly. Totalizer Start values have to be entered in %F.S. engineering unit. The Totalizer will not totalize until the flow rate becomes equal to or more than the Totalizer Start value. Totalizer Stop values must be entered in currently active volume / mass based engineering units. If the Totalizer Stop at preset total volume feature is not required, then set Totalizer Stop value to zero.

Totalizer action conditions become true when the totalizer reading and preset "Stop at Total" volumes are equal.

Local maintenance push button is available for manual Totalizer reset on the field. The maintenance push button is located on the right side of the flow meter inside the maintenance window above the 15 pin D-connector (see **Figure c-1** “XFM configuration jumpers”).

Note: In order to locally Reset Totalizer, the reset push button must be pressed during power up sequence. The following sequence is recommended:

1. Disconnect XFM from the power.
2. Press maintenance push button (do not release).
3. Apply power to the XFM while holding down the maintenance push button.
4. Release maintenance push button after 6 seconds. For XFM with optional LCD, when XFM Main Screen appears (see **Figure b-4**).

5.3.4 Flow Alarm Settings.

XFM provides the user with a flexible alarm/warning system that monitors the Gas Flow for conditions that fall outside configurable limits as well as visual feedback for the user via the status LED and LCD (only for devices with LCD option) or via a Relay contact closure.

The flow alarm has several attributes which may be configured by the user via a digital interface. These attributes control the conditions which cause the alarm to occur and to specify actions to be taken when the flow rate is outside the specified conditions.

Mode Enable /Disable -	Allows the user to Enable/Disable Flow Alarm.
Low Alarm -	The value of the monitored Flow in % F.S. below which is considered an alarm condition.
Note:	**The value of the Low alarm must be less than the value of the High Alarm.**
High Alarm-	The value of the monitored Flow in % F.S. above which is considered an alarm condition.
Note:	**The value of the High alarm must be more than the value of the Low Alarm.**
Action Delay-	The time in seconds that the Flow rate value must remain above the high limit or below the low limit before an alarm condition is indicated. Valid settings are in the range of 0 to 3600 seconds.

Latch Mode- Controls Latch feature when Relays are assigned to Alarm event. Following settings are available:

0 - Latch feature is disabled for both relays
1 - Latch feature is enabled for Relay#1 and disabled for Relay#2
2 - Latch feature is enabled for Relay#2 and disabled for Relay#1
3 - Latch feature is enabled for both relays.

Note: If the alarm condition is detected, and the Relay is assigned to Alarm event, the corresponding Relay will be energized.

Note: By default, flow alarm is non-latching. That means the alarm is indicated only while the monitored value exceeds the specified conditions. If Relay is assigned to the Alarm event, in some cases, the Alarm Latch feature may be desirable.

The current Flow Alarm settings and status are available via digital interface (see paragraph 8.3 ASCII Command Set "XFM SOFTWARE INTERFACE COMMANDS").

5.3.5 Relay Assignment Settings

Two sets of dry contact relay outputs are provided to actuate user supplied equipment. These are programmable via digital interface such that the relays can be made to switch when a specified event occurs (e.g. when a low or high flow alarm limit is exceeded or when the totalizer reaches a specified value).

THE USER CAN CONFIGURE EACH RELAY ACTION FROM 6 DIFFERENT OPTIONS:

No Action	: (N) No assignment (relay is not assigned to any events and not energized).
Totalizer > Limit	: (T) Totalizer reached preset limit volume.
High Flow Alarm	: (H) High Flow Alarm condition.
Low Flow Alarm	: (L) Low Flow Alarm condition.
Range between H&L	: (R) Range between High and Low Flow Alarm condition.
Manual Enabled	: (M) Activated regardless of the Alarm and Totalizer conditions.

5.3.6 K Factors Settings

Conversion factors relative to Nitrogen for up to 36 gases are stored in the XFM (see APPENDIX II). In addition, provision is made for a **user-defined** conversion factor. Conversion factors may be applied to any of the ten gas calibrations via digital interface commands.

The available K Factor settings are:

•	Disabled	(K = 1).
•	Internal Index	The index [0-35] from internal K factor table (see APPENDIX II).
•	User Defined	User defined conversion factor.

> **Note:** The conversion factors will not be applied for % F.S. engineering unit.

5.3.7 Zero Calibration

The XFM includes an auto zero function that, when activated, automatically adjusts the mass flow sensor to read zero. The initial zero adjustment for your XFM was performed at the factory. It is not required to perform zero calibration unless the device has zero reading offset with no flow conditions.

> **Note:** Before performing Zero Calibration, make sure the device is powered up for at least 15 minutes and absolutely no flow condition is established.

Shut off the flow of gas into the Digital Mass Flow Meter. To ensure that no seepage or leak occurs into the meter, it is good practice to temporarily disconnect the gas source. The Auto Zero may be initiated via digital communication interface or locally by pressing the maintenance push button, which is located on the right side of the flow meter inside the maintenance window above the 15 pin D-connector (see **Figure c-1** “XFM configuration jumpers”).

> **Note:** The same maintenance push button is used for Auto Zero initiation and Totalizer reset. The internal diagnostic algorithm will prevent initiating Auto Zero function via the maintenance push button before the 6 minutes sensor warm up period has elapsed.

To start Auto Zero locally, press the maintenance push button. The status LED will flash not periodically with the RED light. On the XFM with optional LCD, the following screen will appear:

AUTOZERO IS ON!

Figure b-6: XFM Screen in the beginning of Auto Zero procedure.

The Auto Zero procedure normally takes 1 - 2 minutes during which time the DP Zero counts and the Sensor reading changes approximately every 3 to 6 seconds.

AUTOZERO IS ON!

S: 405 DP: 512

Figure b-7: XFM during the Auto Zero procedure.

The nominal value for a fully balanced sensor is 120 Counts. If the XFM's digital signal processor was able to adjust the Sensor reading within 120 ± 10 counts, then Auto Zero is considered successful. The status LED will return to a constant GREEN light and the screen below will appear:

AutoZero is Done

S: 122 DP: 544

Figure b-7: XFM during the Auto Zero procedure.

Note: The actual value of the Sensor and DP counts will vary for each XFM.

If the device was unable to adjust the Sensor reading to within 120 ± 10 counts, then Auto Zero is considered as unsuccessful. The constant RED light will appear on the status LED. The user will be prompted with the "AutoZero ERROR!" screen.

Note: For XFM with RS-232 option all Auto Zero status info available via digital communication interface.

5.3.8 Self Diagnostic Alarm

XFM series Mass Flow Meters are equipped with a self-diagnostic alarm which is available via multicolor LED, digital interface and on screen indication (for devices with optional LCD). The following diagnostic events are supported:

NUMBER	DIAGNOSTIC ALARM DESCRIPTION	LED COLOR AND PATTERN	PRIORITY LEVEL
1	Auto Zero procedure is running	Not periodically flashing RED	0
2	FATAL ERROR (reset or maintenance service is required for return in to the normal operation)	Constant RED	1
3	CPU Temperature too high (Electronics Overheating)	Flashing RED/UMBER	2
4	Sensor in the warm up stage (first 6 minutes after power up sequence, normal operation, no critical diagnostic events present)	Constant UMBER	3
5	Flow Sensor Temperature too low	Flashing UMBER/OFF	4
6	Flow Sensor Temperature too high	Flashing RED/OFF	5
7	Totalizer Reading hit preset limit	Flashing GREEN/UMBER	6
8	Low flow Alarm conditions	Flashing GREEN/OFF	7
9	High flow Alarm conditions	Flashing GREEN/RED	8
10	Normal operation, no diagnostic events	Constant GREEN	9

Note: Priority Level is highest (most important). When two or more diagnostic events are present at the same time, the event with the highest priority level will be indicated on the status LED and displayed on the LCD (if equipped). All diagnostic events may be accessed simultaneously via digital communication interface (see paragraph 8.3 “ASCII Command Set”).

5.4 Analog Output Signals configuration

XFM series Mass Flow Meters are equipped with calibrated 0-5 Vdc and 4-20 mA output signals. The set of the jumpers (J7A, J7B, J7C) located on the right side of the flow meter, inside of the maintenance window above the 15 pin D-connector (see **Figure c-1** “XFM configuration jumpers” are used to switch between 0-5 Vdc or 4-20 mA output signals (see Table VI).

Analog output signals of 0-5 Vdc and 4-20 mA are attained at the appropriate pins of the 15-pin "D" connector (see **Figure b-1**) on the side of the XFM transducer.

Table VI Analog Output Jumper Configuration

ANALOG SIGNAL OUTPUT	0-5 Vdc		4-20 mA	
Flow Rate Output Jumper Header J7	J7.A J7.B J7.C	5-9 6-10 7-11	J7.A J7.B J7.C	1-5 2-6 3-7

See APPENDIX IV for actual jumpers layout on the PCB.

Note: Digital output (communication) is simultaneously available with analog output.

6. MAINTENANCE

6.1 Introduction

It is important that the Mass Flow Meter is only used with clean, filtered gases. Liquids may not be metered. Since the RTD sensor consists, in part, of a small capillary stainless steel tube, it is prone to occlusion due to impediments or gas crystallization. Other flow passages are also easily obstructed.

Therefore, great care must be exercised to avoid the introduction of any potential flow impediment. To protect the instrument, a 50 micron (XFM 17) or 60 micron (XFM 37/47/57/67/77) filter is built into the inlet of the flow transducer. The filter screen and the flow paths may require occasional cleaning as described below. There is no other recommended maintenance required. It is good practice, however, to keep the meter away from vibration, hot or corrosive environments and excessive RF or magnetic interference.

If periodic calibrations are required, they should be performed by qualified personnel and calibrating instruments, as described in section 7. It is recommended that units are returned to Aalborg® for repair service and calibration.

CAUTION: TO PROTECT SERVICING PERSONNEL IT IS MANDATORY THAT ANY INSTRUMENT BEING SERVICED IS COMPLETELY PURGED AND NEUTRALIZED OF TOXIC, BACTERIOLOGICALLY INFECTED, CORROSIVE OR RADIOACTIVE CONTENTS.

6.2 Flow Path Cleaning

Before attempting any disassembly of the unit for cleaning, try inspecting the flow paths by looking into the inlet and outlet ends of the meter for any debris that may be clogging the flow through the meter. Remove debris as necessary. If the flow path is clogged, proceed with steps below.

Do not attempt to disassemble the sensor. If blockage of the sensor tube is not alleviated by flushing through with cleaning fluids, please return meter for servicing.

⚠ **CAUTION:** DISASSEMBLY MAY COMPROMISE CURRENT CALIBRATION.

6.2.1 Restrictor Flow Element (RFE)

The Restrictor Flow Element (RFE) is a precision flow divider inside the transducer which splits the inlet gas flow by a preset amount to the sensor and main flow paths. The particular RFE used in a given Mass Flow Meter depends on the gas and flow range of the instrument.

6.2.2 XFM 17 Models

Unscrew the inlet compression fitting of meter. Note that the Restrictor Flow Element (RFE) is connected to the inlet fitting. Carefully disassemble the RFE from the inlet connection. The 50 micron filter screen will now become visible. Push the screen out through the inlet fitting. Clean or replace each of the removed parts as necessary. If alcohol is used for cleaning, allow time for drying.

Inspect the flow path inside the transducer for any visible signs of contaminant. If necessary, flush the flow path through with alcohol. Thoroughly dry the flow paths by flowing clean dry gas through.

Carefully re-install the RFE and inlet fitting avoiding any twisting and deforming to the RFE. Be sure that no dust has collected on the O-ring seal.

⚠ **NOTE:** OVER TIGHTENING WILL DEFORM AND RENDER THE RFE DEFECTIVE. IT IS ADVISABLE THAT AT LEAST ONE CALIBRATION POINT BE CHECKED AFTER RE-INSTALLING THE INLET FITTING. SEE SECTION (7.2.3).

6.2.3 XFM 37/47 Models

Unscrew the four socket head cap screws (two 10-24 and two 6-32) at the inlet side of the meter. This will release the short square block containing the inlet compression fitting.

The 60 micron filter screen will now become visible. Remove the screen. DO NOT remove the RFE inside the flow transducer. Clean or replace each of the removed parts as necessary. If alcohol is used for cleaning, allow time for drying. Inspect the flow path inside the transducer for any visible signs of contaminants.

If necessary, flush the flow path with alcohol. Thoroughly dry the flow paths by flowing clean dry gas through. Re-install the inlet parts and filter screen. Be sure that no dust has collected on the O-ring seal.

It is advisable that at least one calibration point be checked after re-installing the inlet fitting (see section 7).

6.2.4 XFM 57/67/77 Models

It is not recommended to open high flow models. However, if a customer decides to clean the RFE, the procedure below is suggested:

Unscrew the four socket head cap screws (10-24) at the inlet side of the meter. This will release the short square block containing the inlet compression fitting.(3/4" NPT for XFM 77)

Remove the block and connected screens. Clean each of the removed parts as necessary. If alcohol is used for cleaning, allow time for drying. Inspect the flow path inside the transducer for any visible signs of contaminants. If necessary, flush the flow path with alcohol. Thoroughly dry the flow paths by flowing clean dry gas through.

Re-install the inlet parts. Be sure that no dust has collected on the O-ring seal. It is advisable that at least one calibration point be checked after re-installing the inlet fitting (see section 7).

7. CALIBRATION PROCEDURES

NOTE: REMOVAL OF THE FACTORY INSTALLED CALIBRATION SEALS AND/OR ANY ADJUSTMENTS MADE TO THE METER, AS DESCRIBED IN THIS SECTION, WILL VOID ANY CALIBRATION WARRANTY APPLICABLE.

7.1 Flow Calibration

Aalborg® Instruments' Flow Calibration Laboratory offers professional calibration support for Mass Flow Meters using precision calibrators under strictly controlled conditions. NIST traceable calibrations are available. Calibrations can also be performed at customers' site using available standards.

Factory calibrations are performed using NIST traceable precision volumetric calibrators incorporating liquid sealed frictionless actuators.

Generally, calibrations are performed using dry nitrogen gas. The calibration can then be corrected to the appropriate gas desired based on relative correction [K] factors shown in the gas factor table (see APPENDIX III). A reference gas, other than nitrogen, may be used to better approximate the flow characteristics of certain gases. This practice is recommended when a reference gas is found with thermodynamic properties similar to the actual gas under consideration. The appropriate relative correction factor should be recalculated (see section 9).

It is standard practice to calibrate Mass Flow Meters with dry nitrogen gas at 70.0˚F (21.1 ˚C), 20 psia (137.9 kPa absolute) inlet pressure and 0 psig outlet pressure. It is best to calibrate XFM transducers to actual operating conditions. Specific gas calibrations of non-toxic and non-corrosive gases are available for specific conditions. Please contact your distributor or Aalborg® for a price quotation.

It is recommended that a flow calibrator be used which has at least four times better collective accuracy than that of the Mass Flow Meter to be calibrated. Equipment required for calibration includes: a flow calibration standard, PC with available RS-485/RS-232 communication interface, a certified high sensitivity multi meter (for analog output calibration only), an insulated (plastic) screwdriver, a flow regulator (for example - metering needle valve) installed upstream from the Mass Flow Meter, and a pressure regulated source of dry filtered nitrogen gas (or other suitable reference gas). Using Aalborg® supplied calibration and maintenance software to simplify the calibration process is recommended.

Gas and ambient temperature, as well as inlet and outlet pressure conditions, should be set up in accordance with actual operating conditions.

7.2 Gas Flow Calibration of XFM Mass Flow Meters

All adjustments in this section are made from the outside of the meter via digital communication interface between a PC (terminal) and XFM. There is no need to disassemble any part of the instrument or perform internal PCB component (potentiometers) adjustment.

XFM Mass Flow Meters may be field recalibrated/checked for the same range they were originally factory calibrated for. When linearity adjustment is needed or flow range changes are being made, proceed to step 7.2.3. Flow range changes may require a different Restrictor Flow Element (RFE). Consult your distributor or Aalborg® for more information.

7.2.1 Connections and Initial Warm Up

Power up the Mass Flow Meter for at least 15 minutes prior to commencing the calibration procedure. Establish digital RS-485/RS-232 communication between PC (communication terminal) and the XFM. Start Aalborg® supplied calibration and maintenance software on the PC.

7.2.2 ZERO Check/Adjustment

Using Aalborg® supplied calibration and maintenance software open Back Door access:

Query/BackDoor/Open

When software prompts with **Warning**, click the [YES] button. This will open the access to the rest of the Query menu.
Start Sensor Compensated Average reading:

Query/Read/ SensorCompAverage

This will display Device Sensor Average ADC counts.

With no flow conditions, the sensor Average reading must be in the range 120± 10 counts. If it is not, perform Auto Zero procedure (see section 5.3.10 “Zero Calibration”).

7.2.3 Gas Linearization Table Adjustment

Note: Your XFM Digital Mass Flow Meter was calibrated at the factory for the specified gas and full scale flow range (see device’s front label). There is no need to adjust the gas linearization table unless linearity adjustment is needed, flow range has to be changed, or new additional calibration is required. Any alteration of the gas linearization table will VOID calibration warranty supplied with instrument.

Gas flow calibration parameters are separately stored in the Gas Dependent portion of the EEPROM memory for each of 10 calibration tables. See APPENDIX I for complete list of gas dependent variables.

Note: Make sure the correct gas number and name selected are current. All adjustments made to the gas linearization table will be applied to the currently selected gas. Use Gas Select command via digital communication interface (see paragraph 8.3 ASCII Command Set “XFM SOFTWARE INTERFACE COMMANDS”) or Aalborg® supplied calibration and maintenance software to verify current gas table or select a new gas table.

The XFM gas flow calibration involves building a table of the actual flow values (indexes 114, 116, 118, 120, 122, 124, 126, 128, 130, 132, 134) and corresponding sensor readings (indexes 113, 115, 117, 118, 119, 121, 123, 125, 127, 129, 131, 133).

Actual flow values are entered in normalized fraction format: 100.000 % F.S. corresponds to 1.000000 flow value and 0.000 % F.S. corresponds to 0.000000 flow value. The valid range for flow values is from 0.000000 to 1.000000 (note: XFM will accept up to 6 digits after decimal point).

Sensor readings are entered in counts of 12 bits ADC output and should always be in the range of 0 to 4095. There are 11 elements in the table so the data should be obtained at an increment of 10.0 % of full scale (0.0, 10.0, 20.0, 30.0, 40.0, 50.0, 60.0, 70.0, 80.0, 90.0 and 100.0 % F.S.).

> **Note:** Do not alter memory index 113 (must be 120 counts) and 114 (must be 0.0). These numbers represent zero flow calibration points and should not be changed.

If a new gas table is going to be created, it is recommended to start calibration from 100% full scale. If only linearity adjustment is required, calibration can be started in any intermediate portion of the gas table.

Using the flow regulator, adjust the flow rate to 100% of full scale flow. Check the flow rate indicated against the flow calibrator. Observe the flow reading on the XFM. If the difference between calibrator and XFM flow reading is more than 0.5% F.S., make a correction in the sensor reading in the corresponding position of the linearization table (see Index 133).

If the XFM flow reading is more than the calibrator reading, the number of counts in the index 133 must be decreased. If the XFM flow reading is less than the calibrator reading, the number of counts in the index 133 must be increased. Once Index 133 is adjusted with a new value, check the XFM flow rate against the calibrator and, if required, perform additional adjustments for Index 133.

If a simple communication terminal is used for communication with the XFM, then "MW" (Memory Write) command from the software interface commands set may be used to adjust sensor value in the linearization table (see section 8.3 for complete software interface commands list).

Memory Read "MR" command can be used to read the current value of the index. Assuming the XFM is configured with RS-485 interface and has address "11", the following example will first read the existing value of Index 133 and then write a new adjusted value:

!11,MR,133[CR] **- reads EEPROM address 133**

!11,MW,133,3450[CR] **- writes new sensor value (3450 counts) in to the index 133**

Once 100% F.S. calibration is completed, the user can proceed with calibration for another 9 points of the linearization table by using the same approach.

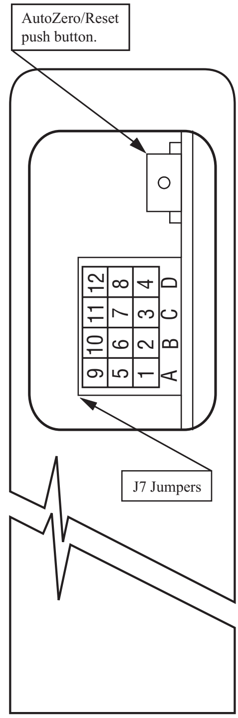
> **Note:** It is recommended to use Aalborg® supplied calibration and maintenance software for gas table calibration. This software includes an automated calibration procedure which may radically simplify reading and writing for the EEPROM linearization table.

7.3 Analog output Calibration of XFM Mass Flow Meters

XFM series Mass Flow Meters are equipped with calibrated 0-5 Vdc and 4-20 mA output signals. The set of the jumpers (J7A, J7B, J7C) on the printed circuit board is used to switch between 0-5 Vdc and 4-20 mA output signals (see **Figure c-1** “XFM configuration jumpers).

Figure c-1 XFM Analog Output Configuration Jumpers

	FUNCTION	J7A	J7B	J7C	JCD
ANALOG	0-5 VDC	5-9	6-10	7-11	
OUTPUT	4-20 mA	1-5	2-6	3-7	
RS485 TERMINAL RESISTOR	OFF				8-12
	ON				4-8



The XFM analog output calibration involves calculation and storing of the offset and span variables in the EEPROM for each available output. The 0-5 Vdc output has only scale variable and 20 mA output has offset and scale variables. The following is a list of the Gas independent variables used for analog output computation:

Note: The analog output available on the XFM Digital Mass Flow Meter was calibrated at the factory for the specified gas and full scale flow range (see the device’s front label). There is no need to perform analog output calibration unless the EEPROM IC was replaced or offset/span adjustment is needed. Any alteration of the analog output scaling variables in the Gas independent table will VOID calibration warranty supplied with instrument.

Note: It is recommended to use the Aalborg® supplied calibration and maintenance software for analog output calibration. This software includes an automated calibration procedure which may radically simplify calculation of the offsets and spans variables and, the reading and writing for the EEPROM table.

Index	Name		Description
25	AoutScaleV	-	DAC 0-5 Vdc Analog Output Scale
27	AoutScale_mA	-	DAC 4-20mA Analog Output Scale
28	AoutOffset_mA	-	DAC 4-20mA Analog Output Offset

7.3.1 Initial Setup

Power up the Mass Flow Meter for at least 15 minutes prior to commencing the calibration procedure. Make sure absolutely no flow takes place through the meter. Establish digital RS-485/RS-232 communication between PC (communication terminal) and XFM. The commands provided below assume that calibration will be performed manually (w/o Aalborg® supplied calibration and maintenance software) and the device has RS-485 address 11. If Aalborg® supplied calibration and maintenance software is used, skip the next section and follow the software prompts.

Enter Backdoor mode by typing:	**!11,MW,1000,1[CR]**
Unit will respond with:	**!11,BackDoorEnabled: Y**
Disable DAC update by typing:	**!11,WRITE,4,D[CR]**
Unit will respond with:	**!11,DisableUpdate: D**

7.3.2 Gas flow 0-5 Vdc analog output calibration

1. Install jumpers J7A, J7B and J7C on the PC board for 0-5 Vdc output (see Table VI).
2. Connect a certified high sensitivity multi meter set for the voltage measurement to the pins 2 (+) and 1 (-) of the 15 pins D connector.
3. Write 4000 counts to the DAC channel 1: !11,WRITE,1,4000[CR]
4. Read voltage with the meter and calculate:

$$\boxed{\mathrm{AoutScaleV} = \frac{20000}{\mathrm{Reading[V]}}}$$

5. Save FlowOutScaleV in to the EEPROM: !11,MW,25,X[CR]

   Where: X – the calculated AoutScaleV value.

7.3.3 Gas flow 4-20 mA analog output calibration

1. Install jumpers J7A, J7B and J7C on the PC board for 4-20 mA output (see Table VI).
2. Connect a certified high sensitivity multi meter set for the current measurement to pins 2 (+) and 1 (-) of the 15 pins D connector.
3. Write 4000 counts to the DAC channel 1: !11,WRITE,1,4000[CR]
4. Read current with the meter and calculate:

$$\boxed{\mathrm{AoutScale\_mA} = \frac{4000}{\mathrm{Reading[mA]}}}$$

5. Write zero counts to the DAC channel 1: !11,WRITE,1,0CR]
6. Read offset current with the meter and calculate:

$$\boxed{\mathrm{AoutOffset\_mA} = -\,\mathrm{FlowOutScale\_mA} * \mathrm{Offset\_Reading[mA]}}$$

7. Save AoutScale_mA in to the EEPROM: !11,MW,27,Y[CR]
Save AoutOffset_mA in to the EEPROM: !11,MW,28,Z[CR]

Where: Y – the calculated AoutScale_mA value.
Z – the calculated AoutOffset_mA value.

Note: When done with the analog output calibration make sure the DAC update is enabled and the BackDoor is closed (see command below).

Enable DAC update by typing:	!11,WRITE,4,N[CR]
Unit will respond with:	!11,DisableUpdate: N
Close BackDoor access by typing:	!11,MW,1000,0[CR]
Unit will respond with:	!11,BackDoorEnabled: N

8. RS-485/RS-232 SOFTWARE INTERFACE COMMANDS

8.1 General

The standard XFM comes with an RS-485 interface. For the optional RS-232 interface, the start character (!) and two hexadecimal characters for the address must be omitted. The protocol described below allows for communications with the unit using either a custom software program or a “dumb terminal.” All values are sent as printable ASCII characters. For RS-485 interface, the start character is always (!). The command string is terminated with a carriage return (line feeds are automatically stripped out by the XFM). See section 2.2.3 for information regarding communication parameters and cable connections.

8.2 Commands Structure

The structure of the command string:

!<Addr>,<Cmd>,Arg1,Arg2,Arg3,Arg4<CR>

Where:

!	Start character **
Addr	RS485 device address in the ASCII representation of hexadecimal (00 through FF are valid).**
Cmd	The one or two character command from the table below.
Arg1 to Arg4	The command arguments from the table below. Multiple arguments are comma delimited.
CR	Carriage Return character.

Note: Default address for all units is 11. Do not submit start character and two character hexadecimal device address for RS-232 option.

Several examples of commands follow. All assume that the XFM has been configured for address 18 (12 hex) on the RS485 bus:

1. To get current calibration tables: !12,G<CR>
   The XFM will reply: !12,G 0 AIR<CR> >
   (Assuming Current Gas table is #0, calibrated for AIR)

2. To get current Alarm status: !12,A,R<CR>
   The XFM will reply: !12,N<CR> (Assuming no alarm conditions)

3. To get a flow reading: !12,F<CR>The XFM will reply:
   !12,50.0<CR> (Assuming the flow is at 50% FS)

4. Set the high alarm limit to 85% of full scale flow rate:
   !12,A,H,85.0<CR>
   The XFM will reply: !12,AH85.0<CR>

Note: Address 00 is reserved for global addressing. Do not assign, the global address for any device. When command with global address is sent, all devices on the RS-485 bus execute the command but do not reply with an acknowledge message.

The global address can be used to change RS-485 address for a particular device with unknown address:

1. Make sure only one device (which address must be changed) is connected to the RS-485 network.

2. Type the memory write command with global address: !00,MW,7,XX[CR] where XX, the new hexadecimal address, can be [01 – FF].

After assigning the new address, a device will accept commands with the new address.

Note: Do not assign the same RS-485 address for two or more devices on the same RS-485 bus. If two or more devices with the same address are connected to the one RS-485 network, a communication collision will take place on the bus and communication errors will occur.

8.3 ASCII Commands Set

AALBORG XFM SOFTWARE INTERFACE COMMANDS

COMMAND NAME	DESCRIPTION	No.	COMMAND SYNTAX					
			Command	Argument 1	Argument 2	Argument 3	Argument 4	Response
Flow	Requests the current flow sensor reading in current EU	1	F					<Value> (Actual flow in current engineering units)
Diagnostic	Enable / Disable LCD Diagnostic messages (only for LCD option). Request current status of the Diagnostic events, LED status and LCD diagnostic mode (enabled/disabled).	2	D	E (enable LCD ** Diagnostic Messages)				D:E
				D (disable LCD ** Diagnostic Messages)				D:D
				NO ARGUMENT (read current status of the diagnostic word)				D:0x0,L:9,E 0x0 – diagnostic word 9 - current LED status E - LCD mode (enabled)
Roll back to N_2 feature.	Enable / Disable Roll back to N_2 feature.	3	N	E (enable Roll back to N_2)				N:E
				D (enable Roll back to N_2)*				N:D
				NO ARGUMENT (read current mode of the N2 Roll back)				N:D Or N:E
Gas Select	Selects one of the ten primary gas calibration tables to use. Tables are entered via the MEM commands at time of calibration.	4	G	0 (gas 0)* to 9 (gas 9)				G0 through G9, <Gas Name>
				NO ARGUMENT (read status)				G0 through G9, <Gas Name>

Note: An “*” indicates power up default settings. An “**”indicates optional feature not available on all models.

COMMAND NAME	DESCRIPTION	No.	COMMAND SYNTAX					
			Command	Argument 1	Argument 2	Argument 3	Argument 4	Response
Auto Zero	Starts /reads the status of the auto zero feature (Note: The Z,N command can be used only when absolutely no flow thru the meter and no earlier then 6 minutes after power up. It can take several minutes to complete. Unit will not respond to other commands when this is in progress.)	5	Z	N (do it now)				ZN
				W (Write Zero to EEPROM)				ZW (when done)
				S (status while auto zero in progress)				ZNI,<value> while Z,N is in progress.
				V (Display zero value)				ZV,<zero value>
Flow Alarms	Sets / reads the status of the gas flow alarms. Note: High and Low limits have to be entered in the %F.S. High alarm value has to be more than Low alarm value. Alarm conditions: Flow > High Limit = H Flow < Low Limit = L Low < Flow < High = N	6	A	H (high flow limit)	<Value> (0-100%FS)			AH<Value>
				L (low flow limit)	<Value> (0-100%FS)			AL<Value>
				A (action delay in seconds)	<Value> (0-3600 sec.)			AA:<Value>
				E (enable alarm)				AE
				D (disable alarm)*				AD
				R (read current status)				N (no alarm) H (high alarm) L (low alarm)
				S (Read current settings)				AS:M,L,H,D,B where: M – mode (E/D) L – Low settings (%FS) H – High settings (%FS) D – Action Delay (sec) B – Latch mode (0-3)
				B Block (Latch) mode	<Value> (0-disabled*) (1-enabl'd L) (2-enabl'd H) (3 –both L,H)			AB:<Value> where: Value = 0 - 3

COMMAND NAME	DESCRIPTION	No.	COMMAND SYNTAX					
			Command	Argument 1	Argument 2	Argument 3	Argument 4	Response
Relay Action	Assigns action of the two SPDT relays. The coil is energized when the condition specified by an Argument 2 becomes true. Argument 2: N - no action, relay disabled* T - totalizer reading > limit H - high flow alarm L - low flow alarm R - Range between High & Low alarms M - Manual Relay overdrive S - Read current status	7	R	1 (relay 1) 2 (relay 2)	N*			R1N or R2N
					T			R1T or R2T
					H			R1H or R2H
					L			R1L or R2L
					R			R1R or R2R
					M			R1M or R2M
					S			RxN, RxT, RxH, RxL, RxR , RxM
Totalizer	Sets and controls action of the flow totalizer. NOTE: If Warm Up Delay option is set to E (enabled) the Totalizer will not totalize the flow during first 6 minutes after power up.	8	T	Z (Reset to zero)				TZ
				F (start totalizer at flow F.S.)	<value> (flow %FS)			TF<value>
				L (Limit gas volume in current E.U.)	<value> (gas volume)			TL<value>
				D (disable totalizer)				TD
				E (enable totalizer)				TE
				R (read current totalizer volume)				<value> (in current EU)
				W (Warm Up Delay)	E – enable D – disable*			TW:E or TW:D
				S (setting status)				TS: Mode, Start, Limit, Warm Up

COMMAND NAME	DESCRIPTION	No.	COMMAND SYNTAX					
			Command	Argument 1	Argument 2	Argument 3	Argument 4	Response
K Factors	Applies a gas correction factor to the currently selected primary gas calibration table. (NOTE: does not work with % F.S. engineering unit.) See list of the internal K-factors in the operating manual.	9	K	D*(disable, sets K=1)				KD
				I (Internal K-factor)	No argument (enable previously set internal K-factor)			KI,<value>,<Gas>
					Gas Index (0 -35)			KI,<Index>,<Gas>
				U (user specified factor)	No argument (enable previously set user K-factor)			KU,<value>
					<value> (decimal correction factor) (0-1000)			KU,<value>
				S (status)				SK, <Mode>, <Index>, <Value> where: Mode: D, I, U Index: 0-35 Value: K-Factor value

COMMAND NAME	DESCRIPTION	No.	COMMAND SYNTAX					
			Command	Argument 1	Argument 2	Argument 3	Argument 4	Response
Units	Set the units of measure for gas flow and totalizer reading. Note: The units of the totalizer output are not per unit time.	10	U	% (% full scale)*				U:%
				mL/sec				U:mL/sec
				mL/min				U:mL/min
				mL/hr				U:mL/hr
				L/sec				U:L/sec
				L/min				U:L/min
				L/hr				U:L/hr
				m3/sec				U:m3/sec
				m3/min				U:m3/min
				m3/hr				U:m3/hr
				f3/sec				U:f3/sec
				f3/min				U:f3/min
				f3/hr				U:f3/hr
				g/sec				U:g/sec
				g/min				U:g/min
				g/hr				U:g/hr
				kg/sec				U:kg/sec
				kg/min				U:kg/min
				kg/hr				U:kg/hr
				Lb/sec				U:Lb/sec
				Lb/min				U:Lb/min
				Lb/hr				U:Lb/hr
				USER (user defined)	<value> (conversion factor from L/min)	S - seconds M – minutes H – hours (Time base)	Y - use density N – do not use density	U:USER,<Factor>, <Time base>, <Density mode>
				No Argument <status>Returns current EU.				U,<EU name>

COMMAND NAME	DESCRIPTION	No.	COMMAND SYNTAX					
			Command	Argument 1	Argument 2	Argument 3	Argument 4	Response
Maintenance Timer	Hours since last time unit was calibrated.	11	C	R (read timer)				<Value> (in Hours)
				C (set timer to zero)				CC
Full Scale	Returns the full scale rated flow in L/min. (Note: This term is not multiplied by the current K factor)	12	E					<Value> (in L/min)
LCD Back Light	LCD Back Light control (0-100.0%) 0 - off 100 - Maximum Intensity	13	B	0 to 100%				B:<Counts> where: Counts (0 – 4095)
				No Argument <Current settings>				B:<Value> where: Value (0 – 100.0)
Read EEPROM Memory	Reads the value in the specified memory location.	14	MR	0000 to999 (Table Index)				<value>
Write EEPROM Memory	Writes the specified value to the specified memory location. Use Carefully, can cause unit to malfunction. (Note: Some addresses are write protected!)	15	MW	0000 to 999 (Table Index)	Value			MW,XXX,<Value> where: XXX=Table Index

UART Error Codes:

1 - Not Supported Command or Back Door is not enabled.
2 - Wrong # of Arguments.
3 - Address is Out of Range (MR or MW commands).
4 - Wrong # of the characters in the Argument.
5 - Attempt to Alter Write Protected Area in the EEPROM.
6 - Proper Command or Argument is not found.
7 - Wrong value of the Argument.
8 - Reserved.
9 - Manufacture specific info EE KEY (wrong key or key is disabled).

9. TROUBLESHOOTING

9.1 Common Conditions

Your XFM Digital Mass Flow Meter was thoroughly checked at numerous quality control points during and after manufacturing and assembly operations. It was calibrated according to your desired flow and pressure conditions for a given gas or a mixture of gases.

It was carefully packed to prevent damage during shipment. Should you feel that the instrument is not functioning properly, please check for the following common conditions first:

Are all cables connected correctly? Are there any leaks in the installation? Is the power supply correctly selected according to requirements? When several meters are used a power supply with appropriate current rating should be selected.

Were the connector pinouts matched properly? When interchanging with other manufacturers' equipment, cables and connectors must be carefully wired for correct pin configurations. Is the pressure differential across the instrument sufficient?

9.2 Troubleshooting Guide

NO.	INDICATION	LIKELY REASON	SOLUTION
1	No zero reading after 15 min. warm up time and no flow condition.	Embedded temperature has been changed.	Perform Auto Zero Procedure (see section 5.3.6 “Zero Calibration”).
2	Status LED indicator and LCD Display remains blank when unit is powered up. No response when flow is introduced from analog outputs 0-5 Vdc or 4-20 mA.	Power supply is bad or polarity is reversed.	Measure voltage on pins 7 and 5 of the 15 pin D-connector. If voltage is out of specified range, then replace power supply with a new one. If polarity is reversed (reading is negative) make correct connection.
		PC board is defective.	Return XFM to factory for repair.
3	LCD Display reading or /and analog output 0-5Vdc signal fluctuate in wide range during flow measurement.	Output 0-5 Vdc signal (pins 2–1 of the D-con nector) is shorted on the GND or overloaded.	Check external connections to pin 2 – 1, of the D-connector. Make sure the load resistance is more than 1000 Ohm.
4	LCD Display reading does correspond to the correct flow range, but 0-5 Vdc output signal does not change (always the same read ing or around zero).	Output 0-5Vdc schematic is burned out or damaged.	Return XFM to factory for repair.
		Analog flow output scale and offset variable are corrupted.	Restore original EEPROM scale and offset variable or perform analog output recalibration (see section 7.3).
5	LCD Display reading and 0-5 Vdc output voltage do correspond to the correct flow range, but 4-20 mA output signal does not change (always the same or reading around 4.0 mA).	External loop is open or load resistance more than 500 Ohm.	Check external connections to pins 2 and 15 of the D-connector. Make sure the loop resistance is less than 500 Ohm.
		Output 4-20 mA schematic is burned out or damaged.	Return XFM to factory for repair.
6	Calibration is off (more than ±1.0 % F.S.).	XFM has initial zero shift.	Shut off the flow of gas into the XFM (ensure gas source is disconnected and no seepage or leak occurs into the meter). Wait for 15 min. with no flow condition and perform Auto Zero calibration Procedure (see section 5.3.7 “Zero Calibration”).
7	LCD Display reading is above maximum flow range and output volt age 0-5 Vdc signal is more than 5.0 Vdc when gas flows through the XFM.	Sensor under swamping conditions (flow is more than 10% above maximum flow rate for particular XFM).	Lower the flow through XFM within calibrated range or shut down the flow completely. The swamping condition will end automatically.
		PC board is defective.	Return XFM to factory for repair.

NO.	INDICATION	LIKELY REASON	SOLUTION
8	Gas flows through the XFM, but LCD Display reading and the output voltage 0-5 Vdc signal do not respond to flow.	The gas flow is too low for particular model of XFM.	Check maximum flow range on transducer's front panel and make required flow adjustment.
		XFM 17 models: RFE is not connected properly to the inlet fitting.	Unscrew the inlet compression fitting of the meter and reinstall RFE (see section 6.2.2). NOTE: Calibration accuracy can be affected.
		Sensor or PC board is defective.	Return XFM to factory for repair.
9	Gas does not flow through the XFM with inlet pressure applied to the inlet fitting. LCD Display reading and output voltage 0-5 Vdc signal show zero flow.	Filter screen obstructed at inlet.	Flush clean or disassemble to remove impediments or replace the filter screen (see section 6.2). NOTE: Calibration accuracy can be affected.
10	Gas flows through the XFM, output voltage 0-5 Vdc signal does not respond to flow (reading near 1mV).	Direction of the gas flow is reversed.	Check the direction of gas flow as indicated by the arrow on the front of the meter and make required reconnection in the installation.
		XFM is connected in the installation with back pressure conditions and gas leak exist in the system.	Locate and correct gas leak in the system. If XFM has internal leak return it to factory for repair.
11	The Status LED indicator is rapidly flashing with UMBER color on /off.	Sensor temperature is too low.	Make sure the ambient and gas temperatures are within specified range (above 5°C)
12	The Status LED indica tor is rapidly flashing with RED color on /off.	Sensor temperature is too high.	Make sure the ambient and gas temperatures are within specified range (below 50°C)
13	The Status LED indicator is rapidly flashing with RED and UMBER colors.	MCU temperature is too high (overload).	Disconnect power from the XFM. Make sure the ambient temperature is within specified range (below 50°C). Let the device cool down for at least 15 minutes. Apply power to the XFM and check Status LED indication. If overload condition will be indicated again the unit has to be returned to the factory for repair.
14	The Status LED indicator is constantly on with the RED light.	Fatal Error (EEPROM or Auto Zero error).	Cycle the power on the XFM. If Status LED still constantly on with RED light, wait 6 minutes and start Auto Zero function (see 5.3.7 Zero Calibration). If after Zero Calibration the Fatal Error condition will be indicated again the unit has to be returned to the factory for repair.

9.3 Technical Assistance

Aalborg® Instruments will provide technical assistance over the phone to qualified repair personnel. Please call our Technical Assistance at 845-770-3000. Please have your Serial Number and Model Number ready when you call.

10. CALIBRATION CONVERSIONS FROM REFERENCE GASES

The calibration conversion incorporates the K factor. The K factor is derived from gas density and coefficient of specific heat. For diatomic gases:

$$K_{gas} = \frac{1}{d \times C_p}$$

where d = gas density (gram/liter)
C_p = coefficient of specific heat (cal/gram)

Note in the above relationship that d and Cp are usually chosen at the same conditions (standard, normal or other).

If the flow range of a Mass Flow Meter remains unchanged, a relative K factor is used to relate the calibration of the actual gas to the reference gas.

$$K = \frac{Q_a}{Q_r} = \frac{K_a}{K_r}$$

where Q_a = mass flow rate of an actual gas (sccm)
Q_r = mass flow rate of a reference gas (sccm)
K_a = K factor of an actual gas
K_r = K factor of a reference gas

For example, if we want to know the flow rate of oxygen and wish to calibrate with nitrogen at 1000 SCCM, the flow rate of oxygen is:

$$Q_{O2} = Q_a = Q_r \times K = 1000 \times 0.9926 = 992.6 \text{ sccm}$$

where K = relative K factor to reference gas (oxygen to nitrogen)

Note: If particular K factor is activated via digital interface, the user does not need to perform any conversion. All conversion computations will be performed internally by MCU.

APPENDIX I

AALBORG® XFM EEPROM Variables Rev.A0 [12/19/2006]

Gas Independent Variables

INDEX	NAME	DATA TYPE	NOTES
0	BlankEEPROM	char[10]	Do not modify. Table Revision [PROTECTED]
1	SerialNumber	char[20]	Serial Number [PROTECTED]
2	ModelNumber	char[20]	Model Number [PROTECTED]
3	SoftwareVer	char[10]	Firmware Version [PROTECTED]
4	TimeSinceCalHr	float	Time since last calibration in hours.
5	Options1	uint	Misc. Options*
6	BackLight	int	Back Light Level [0-4095]
7	AddressRS485	char[4]	Two character address for RS485 only
8	GasNumber	int	Current Gas Table Number [0-9]
9	FlowUnits	int	Current Units of Measure [0-22]
10	AlarmMode	char	Alarm Mode ['E'- Enabled, 'D' - Disabled]
11	LowAlarmPFS	float	Low Flow Alarm Setting [%FS] 0-Disabled
12	HiAlarmPFS	float	High Flow Alarm Setting [%FS] 0-Disabled
13	AlmDelay	uint	Flow Alarm Action Delay [0-3600sec] 0-Disabled
14	RelaySetting	char[4]	Relays Assignment Setting (N, T, H, L, R, M)
15	TotalMode	char	Totalizer Mode ['E'- Enabled, 'D' - Disabled]
16	Total	float	Totalizer Volume in %*s (updated every 6 min)
17	TotalFlowStart	float	Start Totalizer at flow [%FS] 0 - Disabled
18	TotalVolStop	float	Totalizer Action Limit Volume [%*s] 0-Disabled
19	KfactorMode	char	D-Disabled, I-Internal, U-User Defined
20	KfactorIndex	int	Internal K-Factor Index [0-35]**
21	UserDefKfactor	float	User Defined K-Factor
22	UDUnitKfactor	float	K-Factor for User Defined Units of Measure
23	UDUnitTimeBase	int	User Defined Unit Time Base [1, 60, 3600 sec]
24	UDUnitDensity	char	User Defined Unit Density Flag [Y, N]
25	AoutScaleV	float	DAC 0-5 Vdc Analog Output Scale
26	AoutOffsetV	float	DAC 0-5 Vdc Analog Output Offset
27	AoutScale_mA	float	DAC 4-20mA Analog Output Scale
28	AoutOffset_mA	float	DAC 4-20mA Analog Output Offset
29	SensorZero	uint	DPW value for Sensor Zero [0-1023]
30	Klag [0]	float	DRC Lag Constant [Do Not Alter]
31	Klag [1]	float	DRC Lag Constant [Do Not Alter]
32	Klag [2]	float	DRC Lag Constant [Do Not Alter]
33	Klag [3]	float	DRC Lag Constant [Do Not Alter]
34	Klag [4]	float	DRC Lag Constant [Do Not Alter]

INDEX	NAME	DATA TYPE	NOTES
35	Klag [5]	float	DRC Lag Constant [Do Not Alter]
36	Kgain[0]	float	Gain for DRC Lag Constant [Do Not Alter]
37	Kgain[1]	float	Gain for DRC Lag Constant [Do Not Alter]
38	Kgain[2]	float	Gain for DRC Lag Constant [Do Not Alter]
39	Kgain[3]	float	Gain for DRC Lag Constant [Do Not Alter]
40	Kgain[4]	float	Gain for DRC Lag Constant [Do Not Alter]
41	Kgain[5]	float	Gain for DRC Lag Constant [Do Not Alter]
42	Zero_T	float	Resistance when last AutoZero was done [0-4095 count]
43	Tcor_K	float	Resistance correction coefficient [PFS/count]
44	AlarmLatch	uint	Alarm Latch [0-3]
45	TotalWarmDisable	char	Sensor Warm Up period Totalizer [D/E]
46	Reserved1	uint	Reserved
47	LCD_Diagnostic	char	LCD Diagnostic Mode: [E/D]**
48	Reserved2	uint	Flow Reading Averaging: [0,1,2] (100, 250, 1000 ms), Default -1
49	N_2_RollBack	char	Back to N_2 conversion mode: [E, D]
50	Reserved3	uint	Reserved for Troubleshooting (do not change)

Calibration Table: Gas Dependent Variables.

INDEX	NAME	DATA TYPE	NOTES
100	GasIdentifer	char[20]	Name of Gas [If not calibrated = “Uncalibrated”]
101	FullScaleFlow	float	Full Scale Range in l/min
102	StdTemp	float	Standard Temperature
103	StdPressure	float	Standard Pressure
104	StdDensity	float	Gas Standard Density
105	CalibrationGas	char[20]	Name of Gas used for Calibration [If not calibrated=[“Uncalibrated”]
106	CalibratedBy	char[20]	Name of person who performed actual calibration
107	CalibratedAt	char[20]	Name of Calibration Facility
108	DateCalibrated	char[12]	Calibration Date
109	DateCalibrationDue	char[12]	Date Calibration Due
110	K_N_2	float	Gas Parameters: K-factor relative to N_2
111	K_F1	float	Reserved
112	K_F1	float	Reserved
113	SensorTbl[0][Sensor Value]	uint	Index 0: Must be 120 (zero value) Do not Alter!
114	SensorTbl[0][Flow]	float	Index 0: Must be 0.0 (zero PFS) Do not Alter!
115	SensorTbl[1][Sensor Value]	uint	10.0%F.S. A/D value from sensor [counts].
116	SensorTbl[1][Flow]	float	Actual Flow in PFS [0.1].
117	SensorTbl[2][Sensor Value]	uint	20.0%F.S. A/D value from sensor [counts].
118	SensorTbl[2][Flow]	float	Actual Flow in PFS [0.2].
119	SensorTbl[3][Sensor Value]	uint	30.0%F.S. A/D value from sensor [counts].
120	SensorTbl[3][Flow]	float	Actual Flow in PFS [0.3].
121	SensorTbl[4][Sensor Value]	uint	40.0%F.S. A/D value from sensor [counts].
122	SensorTbl[4][Flow]	float	Actual Flow in PFS [0.4].
123	SensorTbl[5][Sensor Value]	uint	50.0%F.S. A/D value from sensor [counts].
124	SensorTbl[5][Flow]	float	Actual Flow in PFS [0.5].
125	SensorTbl[6][Sensor Value]	uint	60.0%F.S. A/D value from sensor [counts].
126	SensorTbl[6][Flow]	float	Actual Flow in PFS [0.6].
127	SensorTbl[7][Sensor Value]	uint	70.0%F.S. A/D value from sensor [counts].
128	SensorTbl[7][Flow]	float	Actual Flow in PFS [0.7].
129	SensorTbl[8][Sensor Value]	uint	80.0%F.S. A/D value from sensor [counts].
130	SensorTbl[8][Flow]	float	Actual Flow in PFS [0.8].
131	SensorTbl[9][Sensor Value]	uint	90.0%F.S. A/D value from sensor [counts].
132	SensorTbl[9][Flow]	float	Actual Flow in PFS [0.9].
133	SensorTbl[10][Sensor Value]	uint	100.0%F.S. A/D value from sensor [counts].
134	SensorTbl[10][Flow]	float	Flow in PFS. Should be 1.0 Do not Alter!

Note: Values will be available for selected gas only.

APPENDIX II INTERNAL "K" FACTORS

⚠ **CAUTION:** K-Factors at best are only an approximation. K factors should not be used in applications that require accuracy better than +/- 5 to 10%.

INDEX	ACTUAL GAS	K Factor Relative to N_2	Cp [Cal/g]	DENSITY [g/l]
0	Acetylene C2H2	0.5829	.4036	1.162
1	Air	1.000	0.24	1.293
2	Allene (Propadiene) C3H4	0.4346	0.352	1.787
3	Ammonia NH_3	.7310	.492	.760
4	Argon Ar	1.4573	.1244	1.782
5	Arsine AsH3	0.6735	0.1167	3.478
6	Boron Trichloride BCl3	0.4089	0.1279	5.227
7	Boron Triflouride BF3	0.5082	0.1778	3.025
8	Bromine Br2	0.8083	0.0539	7.130
9	Boron Tribromide Br3	0.38	0.0647	11.18
10	Boromine Pentaflouride BrF5	0.26	0.1369	7.803
11	Boromine Triflouride BrF3	0.3855	0.1161	6.108
12	Bromotriflouromethane CBrF3	0.3697	0.1113	6.644
13	1,3-Butadiene C4H6	0.3224	0.3514	2.413
14	Butane C_4H_{10}	.2631	.4007	2.593
15	1-Butane C4H8	0.2994	0.3648	2.503
16	2-Butane C4H8 CIS	0.324	0.336	2.503
17	2-Butane C4H8 TRANS	0.291	0.374	2.503
18	Carbon Dioxide CO_2	.7382	.2016	1.964
19	Carbon Disulfide CS_2	0.6026	0.1428	3.397
20	Carbon Monoxide C_0	1.00	.2488	1.250
21	Carbon Tetrachloride CCl4	0.31	0.1655	6.860
22	Carbon Tetrafluoride (Freon-14) CF4	0.42	0.1654	3.926
23	Carbonyl Fluoride COF2	0.5428	0.1710	2.945
24	Carbonyl Sulfide COS	0.6606	0.1651	2.680
25	Chlorine Cl_2	0.86	0.114	3.163
26	Chlorine Trifluoride ClF3	0.4016	0.1650	4.125
27	Chlorodifluoromethane (Freon-22) CHClF2	0.4589	0.1544	5.326
28	Chloroform $CHCl_3$	0.3912	0.1309	5.326
29	Chloropentafluoroethane (Freon -115) C2ClF5	0.2418	0.164	6.892
30	Chlorotrifluoromethane (Freon-13) CClF3	0.3834	0.153	4.660
31	Cyanogen C2N2	0.61	0.2613	3.322
32	Helium He	1.454	1.241	.1786
33	Hydrogen H_2	1.0106	3.419	.0899
34	Hydrogen H_2 (> 100 L/min)	1.92	3.419	0.0899
35	Oxygen O2	0.9926	0.2193	1.427

APPENDIX III GAS FACTOR TABLE ("K FACTORS")

⚠ **CAUTION:** K-Factors at best are only an approximation. K factors should not be used in applications that require accuracy better than +/- 5 to 10%.

ACTUAL GAS	K FACTOR Relative to N_2	Cp [Cal/g]	Density [g/l]
Acetylene C_2H_2	.5829	.4036	1.162
Air	1.0000	.240	1.293
Allene (Propadiene) C_3H_4	.4346	.352	1.787
Ammonia NH_3	.7310	.492	.760
Argon Ar (<=10 L/min) Argon AR-1 (>=10 L/min)	1.4573 1.205	.1244 .1244	1.782 1.782
Arsine AsH_3	.6735	.1167	3.478
Boron Trichloride BCl_3	.4089	.1279	5.227
Boron Trifluoride BF_3	.5082	.1778	3.025
Bromine Br_2	.8083	.0539	7.130
Boron Tribromide Br_3	.38	.0647	11.18
Bromine PentaTrifluoride BrF_5	.26	.1369	7.803
Bromine Trifluoride BrF_3	.3855	.1161	6.108
Bromotrifluoromethane (Freon-13 B1) $CBrF_3$	.3697	.1113	6.644
1,3-Butadiene C_4H_6	.3224	.3514	2.413
Butane C_4H_{10}	.2631	.4007	2.593
1-Butene C_4H_8	.2994	.3648	2.503
2-Butene C_4H_8 CIS	.324	.336	2.503
2-Butene C_4H_8 TRANS	.291	.374	2.503
Carbon Dioxide CO_2 (<10 L/min) Carbon Dioxide CO_2-1 (>10 L/min)	.7382 .658	.2016 .2016	1.964 1.964
Carbon Disulfide CS_2	.6026	.1428	3.397
Carbon Monoxide C0	1.00	.2488	1.250
Carbon Tetrachloride CCl_4	.31	.1655	6.860
Carbon Tetrafluoride (Freon-14)CF_4	.42	.1654	3.926
Carbonyl Fluoride COF_2	.5428	.1710	2.945
Carbonyl Sulfide COS	.6606	.1651	2.680
Chlorine Cl_2	.86	.114	3.163
Chlorine Trifluoride ClF_3	.4016	.1650	4.125
Chlorodifluoromethane (Freon-22)$CHClF_2$	.4589	.1544	3.858
Chloroform $CHCl_3$	.3912	.1309	5.326
Chloropentafluoroethane(Freon-115)C_2ClF_5	.2418	.164	6.892
Chlorotriflurometh ane (Freon-13) $CClF_3$	.3834	.153	4.660
CyanogenC_2N_2	.61	.2613	2.322
CyanogenChloride ClCN	.6130	.1739	2.742
Cyclopropane C_3H_5	.4584	.3177	1.877

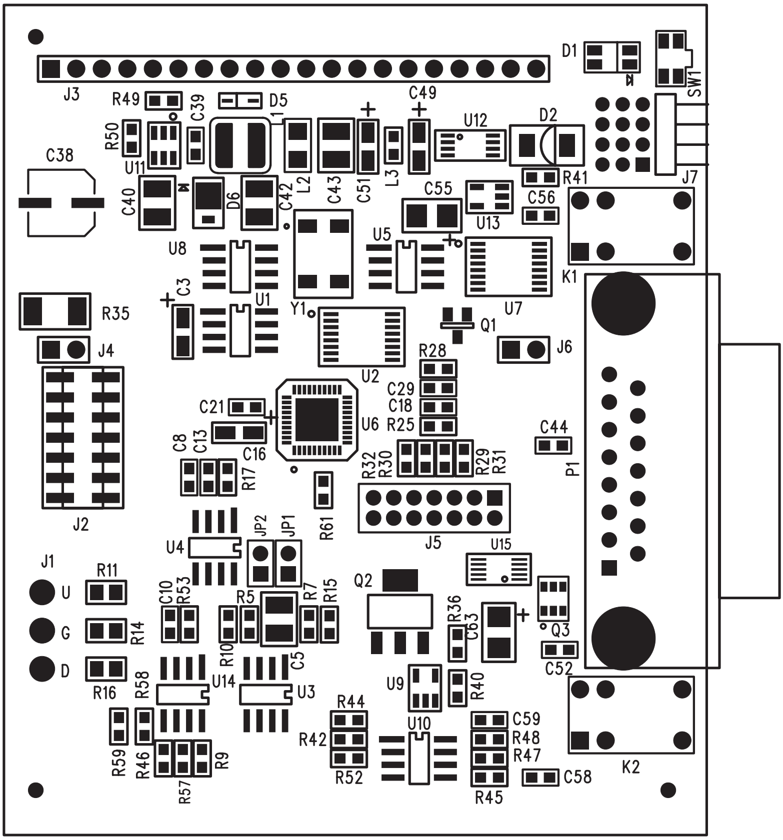
ACTUAL GAS	K FACTOR Relative to N_2	Cp [Cal/g]	Density [g/l]
Deuterium D_2	1.00	1.722	1.799
Diborane B_2H_6	.4357	.508	1.235
Dibromodifluoromethane CBr_2F_2	.1947	.15	9.362
Dichlorodifluoromethane (Freon-12) CCl_2F_2	.3538	.1432	5.395
Dichlofluoromethane (Freon-21) $CHCl_2F$	.4252	.140	4.592
Dichloromethylsilane $(CH_3)_2SiCl_2$	.2522	.1882	5.758
Dichlorosilane SiH_2Cl_2	.4044	.150	4.506
Dichlorotetrafluoroethane (Freon-114) $C_2Cl_2F_4$	.2235	.1604	7.626
1,1-Difluoroethylene (Freon-1132A) $C_2H_2F_2$	.4271	.224	2.857
Dimethylamine $(CH_3)_2NH$	.3714	.366	2.011
Dimethyl Ether $(CH_3)_2O$	.3896	.3414	2.055
2,2-Dimethylpropane C_3H_{12}	.2170	.3914	3.219
Ethane C_2H_6	.50	.420	1.342
Ethanol C_2H_6O	.3918	.3395	2.055
Ethyl Acetylene C_4H_6	.3225	.3513	2.413
Ethyl Chloride C_2H_5Cl	.3891	.244	2.879
Ethylene C_2H_4	.60	.365	1.251
Ethylene Oxide C_2H_4O	.5191	.268	1.965
Fluorine F_2	.9784	.1873	1.695
Fluoroform (Freon-23) CHF_3	.4967	.176	3.127
Freon-11 CCl_3F	.3287	.1357	6.129
Freon-12 CCl_2F_2	.3538	.1432	5.395
Freon-13 $CClF_3$	.3834	.153	4.660
Freon-13B1 $CBrF_3$	.3697	.1113	6.644
Freon-14 CF_4	.4210	.1654	3.926
Freon-21 $CHCl_2F$	.4252	.140	4.592
Freon-22 $CHClF_2$	.4589	.1544	3.858
Freon-113 CCl_2FCClF_2	.2031	.161	8.360
Freon-114 $C_2Cl_2F_4$	.2240	.160	7.626
Freon-115 C_2ClF_5	.2418	.164	6.892
Freon-C318 C_4F_8	.1760	.185	8.397
Germane GeH_4	.5696	.1404	3.418
Germanium Tetrachloride $GeCl_4$	.2668	.1071	9.565
Helium He (=<10 L/min) Helium He-1 (>50 L/min) Helium He-2 (>10-50 L/min)	1.454 2.43 2.05	1.241 1.241 1.241	.1786 .1786 .1786
Hexafluoroethane C_2F_6 (Freon-116)	.2421	.1834	6.157
Hexane C_6H_{14}	.1792	.3968	3.845
Hydrogen H_2-1 (=<10 L/min) Hydrogen H_2-2 (>10-100 L) Hydrogen H_2-3 (>100 L)	1.0106 1.35 1.9	3.419 3.419 3.419	.0899 .0899 .0899

ACTUAL GAS	K FACTOR Relative to N_2	Cp [Cal/g]	Density [g/l]
Hydrogen Bromide HBr	1.000	.0861	3.610
Hydrogen Chloride HCl	1.000	.1912	1.627
Hydrogen Cyanide HCN	.764	.3171	1.206
Hydrogen Fluoride HF	.9998	.3479	.893
Hydrogen Iodide HI	.9987	.0545	5.707
Hydrogen Selenide H_2Se	.7893	.1025	3.613
Hydrogen Sulfide H_2S	.80	.2397	1.520
Iodine Pentafluoride IF_5	.2492	.1108	9.90
Isobutane $CH(CH_3)_3$	.27	.3872	3.593
Isobutylene C_4H_6	.2951	.3701	2.503
Krypton Kr	1.453	.0593	3.739
Methane CH_4 (<=10 L/min) Methane CH_4-1 (>=10 L/min)	.7175 .75	.5328 .5328	.715 .715
Methanol CH_3	.5843	.3274	1.429
Methyl Acetylene C_3H_4	.4313	.3547	1.787
Methyl Bromide CH_2Br	.5835	.1106	4.236
Methyl Chloride CH_3Cl	.6299	.1926	2.253
Methyl Fluoride CH_3F	.68	.3221	1.518
Methyl Mercaptan CH_3SH	.5180	.2459	2.146
Methyl Trichlorosilane $(CH_3)SiCl_3$	.2499	.164	6.669
Molybdenum Hexafluoride MoF_6	.2126	.1373	9.366
Monoethylamine $C_2H_5NH_2$	.3512	.387	2.011
Monomethylamine CH_3NH_2	.51	.4343	1.386
Neon NE	1.46	.246	.900
Nitric Oxide NO	.990	.2328	1.339
Nitrogen N_2	1.000	.2485	1.25
Nitrogen Dioxide NO_2	.737	.1933	2.052
Nitrogen Trifluoride NF_3	.4802	.1797	3.168
Nitrosyl Chloride NOCl	.6134	.1632	2.920
Nitrous Oxide N_2O	.7128	.2088	1.964
Octafluorocyclobutane (Freon-C318) C_4F_8	.176	.185	8.397
Oxygen O_2	.9926	.2193	1.427
Oxygen Difluoride OF_2	.6337	.1917	2.406
Ozone	.446	.195	2.144
Pentaborane B_5H_9	.2554	.38	2.816
Pentane C_5H_{12}	.2134	.398	3.219
Perchloryl Fluoride ClO_3F	.3950	.1514	4.571
Perfluoropropane C_3F_8	.174	.197	8.388
Phosgene $COCl_2$	.4438	.1394	4.418
Phosphine PH_3	.759	.2374	1.517

ACTUAL GAS	K FACTOR Relative to N_2	Cp [Cal/g]	Density [g/l]
Phosphorous Oxychloride $POCl_3$	.36	.1324	6.843
Phosphorous Pentafluoride PH_5	.3021	.1610	5.620
Phosphorous Trichloride PCl_3	.30	.1250	6.127
Propane C_3H_8	.35	.399	1.967
Propylene C_3H_6	.40	.366	1.877
Silane SiH_4	.5982	.3189	1.433
Silicon Tetrachloride $SiCl_4$	.284	.1270	7.580
Silicon Tetrafluoride SiF_4	.3482	.1691	4.643
Sulfur Dioxide SO_2	.69	.1488	2.858
Sulfur Hexafluoride SF_6	.2635	.1592	6.516
Sulfuryl Fluoride SO_2F_2	.3883	.1543	4.562
Tetrafluoroethane (Forane 134A) CF_3CH_2F	.5096	.127	4.224
Tetrafluorohydrazine N_2F_4	.3237	.182	4.64
Trichlorofluoromethane (Freon-11) CCl_3F	.3287	.1357	6.129
Trichlorosilane $SiHCl_3$	.3278	.1380	6.043
1,1,2-Trichloro-1,2,2 Trifluoroethane (Freon-113) CCl_2FCClF_2	.2031	.161	8.36
Triisobutyl Aluminum $(C_4H_9)AL$	.0608	.508	8.848
Titanium Tetrachloride $TiCl_4$	.2691	.120	8.465
Trichloro Ethylene C_2HCl_3	.32	.163	5.95
Trimethylamine $(CH_3)_3N$	.2792	.3710	2.639
Tungsten Hexafluoride WF_6	.2541	.0810	13.28
Uranium Hexafluoride UF_6	.1961	.0888	15.70
Vinyl Bromide CH_2CHBr	.4616	.1241	4.772
Vinyl Chloride CH_2CHCl	.48	.12054	2.788
Xenon Xe	1.44	.0378	5.858

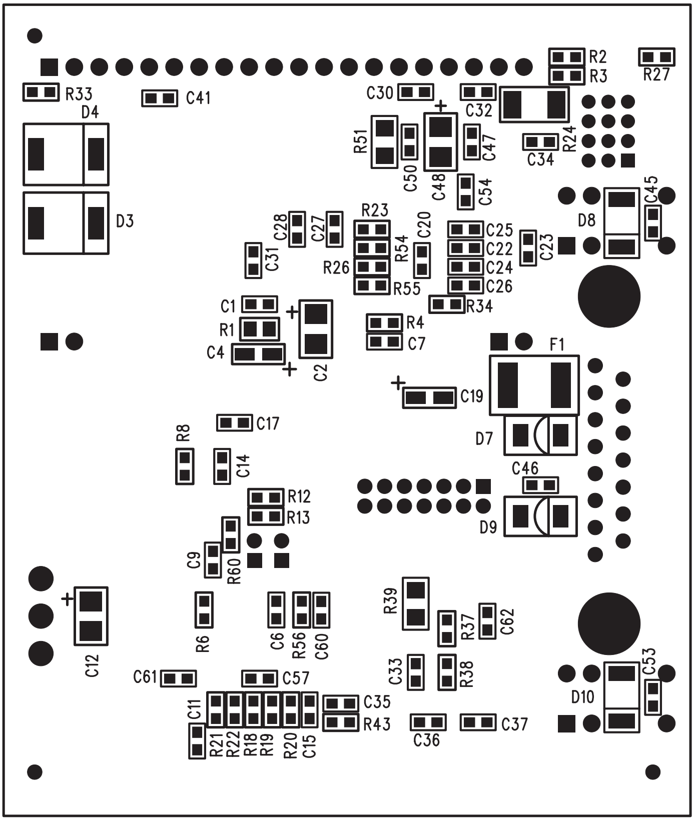
APPENDIX IV COMPONENT DIAGRAM

TOP COMPONENT SIDE



Aug. 09, 2007

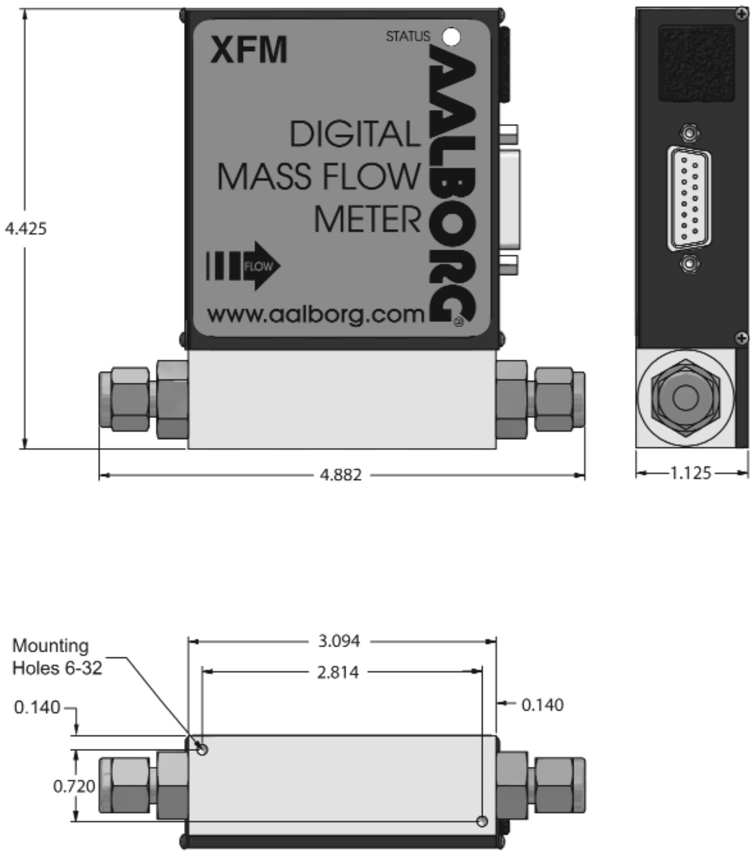
BOTTOM COMPONENT SIDE



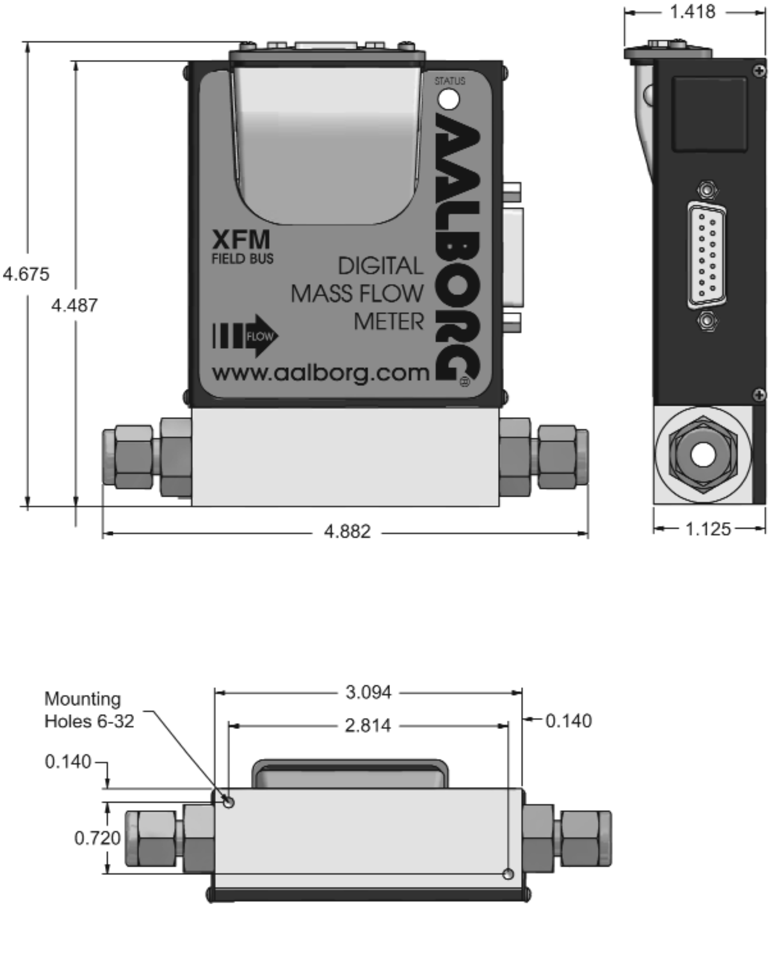
Aug 09, 2007

APPENDIX V

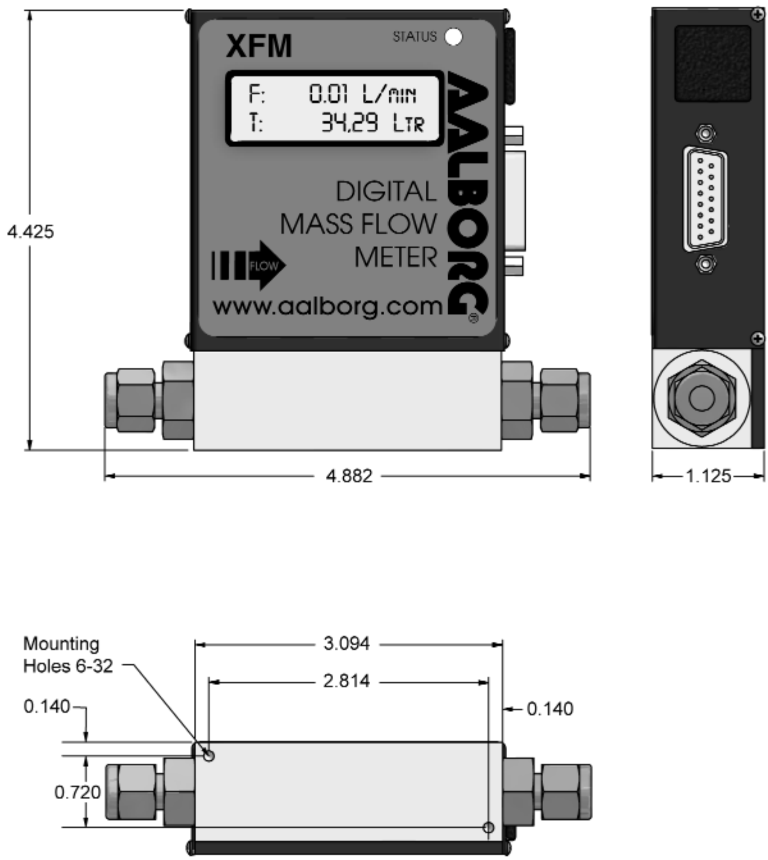
DIMENSIONAL DRAWINGS



XFM WITHOUT READOUT



XFM WITH PROFIBUS CAPABILITY



XFM WITH READOUT OPTION

WARRANTY

Aalborg® Mass Flow Systems are warranted against parts and workmanship for a period of one year from the date of purchase. Calibrations are warranted for up to six months after date of purchase, provided calibration seals have not been tampered with. It is assumed that equipment selected by the customer is constructed of materials compatible with gases used. Proper selection is the responsibility of the customer. It is understood that gases under pressure present inherent hazards to the user and to equipment, and it is deemed the responsibility of the customer that only operators with basic knowledge of the equipment and its limitations are permitted to control and operate the equipment covered by this warranty. Anything to the contrary will automatically void the liability of Aalborg® and the provisions of this warranty. Defective products will be repaired or replaced solely at the discretion of Aalborg® at no charge. Shipping charges are borne by the customer.This warranty is void if the equipment is damaged by accident or misuse, or has been repaired or modified by anyone other than Aalborg® or factory authorized service facility. This warranty defines the obligation of Aalborg® and no other warranties expressed or implied are recognized.

NOTE: *Follow Return Procedures In Section 1.3.*