OPERATING MANUAL

DFC MASS FLOW CONTROLLER

QUALITY SYSTEM REGISTERED

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1. UNPACKING THE DFC MASS FLOW CONTROLLER

1.1 Inspect Package for External Damage

Your DFC Mass Flow Controller 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 Controller

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 Controller 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 DFC Mass Flow Controller 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:** DFC 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 sensitivity of the Mass Flow Controller is ±15°. This means that the gas flow path of the Flow Controller must be horizontal within those stated limits. Should there be need for a different orientation of the meter, re-calibration may be necessary. It is also preferable to install the DFC 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 contaminants.

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

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

DFC transducers are supplied with standard 1/4 inch (DFC 26 and 36) or 3/8 inch (DFC 46), 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.

Using a Helium Leak Detector or other equivalent method perform a thorough leak test of the underline entire system. (All DFC's are checked prior to shipment for leakage within stated limits. See specifications in this manual.)

2.2   Electrical Connections

DFC transducers require a +15VDC and -15VDC power supply to operate. Additionally, a readout panel meter, digital multimeter, or other equivalent device is required to observe the flow signal in analog mode. A variable analog 0-5VDC reference input is required for DFC models to operate in analog mode. The Aalborg® SDPROC accessory Command Modules offer a convenient and compact means to fulfill these needs.

DFC is supplied with a 25 pin "D" connector. Pin diagram is presented in figure b-2.

2.3   Communication Parameters and Connections

Baud rate:	9600 baud	**Stop bit:**	1
Data bits:	8	**Parity:**	NON

RS-232 option: Crossover connection has to be established:

Pin 11 (TX) of the "D" connector has to be connected to RX (pin 2 on the DB9 connector).
Pin 24 (RX) of the "D" connector has to be connected to TX (pin 3 on the DB9 connector).
Pin 20 (Common) of the "D" connector has to be connected to GND (pin 5 on the DB9 connector).

RS-485 option:

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

Pin 11 (-) of the "D" connector has to be connected to
T- or R- on the RS-485 converter/adapter.
Pin 24 (+) of the "D" connector has to be connected to
T+ or R+ on the RS-485 converter/adapter.
Pin 20 (Common) of the "D" connector has to be connected
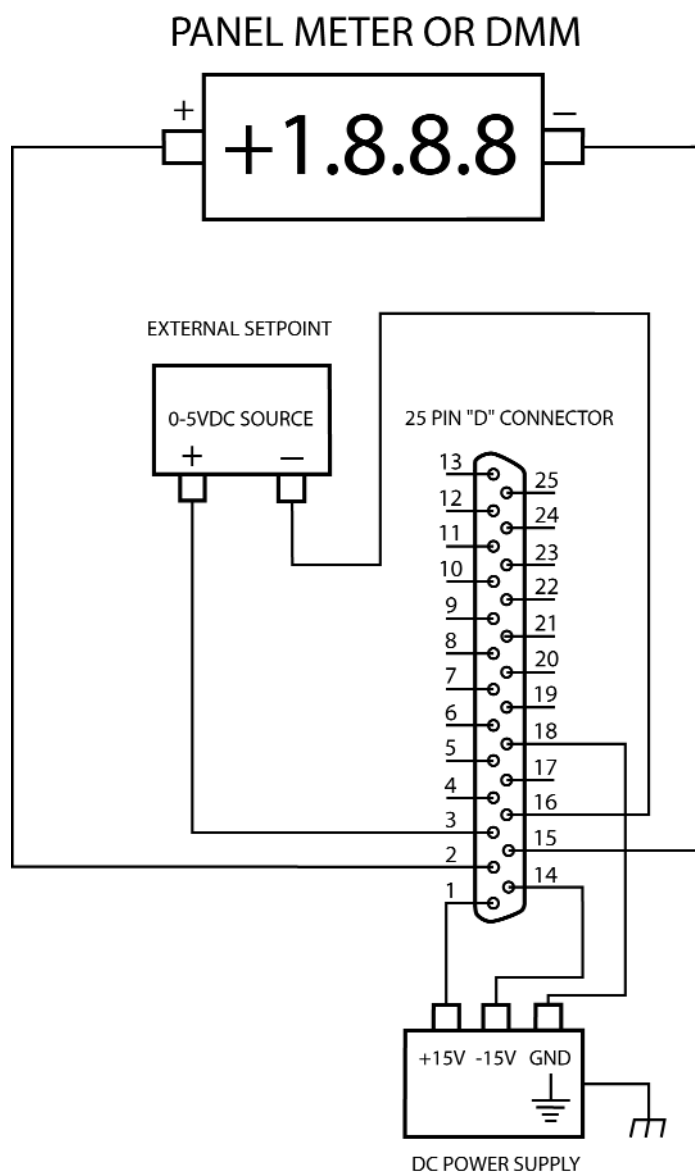to GND on the RS-485 converter/adapter.

PANEL METER OR DMM

FIGURE b-1, WIRING DIAGRAM FOR DFC TRANSDUCERS.

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PIN	FUNCTION
1	+15 VDC Power Supply
2	0-5 VDC Flow Signal (4-20mA Option)
3	0-5 VDC Set Point Input (4-20mA Option)
4	Force Valve Open Control
5	Force Valve Closed Control
6	(Reserved)
7	(Reserved)
8	Relay No. 1 - Common Contact
9	Relay No. 1 - Normally Open Contact
10	Relay No. 2 - Normally Closed Contact
11	RS485 (-) (Optional RS232 TX)
12	(No Connection)
13	Chassis Ground
14	-15 VDC Power Supply
15	Common, Signal Ground For Pin 2
16	Common, Signal Ground For Pin 3
17	(Optional) RS232 Common
18	Common, Power Supply
19	Common
20	Common
21	Relay No. 1 - Normally Closed Contact
22	Relay No. 2 - Common Contact
23	Relay No. 2 - Normally Open Contact
24	RS485 (+) (Optional RS232 RX)
25	Return for Pin 2 (Optional 4-20 mA Only)
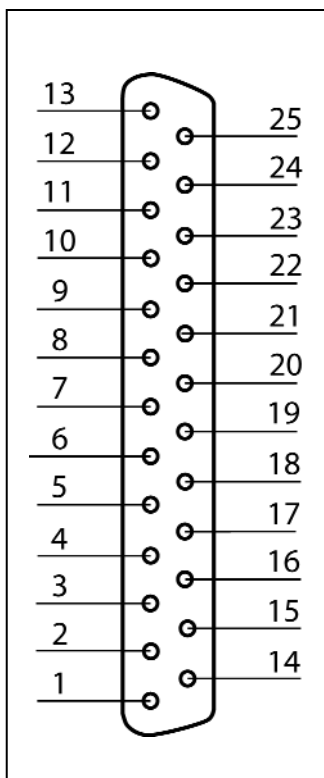
FIGURE b-2, DFC 25 PIN "D" CONNECTOR CONFIGURATION

⚠ **Important notes:**

In general, "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 your 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 500mA 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.

Cable length may not exceed 9.5 feet (3 meters).
Use of the DFC 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 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, DFC model Mass Flow Controllers incorporate a microprocessor and non-volatile memory that stores all calibration factors and directly controls a proportioning solenoid valve. The digital closed loop control system of the DFC continuously compares the mass flow output with the selected flow rate. Deviations from the set point are corrected by compensating valve adjustments, thus maintaining the desired flow parameters with a high degree of accuracy.

4.   SPECIFICATIONS

FLOW MEDIUM: Please note that DFC Mass Flow Controllers are designed to work with clean gases only. Never try to meter or control flow rates of liquids with any DFC.

CALIBRATIONS: Performed at standard conditions [14.7 psia (1.01 bars) and 70°F (21.1°C)] unless otherwise requested or stated.

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

4.1 DFC 26/36/46 Mass Flow Controllers

ACCURACY: $\pm$1% of full scale, including linearity for gas temperatures ranging from 59°F to 77°F (15°C to 25°C) and pressures of 10 to 60 psia (0.7 to 4.1 bars).

REPEATABILITY: $\pm$0.15% of full scale.

TEMPERATURE COEFFICIENT: 0.1% of full scale/ °C.

PRESSURE COEFFICIENT: 0.01% of full scale/psi (0.07 bar).

RESPONSE TIME: **DFC26:** 300ms time constant; approximately 1 second to within $\pm$2% of set flow rate for 25% to 100% of full scale flow.

DFC36/46: 600ms time constant; approximately 2 seconds to within $\pm$2% of set flow rate for 25% to 100% of full scale flow.

GAS PRESSURE: 500 psig (34.5 bars) maximum; optimum pressure is 20 psig (1.4 bars); 25 psig (1.7 bars gauge) for DFC46.

DIFFERENTIAL PRESSURES REQUIRED: 5 to 50 psig (0.35 to 3.34 bars) differential pressures. Optimum differential pressure is 25 psid (1.7 bars). See Table IV for pressure drops associated with various models and flow rates.

MAXIMUM PRESSURE DIFFERENTIAL: 50 psid for DFC26/DFC36, 40 psid for DFC46.

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%.

MAXIMUM INTERNAL LEAK: 0.5%FS.

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

ATTITUDE SENSITIVITY: 1% shift for a 90 degree rotation from horizontal to vertical; standard calibration is in horizontal position.

OUTPUT SIGNALS: Linear 0-5 VDC (2000 Ω minimum load impedance); 4-20 mA optional (50-500 Ω loop resistance); 20 mV peak to peak max noise.

Contact your distributor or Aalborg® for optional RS232 or IEEE488 interfaces.

COMMAND SIGNAL: 0-5 VDC (200K Ω input impedance); 4-20 mA optional.

TRANSDUCER INPUT POWER: DFC - +15 $\pm$5% VDC, 450 mA max, 6.75 watts max; -15 $\pm$5% VDC, 450 mA max; 6.75 watts max;

Power inputs are each protected by a 500mA M (medium time-lag) resettable fuse, and an inverse shunt rectifier diode for polarity protection.

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

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: 1/4" (DFC 26/DFC 36) or 3/8" (DFC 46) compression fittings standard. 1/8" (DFC26) or 3/8" (DFC26/DFC36) compression fittings or 1/4" (DFC26/DFC36) VCR® fittings are optional.

TRANSDUCER INTERFACE CABLE: Flat cable with 25-pin "D" connectors on the ends is standard. Optional shielded cable is available with male/female 25-pin "D" connector ends. [Cable length may not exceed 9.5 feet (3 meters)].

4.2   CE Compliance

Any model DFC bearing a CE marking on it, is in compliance with the below stated test standards currently accepted.

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 DFC 26 LOW FLOW MASS FLOW CONTROLLERS*

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

TABLE II DFC 36 MEDIUM FLOW MASS FLOW CONTROLLERS*

CODE	standard liters/min [N_2]
11	0 to 15
30	20
31	30
32	40
33	50

TABLE III DFC 46 HIGH FLOW MASS FLOW CONTROLLERS*

CODE	standard liters/min [N_2]
40	60
41	80
42	100

* 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$_2$O]	[psid]	[mbar]
DFC 26	up to 10	720	1.06	75
DFC 36	15	2630	3.87	266
	20	1360	2.00	138
	30	2380	3.50	241
	40	3740	5.50	379
	50	5440	8.00	551
DFC 46	60	7480	11.00	758
	100	12850	18.89	1302

TABLE V APPROXIMATE WEIGHTS

MODEL	WEIGHT	SHIPPING WEIGHT
DFC 26 transmitter	2.20 lbs (1.00 kg)	3.70 lbs (1.68 kg)
DFC 36/46 transmitter	2.84 lbs (1.29 kg)	4.34 lbs (1.97 kg)

5.   OPERATING INSTRUCTIONS

5.1   Preparation and Warm Up

It is assumed that the Mass Flow Controller or Controller has been correctly installed and thoroughly leak tested as described in section (2). Make sure the flow source is OFF. Power up the transducer using your own power supply (or switch the POWER switch to the ON position at the front panel of your SDPROC Command Module). Allow the Mass Flow Meter or Controller to warm-up for a minimum of 15 minutes.

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

⚠️   **Caution:** If the valve is left in the AUTO (control) or OPEN mode for an extended period of time, it may become warm or even hot to the touch. Use care in avoiding direct contact with the valve during operation.

5.2   Flow Signal Output Readings

The flow signal output can be viewed on the panel meter, digital multimeter, or other display device used as shown in figure b-1.

When using the accessory SDPROC Command Module the flow rate will appear on the display at the front panel. The observed reading is a 0 to 100% indication (direct engineering units are optional). [If using a multichannel readout, be sure that the CHANNEL selector switch is set to the correct channel.]

Analog output flow signals of 0 to 5 VDC or optional 4 to 20 mA are attained at the appropriate pins the 25-pin "D" connector (see Figure b-2) on the side of the DFC transducer. The output flow signal is also available at the DATA connector on the rear panel of the SDPROC Command Module.

Meter signal output is linearly proportional to the mass molecular flow rate of the gas being metered. The full scale range and gas for which your meter has been calibrated are shown on the flow transducer's front label.

For information on the RS485 or optional RS232 interfaces please contact your distributor or Aalborg®.

5.3   Swamping Condition

If a flow of more than 10% above the maximum flow rate of the Mass Flow Controller 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.

5.4   Set Point Reference Signal

DFC flow controllers have a built-in solenoid valve and allow the user to set the flow to any desired flow rate within the range of the particular model installed. This valve is normally closed when no power is applied.

The set point input in analog mode responds to an analog 0 to 5 VDC reference voltage or 4-20mA reference current. This voltage is a linear representation of 0 to 100% of the full scale mass flow rate. Response time to set point changes are 1 second to within 2% of the final flow over 25 to 100% of full scale.

A variable 0 to 5VDC analog signal may be applied directly to the SET POINT and COMMON connections of the DFC transducer (see Figure b-1).

If a potentiometer is used to adjust the set point reference signal its value should be between 5K to 100K ohm and it should be capable of at least 10-turns or more for adjustment.

5.5   Valve OFF Control

It may, at times, be desirable to set the flow and maintain that setting while being able to turn the flow control valve off and on again. This can be accomplished via pin 5 on the 25-pin "D" connector. When 0 VDC (LOW) signal is applied (connection via a relay, switch or NPN open collector transistor is permissible), the solenoid valve is not powered and therefore will remain normally closed. Conversely, when the pin is disconnected from 0 VDC ("floating") the solenoid valve will remain active.

The simplest means for utilizing the VALVE OFF control feature, is to connect a toggle switch between the COMMON and FORCE VALVE CLOSED pins of the DFC transducer. Toggling the switch on and off will allow for activating and deactivating the solenoid valve.

5.6   Valve Open /Purge

At times, it may be necessary to purge the flow system with a neutralizing gas such as pure dry nitrogen. The DFC transducer is capable of a full open condition for the solenoid valve, regardless of set point conditions. Connecting the FORCE VALVE OPEN pin (pin 4 on 25-pin "D" connector) to ground will fully open the valve. This connection can be made with a relay, switch or NPN open collector transistor. Conversely, when the pin is disconnected from 0 VDC ("floating") the solenoid valve will remain active. (Note: in digital mode hardware I/O overrides software command).

The simplest means for utilizing the VALVE OPEN control feature, is to connect a toggle switch between the COMMON and FORCE VALVE OPEN pins of the DFC transducer. Toggling the switch on will cause the valve to open fully and purge the system. Toggling the switch off will allow the solenoid valve to resume normal activity.

⚠ **Caution:** If the valve is left in the AUTO (control) or OPEN mode for an extended period of time, it may become warm or even hot to the touch. Use care in avoiding direct contact with the valve during operation.

5.7   Analog Interface Configuration

The DFC can be configured for the desired range and scaling by selection of analog board (see APPENDIX 1 on page 21) jumpers as follows:

0 to 5 V output: Jumper pins 2 and 3 of JP6.
Jumper pins 2 and 3 of JP3.
Jumper pins 2 and 3 of JP5.
Jumper pins 1 and 2 of JP12.

0 to 5 V input: Jumper pins 2 and 3 of JP2.
Jumper pins 2 and 3 of JP4.
Jumper pins 1 and 2 of JP11.

0 to 10 V output: As for 0 to 5V, but jumper pins 2 and 3 of JP12.

4 to 20 mA output: Jumper pins 1 and 2 of JP6.
Jumper pins 1 and 2 of JP3.
Jumper pins 1 and 2 of JP5.
Jumper pins 1 and 2 of JP12.

4 to 20 mA input: Jumper pins 1 and 2 of JP2.
Jumper pins 1 and 2 of JP4.
Jumper pins 1 and 2 of JP11.

By default the DFC is configured for analog input output ranges set to 0-5V (unless ordered with special configuration).

6.   MAINTENANCE

6.1   Introduction

It is important that the Mass Flow Controller is used with clean, filtered gases only. 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 (DFC26) or 60 micron (DFC36/46) 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 not unclogged, then 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 to Aalborg® for servicing.

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 Controller depends on the gas and flow range of the instrument.

6.2.2 DFC 26 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 contaminants. 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 the RFE. Be sure that no dust has collected on the O-ring seal.

⚠ **Note:** Overtightening 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).

6.2.3 DFC 36/46 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 through 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 Valve Maintenance (DFC)

The solenoid valve consists of 316 and 416 stainless steel, and VITON® (or optional EPR or KALREZ®) O-rings and seals. No regular maintenance is required except for periodic cleaning.

Various corrosive gases may demand more frequent replacement of VITON® O- rings and seals inside the valve. Be sure to use an elastomer material, appropriate for your specific gas application. Contact your distributor or Aalborg® for optional sealing materials available.

Set the DFC into PURGE mode, and attempt to flush through with a clean, filtered, and neutral gas such as nitrogen. [Another option for fully opening the valve is to remove the plastic cap on top of the valve, and turn the set screw counterclockwise until it stops. Set valve for the closed position. Apply an inlet pressure of 5 psig and atmospheric pressure at the outlet. If a small flow occurs, turn the set screw on top of the solenoid valve clockwise until the flow through the DFC just stops.

⚠ **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.   CALIBRATION PROCEDURES

7.1   Flow Calibration

Aalborg® Instruments' Flow Calibration Laboratory offers professional calibration support for Mass Flow Meters and Controllers, 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 2. A reference gas, other than nitrogen, may be used to closer 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 appro-

priate relative correction factor should be recalculated see section (9).

It is standard practice to calibrate Mass Flow Meters/Controllers with dry nitrogen gas at 70°F (21.1EC), 20 psig (1.4 bars) [25 psig (1.7 bars) for DFC46] inlet pressure and 0 psig (0 bar) outlet pressure. It is best to calibrate the DFC transducers to actual operating conditions. Specific gas calibrations of non-toxic and non-corrosive gases are available at specific conditions. Please contact your distributor or Aalborg® for a price quotation.

It is recommended that a flow calibrator of at least four times better collective accuracy than that of the Mass Flow Controller to be calibrated be used. Equipment required for calibration includes a flow calibration standard and a certified high sensitivity multimeter (which together have a collective accuracy of $\pm$0.25% or better), an insulated (plastic) screwdriver, a flow regulator (example: metering needle valve) installed upstream from the Mass Flow Controller and a pressure regulated source of dry filtered nitrogen gas (or other suitable reference gas).

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

7.2   Calibration of DFC Mass Flow Controllers

All adjustments to the DFC calibration and control loop tuning are accomplished using the RS485 (or optional RS232) interface in conjunction with setup and calibration software available from Aalborg®. The sensor zero is automatically adjusted internally whenever the control valve is fully closed (set point less than 2% of full scale) and the unit is warmed up.

DFC Mass Flow Meters may be field recalibrated/checked using the setup and calibration program for the same range they were originally factory calibrated for. Flow range changes may require a different Restrictor Flow Element (RFE). Additionally, a different Solenoid Valve Orifice for the DFC Mass Flow Controller (see Table VI) may also be required. Consult your distributor or Aalborg® for more information.

TABLE VI DFC SOLENOID VALVE ORIFICE SELECTION TABLE

ORIFICE PART NUMBER	FLOW RATE [N$_2$]
OR.010	Under 10 sccm
OR.020	10 to 1000 sccm
OR.040	1 to 5 slpm
OR.055	5 to 10 slpm
OR.063	10 to 15 slpm
OR.073	15 to 20 slpm
OR.094	20 to 50 slpm
OR.125	50 to 100 slpm

8.   TROUBLESHOOTING

8.1   Common Conditions

Your Mass Flow Controller was thoroughly checked at numerous quality control points during and after manufacturing and assembly operations. It was calibrated in accordance 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?

For best results it is recommended that instruments are returned to the factory for servicing. See section 1.3 for return procedures.

8.2   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.

8.3   Troubleshooting Guide

Indication	Likely Reason	Remedy
lack of reading or output	power supply off	check connection of power supply
	fuse blown (DFC)	disconnect DFC transducer from power supply; remove the shorting condition or check polarities; fuse resets automatically
	fuse blown (SDPROC)	disconnect power cord from AC supply; remove and inspect fuses at AC power input connector of SDPROC; replace as necessary
		REMOVE CAUSE OF SHORT CIRCUIT!
	filter screen obstructed at inlet	flush clean or disassemble to remove impediments or replace
	occluded sensor tube	flush clean or disassemble to remove impediments or return to factory for replacement
	pc board defect	return to factory for replacement
	valve adjustment wrong	re-adjust valve (section 6.2.4)
output reads at (+) or (-) saturation only	fuse blown (DFC)	disconnect DFC transducer from power supply; remove the shorting condition or check polarities; fuse resets automatically
		REMOVE CAUSE OF SHORT CIRCUIT!
flow reading does not coincide with the set point (DFC models only)	inadequate gas pressure	apply appropriate gas pressure
	filter screen obstructed at inlet	flush clean or disassemble to remove impediments or replace
	ground loop	signal and power supply commons are different
no response to set point (DFC models only)	inadequate gas pressure	apply appropriate gas pressure
	cable or connector malfunction	check cables and all connections or replace
	set point is too low (<2% of full scale)	re-adjust set point
	valve adjustment wrong	re-adjust valve (section 6.2.4)
unstable or no zero reading	gas leak	locate and correct
	pc board defective	return to factory for replacement

Indication	Likely Reason	Remedy
full scale output at "no flow" condition or with valve closed	defective sensor gas Leak	return to factory for replacement locate and repair
calibration off	gas metered is not the same as what meter was calibrated for composition of gas changed gas leak pc board defective RFE dirty occluded sensor tube filter screen obstructed at inlet transducer is not mounted properly	use matched calibration see K factor tables in APPENDIX 2 locate and correct return to factory for replacement flush clean or disassemble to remove impediments flush clean or disassemble to remove impediments or return to factory for replacement flush clean or disassemble to remove impediments or replace check for any tilt or change in the mounting of the transducer; generally, units are calibrated for horizontal installation (relative to the sensor tube)
DFC valve does not work in open position	incorrect valve adjustment pc board defect cable or connectors malfunction differential pressure too high insufficient inlet pressure	re-adjust valve (section 6.2.4) return to factory for replacement check cable and connectors or replace decrease pressure to correct level adjust appropriately
DFC valve does not work in close position	incorrect valve adjustment pc board defect cable or connectors malfunction orifice obstructed	re-adjust valve (section 6.2.4) return to factory for replacement check cable and connectors or replace disassemble to remove impediments or return to factory

9.   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 C_p are usually chosen at standard conditions of one atmosphere and 25° C.

If the flow range of a Mass Flow Controller or Controller 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:

$$Q_{O_2} = Q_a = Q_r \times K = 1000 \times 0.9926 = 992.6 \text{ sccm}$$

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

APPENDIX 1

COMPONENTS DIAGRAMS
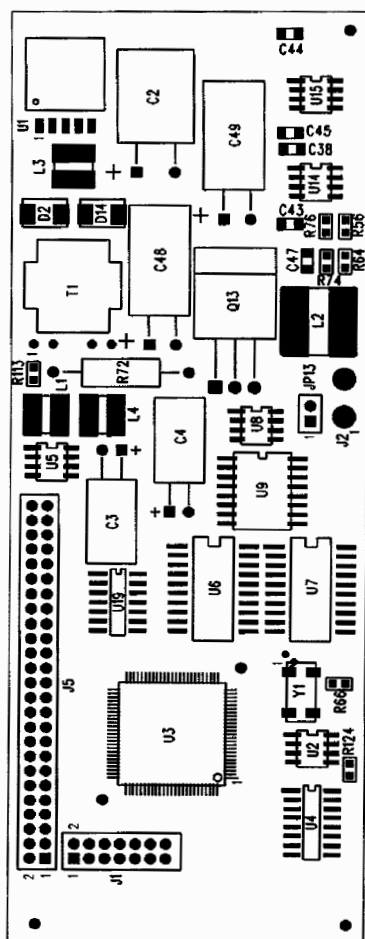
DFC Digital PC Board
(Primary Side)
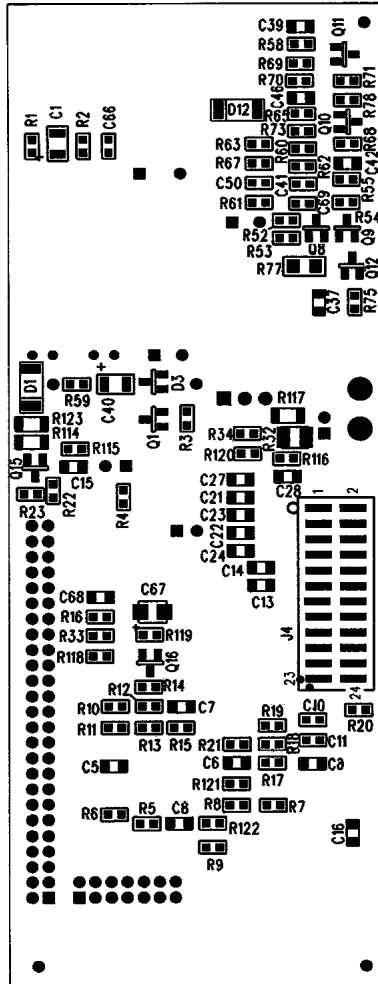
DFC Digital PC Board
(Secondary Side)

(CONTINUED)

DFC Analog PC Board
(Primary Side)

(CONTINUED)

DFC Analog PC Board
(Secondary Side)
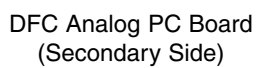
APPENDIX 2
GAS FACTOR TABLES ("K" FACTORS)

⚠ **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	1.4573	.1244	1.782
Argon AR-1 (>10 L/min)	1.205	.1244	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	.7382	.2016	1.964
Carbon Dioxide CO_2-1 (>10 L/min)	.658	.2016	1.964
Carbon Disulfide CS_2	.6026	.1428	3.397
Carbon Monoxide CO	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
Chlorotrifluromethane (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 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 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 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 3

DIMENSIONAL DRAWINGS

DFC 26 Mass Flow Controller
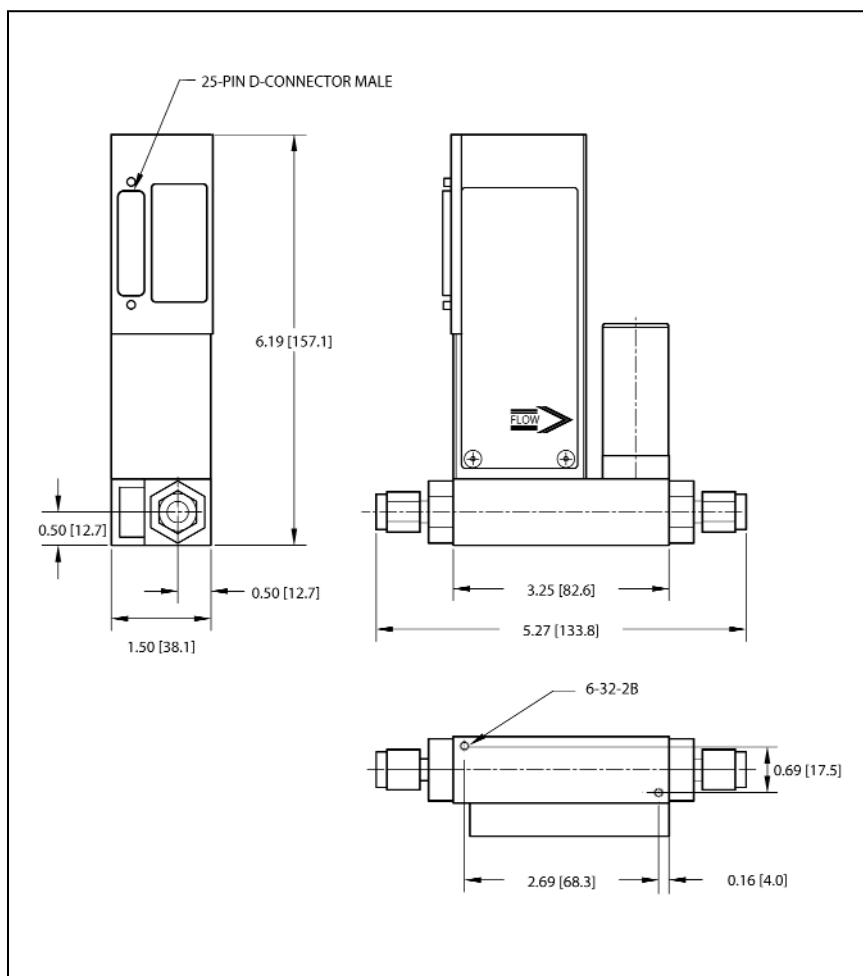
NOTES: Aalborg® reserves the right to change designs and dimensions at its sole discretion at any time without notice. For certified dimensions please contact Aalborg®.

DFC 36/46 Mass Flow Controller

25-PIN D-CONNECTOR MALE

6.58 [167.0]

0.63 [15.9]

0.63 [15.9]

1.88 [47.6]

FLOW

3.63 [92.1]

5.65 [143.5]
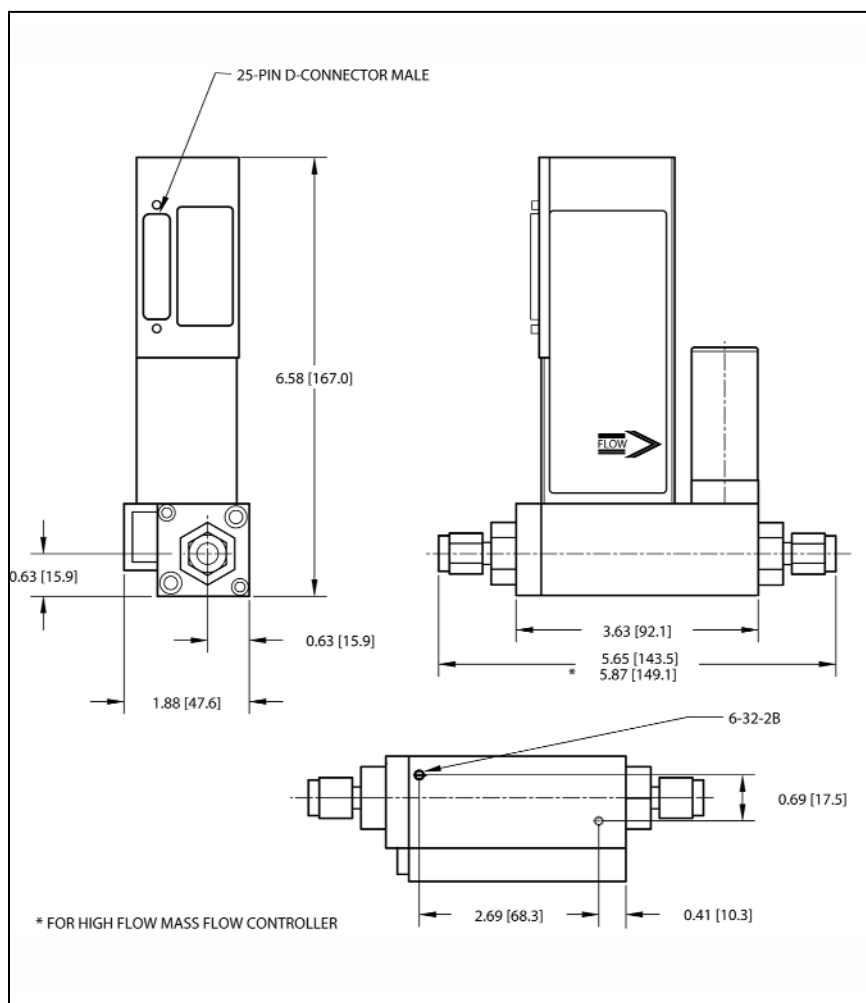* 5.87 [149.1]

6-32-2B

0.69 [17.5]

2.69 [68.3]

0.41 [10.3]

* FOR HIGH FLOW MASS FLOW CONTROLLER

NOTES: Aalborg® reserves the right to change designs and dimensions at its sole discretion at any time without notice. For certified dimensions please contact Aalborg®.

APPENDIX 4

SENDING COMMANDS TO THE DFC

RS485

The standard DFC comes with an RS485 interface. The protocol described below allows for the unit using either a custom software program or a "dumb terminal". All values are sent as printable ASCII characters. The start character is always !and the command string is terminated with a carriage return (line feeds are automatically stripped out by the DFC:

!<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 above.
Arg1 to Arg4	The command arguments from the table above. Multiple arguments are comma delimited.
CR	Carriage return character.
**	Default address for all units is 11.

Several examples of commands follow.
All assume that the DFC has been configured for address 15 (0F hex) on the RS485 bus:

1. To put the unit in digital mode: !0F,M,D<CR>
    The DFC will reply: !0FMD<CR>

2. To set the flow of 50% of FS: !0F,S,50.0<CR>
    The DFC will reply: !0FS50.0<CR>

3. To get a flow reading: !0F,F<CR>
    The DFC will reply: !0F50.0<CR>
                                               (Assuming the flow is at 50% FS)

4. Set the high alarm limit to 5% above Set point: !0F,A,H,5.0<CR>
    The DFC will reply: !0FA5.0<CR>

AALBORG DFC SOFTWARE INTERFACE COMMANDS

NOTE: An "*" indicates power up default settings.

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
Mode	Selects Analog or Digital mode for set point and feed back signals	1	M	A (sets analog mode)*				MA
				D (sets digital mode)				MD
				S (Returns Status)				MA or MD
Set Point	Sends the desired flow setting to the unit in digital mode	2	S	<Value> (Desired flow in current engineering units)				S <Value>
Flow	Requests the current sensor reading	3	F					<Value> (Actual flow in current engineering units)
Valve	Sets or reads the operating mode of the control valve. (Note:Hardware I/O overrides software command.)	4	V	A (Automatic Mode)*				VA
				O (Force Open)				VO
				C (Force Closed)				VC
				S (Return Status)				VA, VO or VC
Gas Select	Selects one of the ten primary gas calibration tables to use. Tables are entered via the MEM commands at time of calibration.	5	G	0 (gas 0)* to 9 (gas 9)				G1 through G10

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COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
Auto Zero	Sets/reads the status of the auto zero feature (Note: The Z,N command can take several minutes to complete. Unit will not respond to other commands when this is in progress)	6	Z	E (enable, do when SP<2% FS)*				ZE
				D (disable, never do it)				ZD
				N (do it now)				ZN
				W (Write Zero to SDPROC)				ZW(when done)
				S (status)				ZE, ZD or ZIN, <value> while Z,N is in progress.
Flow Alarms	Set/reads the status of the gas flow alarms.	7	A	H (high deviation)	<Value>			AH<Value>
				L (low deviation)	<Value>			AL<Valve>
				D (disable)*				AD
				S (status)				N (no alarm) H (high alarm) L (low alarm)
Relay Action	Assigns action of the two SPDT relays. The coil is energized when the condition specified by "Argument 2" becomes true.	8	R	1 (relay 1) 2 (relay 2)	N (no action, relay disabled)*			RN
					T (totalizer >limit)			RT
					H (high flow alarm)			RH
					L (low flow alarm)			RL
					R (Range between high & low flow alarm)			RR

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
					S (status)			RN, RT, RH, RL, RR
Totalizer	Controls action of the flow totalizer.	9	T	Z (set to zero)				TZ
				S (start the totalizer)	N (now)			TSN
					F (at flow)	<value> (gas flow)		TS <value>
				P (stop the totalizer)	N (now)			TPN
					T (at total)	<value> (gas volume)	N (no action) C (valve closed)	TPT {N/C} <valve>
				R (read the totalizer)				<value>(total gas volume)
				D (disable)*				TD
K Factors	Applies a gas correction factor to the currently selected primary gas calibration table. (NOTE: Does not work with %F.S. engineering unit. Changes take affect after next set point command).	10	K	D (disable, sets K=1)*				KD
				I (internal K factor table)	<index> (index to K factor)			KI <index><name> <value>
				E (user specified factor)	<value> (decimal correction factor)			KE <Value>
Units	Set the units of measure for the digital flow set point, flow signal and totalizer. Note: The units of the totalizer output are not per unit time.	11	U	% (%full scale)*				U%
				SLPM (standard liters per min.)				USLPM
				SLPH (standard liters per hr.)				USLPH

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
				MLPH (standard milliliters per min.)				UMLPM
				MLPH (standard milliliters per hour)				UMLPH
				SCFH (standard cubic feet per hour)				USCFH
				SCFM (standard cubic feet per min.)				USCFM
				LBPH (pounds per hour)				ULBPH
				LBPM (pounds per min.)				ULBPM
				UD (user defined)	<value>(conversion factor from SLPM)	Time Base: S = Seconds M= Minutes H= Hours		UUD<value>
Maintenance Timer	Hours since last time unit was calibrated.	12	C	R (read timer)				<value>
				C (set timer to zero)				CC
Full Scale	Returns the full scale rated flow in SLPM. (Note: This term is not multiplied by the current K factor)	13	E					<value>
Read Mem.	Reads the value in the specified memory location.	14	MR	0000 to 999 (Table Index)				<value>
Write Mem.	Writes the specified value to the specified memory location. Use CAREFULLY, can cause unit to malfunction.	15	MW	0000 to 999 (Table Index)	<value>			MWXXX<value> XXX=Table Index

COMMAND NAME	DESCRIPTION	NO.	COMMAND SYNTAX					
			COMMAND	ARGUMENT 1	ARGUMENT 2	ARGUMENT 3	ARGUMENT 4	RESPONSE
Auto Tune (Available for units with maximum flow up to 80L/min)	Performs Auto Tune	16	AT	<Value> (Desired flow in current engineering units, use 80-90% F.S. for best results)				AT<Value> (when auto tune starts)
			S (Status)					ATSI<Kp, Ki, Kd> (in progress) ATSD<Kp, Ki, Kd> (done)

APPENDIX 5

CALIBRATION TABLE: GAS INDEPENDENT VARIABLES

INDEX	NAME	DATA TYPE	NOTES
0	BlankSDPROC	char[10]	Do not modify. For internal use only.
1	SerialNumber	char[20]	
2	ModelNumber	char[20]	
3	SoftwareVer	char[10]	
4	TimeSinceCalHr	float	Time since last calibration in hours.
5	Options	uint	Misc. Options.
6	AOutOffset_mA	int	
7	AddressRS485	char[3]	Two character address for RS485 only.
8	AInScaleV	float	
9	AInOffsetV	float	
10	AInScale_mA	float	
11	AInOffset_mA	float	
12	AoutScaleV	float	
13	AoutScale_mA	float	
14	SensorZero	uint	
15	Klag[0]	float	
16	Klag[1]	float	
17	Klag[2]	float	
18	Klag[3]	float	
19	Klag[4]	float	
20	Klag[5]	float	
21	Reserved	float	
22	Reserved	float	
23	Reserved	float	
24	Reserved	float	
25	Reserved	float	
26	Reserved	float	
27	Kgain[0]	float	
28	Kgain[1]	float	

INDEX	NAME	DATA TYPE	NOTES
29	Kgain[2]	float	
30	Kgain[3]	float	
31	Kgain[4]	float	
32	Kgain[5]	float	
33	Reserved	float	
34	Reserved	float	
35	Reserved	float	
36	Reserved	float	
37	Reserved	float	
38	Reserved	float	
39	ValveTbl[0][open]	float	Index 0: Valve actuation. Must be 0.0.- Do Not Alter
40	ValveTbl[0][valve value]	uint	Index 0: Valve: D/A value - Do Not Alter
41	ValveTbl[1][flow]	float	Index 1: Actual valve opening in % FS. Do Not Alter
42	ValveTbl[1][valve value]	uint	Index 1: Valve D/A counts corresponding to flow. Do Not Alter
43	ValveTbl[2][flow]	float	Do Not Alter
44	ValveTbl[2][valve value]	uint	Do Not Alter
45	ValveTbl[3][flow]	float	Do Not Alter
46	ValveTbl[3][valve value]	uint	Do Not Alter
47	ValveTbl[4][flow]	float	Do Not Alter
48	ValveTbl[4][valve value]	uint	Do Not Alter
49	ValveTbl[5][flow]	float	Do Not Alter
50	ValveTbl[5][valve value]	uint	Do Not Alter
51	ValveTbl[6][flow]	float	Do Not Alter
52	ValveTbl[6][valve value]	uint	Do Not Alter
53	ValveTbl[7][flow]	float	Do Not Alter
54	ValveTbl[7][valve value]	uint	Do Not Alter
55	ValveTbl[8][flow]	float	Do Not Alter
56	ValveTbl[8][valve value]	uint	Do Not Alter
57	ValveTbl[9][flow]	float	Index 9: Valve fully open. Must be 1.0- Do Not Alter
58	ValveTbl[9][valve value]	uint	Index 9: D/A count for a fully open valve. Must be 4095.- Do Not Alter
59	AutoTune Time Constant	uint	Do Not Alter

CALIBRATION TABLE: GAS DEPENDENT VARIABLES

INDEX	NAME	DATA TYPE	NOTES
100	GasIdentifer	char[27]	
101	FullScaleRange	float	
102	StdTemp	float	
103	StdPressure	float	
104	StdDensity	float	
105	CalibrationGas	char[27]	
106	CalibratedBy	char[20]	
107	CalibratedAt	char[20]	
108	DateCalibrated	char[10]	
109	DateCalibrationDue	char[10]	
110	PID_Kp	float	
111	PID_Ki	float	
112	PID_Kd	float	
113	SensorTbl[0][Sensor Value]	uint	Index 0: Must be 120 (zero value)
114	SensorTbl[0][Flow]	float	Index 0: Must be 0.0 (zero PFS)
115	SensorTbl[1][Sensor Value]	uint	A/D value from sensor.
116	SensorTbl[1][Flow]	float	Actual Flow in PFS.
117	SensorTbl[2][Sensor Value]	uint	
118	SensorTbl[2][Flow]	float	
119	SensorTbl[3][Sensor Value]	uint	
120	SensorTbl[3][Flow]	float	
121	SensorTbl[4][Sensor Value]	uint	
122	SensorTbl[4][Flow]	float	
123	SensorTbl[5][Sensor Value]	uint	
124	SensorTbl[5][Flow]	float	
125	SensorTbl[6][Sensor Value]	uint	
126	SensorTbl[6][Flow]	float	
127	SensorTbl[7][Sensor Value]	unit	
128	SensorTbl[7][Flow]	float	

INDEX	NAME	DATA TYPE	NOTES
129	SensorTbl[8][Sensor Value]	uint	
130	SensorTbl[8][Flow]	float	
131	SensorTbl[9][Sensor Value]	uint	
132	SensorTbl[9][Flow]	float	
133	SensorTbl[10][Sensor Value]	uint	
134	SensorTbl[10][Flow]	float	Flow in PFS. Should be 1.0
135			
136			
137			

Note: Values will be available for selected gas only.

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.

⚠ CAUTION:

This product is not intended to be used in life support applications!

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