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</tbody>
</table>
1. **UNPACKING THE AFC MASS FLOW CONTROLLER**

1.1 **Inspect Package for External Damage**

Your AFC 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 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 AFC 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: It is the users responsibility to determine if the instrument is appropriate for their OXYGEN application, and for specifying O2 cleaning service if required. Aalborg is not liable for any damage or personal injury, whatsoever, resulting from the use of this instrument for oxygen.

Attitude sensitivity of the Mass Flow Controller is $\pm 15^\circ$. 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 AFC 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)!

AFC transducers are supplied with standard 1/4 inch (AFC 26 and 36) or 3/8 inch (AFC 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 entire system. (All AFC's are checked prior to shipment for leakage within stated limits. See specifications in this manual.)

2.2 Electrical Connections

AFC 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. A variable analog 0-5VDC reference input is required for AFC models. The Aalborg® SDPROC accessory Command Modules offer a convenient and compact means to fulfill these needs.

AFC transducers come with a 15 pin "D" connector. The pin diagram is provided on figure 2-3.
TABLE 2-1: AFC 15 PIN ‘D’ CONNECTOR CONFIGURATION

<table>
<thead>
<tr>
<th>PIN</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Chassis Ground</td>
</tr>
<tr>
<td>2</td>
<td>Common, Signal Ground For Pin 3</td>
</tr>
<tr>
<td>3</td>
<td>0–5 VDC Flow Signal</td>
</tr>
<tr>
<td>4</td>
<td>+15 VDC Power Supply</td>
</tr>
<tr>
<td>5</td>
<td>(-) 4–20 mA Flow Signal (optional)</td>
</tr>
<tr>
<td>6</td>
<td>+7 VDC for Local Set Point</td>
</tr>
<tr>
<td>7</td>
<td>(unassigned)</td>
</tr>
<tr>
<td>8</td>
<td>TTL Valve Off Control</td>
</tr>
<tr>
<td>9</td>
<td>Control Set Point Input 0-5 VDC</td>
</tr>
<tr>
<td>10</td>
<td>Common, Signal Ground for Pin 9</td>
</tr>
<tr>
<td>11</td>
<td>Common, Power Supply</td>
</tr>
<tr>
<td>12</td>
<td>Valve Test Point/Purge</td>
</tr>
<tr>
<td>13</td>
<td>(unassigned)</td>
</tr>
<tr>
<td>14</td>
<td>-15 VDC Power Supply</td>
</tr>
<tr>
<td>15</td>
<td>(+) 4–20 mA Flow Signal (optional)</td>
</tr>
</tbody>
</table>
**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 750mA 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 AFC 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, AFC model Mass Flow Controllers incorporate a proportionating solenoid valve. The closed loop control circuit of the AFC 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.
4. SPECIFICATIONS

FLOW MEDIUM: Please note that AFC 26/36/46 Mass Flow Controllers are designed to work with clean gases only. Never try to meter or control flow rates of liquids with any AFC’s.

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 AFC 26/36/46 Mass Flow Controllers

ACCURACY: ±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: ±0.2% of full scale.

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

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

RESPONSE TIME: AFC 26: 300ms time constant; approximately 1 second to within ±2% of set flow rate for 25% to 100% of full scale flow.

AFC 36/46: 600ms time constant; approximately 2 seconds to within ±2% of set flow rate for 25% to 100% of full scale flow.

GAS PRESSURE: 1000 psig (68.9 bars) maximum; optimum pressure is 20 psig (1.4 bars); 25 psig (1.7 bars gauge) for AFC 46.

MAXIMUM DIFFERENTIAL PRESSURES: 40 psig (2.61 bars) for AFC 46. 50 psig (3.34 bars) for AFC 26/ 36. Optimum differential pressure is 25 psid (1.7 bars). See Table IV for pressure drops associated with various flow rates.

GAS AND AMBIENT TEMPERATURE: 41°F to 122°F (5°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 10⁹ 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 (2000Ω minimum load impedance); 4-20 mA optional (50-500Ω 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).

**TRANSODUCER INPUT POWER:**

- **AFC 26:** (10 sLit/min max) +15 ±5% VDC, 80 mA max, 1.2 watts max; -15 ±5% VDC, 200 mA max; 3 watts max;
- **AFC 36:** (50 sLit/min max) +15 ±5% VDC, 80 mA max, 1.2 watts max; -15 ±5% VDC, 600 mA max, 9 watts max;
- **AFC 46:** (100 sLit/min max) +15 ±5% VDC, 80 mA max, 1.2 watts max; -15 ±5% VDC, 600 mA max, 9 watts max.

Power inputs are each protected by a 750mA M (medium time-lag) resettable fuse, and a 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 controllers as pertains to different flow media reacting with components of controllers. 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” (AFC 26/ AFC 36) or 3/8” (AFC 46) compression fittings standard; 1/8” or 3/8” compression fittings and 1/4” VCR® fittings are optional.

**TRANSODUCER INTERFACE CABLE:** Flat cable with female 15-pin “D” connector ends is standard. Optional shielded cable is available with male/female 15-pin “D” connector ends. [Cable length may not exceed 9.5 feet (3 meters)].

**4.2 CE Compliance**

AFC 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 AFC 26 LOW FLOW MASS CONTROLLERS*

<table>
<thead>
<tr>
<th>CODE</th>
<th>scc/min [N₂]</th>
<th>CODE</th>
<th>std liters/min [N₂]</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>0 to 10</td>
<td>07</td>
<td>0 to 1</td>
</tr>
<tr>
<td>02</td>
<td>0 to 20</td>
<td>08</td>
<td>0 to 2</td>
</tr>
<tr>
<td>03</td>
<td>0 to 50</td>
<td>09</td>
<td>0 to 5</td>
</tr>
<tr>
<td>04</td>
<td>0 to 100</td>
<td>10</td>
<td>0 to 10</td>
</tr>
<tr>
<td>05</td>
<td>0 to 200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>06</td>
<td>0 to 500</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## TABLE II AFC 36 MEDIUM FLOW MASS CONTROLLERS*

<table>
<thead>
<tr>
<th>CODE</th>
<th>standard liters/min [N₂]</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>0 to 15</td>
</tr>
<tr>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>31</td>
<td>30</td>
</tr>
<tr>
<td>32</td>
<td>40</td>
</tr>
<tr>
<td>33</td>
<td>50</td>
</tr>
</tbody>
</table>

## TABLE III AFC 46 HIGH FLOW MASS CONTROLLERS*

<table>
<thead>
<tr>
<th>CODE</th>
<th>standard liters/min [N₂]</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>41</td>
<td>80</td>
</tr>
<tr>
<td>42</td>
<td>100</td>
</tr>
</tbody>
</table>

* 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 AFC

<table>
<thead>
<tr>
<th>MODEL</th>
<th>FLOW RATE [std liters/min]</th>
<th>MAXIMUM PRESSURE DROP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>[mm H₂O]</td>
</tr>
<tr>
<td>AFC 26</td>
<td>up to 10</td>
<td>720</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>2630</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>1360</td>
</tr>
<tr>
<td>AFC 36</td>
<td>30</td>
<td>2380</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>3740</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>5440</td>
</tr>
<tr>
<td>AFC 46</td>
<td>60</td>
<td>7480</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>12850</td>
</tr>
</tbody>
</table>

### TABLE V APPROXIMATE WEIGHTS

<table>
<thead>
<tr>
<th>MODEL</th>
<th>WEIGHT</th>
<th>SHIPPING WEIGHT</th>
</tr>
</thead>
<tbody>
<tr>
<td>AFC 26 transmitter</td>
<td>2.20 lbs (1.00 kg)</td>
<td>3.70 lbs (1.68 kg)</td>
</tr>
<tr>
<td>AFC 36/46 transmitter</td>
<td>2.84 lbs (1.29 kg)</td>
<td>4.34 lbs (1.97 kg)</td>
</tr>
</tbody>
</table>
5. OPERATING INSTRUCTIONS

5.1 Preparation and Warm Up

It is assumed that the Mass Flow 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 turn the POWER switch to the ON position at the front panel of your SDPROC Command Module). Allow the Mass Flow Controller to warm-up for a minimum of 15 minutes.

During initial powering of the AFC transducer, the flow output signal will be indicating a higher than usual output. This is indication that the AFC 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 2-1.

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 of the 15-pin "D" connector (see Figure 2-3) on the top of the AFC transducer. The output flow signal is also available at the DATA connector on the rear panel of the SDPROC Command Module.

The default calibration is performed for 0-5 VDC output signal. If 4-20 mA output signal is used for flow indication on the AFC, the accuracy of the actual flow rate will be in the specified range (+1.0%) of full scale, but the total uncertainty of the output reading may be in the range of ±2.0% of full scale. Optional calibration for 4-20 mA output signal is available upon request at time of order.

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 optional RS232 or IEEE488 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

AFC 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 responds to an analog 0 to 5 VDC reference voltage. 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 (AFC 26) and 2 seconds (AFC 36/46) to within 2% of the final flow over 25 to 100% of full scale.

On pin 6 of the AFC transducer is a regulated and constant +5VDC output signal. This signal may be used in conjunction with a local set point potentiometer for flow setting.

![Local Set Point Potentiometer Connections](image)
It is recommended that a potentiometer between 5K to 100K ohm and capable of at least 10-turns or more for adjustment be used. Use the control potentiometer to command the percentage of flow desired.

Alternatively, a variable 0 to 5VDC analog signal may be applied directly to the SET POINT and COMMON connections of the AFC transducer (see Figure 2-1).

5.5 TTL, 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 by applying a (TTL compatible) high and low signal of +5 VDC and 0 VDC to pin 8, on the 15-pin "D" connector. When 0 VDC (LOW) signal is applied, the solenoid valve is not powered and therefore will remain normally closed. Conversely, a +5 VDC (HIGH) signal applied will allow the solenoid valve to remain active. The solenoid valve will remain active when the VALVE OFF pin remains "floating".

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

5.6 Valve Test/Purge

At times, it may be necessary to purge the flow system with a neutralizing gas such as pure dry nitrogen. The AFC transducer is capable of a full open condition for the solenoid valve, regardless of set point conditions. For AFC's utilizing +15VDC valve configuration, connecting the TEST pin 12 on 15-pin "D" connectors) to ground will fully open the valve. For AFC's with a +30VDC valve configuration, connecting the TEST pin to +15VDC will fully open the valve.

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 (AFC 26) or 60 micron (AFC 36/46) 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.
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 AFC 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 contaminant's. 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: 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.
6.2.3 AFC 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 contaminant's. 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 AFC

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 AFC 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. See section 7.2 for valve adjustment, to return the valve to functional use.]

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 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 appropriate relative correction factor should be recalculated - see section 9.

It is standard practice to calibrate Mass Flow Controllers with dry nitrogen gas at 70°F (21.1°C), 20 psig (1.4 bars) [25 psig (1.7 bars) for AFC 46] inlet pressure and 0 psig (0 bar) outlet pressure. It is best to calibrate the AFC 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 ±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.

Calibration potentiometer locations are illustrated in Figure 7-1.
7.2 Calibration of AFC Mass Flow Controllers

All adjustments in this section are made from the outside of the meter, there is no need to disassemble any part of the instrument.

AFC Mass Flow Controllers may be field recalibrated/checked for the same range they were originally factory calibrated for.

7.2.1 Disable Solenoid Valve

Remove the round plastic cap on top of the solenoid valve. Turn the set screw on top of the valve counterclockwise until it stops, to open the valve. Set the valve into PURGE mode. This step essentially bypasses the flow control properties of the transducer. The unit will now act as a mass flow meter.

⚠️ **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.

Follow steps outlined in section 7.2 and 7.3, then continue with step 7.4.2 below.
**7.2.2 Valve Adjustment**

Discontinue the PURGE mode (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 AFC just stops.

**7.2.3 Full Scale Flow Adjustment**

Fully open the flow regulator upstream of the AFC. Increase the inlet pressure to 20 psig (25 psig for AFC 46). Apply a +5.00 VDC set point reference. Using the calibrator check the flow rate. If necessary, adjust R21 to match the desired full scale flow rate. [In control mode, turning R21 clockwise will decrease the flow. Conversely, turning R21 counterclockwise will increase the flow through the AFC.]

**7.2.4 25% Flow Adjustment**

Change the set point to 1.25 VDC to control at 25% of full scale flow. Check the flow rate indicated against the flow calibrator. If the flow rate is not within ±0.75% of full scale, re-adjust the setting for potentiometer [R21], until the flow output is correct.

**7.2.5 50% Flow Adjustment**

Change the set point to 2.50 VDC to control at 50% of full scale flow. Check the flow rate indicated against the flow calibrator. If the flow rate is not within ±0.75% of full scale, re-adjust the setting for potentiometer [R45], until the flow output is correct.

**7.2.6 75% Flow Adjustment**

Change the set point to 3.75 VDC to control at 75% of full scale flow. Check the flow rate indicated against the flow calibrator. If the flow rate is not within ±0.75% of full scale, re-adjust the setting for potentiometer [R44], until the flow output is correct.

**7.2.7 100% Flow Adjustment**

Change the set point to 5.00 VDC to control at 100% of full scale flow. Check the flow rate indicated against the flow calibrator. If the flow rate is not within ±0.75% of full scale, re-adjust the setting for potentiometer [R43], until the flow output is correct.

Repeat steps 7.2.4 to 7.2.7 at least once more.
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?

### TABLE VI AFC SOLENOID VALVE ORIFICE SELECTION TABLE

<table>
<thead>
<tr>
<th>ORIFICE PART NUMBER</th>
<th>FLOW RATE [N₂]</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR.010</td>
<td>under 10 sccm</td>
</tr>
<tr>
<td>OR.020</td>
<td>10 to 1000 sccm</td>
</tr>
<tr>
<td>OR.040</td>
<td>1 to 5 slpm</td>
</tr>
<tr>
<td>OR.055</td>
<td>5 to 10 slpm</td>
</tr>
<tr>
<td>OR.063</td>
<td>10 to 15 slpm</td>
</tr>
<tr>
<td>OR.073</td>
<td>15 to 20 slpm</td>
</tr>
<tr>
<td>OR.094</td>
<td>20 to 50 slpm</td>
</tr>
<tr>
<td>OR.125</td>
<td>50 to 100 slpm</td>
</tr>
</tbody>
</table>
### 8.2 Troubleshooting Guide

<table>
<thead>
<tr>
<th>INDICATION</th>
<th>LIKELY REASON</th>
<th>REMEDY</th>
</tr>
</thead>
<tbody>
<tr>
<td>lack of reading or output</td>
<td>power supply off</td>
<td>check connection of power supply</td>
</tr>
<tr>
<td>fuse blown</td>
<td>disconnect AFC transducer from power supply; remove the shorting condition or check polarities; fuse resets automatically</td>
<td></td>
</tr>
<tr>
<td>fuse blown (SDPROC)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>filter screen obstructed at inlet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>occluded sensor tube</td>
<td></td>
<td></td>
</tr>
<tr>
<td>pc board defect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>valve adjustment wrong</td>
<td></td>
<td></td>
</tr>
<tr>
<td>output reads at (+) or (-) saturation only</td>
<td>fuse blown</td>
<td>disconnect AFC transducer from power supply; remove the shorting condition or check polarities; fuse resets automatically</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>REMOVE CAUSE OF SHORT CIRCUIT!</strong></td>
</tr>
<tr>
<td>flow reading does not coincide with the set point (AFC models only)</td>
<td>inadequate gas pressure</td>
<td>apply appropriate gas pressure</td>
</tr>
<tr>
<td></td>
<td>filter screen obstructed at inlet</td>
<td>flush clean or disassemble to remove impediments or replace</td>
</tr>
<tr>
<td></td>
<td>ground loop</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>REMOVE CAUSE OF SHORT CIRCUIT!</strong></td>
</tr>
<tr>
<td>no response to set point (AFC models only)</td>
<td>inadequate gas pressure</td>
<td>apply appropriate gas pressure</td>
</tr>
<tr>
<td></td>
<td>cable or connector malfunction</td>
<td>check cables and all connections or replace</td>
</tr>
<tr>
<td></td>
<td>set point is too low (&lt;2% of full scale)</td>
<td>re-adjust set point</td>
</tr>
<tr>
<td></td>
<td>valve adjustment wrong</td>
<td>re-adjust valve (section 7.4)</td>
</tr>
<tr>
<td>INDICATION</td>
<td>LIKELY REASON</td>
<td>REMEDY</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>unstable or no zero reading</td>
<td>gas leak</td>
<td>locate and correct</td>
</tr>
<tr>
<td></td>
<td>pc board defective</td>
<td>return to factory for replacement</td>
</tr>
<tr>
<td>full scale output at “no flow” condition or with valve closed</td>
<td>defective sensor</td>
<td>return to factory for replacement</td>
</tr>
<tr>
<td></td>
<td>gas leak</td>
<td>locate and repair</td>
</tr>
<tr>
<td>calibration off</td>
<td>gas metered is not the same as what meter was calibrated for</td>
<td>use matched calibration</td>
</tr>
<tr>
<td></td>
<td>composition of gas changed</td>
<td>see K factor tables in APPENDIX 2</td>
</tr>
<tr>
<td></td>
<td>gas leak</td>
<td>locate and correct</td>
</tr>
<tr>
<td></td>
<td>pc board defective</td>
<td>return to factory for replacement</td>
</tr>
<tr>
<td></td>
<td>RFE dirty</td>
<td>flush clean or disassemble to remove impediments</td>
</tr>
<tr>
<td></td>
<td>occluded sensor tube</td>
<td>flush clean or disassemble to remove impediments or return to factory for replacement</td>
</tr>
<tr>
<td></td>
<td>filter screen obstructed at inlet</td>
<td>flush clean or disassemble to remove impediments or replace</td>
</tr>
<tr>
<td></td>
<td>transducer is not mounted properly</td>
<td>check for any tilt or change in the mounting of the transducer; generally, units are calibrated for horizontal installation (relative to the sensor tube)</td>
</tr>
<tr>
<td>AFC valve does not work in open position</td>
<td>incorrect valve adjustment</td>
<td>re-adjust valve (section 7.4)</td>
</tr>
<tr>
<td></td>
<td>pc board defect</td>
<td>return to factory for replacement</td>
</tr>
<tr>
<td></td>
<td>cable or connectors malfunction</td>
<td>check cable and connectors or replace</td>
</tr>
<tr>
<td></td>
<td>differential pressure too high</td>
<td>decrease pressure to correct level</td>
</tr>
<tr>
<td></td>
<td>insufficient inlet pressure</td>
<td>adjust appropriately</td>
</tr>
<tr>
<td>AFC valve does not work in close position</td>
<td>incorrect valve adjustment</td>
<td>re-adjust valve (section 7.4)</td>
</tr>
<tr>
<td></td>
<td>pc board defect</td>
<td>return to factory for replacement</td>
</tr>
<tr>
<td></td>
<td>cable or connectors malfunction</td>
<td>check cable and connectors or replace</td>
</tr>
<tr>
<td></td>
<td>orifice obstructed</td>
<td>disassemble to remove impediments or return to factory</td>
</tr>
</tbody>
</table>
For best results it is recommended that instruments are returned to the factory for servicing. See section 1.3 for return procedures.

8.3 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.

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:

\[
K_{\text{gas}} = \frac{1}{d \times C_p}
\]

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\(^\circ\) 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

AFC METERING PC BOARD

AFC CONTROL PC BOARD
APPENDIX 2
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%.

<table>
<thead>
<tr>
<th>ACTUAL GAS</th>
<th>K FACTOR Relative to N₂</th>
<th>Cp [Cal/g]</th>
<th>Density [g/l]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetylene C₂H₂</td>
<td>.5829</td>
<td>.4036</td>
<td>1.162</td>
</tr>
<tr>
<td>Air</td>
<td>1.0000</td>
<td>.240</td>
<td>1.293</td>
</tr>
<tr>
<td>Allene (Propadiene) C₃H₄</td>
<td>.4346</td>
<td>.352</td>
<td>1.787</td>
</tr>
<tr>
<td>Ammonia NH₃</td>
<td>.7310</td>
<td>.492</td>
<td>.760</td>
</tr>
<tr>
<td>Argon Ar</td>
<td>1.4573</td>
<td>.1244</td>
<td>1.782</td>
</tr>
<tr>
<td>Argon AR-1 (&gt;10 L/min)</td>
<td>1.205</td>
<td>.1244</td>
<td>1.782</td>
</tr>
<tr>
<td>Arsine AsH₃</td>
<td>.6735</td>
<td>.1167</td>
<td>3.478</td>
</tr>
<tr>
<td>Boron Trichloride BCl₃</td>
<td>.4089</td>
<td>.1279</td>
<td>5.227</td>
</tr>
<tr>
<td>Boron Trifluoride BF₃</td>
<td>.5082</td>
<td>.1778</td>
<td>3.025</td>
</tr>
<tr>
<td>Bromine Br₂</td>
<td>.8083</td>
<td>.0539</td>
<td>7.130</td>
</tr>
<tr>
<td>Boron Tribromide Br₃</td>
<td>.38</td>
<td>.0647</td>
<td>11.18</td>
</tr>
<tr>
<td>Bromine PentaTrifluoride BrF₅</td>
<td>.26</td>
<td>.1369</td>
<td>7.803</td>
</tr>
<tr>
<td>Bromine Trifluoride Br₃F₃</td>
<td>.3855</td>
<td>.1161</td>
<td>6.108</td>
</tr>
<tr>
<td>Bromotrifluoromethane (Freon-13 B1) CBrF₃</td>
<td>.3697</td>
<td>.1113</td>
<td>6.644</td>
</tr>
<tr>
<td>1,3-Butadiene C₄H₆</td>
<td>.3224</td>
<td>.3514</td>
<td>2.413</td>
</tr>
<tr>
<td>Butane C₄H₁₀</td>
<td>.2631</td>
<td>.4007</td>
<td>2.593</td>
</tr>
<tr>
<td>1-Butene C₄H₈</td>
<td>.2994</td>
<td>.3648</td>
<td>2.503</td>
</tr>
<tr>
<td>2-Butene C₄H₈ CIS</td>
<td>.324</td>
<td>.336</td>
<td>2.503</td>
</tr>
<tr>
<td>2-Butene C₄H₈ TRANS</td>
<td>.291</td>
<td>.374</td>
<td>2.503</td>
</tr>
<tr>
<td>Carbon Dioxide CO₂</td>
<td>.7382</td>
<td>.2016</td>
<td>1.964</td>
</tr>
<tr>
<td>Carbon Dioxide CO₂-1 (&gt;10 L/min)</td>
<td>.658</td>
<td>.2016</td>
<td>1.964</td>
</tr>
<tr>
<td>Carbon Disulfide CS₂</td>
<td>.6026</td>
<td>.1428</td>
<td>3.397</td>
</tr>
<tr>
<td>Carbon Monoxide CO</td>
<td>1.00</td>
<td>.2488</td>
<td>1.250</td>
</tr>
<tr>
<td>Carbon Tetrachloride CCl₄</td>
<td>.31</td>
<td>.1655</td>
<td>6.860</td>
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<tr>
<td>Carbon Tetrafluoride (Freon-14)CF₄</td>
<td>.42</td>
<td>.1654</td>
<td>3.926</td>
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<tr>
<td>Carbonyl Fluoride COF₂</td>
<td>.5428</td>
<td>.1710</td>
<td>2.945</td>
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<tr>
<td>Carbonyl Sulfide COS</td>
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<td>.1651</td>
<td>2.680</td>
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<tr>
<td>Chlorine Cl₂</td>
<td>.86</td>
<td>.114</td>
<td>3.163</td>
</tr>
<tr>
<td>Chlorine Trifluoride ClF₃</td>
<td>.4016</td>
<td>.1650</td>
<td>4.125</td>
</tr>
<tr>
<td>Chlorodifluoromethane (Freon-22)CHClF₂</td>
<td>.4589</td>
<td>.1544</td>
<td>3.858</td>
</tr>
<tr>
<td>Chloroform CHCl₃</td>
<td>.3912</td>
<td>.1309</td>
<td>5.326</td>
</tr>
<tr>
<td>Chloropentafluoroethane(Freon-115)C₂ClF₅</td>
<td>.2418</td>
<td>.164</td>
<td>6.892</td>
</tr>
<tr>
<td>Chlorotrifluoromethane (Freon-13) CClF₃</td>
<td>.3834</td>
<td>.153</td>
<td>4.660</td>
</tr>
<tr>
<td>CyanogenC₂N₂</td>
<td>.61</td>
<td>.2613</td>
<td>2.322</td>
</tr>
<tr>
<td>CyanogenChloride CICN</td>
<td>.6130</td>
<td>.1739</td>
<td>2.742</td>
</tr>
<tr>
<td>Cyclopropane C₃H₅</td>
<td>.4584</td>
<td>.3177</td>
<td>1.877</td>
</tr>
<tr>
<td>ACTUAL GAS</td>
<td>K FACTOR Relative to N₂</td>
<td>Cp [Cal/g]</td>
<td>Density [g/l]</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>-------------------------</td>
<td>------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Deuterium D₂</td>
<td>1.00</td>
<td>1.722</td>
<td>1.799</td>
</tr>
<tr>
<td>Diborane B₂H₆</td>
<td>.4357</td>
<td>.508</td>
<td>1.235</td>
</tr>
<tr>
<td>Dibromodifluoromethane CBr₂F₂</td>
<td>.1947</td>
<td>.15</td>
<td>9.362</td>
</tr>
<tr>
<td>Dichlorodifluoromethane (Freon-12) CCl₂F₂</td>
<td>.3538</td>
<td>.1432</td>
<td>5.395</td>
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<tr>
<td>Dichlorofluoromethane (Freon-21) CHCl₂F</td>
<td>.4252</td>
<td>.140</td>
<td>4.592</td>
</tr>
<tr>
<td>Dichloromethylsilane (CH₃)₂SiCl₂</td>
<td>.2522</td>
<td>.1882</td>
<td>5.758</td>
</tr>
<tr>
<td>Dichlorosilane SiH₂Cl₂</td>
<td>.4044</td>
<td>.150</td>
<td>4.506</td>
</tr>
<tr>
<td>Dichlorotetrafluoroethane (Freon-114) C₂Cl₃F₄</td>
<td>.2235</td>
<td>.1604</td>
<td>7.626</td>
</tr>
<tr>
<td>1,1-Difluoroethylene (Freon-1132A) C₂H₂F₂</td>
<td>.4271</td>
<td>.224</td>
<td>2.857</td>
</tr>
<tr>
<td>Dimethylamine (CH₃)₂NH</td>
<td>.3714</td>
<td>.366</td>
<td>2.011</td>
</tr>
<tr>
<td>Dimethyl Ether (CH₃)₂O</td>
<td>.3896</td>
<td>.3414</td>
<td>2.055</td>
</tr>
<tr>
<td>2,2-Dimethylpropane C₃H₁₂</td>
<td>.2170</td>
<td>.3914</td>
<td>3.219</td>
</tr>
<tr>
<td>Ethane C₂H₆</td>
<td>.50</td>
<td>.420</td>
<td>1.342</td>
</tr>
<tr>
<td>Ethanol C₂H₆O</td>
<td>.3918</td>
<td>.3395</td>
<td>2.055</td>
</tr>
<tr>
<td>Ethyl Acetylene C₄H₆</td>
<td>.3225</td>
<td>.3513</td>
<td>2.413</td>
</tr>
<tr>
<td>Ethyl Chloride C₂H₅Cl</td>
<td>.3891</td>
<td>.244</td>
<td>2.879</td>
</tr>
<tr>
<td>Ethylene C₂H₄</td>
<td>.60</td>
<td>.365</td>
<td>1.251</td>
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<tr>
<td>Ethylene Oxide C₂H₄O</td>
<td>.5191</td>
<td>.268</td>
<td>1.965</td>
</tr>
<tr>
<td>Fluorine F₂</td>
<td>.9784</td>
<td>.1873</td>
<td>1.695</td>
</tr>
<tr>
<td>Fluoroform (Freon-23) CHF₃</td>
<td>.4967</td>
<td>.176</td>
<td>3.127</td>
</tr>
<tr>
<td>Freon-11 CCl₃F</td>
<td>.3287</td>
<td>.1357</td>
<td>6.129</td>
</tr>
<tr>
<td>Freon-12 CCl₂F₂</td>
<td>.3538</td>
<td>.1432</td>
<td>5.395</td>
</tr>
<tr>
<td>Freon-13 CClF₃</td>
<td>.3834</td>
<td>.153</td>
<td>4.660</td>
</tr>
<tr>
<td>Freon-13B1 CBrF₃</td>
<td>.3697</td>
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AFC 36/46 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®.
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NOTE: Follow Return Procedures In section 1.3.