1152C

Vapor Source Mass-Flo® Controller

Many new processing techniques, such as MOMBE (CBE) for III-V compounds, silicon deposition using TEOS, and plasma polymerization are placing increased demands on mass flow control techniques. All of the above applications use source materials that are liquids or solids at room temperature and require heating to increase the vapor source pressure.

MKS Thermal Mass Flow Controllers (MFCs) have gained wide acceptance due to their proven use in many difficult control applications, and are widely used in traditional "bubbler systems" employed in the past and present to deliver these hard-to-handle source materials. However, thermal mass flow meters require a specific internal temperature profile for optimum operation. Thus, the elevated source temperature required to develop sufficient pressure for these devices to work often precludes their use without a carrier gas. This means another flow measurement technique must be used. Our extensive experience with precision pressure measurement instrumentation made the addition of a pressure measurement-based mass flow meter and controller a natural extension of this technology, and led to the development of the 1152.

Product Features

- Deliver source vapor without the need of a carrier gas system, for precise and repeatable vapor source delivery
- Wide operating temperature range (30°C to 150°C) for delivery of a variety of source materials
- Precise temperature control of source material, as needed in carrier gas systems, is not required
- Temperature output is provided to monitor the mechanical assembly's temperature, preventing condensation

Key Benefits

- All-metal seal design eliminates contamination due to permeation of elastomeric seals
- High level (0-5 VDC) output, which is proportional to mass flow of vapor, for indication of flow amount

The 1152 Vapor Source MFC is a pressure-based measurement and control system designed to meter and control vapor from low vapor pressure liquid and solid sources directly, without the need of a carrier gas.

The 1152 MFC consists of a fixed flow element and two capacitance manometers for flow measurement, with a proportioning solenoid control valve for flow control (U.S. Patent No. 4,679,585). The 1152 has all components and associated circuitry contained within a compact temperature-controlled assembly with a temperature status LED and relay to indicate when temperature is in range. A temperature sensor and voltage output is available to indicate that the 1152 controller is at an elevated temperature to prevent vapor condensation within the mechanical assembly.

Extremely tight temperature control of the vapor source is not required with the 1152, as the control loop will compensate for minor inlet pressure variations. The source material simply needs to be heated to a minimum temperature to develop a sufficient upstream pressure to push the vapor into the processing chamber at the desired flow rate, and which accommodates the pressure drop caused by system plumbing and the 1152 controllers.

The 1152 is capable of delivering vaporized liquid source materials such as: TEOS, DADBS, HMDS, TMCTS, TEAL, TEB, TEG, TEI, TMAL, TMB, TMG, TMI, TaCl5, DMEAA, Ti[OCH(CH3)2]4, TiCl4, TIBAL, and TMP.

Mass-Flo® Measurement Theory

The 1152 is based on viscous laminar flow technology. The equation describing choked flow through an orifice is shown in Figure 1.

Figure 1, Equation 1, shows how the flow through a laminar flow element (LFE) is related to the pressure upstream and downstream of the LFE. Both upstream and downstream pressures of the flow elements must be monitored. Since the difference and sum of these pressures are required $[(P_1 - P_2) \times (P_1 + P_2)]$ to compute flow, circuitry for the measurement is also more advanced. The benefit of this approach is the upstream pressures need only be slightly higher than downstream or process pressures, minimizing heating requirements of the source material and allowing use at higher system pressures.

The equation may be simply noted as follows:

Flow through a laminar tube

$$Q = K (P_1^2 - P_2^2)$$

Where:

P_1 = upstream pressure

P_2 = downstream pressure

Q = mass flow

K = constant

Figure 1 - Gas Flow Measurement Equation

MKS has developed the capability to computer- configure the 1152 Vapor Source Flow Controller best suited to a particular material, flow rate, and system pressure. Given the necessary information, a computer generated plot of flow rate versus voltage is easily obtained for the user.

In application, the 1152 is placed downstream of the source material oven. Precise temperature control is not required as the unit control loop will compensate for inlet pressure variations. Delivery lines to or from the 1152 or from the source oven to the process system, should be as short as possible and heated. A positive temperature gradient should be maintained on the components and plumbing from the source oven to the process chamber to prevent condensation. Condensation causes oscillation in flow stability or non-repeatability in film deposition rates. Similar problems may occur in bubbler systems if one is not careful.

System Components

The critical pressure measurement in the 1152 is made by the reliable Baratron® capacitance manometer (Figure 2). With the 1152, two sensors are used. Components are assembled to the flow element body using nickel seals. The environment around the mechanical assembly of control valve, flow element, and sensor in the 1152 is temperature controlled up to 100°C (temperature control to 150°C is available upon request). Above the mechanical assembly in the 1152 is the pressure sensor signal conditioning and P.I.D. control loop circuitry. The valve driver output of the controller is sent to a solenoid-type proportioning valve upstream of the flow element to deliver the desired amount of gas flow to the process chamber.

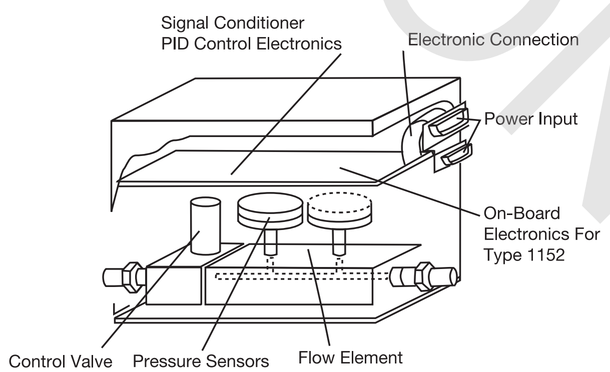
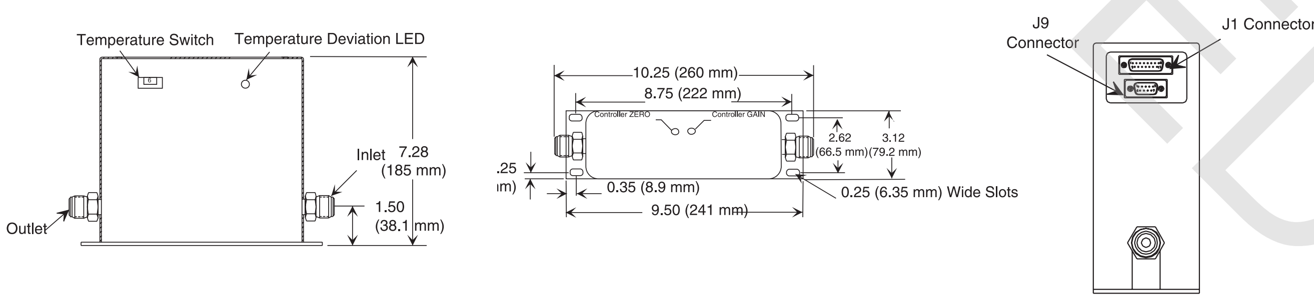


Figure 2 - Component Assembly

Accessories

Electrical requirements (power supply voltages, input command signal, and flow output signal) for the 1152 has been tailored to match those of thermal MFCs so minimum work is necessary to integrate these flow controllers into a system's gas control panel. The 1152 uses ±15 VDC for input power to the flow control electronics board, have a 0 to 5 VDC signal proportional to mass flow, and require a 0 to 5 VDC input for set point. Standard MKS electronic modules, such as the 946, may be used with the 1152 to form a complete system. Power for the 1152 heaters can be obtained from power supplies capable of providing the required current to generate the specified control temperature. Units up to 100°C require ±15 VDC power at 1.5A, while units up to 150°C require ±15 VDC power at 3.5A.



Dimensional Drawing — Unless otherwise specified, dimensions are nominal values in inches (mm referenced).

Specifications

Specifications	
Full Scale Ranges (N_2 equivalent)	1 to 1000 sccm typical (dependent upon source material)
Control Range	5.0 to 100% of Full Scale
Accuracy (including linearity and hysteresis)	±5.0% of Full Scale
Repeatability	±0.2% of Full Scale
Measurement Resolution	±0.1% of Full Scale
Operating Temperature Range — **Standard** / **Optional**	• 30°C to 100°C, adjustable • 90°C to 150°C
Setting Time (to 100% of Full Scale)	1 second to within 2% of set point
Input Power Required — **Meter/Controller** / **Heater**	• ±15 VDC (±2%) @ 0.28 Amps • ±15 VDC @ 1.5 Amps (3 Amps with 90°C to 150°C option)
Set Point Signal	0-5 VDC from <20K Ω (Although DC input impededance of the set point circuit is high, we recommend a relatively low set point drive signal impedance (1000 Ω or less) for good noise immunity when the unit is used in high RFI or EMI environments.)
Output Flow Signal	0-5 VDC into >10K Ω
Temperature Output	10 mV/°C (0°C=0 VDC)
Relay Contact Ratings	2 Amps @ 28 VDC; 1 Amp @ 120 VAC resistive
Connector Type — **Signal** / **Heater**	• 15-pin Type "D", RFI/EMI shielded • 9-pin Type "D", RFI/EMI shielded
Maximum Line Pressure	35 psia
Leak Integrity — **To atmosphere** / **Through closed valve**	• <1 x 10^{-9} scc/sec He • <1% of Full Scale or 1 sccm, whichever is greater (for specific applications, consult MKS Applications Engineering)
Process Wetted Materials	Inconel, 316 S.S., nickel, Elgiloy®
Mounting Position	Do not mount upside-down
Fittings	Swagelok® 8 VCR® male
Weight	7.9 lbs (3.59 kg)

Ordering Code Example: 1152C-1234V

Ordering Code Example: 1152C-1234V	Configuration
Model	
1152C Mass-Flo Controller	1152C
File Numbers	
To be provided by MKS Applications Engineering Group	1234V

Note

MKS Instruments has developed computer design programs for the 1152 that use various physical properties of the vapor source material to analyze the performance of those materials. The programs are a combination of vacuum system design routines used to determine pressure drops in upstream and downstream piping, and solutions to the generalized flow equations for viscous choked flow. This allows the determination of the best combination of source and MFC temperatures, pressure transducer(s) range, control valve size, and flow element to meet the particular customer requirement. These programs do not address the thermal stability or reactivity of the vapor phase material. MKS Instruments cannot be responsible for any reaction of the source material at the temperature required or any physical deposition of the source material or its reaction products in the flow controller. Please contact MKS Applications Engineering Group with information regarding your application for determination of an appropriate 1152 system configuration.

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