

1150C

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 1150.

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 1150 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 1150 MFC consists of a fixed flow element and one capacitance manometer for flow measurement, with a proportioning solenoid control valve for flow control (U.S. Patent No. 4,679,585). The 1150 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 1150 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 1150, 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 1150 controllers.

The 1150 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.

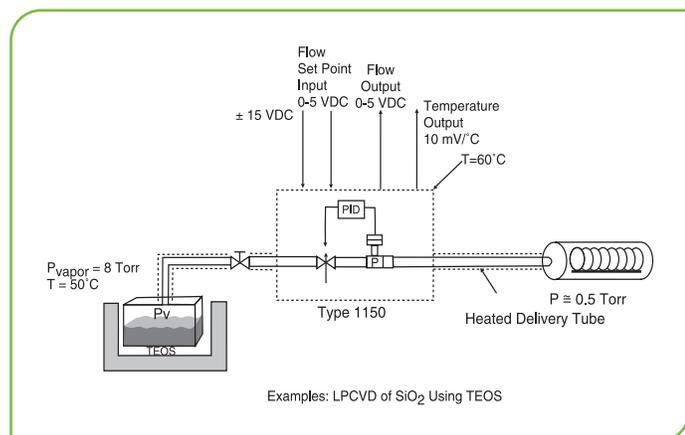
Mass-Flo® Measurement Theory

The 1150 is based on viscous choked 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 choked orifice is related to the pressure upstream of that orifice. An absolute pressure measurement before the orifice is required. Choked flow is achieved when the upstream pressure (P₁) is approximately twice the downstream pressure (P₂). This condition can limit the dynamic range of accurate measurement; however, the control range repeatability is not compromised. (Upon entering non-choked flow, mass flow becomes a function of the upstream and downstream pressure ratio times the upstream pressure). Since the upstream pressure must be twice the downstream pressure, this system is best suited for applications in which processing system pressure is less than a few Torr.

MKS has developed the capability to computer-configure the 1150 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 1150 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 1150 or from the source oven to the process system, should be



System Integration

The equation may be simply noted as follows:

Flow through a choked orifice

$$Q = CP_1$$

Where:

P₁ = upstream pressure

Q = mass flow

C = constant

Figure 1 - Gas Flow Measurement Equation

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 1150 is made by the reliable Baratron® capacitance manometer (Figure 2). With the 1150, one sensor is 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 1150 is temperature controlled up to 100°C (temperature control to 150°C is available upon request). Above the mechanical assembly in the 1150 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.

Accessories

Electrical requirements (power supply voltages, input command signal, and flow output signal) for the 1150 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

1150 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 1150 to form a complete system. Power for the 1150 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.

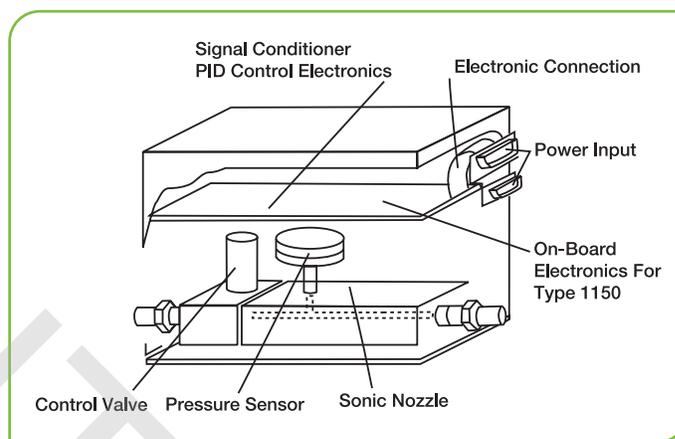
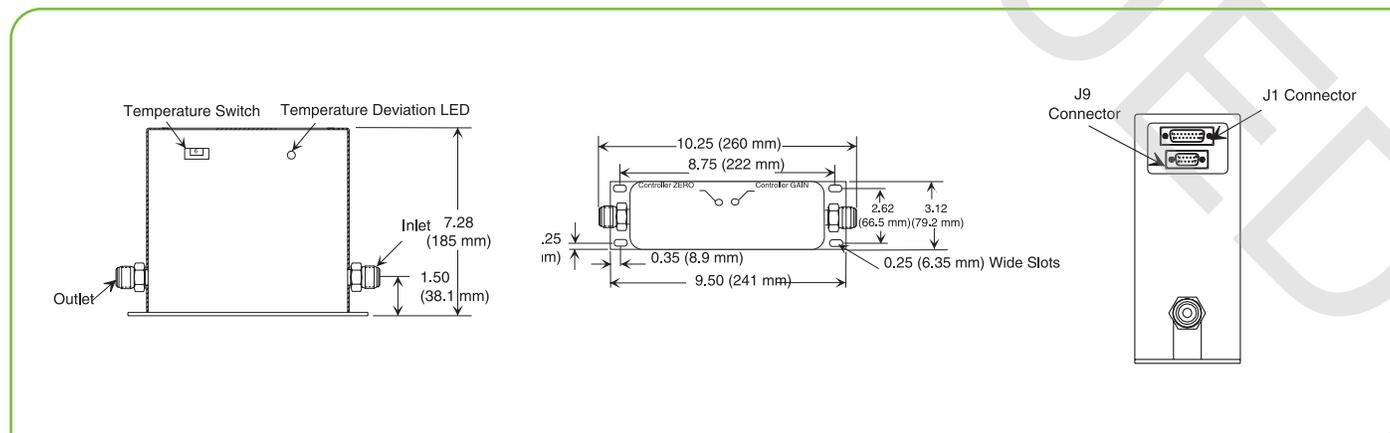


Figure 2 - Component Assembly



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

Specifications

Full Scale Ranges (N₂ 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • ±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 impedance 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • <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: 1150C-4567V

	Configuration
Model	
1150C Mass-Flo Controller	1150C
File Numbers	
To be provided by MKS Applications Engineering Group	4567V
Note	

MKS Instruments has developed computer design programs for the 1150 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 1150 system configuration.