



## Model FT1 Gas Mass Flow Meter For Industrial Applications

- 2nd Generation DDC-Sensor™: Robust, non-cantilevered design
- Gas-SelectX®: menu of field selectable gas compositions
- Zero CAL-CHECK® Calibration Validation
- Insertion and Inline styles
- FC10 Flow Conditioners for use with insertion meters
- Measures gas flow rate in SCFM, MSCFD, KG/HR, & many more
- Wide measurement range: up to 1000:1 turndown; 100:1 typical
- 4-20mA for flow rate or temperature; HART option
- Choice of second output: pulse output for flow/total, RS485 Modbus RTU, or BACnet MS/TP
- USB port to connect to a PC, standard
- Free FT1 View™ Software available
- Welded, 316 SS sensor and flow body construction, Carbon Steel flow body optional
- Microprocessor based, field-programmable electronics
- Optional on-board 2 line x 16 character, backlit display with configuration panel
- NIST traceable calibration
- Low-end sensitivity for leak detection
- Negligible pressure drop
- FM (U.S.) & FMc (CANADIAN) approved for Class I, Div 1; ATEX/IECEx approved for Zone 1
- NEMA 4 and CE Mark
- 2015 Flow Control Innovation Award Winner
- Processing's 2015 Breakthrough Product Award Winner

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# Model FT1

## Thermal Mass Flow Meter & Temperature Transmitter



### DDC-Sensor™ Technology

The Fox Thermal DDC-Sensor™ is a state-of-the-art sensor technology used in the Fox Thermal Model FT1 Thermal Gas Flow Meter. The DDC-Sensor™, a Direct Digitally Controlled sensor, is unlike other thermal flow sensors available on the market. Instead of using traditional analog circuitry, the DDC-Sensor™ is interfaced directly to the FT1 microprocessor for more speed and programmability. The DDC-Sensor™ accurately responds to changes in process variables (gas flow rate, pressure, and temperature) to determine mass flow rate, totalized flow, and temperature.

Fox Thermal's DDC-Sensor™ provides a technology platform for calculating accurate gas correlations. The FT1 correlation algorithms allow the meter to be calibrated on a single gas in the factory while providing the user the ability to select other gases in the Gas-SelectX® menu. With its DDC-Sensor™ and advanced correlation algorithm, the FT1 is a precision, multi-gas-capable thermal gas flow meter.

### Gas-SelectX® Gas Selection Menu

Customers need a fast solution to their monitoring needs. For these cases, Fox Thermal has developed the Gas-SelectX® gas menu feature for the Model FT1 flowmeter. Gas-SelectX® allows the user to choose from a menu of several common gases or gas mixtures for their application. Available gases: Air, Argon, Butane, Carbon Dioxide, Ethane, Methane, Natural Gas (NAESB composition), Nitrogen, Oxygen, Helium, Hydrogen, Propane, & gas mix (mix of any five gases in this list to create a custom gas composition totalling 100%).

The meter's proprietary algorithms allow the user to switch gases or gas mixes in the field, as needed. This makes the FT1 ideal for measurement of Digester Gas, Liquefied Petroleum Gas (LPG) and a variety of other biogases. Whether you need to measure natural gas or air, CO2 or digester gas, the FT1 brings these options and more to the user with a push of a button.

## THERMAL MASS TECHNOLOGY

### Fast and Flexible Gas Flow Measurement

Offering you the flexibility to monitor multiple gas types at the push of a button, rotate the housing as needed for tight installations, and configure meter settings from advanced software, the Model FT1 thermal mass flow meter and temperature transmitter can be used in a large variety of industrial and commercial gas flow measurement applications.

#### Theory of Operation

Fox Thermal flow meters use a constant temperature differential (constant  $\Delta T$ ) technology to measure the mass flow rate of gases. The thermal mass flow sensor consists of 2 Resistance Temperature Detectors (RTD's).

The Reference RTD measures the gas temperature. The instrument electronics heat the mass flow sensor, or heated element, to a constant temperature differential (constant  $\Delta T$ ) above the gas temperature and measures the cooling effect of the gas flow. The electrical power required to maintain a constant temperature differential is directly proportional to the gas mass flow rate.



*The Model FT1 flowmeter and temperature transmitter is approved for FM/FMc Class I, Division 1, ATEX/IECEX Zone 1. CE Mark.*

## MODEL FT1

### Fox Thermal Model FT1 Thermal Gas Mass Flow Meter Features

The Fox Thermal Model FT1 measures gas flow rate in standard units without the need for temperature or pressure compensation. It provides an isolated 4-20mA output (with a HART option) and a selection of pulse, RS485 Modbus RTU, or BACnet MS/TP for a second output.

With an optional on-board 2-line x 16-character, backlit display, operators can view flow rate, total, elapsed time, process gas temperature, and alarms. The display is also used in conjunction with the Configuration Panel to access flow meter settings, such as 4-20mA and pulse output scaling, pipe diameter, zero flow cutoff, flow filtering (damping), display options, and high or low alarm limits.

The Model FT1 is available in insertion and inline styles. The insertion style FT1 has a robust stainless steel probe and is easily installed by drilling a hole in the



*The DDC Sensor™ allows the user to swivel the probe  $\pm 180^\circ$  into four positions.*

pipe and welding on a 1" NPT coupling. A Fox Thermal-supplied compression fitting secures the probe in place. It is supplied with 316 stainless steel wetted materials standard. Inline styles of the FT1 are available in both stainless steel and carbon steel with NPT and 150lb flange options. See Specification section for details on sizing. A USB port to connect to a computer or laptop is standard; interface options include HART, RS485 Modbus RTU and BACnet MS/TP.

Fox Thermal has certified cleaning and bagging procedures for flow meters to be used in oxygen applications.

#### Advanced Features

Suitable for harsh and hazardous environments, the instrument features:

- Robust DDC-Sensor™ Design
- Gas-SelectX® with a selection of pure gases or a gas mix up to five gases
- Zero CAL-CHECK® Calibration Validation
- Rotatable probe: allows  $\pm 180$  degree swivel
- FM/FMc, ATEX, IECEx approvals. CE mark.
- 10-30VDC power input, standard
- NIST-traceable calibration
- Free FT1 View™ Software
- High and low alarm limits
- Wetted materials are all welded, 316 stainless steel

Perfect for commercial and industrial applications, the Model FT1 is a superior flow measurement instrument with excellent accuracy!

### Zero CAL-CHECK®

For customers that need a quick and easy way to verify the calibration of the meter in the field, the Model FT1 offers the Zero CAL-CHECK® feature. This feature can be initiated through the meter's optional display configuration panel or the FT1 View™ Software. The test takes fewer than 5 minutes to run and produces a pass/fail result at the conclusion of the test. A fail result may indicate either a dirty sensor or the need to recalibrate.

If the Zero CAL-CHECK® test is performed using the FT1 View™ software, a Calibration Validation Certificate can be produced at the conclusion of the test. The certificate will show the date and time of the test along with meter data such as firmware version and meter serial number. This in situ calibration validation helps operators comply with environmental mandates and eliminates the cost and inconvenience of annual factory calibration.

### FC10 Flow Conditioners

Fox Thermal now offers flow conditioners for use with insertion meters. The FC10 meets the needs of users who require the shorter straight pipe run associated with inline style meters, but need the lower cost and easy installation of an insertion style flow meter.

The FC10 is installed between two flanges upstream of the insertion flow meter and used to correct irregular flow profiles due to elbows or obstructions upstream. Use of the FC10 helps ensure the highest flow meter accuracy.

### FT1 View™ Software

Fox Thermal has developed advanced software - FT1 View™ - a free PC-compatible application available for download from the Fox Thermal website. Connect your laptop, PC, or control station to the meter using the USB port interface to access the meter's data and configure the meter's settings.

FT1 View™ allows:

- Quick access to all configuration parameters with pop-up windows and pull down menus
- Selection of measurement units, flow and temperature ranges, alarm settings and more
- Print or save a Zero CAL-CHECK® Calibration Validation Certificate
- Set alarms; display alarm codes
- Storage of meter configurations to a file that can be archived
- Simulation mode used to align 4 to 20mA output with the input to customer's PLC/DCS
- Raw data to be viewed in order to diagnose or troubleshoot your meter
- Data logging to an Excel™ spreadsheet

## APPROVALS & SPECIFICATIONS

### Approvals

CE Mark: Approved

EMC Directive: 2014/30/EU

Emissions and Immunity Testing: EN61326-1:2013

Pressure Equipment Directive: 97/23/EC

Weld Testing: EN ISO 15614-1 and EN ISO 9606-1, ASME B31.3

FM (U.S.) & FMc (CANADA): Approved

Class I, Division 1, Groups B, C, D; Class II, Division 1, Groups E, F, G; and Class III, Division 1; T4, Ta = -40° to 70°C; Class I, Zone 1, AEx/Ex db IIB + H2 T4; Gb Ta = -40°C to 70°C; Type 4X, IP66/67

ATEX (FM16ATEX0013X): Approved

II 2 G Ex db IIB + H2 T4; Gb Ta = -40°C to 70°C; IP66/67

II 2 D Ex tb IIIC T135°C; Db Ta = -40°C to 70°C; IP66/67

IECEx (IECEx FMG 16.0010X): Approved

Ex d IIB + H2 T4; Gb Ta = -40°C to 70°C; IP66/67

Ex tb IIIC T135°C; Db Ta = -40°C to 70°C; IP66/67

ATEX and IECEx Standards:

EN 60079-0:2012 + A11:2013 IEC 60079-0:2011

EN 60079-1:2014 IEC 60079-1:2014

EN 60079-31:2014 IEC 60079-31:2013

EN 60529:1991 + A1:2000 IEC 60529:2001

### Performance Specs

Flow Accuracy:

Air: ±1% of reading ±0.2% of full scale

Other gases: ±1.5% of reading ±0.5% of full scale

Accuracy specification applies to customer's selected flow range

Maximum range: 15 to 25,000 SFPM (0.07 to 120 NMPS)

Minimum range: 15 to 500 SFPM (0.07 to 2.4 NMPS)

Straight, unobstructed pipe requirement:

Insertion: 15 diameters upstream; 10 downstream.

Inline: 8 diameters upstream; 4 downstream.

Flow Repeatability: ±0.2% of full scale

Flow Response Time: 0.8 seconds (one time constant)

Temperature Accuracy: ±1° F (±0.6° C)

Calibration:

Factory Calibration to NIST traceable standards

Zero CAL-CHECK®: In-situ, operator-initiated calibration validation

# SPECIFICATIONS

## Operating Specs

### Gas-SelectX® Gas Selections:

Air, Argon, Butane, Carbon Dioxide, Ethane, Methane, Natural Gas (NAESB gas composition), Nitrogen, Oxygen, Helium, Hydrogen, Propane, 5-gas mix (any five gases in this list equalling 100%). See the Fox Thermal website for more information on current gases.

### Units of Measurement:

SCFM, SCFH, NM3/M, NM3/H, NM3/D, NLPS, NLPM, NLPH, MCFD, MSCFD, SCFD, MMSCFD, MMSCFM, SM3/D, SM3/H, SM3/M, LB/S, LB/M, LB/H, LB/D, KG/S, KG/M, KG/H, SLPM, MT/H

### Gas Pressure (maximum; at 100°F):

Insertion meter: 300 psig (20 barg)\*  
 Inline meter: NPT 300 psig (20 barg); ANSI 150 flange 230 psig (16 barg)  
 Retractor: 150 psig (10.3 barg)  
 Check with factory for higher pressure options.  
 \*NOTE! When teflon ferrule option ordered, maximum gas pressure is 60psig (4.1 barg).

### Relative Humidity: 90% RH maximum; non-condensing

### Temperature:

DDC-Sensor™: -40 to 250°F (-40 to 121°C)  
 Enclosure: -40 to 158°F (-40 to 70°C)\*\*  
 \*\*NOTE! Display dims below -4°F (-20°C); function returns once temperature rises again.

### Flow Velocity Range: 15 to 25,000 SFPM at 70°F (0.07 to 120 NMPS at 0°C)

Turndown: up to 1000:1; 100:1 typical

| Flow Ranges - Insertion Meters |            |            |            |
|--------------------------------|------------|------------|------------|
| Pipe Diameter                  | SCFM       | MSCFD      | NM3/H      |
| 1.5" (40mm)                    | 0 - 354    | 0 - 510    | 0 - 558    |
| 2" (50mm)                      | 0 - 583    | 0 - 840    | 0 - 920    |
| 2.5" (63mm)                    | 0 - 830    | 0 - 1,310  | 0 - 1,200  |
| 3" (80mm)                      | 0 - 1,280  | 0 - 1,840  | 0 - 2,020  |
| 4" (100mm)                     | 0 - 2,210  | 0 - 3,180  | 0 - 3,480  |
| 6" (150mm)                     | 0 - 5,010  | 0 - 7,210  | 0 - 7,910  |
| 8" (200mm)                     | 0 - 8,680  | 0 - 12,500 | 0 - 13,700 |
| 10" (250mm)                    | 0 - 13,600 | 0 - 19,600 | 0 - 21,450 |
| 12" (300mm)                    | 0 - 19,400 | 0 - 27,900 | 0 - 30,600 |

NOTE! To determine if the FT1 will operate accurately in other pipe sizes, divide the maximum flow rate by the pipe area. The application is acceptable if the resulting velocity is within the velocity range above. Check Fox Thermal website for velocity calculator.

| Flow Ranges - Inline Meters |           |           |           |
|-----------------------------|-----------|-----------|-----------|
| Pipe Diameter               | SCFM      | MSCFD     | NM3/H     |
| 0.75"                       | 0 - 93    | 0 - 134   | 0 - 146   |
| 1"                          | 0 - 150   | 0 - 216   | 0 - 237   |
| 1.25"                       | 0 - 260   | 0 - 374   | 0 - 410   |
| 1.5"                        | 0 - 354   | 0 - 510   | 0 - 558   |
| 2"                          | 0 - 583   | 0 - 840   | 0 - 920   |
| 2.5"                        | 0 - 830   | 0 - 1,310 | 0 - 1,200 |
| 3"                          | 0 - 1,280 | 0 - 1,840 | 0 - 2,020 |
| 4"                          | 0 - 2,210 | 0 - 3,180 | 0 - 3,480 |
| 6"                          | 0 - 2,500 | 0 - 3,600 | 0 - 3,950 |

NOTE! Consult factory for flow ranges above those listed. Inline meters above 2,500 SCFM (3,950 NM3/H) may require third party calibration. Contact Fox Thermal.

Input power: 12 to 28 VDC, 6 watts max.  
 Full input power range: 10 to 30 VDC.

### Outputs:

One standard isolated 4-20mA output for flow or temperature; fault indication per NAMUR NE43; HART communication option.  
 Second output for pulse, RS485 Modbus RTU, or BACnet MS/TP.  
 Isolated pulse output: 5 to 24VDC, 20mA max., 0 to 100Hz for flow (the pulse output can be used as an isolated solid state output for alarms).

### Serial Communication:

USB connector for connecting to a laptop or computer is standard.  
 Optional isolated communication outputs: RS485 Modbus RTU, BACnet MS/TP.  
 Free PC-based software tool - FT1 View™ - provides complete configuration, remote process monitoring and data logging functions.

### 4-20mA and Pulse Verification:

Simulation mode used to align 4-20mA output and pulse output (if ordered) with the input to user's PLC/DCS.

## Physical Specs

Probe diameter: 3/4"

Sensor Material: 316 stainless steel

Enclosure: NEMA 4, aluminum, dual 3/4" FNPT conduit entries.

Fox Thermal recommends the following probe lengths (without insulation):

| Pipe Diameter              | Probe Length |
|----------------------------|--------------|
| 1.5" (40mm) to 6" (150mm)  | 6-inch       |
| 8" (200mm) to 12" (300mm)  | 9-inch       |
| 14" (350mm) to 18" (450mm) | 12-inch      |

Use equation below for selecting probe length of larger pipe sizes

Probe Lengths (LL\*) in inches (cm) =

6.0 (15.2)    9.0 (22.9)    12.0 (30.5)  
 15.0 (38.1)    18.0 (45.7)    24.0 (61.0)  
 30.0 (76.2)    36.0 (91.4)

\*See dimensional drawings on Fox Thermal website.

## Dimensional

Refer to dimensional drawings on Fox Thermal website.

### Equation for Selecting Probe Length

Probe length = 1/2 pipe ID (in inches) + 3" + thickness of insulation (if any). Round up to the next standard probe length available.

**FT1 Insertion Flow Meter**  
*MODEL CODES*

**MODEL FT1**

|                            | Code | Description   |
|----------------------------|------|---|
| <b>Parent Model No.*</b>   | FT1  | Insertion Mass Flow meter; 4 to 20 mA and USB outputs standard                      |
| <b>Feature 1: Probe*</b>   | 06I  | Insertion meter with 6-inch probe   |
|                            | 09I  | Insertion meter with 9-inch probe   |
|                            | 12I  | Insertion meter with 12-inch probe  |
|                            | 15I  | Insertion meter with 15-inch probe  |
|                            | 18I  | Insertion meter with 18-inch probe  |
|                            | 24I  | Insertion meter with 24-inch probe  |
|                            | 30I  | Insertion meter with 30-inch probe  |
|                            | 36I  | Insertion meter with 36-inch probe  |
|                            | 15R  | 15" Probe w/ 150 PSI retractor & full port valve - 1" male NPT, 316 SS wetted parts |
|                            | 18R  | 18" Probe w/ 150 PSI retractor & full port valve - 1" male NPT, 316 SS wetted parts |
|                            | 24R  | 24" Probe w/ 150 PSI retractor & full port valve - 1" male NPT, 316 SS wetted parts |
|                            | 30R  | 30" Probe w/ 150 PSI retractor & full port valve - 1" male NPT, 316 SS wetted parts |
|                            | 36R  | 36" Probe w/ 150 PSI retractor & full port valve - 1" male NPT, 316 SS wetted parts |
|                            |      |   |
| <b>Feature 2: Display*</b> | D0   | No Display and Configuration Panel  |
|                            | DD   | Include Rate/Total Display & Configuration Panel                                    |
|                            |      |   |
| <b>Feature 3: Outputs*</b> | P1   | 4 to 20mA + Pulse Output  |
|                            | BH   | 4 to 20mA/HART + Pulse Output   |
|                            | RS   | 4 to 20mA + RS 485 (Modbus RTU or BACnet MS/TP - Field selectable)                  |

**OPTIONS**

| Part # | Description                     |
|--------|---------------------------------|
| 108046 | 1.5" FC10 SS Flow Conditioner** |
| 108047 | 2" FC10 SS Flow Conditioner**   |
| 108048 | 2.5" FC10 SS Flow Conditioner** |
| 108049 | 3" FC10 SS Flow Conditioner**   |
| 108050 | 4" FC10 SS Flow Conditioner**   |
| 108051 | 5" FC10 SS Flow Conditioner**   |
| 108052 | 6" FC10 SS Flow Conditioner**   |
| 108053 | 8" FC10 SS Flow Conditioner**   |
| 108054 | 10" FC10 SS Flow Conditioner**  |

**OPTIONS**

| Part#  | Description                                      |
|--------|--|
| 890000 | Flow meter cleaned and bagged for Oxygen service |
| 999992 | Certificate of Conformance                       |
| 999995 | Certificate of Origin                            |
| 106012 | Extra instruction manual                         |
| 104870 | USB Cable, A-male/mini USB-B male, 6 feet        |
| 106415 | Teflon Ferrule Kit, 60 PSI max.                  |
| 100657 | Stainless Steel Tags                             |
| 106728 | 24VDC power supply with DIN mounting rail        |
| 106658 | Conduit Entry Adapter, 3/4" NPT to M20x1.5       |

**NOTES:** \* The Parent Model Number and one of each Feature must be specified.  
Example: FT1-09I-DD-RS  
\*\* FC10 Flow Conditioners are designed for use in schedule 40 pipes only

Insertion flow meters can be installed in 1.5" pipes or larger.  
Calculating Probe Length: position the Fox Sensor in the center of the pipe. Use the following to calculate the probe length:  
Probe Length = 1/2 pipe diameter (D) + 3" + insulation + retractor (for codes 15R through 36R, add 10"). Round up to next larger probe available.  
D = pipe diameter; Insulation = Thickness of insulation ( if any); Retractor = Dimension of retractor (10"), if supplied.  
Example 1: Pipe ID = 10", no insulation or retractor: 5" + 3" = 8". Round up to 9" probe (09I).  
Example 2: Pipe ID = 10" with retractor, no insulation: : 5" + 3" + 10"(retractor) = 18" (18R probe with retractor).

**FT1 Insertion Flow Meter  
MODEL CODES**

**MODEL FT1 INLINE METER**

| Feature Codes                      | Code | Description   |
|------------------------------------|------|---|
| Parent Model No.*                  | FT1  | Inline Mass Flow Meter  |
| <b>Feature 1 : Flow Body Size*</b> |      | <b>316 Stainless steel flow body</b>                                |
|                                    | 075P | 0.75 inch flow body, male NPT ends (schedule 40) 12" Face to Face   |
|                                    | 10P  | 1 inch flow body, male NPT ends (schedule 40) 12" Face to Face      |
|                                    | 125P | 1.25 inch flow body, male NPT ends (schedule 40) 12" Face to Face   |
|                                    | 15P  | 1.5 inch flow body, male NPT ends (schedule 40) 12" Face to Face    |
|                                    | 20P  | 2 inch flow body, male NPT ends (schedule 40) 12" Face to Face      |
|                                    | 25P  | 2.5 inch flow body, male NPT ends (schedule 40) 18" Face to Face    |
|                                    | 30P  | 3 inch flow body, male NPT ends (schedule 40) 18" Face to Face      |
|                                    | 075F | 0.75 inch flow body, 150# RF flanges (schedule 40) 12" Face to Face |
|                                    | 10F  | 1 inch flow body, 150# RF flanges (schedule 40) 12" Face to Face    |
|                                    | 125F | 1.25 inch flow body, 150# RF flanges (schedule 40) 12" Face to Face |
|                                    | 15F  | 1.5 inch flow body, 150# RF flanges (schedule 40) 12" Face to Face  |
|                                    | 20F  | 2 inch flow body, 150# RF flanges (schedule 40) 12" Face to Face    |
|                                    | 25F  | 2.5 inch flow body, 150# RF flanges (schedule 40) 18" Face to Face  |
|                                    | 30F  | 3 inch flow body, 150# RF flanges (schedule 40) 18" Face to Face    |
|                                    | 40F  | 4 inch flow body, 150# RF flanges (schedule 40) 18" Face to Face**  |
|                                    | 60F  | 6 inch flow body, 150# RF flanges (schedule 40) 24" Face to Face**  |
|                                    |      | <b>A106 Grade B Carbon steel pipe (+ A105 flanges - if ordered)</b> |
|                                    | 20PC | 2 inch, male NPT ends (schedule 40) 12" Face to Face                |
|                                    | 25PC | 2.5 inch, male NPT ends (schedule 40) 18" Face to Face              |
|                                    | 30PC | 3 inch, male NPT ends (schedule 40) 18" Face to Face                |
|                                    | 20FC | 2 inch, 150# RF flanges (schedule 40) 12" Face to Face              |
|                                    | 25FC | 2.5 inch, 150# RF flanges (schedule 40) 18" Face to Face            |
|                                    | 30FC | 3 inch, 150# RF flanges (schedule 40) 18" Face to Face              |
|                                    | 40FC | 4 inch, 150# RF flanges (schedule 40) 18" Face to Face **           |
|                                    | 60FC | 6 inch, 150# RF flanges (schedule 40) 24" Face to Face **           |
| <b>Feature 2: Display*</b>         | D0   | No Display and Configuration Panel                                  |
|                                    | DD   | Include Rate/Total Display & Configuration Panel                    |
| <b>Feature 3: Outputs*</b>         | P1   | 4 to 20mA + Pulse Output  |
|                                    | BH   | 4 to 20mA/HART + Pulse Output                                       |
|                                    | RS   | 4 to 20mA + RS 485 (Modbus RTU or BACnet MS/TP - Field selectable)  |

**OPTIONS**

| Part#  | Description  |
|--------|--|
| 890000 | Flow meter cleaned and bagged for Oxygen service   |
| 999995 | Certificate of Origin                              |
| 106012 | Extra Instruction Manual                           |
| 100657 | Stainless Steel Tags                               |
| 999992 | Certificate of Conformance                         |
| 106415 | Teflon Ferrule Kit, 60 psi max.                    |
| 106658 | Conduit Entry Adapter, 3/4" NPT to M20x1.5         |
| 106728 | AC to 24VDC Power converter with DIN mounting rail |
| 104870 | USB Cable, A-male/mini USB-B male, 6 feet          |

**Notes:** \* The Parent Model Number and one of each Feature must be specified.  
Example: FT1-10P-D0-P1

\*\* Above 2,500 SCFM (4,250 NM3H) consult factory for calibration charge.