SIEMENS

# Fume Hood Controller

# Application 940: 2-Position Constant Volume with Damper

## Application Note

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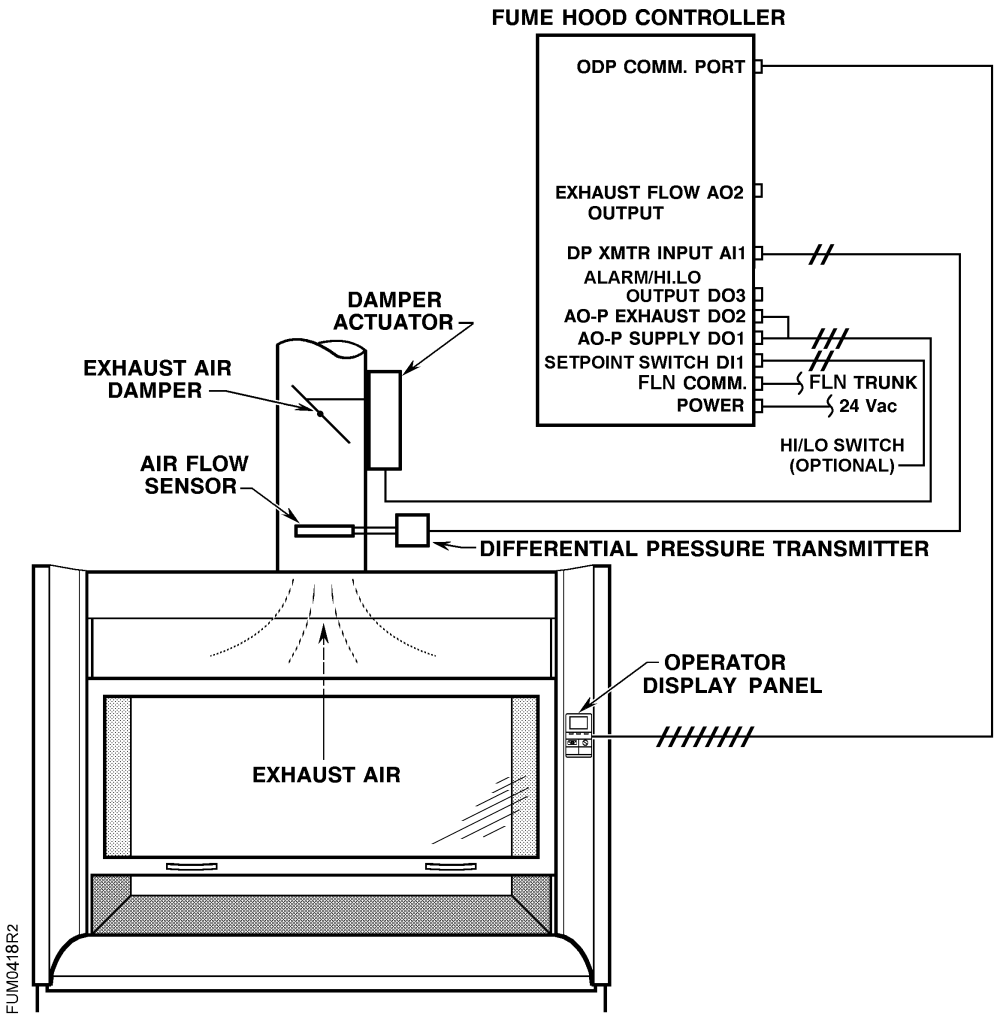
# Overview

Application 940 is designed for use with a constant volume or two position fume hood in a manifold fume hood exhaust system. In this application, two position fume hoods have an individual exhaust damper connected to a central fan. The application modulates the exhaust damper to maintain a high or low flow set point based on inputs from the ODP (Operators Display Panel), Digital Input, an exhaust air flow sensor and the controller setpoints. See Figure 1.




*Application 940 Control Diagram,*

# Hardware Inputs

## Analog

- Differential pressure transmitter/Linear Flow input (Vortex Shedder)

### Digital

- Operator Display Panel (ODP)
- Spare DI (High/Low select)

## Hardware Outputs

### Analog

- Operator Display Panel (ODP)
- AO2 (flow signal, 1 to 10 Vdc)

### Digital

- FLN communications trunk
- DO1 and DO2 Floating Control Actuation
- DO3 (24 Vac, Alarm/Hi/Low Output)
- Sash Alert

## Ordering Notes

| | |
|---|---|
| 546-00750A | 2-Position Constant Volume Fume Hood Controller – Application 940 |
| 546-00750AE | 2-Position Constant Volume Fume Hood Controller – Application 940 with enclosure |
| 546-00750BE | 2-Position Constant Volume Fume Hood Controller – Application 940 with enclosure and ODP assembly |

# Sequence of Operation

The following paragraphs present the sequence of operation for Fume Hood Controller Application 940, 2-Position Constant Volume Controller with Damper.

The Fume Hood Controller can operate at two different setpoints, described as HI flow and LOW flow setpoints. The low setpoint can be set to zero to send the controller into an OFF mode. The OFF mode shuts off the flow alarms, AO2 flow signal is locked at the last know value (this value will be close to the HI flow setpoint). The damper is closed and the controller enters into a standby mode of operation.

The Operators Display Panel (ODP) can display HI/LOW setpoint or output exhaust flow in CFM. Due to display limits, the actual number displayed is CFM divided by 10.

The Fume Hood Controller maintains the duct air flow at the flow setpoint, FLOW STPT. This is accomplished as follows:

**FLOW STPT** — The FLOW STPT will be equal to FLOW LO STPT or FLOW HI STPT, both of which are set to field requirements. The LOW or HI set point is determined by the state of DI STPT SW (DI 1) and ODP STPT SW (lower left ODP switch). The priority sequence of operation is shown in Table 1. If the FLOW LO STPT is set to zero, then controller will operate in an OFF mode.

**Table 2. FLOW STPT Priority Schedule.**

| IF | DI STPT SW | AND | ODP STPT SW | THEN | FLOW STPT |
|---|---|---|---|---|---|
| | LO | | LO | | LO |
| | LO | | HI | | HI |
| | HI | | LO | | HI |
| | HI | | HI | | HI |

**DO3 Output Functionality** — The function of DO3 is controlled by DO3 MODE. When DO3 MODE is equal to ALARM, then DO3 is turned ON when the ODP displays an alarm condition and OFF during normal operation. When DO3 MODE is equal to HI.LOW, then DO3 is ON while the controller is in LOW flow operation and OFF when the controller is in HI flow operation.

**AO2 FLOW SIG** — An analog signal of the exhaust flow is available at AO2 of the controller board and is displayed at AO2 FLOW SIG. To get an output from AO2 FLOW SIG, command AO2 RANGE to the maximum expected flow for the fume hood. Then AO2 is scaled such that 1 Vdc is equal to zero CFM and 10 Vdc is equal to AO2 RANGE. If the output drops below 1 Vdc this indicates a GENERAL FAILURE or loss of power. When the controller enters OFF mode, AO2 FLOW SIG remains at the last know value (this value will be close to the HI flow setpoint).

To obtain a better shutdown sequence, set FLOW LO STPT = 1 and use the network to monitor that point and then command the point to Zero to force the controller to enter the OFF mode.

When the corresponding input point is created in a Unitary Controller, an MBC or SCU, the slope and intercept must be calculated.

The value of AO2 is determined by the following conditions:

| Operating Condition | AO2 FLOW SIG Value |
|---|---|
| Normal/warning condition inside the range of AO 2 DEADBAND. | FLOW STPT |
| Normal/warning condition outside the range of AO 2 DEADBAND. | EXH STPT |
| Alarm and emergency purge condition | |

AO2 DEADBAND defaults to 5.2%. If FLOW STPT is 1000 cfm, AO2 FLOW SIG = FLOW STPT if the actual flow is between 948 and 1052 cfm (these values are approximate and will vary based on duct area). If the actual flow is outside these values AO2 FLOW SIG = EXH FLOW.

AO2 DEADBAND can be set from 0 to 102% in 0.4% increments. 0% will give the actual flow all the time. This signal may be too bouncy to give a stable output and will cause short-term room instability during fume hood sash movements. 5.2% removes most of the signal bounce, maintains tighter control of actual flow changes and maintains room stability during fume hood sash movements. Any value over 100% will turn the feature off and revert to standard control output flow setpoint while in all non-alarm conditions.

For stable pressure reading, lower the AO2 DEADBAND. For unstable pressure readings, raise the AO2 DEADBAND until the output signal stabilizes

# Control Loop

The PID loop controls the damper based on the values of EXH FLOW and FLOW STPT. The loop output, CTRL LOOPOUT, controls DO1 SUP and DO2 EXH through a time modulation scheme. The CTRL LOOPOUT ranges of -100 to 100%.

- -100% is the maximum supply which closes the damper at full speed.
- 0% holds the damper at its current position.
- 100% is the maximum bleed which opens the damper at full speed.

Example: if you command the point to -50, the valve will still drive closed but not as quickly as if it were commanded to -100.

# Actuation

The controller sends a separate signal to each of the two inputs that reside on the actuator or AO-P module. For values of 100% to 0%, the controller sends a decreasing percentage of the full signal length to the retract input (exhaust solenoid). For values of 0% to -100%, the controller sends an increasing percentage of the full signal to the extend input (supply solenoid).

# Actuator Operation

There are two options for using floating point control; commanding the actuator to extend or retract using proprietary pulsed control signal or the industry standard 3-position pulsed signals.

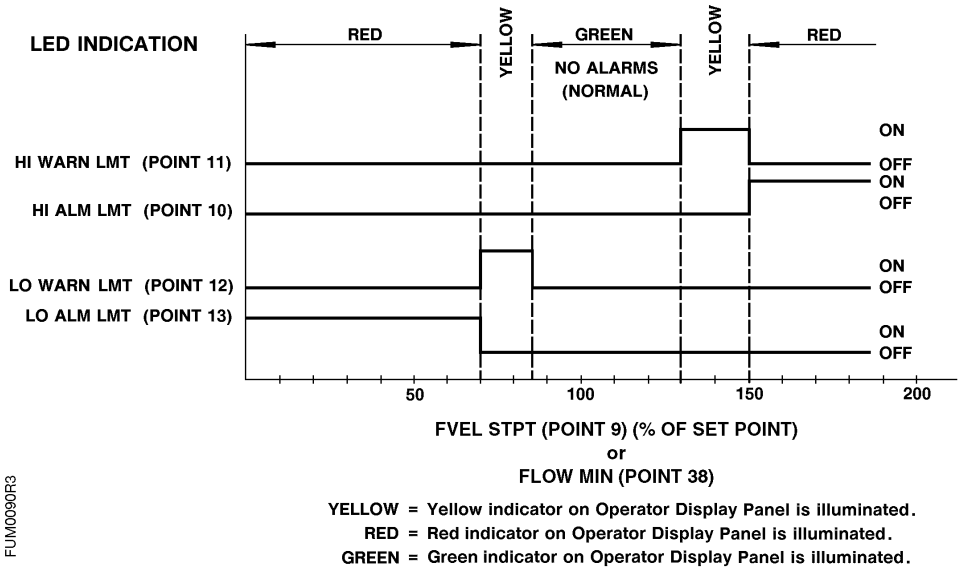
The default actuator operation is designed to use floating point control logic, where DO2 (the retract input or exhaust solenoid) is normally on and pulsed off as needed (DO2 INVERTER = NOPEN).

When using an actuator that does not use this type of floating point control logic, DO2 can be inverted to work with other standard actuators, set DO2 INVERTER to NCLOSE (normally off and pulsed on as needed).

# Warning Limits

The Fume Hood Controller contains high and low flow warning limits, HI WARN LMT and LOW WARN LMT, respectively. The warning limits are defined as a percentage of the controller set point; therefore, the warning limits apply to FLOW STPT during normal control. For either of the warnings to become active, the warning condition must be maintained for the time specified in ALARM TIME.

When the actual flow is greater than HI WARN LMT or less than LOW WARN LMT for a time greater than ALARM TIME, the yellow LED illuminates and HIGH WARN or LOW WARN turns ON.




*Warning and Alarm Schedule.*

# Alarm Limits

The Fume Hood Controller contains high and low flow alarm limits, HI ALM LMT and LOW ALM LMT, respectively. The alarm limits are defined as a percentage of the controller set point; therefore, the alarm limits apply to FLOW STPT during normal control. For either of the alarms to become active, the alarm condition must be maintained for the time specified in ALARM TIME.

When the actual flow is greater than HI ALM LMT or less than LOW ALM LMT for a time greater than ALARM TIME, the red LED illuminates, HIGH ALM or LOW ALM turns ON, the audible alarm on the Operator Display Panel sounds, “FLOW HI” or “FLOW LO” is displayed. See the Warning and Alarm Schedule figure.

# Horn Disable

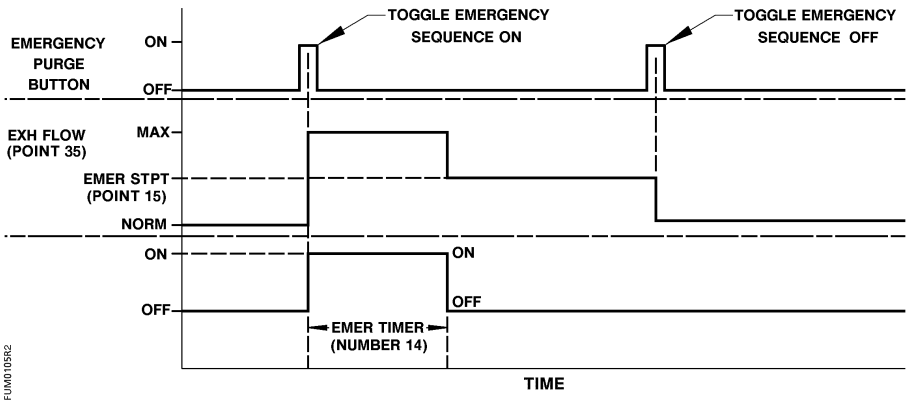
When HORN is DISABLE (disabled) the audible alarm will not sound.

When the alarm silence button is pressed, ALM AKNLG turns ON, the audible alarm turns OFF, and the red LED stays ON. The alarm descriptor remains until the flow returns to the normal range for the time set in ALARM TIME and ALM AKNLG turns OFF. Alarm limits always override any current warning limits.

# Emergency Mode

The emergency mode operation overrides any other control mode in the Fume Hood Controller. When the Emergency Purge Button on the ODP is pressed, the following sequence of events occurs.

1. EMER ALM turns ON, the horn sounds, and the red LED on the ODP illuminates. The ODP displays “EEE” and “EMERGENCY MODE”.
2. The Fume Hood Controller commands the damper to fully open for the time (in seconds) specified in EMER TIMER.
3. After EMER TIMER has timed out, the Fume Hood Controller controls the flow at the flow set point, FLOW STPT, multiplied by the emergency set point percentage, EMER STPT.
4. When the Emergency Purge Button is pressed a second time, the Fume Hood Controller reverts back to normal operation for the current conditions.




*Emergency Purge Schedule.*

**NOTE:**
**Norm** = Normal operation in which control is at the FLOW STPT.
**EMER STPT** = FLOW STPT increased by the value (%) of EMER STPT.
**MAX** = Maximum flow, where the damper is controlled to fully opened.

# Fail Mode

If the Fume Hood Controller or one of its accessories fails, then a failure mode sequence is initiated.

**Fume Hood Controller** - If the Fume Hood Controller power fails, the exhaust damper goes to the fully opened position. Since there is no power to the controller, no LEDs or displays are available on the ODP. If the power fails to both the exhaust fan and the controller, there is no indication except for the absence of the noise that the air makes during normal operation.

**Operator Display Panel** - If the ODP fails, then the Fume Hood Controller continues to control the flow. However, displays and audible alarms are not available.

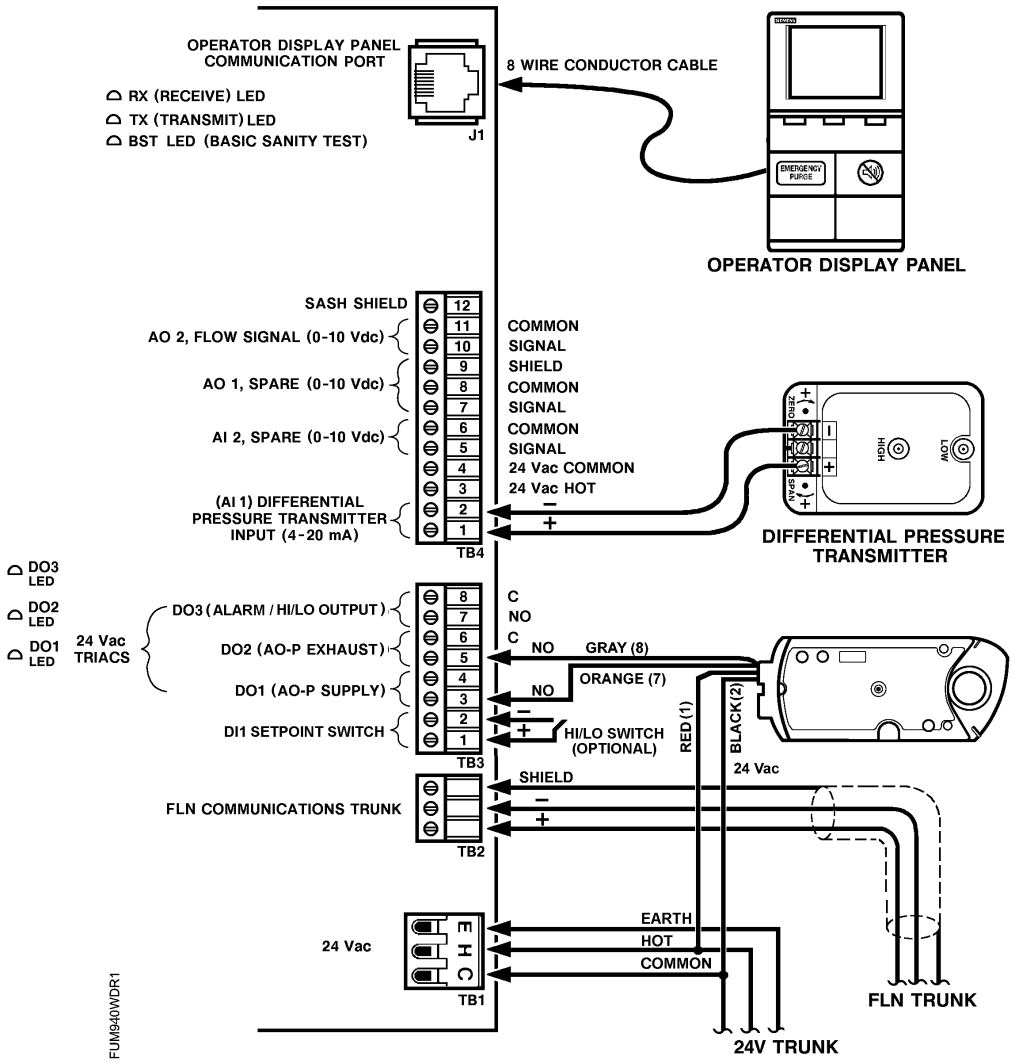
**Differential Pressure Transmitter** - If the differential pressure transmitter fails by losing the 4 to 20 mA signal, then GEN FAILURE turns ON, AO2 goes to zero Vdc, and the Fume Hood Controller controls the exhaust damper to the fully open position. The ODP displays “FFF” and “GENERAL FAILURE”.

**Pneumatic Damper Actuator** - If the damper actuator fails due to a leak, the damper goes to the fully opened position. Flow control is lost and the alarms are displayed on the ODP indicating unsafe operating conditions.

**Electronic Actuator** – If the actuator fails and flow control is lost, the ODP displays alarms indicating unsafe operating conditions.

Upon loss of power the actuator will fail based on the related dipswitch settings. By default the actuator fully retracts upon power failure.

# Wiring Diagram




*Application 940 Wiring Diagram.*

# Point Database Application 940

| Point Number [a), b)] | Descriptor | Factory Default (SI Units) [c)] | Eng Units (SI Units) [c)] | Slope (SI Units) [c)] | Intercept (SI Units) [c)] | On Text | Off Text |
|---|---|---|---|---|---|---|---|
| 1 | CTLR ADDRESS | 99 | -- | 1.000 | 0.000 | -- | -- |
| 2 | APPLICATION | 990 | -- | 1.000 | 0.000 | -- | -- |
| {05} | LOW ALM | OFF | -- | -- | -- | ON | OFF |
| {06} | HIGH ALM | OFF | -- | -- | -- | ON | OFF |
| {07} | EMER ALM | OFF | -- | -- | -- | ON | OFF |
| {08} | GEN FAILURE | OFF | -- | -- | -- | ON | OFF |
| 10 | HI ALM LMT | 150 | PCT | 1.000 | 0.000 | -- | -- |
| 11 | HI WARM LMT | 135 | PCT | 1.000 | 0.000 | -- | -- |
| 12 | LOW WARN LMT | 85 | PCT | 1.000 | 0.000 | -- | -- |
| 13 | LOW ALM LMT | 70 | PCT | 1.000 | 0.000 | -- | -- |
| 14 | EMER TIMER | 300 | SEC | 1.000 | 0.000 | -- | -- |
| 15 | EMER STPT | 150 | PCT | 1.000 | 0.000 | -- | -- |
| {16} | LOW WARN | OFF | -- | -- | -- | ON | OFF |
| {17} | HIGH WARN | OFF | -- | -- | -- | ON | OFF |
| {19} | ALM AKNLG | OFF | -- | -- | -- | ON | OFF |
| {27} | AO 2 DEADBAND | 5.2 | PCT | 0.4 | 0.000 | -- | -- |
| 30 | AO2 RANGE | 250 (117.7085) | CFM (LPS) | 1.00 (0.470834) | 0.000 | -- | -- |
| 34 | TRANS RANGE | 1.0 (249.1000064) | IN WC (PA) | 0.00390625 (0.9730469) | 0.00390625 (0.9730469) | -- | -- |
| {35} | EXH FLOW [d)] | 1.0 (0.0) | CFM (LPS) | 15.70588 (79.78588) | 0.000 | -- | -- |
| 36 | FLOW COEFF | 73 | PCT | 1.000 | 0.000 | -- | -- |
| {37} | FLOW STPT [d)] | 0.0 (0.0) | CFM (LPS) | 15.70588 (79.78588) | 0.000 | -- | -- |
| {38} | FLOW LO STPT | 706.7646 (3590.3646) | CFM (LPS) | 15.70588 (79.78588) | 0.000 | -- | -- |
| {40} | CAL DP TRANS | NO | -- | -- | -- | YES | NO |
| {41} | DO 1 SUP | CLOSE | -- | -- | -- | HOLD | CLOSE |
| {42} | DO 2 EXH | OFF | -- | -- | -- | ON | OFF |
| {43} | DO 3 | OFF | -- | -- | -- | ON | OFF |
| {44} | AI 1 DP TRANS | 0 | MA | 0.0784314 | 0.000 | -- | -- |
| {45} | AI 2 0.10V | 0 | VOLTS | 0.0392157 | 0.000 | -- | -- |
| {46} | AO 1 0.10V | 0 | PCT | 0.3921569 | 0.000 | -- | -- |
| {47} | AO 2 FLOW SIG [e)] | 0 | PCT | 0.3921569 | 0.000 | -- | -- |

| Point Number [a), b)] | Descriptor | Factory Default (SI Units) [c)] | Eng Units (SI Units) [c)] | Slope (SI Units) [c)] | Intercept (SI Units) [c)] | On Text | Off Text |
|---|---|---|---|---|---|---|---|
| {48} | DI 1 STPT SW | LO | -- | -- | -- | HI | LO |
| {54} | ODP DISPLAY | MODE | -- | -- | -- | CFM | MODE |
| {55} | DO 3 MODE | HI.LOW | -- | -- | -- | ALARM | HI.LOW |
| {56} | ODP STPT SW | HI | -- | -- | -- | HI | LO |
| {57} | RIGHT SW | OFF | -- | -- | -- | ON | OFF |
| 63 | FLOW P GAIN | 0.1 (19.685) | -- | 0.004 (0.7874) | 0.000 | -- | -- |
| 64 | FLOW I GAIN | 0.0 (0.0) | -- | 0.001 (0.1968504) | 0.000 | -- | -- |
| 66 | FLOW D GAIN | 0 (0.0) | -- | 0.002 (0.3937) | 0.000 | -- | -- |
| {67} | FLOW BIAS | 0.39168 | PCT | 0.78431 | -100 | -- | -- |
| {68} | CTRL LOOPOUT | -100 | PCT | 0.78431 | -100 | -- | -- |
| {87} | FLOW HI STPT | 2748.529 (13962.529) | CFM (LPS) | 15.70588 (79.78588) | 0.000 | -- | -- |
| {89} | HORN | ENABLE | -- | -- | -- | ENABLE | DISABL |
| 91 | BLANK DSPLY | NO | -- | -- | -- | YES | NO |
| {92} | DO 2 INVERTER | NOPEN | -- | -- | -- | NOPEN | NCLOSE |
| 93 | ENG UNITS | ENG | -- | -- | -- | SI | ENG |
| {94} | LAMP TEST | OFF | -- | -- | -- | ON | OFF |
| 96 | ALARM TIME | 5 | SEC | 1.000 | 0.000 | -- | -- |
| 97 | DUCT AREA | 0.545619887 (0.050687784) | SQ. FT (SQ M) | 0.000884311 (0.000082152) | 0.000 | -- | -- |
| 98 | LOOP TIME | 0.2 | SEC | 0.1 | 0.000 | -- | -- |
| {99} | ERROR STATUS | 0 | -- | 1.000 | 0.000 | -- | -- |

a) Points not listed are not used in this application.

b) A single value in a column means that the value is the same in English units and in SI units.

c) Point numbers that appear in brackets { } may be unbundled at the field panel.

d) If you unbundle this point, you must enter a new slope at the filed panel to display accurate readings in CFM (LPS). Calculate the new slope as follows: New Slope = Default Slope x Duct Area.

e) If you unbundle this point, and you want it to read in CFM (LPS), calculate the slope = 0.00436 x AO 2 RANGE and the intercept = -AO 2 RANGE, 9. If you want the point to read in PCT, use the slope and intercept listed.

Issued by
Siemens Industry, Inc.
Building Technologies Division
1000 Deerfield Pkwy
Buffalo Grove IL 60089
Tel. +1 847-215-1000