Manual Supplement

Model Number: **8650-MON**

Product/System Title: **Fume Hood Face Velocity and Flow Monitor**
Upgradable to Controller

Contents of this manual supplement include:

1) Sequence of operation
2) Application drawing
3) New menu structure
4) Description of new software items
5) Deleted software items
6) Modbus Communications
7) N2 Variable Map
8) Wiring diagram

Note: The Model 8650-MON will function as a monitor only. To access the control functions, contact your local representative or the IEG Division of TSI at (800) 874-2811.

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Sequence of Operation

Monitor mode

The Model 8650-MON continuously monitors the face velocity and volumetric flow rate of the fume hood. When the fume hood face velocity is in the user-configurable safe range, a green light is on. When the face velocity is either too low or too high, a red alarm light and an audible alarm turn on. Similarly, if the measured flow rate is too low or too high, the red alarm light and audible alarm will turn on.

The volumetric flow rate and face velocity measurements are only active when programmed to be. The 8650-MON can therefore be used to monitor only flow rates and face velocities.

Face velocity alarms have a higher priority than flow alarms. If both face velocity and flow alarms are active, only the face velocity alarm will initially be displayed. Once the face velocity alarm is cleared, then the flow alarm will display, provided that it is still active.

The current measured face velocity is always displayed when the face velocity sensor is enabled. If the face velocity sensor is disabled, then the current measured flow rate will be displayed. The current mode, either normal or the actual alarm mode, is also displayed. The flow alarms will not trip the high and low alarm relays.

The Model 8650-MON features alarm relays and RS-485 communications to communicate with a building management system. The Model 8650-MON also has an analog output of the measured face velocity, measured flow rate, or calculated sash opening. Modbus Communications and N2 Communications are installed on the Model 8650-MON fume hood face velocity monitors. This document provides the technical information needed to communicate between the host DDC system and the Model 8650 units. This document assumes the programmer is familiar with either Modbus or N2 protocol. Further technical assistance is available from TSI if your question is related to TSI interfacing to a DDC system. If you need further assistance regarding either Modbus or N2 protocol please contact Modicon Incorporated (for Modbus assistance) or Johnson Controls (for N2 assistance).

Controller mode

The Model 8650-MON can be upgraded and configured in the field to function as a face velocity and flow controller. As a controller, the Model 8650-MON continuously monitors and controls the fume hood face velocity by modulating the exhaust flow. The face velocity controller increases or decreases the exhaust flow by modulating either a duct-mounted damper or a variable frequency drive controlling the fan speed. A closed loop control system maintains the required face velocity by continuously measuring the face velocity and then adjusting the control output, as needed. This closed-loop control cycle occurs 20 times per second.

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The Model 8650-MON has user-programmable minimum and maximum flow set points. When controlling to a face velocity, the Model 8650-MON will not allow the flow to become greater than the maximum flow value, or less than the minimum flow value. In the event that the Model 8650-MON is controlling to a minimum or maximum flow, the face velocity may rise or drop to the point where a face velocity alarm is indicated. Additionally, if the face velocity sensor is disabled, then the Model 8650-MON will always control to the minimum flow volume.

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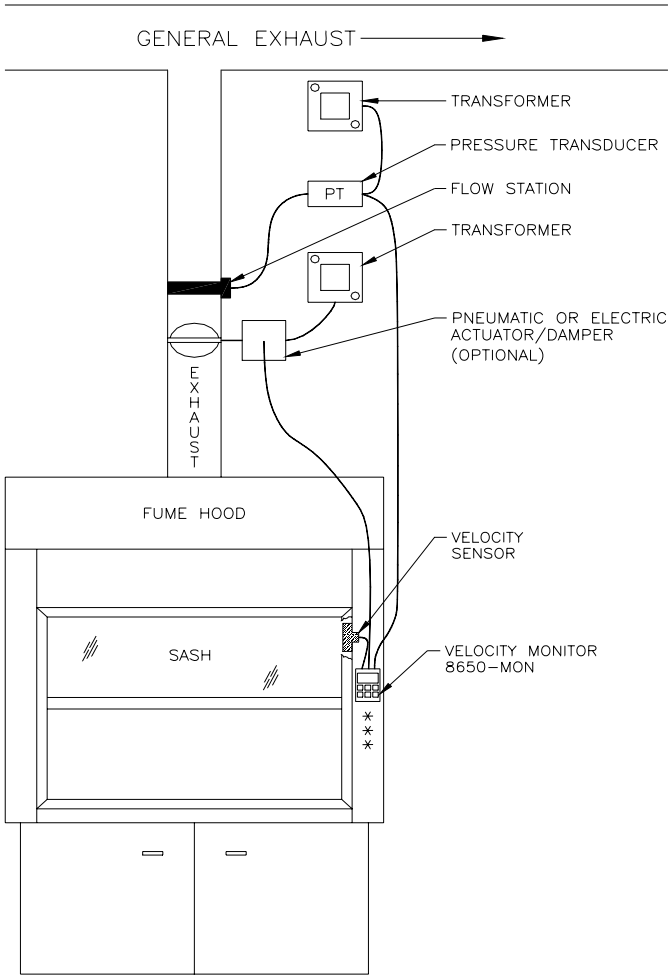
Application Drawing

MODEL 8650-MON
UPGRADEABLE FUME HOOD MONITOR
WITH CFM MEASUREMENT



TSI INCORPORATED
500 CARDIGAN ROAD
SHOREVIEW, MN 55126

TELEPHONE: 800-874-2811 FAX: 651-490-3824

ENGINEER:
SOLD TO:
PROJECT:
JOB NO.:
REP: DATE:

7/26/02

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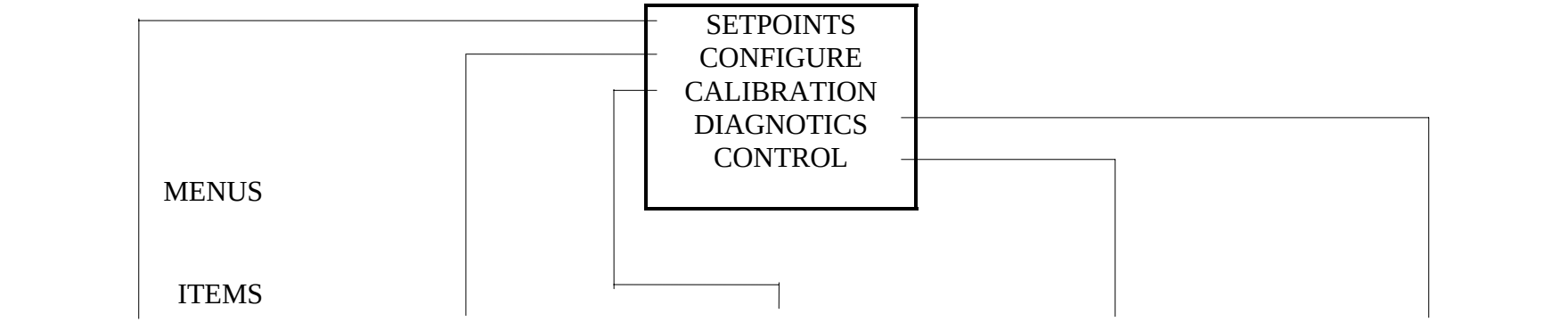
SUREFLOW MODEL 8650-MON MENU STRUCTURE



SETPOINTS
LOW ALARM
HIGH ALARM
SETB LOW AL
SETB HIGH AL
LOW FLOW ALM
HIGH FLO ALM
ACCESS CODE

CONFIGURE
DISPLAY AVG
UNITS
ALARM RESET
OUTPUT SIG
AUD. DISABLE
NET PROTOCOL
NET ADDRESS
DUCT AREA
ANALOG OUTPT
SENSOR ENABL
XDCR OUT
K FACTOR
FLO STA TYPE
TOP VELOCITY
ACCESS CODE

CALIBRATION
SENSOR ZERO
SENSOR SPAN
PRESSRE ZERO
FLOW MINIMUM
FLOW MAXIMUM
ACCESS CODE

CONTROL
CONTROL ENAB
CONTROL OUT
SETPOINT
SETBACK
MINIMUM FLOW
MAXIMUM FLOW
MIN DAMPER
MAX DAMPER
SENSITIVITY
SPEED
CONTROL SIG
Kc VALUE
Ti VALUE
ACCESS CODE

DIAGNOSTICS
ANALOG OUT
LOW RELAY
HIGH RELAY
EMERGENCY IN
FLOW
SENSOR INPUT
% OPEN AREA
ACCESS CODE

Project:	
Date:	
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Description of New Software Items

The Model 8650-MON has new software items, which allow the units to be calibrated and configured for each fume hood application. The new software items are located in various menus as shown in the attached Menu Structure drawing.

SETPOINTS MENU

Item	Description
SETB LOW AL	The **SETB LOW AL** menu item is used to set the setback low alarm set point. The **SETB LOW AL** is activated when the Model 8650-MON is in setback mode and the measured face velocity is below the **SETB LOW AL** set point. The **SETB LOW AL** has a range of from 5 to 945 ft/min, or it can be set to OFF. The default value is **20** ft/min.
SETB HIGH AL	The **SETB HIGH AL** menu item is used to set the setback high alarm set point. The **SETB HIGH AL** is activated when the Model 8650-MON is in setback mode and the measured face velocity is above the **SETB HIGH AL** set point. The **SETB HIGH AL** has a range of from 50 to 1000 ft/min. The default value is **100** ft/min.

CONFIGURE MENU

Item	Description
DUCT AREA	The **DUCT AREA** item is used to program the cross-sectional area of the duct where the flow station is mounted. Since the flow station and pressure transducer are used to measure duct velocity, the **DUCT AREA** is necessary to calculate the duct air flow

WARNING: If the proper **DUCT AREA** is not programmed into the Model 8650-MON, the flow measurement will be incorrect. Thus, all the other information that uses the flow measurement, such as minimum flow and percent sash open, will also be incorrect.

When this item is entered, the display will indicate a value in square feet (**sq ft**) or square meters (**sq m**). The displayed value ranges from 0.050 to 9.999 sq ft. The unit is sent out with a factory default of 0.500 **sq ft**. Pressing the ▲ and ▼ keys will change the displayed **DUCT AREA** in increments of 0.001.

Use the following equations to calculate the **DUCT AREA** (in **square feet**):

For **round** ducts:

$$\textbf{DUCT AREA} = \frac{3.14 * (\text{duct diameter in inches}/2)^2}{144}$$

For **rectangular** ducts:

$$\textbf{DUCT AREA} = \frac{(\text{width in inches}) * (\text{height in inches})}{144}$$

ANALOG OUTPT

The **ANALOG OUTPT** item is used to toggle the information output by the analog output. The analog output on the Model 8650-MON is either 0-10 VDC or 4-20 mA. The analog output can be configured to output either **VELOCITY**, **FLOW RATE**, or **OPEN AREA**.

The **ANALOG OUTPT** has a factory default of **VELOCITY** (face velocity). Pressing the ▲ or ▼ key toggles the **ANALOG OUTPT** to **OPEN AREA** and **FLOW RATE**. Use the chart on the next page for the ranges of each analog output option.

Analog Output	0 VDC	10 VDC
Option	4 mA	20 mA
VELOCITY	0 ft/min	1000 ft/min
FLOW RATE	0 CFM	max CFM*
OPEN AREA	0 % Open	100% Open

* Max CFM = (4005 * (**XDCR OUT**)$^{0.5}$) ft/min * **DUCT AREA** * **K FACTOR**

SENSOR ENABL — The **SENSOR ENABL** item is used to enable and disable the face velocity sensor. When the face velocity sensor is disabled, the Model 8650-MON will only monitor/control based on flow. The **SENSOR ENABL** item can be set to ON or OFF, with a default value of **ON**.

XDCR OUT — The **XDCR OUT** item is used to set the range of the pressure transducer for the flow rate measurement. The **XDCR OUT** has a range of from 0.1-0.5 in H_2O (25 - 125 Pa) in 0.1 in H_2O (25 Pa) increments, with a default of **0.5 in H_2O** (**125 Pa**).

K FACTOR — The **K FACTOR** menu item sets the "K" factor for the flow probe being used. The flow signal is multiplied by the **K FACTOR** so that the flow measurement matches the actual flow, usually determined with a pitot tube traverse. The **K FACTOR** has a minimum value of 0.00 and a maximum value of 10.00, with a default value of **1.00**

FLO STA TYPE — The **FLO STA TYPE** menu item is used to select the flow station input signal. PRESSURE is selected when TSI flow stations with pressure transducers are installed. LINEAR is selected when a linear output flow station, typically a thermal anemometer, is installed (0-5 VDC). This item defaults to **PRESSURE**.

TOP VELOCITY — The **TOP VELOCITY** item is used to input the maximum velocity of a linear flow station output. A TOP VELOCITY must be input for the linear flow station to operate. This item has a range of from 0 to 5,000 fpm in 1,000 fpm increments, with a default of **0 fpm**.

Note: This item is disabled if a pressure-based flow station is installed.

CALIBRATION MENU

Item	Description
PRESSRE ZERO	The **PRESSRE ZERO** item is used to calibrate the zero in the pressure transducer. A zero or no flow point needs to be established prior to using the flow measurement. When this item is entered, the display will instruct the user to Remove Pressure Tap then press SELECT key. After the pressure taps are removed and the SELECT key pressed, the display will go through a 10 second countdown of the calibration, followed by the Saving Data message and three beeps indicating the pressure zero calibration is complete. The Model 8650-MON then automatically exits back out to the item level.
FLOW MINIMUM	The **FLOW MINIMUM** item is used to calibrate the minimum flow in the fume hood exhaust with the sash completely closed. Calibration of this item is necessary for proper calculation of percent open sash area. When this item is entered, the display will read Lower Fume Hood Sash then press SELECT key. After the sash has been closed and the SELECT key pressed, the display will go through a 10 second countdown of the calibration, followed by the Saving Data message and three beeps indicating the flow minimum calibration is complete. The Model 8650-MON then automatically exits back out to the item level.
FLOW MAXIMUM	The **FLOW MAXIMUM** item is used to calibrate the maximum flow in the fume hood exhaust with the sash completely open. Calibration of this item is necessary for proper calculation of percent open sash area. When this item is entered, the display will read Raise Fume Hood Sash then press SELECT key. After the sash has been raised and the SELECT key pressed, the display will go through a 10 second countdown of the calibration, followed by the Saving Data message and three beeps indicating the flow maximum calibration is complete. The Model 8650-MON then automatically exits back out to the item level.

CONTROL MENU

Item	Description
CONTROL ENAB	The **CONTROL ENAB** menu item is used to enable and disable the control functions of the Model 8650-MON. This item can be set to either ON or OFF, with a default of **OFF**.
CONTROL OUT	The **CONTROL OUT** menu item manually controls the control output signal to the damper actuator or variable frequency drive. When the **CONTROL OUT** item is entered, a number from 0 to 255 will be displayed, indicating the current output. This value can be changed by using the ▲/▼ keys. Pressing the MENU or SELECT key will escape this item, without saving the settings.
SETPOINT	The **SETPOINT** menu item sets the face velocity control set point. The Model 8650-MON controller will maintain this face velocity when normal operating conditions exist. The **SETPOINT** item has a range of from 60 to 1000 ft/min, with a default value of **100** ft/min.
SETBACK	The **SETBACK** menu item sets an alternate face velocity control set point. The Model 8650-MON controller will maintain this face velocity when normal operating conditions exist. A setback condition exists when the SETBACK key is pressed or a command is received through the RS-485 network. The **SETPOINT** item has a range of from 60 to 1000 ft/min, with a default value of **60** ft/min.
MINIMUM FLOW	The **MINIMUM FLOW** item is used to set the minimum flow set point. When the fume hood exhaust reaches the minimum flow set point, or when the face velocity sensor is disabled, the controller will modulate the hood exhaust damper to maintain this minimum flow. When this item is entered, the display will indicate the minimum flow set point. The value displayed will be **OFF**, or a value in CFM (or l/s). This value ranges from 0 to (DUCT AREA) * (4005 * (XDCR OUT)$^{0.5}$) * **K FACTOR** or OFF, with a default of **OFF**.
MAXIMUM FLOW	The **MAXIMUM FLOW** item is used to set the maximum flow set point. When the fume hood exhaust reaches the maximum flow set point, or when the face velocity sensor is disabled, the controller will modulate the hood exhaust damper to maintain this maximum flow.

When this item is entered, the display will indicate the maximum flow set point. The value displayed will be **OFF**, or a value in CFM (or l/s). This value ranges from 0 to (DUCT AREA) * (4005 * (XDCR OUT)$^{0.5}$) * **K FACTOR** or OFF, with a default of **OFF**.

MIN DAMPER

The **MIN DAMPER** item is used to set the minimum damper position. The minimum damper position allows the setting of a minimum airflow through the fume hood. When the fume hood exhaust volume needed to maintain the set face velocity is less than the set minimum damper position, (typically sash closed), the damper maintains the minimum damper position. Closing the sash further will result in an increase in the face velocity above the control setpoint.

When this item is entered, the display will indicate the minimum damper position. The value displayed will be the % OPEN. The default value is 0% OPEN.

MAX DAMPER

The **MAX DAMPER** item is used to set the maximum damper position. The maximum damper position allows the setting of a maximum airflow through the fume hood. When the fume hood exhaust volume needed to maintain the set face velocity is greater than the set maximum damper position (typically sash open), the damper maintains the maximum damper position. Opening the sash further will result in a decrease in face velocity, which may cause a low alarm indicating an unsafe hood condition exists.

When this item is entered, the display will indicate the maximum damper position. The value displayed will be the % OPEN. The default value is 100% OPEN.

DIAGNOSTICS MENU

Item	Description
FLOW	The **FLOW** item is used to read the current rate of the fume hood exhaust flow. When this item is entered, the display will indicate the current flow in **CFM** or (**l/s**). Escaping from this item is done only by pressing the MENU key.
% OPEN AREA	The **% OPEN AREA** item is used to read the current percentage of open sash area. When this item is entered, the display will indicate the current open area in **PERCENT**. Escaping from this item is done only by pressing the MENU key.

Deleted Software Items

Menu	Item
SETPOINTS	SETPOINT
	SETBACK
	NO-FLOW ALARM
DIAGNOSTICS	CONTROL OUT
	NO-FLO RELAY
	SETBACK IN

MODBUS COMMUNICATIONS

Modbus communications are installed in all Model 8650 fume hood face velocity controllers. This document provides the technical information needed to communicate between the host DDC system and the Model 8650 units. This document assumes the programmer is familiar with Modbus protocol. Further technical assistance is available from TSI if you question is related to TSI interfacing to a DDC system. If you need further information regarding Modbus programming in general, please contact:

Modicon Incorporated
One High Street
North Andover, MA 01845
Phone (508) 794-0800

The Modbus protocol utilizes the RTU format for data transfer and Error Checking. Check the Modicon Modbus Protocol Reference Guide (PI-Mbus-300) for more information on CRC generation and message structures.

The messages are sent at 9600 baud with 1 start bit, 8 data bits, and 2 stop bits. Do not use the parity bit. The system is set up as a master slave network. The TSI units act as slaves and respond to messages when there correct address is polled.

Blocks of data can be written or read from each device. Using a block format will speed up the time for the data transfer. The size of the blocks is limited to 20 bytes. This means the maximum message length that can be transferred is 20 bytes. The typical response time of the device is around 0.05 seconds with a maximum of 0.1 seconds.

Unique to TSI
The list of variable addresses shown below skips some numbers in the sequence due to internal Model 8650 functions. This information is not useful to the DDC system and is therefore deleted. Skipping numbers in the sequence will not cause any communication problems.

All variables are outputted in English units: ft/min, and CFM. If the DDC system is to display different units, the DDC system needs to make the conversion.

MODBUS COMMUNICATIONS (continued)

XRAM Variables

These variables can be read using Modbus command **03 Read Holding Registers**. They can be written to using Modbus command **16 Preset Multiple Regs.** These variables are the same "menu items" that are configured from the PRESSURA keypad. The calibration and control items are not accessible from the DDC system. This is for safety reasons, since each room is individually setup for maximum performance. TSI offers a number of different models, so if a feature is not available on a unit, the variable is set to 0.

Variable Name	Variable Address	Input Provided to Master System	Integer DDC system receives
Velocity	0	Current Face Velocity	Displayed in ft./min.
Status Index	1	Status of SureFlow Device	*0 Normal* *1 Setback* *2 Low Alarm* *4 High Alarm* *8 Sensor Error* *10 Data Error* *12 Emergency* *19 Low Flow Alarm* *21 High Flow Alarm*
Emergency Mode	2	Put unit in or out of emergency	Write only variable 0 will take unit out of emergency 1 will put unit into emergency
Setback Mode	3	Put unit in or out of setback	Write only variable 0 will take unit out of emergency 1 will put unit into emergency
Main Setpoint	4	Main Control Setpoint	Displayed in ft./min.
Setback Setpoint	5	Setback Control Setpoint	Displayed in ft./min.
Low Alarm	6	Low Face Velocity Alarm Setpoint	Displayed in ft./min.
High Alarm	7	High Face Velocity Alarm Setpoint	Displayed in ft./min.
Units	10	Units of device	0 ft./min. 1 m/s
Alarm Mode	11	Alarm reset mode	0 Unlatched 1 Latched
Audible Disable	13	Permanent Mute Enable	0 Off 1 On

MODBUS COMMUNICATIONS (continued)

Variable Name	Variable Address	Input Provided to Master System	Integer DDC system receives
Minimum Damper	39	Minimum Damper Position	0-255 (0 = 10 V, 255 = 0 V)
Maximum Damper	40	Maximum Damper Position	0-255 (0 = 10 V, 255 = 0 V)
Setback Low Alarm	43	Setback Low Face Velocity Alarm	Displayed in ft./min.
Setback High Alarm	44	Setback High Face Velocity Alarm	Displayed in ft./min.
Low Flow Alarm	45	Low Flow Alarm	Displayed in CFM
High Flow Alarm	46	High Flow Alarm	Displayed in CFM
Duct Area	47	Duct Area	Host system must divide value by 1000 to get ft^2
Analog Output Configuration	48	Configures what the analog output represents	0 Velocity 0 Flow Rate 0 Percent Open
Maximum Transducer Range	49	Maximum Transducer Range	Host system must divide value by 1000 to get "H_2O
K Factor	50	Flow rate multiplier	Host system must divide value by 100 to get correct factor
Sensor Enable	56	Face Velocity Sensor Enable	0 Off 1 On

N2 Variable Map

NPT	NPA	UNITS[1]	DESCRIPTION	
AI	1	ft/min, m/s	Face Velocity	
AI	2	CFM, l/s	Flow Rate	
AI	3	%	% Sash Open	
AI	4	ft/min, m/s	Face Velocity Setpoint	
AI	5	#	Control Output	0-255
BI	1		Low Face Velocity Alarm	0=Normal 1=Low Alarm
BI	2		High Face Velocity Alarm	0=Normal 1=High Alarm
BI	3		Low Flow Volume Alarm	0=Normal 1=Low Flow Alarm
BI	4		High Flow Volume Alarm	0=Normal 1=High Flow Alarm
BI	5		Sensor Error	0=Normal 1=Sensor Error
BI	6		Data Error	0=Normal 1=Data Error
BI	7		Setback Mode	0=Normal 1=Setback
BI	8		Emergency Mode	0=Normal 1=Emergency
AO	1	ft/min, m/s	Low Alarm Setpoint	
AO	2	ft/min, m/s	High Alarm Setpoint	
AO	3	ft/min, m/s	Setback Low Alarm Setpoint	
AO	4	ft/min, m/s	Setback High Alarm Setpoint	
AO	5	cfm, l/s	Low Flow Volume Alarm Setpoint	
AO	6	cfm, l/s	High Flow Volume Alarm Setpoint	
AO	7	ft/min, m/s	Velocity Setpoint	
AO	8	ft/min, m/s	Setback Velocity Setpoint	
AO	9	cfm, l/s	Minimum Flow Volume Setpoint	
AO	10	cfm, l/s	Maximum Flow Volume Setpoint	
AO	11	ft/min, m/s	Units	0=Feet per minute 1=Meters per second

[1] Units will correspond with choice in UNITS variable (AO #11). Flow rates will either be CFM or l/s, based on whether UNITS variable is set for an english or metric unit type.

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N2 Variable Map (continued)
Description of Variables

NPT - Network Point Type
Variables are defined as analog inputs, binary inputs, and analog outputs. Analog inputs are current control parameters and items that the controller is measuring. Binary inputs represent controller states. Analog outputs are the programmable setpoints for the isolation room pressure controller and monitor. These setpoints can be changed through the keypad or by overriding the current setpoint.

NPA - Network Point Address
Address of the desired point.

Change of Status (COS) – Face Velocity Analog Input
The 8650-MON has the ability to change control setpoints locally. The alarm setpoints need to be based on the controller's control setpoint (AI #4). For example the setpoint could go from 100 ft/min to 60 ft/min. If the COS alarm setpoints are not changed to accommodate you could get low alarm or low warning messages when the unit is working correctly. If these alarm points are set outside of the setpoint values, incorrect alarm messages can be prevented.

Override Analog Input Command
Analog Input values can be set using the override command. These values will be reset to the correct items when the Override is released. There is not a time-out on the override command.

Override Binary Input Command
Overriding a 1 to Emergency or Setback binary inputs enables that mode. To release the controller from emergency state, override a 0 to the Emergency input or press either the emergency or reset key. To release the controller from setback mode, override a 0 to the Setback input or press either the setback or reset key. Releasing the override will return the controller to the Normal state. If the 8650-MON had been put into Emergency mode from the keypad, then it cannot be cleared remotely.

The alarm and data error variables can be overridden, but this will not affect the controller. Overriding the low alarm variable will result in a change of status, but will not put the controller into low alarm mode. The local alarm modes can only be controlled locally. Only override these variables for diagnostic purposes, and release them for normal operation.

N2 Variable Map (continued)

Binary Input Data Error

Data Error binary inputs are used to indicate if something has gone wrong with the controller. Data Error indicates when some of the data stored on the device has been corrupted. The calibration and setpoint values should be checked on the controller.

Override Analog Output Command

The analog output variables can be overridden to change their values. The overridden value will be checked for validity. If invalid, the override command will be ignored, and the value will not change. The override flag will not be set when the value is ignored. The override command will be cleared when the variable is reset in the menus. The variable will not reset with the release command.

Supported Commands

Command	Response
Request Device ID	Returns 0x10
Synchronize Time Command	Acknowledged. There Is No Internal Clock To Synchronize.
Poll Without/With Ack Message	Any Change Of Status Is Returned
Read Analog Input Command	Variable Value
Read Binary Input Command	Variable Value
Read Analog Output Command	Variable Value
Write Analog Input	Acknowledge
Write Binary Input	Acknowledge
Write Analog Output	Acknowledge
Override Analog Input Command	Acknowledge
Override Binary Input Command	Acknowledge
Override Analog Output Command	Acknowledge
Override Release Request	Acknowledge
Identify Device Type Command	Returns 0x10h

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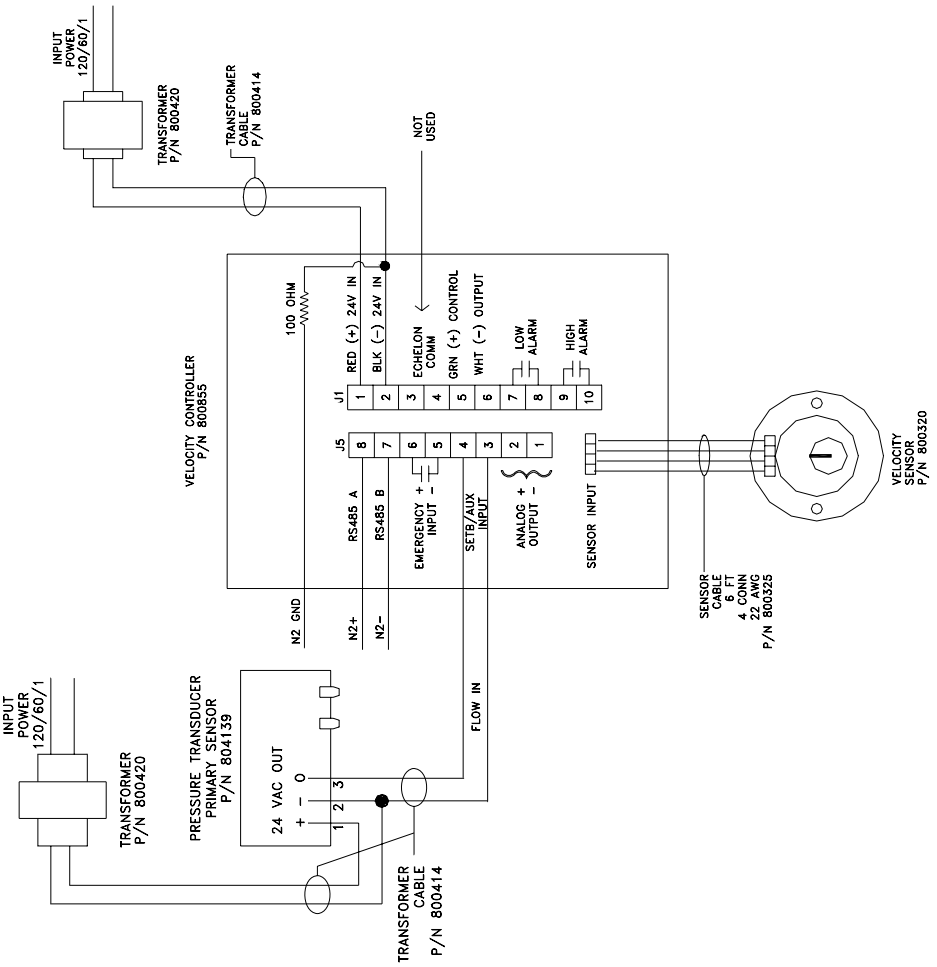
Wiring Diagrams

MODEL 8650 - MON WIRING DIAGRAM

FACE VELOCITY MONITOR WITH CFM MEASUREMENT

N2 COMMUNICATIONS WIRING DIAGRAM



TSI INCORPORATED
500 CARDIGAN ROAD
SHOREVIEW, MN 55126

TELEPHONE: 800-874-2811 FAX: 651-490-3824

ENGINEER:	
SOLD TO:	
PROJECT:	
JOB NO.:	DWG NO.:
REP:	DATE:

8/8/02