OPERATION MANUAL

MST2000 SERIES

Loop Powered Multivariable SMARTFLOW® Transmitter

For English and Metric Unit Versions

See Section 15 for approval information

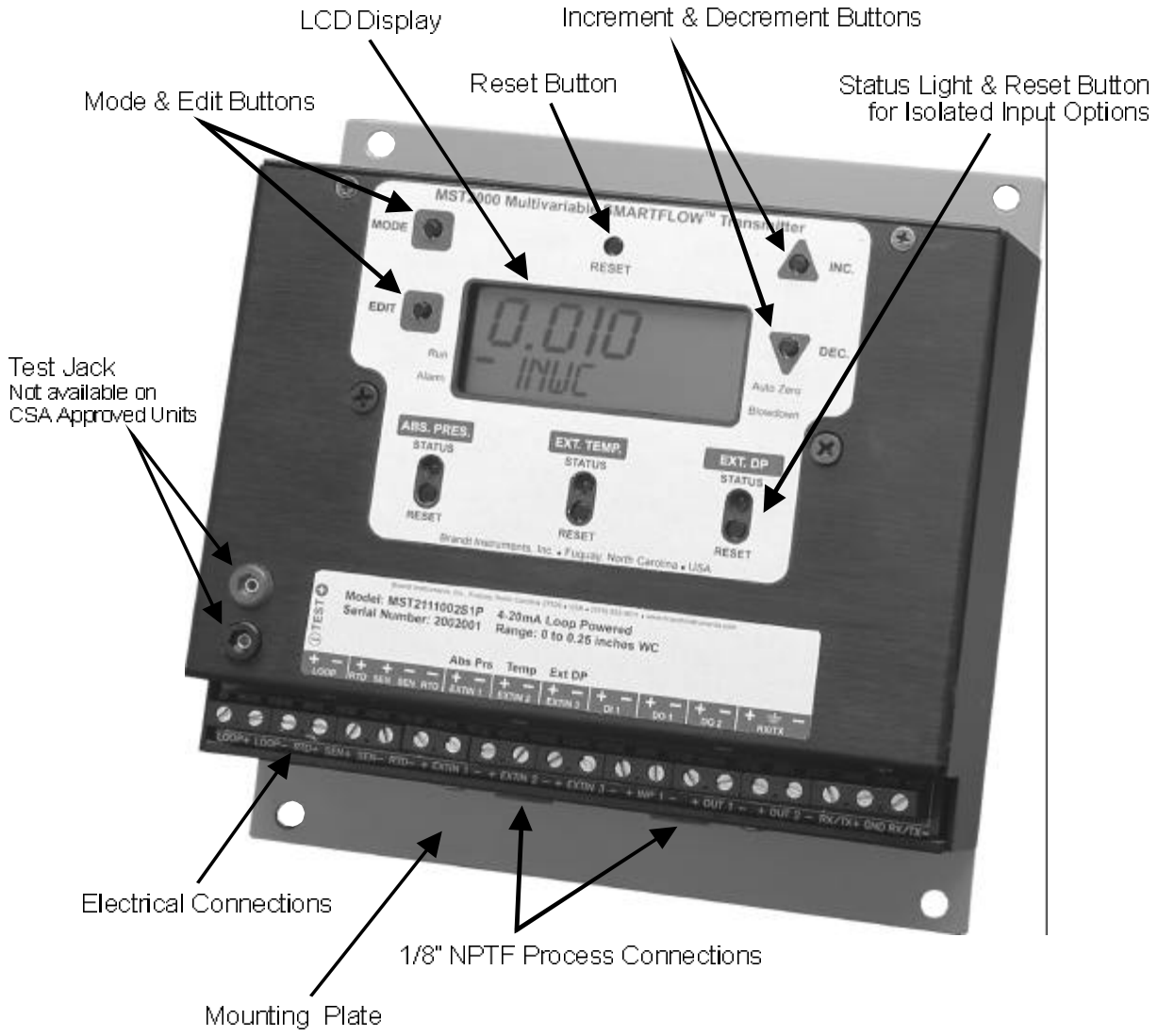
MST2400, NEMA 4X

MST2100, NEMA 1

www.thermobrandt.com

Let us point you in the right direction.

English Unit Software Release H03
Metric Unit Software Release HM3
CSA Approvals
MA37-2000-00, November 2001



MST2100, NEMA 1

Thermo Brandt Instruments

ISO 9001

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This manual is designed to optimize the performance of the MST2000 Series Loop Powered Multivariable SMARTFLOW® Transmitter. The end user should read and review it carefully before installing, using or maintaining the transmitter. The information contained in this manual corresponds to the revision level of the software shipped with your MST2000. You can download a copy of the latest version of this manual along with other information from our web site.

IMPORTANT: This manual covers both the ENGLISH and METRIC Unit Versions of the MST2000 operating software. The ENGLISH or METRIC configuration must be selected at the time of order and configured at the factory. ENGLISH or METRIC UNIT CONFIGURATION IS NOT FIELD SELECTABLE.

It is the desire of Thermo Brandt Instruments that the MST2000 be setup and used as effectively and efficiently as possible. If you have any questions or concerns please contact your Thermo Brandt representative or Thermo Brandt Instruments at the following:

Telephone:	**(919) 552-9011. Customer Service: Extension 28**
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TABLE OF CONTENTS

PRODUCT OVERVIEW

Thermo Brandt Instruments’ **MST2000 Series Loop Powered Multivariable SMARTFLOW® Transmitter** provides the necessary versatility required to satisfy today’s demanding industrial process applications. With programmable constants, input/output options and communication features the MST2000 will concurrently measure and/or apply the numerous process variables for a true mass flow measurement.

The MST2000’s configuration is user friendly and is accomplished through the integral key pad (no external software or hardware is required). The MST2000 is capable of producing and displaying signals for Differential Pressure or for Flow. Optional input, digital I/O and communication modules can be installed at the factory or in the field as required.

MODEL NUMBER

SERIES: LOOP POWERED MULTIVARIABLE SMARTFLOW™ TRANSMITTER

MST21 = MST2100, NEMA 1 Panel Mount Enclosure, Differential Pressure Configuration & Non-isolated 4 Wire RTD Input Standard. ❶

MST24 = MST2400, NEMA 4X, Fiberglass Enclosure, Differential Pressure Configuration & Non-isolated 4 Wire RTD Input Standard. ❶

ISOLATED INPUT MODULE: Absolute Pressure Transmitter

0 = None

1 = Isolated Input Module: Accepts 4-20mA input signal from an External Absolute Pressure Transmitter. ❶

2 = Isolated Input Module with Integral Absolute Pressure Transmitter, 0-25 PSI (0-1.7 bar) range standard. Consult factory for other ranges. MST2400 only. Requires Integral 24V Power Supply. See Output option 2 below.

ISOLATE MODULE: Temperature Transmitter

0 = None

CERTIFICATION

0 = None

1 = CSA Approved Intrinsically Safe

2 = CSA Approved Division 2.

Review Section 15 of this manual for approval information.

COMMUNICATIONS

H = HART® Communications Module. ❶

DIGITAL I/O

D = Digital I/O Module with 1 Input, 1 Outputs. ❷

PRESSURE RANGES

1S = Standard Range 1 Max. Span: 0-0.10" (0 to 2.54mm) W.C. Turndown to 0.010" (0.254mm) W.C. (10:1).

2S = Standard Range 2 Max. Span: 0-0.25" (0-6.35mm) W.C. Turndown to 0.025" (0.635mm) W.C. (10:1).

3S = Standard Range 3 Max. Span: 0-1.00" (0-25.4mm) W.C. Turndown to 0.10" (2.54mm) W.C. (10:1).

4S = Standard Range 4 Max. Span: 0-4.00" (0-101.6mm) W.C. Turndown to 0.40" (10.16mm) W.C. (10:1).

5S = Standard Range 5 Max. Span: 0-16.0" (0-406.4mm) W.C. Turndown to 1.60" (40.64mm) W.C. (10:1).

6S = Standard Range 6 Max. Span: 0-50.0" (0-1270.0mm) W.C. Turndown to 5.00" 127.0mm) W.C. (10:1).

CR = Compound Range Consult factory. Supply desired Compound Range.

All maximum pressure ranges have a turndown of 10:1.

Specify Pressure Range # in model number (example 1S or CR).

Standard Ranges: MST2000 will be calibrated at Maximum Span. If an Initial Range Setting is desired, supply with order and unit will be shipped with this Initial Range preset. (Example: 3S set to 0 to 0.5" W.C.).

Compound Ranges: MST2000 will be calibrated at desired Compound Range. Supply compound range with order (example: -0.25 to +0.25" W.C.).

All spans will be calibrated in Inches of W.C. Other Units of measure will be converted to Inches of W. C.

OUTPUT & VERSION. See Note Below.

1 = 4-20mA Output. *English Units Version*. ❶

2 = 4-20mA Output with Integral 120VAC to 24VDC Power Supply. 120VAC Source Required. MST2400 only. *English Units Version.*

3 = 4-20mA Output. *Metric Units Version.* ❶

4 = 4-20mA output with Integral 120VAC to 24VDC Power Supply. 120VAC Source Required. MST2400 only. *Metric Units Version.*

OPTIONS

0 = None

B = Integral High Pressure Blowdown System. MST2400 Only. Requires Digital I/O Module. 120VAC source required. Regulated air supplied to 100 PSIG. Enclosure size will change. Consult Factory for specifications and availability.

P = Continuous Purge to Flowmeter. MST2400 Only. Spans of 0.25" W.C. (6.35mmWC) or greater. A filtered air supply source of 20 to 100 PSI (1.4 to 6.9 bar) is required. ❶

ACCESSORIES

0 = None

P = Pipe Mount. MST2400 Only.

❶ Denotes options & features available with CSA Intrinsically Safe and Division 2 hazardous area approvals.

❷ Denotes options & features available with CSA Division 2 Approvals Only.
Review Section 15, for CSA approval information.

MST24 1 1 1 H D 2S 1 0 P

MST2000's with English or Metric Unit Versions are available but must be selected at time of order and configured at the factory. IT IS NOT A FIELD SELECTABLE OPTION.

SPECIFICATIONS

FUNCTIONAL SPECIFICATIONS

Service: Clean, dry, non-corrosive Air or Gas. Other me dia may be pos si ble with the use of the Con-tin u ous Purge op tion. Con sult fac tory .

Pres sure Ranges: Stan dard Pres sure Ranges:

Range 1: 0 to 0.10" (0 TO 2.54mm) W.C.
Range 2: 0 to 0.25" (0 to 6.35mm) W.C.
Range 3: 0 to 1.0" (0 to 25.4mm) W.C.
Range 4: 0 to 4.0" (0 to 101.6mm) W.C.
Range 5: 0 to 16.0" (0 to 406.4mm) W.C.
Range 6: 0 to 50.0" (0 to 1270.0mm) W.C.

Out put Sig nals: *An a log:* 4-20 mA sig nal (Max. Loop re sis tance = 615 Ohms @ 24 VDC) is user pro gram ma-ble to Dif fer en tial Pres sure or Flow Parameters. Ex ter nal in puts or pro grammed con stants for tem per a ture and ab so lute pres sure along with con stants for Ef fec tive Area and Stan dard Den sity, are nec es sary for a true flow mea sure ment.

Op tional Dig i tal: One (1) op tional dig i tal (open col lec tor) out put avail able. Ac ti va tion pro-gram ma ble by end user.

Communications: *Op tional:* dig i tal HART® Com mu ni ca tions mod ule. See Sec tion 13, page 23 for HART® com-munication information.

Alarms: Pro gram ma ble hard ware alarms, underrange and overrange.

Display: High Con trast, 2 line, al pha nu meric LCD with -20 to 150°F (-28 to 66°C) op er at ing tem per-ature.

Power Sup ply Re quired: 24 to 40 VDC loop power, min i mum 11 volts re quired at in puts.

Re verse Po lar ity Pro tec tion: Yes

Turn On Time: 4 sec onds (max i mum).

Tem per a ture Limits: *Op er at ing:* -40 to 150°F (-40 to 66°C) *Stor age:* -40 to 180° F (-40 to 82°C)

Overpressure Limits: *Proof Pres sure*: 10 PSID (0.7 Bar) *Burst Pres sure:* 50 PSID (3.45 Bar)
Max Line Pres sure: 50 PSIG (3.45 Bar).

Damping: Stan dard Time Con stant: 500 mSec. Ad di tional damp ing ad just able via in te gral key pad from 0.5 to 5 Sec onds in 0.5 sec ond in cre ments.

Hu mid ity Limits: 100% Non-condensing, (MST2400 Only).

Inputs: *Standard:* Non-isolated, 4 wire RTD in put con nec tion.

Op tional 4-20mA Iso lated In puts: In put ranges are soft ware rangeable.

- *External Tem per a ture:* 4-20mA In put
- *External Ab so lute Pres sure:* 4-20 mA In put

Op tional Dig i tal In put: One op tional dig i tal (TTL level) in put is avail able.

PERFORMANCE SPECIFICATIONS

Accuracy: For spans from 40% to 100% of max i mum range with TD of 1:1 to 2.5:1 then ac cu racy = 0.15% of Re-ranged Span.

For spans from 20% to 39% of max i mum range with TD of 2.5:1 to 5:1 then ac cu racy = (0.15 + 0.005 X TD)% of Re-ranged Span.

For spans from 10% to 19% of max i mum range with TD of 5:1 to 10:1 then ac cu racy = (0.15 + 0.010 X TD)% of Re-ranged Span.

- TD = Max i mum Range / Re-ranged Span

Stability: 0.1% of Max i mum Range / 12 Months

Ambient Tem per a ture: *Zero:* No Ef fect *Span:* Less than 0.001% of Re-ranged Span per Deg F. Cor rected by in-ter nal tem per a ture sen sor.

Mount ing Po si tion Ef fect: Mi nor ef fect on Zero. Cor rected by setup pa ram e ters.

Vi bra tion Ef fect: Less than 0.2% of Max i mum Range / g, 10-130 Hz.

PHYSICAL SPECIFICATIONS:

En clo sure Types: *MST2100:* NEMA 1, An od ized Alu mi num. *MST2400:* NEMA 4X, Fi ber glass.

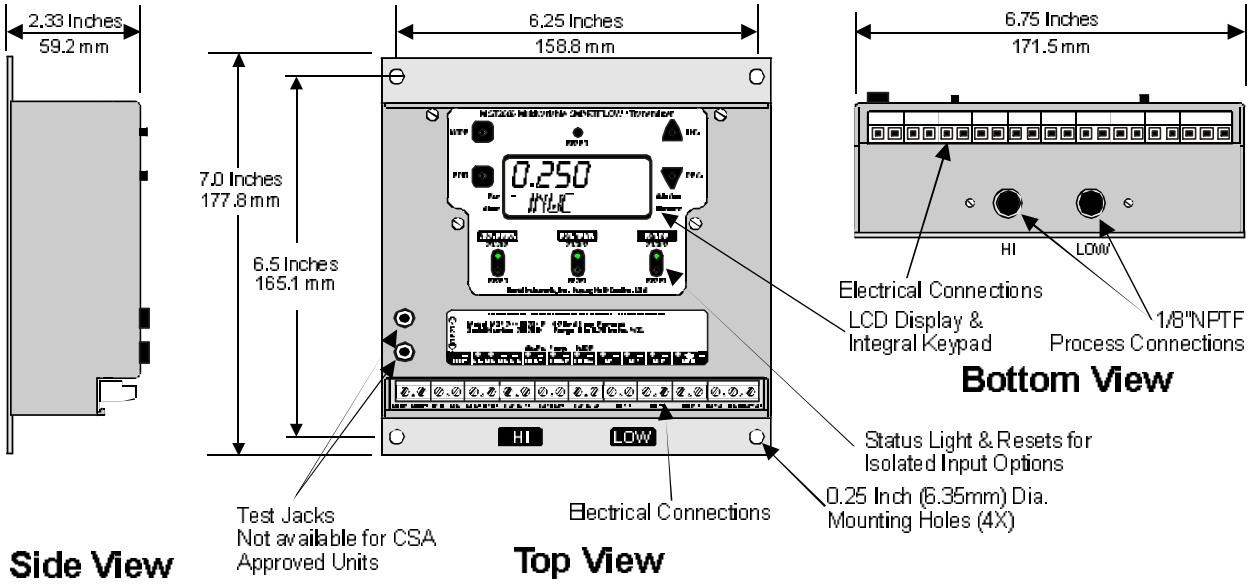
Process Con nec tions: *MST2100:* 1/8" NPTF *MST2400:* 1/4" NPTF Stain less Steel

Electrical Con nec tions: *MST2100 & MST2400:* Cage Clamp style ter mi nal block. 12-24 AWG wire size.

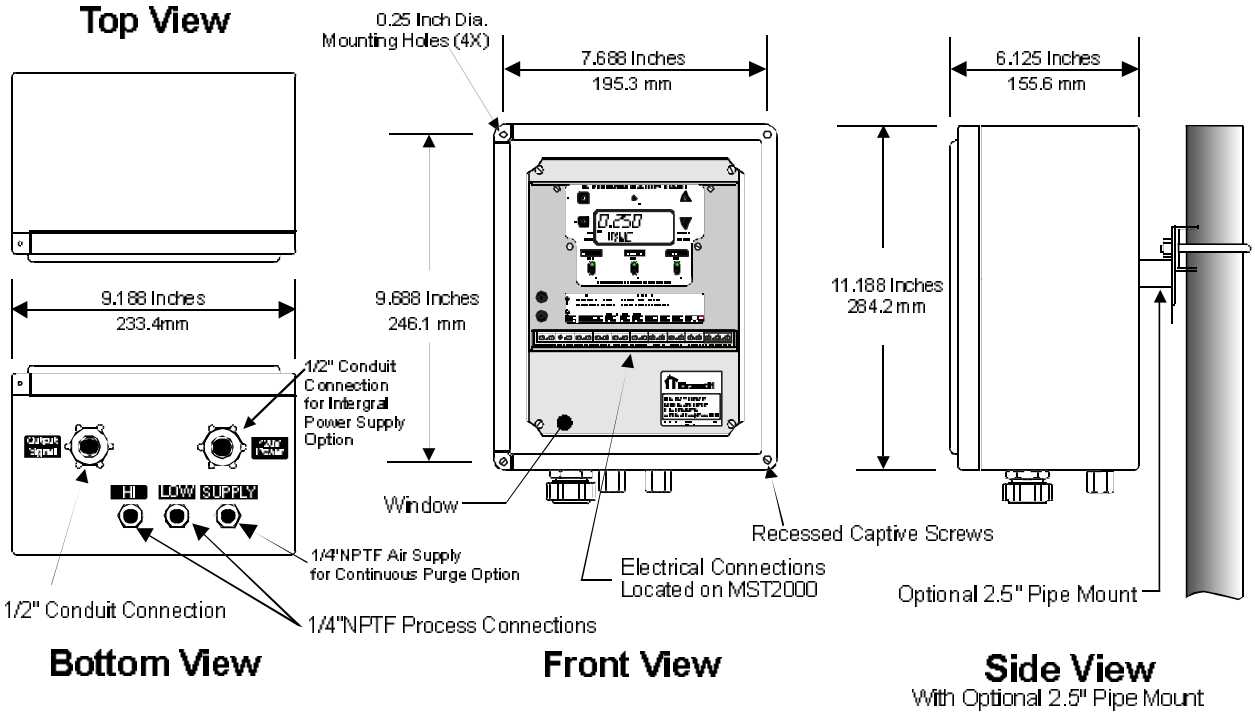
MST2400: ½" Liq uid-Tight flex i ble con duit con nec tions.

Weight: *MST2100:* 2.5 . (1.14 kg) *MST2400:* 8.0 lbs. (3.63 kg)

DIMENSIONS



MST2100: NEMA 1 Enlcosure



MST2400: NEMA 4X Fiberglass Enclosure

1. MOUNTING AND PROCESS CONNECTIONS

The MST2000 can be mounted in any direction. There may be a minor effect on Zero that can be corrected by the setup parameters.

1.1 MST2100: NEMA 1 Enclosure

A. Review the dimensional drawing on page 5.
B. Process connections are via 1/8" NPT female ports located on the bottom of the housing. The high pressure port is labeled “HIGH”, the Low pressure port is labeled “LOW” on the mounting plate.

1.2 MST2400: NEMA 4X Enclosure

A. Review the dimensional drawing on page 5.
B. Without a continuous purge option, process air should be non-corrosive and dry. If a continuous purge option is installed please review section 2 on the continuous purge. The continuous purge must be balanced.
C. Process connections are via 1/4" NPT female ports located on the bottom of the enclosure. The high pressure port is labeled “HIGH”, the Low pressure port is labeled “LOW”.

1.3 Three Valve Manifold

A. It is recommended that a three valve manifold be installed in the process, **unless a continuous purge is installed** . A three valve manifold is available from the factory. It is installed in the process lines to isolate the process signal during installation and/or removal of the MST2000 thus preventing possible transducer over-pressurization and to zero transmitter.

☑ ***Notes:***

- Before connections are made blow out process lines throughly.
- It is recommended that pipe thread tapes not be used on pneumatic piping.
- Soap test all joints and fittings for leaks.
- Process lines should be the same diameter and approximately the same length.

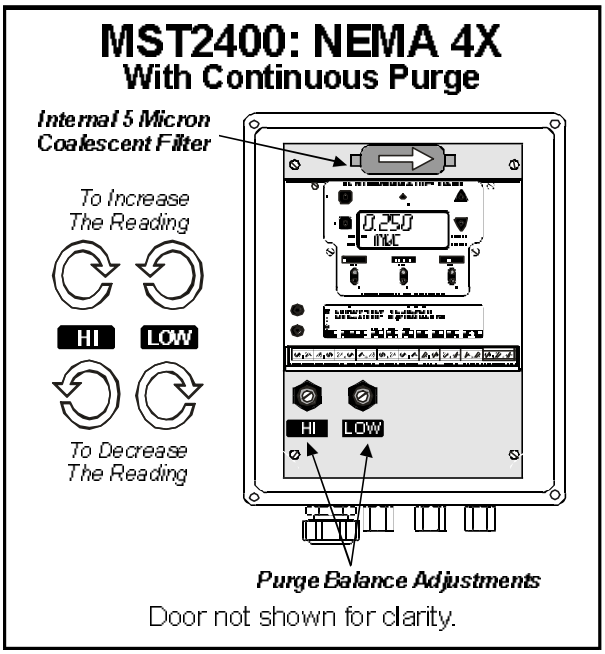
☑ ***Note: MST2000 DP sensor maximum operating static pressure is 25 PSID.***

2. CONTINUOUS PURGE OPTION

The MST2400 can be ordered with a Continuous Purge Option. This option supplies a continuous pneumatic purge to a Thermo Brandt pitot flow sensor to keep the sensing ports free from plugging during operation. There are Purge Balance adjustments located on the front panel which provide for the zeroing of process air resistance. If the Continuous Purge Option has been ordered, please read the following setup instructions. **The Continuous Purge Option must be balanced once the process is connected to the MST2400**.

A 1/4" NPT female air supply port is provided on the bottom of the enclosure for the Purge.

An internal filter is supplied with the unit, but air supply should also be filtered and regulated.



☑ ***PROCESS LINE LENGTH & SIZE***

- When a continuous purge option is used, the process lines (Hi and Low lines) must be the same diameter (preferably 3/8" or larger) and the length of each line should be the same within +/- 5%.

☑ ***IMPORTANT:***

- The Continuous purge option air supply should be only clean, instrument quality air and should be greater than 20 psi (1.4 bar) and not exceed 100 psi (6.9 bar). A pre-filter should be installed in the supply line if the air quality is suspect. A 5 micron filter and a 0.3 micron coalescent filter are recommended. Failure to provide clean, instrument quality air through the Continuous Purge can cause the MST2000 to give erratic readings. Failures attributed to a contaminated air supply are not covered under the warranty.

2.1 Balancing the Purge if the Process is in Operation

A. Review the drawing on page 5.
B. Process must be in a steady state.
C. Disconnect the HIGH and LOW lines from the transmitter. Measure the DP from the process with a pressure calibrator or other DP measuring device..
D. Record the DP reading. _____
E. Reconnect the HIGH and LOW lines back to the transmitter. Make sure the Purge is operating.
F. Adjust the “HIGH” and “LOW” Purge Balance adjustments on the mounting plate until the display reading equals the reading recorded in Step D. See the drawing on page 5.

2.2 Balancing the Purge if the Process is not in Operation

A. Review the drawing on page 5.
B. Ensure that there is no flow in the process. If the flow cannot be stopped completely follow the instructions in Section 2.1.
C. Attach the HIGH and LOW lines to flow meter.
D. Adjust the “HIGH” and “LOW” Purge Balance adjustments on the front panel till the display reading equals 0.0000 Inch W.C. See drawing on page 5.

☑ ***IMPORTANT: It is recommended that a Three Valve Manifold not be used with an MST2400 which contains the Continuous Purge Option. Consult factory.***

2.3 Integral 5 Micron Coalescent Filter

A. The MST2400 with continuous purge comes with an integral 5 micron Coalescent Filter. See the Drawing on page 5.
B. The filter is intended as a secondary device. The supply air should be regulated and filtered before entering the enclosure.
C. The integral filter will turn “RED” as it cleans the air. Replace the filter before the “RED” reaches the right side, or outlet end.

3. Integral “High Pressure” Blowdown System

The MST2400 can be ordered with an Integral “High Pressure” Blowdown System. This option is designed to clean out Pitot Averaging Flow sensors using a blast of “High Pressure” Air (up to 100 PSIG or 6.9 bar) while holding the last output signal from the MST2400.

The MST2400 is capable of being programmed to perform a blowdown sequence anywhere from every 2 minutes up to once every 24 hours (1440 minutes). The blowdown sequence can also be activated by a remote pulse from a DCS or other controller.

A. Specifications:
   a. Air Supply: Maximum of 100 PSIG (6.9 bar) . If air supply is over 100 PSIG then a regulator must be installed.
   b. Voltage: 120 VAC. Option contains integral 24VDC power supply.
   c. Sequence Duration: Approximately 30 seconds from time signal is held till signal is restored.
   d. Temperature: Maximum 150°F.
   e. Programmable intervals: 2 minutes to 1440 minutes (24 hours).
   f. Pulse Signal from external controller: Contact closure for ½ second (500 milliseconds).
B. Sequence of Operation
   a. The MST2400 begins the Blowdown sequence by holding the last output signal. **“-HOLD-”** will appear on the LCD. The Blowdown Status Indicator will also be lit. See the section on the LCD Display.
   b. Valves are activated to isolate and vent the transmitter from the process to prevent damage.
   c. The Hi & Low process lines are alternately blown down for approximately 11 seconds each.
   d. Valves are automatically activated to restore signal from process back to MST2400.
C. External Activation Signal

The MST2400 Integral Blowdown can be activated by a ½ second external contact closure pulse signal. The Blowdown can be controlled by this signal only or in combination with the integral control of the MST2400. The MST2000 must be programmed to accept this signal. Refer to Programming Parameters, Section 8. See Wiring Diagrams in Section 14.

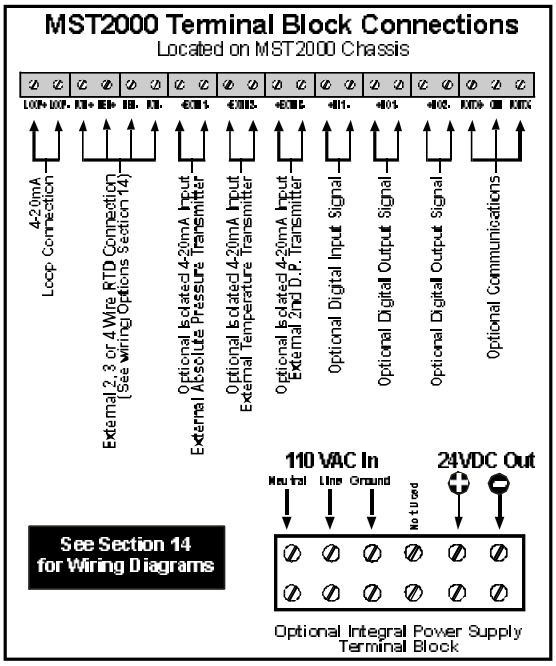
☑ ***Note: A 110VAC power source is required for the Integral Blowdown System. An internal 24VDC power supply is furnished with the Blowdown. DO NOT USE THIS POWER SUPPLY TO POWER THE LOOP SIGNAL.***

4. ELECTRICAL CONNECTIONS

4.1 MST2100: NEMA 1 Enclosure

A. Review the MST2100 and MST2400 dimensional drawings.
B. Refer to the MST2000 Terminal Block Drawing.
C. MST2000 Instrument Electrical Connections are cage clamp style for 12-24 AWG. Wire should be stripped back a minimum of 3/16" inches (5mm).
D. The MST2000 Multivariable differential pressure transmitter is a HART® compatible loop-powered 4-20 milliamp transmitter. Power connection is made at the two left terminal positions marked LOOP+ and LOOP-. Nominal power supply voltage is 24 volts DC which allows up to 600 ohms series resistance in the loop circuit.

☑ ***For HART® applications, minimum loop resistance is 250 ohms.***



4.2 MST2400: NEMA 4X Enclosure

A. A ½" Liquid Tite conduit connection is located on the bottom of the Enclosure.
B. Conduit should be installed to prevent condensation from collecting in the instrument.

4.3 Integral Power Supply Option.

A. The Integral Power Supply Option requires an external 120 Volt Power Supply.
B. A six (6) position screw type terminal block and ½" Liquid Tite Conduit connection are supplied with the Integral Power Supply Option.

4.4 Canadian Standards Association Hazardous Area Approvals

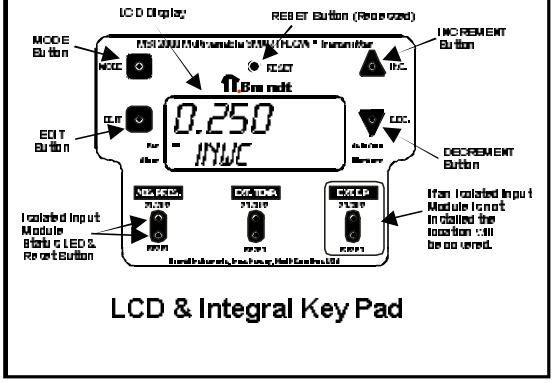
The MST2100 and MST2400 have been approved by CSA for hazardous area installations. See Section 15 for details or contact the factory.

5. LCD DISPLAY and INTEGRAL KEY PAD

All controls and indicators are Located on the front panel of the MST2000. Refer to the LCD & Key Pad Drawing.

5.1 Key Pad

All programming and control operations are performed using four (4) pushbuttons on the key pad. Following are summaries of each key.



MODE:
- Toggles the MST2000 between *RUN* Mode and *PROGRAM* Mode.
- Also used to change the edit cursor when entering a numeric value.

EDIT:
- Selects the parameter to edit when in Programming Mode.
- Also saves the edited parameter data to memory.

INCREMENT:
- Increments (steps forward) through parameters and/or numeric values.

DECREMENT:
- Decrements (steps backwards) through parameters and/or numeric values.

RESET:
- Resets the CPU. Restarts program and loads in programmed variables stored in the E-Prom

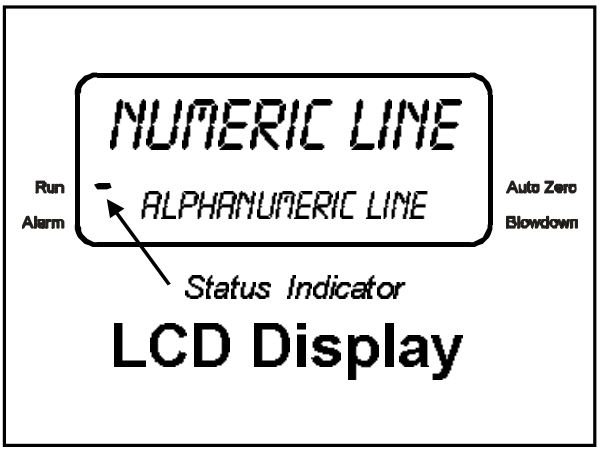
5.2 LCD Display

The MST2000 High Contrast LCD display will display two (2) lines simultaneously. The display is used to setup and calibrate the MST2000 and display and monitor input and output signals and other variables.

The lines of display are:

Numeric:
- Where the values for DP or Flow are displayed.
- The variables for parameters are edited and displayed.

Alphanumeric:
- Where units of measure and parameter names are displayed.



Status Indicators:
- Used to display the operational status of the MST2000. The Status indicator will indicate when the MST2000 is in "RUN Mode", if there is an Alarm and whether an AutoZero or Blowdown sequence is in process.

6. MST2000 OPERATIONAL MODES and START UP

The MST2000 has two basic operational Modes. They are:

RUN MODE
- In this mode the MST2000 is operating and displaying the measurements.

PROGRAM MODE
- In this mode the MST2000 is ready for programming. Note: The *PROGRAM* Mode can be password protected.

Startup

When power is first applied, the MST2000 Liquid Crystal Display (LCD) will first display RESET followed by READEE and then display the selected runtime parameter. The available runtime parameters are listed below.

ENGLISH UNITS VERSION		METRIC UNITS VERSION	
INWC	DP in Inches of Water Column	MMWC	DP in millimeters of Water Column
SCFM	Gas Flow in Standard Cubic Feet per Minute	NM3-HR	Gas Flow in Normal Cubic Meters per Hour
ACFM	Gas Flow in Actual Cubic Feet per Minute	M3-HR	Gas Flow in Cubic Meters per Hour
LBHR	Mass Flow in Pounds per Hour	KG-HR	Mass Flow in Kilograms per Hour
TEMP	Process Temperature in Degrees Fahrenheit	TEMP	Process Temperature in Degrees Celsius
ABS_PR	Process Absolute Pressure in PSI	ABS_PR	Process Absolute Pressure in Bar
ALARMS	MST2000 Alarm Status	ALARMS	MST2000 Alarm Status

- The default display mode is initially set at the factory for inches of water column (INWC) or millimeters of water column (MMWC). The user may select other runtime flow variables by pressing the **INC** (increment) or the **DEC** (decrement) keys. **Note: English or Metric Unit Configurations are not field selectable. They must be set at the factory.**
- The **MODE** key is used to toggle between *RUN mode* and *PROGRAM mode*.
- The **EDIT** key is used to clear 'latched' alarms in runtime (RUN) mode.

7. PROGRAMMING

The MST2000 PROGRAM mode is accessed by pressing the **MODE** key. When the MODE key is pressed one of the following will occur.

☑ ***NOTE:***

- The MST2000 can be Password protected to prevent unauthorized access to programming parameters. The MST2000 is shipped from the factory with the Password disabled.

7.1 If the Password Parameter is Enabled (else go to Section 7.2)

A. The MST2000 will then display ENT_PW prompting the user to enter the required password.

☑ ***NOTE:***

- The user must press the EDIT key within 4 seconds to begin entering the current password or the MST2000 will return to RUN mode. The password is a unique number between 1 and 9999 and is entered as described in Section 7.5.
- During password entry, if no keys are pressed for more than 4 seconds, the MST2000 will return to RUN mode.

7.2 If the Password Parameter is Disabled or after the Password is successfully entered.

After the password has been properly entered, BRANDT and VERXXX will be momentarily displayed and then followed by the first available PROGRAM parameter.

☑ ***NOTE: VERXXX indicates the installed software revision level.***

7.3 Select the Parameter to Edit

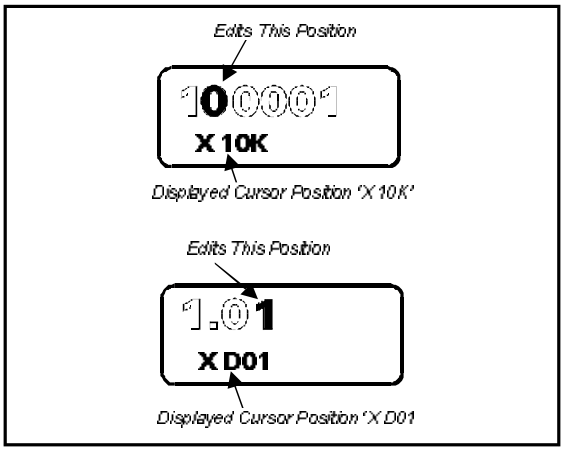
A. Once the Parameters are displayed use the **INC** and **DEC** keys to scroll up and down through the available parameters. See parameters, Section 8.0.
B. To edit a selected parameter, press the **EDIT** key and the editing menus will become active.
C. Parameters are either a numeric value (example: Effective Area) or control a hardware/operating mode.

7.4 Editing of a Hardware/Operating Mode Parameter.

A. If a parameter controls a hardware or operating mode feature, use the **INC** and **DEC** keys to scroll through the available settings.
B. After the desired setting is selected, press the **EDIT** key again to save the selected setting to memory.
C. The LCD will display SAVED for approximately 1 second and then redisplay the new setting.

7.5 Editing a Numeric Value Parameter.

A. If the selected parameter to edit is a numeric value, the editing menus will display the current value and the current cursor position for the decimal position.
B. Use the **INC** and **DEC** keys to increment or decrement the numeric value at the current cursor position.
C. To change the cursor position press the **MODE** key. The LCD will display 'x 1' if the ones column is to be changed, 'x 10' for the tens column, 'x D1' for the tenths column, 'x D01' for the hundredths column, etc. The number will not increment or decrement if the parameter limit is reached. See the Chart Below and the examples to the right.



LEFT OF DECIMAL	1000000.	100000.	10000	1000.	100.	10.	1.	RIGHT OF DECIMAL	.1	.01	.001	.0001
X1							X	X D1	X			
X10						X		X D01		X		
X100					X			X D001			X	
X1K				X				X D0001				X
X10K			X									
X100K		X										
X1M	X											

D. After the number is changed to the desired value, press the **EDIT** key again to save the new value to memory.
E. The LCD will display SAVED for approximately 1 second and then redisplay the new setting.

8. PROGRAM PARAMETERS

The Available PROGRAM parameters are shown below along with a description of how each parameter is applied. They are listed in the order they appear in the PROGRAM menus.

Parameter	Description	Factory Default
LCDCON	**LCD Contrast** adjustment. Available range is from 0 to 10. Use lower settings for best contrast in colder environments and higher settings for best contrast in hotter environments.	5
4200UT	**4-20 milliamp Output** assignment**.** Available assignments are: *English Units Version:* 0 = INWC (primary variable), 1 = SCFM, 2 = ACFM, 3 = LBHR. *Metric Units Version:* 0 = MMWC (primary variable), 1 = NM3-HR, 2 = M3-HR, 3 = KG-HR	0 = INWC or MMWC
420_ZE	**4 Milliamp Zero** setting. The 4 milliamp zero setting adjusts the milliamp lower range of the primary variable (INWC or MMWC). The available range is the natural span of the differential pressure sensor.	Set equal to the low range of the natural span.
420_SP	**20 Milliamp Span** setting**.** The 20 milliamp span setting adjusts the milliamp span value of the primary variable (INWC or MMWC). The available range is the natural span of the differential pressure sensor. ☑ ***NOTE: The 420_SP value (span) must always be greater than the 420_ZE value (zero) for proper operation.***	Set equal to the upper range of the natural span.
F_SPAN	**Flow Span** setting. The flow span setting controls the upper 4-20 milliamp value assignment (turn down) when the 4-20 output is assigned to the runtime calculated flow variables (SCFM, ACFM, LBHR or NM3-HR, M3-HR, KG-HR). The lower 4-20 milliamp value assignment is always referenced to zero (0). The available range is: *English Unit Version:* 0 to 10,000,000 (no units). *Metric Unit Version:* 0 to 50,000,000 (no units).	20000

Parameter	Description	Factory Default
E_AREA	**Effective Area** of flow meter device. The effective area is required for flow calculations and is entered to be the same as shown on the Thermo Brandt flow meter label. The available range is: English Unit Version: 0.0000 to 500.0000 square feet. Metric Unit Version: 0.0000 to 100.0000 square meters. ☑ ***NOTE: Some flow meter devices use 'K factors' instead of effective areas to define mass flow relationships. Effective areas can be calculated from given K factors. See Formulas, Section 10.*** ☑ ***NOTE: Thermo Brandt flow meter devices are specified in square feet. To convert to square meters, multiply the square feet value by 0.0929.***	1.0000 for English. 0.0929 for Metric.
STDDEN	**Standard Density.** The standard density is required for mass flow calculations and is entered for the specific gas being measured. The standard density is entered at the standard reference temperature of 68 degrees F or 20 degrees C. The available range is: *English Unit Version:* 0.0000 to 2.0000 pounds per cubic foot. *Metric Unit Version*: 0.0000 to 40.0000 Kilograms per cubic meter.	0.07517 for English. 1.20367 for Metric.
TMPSRC	**Temperature source.** Available assignments are 0 = CONstant, 1 = EXTernal and 2 = RTD.	0 = CONstant
TMPCON	**Temperature Constant.** The temperature constant can be used for mass flow calculations when no external temperature inputs are available and is entered as the average gas temperature. The available range is: *English Unit Version:* -50.0000 to 900.0000 degrees F. *Metric Unit Version:* -50.0000 to 900.0000 degrees C.	68.0000 for English. 20.0000 for Metric
RTDCAL	**RTD Calibration** offset. The RTD calibration offset constant allows the user to offset the actual measured value from the direct RTD input. The value may be positive or negative and is entered in degrees F. The available range is : *English Unit Version:* -10.0000 to 10.0000 degrees F. *Metric Unit Version:* -10.0000 to 10.0000 degrees C.	0.0000
EX_TPZ	**External Temperature Zero.** The External Temperature Zero is the lower range (4 milliamp zero) setting for the external 4-20 milliamp 'temperature' input channel. The available range is: *English Unit Version:* -50.0000 to 100.0000 degrees F. *Metric Unit Version:* -50.0000 to 100.0000 degrees C.	0.0000
TPZCAL	**Temperature Zero Calibration.** The Temperature Zero Calibration value is the 4 milliamp (zero) count value from the external 4-20 milliamp 'temperature' input channel. This parameter is used to calibrate the zero point of the incoming 4-20 signal from the external 4-20 temperature device. To calibrate the zero point of the incoming 4-20 signal, press the EDIT key. The screen will display IN4MA. Set the incoming signal for 4 milliamps (or connect an external 4-20 calibrator set for 4 milliamps) and press the EDIT key. The MST2000 will measure the external temperature input channel and save the new 4 milliamp reference to memory.	4175 If an external temperature option is pre-installed and calibrated at the factory this will be custom set for that unit.

Parameter	Description	Factory Default
EX_TPS	**External Temperature Span.** The External Temperature Span is the upper range setting for the external 4-20 milliamp 'temperature' input channel. The available range is: *English Unit Version:* 0.000 to 990.0000 degrees F. *Metric Unit Version:* 0.000 to 990.0000 degrees C.	200.0000
TPSCAL	**Temperature Span Calibration.** The Temperature Span Calibration Value is the 20 milliamp (span) count value from the external 4-20 milliamp 'temperature' input channel. This parameter is used to calibrate the span point of the incoming 4-20 signal from the external temperature device. To calibrate the span of the incoming 4-20 signal, press the EDIT key. The screen will display IN20MA. Set the incoming signal for 20 milliamps (or connect an external 4-20 calibrator set for 20 milliamps) and press the EDIT key. The MST2000 will measure the external temperature input channel and save the new 20 milliamp reference to memory.	21000 If an external temperature option is pre-installed and calibrated at the factory this will be custom set for that unit.
APRSRC	**Absolute Pressure Source.** Available assignments are 0 = CONstant and 1 = EXTernal. ☑ ***Note: MST2000 DP sensor maximum operating static pressure is 25 PSID.***	0 = CONstant
APRCON	**Absolute Pressure Constant.** The absolute pressure constant can be used for mass flow calculations when no external absolute pressure input is available and is entered as the average absolute pressure inside the duct. The available range is: *English Unit Version:* 0.000 to 100.0000 PSIA. *Metric Unit Version:* 0.000 to 100.0000 Bar.	14.6960 for English. 1.01325 for Metric.
EX_APZ	**External Absolute Pressure Zero**. The External Absolute Pressure Zero is the lower range (4 milliamp zero) setting for the external 4-20 milliamp 'absolute pressure' input channel. The available range is: *English Unit Version:* 0.000 to 100.0000 PSIA. *Metric Unit Version:* 0.000 to 100.0000 Bar. ☑ ***Note: MST2000 DP sensor maximum operating static pressure is 25 PSID.***	0.000
APZCAL	**Absolute Pressure Zero Calibration** The Absolute Pressure Zero Calibration value is the 4 milliamp (zero) count value from the external 4-20 milliamp 'absolute pressure' input channel. This parameter is used to calibrate the zero point of the incoming 4-20 signal from the external 4-20 absolute pressure device. To calibrate the zero point of the incoming 4-20 signal, press the EDIT key. The screen will display IN4MA. Set the incoming signal for 4 milliamps (or connect an external 4-20 calibrator set for 4 milliamps) and press the EDIT key. The MST2000 will measure the external absolute pressure channel and save the new 4 milliamp reference to memory.	4175 If an external absolute pressure option is pre-installed and calibrated at the factory this will be custom set for that unit.
EX_APS	**External Absolute Pressure Span.** The External Absolute Pressure Span is the upper range setting for the external 4-20 milliamp 'absolute pressure' input channel. The available range is: *English Unit Version:* 0.000 to 100.0000 PSIA. *Metric Unit Version:* 0.000 to 100.0000 Bar. ☑ ***Note: MST2000 DP sensor maximum operating static pressure is 25 PSID.***	25.0000 for English. 1.7237 for Metric

Parameter	Description	Factory Default
APSCAL	**Absolute Pressure Span Calibration**. The Absolute Pressure Span Calibration value is the 20 milliamp (span) count value from the external 4-20 milliamp 'absolute pressure' input channel. This parameter is used to calibrate the span point of the incoming 4-20 signal from the external absolute pressure device. To calibrate the span point of the incoming 4-20 signal, press the EDIT key. The screen will display IN20MA. Set the incoming signal for 20 milliamps (or connect an external 4-20 calibrator set for 20 milliamps) and press the EDIT key. The MST2000 will measure the external absolute pressure channel and save the new 20 milliamp reference to memory.	21000 If an external absolute pressure option is pre-installed and calibrated at the factory this will be custom set for that unit.
INPUTO	**Input Offset.** The Input Offset parameter allows the user to adjust (calibrate) the actual pressure (zero) value to the MST2000 displayed value. The input offset parameter is displayed and stored in memory as counts. After the EDIT key is pressed, the edit menu displays the real time pressure input. The user then uses the INC and DEC keys to adjust the desired offset. The pressure input must be connected to a pressure source and be at minimum range value (zero reference) during this adjustment. Use the MODE key to adjust the cursor position (i.e.. x D1, x D10, x D100, etc.) to change the offset count by different increments. The available range is –50,000 to 50,000 counts (approximately +/- 20% adjustment of full scale). The factory default is as set by the factory during initial system calibration.	This is a factory default setting determined during calibration. It should be recorded by the user in the event it will be necessary to restore the *Input Offset t*o the original value. This setting is also recorded on a label located under the cover of the MST2000.
INPUTG	**Input Gain.** The Input Gain parameter allows the user to adjust the gain of the actual pressure (full scale) value to the MST2000 displayed value. The input gain parameter is displayed and stored in memory as a gain multiplier. After the EDIT key is pressed, the edit menu displays the real time pressure input. The user then uses the INC and DEC keys to adjust the desired gain. The pressure input must be connected to a pressure source and at maximum range value during this adjustment. Use the MODE key to adjust the cursor position (i.e.., x D1, x D01, x D001 etc.) to change the gain multiplier by different increments. The available range is 0.8000 to 1.2000 (approximately +/- 20 % adjustment of full scale). The factory default is as set by the factory during initial system calibration.	This is a factory default setting determined during calibration. It should be recorded by the user in the event it will be necessary to restore the *Input Gain* to the original value. This setting is also recorded on a label located under the cover of the MST2000.
OUTPTO	**Output Offset.** The Output Offset parameter allows the user to adjust the actual 4 milliamp (zero) output value as referenced to the MST2000 displayed zero value. The output offset parameter is displayed and stored in memory as counts. After the EDIT key is pressed, the edit menu displays the actual count offset and the microprocessor sets the output to the 4.000 milliamp value. The user then presses the INC and DEC keys to adjust the desired milliamp offset. Use the MODE key to adjust the cursor position (i.e. x D1, x D10, x D100, etc.) to change the offset count by different increments. The available range is –1,000 to 10,000 counts (approximately 3.9 to 6.5 milliamp adjustment range). The factory default is as set by the factory during initial system calibration.	This is a factory default setting determined during calibration. It should be recorded by the user in the event it will be necessary to restore the *Output Offset* to the original value. This setting is also recorded on a label located under the cover of the MST2000.

Parameter	Description	Factory Default
OUTPTG	**Output Gain.** The Output Gain parameter allows the user to adjust the actual 20 milliamp (span) output value as referenced to the MST2000 displayed full scale value. The output gain parameter is displayed and stored in memory as a gain multiplier. After the EDIT key is pressed, the edit menu displays the actual multiplier value and the microprocessor sets the output to the 20.000 milliamp value. The user then uses the INC and DEC keys to adjust the desired full scale milliamps. Use the MODE key to adjust the cursor position (i.e., x D1, x D01, x D001 etc.) to change the gain multiplier in different increments. The available range is 0.8000 to 1.1000. (Approximately 16.5 to 20.5 milliamp adjustment range). The factory default is as set by the factory during initial system calibration. ☑ ***NOTE: The minimum and maximum output current range is 3.9 milliamps and 20.5 milliamps (3.8 milliamps is reserved for fault 'low' current and 21.0 milliamps is reserved for fault 'high' current).*** ☑ ***Note: If HART® communications are enabled, the minimum current is limited to 4.0 milliamps.***	This is a factory default setting determined during calibration. It should be recorded by the user in the event it will be necessary to restore the *Output Gain* to the original value. This setting is also recorded on a label located under the cover of the MST2000.
AVGFAC	**Averaging Factor.** The Averaging Factor controls the digital filtering level (damping) of the displayed pressure value (and the 4-20 milliamp output). The average factor parameter controls the size (depth) of the digital FILO (first in – last out) filter algorithm. Available range is 1 to 10. The average factor does not affect the inherent update rate of the LCD or 4-20 milliamp output (approximately two times per second) except during power up initialization when the FILO registers are first being loaded.	1= No Filtering
DEFDSP	**Default Display.** The Default Display parameter assignment selects the LCD display mode after power up and initialization. Available assignments are: *English Unit Version:* 0 = INWC (primary variable), 1 = SCFM, 2 = ACFM, 3 = LBHR or 4 = SCAN. Selecting SCAN will cause the display to sequence through the calculated variables at 4 second intervals. *Metric Unit Version:* 0 = MMWC (primary variable), 1 = NM3-HR, 2 = M3-HR, 3 = KG-HR or 4 = SCAN. Selecting SCAN will cause the display to sequence through the calculated variables at 4 second intervals.	0 = INWC for English. 0 = MMWC for Metric.
DSPRES	**Display Resolution**. The Display Resolution parameter assignment controls the number of digits that are displayed to the right of the decimal. The display resolution can be set as follows: English Unit Version: From 1 to 4 Digits to the right of the decimal. Metric Unit Version: From 1 to 3 Digits to the right of the decimal.	3 = X.XXX
ALARMS	The MST2000 has multiple alarm features. Alarms are available for 4-20 milliamp limit checks (under-range and over-range), RTD faults, external 4-20 milliamp PCB communication failures and internal hardware circuit faults. Alarms are enabled and disabled by setting the individual binary bits in the ALARM WORD register to a '1' or '0' respectively. Since the individual binary bits cannot be displayed on the LCD, the user must input the decimal word equivalent representing the enabled and disabled bits. The individual alarm bit assignments and the associated binary values are shown in Section 9.	0 = Alarms Disabled

Parameter	Description	Factory Default
P_WORD	**Password.** The password is used to prevent unauthorized access to the programming parameters. The password may be any value between 0 and 9999. A password value of 0 disables the password feature.	0 = Password Disabled
BD_ENB	**Blow Down Enable**. The Blow Down Enable parameter allows the user to enable or disable the integrated blow down sys tem. • A value of '0' disables the Blowdown Sequence. • A value of '1' en ables the blowdown func tion with ex ter nal trig ger only. An external trigger must be ap plied to the 'IN1' ter mi nal to initiate the Blowdown se quence. • A value between 2 and 1440 en ables the MST2000 to con trol the Blowdown sequence on timed intervals (in min utes). The time interval be gins as soon as the MST2000 is put back in 'RUN' mode. For values be tween 2 and 1440 min utes, an ex ter nal trigger may also be applied to com mand ad di tional blowdown sequences. The external trigger event does not re set the MST2000 blowdown in ternal timer. ☑ ***Note: The min i mum ex ter nal trig ger pulse width is 500 mil li sec onds.***	0 = Blowdown Disabled.
HT_ENB	**HART En able.** The HART® En able pa ram e ter al lows the user to en able or dis able the HART® Com mu ni ca tion op tion. Avail able as sign ments are 0 = Dis abled and 1 = En abled. ☑ ***Note: IF the HART® option is enabled, 3.8 milliamp 'fault current' and 3.9 milliamp 'un der range' cur rent val ues are not al lowed on the 4-20mA out put ter mi nals dur ing RUN Mode.***	0 = Default if no HART® option installed. 1 = Enabled if HART® option installed.

9. ALARM PROGRAMMING INFORMATION

9.1 Alarm 'ENABLE' Word Definition

The ALARM 'ENABLE' WORD (16 bit word) is divided into two 8 bit bytes. The lower order byte (bits 1 – 8) is used to enable and disable the alarm functions. The higher order byte (bits 9 – 16) is used to control how the alarm is displayed and/or output to the user interface. Some bits are currently undefined and reserved for future use.

BIT 16	BIT 15	BIT 14	BIT 13	BIT 12	BIT 11	BIT 10	BIT 9	BIT 8	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1
32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
	External Constants	Digital Out	Latched Output	LCD Icon	Last-Val	Fail-High	Fail-Low				Hardware Fault	Comm Error	RTD FAULT	OVER-RANGE	UNDER-RANGE

9.2 Low Byte 'BIT' Definitions

A. **Under-range:** Enabling the un der-range alarm bit will cause the under-range alarm to become active when the 4-20 milliamp output cur rent reaches 3.9 milliamps.
B. **Over-range:** Enabling the over-range alarm bit will cause the over-range alarm to become active when the 4-20 milliamp output current reaches 20.5 milliamps.
C. **RTD Fault:** Enabling the RTD fault alarm bit will cause the RTD fault alarm to become active if an open circuit or short circuit is sensed in the 4-wire RTD loop connection. See Section 9.3 G
D. **ISO Comm error:** Enabling the ISO Comm er ror alarm bit will cause the ISO Comm er ror alarm(s) to become active if any communication er rors or hard ware faults are de tected from any of the ex ternal 4-20 milliamp input boards. (ISO = Iso lated Out put Mod ule). See Sec tion 9.3 G.
E. **Hardware Fault**: Enabling the Hardware Fault error alarm bit will cause the Hardware Fault error alarm to become active if any internal hardware circuit faults (including microprocessor watchdog timer faults) are detected from the MST2000 internal circuitry.

☑ ***Note: For each alarm fault bit above, in di vid ual alarm sta tus bit(s) are pro vided in the ALARM STATUS word to iden tify which alarm is ac tive. Each alarm sta tus bit and the as so ci ated bi nary val ues are de scribed later in this section.***

9.3 High Byte 'BIT' Definitions

A. **Fail-low:** Enabling the Fail-low bit will cause the 4-20 milliamp output to change to the fault current value of 3.8 milliamps if any alarm is active.
B. **Fail-high:** Enabling the Fail-high bit will cause the 4-20 milliamp output to change to the fault current value of 21.0 milliamps if any alarm is active.
C. **Last-val:** Enabling the Last-val bit will cause the 4-20 milliamp output to hold at the last value if any alarm is active.

☑ ***Note:***

- The user must insure that only one of the 3 fault current control bits is set for proper operation.
- When entering PROGRAM mode, the 4-20 milliamp output current will change to the fault current as set by the fault current control bits.

D. **LCD Icon:** Enabling the LCD Icon bit will cause the LCD 'Alarm' icon to be turned on if any alarm is active.

E. **Latched Output:** Enabling the Latched Output bit will cause any active alarm to become latched and held active even if the alarm condition clears. Any 'latched' alarms can be cleared during RUN mode by pressing the EDIT key (if the active alarm(s) are no longer active). After pressing the EDIT key, any latched alarms that are no longer active will be cleared and any alarms that are still active will remain latched.

F. **Digital Out1:** Enabling the Digital Out1 bit will cause the digital output channel (OUT1) to change to the LOW state if any alarm is active.

☑ ***Note: The OUT1 (and OUT2) channels are 'open collector' style outputs. The user must externally connect an active pull-up voltage to the output pins for proper operation. The maximum external pull-up voltage that can be applied to the output pins is 24 volts DC.***

G. **External Constants:** Enabling the External Constants bit will cause the programmed constants for temperature or pressure to be used in the mass flow calculations if either the external temperature or pressure inputs are selected and in fault conditions.

9.4 Alarm 'STATUS' Word Definition

The **ALARM STATUS** word indicates which alarms are active during RUN mode. Since the individual binary bits cannot be displayed on the LCD, the decimal word equivalent representing the active alarm status bits is displayed. The individual alarm status bit assignments and the associated binary values are shown below.

☑ ***Note: If alarms are active, the alarm ICON on the LCD will be lit and the ALARM status value will be displayed every 10 seconds. The user may also use the INC/DEC keys to access the alarm status value on the LCD.***

BIT 16	BIT 15	BIT 14	BIT 13	BIT 12	BIT 11	BIT 10	BIT 9	BIT 8	BIT 7	BIT 6	BIT 5	BIT 4	BIT 3	BIT 2	BIT 1
32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1
								Watchdog Timer Fault	Hardware Fault	Comm 3 Error	Comm 2 Error	Comm 1 Error	RTD FAULT	OVER-RANGE	UNDER-RANGE

9.5 Alarm Status 'BIT' Definitions

A. **Under-range:** Indicates Under-range alarm is active.
- Binary value = 1.

B. **Over-range:** Indicates Over-range alarm is active.
- Binary value = 2.

C. **RTD Fault:** Indicates RTD fault (open circuit or short circuit) alarm is active.
- Binary value = 4.

D. **ISO Comm1 error:** Indicates communication or hardware fault error alarm from external 4-20 PCB channel 1 is active.
- Binary value = 8.

E. **ISO Comm2 error**: Indicates communication or hardware fault error alarm from external 4-20 PCB channel 2 is active.
- Binary value = 16.

F. **ISO Comm3 error:** Indicates communication or hardware fault error alarm from external 4-20 PCB channel 3 is active.
- Binary value = 32.

G. **Hardware Fault:** Indicates hardware fault error from MST2000 internal circuitry is active.
- Binary value = 64.

H. **Watchdog Timer Fault**: Indicates watchdog timer fault error from internal microprocessor is active.
- Binary value = 128.

9.6 Alarm 'ENABLE' Word Decimal Calculation Examples

To calculate the decimal word equivalent for the ALARM 'ENABLE' WORD the user must determine which alarms and alarm control bits are to be enabled and then sum the binary values of each enabled bit. The decimal word equivalent is then programmed into the ALARM 'ENABLE' WORD using the programming menus.

A. EXAMPLE 1

The user desires to enable the following alarm/alarm control enable bits:

LCD Icon, Fail-low, RTD Fault and **Under-range.**

a. LCD Icon binary value = 2048
b. Fail-low binary value = 256
c. RTD Fault binary value = 4
d. Under-range binary value = 1

- Decimal equivalent sum = 2309 (decimal value to program into ALARM 'ENABLE' WORD).

B. EXAMPLE 2

The user desires to enable the following alarm/alarm control enable bits:

Digital Out1, Latched Output, Fail-high, ISO Comm error, Over-range and **Under-range.**

a. Digital Out1 binary value = 8192
b. Latched Output binary value = 4096
c. Fail-high binary value = 512
d. ISO Comm error binary value = 8
e. Over-range binary value = 2
f. Under-range binary value = 1

- Decimal equivalent sum = 12811 (decimal value to program into ALARM 'ENABLE' WORD).

9.7 Alarm 'STATUS' Word Decimal Decode Examples

To determine which individual alarm status bits are active, the user must take the decimal equivalent value from the ALARM 'STATUS' WORD register and decode it into the associated binary bit values. This is accomplished using binary division of the decimal word. The examples below show manual division. The user may also use a decimal to binary calculator to simplify this procedure.

A. Example 1

- ALARM 'STATUS' WORD = 37
- Using binary division, divide the decimal word by each binary bit value starting with the most significant bit value (bit 8 = 128) and then each successive lower bit.

a. 37 ÷ 128 = 0 with a remainder of 37 . . . . . bit 8 (Watchdog timer fault) = 0
b. 37 ÷ 64 = 0 with a remainder of 37 . . . . . bit 7 (Hardware fault) = 0
c. 37 ÷ 32 = 1 with a remainder of 5 . . . . . bit 6 (ISO comm3 error) = 1
d. 5 ÷ 16 = 0 with a remainder of 5 . . . . . bit 5 (ISO comm2 error) = 0
e. 5 ÷ 8 = 0 with a remainder of 5 . . . . . bit 4 (ISO comm1 error) = 0
f. 5 ÷ 4 = 1 with a remainder of 1 . . . . . bit 3 (RTD fault) = 1
g. 1 ÷ 2 = 0 with a remainder of 1 . . . . . bit 2 (Over-range) = 0
h. 1 ÷ 1 = 1 with a remainder of 0 . . . . . bit 1 (Under-range) = 1

- The decimal ALARM 'STATUS' WORD of 37 indicates the following active alarms:
ISO Comm3 error, RTD fault and **Under-range**.

B. Example 2

- ALARM 'STATUS' WORD = 206
- Using binary division, divide the decimal word by each binary bit value starting with the most significant bit value (bit 8 = 128) and then each successive lower bit.
  a. 206 ÷ 128 = 1 with a remainder of 78 . . . . . bit 8 (Watchdog timer fault) = 1
  b. 78 ÷ 64 = 1 with a remainder of 14. . . . . bit 7 (Hard ware fault) = 1
  c. 14 ÷ 32 = 0 with a remainder of 14 . . . . . bit 6 (ISO comm3 error) = 0
  d. 14 ÷ 16 = 0 with a remainder of 14 . . . . . bit 5 (ISO comm2 error) = 0
  e. 14 ÷ 8 = 1 with a remainder of 6 . . . . . bit 4 (ISO comm1 error) = 1
  f. 6 ÷ 4 = 1 with a remainder of 2 . . . . . bit 3 (RTD fault) = 1
  g. 2 ÷ 2 = 1 with a remainder of 0 . . . . . bit 2 (Over-range) = 1
  h. 0 ÷ 1 = 0 with a remainder of 0 . . . . . bit 1 (Under-range) = 0

- The decimal ALARM 'STATUS' WORD of 206 indicates the following active alarms:
  Watchdog timer fault, Hardware fault, ISO Comm1 error, RTD fault and **Over-range.**

10. FORMULAS & CONVERSION FACTORS

The following formulas are used in the MST2000 software calculations:

- **Velocity** $= 1096.845 \times \sqrt{DP \div Density}$
- **ACFM** $= Ae \times 667.657 \times \sqrt{DP \times (T \div P)}$
- **SCFM** $= Ae \times 23972.677 \times \sqrt{DP \times (P \div T)}$
- **LB / HR =** *SCFM* $\times$ *Standard Density (@*68^{o} *F)* $\times$ 60
- **Ae or Effective Area (sq. ft)** $=$ *Kfactor* $\times$ *Nominal Area (sq.ft)*. Thermo Brandt supplies the Effective Area (Ae) specification with each of its flowmeters.
  - Where:
    - *Velocity* is in Feet per Minute
    - *DP* (Differential Pressure) is in Inches of Water Column
    - *T* (Temperature) is in degrees Rankine (degrees Rankine = degrees Fahrenheit + 459.67)
    - *P* (Absolute pressure) is in pounds per square inch (PSI)
    - *Density* is in pounds per cubic foot (Lb/FT^3)
    - *Ae* (Effective Area) is in Square Feet.

Metric Conversion Factors

- Meters per second x 196.850 = Feet per minute
- Bar x 14.5038 = PSIA
- Square meters x 10.7643 = Square feet
- Millimeters of water column ÷ 25.4 = Inches of Water Column
- Kilograms per hour x 2.205 = Pounds per hour
- Kilograms per cubic meter ÷ 16.0136 = Pounds per cubic foot.
- Cubic meters per hour x 0.5885 = Cubic feet per minute
- (Degrees C + 273.15) x 1.8 = degrees Rankine
- Ae or Effective area (in square feet) = Kfactor x Nominal Area (square meters) x 0.0929. Thermo Brandt supplies the Effective Area (Ae) specification with each of its flowmeters. The user must convert to square meters before entering the effective area parameter in the '*E_AREA*' programming menu.

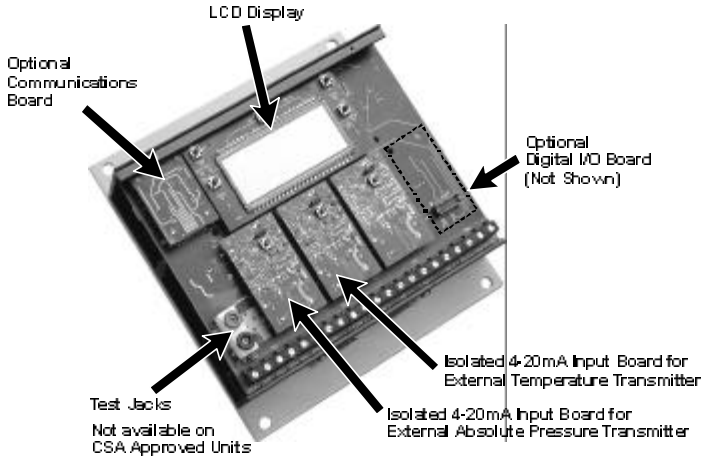
11.

TEST JACK

A Test Jack is standard on the **Non I.S. Approved MST2000's**. It allows the user to monitor the mA output of the unit without disconnecting the loop. Review dimensional drawings on page 4. **The Test Jack is removed for all I.S. and Division 2 approved MST2000's.**

To monitor the mA output of the MST2000 you will need a precision milliammeter. Push the positive lead from the meter into the positive jack (RED) and the negative lead from the meter into the negative jack (BLACK).

12. OPTIONAL MODULE INSTALLATION



The **MST2000 Loop Powered Multivariable SMARTFLOW® Transmitter's** design is such that optional input, digital I/O and HART® communication modules can be installed in the field. This allows the user the versatility to change and adapt to different application needs. This section contains guidelines for installing the optional modules and updating the MST2000's programming if necessary. Please review this section before attempting to make any upgrades. If there are any questions or problems please call the factory for assistance.

☑ ***NOTE:***

- Any upgrades should be made in a clean and dust free environment.
- Anti-static discharge precautions should be adhered to.

12.1 Isolated 4-20mA Input Modules (ISO Module)

A. Thermo Brandt Part Number FP37-OPTN-ISO

a. The Isolated 4-20mA Input Module (ISO) allows the MST2000 to accept an isolated 4-20mA signal from either an Absolute Pressure Transmitter or External Temperature Transmitter. The 2nd D.P. Transmitter Option is unavailable at the time this manual was printed.
b. All isolated 4-20mA Input Modules are identical, but they must be mounted in the correct location on the Main Board. See photograph and drawings in this section.
c. The Module will be shipped in a sealed bag along with stand offs (2) and instruction sheet.

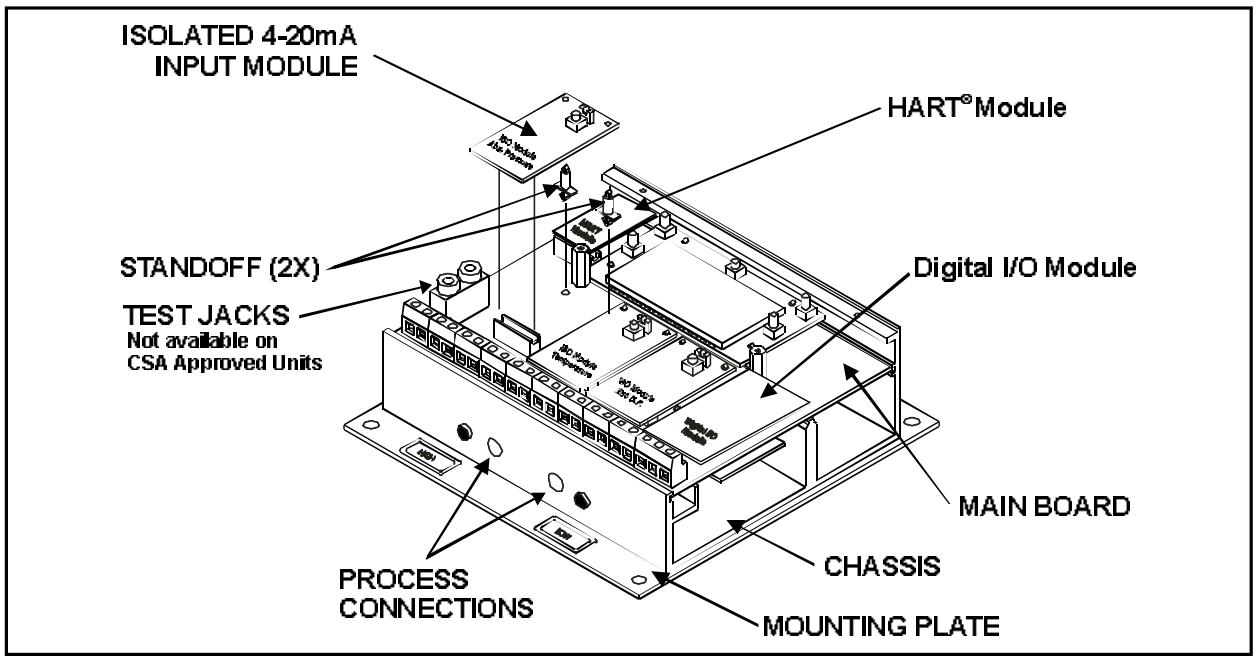
B. Installing the ISO Module Option.

a. Disconnect all power from the MST2000.
b. Decide which slot the ISO Module will fill. Remove the Option Cover Label covering that slot.
c. Take off the MST2000 Cover by removing the 4 flat head screws. It is not necessary to remove the Main Board from the housing.
d. Locate the slot, connector and two mounting holes for the ISO Module on the Main Board.
e. Remove the ISO Module and two (2) stand offs from the bag.
f. Snap the Stand offs into the two holes located on the Main Board as shown in the drawing. Note the orientation of the stand off.
g.

Align the ISO Module such that the reset button and LED are toward the LCD and facing up. The connector will be on the bottom of the board. Snap the ISO Module into the standoffs while making sure the connector and header are properly aligned.

h. Replace the cover.
i. Hook up the MST2000 as per the terminal block wiring diagram on page 7.
j. Apply Power to the MST2000.

C. Programming the MST2000 to recognize the ISO Module(s)



a. Review Section 7 on Programming and Section 8 on Parameters.
b. Depending on which slot the ISO Module was installed, select one of the following parameters to edit:
c. *TMPSRC:* Temperature Source.
d. *APRSRC*: Absolute Pressure Source.
e. Use the **INC** or **DEC** buttons to scroll to *'1=EXT'* (1 = EXTernal)
f. Press the EDIT key to save this change to memory.

D. Calibrating the ISO Module

a. External Absolute Pressure Transmitter ISO Module. Review the Program Parameters in section 8.
   i. Connect a 4-20 mA source to the Absolute Pressure Transmitter ISO Module input terminals (marked EXTIN 1). See terminal block drawing on page 7.
   ii. Make sure parameter *APRSRC* (Absolute Pressure Zero Source) is set to *1* (1 = EXTernal).
   iii. Set the *EX_APZ* (Absolute Pressure Zero) parameter.
   iv. Set the *APZCAL* (Absolute Pressure Zero Calibration) parameter:
   - Press the Edit key. Display will change to read *IN4MA*.
   - Apply 4.0 milliamps. Press the Edit Key to read and store the 4 milliamp calibration value.

   v. Set the *EX_ABS* (Absolute Pressure Span) parameter.
   vi. Set the *APSCAL* (Absolute Pressure Span Calibration) parameter.
   - Press the Edit key. Display will change to read *IN20MA*.
   - Apply 20.0 milliamps. Press the Edit Key to read and store the 20 milliamp calibration value.

☑ ***NOTE: For those MST2400 with the Integral Absolute Pressure Transmitter option installed , the ISO Module has been calibrated at the factory.***

b. External Temperature Transmitter ISO Module. Review the Program Parameters in section 8.
   i. Connect a 4-20 mA source to the External Temperature Transmitter ISO Module input terminals (marked EXTIN 2). See terminal block drawing on page 7.
   ii. Make sure parameter TMPSRC (Temperature Source) is set to 1 (1 = EXTernal).
   iii. Set the EX_TPZ (Temperature Zero) parameter.
   iv. Set the TPZCAL (Temperature Zero Calibration) parameter.
   - Press the Edit key. Display will change to read IN4MA.
   - Apply 4.0 milliamps. Press the Edit Key to read and store the 4 milliamp calibration value.

   v. Set the EX_TPS (Temperature Span) parameter.
   vi. Set the TPSCAL (Temperature Span Calibration) parameter.
   - Press the Edit key. Display will change to read IN20MA.
   - Apply 20.0 milliamps. Press the Edit Key to read and store the 20 milliamp calibration value.

12.2 Digital Input / Output Module Installation

A. Thermo Brandt Part Number FP37-OPTN-DIO
   a. The Digital I/O module allows the MST2000 to accept one (1) digital input and output (1) digital outputs.
   b. The Digital I/O module must be installed on the rightmost connector. See photograph and drawings in this section.
   c. The Digital I/O module will be shipped in a sealed bag along with standoffs (2) and instruction sheet.

B. Installing the Digital I/O Module Option.
   a. Disconnect all power from the MST2000.
   b. Take off the MST2000 Cover by removing the 4 flat head screws. It is not necessary to remove the Main Board from the housing.
   c. Locate the slot, connector and two mounting holes for the Digital I/O module on the Main Board.
   d. Remove the Digital I/O module and two (2) standoffs from the bag.
   e. Snap the standoffs into the two holes located on the Main Board as shown in the drawing. Note the orientation of the standoffs.
   f. Align the Digital I/O module such that connector will be on the bottom of the board. Snap the module into the standoffs while making sure the connector and header are properly aligned.
   g. Replace the cover.
   h. Hook up the MST2000 as per the terminal block wiring diagram on page 7.
   i. Apply Power to the MST2000.

C. For Digital I/O wiring configurations see section 14.

12.3 HART® Communications Module

A. Thermo Brandt Part Number FP37-OPTN-HART
   a. The HART® Communication module allows the MST2000 to communicate with standard HART® Interfaces.
   b. The HART® Communication module must be installed on the upper left most connector. See photograph and drawings in this section.
   c. The HART® Communication module will be shipped in a sealed bag along with standoffs (2) and instruction sheet.

B. Installing the HART® Communication Module Option.
   a. Disconnect all power from the MST2000.
   b. Take off the MST2000 Cover by removing the 4 flat head screws. It is not necessary to remove the Main Board from the housing.
   c. Locate the slot, connector and two mounting holes for the HART® module on the Main Board.
   d. Remove the HART® module and two (2) standoffs from the bag.
   e. Snap the Standoffs into the two holes located on the Main Board as shown in the drawing. Note the orientation of the standoff.
   f.

Align the HART® module such that connector will be on the bottom of the board. Snap the module into the standoffs while making sure the connector and header are properly aligned.

g. Replace the cover.
h. Hook up the MST2000 as per the terminal block wiring diagram on page 7.
i. Apply Power to the MST2000.

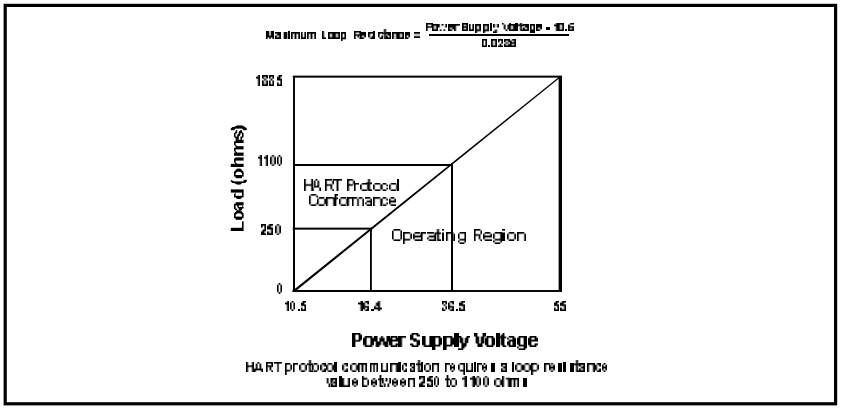
13. MST2000 HART® Communications Information

13.1 Power and Loop Conditions

The MST2000 Multivariable differential pressure transmitter is a HART® conforming loop-powered 4-20 milliamp transmitter. Power connection is made at the two left terminal positions marked LOOP+ and LOOP-. Nominal power supply voltage is 24 volts DC which allows up to 600 ohms series resistance in the loop circuit. Higher loop resistance can be used with higher power supply voltages as required. See the loop resistance-voltage graph below in determining the minimum loop voltage required.

Note: For HART® communication applications, minimum loop resistance is 250 ohms.

13.2 HART® Connections

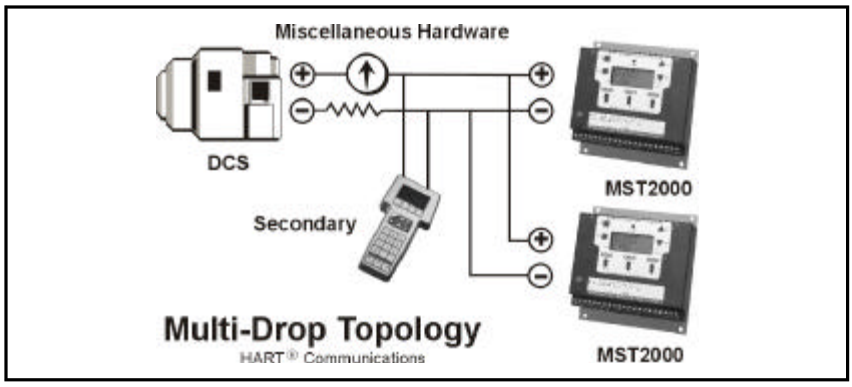


Maximum resistance versus DC loop voltage

All electrical connections are per standard HART® connections. Refer to HART® Communication Foundation Document HCF_SPEC-54 (HART® FSK Physical Layer Specification, Revision 8.0) for additional information. The current sense resistor may be connected in either the high or low side of the field loop wiring. HART® communication devices must be connected in accordance with HCF_SPEC-54 for proper operation. Typical connection methods are shown in the following diagrams.

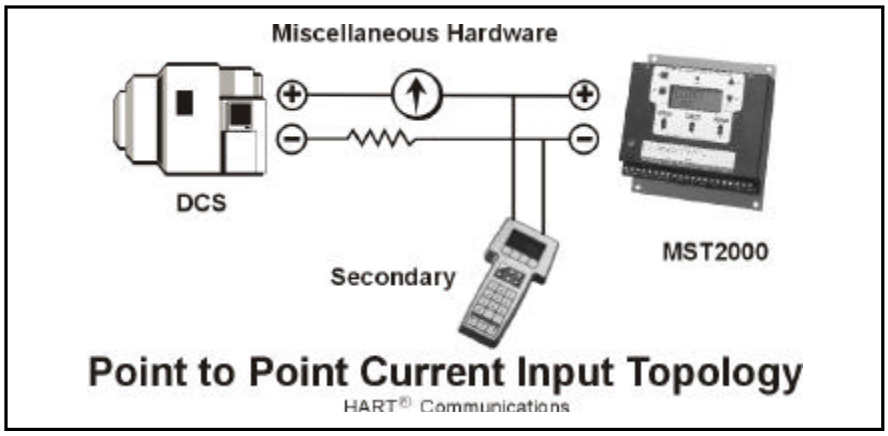
13.3 Cabling Requirements

The field wiring of a HART® based system should use shielded twisted pair cable. When using cable with multiple twisted pairs, it is important not to use the other pairs for signals that might interfere with the HART® communication signals.



Typical multi-drop connection with digital communications.

Typical Point to Point Connection with analog signaling.



If the cable is longer than several meters, it's resistance and capacitance may become significant in the HART® RC time-constant limitation ® x C ☯ 65 microseconds). When using a single field device and a host with a 250 ohm load and no other significant resistance, the 65 microsecond limitation would allow 0.26 uF of capacitance for the system. Allowing 0.01 uF (10,000 pF) for the host and field device (each having a CN=1), the total cable capacitance could be up to 0.25 uF. However, if the cable resistance was 110 ohms, the system resistance becomes 360 ohms, which then allows for a total permitted cable capacitance of 0.18 uF. This corresponds to a nominal cable length of 900 meters for a cable with a rating of 200 pF/meter. If the cable needs to be extended upward towards the maximum HART® cable length of 1500 meters, a cable with a lower capacitance rating must be selected.

- In a multi-dropped system, the additional capacitance from each networked transmitter must also be considered. Each transmitter has an established CN value. A CN value of 1 indicates that the transmitter represents 5000 pF of load capacitance.
- The MST2000 transmitter has a CN Value of 1 (5000pF).
- The internal resistance of the MST2000 transmitter is in excess of 100,000 ohms and can be ignored in the cable length calculations.

13.4 HART® Communication Distance

Up to 1.5 km (1 mile) when using multiple twisted pair cables. Communication distance varies depending on type of cable used.

Use the following formula to determine cable length for specific applications:

$$L = \frac{65 \times 10^6}{(R \times C)} - \frac{(C_f + 10000)}{C}$$

Where:

L = Length in Meters or Feet

R = Resistance in Ohms (Ω) including barrier resistance.

C = Cable capacitance in pF/m or pF/ft

C_f = Maximum shunt capacitance of receiving devices in pF/m or pF/ft.

13.5 Power Supply Requirements

To minimize signal degradation of the HART® communication signals, the following power supply specifications are required.

- Voltage: . . . . . 24 V DC (typical)
- Maximum ripple (47 to 125 Hz): . . . . . 0.2 V (peak to peak)
- Maximum noise (500 Hz to 10 kHz): . . . . . 1.2 mV
- Maximum series impedance (500 Hz to 10 kHz):. . 10 ohms

13.6 Intrinsic Safety Considerations

Intrinsic safety approvals for the MST2000 are pending. Contact the factory for additional information involving hazardous applications with the use of safety barriers.

13.7 HART® Command Information

The MST2000 transmitter is compliant with HART® Command Revision 5.1. The following commands are supported. Reference HART® Document HCF_LIT-20 (HART® Technical Overview) for additional information.

COMMAND	HART® Command Set	Description
0	Universal	Read Unique Identifier
1	Universal	Read Primary Variable (pv)
2	Universal	Read (pv) current and percent of range
3	Universal	Read (pv) current and four predefined variables
6	Universal	Write Polling Address
11	Universal	Read Unique Identifier associated with Tag
12	Universal	Read Message
13	Universal	Read Tag, Descriptor, Date
14	Universal	Read sensor information
15	Universal	Read output information
16	Universal	Read final assembly number
17	Universal	Write message
18	Universal	Write tag, descriptor, date
19	Universal	Write final assembly number
35	Common Practice	Write (pv) range values
50	Common Practice	Read dynamic variable assignments
51	Common Practice	Write dynamic variable assignments
59	Common Practice	Write number of response preambles

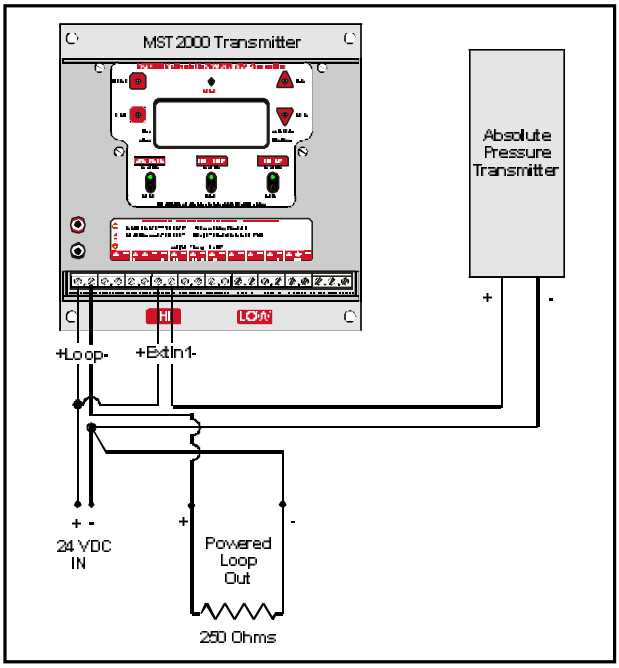
pv = primary variable

13.8 Thermo Brandt Instruments HART® ManufacturerIdentification Code = 96 Hex, 150 Decimal

13.9 MST2000 HART® Transmitter Variable Code Assignments.

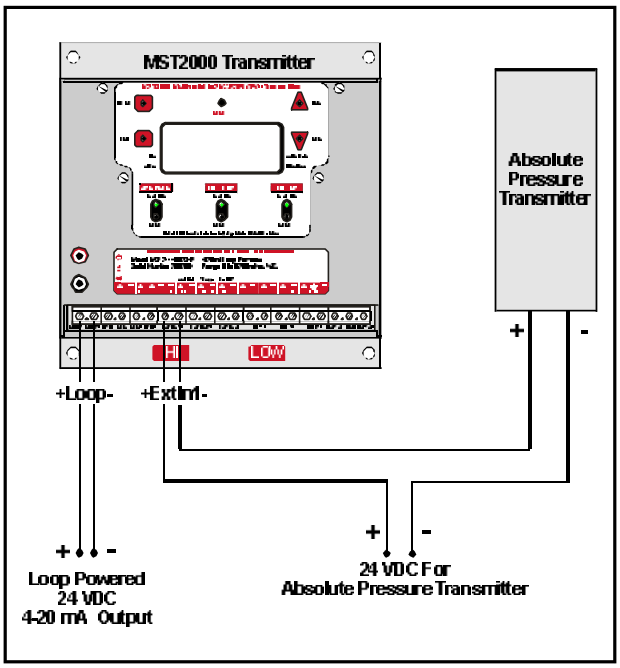
Variable Code	ENGLISH UNIT VERSION	METRIC UNIT VERSION
0 or 1	DP in Inches of W.C.	D.P. In Millimeters of W.C.
2	Standard Cubic Feet Per Minute (SCFM)	Normal Cubic Meters Per Hour (NM3-HR)
3	Actual Cubic Feet per Minute (ACFM)	Cubic Meters per Hour (M3-HR)
4	Mass in Pounds per Hour (LB/HR)	Mass in Kilograms per Hour (KG-HR)
5	External Temperature in Degree Fahrenheit	External Temperature in Degree Celsius
6	External Absolute Pressure in PSIA	External Absolute Pressure in BAR

14. Wiring Diagrams



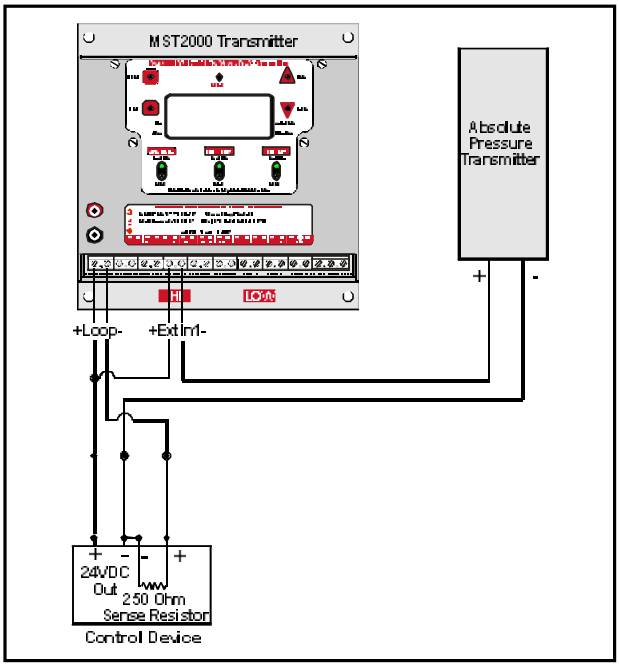
Four Wire Connection with Absolute Pressure Transmitter

The MST2000 with a Absolute Pressure Transmitter can be wired to replace your existing four wire transmitter



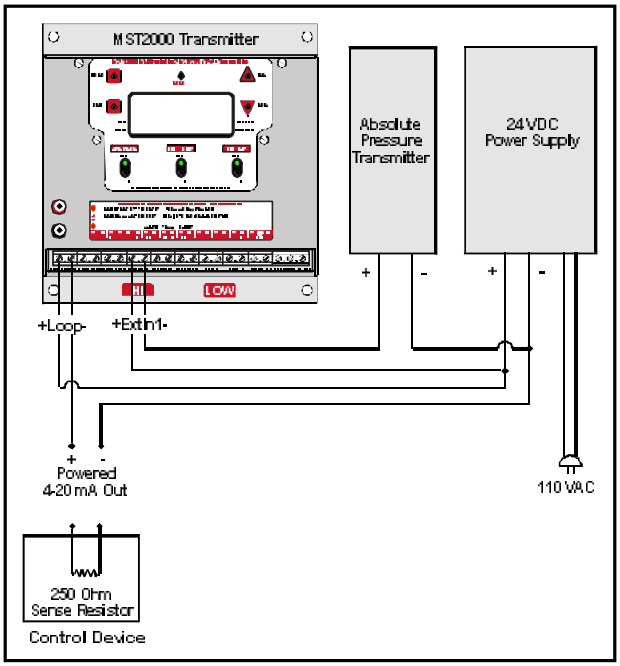
Dual 2 Wire Connection with Absolute Pressure Transmitter

The MST2000 with Absolute Pressure Transmitter can be wired to replace your existing four wire transmitter. Requires two 24Vdc power sources.



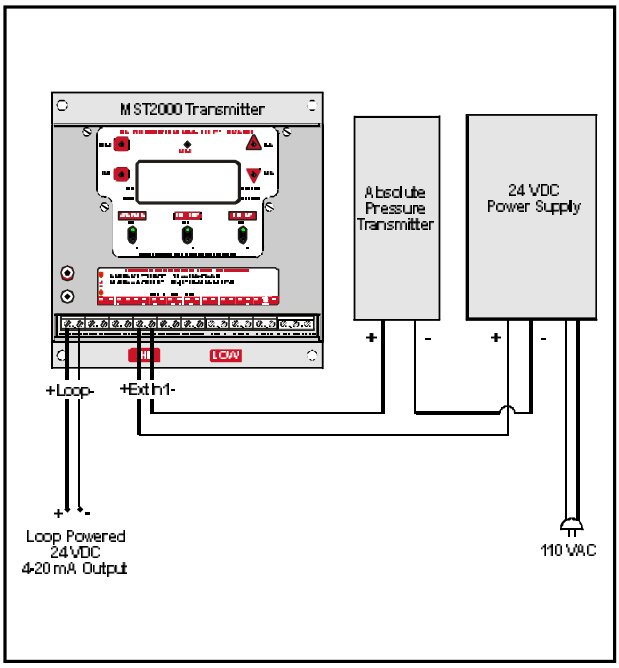
Three Wire Connection with Absolute Pressure Transmitter.

The MST2000 with Absolute Pressure Transmitter can be wired to replace your existing three wire transmitter.



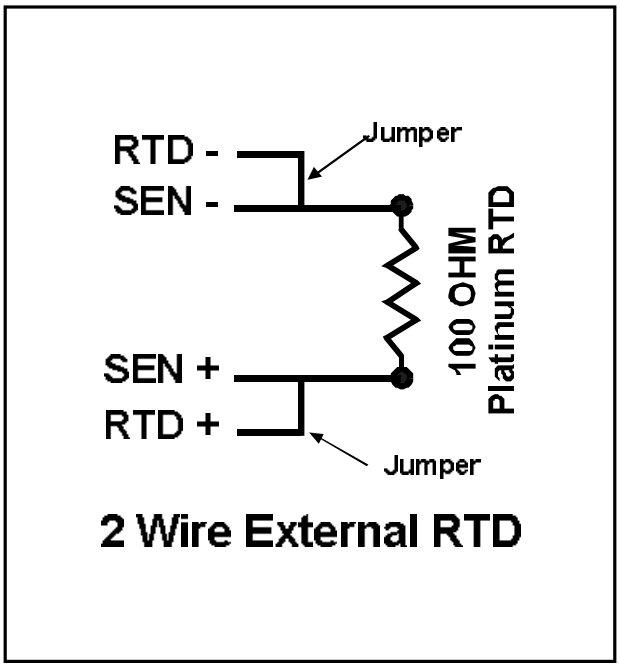
Power Supply & Absolute Pressure Transmitter

The MST2000 with Absolute Pressure Transmitter can be supplied with a power supply to power the MST2000 and Absolute Pressure Transmitter.

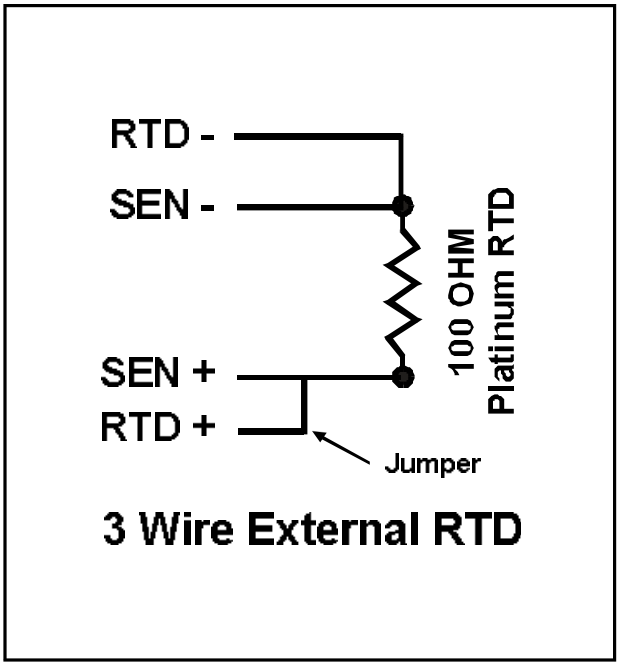


Power Supply and Absolute Pressure Transmitter

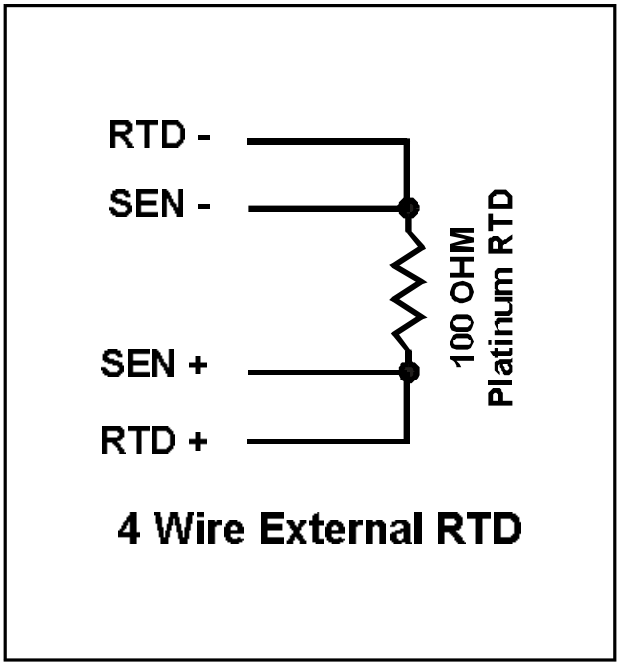
The MST2000 with Absolute Pressure Transmitter can be supplied with a power supply to power the Absolute Pressure only. The MST2000 will be powered by a 24Vdc, 4-20mA loop.



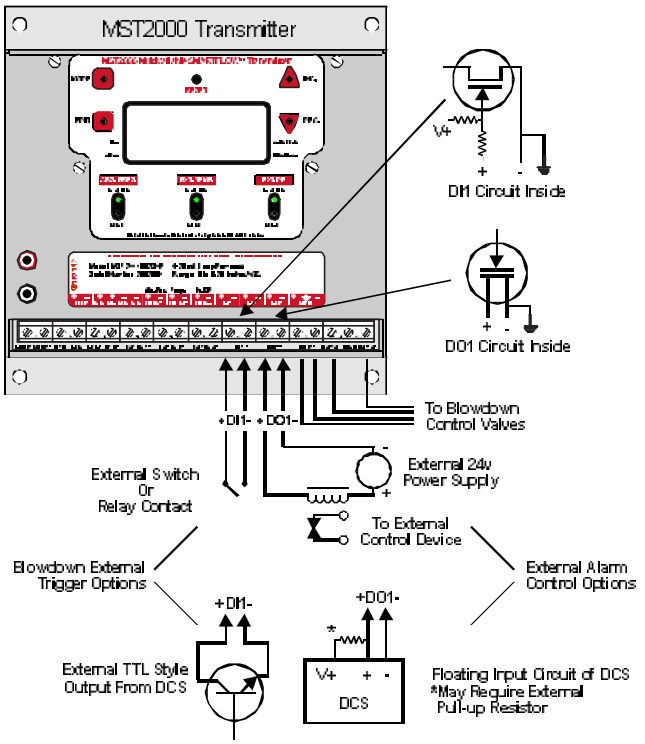
2 Wire RTD Connection



3 Wire RTD Connection



4 Wire RTD Connection



The DI1 (Digital In) connection accepts TTL level signals (isolated) or dry contact closures. If TTL signals are used, the ground connection must be floating and isolated from the 4-20mA loop connections.

The DO1 (Digital Out) connection is a MOSFET open drain style output. External ground connections must be floating and isolated from the 4-20mA loop connections.

The MST2000 Blowdown is supplied with an internal power supply, this power supply is isolated and can be used to provide isolated power connections to the external alarm circuit. Do not use it to supply power to the Loop Signal.

Digital I/O Connections for Integral Blowdown System

15. MST2000 Hazardous Area Installation

The MST2000 Multivariable SMARTFLOW™ Transmitter is Canadian Standards Association approved for the following hazardous area classifications.

15.1 Intrinsically Safe Installations

A. ***Model MST2100 (NEMA 1):*** Intrinsically Safe for CL. I, Grps. C & D
B. ***Model MST2400 (NEMA 4X):*** Intrinsically Safe for CL. I, Grps. C & D. CL. II, Grps. E, F & G

- For Intrinsically Safe applications, unit must be installed per Thermo Brandt installation drawing number SC37-4000-00. See Page 29.
- Intrinsically safe entity parameters: Vmax = 40 VDC, Imax = 165mA, Ci = 0uf, Li = 240uH.
- Maximum operating ambient temperature: 66 Degrees C (151 Degrees F)

15.2 Division 2 And Other Installations:

A. ***Model MST2100 (NEMA 1):*** CL I, Div. 2, Grps. C & D
B. ***Model MST2400 (NEMA 4X):*** CL I, Div. 2 Grps. C & D. CL II, Div. 2 Grps. E, F & G. CL. III, Div. 2

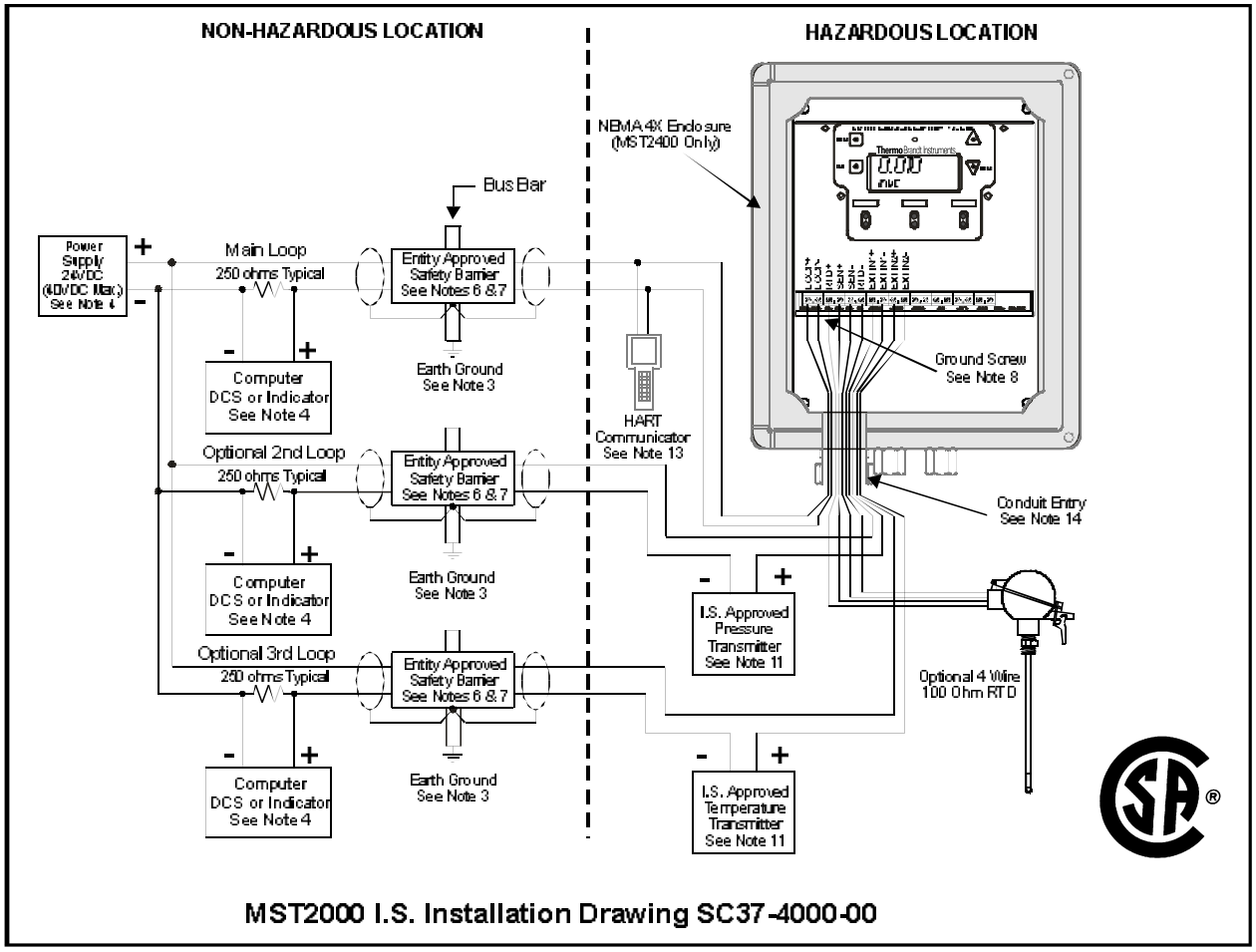
- For Division 2 applications, unit must be installed per Canadian and/or National Electrical Code requirements for Division 2 areas. Intrinsic safety barriers are not required.
- Division 2 power ratings: Vmax = 40 VDC, Imax = 165mA.
- Maximum operating ambient temperature: 66 degrees C (151 Degrees F).

15.3 Approved Options.

See the chart below and review the Model Number Description on Page 2.

OPTION	MST2100			MST2400		
	Intrinsically Safe	Division2	Not Certified	Intrinsically Safe	Division2	Not Certified
HART COMMUNICATIONS	X	X	X	X	X	X
4 Wire RTD	X	X	X	X	X	X
ISO 4-20mA Temperature Input Module	X	X	X	X	X	X
ISO 4-20mA Pressure Input Module	X	X	X	X	X	X
Digital I/O Card		X	X		X	X
High Pressure Blow Down			N/A			X
Integral 120VAC Power Supply			N/A			X
Absolute Pressure Transmitter			N/A			X
Heater			N/A			X
Continuous Purge			N/A	X	X	X
Test Jacks			X			X
Terminal Block 4			X			X

15.4 MST2000 I.S. Installation Drawing SC37-4000-00



MST2000 I.S. Installation Drawing SC37-4000-00

See Notes for Drawing SC37-4000-00 on next page:

15.5 Notes for MST2000 I.S. Installation Drawing SC37-4000-00

1. For I.S. Installations, field wiring shall be installed in accordance with Canadian Electrical Code and/or National Electrical code ANSI/NFPA 70, Article 504-30
2. Wiring cable shall be 24 AWG or heavier, separate shielded pairs.
3. The grounding connection between the safety barrier and earth ground must be less than 1 ohm.
4. Control room equipment must not generate more than 250 Volts rms.
5. Safety Barriers must be of approved types and used in an approved configuration where the transmitter Vmax value is greater than the barrier Voc rating and the transmitter Imax value is greater than the Barrier Isc rating.
6. The transmitter input capacitance (Ci) plus the total cable capacitance for each loop must not exceed the barrier Ca rating.
7. The transmitter input inductance (Li) plus the total cable inductance for each loop must not exceed the barrier La rating.
8. Transmitter enclosure must be grounded to earth ground using the provided ground lug on the enclosure.
9. The MST2000 Transmitter is Intrinsically Safe for:
   - Class I, Division 1, Groups C and D
   - Class II, Division 1 Groups E, F and G.
10. Loop entity parameters per circuit are:
    - Vmax = 40 VDC
    - Imax = 165mA
    - Ci = 0uF
    - Li = 240uH
11. Use only CSA approved I.S. Pressure transmitters where the Vmax and Imax of the transmitter is greater than the Voc and Isc of the barrier. The Ci and Li of the transmitter must be included in system total capacitance and inductance calculation and must be less than barrier Ca and La Ratings.
12. Approved methods for separation of each loop are:
    - Running Loops in separate cables
    - Running Loops in separate shields
13. When connecting HART communicator the Vmax and Imax of the communicator must be greater than the Voc and Isc of the barrier. Voc of communicator plus Voc of barrier must be less than Vmax of transmitter, ISC of Communicator plus Isc of Barrier must be less than Imax of Transmitter. Li of Transmitter plus Li of Communicator must be less than La of Barrier, Ci of transmitter plus Ci of Communicator must be less than Ca of Barrier.
14. Use only listed and approved dust tight seal for Class II and Class III Hazardous Locations.
15. Other wire terminals not available for use on Intrinsically Safe version
16. No revisions shall be made without notification of Approval Agency(s).

16. Calibration of the MST2000

Basic calibration of the MST2000 Series transmitters is done in two parts: 1) setting the 4-20 mA output from the digital to analog converter and 2) setting the 0 & 100% values of the displayed DP. Both parts are done by the setting of parameters, entered via the integral keypad.

16.1 OUTPUT mA CALIBRATION

A. ZERO and SPAN of the mA output are set by the OUTPTO and OUTPTG parameters, respectively. You do not need to apply any DP signal for the mA calibration, only an accurate mA test meter is required.
B. Following the procedures of Section 7, enter the PROGRAMMING Mode and select the OUTPTO parameter. The existing value of OUTPUT OFFSET will be displayed.
C. Press the EDIT/SAVE key once to force the digital to analog converter to its 0% output value and to allow you to adjust the output to exactly 4.00mA as read on a mA test meter. Use the INCREMENT & DECREMENT keys as needed.
D. Press the EDIT/SAVE key to exit the edit mode and save the OUTPUT OFFSET value (even if there was no adjustment made). Now step to the OUTPTG parameter to display the existing value of OUTPUT GAIN.
E. Press the EDIT/SAVE key once to force the digital to analog converter output to its 100% value and to allow you to adjust the output to exactly 20.00mA as read on a mA test meter. Use the INCREMENT & DECREMENT keys as needed.
F. Press the EDIT/SAVE key to exit the edit mode and save the OUTPUT GAIN value. This completes the output mA calibration.
G. Exit the PROGRAMMING Mode, by pressing the MODE key, or continue with the DP calibration.

16.2 DP CALIBRATION

☑ ***NOTE: For MST2000 Transmitters with CONTINUOUS PURGE OPTION. Do not use a hand pump, or compression cylinder type of pressure source for the DP test signals. You must use a vented source to permit continuous flow of purge air. Contact the factory for additional information on calibrating transmitters with continuous purge.***

☑ ***NOTE: Do not turn off the purge air supply to use the transmitter as though it does not have the purge option; this will cause errors.***

A. Connect an accurate test DP signal to the MST2000, equal to the 0% minimum range value.
B. While in the PROGRAMMING MODE, step to the INPUTO parameter to display the existing value of INPUT OFFSET.
C. Press the EDIT/SAVE key once to display the DP reading. Use the INCREMENT/DECREMENT keys as needed to adjust the display to match the test DP signal value.
D. Press the EDIT/SAVE key to exit the edit mode and to save the INPUT OFFSET value, (even if it was not changed).
E. Adjust the test DP signal to the 100% maximum range value. Step to the INPUTG parameter to display the existing value of INPUT GAIN.
F. Press the EDIT/SAVE key once to display the DP reading. Use the INCREMENT/DECREMENT keys as needed to adjust the display to match the test DP signal value.
G. Press the EDIT/SAVE key to exit the edit mode and to save the INPUT GAIN value.

☑ ***NOTE: Changes to INPUTO or INPUTG will affect both the display & the mA for any applied DP value. Adjusting OUTPTO or OUTPTG will affect only the mA value for any applied DP value.***