MILLTRONICS

Mercap

Instruction Manual March 2001

MERCAP MERCAP

Safety Guidelines

Warning notices must be observed to ensure personal safety as well as that of others, and to protect the product and the connected equipment. These warning notices are accompanied by a clarification of the level of caution to be observed.

Qualified Personnel

This device/system may only be set up and operated in conjunction with this manual. Qualified personnel are only authorized to install and operate this equipment in accordance with established safety practices and standards.

Warning: This product can only function properly and safely if it is correctly transported, stored, installed, set up, operated, and maintained.

Note: Always use product in accordance with specifications.

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Introduction

The Mercap system is a high performance, level measurement instrument consisting of a sophisticated, easy-to-adjust, transmitter (MST9500) combined with measurement electrodes and process seals designed to accommodate numerous configurations. The electrode, comprised of a measurement section and an active shield section, is the primary sensor of the system, and it indicates the electrical capacitance value of the measurement section relative to the environment (tank wall, stilling well, or conductive material). This electrode then connects to the capacitance detector portion of the two-wire loop powered electronic transmitter. The measurement section can be set up to measure the level of solids, liquids and slurries, as well as the interface between two immiscible liquids.

The manual is presented in three sections:

1. The electrode process connections and seals
2. The transmitter
3. Appendix sections providing supplementary information.

Identifications and Abbreviations

Various mnemonics and abbreviations are used in this manual. See below:

Short form	Long Form	Description	Units
CE /FM /CSA	Conformitè Europèene/ Factory Mutual/Canadian Standards Association		
DAC	Digital Analog Converter		
DCS	Distributed Control System	Control Room apparatus	
Ex	Explosion Proof		
Exd	Flame Proof		
FV	Full Vacuum		
ESD	Electrostatic Discharge		
HART™	Highway Addressable Remote Transducer		
LRV	Lower Range Value	value for 0 %	4 mA
LSL	Lower Sensor Limit	below which PV is incorrect	
pF	pico Farads	0.000000000001	Farad
ppm	parts per million		
PV	Primary Variable	measured value	
Stilling Well	grounded metal tube with openings		
SV	Secondary Variable	equivalent value	
SVLRV	Sec. Var. Lower Range Value	0 % equivalent value	
SVURV	Sec. Var. Upper Range Value	100 % equivalent value	
µF	micro Farads	0.000001	Farad
URV	Upper Range Value	value for 100%	20 mA
µSec	micro Seconds	0.000001	Seconds
USL	Upper Sensor Limit	above which PV is incorrect	

HART™ Communication Foundation, Austin, Texas, USA

Technical Specifications

Electrodes

Process connections	
Screw mounting:	NPT, BSPT, JIS.
Flange mounting:	ANSI, DIN
Process material:	C 22.8 N, AISI 316 L, Monel 400, Hastelloy C22
Probe diameter (mm/inch):	9/0.35 (cable), 16/0.63 (rod), or 24/0.95 (rod)
Probe length (mm/inch)	
Rod version:	5500/216
Cable version:	35000/1378
Probe lining:	PFA, Enamel, PTFE
Pressure rating (bar/psi):	FV - 200/2920 up to 525/7665 as option
Temperature rating (°C/°F):	-200°/-328° to 200°/392° up to 450°/842° as option

Wetted Parts

Liner:	PFA/PTFE
Flange:	stainless steel or teflon lined

Transmitter

Measurement range (pF):	0 – 3300
Span (pF):	minimum 3.3
Supply voltage (Vdc):	• maximum 33 • minimum 12 Vdc at 3.6 mA • minimum 9.5 Vdc at 22 mA
Output current (mA):	3.6 – 22 / 22 - 3.6 (2-wire current loop)
Smart communication:	Acc. the HART Communication Foundation (HCF)
Temperature range (°C/°F):	-40°/-40° to 85°/185°

Temperature stability:	0.15 pF (0pF) or <0.25% (typically <0.1%) of actual measurement value, whichever is greater over the full temperature range of the product.
Non linearity and reproducibility:	< 0.1% full scale and actual measurement respectively
Accuracy:	<0.1% of actual measurement value
Features:	• polarity protection input circuit • E.S.D. protected (Loop) • galvanically isolated measurement circuit • fully potted with epoxy resin
Diagnostics (Includes fault alarm):	• primary variable (PV) out of limits • system failure measurement circuit • deviation between A/D and D/A converter values • check sum • watch dog • measurement current out of range
Measurement current signalling:	NAMUR NE 43
Function rotary switch[1]	
Position 1:	4 mA measurement value (set)
Position 2:	20 mA measurement value (set)
Position 3:	3.8 up to 20.5 mA range by means of a field service programmer
Position 4:	functionality test
Approvals:	• Cenelec, FM/CSA (IS), FM (Ex-proof), CE, ATEX

[1] HART communication in all switch positions

Electrodes and Process Connections

This section of the manual is designed to assist in the determination of the best possible probe configuration for your application. Therefore, we discuss the electrodes and process connections before the instrumentation and the operation procedures. When configuring the unit to your application, use the sample configurations below as your criteria.

Mercap electrodes come in a variety of formats to provide the necessary characteristics for correct mounting, chemical compatibility, temperature and pressure requirements, and dielectric constant. Most applications use the simple threaded connection, which is directly mounted in the tank with the mating threaded nipple, or with a flange adapter that includes a threaded hole.

For applications requiring higher temperature and pressure, or greater integrity, welded and solid machined flange versions are available with single or double cone seals, and/or a second seal on the flange plate to avoid any metallic wetted parts.

Handling of Electrodes

> **WARNING**: Do not scratch or gouge the PFA electrode insulation since this could reduce the integrity of the insulation and the useful life of the electrode.

> **WARNING**: Be careful with an enamel insulated electrode. Normally an enamel lining is protected by a stilling well, which is part of the design.

> **WARNING**: Do not damage the insulation jacket on the electrode during shipping, packing, and installation. Most electrodes use PFA insulation, a very dense and reliable type of Teflon® that prevents leakage and corrosion of the metal electrode and acts as an insulator when conductive materials are being measured. Any damage to the electrode can prevent proper performance.

Characteristics

The following characteristics apply to all general connection configurations:

- The standard Mercap insulated electrode is designed for use in both conducting and non-conducting liquid applications.
- All electrodes consist of an active shield portion and a measurement portion, which combine to form the complete electrode.
- The sum of the active shield length and the measurement length is the total insertion length.
- The active shield design provides continuous immunity to the known changes in conditions at the top of many vessels, where levels of vapours, dust, and condensation are constantly changing.
- All changes in capacitance due to temperature and pressure changes that could cause small changes in the seal geometry are also isolated from the measurement signal because they are not included in the starting capacitance of the electrode by virtue of the action of the active shield.
- Due to the well-controlled diameter of the electrodes and insulation, a linear output is achieved over a wide range of capacitance values (3.3 to 3300 pF).
- The end seal is formed as an integral part of the electrode lining, giving smooth and uniform insulation characteristics (tested to 55 kV).
- Standard single cone usage
- Secondary cone usage

General Design Principles

The Mercap capacitance level instrument combines an optimum combination of mechanical and electrical/electronic principles in its design. Combining a single transmitter with as few electrode configurations as possible maximizes the number of potential applications while it minimizes the complexity of the instrument.

In principal, the standard threaded process connection (S-Series) with PFA insulated electrode, including the active shield, provides good results in all measurement situations that are within the temperature, pressure, and corrosive capabilities of the materials and seals. This is true over a wide range of dielectric constants in both non-conducting and conducting materials.

Applications outside of the standard capabilities of the S-Series would require a different design configuration. These non-standard applications include:

Non-Standard Application	Mercap Configuration
Non-metallic tanks with both conducting and non-conducting liquids.	Use a stilling well to provide second electrode reference.
Non-conducting liquids in spherical and horizontal-cylindrical tanks.	Use a stilling well as linearizer.
Highly corrosive materials requiring no metallic wetted parts.	Use flange mount with D, DD seal version.
High pressure and temperature (greater than 200 bar) with conductive liquid.	Use HP version.
Sanitary/food safe applications.	Use Mercap MCP 03.

Mercap Configurations

The Mercap is a versatile level measurement instrument that can be designed for your specific application by taking the following conditions into consideration:

Process Connections

Any standard process connection is available with Mercap, and special versions can be fabricated to match the mounting and application requirements. Various sizes of threaded and flanged fittings are available.

Seal Types

The basic internal seal for the Mercap is of a conical-shaped, preloaded pressure/leak resistant construction. Up to three levels of seal protection are implemented depending on the integrity requirements of the application. A single or double cone internal seal forms 1 or 2 blocks against leaking, and a third flange face gasket is also available in the D and DD seal construction. The flange face seal also provides a design with no metal wetted parts if required.

Pressure and Temperature Considerations

The maximum temperature and pressure of operation for the standard Mercap level probe is 200°C (392°F) and 200 bar (2900 psi). There are, of course, qualifications that must be applied to these maximums.

Enamel probes are suggested when process temperature exceeds 200 °C, and/or in combination with very high pressure.

Note: Consult Milltronics for chemical applications other than water.

Process Connection and Seal Configuration of Mercap

Process Connection	Seal Type	Seal Description
Threaded	S	Single Cone
Welded Flange	S	Single Cone
Solid Machined Flange	S	Single Cone
	D	Single Cone + Teflon flange seal
	DD	Double Cone + Teflon flange seal Consult factory*
	SD	Double Cone (used for stilling well applications)
	HP	Consult factory*

Note: HP (high pressure) is only supplied with enamel insulation and a recommended stilling well for protection of the enamel. A cone seal plus a secondary redundant seal is provided between the electrode and the stilling well.

Examples of Mercap Level Instruments

The following graphics illustrate the variation in configurations available for the Standard series, Level and Interface series, and Sanitary series Mercap level instrument.

Note: All measurements are given in millimeters/inches.

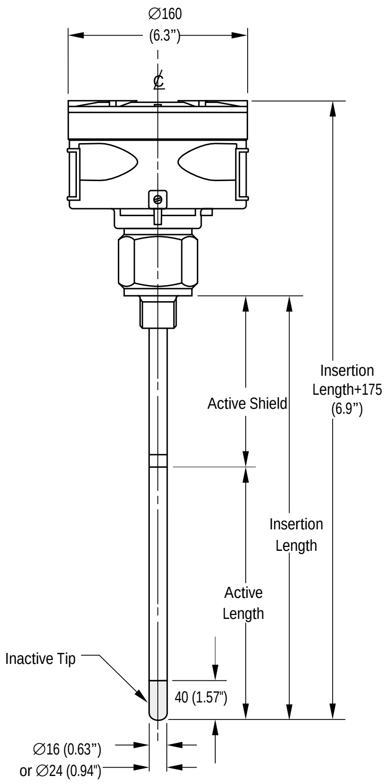
Standard Level Version (Mercap MCP01)

This is the most common version of Mercap and is available with the following features:

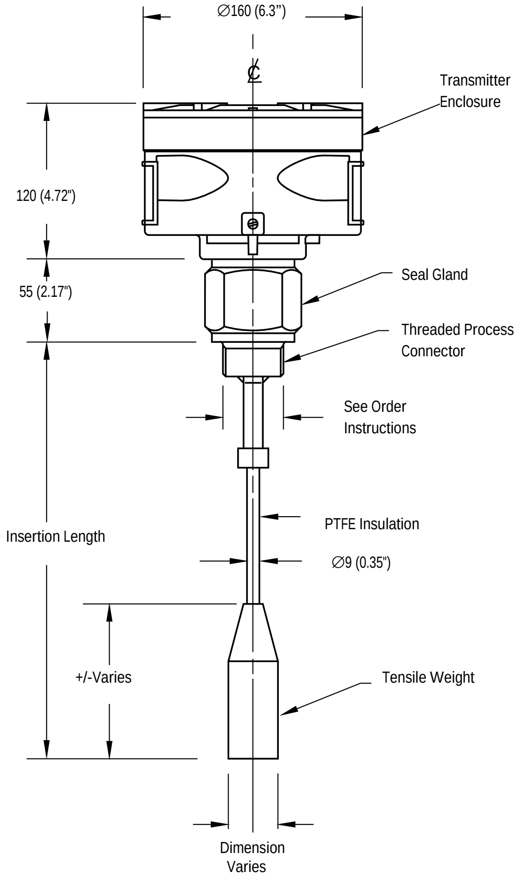
- Threaded flanges, welded flanges, and solid flanges
- S series, D series, SD series, DD series, and HP series process seals.
- Selections of standard ANSI and DIN flanges are available
- The most common electrode is insulated with PFA, but Enamel (HP seal) is also available as standard (Enamel is only available on rigid design).
- Various process connection materials are also available
- Rigid and Flexible Cable versions available

MCP01 (Standard) S-Series: Threaded Versions

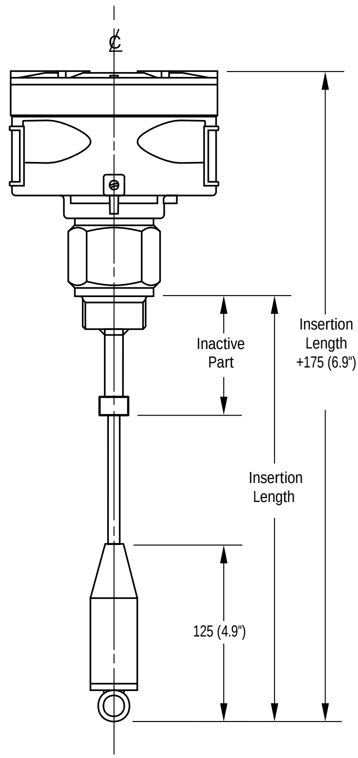
S-Series: Threaded



S-Series Cable Version



S-Series Cable Version (with anchor)

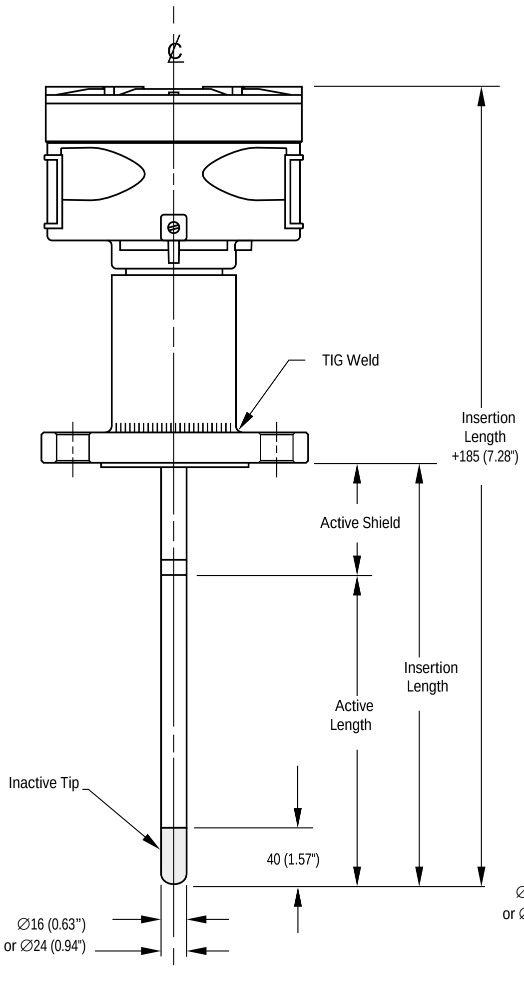


MCP01 S-Series Threaded Features

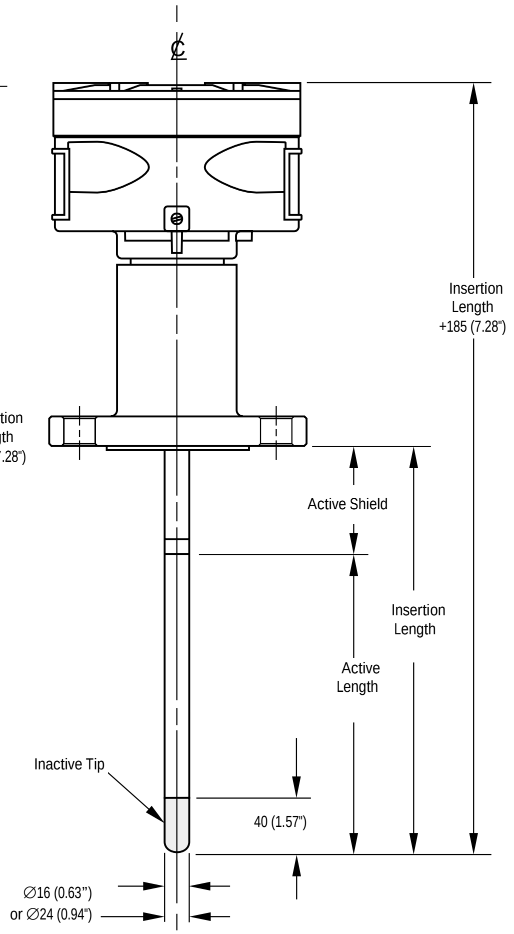
- single process seal
- suitable for most level, interface, or detection applications
- high temperature and pressure resistance

MCP01 (Standard) S-Series: Welded and Machined Flanged Versions

S-Series Welded Flange



S-Series Machined Flange

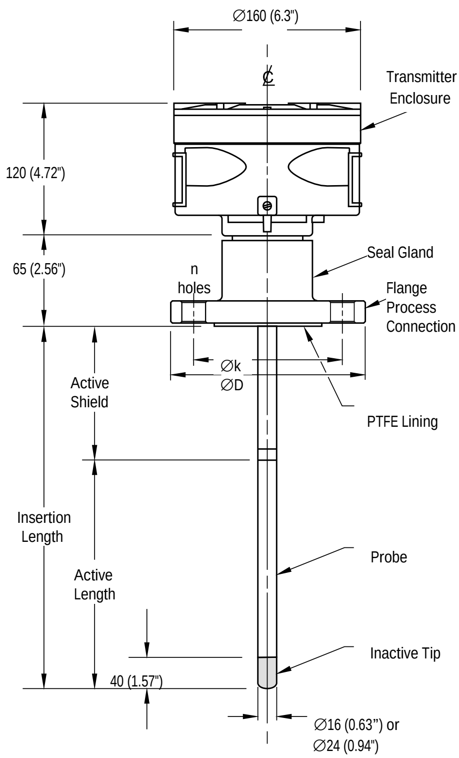


MCP01 S-Series Flange Features

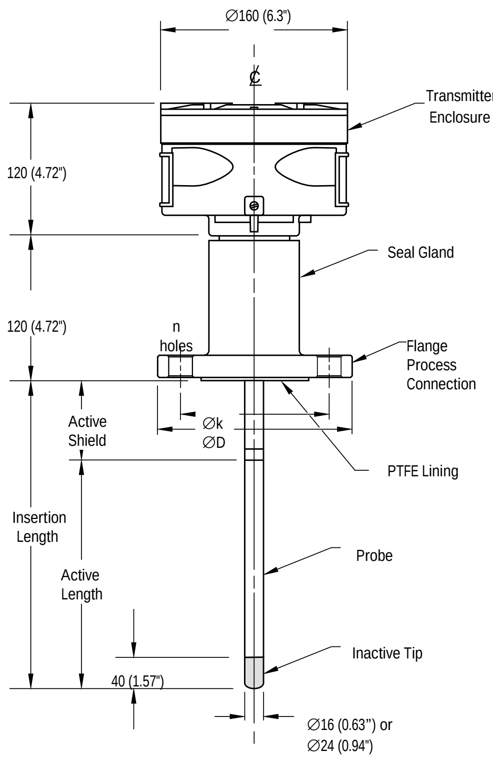
- single process seal
- suitable for most level, interface, or detection applications
- high temperature and pressure resistant

MCP01 Standard D-Series: Machined Flanged Versions

D-Series



DD-Series



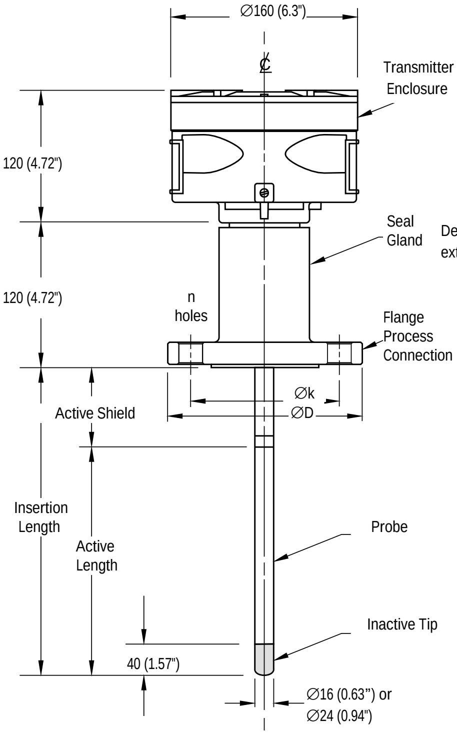
MCP01 Standard D-Series Features

- single process seal
- all wetted parts made of PFA (probe lining) or PTFE (flange face)
- according to NACE requirements

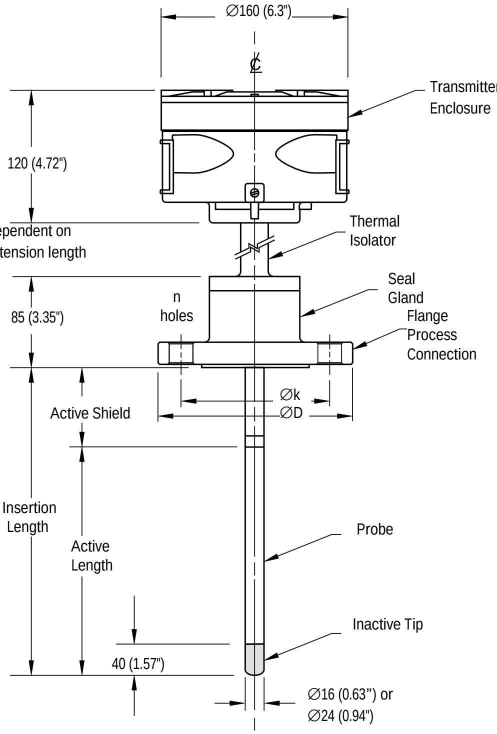
MCP01 Standard DD-Series Features

- double process seal
- redundant safety (e.g. Phenol, Phosgene applications, etc.)
- all wetted parts made of PFA (probe lining) or PTFE (flange face)
- according to NACE requirements
- suitable for turbulent and toxic chemical applications

SD-Series



Probe/Thermal Isolator



MCP01 Standard SD-Series Features

- double process seal
- redundant safety (e.g. Phenol, Phosgene applications, etc.)
- all wetted parts made of PFA/PTFE
- according to NACE requirements
- suitable for turbulent and toxic chemical applications

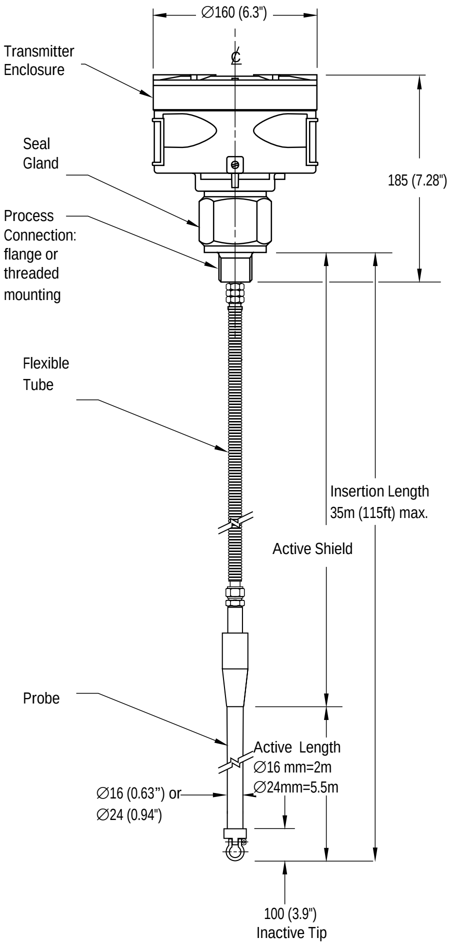
MCP01 Probe/Thermal Isolator Features

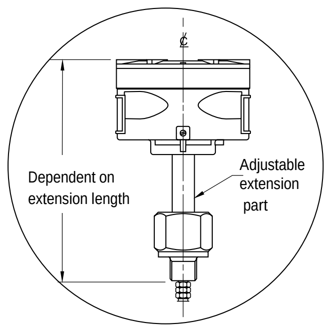
- thermal isolator

Interface and Level Version (Mercap MCP 02)

This version is designed specifically for interface level where a long distance active shield portion of the electrode is required (up to 35 meters) before the measurement portion of the electrode begins. This type of application is common in large storage tanks for oil where the bottom of the tank invariably has a layer of water below the oil. Often, when measurement spans as much as 5.5 meters (for the water), up to 35 meters of flexible bellows cable are used.

MCP02: Interface Version





Process Connection Size

- threaded version: ¾", 1", 1½", 2" NPT, BSPT, or JIS
- sanitary version: on customer request
- flange version: on customer request

Options

- thermal isolator
- stilling well

Aluminum Enclosure

- Nema 4/Type 4/IP65

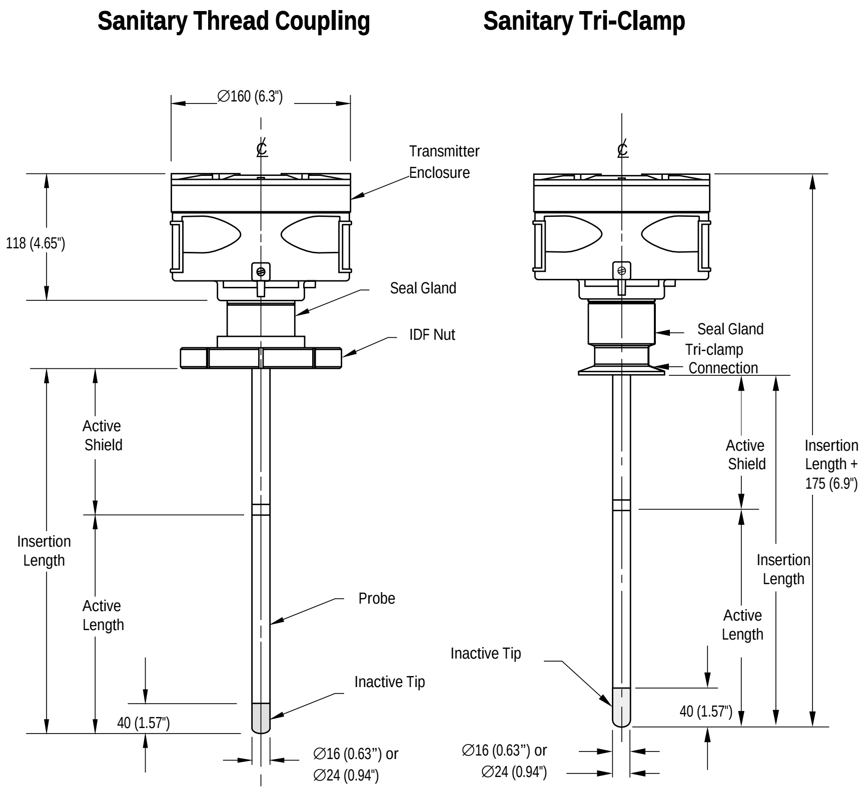
Conduit Entry:

- ½" NPT (2x)

Sanitary Level Version (Mercap MCP 03)

The hygienic design includes threaded and tri-clamp versions for use in the food and pharmaceutical industry.

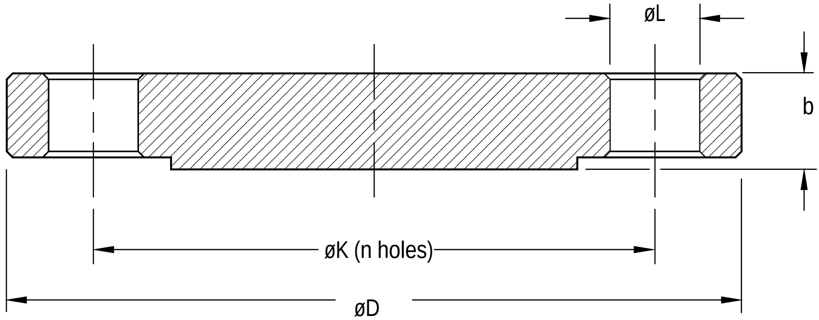
MCP03: Sanitary Versions



MCP03 Sanitary Tri-Clamp Features

- maximum active length 5.5m
- minimum active length 50mm

Flanges



Flange Standards

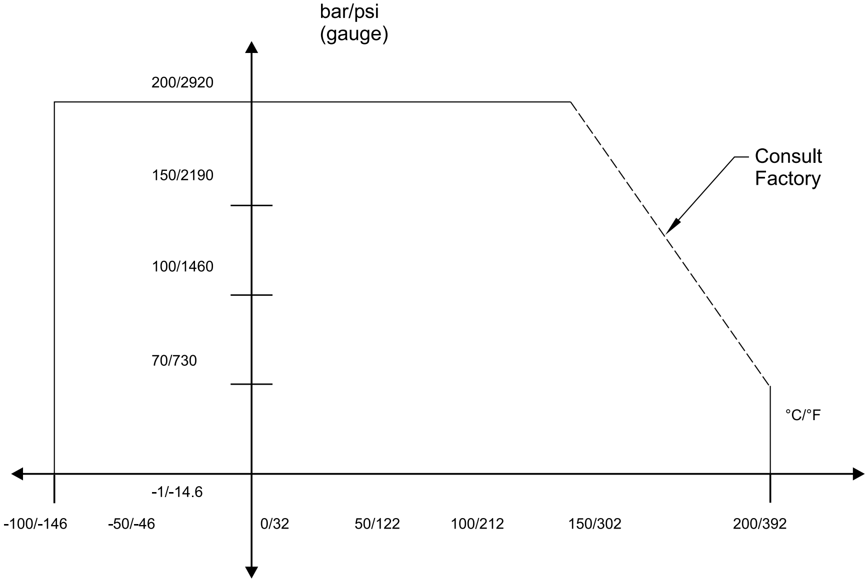
FLANGES acc. ANSI standards															
	150lbs					300lbs					600lbs				
	D	k	L	b	n	D	k	L	b	n	D	k	L	b	n
2"	152.4	120.6	19	19.0	4	165.1	127.0	19	22.2	8	165.1	127.0	19	25.4	8
3"	190.5	152.4	19	23.8	4	209.6	168.3	22	28.6	8	209.6	168.3	22	31.8	8
4"	228.6	190.5	19	23.8	8	254.0	200.0	22	31.8	8	273.1	215.9	26	38.1	8
6"	279.4	241.3	22	25.4	8	317.5	269.9	22	36.5	12	355.6	292.1	29	47.6	12

FLANGES acc. DIN standards															
	PN 10 (PN 16)					PN 25 (PN 40)					PN 64				
	D	k	L	b	n	D	k	L	b	n	D	k	L	b	n
NW50	165	125	18	18	4	165	125	18	20	4	180	135	23	26	4
NW80	200	160	18	20	8	200	160	18	24	8	215	170	23	28	8
NW100	220	180	18	20	8	235	190	23	24	8	250	200	27	30	8
NW150	285	240	23	22	8	300	250	27	28	8	345	280	33	36	8

Note:
- All Sizes: MM
- One (1) inch: ≙ 25.4mm
- Details: See drawings, technical data, and measuring probe details

Temperature Versus Pressure Curve Mercap Level Probe

In this situation, as the temperature reaches 75°C (167°F) the maximum pressure must be derated. As the temperature reaches 200°C (392°F) the maximum pressure is limited to 50 bar (725 psi). This curve is typical for water only, for other, more aggressive chemicals the derating curve will be more severe.



Reference Product: Water

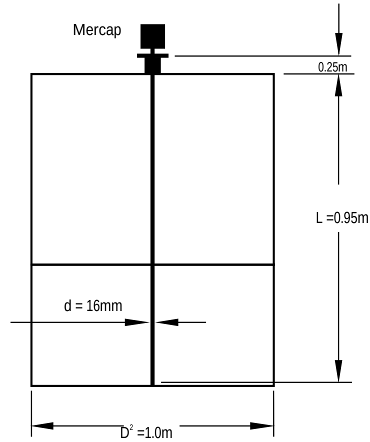
Note: For high temperature and pressure ratings for the Enamel probe, please contact your Siemens Milltronics representative.

Applications Examples

Generic Application Calculations

The capacitance expected in a cylindrical tank with a probe centrally mounted is estimated using the following formula:

$$C=\xi_{r\_air}\,\frac{24 \times 0.95}{\text{Log}\,(1/0.016)}\ \text{pF} = 12.7\text{pF}$$



In which

C = capacitance value in pF
ξ_r = relative dielectric constant
L = active measurement length in meters
D = internal tank diameter in meters
d = electrode diameter in meters
ξ_r = 1 (air)
ξ_r = 2 (oil)
24 = a K constant (can be substituted for 7.32)

For Vessels Filled with Oil

The following equation applies to oil-filled vessels matching the dimensions shown above. Please note that the probe must be properly mounted and the metal tank is grounded.

$$C_{\text{increase for oil}}=\xi_{r\_oil}-\xi_{r\_air}\,\frac{24 \times 0.95}{\text{Log}\,(1/0.016)}\ \text{pF}= 12.7\text{pF}$$

OR

$$C_{\text{increase for oil}}=\xi_{r\_oil}-\xi_{r\_air}\,\frac{7.32 \times 3.12}{\text{Log}\,(1/0.016)}\ \text{pF}= 12.7\text{pF}$$

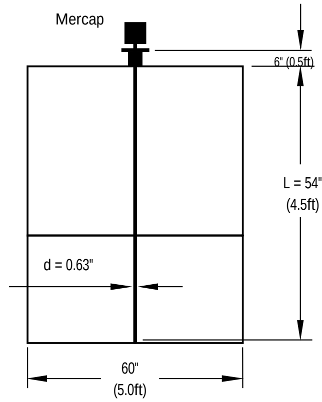
This means that the capacitance value for 0% to 100% changes from 12.7 to 25.4 pF. After calibration then:

12.7 pF $\cong$ 0% $\cong$ 4 mA or 20 mA
25.4 pF $\cong$ 100% $\cong$ 20 mA or 4 mA

A similar example in inches yields the following:

$$C_{\text{increase for oil}} = \xi_r\_oil - \xi_r\_air \; \frac{7.32 \times 4.5}{\text{Log}\,(60/0.63)} = 16.6\text{ pF}$$

So for this slightly larger tank, the capacitance ranges from 16.6 pF to 33.2 pF.



So on calibration:

16.6 pF ≅ 0% ≅ 4 mA or 20 mA
33.2 pF ≅ 100% 20 mA or 4 mA

Flow-Through Electrode

The Mercap flow-through electrodes provide the following multi-functional applications for a liquid pipe system:

- quality measurement
- interface measurement and detection
- product presence detection

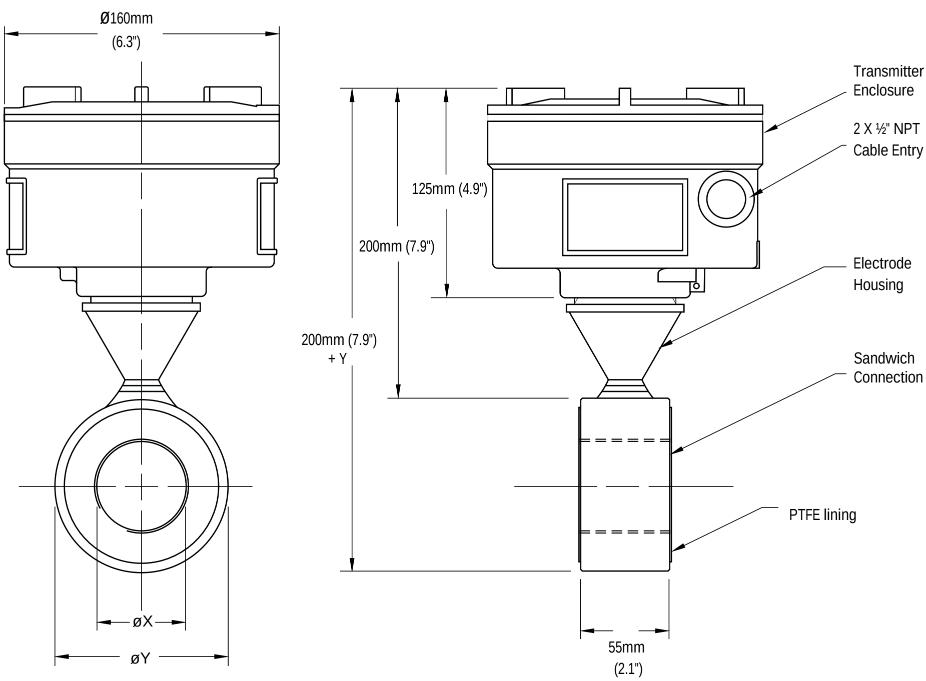
The measurement occurs without placing an obstacle in the product line and uses capacitance to determine the physical characteristics of the product. In mixed liquids, the flow-through electrode can measure the degree of proportions (e.g. water in oil). The capacitance change is measured and transmitted by a 4-20/20-4mA signal and HART protocol.

> **Note**: If the transmitter's ambient temperature exceeds 85° C/185° F (70° C/158° F) in Ex zones) mount a thermopart between electrode head and transmitter housing.

FTS Series

The FTS series flow-through electrode is suitable for relatively high pressure and temperature conditions. It is installed using a sandwich connection between two flanges and a PTFE sealing ring to provide high chemical resistance.

> **Note**: For flange dimensions and pressure ratings, refer to the chart on page 23.



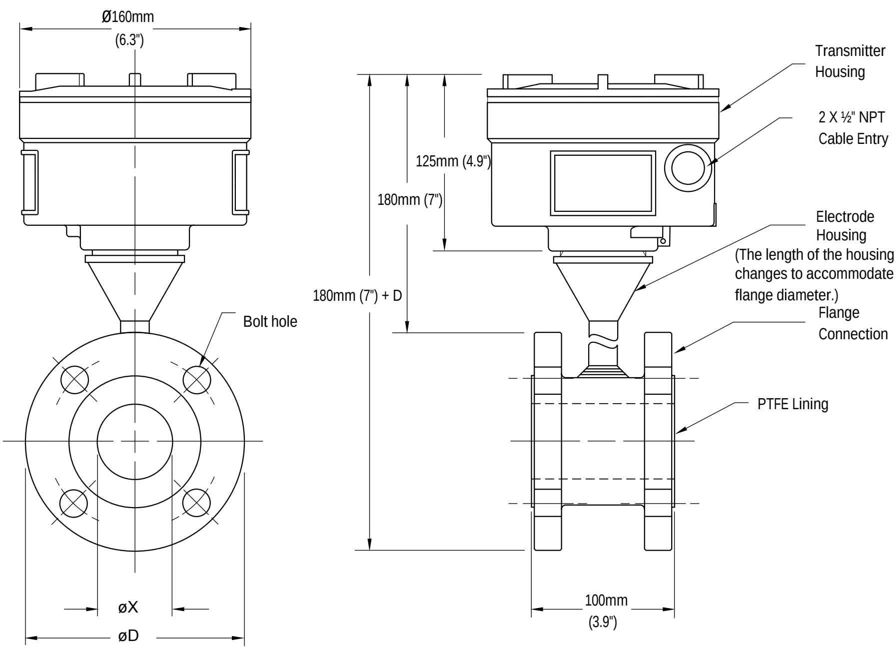
FTS Specifications

Process Connections:	Sandwich, acc. ANSI and DIN standards (table p. 23)
Fitting length:	55mm (2.1")
Material:	AISI 316L or carbon steel C 35
Max. Pressure:	50 bar (dependent on pressure rated flanges)
Max. Temperature:	200°C (398°F)
Lining:	PTFE (1mm thick)
Transmitter Enclosure	Aluminum ø160mm (6.3")
Waterproof Classification:	IP 65, NEMA 4/Type 4 acc. DIN 40050

FTF Series

The FTF series flow-through electrode is designed to accommodate the combination of high-temperature and high-pressure conditions. The electrode is installed using a flange mounting, and the PTFE sealing ring provides high chemical resistance.

Note: For flange dimensions and pressure ratings, refer to the chart on page 25.



FTF Specifications

Process Connections:	Flange, acc. ANSI and DIN standards (table p. 23)
Fitting length:	100mm (3.9")
Material:	AISI 316L or carbon steel C 35
Max. Pressure:	50 bar (dependent on pressure rated flanges)
Max. Temperature:	200°C (398°F)
Lining:	PTFE (1mm thick)
Transmitter Enclosure:	Aluminum ø160mm (6.3")
Waterproof Classification:	IP 65, NEMA 4/Type 4 acc. DIN 40050

Flanges acc. ANSI Standards (inches)

class ►	150 lbs			300 lbs			600 lbs		
nom. size ▼	D	x	y	D	x	y	D	x	y
1"	4.3	1.1	2.5	4.9	1.1	2.8	4.9	1.0	2.7
2"	6.0	2.1	4.0	6.5	2.1	4.3	6.5	1.9	4.2
3"	7.5	3.1	5.2	8.2	3.1	5.7	8.3	2.9	5.7
4"	9.0	4.0	6.7	10.0	4.0	7.0	10.8	3.8	7.5
5"	10.0	5.1	7.6	12.5	5.1	8.4	13.0	4.8	9.4
8"	13.5	8.0	10.9	15.0	8.0	12.0	16.5	7.6	12.5
10"	16.0	10.0	13.3	17.5	10.0	14.1	20.0	9.8	15.6
12"	19.0	12.0	16.0	20.5	12.0	16.5	22.0	11.8	17.9

Flanges acc. DIN Standards (mm)

class ►	PN 16			PN25			PN40		
nom. size ▼	D	x	y	D	x	y	D	x	y
NW 25	115	24.8	71	115	24.8	71	115	24.8	71
NW 50	165	51.2	107	165	51.2	107	165	51.2	107
NW 80	200	82.5	142	200	82.5	142	200	82.5	142
NW 100	220	100.8	162	235	100.8	167	235	100.8	167
NW 125	250	125	192	270	125	193	270	125	193
NW 150	285	150	217	300	150	223	300	150	223
NW 200	340	204.2	272	360	203.4	283	375	203.4	290
NW 250	405	254.4	328	425	252.8	340	450	252.8	352
NW 300	460	303.8	383	485	302	400	515	302	417

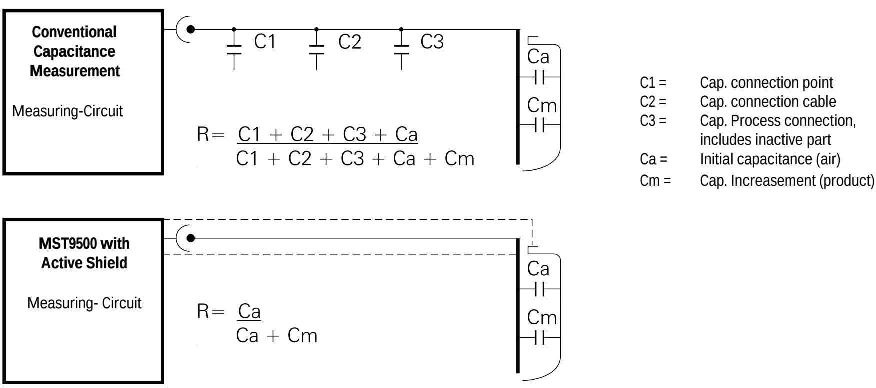
Operating Principles

The instrument's MST9500 transmitter measures the capacitance of a sensor/electrode relative to the reference electrode (often the tank wall) and transforms it to a 4-20 mA signal. Applications include level measurement, level detection, flow measurement, and flow detection.

The measurement capacitance is usually obtained by using an insulated probe inserted in the tank, forming one electrode of the capacitor. The wall of the tank forms the other electrode of the capacitor.

A stilling well is used when the silo or tank is not conductive, or when the shape of the tank cannot guarantee linear measurement. The stilling well is a (grounded) metal tube with vent openings, which fits around the electrode. The stilling well diameter is somewhat larger than the diameter of the electrode, depending on the application.

A significant advantage of the MST9500 is the Active Shielding feature. It prevents any capacitance that may occur in the connection cable, process connection, and non-active parts of the probe from interfering with the measurement. As a result, the capacitance registered by the MST9500 consists only of the measuring capacitor, and a more stable and more reliable measurement is provided.



Due to intrinsic safety requirements, the entire MST9500 transmitter is potted in epoxy resin that also protects the electronics against mechanical vibration and moisture influences. The maximum measuring range of the MST9500 is 3300 pF (1pF $\cong 10^{-12}$F).

The electrode is connected by means of a mini-coax cable. The screw connection is intended for grounding the tank or stilling well.

Note: This ground must be connected to the tank and/or stilling well.

Installation and Interconnection

This section discusses the following:

- housing types supplied with the MST9500
- supply voltage requirements
- cable requirements
- connection diagrams

Transmitter Module Housing

The MST9500 electronics is housed in a plastic box and fully potted in epoxy resin. This construction is necessary for EEx approval and protects the components against mechanical shock and the influence of moisture. The microprocessor is placed on an IC socket so the unit can be upgraded at a later stage by implementing software changes.

The processor chip is covered with a special sticker that contains product information and acts as a protection seal for moisture.

> **Note**: Damage or removal of the sticker voids the warranty for the MST9500.

In most cases, the transmitter is in a Milltronics-supplied metal housing, providing reliable operation in environments with dust, moisture, and high frequency interference.

The electronics operate at temperatures ranging between -40°C to 85°C, which means that protection equipment, such as sun shields, are not normally required.

Metal Housing and Electrode Assembly

The MST9500 is mounted in a powder-coated aluminium housing. The housing provides a separate customer wiring area in line with the cable conduit inlet/outlet openings.

Terminals for:

- Instrument connection (2-wire current loop)
- Ground connection (wire with a sufficiently large conductor diameter)

As the measurement occurs between the Measurement and Ground connection, it is important to have good, low-resistance, reliable connections in this circuit.

IMPORTANT: A reliable and stable ground connection is required to achieve a stable and reliable measurement.

For the Ground connection, a solid electrical connection must be made between the **ground point** on the housing and the process connection with either a stilling well and/or tank wall. In the Milltronics housing, the ground connection between the transmitter and the housing has already been made with the **ground connection point**. The instrument system ground must be connected to this **ground connection point**.

The instrument loop connection for the MST9500 is a 2-wire cable. The positive wire must be connected to terminal **1** (the terminal slot nearest the housing wall), and the negative wire to terminal **2**. (See the connection diagrams on page 27.)

Incorrect power connection will not damage the MST9500. However, it can lead to a larger current (~40 mA) through the loop, and it will not operate with incorrect polarity.

The MST9500 is isolated from the power supply that provides for the opportunity of grounding either line (positive or negative) if requirements for Ex safety are followed and the power supply voltage is less than 33 Vdc.

Caution: During connection, do not leave moisture or metal scrap (of the cable shielding etc.) in the housing. This can interfere with transmitter operation.

Interconnection

Supply

The supply voltage requirements for the MST9500 are shown in the installation figures on page 27. Because the MST9500 uses a switched power supply circuit, the required **terminal voltage** depends on the total measuring current. In case of a higher current value, a lower terminal voltage is allowed.

For example, when using a 250 Ohm measuring resistance without barrier and cable resistance, the supply voltage should be at least 14.5V. A 250 Ohms measuring resistance, a barrier of 280 Ohm, and 20 Ohm cable resistance (500 m) results in a total of 550 Ohm, therefore a minimum supply voltage of 20.5 Volts (approx.). In case of a multi-drop application, where the measuring current is fixed to 4 mA, the supply voltage on the terminals of the MST9500 should be at least 12 Volts.

Cable

The selection of the cable is mainly determined by two criteria:

1. The resistance of the copper conductor (Ohm)
2. The cable capacity (pF)

The copper resistance influences the voltage drop over the cable. The cable capacitance influences the HART™ signals and is important for intrinsically safe applications. If, for example, it has a diameter of 1 mm^2, the result is a copper resistance of 36.8 Ohm/km and a capacitance of 100 pF/m. To maintain reliable transfer of the HART™ modem signals, it is indicated that the RC time of the connection parts should never be more than 65 µSec. For output signals (from the MST9500), only the cable and barrier resistance counts. For input signals it is less favourable since the measuring resistance also counts.

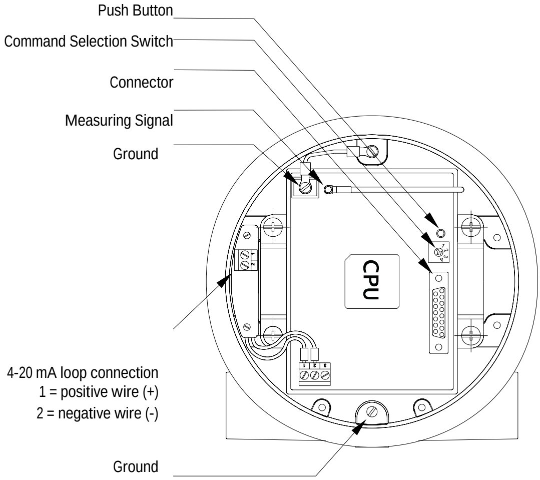
(RB + RM) x CC should be max. 65 µSec. (R in Ohm, C in Farad, T in Sec). For a standard 28 V 280 Ohm barrier and a 250 Ohm measuring resistance, a field capacitance of 0.123 µF is allowed. This is higher for IIC (I/S) applications than allowed; therefore, attenuation of HART signal will not occur.

In IIB applications, where the maximum allowed capacity value is 0.33 µF, the cable length allowed will be longer than actually allowed for HART™. Depending on cable specifications, the maximum length lies between 1 and 3 km.

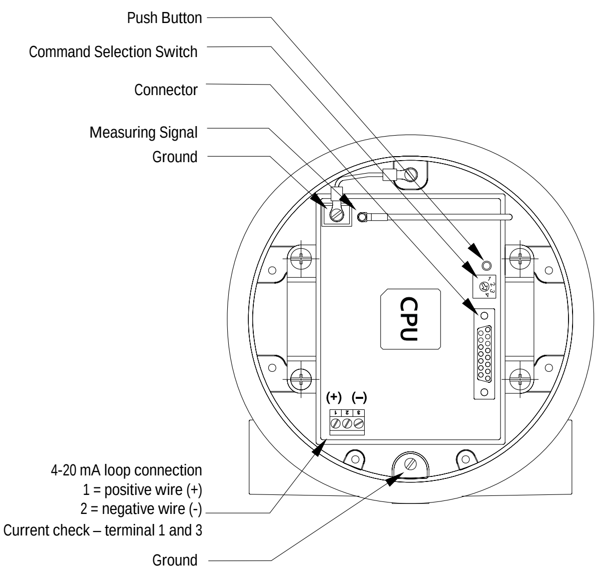
When making Ex calculations, only the cable capacitance at the transmitter side of the barrier counts. For damping calculations, the cable capacity at the other side of the barrier should also be considered.

Connection Diagrams

XP∗ (Cenelec) Version



GP* (FM/CSA/Cenelec) Version / IS* (FM/CSA/Cenelec) Version / XP* (FM) Version



∗ GP = General Purpose
IS = Intrinsically Safe
XP = Explosion Proof

The MST9500 is equipped with three terminals, two of which are intended for connecting loop power instrument cables. This connection is protected against incorrect polarity. The third terminal allows the measurement of the current in the instrument cable with any digital current meter instrument, without breaking the loop circuit.

The MST9500 also includes the following:

- command push-button
- command selection switch (4 positions)
  position **1** record measured value for 4 mA
  position **2** record measured value for 20 mA
  position **3** field service use
  position **4** TEST function
- 15 pin sub-D connector — field service use

The transmitter is powered by the current loop and needs at least 9-13 Volt (9 V at 22 mA, 13 V at 3.6 mA) on the terminals. The maximum supply is 33 Volt. In case of higher voltages, the safety diode will conduct, leading to an increase in power consumption. Some overload can be tolerated indefinitely.

As a result of well-designed circuitry, the internal capacitance and inductance on the terminals are isolated and do not interfere with safety calculations.

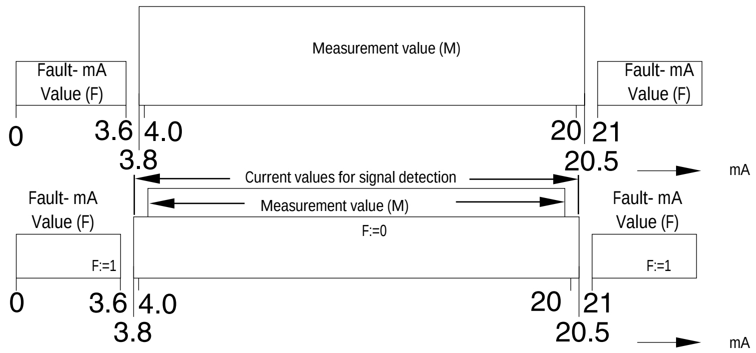
The MST9500 is equipped with the HART™ communication protocol so that settings and information can be obtained and altered locally or remotely.

The internal diagnostic functions continuously monitor the correct operation of the electronics. An error signal is generated if a failure or irregularity occurs.

MST9500 sends the signal current according to the NAMUR NE 43 recommendation. This means that the current remains between 3.8 and 20.5 mA during normal operation. If the process exceeds its normal limits, the current will be limited to 3.8 or 20.5 mA.

If there is a transmitter fault in the MST9500, or a test (position **4**) produces an error result, the signal is changed to 3.6 or 22 mA.

Current values to signalize from digital transmitters



Whenever the local situation allows, the zero adjustment and the full scale can be recorded with the press of a button. Furthermore, the HART™ implementation allows for adjustment of the MST9500 according to specific requirements.

The galvanic isolation between the measuring circuit and current loop provides immunity during the use of cathode protected measuring tanks. Connection to PLC equipment is possible without any problems.

Factory Settings

The MST9500 has a number of default factory settings. If the required settings for the application are known, the settings can be modified during final testing.

Settings:

Setting	Description
ID	has a unique serial number
PV Units	pF
USL(PV)	3300 pF
LSL(PV)	1.666 pF
URV(PV)	3300 pF [switch. position 2]
LRV(PV)	0.00 pF [switch. position 1]
AO1(PV)	4-20 mA is 0-100%
TAG	"customer input data via HART"
DESCRIPTOR	"customer input data via HART"
MESSAGE	"Milltronics"
DATE	"customer input data via HART"
SENSOR SERIAL NUMBER	"customer input data via HART"
FINAL ASSEMBLY NUMBER	"customer input data via HART"
SV Units	UNDEFINED
SVLRV	0
SVURV	1.0

As the USL and LSL are set to 3300 respectively 1.666 pF, the following applies:

- The MST9500 can be adjusted with the push-button. The URV and LRV, which should be **inside** the USL and LSL, can be set anywhere in the entire range.
- Interruption of the measuring connection is detected. A loose or interrupted connection results in to up to 0.5 pF capacity, which is below the adjusted LSL.

Applications and Grounding

Several common applications appear in this section. Common applications are separated into two types: those with System Grounding and those with Safety Grounding.

System Grounding (referencing)

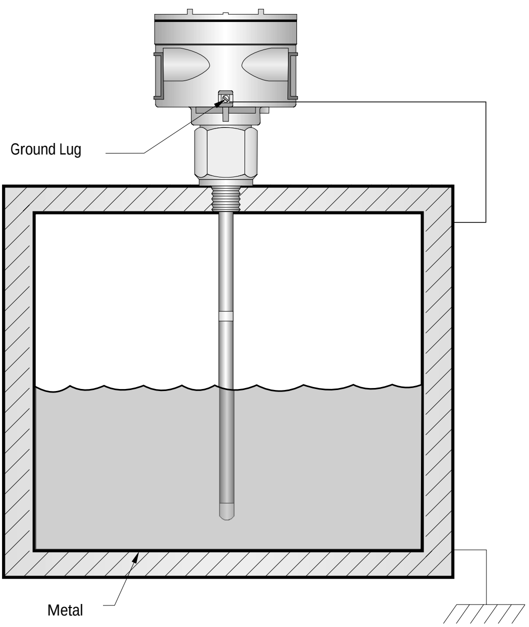
The correct operation of the measuring system depends on the correct method of grounding. Make sure that there is a reliable connection to the reference electrode (usually a metal tank). Some common applications involving system grounding include:

- metal tanks
- metal tanks, cathodically protected
- non-conductive tanks

Metal Tanks

Metal tanks can be (and in most cases are) normally grounded.

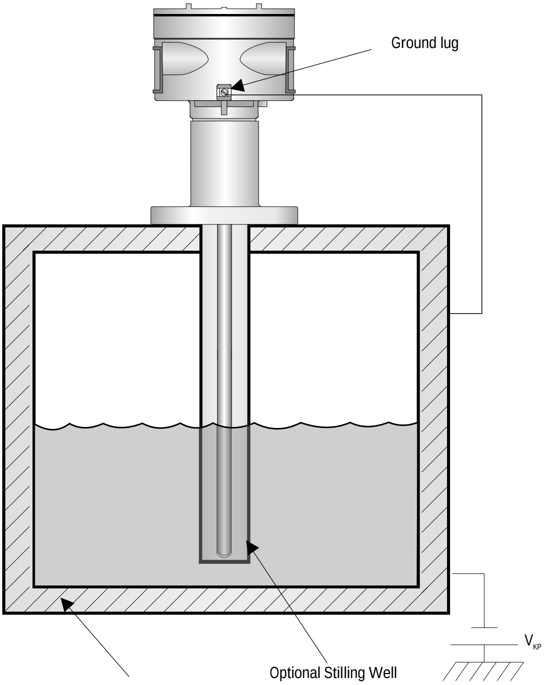
The connection of the MST9500 can be accomplished as shown here. If a stilling well is used, it is important that its metal parts are properly grounded.



Cathodically Protected Metal Tanks

Cathodically protected metal tanks are never directly grounded. However, the impedance of the supply source is so low that this does not cause any problems.

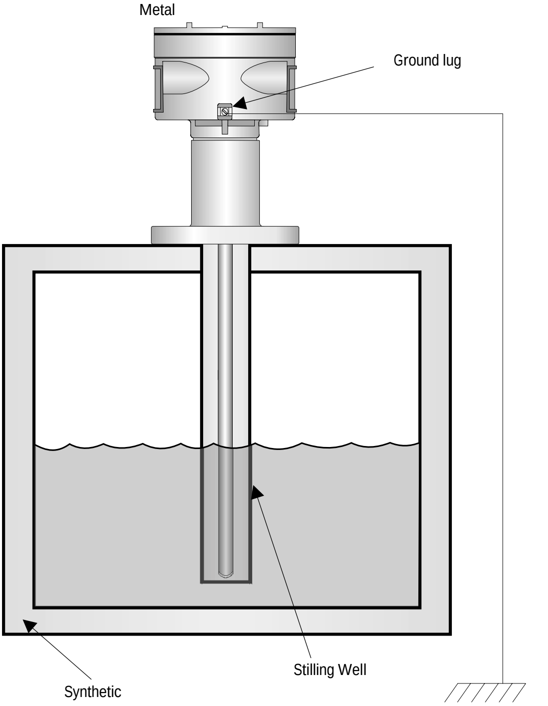
The connection of the MST9500 in such a situation can be realised as shown here. If a stilling well is used, it is important that the metal parts of it are **grounded on the tank**, which means being connected through an electrical connection.



Non-Conductive Tanks

Non-metallic tanks always require a stilling well or proper grounded conductive medium.

The connection of the MST9500 in such a situation can be realised as shown here. The metal parts of the stilling well should be properly grounded.



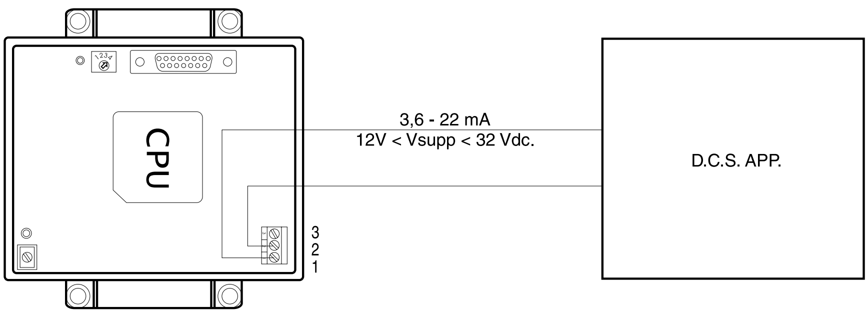
Safety Grounding

The application, in combination with the connected instruments, determines the safety grounding. The MST9500 transmitter does not have any special requirements due to the galvanic separation between the measurement section and the loop section.

The characteristics of DCS can vary. Some DCSs measure the current through the loop compared to a common 0 Volt point, others measure in the positive wire or connector. In the first case, the negative side of the current loop should not be grounded because measurement inputs can become short-circuited. In the second case, the negative side of the current loop can be grounded. Another type of DCS has galvanically separated inputs for each measurement channel, so the grounding method can be chosen as required.

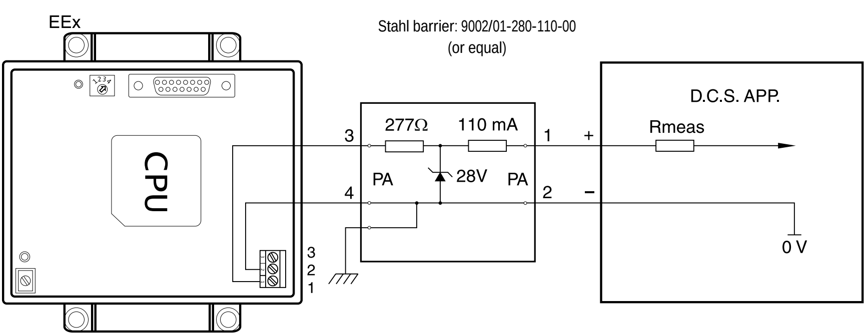
If no specific Ex conditions apply, the MST9500 can, and is allowed to be, directly connected to the control system (DCS). The supply voltage, however, should remain within the limits set by the MST9500. Connecting an MST9500 to DCS does not influence that equipment, see Example 1 below. Grounding of one of the connection cables can be done if desired.

Example 1



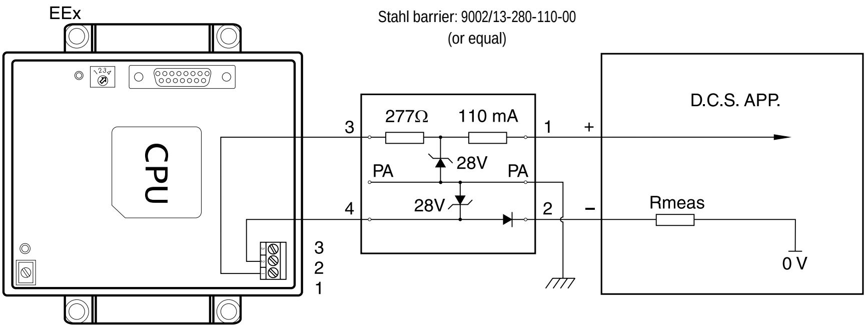
In case of Ex applications, where the DCS equipment measure in the positive connection and the negative connection can be grounded, a barrier type as shown in Example 2 is sufficient.

Example 2



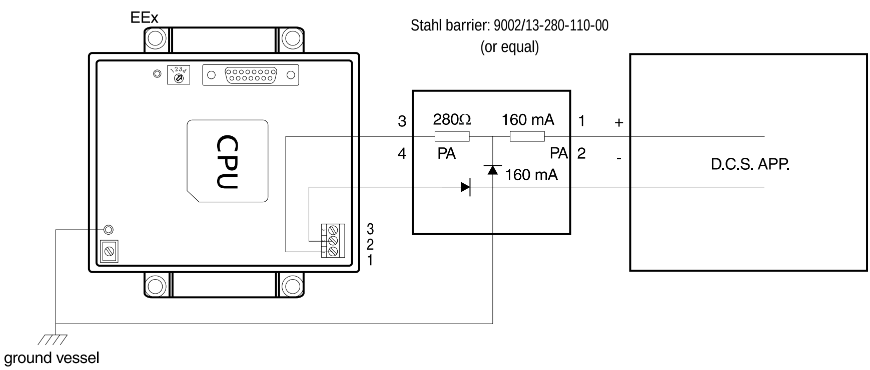
However, if you do not want a direct grounding of the negative connection, and in the case of Ex applications where the DCS measures in the negative connection, and that wire cannot be grounded, a barrier type as shown in Example 3 is required.

Example 3



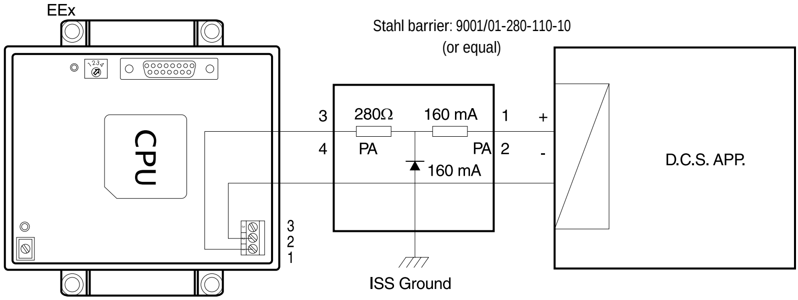
This barrier is also used in case of XP (Cenelec) applications. The barrier is then placed in the transmitter housing. Grounding is not always direct in this case, because of a possible installation on cathodically protected tanks, as in Example 4.

Example 4



In case of Ex applications where the DCS have galvanically separated inputs, both types of barriers can be used. See Examples 2 and 5.

Example 5



When Ex applications are using an Ex approved supply unit, the barriers are not used and grounding is optional.

Start-up

Capacitive measurement requires adjustment of the instrument based on the application conditions. Two types of adjustment methods are available:

- push-button
- HART™

Push-Button Adjustment

If it is possible to adjust the level of the tank as required to the 0% and 100%, the MST9500 transmitter can be set very easily using the push-button.

1. Set value for 0%:
   a. Bring the level of the product to the value that corresponds with 0%.
   b. Turn the rotary switch to position 1.
   c. Press the push-button, hold for approximately 2 seconds.
2. Set value for 100%:
   a. Bring the level of the product to be measured to the level which corresponds with 100%
   b. Turn the rotary switch to position 2.
   c. Press the push-button, hold for approximately 2 seconds.
3. The MST9500 transmitter is now set.
   a. Turn the rotary switch back to position 4. Position 4 prevents the alteration of settings if the push-button is pressed accidentally.

Note: If the difference in the capacitance value between the 4 mA point and the 20 mA point is smaller than the minimum span value (3.3 pF), the new value will not be accepted.

During normal operation, the 4 and/or 20 mA point can be set at any time.

Adjustment using HART™

The MST9500 transmitter can be adjusted using HART™, with a HART communicator, a laptop running Cornerstone or with the Host system (D.C.S.). The local circumstances determine the manner in which adjustment takes place. If the circumstances allow the product to be brought up to the 0% and 100% point level, adjustment is simple.

Example of adjustment by means of a Rosemount 275 hand-held communicator, fitted with the GENERIC device descriptor:

Example 1

In this situation, the level of the product can be easily adjusted to 0 and 100%.

1. Switch on the 275 and request connection with the MST9500.
   a. Select: Online
   b. Select: Device set-up
   c. Select: Diag service
   d. Select: Calibration
   e. Select: Apply values
   f. Select: 4 mA
2. Bring the level of the product to the level which corresponds with 4mA.
   a. Select: Read new value
   b. Select: Set as 4 mA level
3. The 4 mA point has now been set.
   a. Select: Exit (you return to Apply values)
   b. Select: 20 mA
4. Bring the level of the product to the level which corresponds with 20 mA.
   a. Select: Read new value
   b. Select: Set as 20 mA level
5. The 20 mA point has now been set.

Example 2

In this situation, the capacitance values are known in advance.

1. Switch on the 275 and establish connection with the MST9500.

   a. Select: Online

   b. Select: Device set-up

   c. Select: Diag service

   d. Select: Calibration

   e. Select: Enter values

   f. Select: PV LRV

2. Enter required capacitance value for 0% of the range

   a. Select: PV URV

3. Enter required capacitance value for 100% of the range

   a. Select: Send (the values are now sent)

Example 3

*In this situation, the capacitance values are not known and the level of the product can not be set to 0% and 100%. To do this it is necessary to perform a number of measurements of the capacitance value at various levels. These values can be read in **%** with the 275 communicator.*

1. Switch on the 275 and establish connection with the MST9500.

   a. Select: Online

   b. Select: PV

   The measured value can be read continuously, even if current loop value is min. or max.

2. Write down the measured value in pF with the corresponding level. Suppose the following results were recorded:

   a. at 17% the measured PV value was 52 pF

   b. at 79% the measured PV value was 181 pF

This results in a difference of (181-52)/(79-17)=2.08 pF per %.

   c. 17% means 17 * 2.08 = 35.37 pF.

   d. For 0% the capacitance value has to be 52-35.37=16.62 pF.

   e. 100% is 100 * 2.08=208 + 16.62 = 224.6 pF.

With these calculated values, the MST9500 can be adjusted as described in **Example 2**. The more accurately the values are measured at 0%, and, respectively, at 100%, the more accurate the final result will be.

Example 4

This situation involves the re-adjustment of the LRV where the actual value is determined to be 17% and the measurement shows e.g. 14%. Assume that the URV was set to 240 pF.

1. Switch on the 275 and establish connection with the MST9500.

   a. Select: Online

   b. Select: PV

   The measured value can now be read continuously.

2. Write down the measured value in pF, e.g. 80 pF.

3. We now calculate 100-17=83%.
   We calculate 240-80=160pf.
   We calculate 160/83=1.927
   100 % will be 100 x 1.927= 192.7pF
   The new LRV should be 240-192.7=47.22 pF.

4. Adjust URV and LRV according to **Example 2**, whereby the URV value is simply copied.

If the D.C.S. and/or the 275 are fitted with the Device Descriptor for the MST9500, more functions can be used.

The available functions are:

Number	Description
(48)	Read Additional Transmitter Status
(38)	Reset Configuration Changed Flag
(128)	Set Alarm Select
(129)	Adjust for Product Build-up on Sensor
(130)	Set Sensor Upper Limit (USL)
(131)	Set Sensor Lower Limit (LSL)
(132)	Write Sensor Limit Values (USL/LSL)
(140)	Write SV Units and Range Values
(141)	Read SV Units and Range Values
(144)	Reset recorded PV min./max values back to PV
(145)	Show recorded PV min./max. values
(146)	Set ratio for Span
(147)	Read ratio for Span
(148)	Set ratio for Zero
(149)	Read ratio for Zero

Maintenance

This section discusses the test function and maintenance checks.

Test function

The MST9500 has a test function, which changes the measuring reference, allowing for the operation of the entire circuitry to be checked from input to output. The essence of the test function is changing the measuring capacitance by a fixed factor; the resulting measured value is evaluated for accuracy. If the capacitance 'registered' by the sensor changes significantly, the result of the test yields an error result.

The test function can be activated in the following ways:

- Via the push-button
- Via HART™

Starting TEST via the push-button

To do this, the four-position switch has to be set to position **4** (this is also the recommended position during normal operation). After pressing the key (approximately 1 second) the test cycle starts. To indicated that the test has started the current through the loop increases by 0.25 mA. During the test, the loop current stays within the values of the process limits; if the original current was 20.5 mA the difference will be less due to the transmitter saturation at the top end of the normal active range.

The test cycle lasts for a total of 10 seconds. At the end, if the test is successful, the current will return to the original value. If the test fails, the current will show the error value. The error value remains until the next test is completed successfully or the MST9500 is started again (switch power off and on again). The test cycle status is available through HART™.

Starting TEST from HART™

If the test is started through a HART™ command, the current will be fixed during the test to the value present at the start of the test. The running of the test cycle is available as a status via HART™. After the test completes the current reflects the process value again and pass on the test result via HART™. The current is given an error value if the test fails. The test result can be read via HART™.

Checks

The MST9500 transmitter has been manufactured with high-grade components, which means ageing will not have any significant influence on the performance of the electronics. The unit also performs an extensive self-diagnosis. It is recommended that periodic inspections of the MST9500 be scheduled.

The possible checks can be subdivided in two main groups:

1. Visual Checks

    a. inside enclosure clean and dry

    b. enclosure sealing intact and working properly (not hardened)

    c. all screw connections are tight

    d. ground connections inside intact

    e. ground connections outside intact

    f. no oxidation on push-button and 15 pole source connector

    g. no dirt or deposits on coax connector

    h. no cable or wires jammed under cover

2. Functional Checks

    a. provides manual test function 0.25 mA current increase during 10 seconds

    b. check for required minimum terminal voltage

    c. does the current go to the alarm position (3.6 or 22 mA) if the coax plug is unplugged? If so, fasten it again.

    d. via HART™
    Does the PV go to 0 pF when the coax plug is unplugged (±0.15 pF is allowed)? If so, switch the output current to 4 respectively 20 mA and check the current through the loop.

Appendix A: HART™ Documentation

This section provides information on using HART™.

HART™ info

Expanded Device Type Code:

Manufacturer Identification Code	=	84
Manufacturer Device Type Code	=	249
Expanded Device Type Code	=	21753

Physical Layer Information

Field Device Category	=	A
Capacitance Number (CN)	=	1

HART™ Conformance and Command Class

MST9500 transmitter Conformance and Command Class summary.

Command Number	Description	Usage
Conformance Class #1		
0	Return Unique Identifier	Universal
1	Read Primary Variable	

Conformance Class #1A		
0	Return Unique Identifier	Universal
2	Read P.V. Current and Percent of Range	

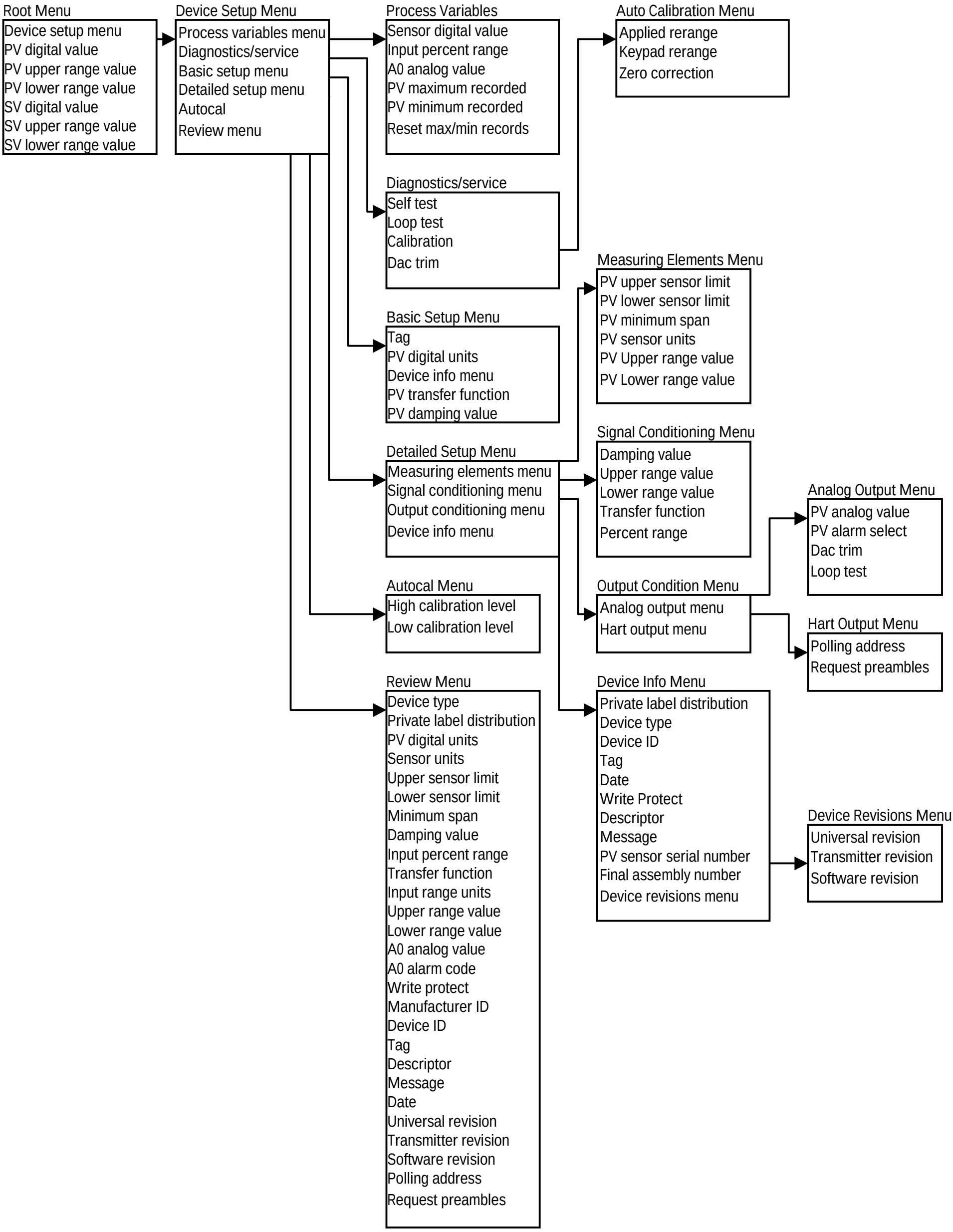
Conformance Class #2		
11	Read Unique Identifier Associated with Tag	Universal
12	Read Message	
13	Read Tag, Descriptor and Date	
14	Read Primary Variable Sensor Information	
15	Read Primary Variable Output Information	
16	Read Final Assembly Number	

Conformance Class #3		
3	Read Dynamic Variables and P.V. Current	Universal
48	Read Additional Transmitter Status	Common Practice

Command Number	Description	Usage
Conformance Class #4		
35	Write Primary Variable Range Values	Common Practice
36	Set Primary Variable Upper Range Value	
37	Set Primary Variable Lower Range Value	
38	Reset Configuration Changed Flag	
40	Enter/Exit Fixed Primary Var. Current mode	
41	Perform Transmitter Self Test	

Conformance Class #5		
6	Write Polling Address	Universal
17	Write Message	
18	Write Tag, Descriptor and Date	
19	Write Final Assembly Number	
44	Write Primary Variable Units	Common Practice
45	Trim Primary Variable Current DAC Zero	
46	Trim Primary Variable Current DAC Gain	
49	Write Primary Variable Sensor Serial Number	
59	Write Number of Response Preambles	
128	Set Alarm Select	Transmitter Specific
129	Adjust for Product Build-up on Sensor	
130	Set Sensor Upper Limit	
131	Set Sensor Lower Limit	
132	Write Sensor Limit Values	
140	Write S.V. Units and Range Values	
141	Read S.V. Units and Range Values	
144	Reset recorded PV min./max values back to PV	
145	Show recorded PV min./max. values	
146	Set ratio for Span	
147	Read ratio for Span	
148	Set ratio for Zero	
149	Read ratio for Zero	

MST9500 DD Menu/Variable Organization



HART™ Response Code information

Additional response code information, Second Byte.

Bit #7: Field Device Malfunction

When the transmitter detects a malfunction, the Analog Output will be set in a fault state.

Bit #6: Configuration Changed

When any of the settings in EEROM is changed either by a write command or by manual ZERO or SPAN adjust, this bit is set. Use command 38 to reset.

Bit #5: Cold Start

This bit is issued once after an initialization cycle is complete; this can occur after a power loss or as a result of a (watchdog) reset.

Bit #4: Extended Status Available

When any of the extended status bits is set this flag is raised. Use command 48 to get detailed status information.

Bit #3: Output Current Fixed

This bit is set as long as the Primary Variable Analog Output is set to a fixed value.

Bit #2: Primary Variable Analog Output Saturated

Flag is set when the Primary Analog Output saturates below 3.8 mA and above 20.5 mA.

Bit #0: Primary Variable Out of Limits

This flag is set whenever the Transmitter Variable #0 (in pF), the Primary Variable exceeds the Sensor Limits returned with Command 14, Read Primary Variable Sensor Limits.

General transmitter information

Damping information

The MST9500 transmitter implements damping only on the Analog Output Current signal. This is a fixed algorithm.

Non-volatile Memory Data Storage

The flags byte of Command #0 referenced in the Universal Command Specification document, will have Bit #1 (Command #39, EEPROM Control Required) set to 0, indicating that all data sent to the transmitter will be saved automatically in the non-volatile memory upon receipt of the Write or Set Command. Command #39, EEPROM Control, is not implemented.

MultiDrop operation

This revision of the MST9500 transmitter supports MultiDrop Operation.

Burst mode

This revision of the MST9500 transmitter does not support Burst Mode.

Units conversions

The Primary Variable Units are in pF and cannot be changed. The Primary Variable Sensor Limits are also in pF and the same for the Primary Variable Range Values.

The Secondary Variable Range Values may be set to any Units and Value with Command #140. The S.V. Range Values may be read at any time with Command #141.

The value returned as S.V. is the result of the following calculation:

S.V. = P.V. Range in percent x (SVURV - SVLRV) + SVLRV.

This method provides a means to transfer the P.V. which is always in pF, to an alternative level- or contents value.

Additional universal command specifications

Command #3 Read Dynamic Variables and P.V. Current

The Primary Variable returns the Transmitter Variable #0 always in pF.

The Secondary Variable returns the Transmitter Variable #1 which is the Alternative Range Value.

Additional common-practice command specifications

The MST9500 implements a subset of the Common Practice Commands specified in the Common-Practice Specification document. This section contains information pertaining to those commands that require clarification.

Command #35 Write Primary Variable Range Values

The Primary Variable Range Unit Codes will only accept units in pF.

Command #41 Perform Transmitter Self Test

The Self Test for the MST9500 will commence as soon as the response from the transmitter is complete and during this time the Primary Variable Value and thus the Primary Variable Analog Output remains frozen at the level existing at the initiation of the test. The test requires about 10 seconds to complete and tests if the measuring circuit operates as expected. The status of the test and the results can be read using Command #48, Read Additional Transmitter Status. During test the HART™ communication operates normally, however if a second Command #41 is send during the test a 'Transmitter Specific Command Error' is returned.

Command #44 Write Primary Variable Units

The Primary Variable Units accepted by this transmitter is only pF (pico Farads).

Command #48 Read Additional Transmitter Status

This command returns the results of the Transmitter Self Test along with other transmitter information.

Byte #0	Events (May be gone, but sent at least once)	
	Bit #0	EEROM write error
	Bit #1	Floating point Math error
	Bit #2	Undefined
	Bit #3	Undefined
	Bit #4	Undefined
	Bit #5	WatchDog Reset occurred
	Bit #6	Local (manual) test active
	Bit #7	Proprietary commands enabled

Byte #1	Status (will be sent as long as status exists)	
	Bit #0	Undefined
	Bit #1	Undefined
	Bit #2	Undefined
	Bit #3	DAC output drive failure
	Bit #4*	Measuring circuit failure
	Bit #5*	ROM/EEROM checksum error
	Bit #6	Test active (manual or cmd #48 started)
	Bit #7	Test Fail (manual or cmd #48 started)

(*) causes Device Malfunction to be set.

Byte #2,3,4,5, 14 thru 24 are undefined.

Transmitter specific commands

Command #128 Set Alarm Select

This command specifies the state of the Primary Variable Analog Output in case of device malfunction. The status of this variable is returned in byte #0 with Command #15 Read Primary Variable Output Information.

This command accepts only the values 0 or 1 resp. Alarm Select High or Alarm Select Low.

Request data bytes

Data bytes	#0	
Alarm Select Code		
Data byte	#0	Alarm Select Code, 8-bit unsigned integer, Selection may be either 0 or 1.

Response data bytes

Data bytes	#0	
Alarm Select Code		
Data byte	#0	Alarm Select Code, 8-bit unsigned integer, Refer to Alarm Selection Codes, table VI.

Command #129 Adjust for Product Build-Up on Sensor

This command sets the lowest of LRV/URV equal to the actual P.V. value.

This compensates for shift in LRV (0-100% range) or URV (100-0% range) due to product-build-up on the sensor.

Request data bytes

None

Response data bytes

None

Command #130 Set Upper Sensor Limit

This command sets the Upper Sensor Limit value to the actual P.V. value.

Request data bytes

None

Response data bytes

None

Command #131 Set Lower Sensor Limit

This command sets the Lower Sensor Limit value to the actual P.V. value.

Request data bytes

None

Response data bytes

None

Command #132 Write Sensor Limit Values

This command writes specific values to the Upper and Lower Sensor Limits. The Units selection is only accepted in pF. The Lower Sensor Limit Value must not be less than zero and not more than the Upper Sensor Limit Value.

The Upper Sensor Limit Value may not be more than 3300 and no less than the Lower Sensor Limit. The minimum distance between Upper- and Lower Sensor Limit is forced to be at least 3.3 pF. The actual Upper- and Lower Sensor Limit Values can be read with command #14 Read Primary Variable Sensor Information.

Request data bytes

Data byte	#0 Sensor Limits Units			
	#1 Upper Sensor Limit MSB	#2	#3	#4 Upper Sensor Limit LSB
	#5 Lower Sensor Limit MSB	#6	#7	#8 Lower Sensor Limit LSB

Data byte #0	Sensor Limits Units Code, 8-bit unsigned integer, must be 153 (pF)
Data byte #1-#4	Sensor Upper Limit Value, IEE754
Data byte #5-#8	Sensor Lower Limit Value, IEE754

Response data bytes

Data byte	#0 Sensor Limits Units			
	#1 Upper Sensor Limit MSB	#2	#3	#4 Upper Sensor Limit LSB
	#5 Lower Sensor Limit MSB	#6	#7	#8 Lower Sensor Limit LSB

Data byte #0	Sensor Limits Units Code, 8-bit unsigned integer.
Data byte #1-#4	Sensor Upper Limit Value, IEE754
Data byte #5-#8	Sensor Lower Limit Value, IEE754

Command #140 Write S.V. Units, Upper and Lower-Range Values

This command writes the units and values for the Secondary Variable Range Values. The command accepts any Units type and/or values. It is up to the user to choose input that makes sense for the application.

Request data bytes

Data byte	#0 S.V Range Units Code			
	#1 S.V. Upper Range MSB	#2	#3	#4 S.V Upper Range LSB
	#5 S.V. Lower Range MSB	#6	#7	#8 S.V. Lower Range LSB

Data byte #0	S.V. Units Code, 8-bit unsigned integer.
Data byte #1-#4	S.V. Upper Range Value, IEE754
Data byte #5-#8	S.V. Lower Range Value, IEE754

Response data bytes

Data byte				
	#0 S.V Range Units Code			
	#1 S.V. Upper Range MSB	#2	#3	#4 S.V Upper Range LSB
	#5 S.V. Lower Range MSB	#6	#7	#8 S.V. Lower Range LSB

Data byte #0	S.V. Units Code, 8-bit unsigned integer.
Data byte #1-#4	S.V. Upper Range Value, IEE754
Data byte #5-#8	S.V. Lower Range Value, IEE754

Command #141 Return S.V. Units, Upper and Lower-Range Values

This command returns the units and values for the Secondary Variable Range Values.

Request data bytes

None

Response data bytes

Data byte				
	#0 Range Units Code			
	#1 S.V. Upper Range MSB	#2	#3	#4 S.V Upper Range LSB
	#5 S.V. Lower Range MSB	#6	#7	#8 S.V. Lower Range LSB

Data byte #0	S.V. Units Code, 8-bit unsigned integer.
Data byte #1-#4	S.V. Upper Range Value, IEE754
Data byte #5-#8	S.V. Lower Range Value, IEE754

Command #144 Reset Recorded P.V. Max./Min. Values

This command rests the recorded maximum and minimum values for PV back to a start value, in this case, the current PV value.

Request data bytes

None

Return data bytes

None

Command # 145 Read Recorded P.V. Max./Min. Values

This command returns the recorded maximum and minimum values for PV since the last reset command or the last power cycle.

Request data bytes

None

Return data bytes

Data byte	#0 P.V Range Units Code			
	#1 PV Max Recorded Value MSB	#2	#3	#4 PV Max Recorded Value LSB
	#5 P.V Min. Recorded Value MSB	#6	#7	#8 P.V Min. Recorded Value LSB

Data byte #0	P.V. Units Code, 8-bit unsigned integer
Data byte #1-#4	P.V Max. Recorded Value, IEE754
Data byte #5-#8	P.V Min. Recorded Value, IEE754

Command #146 Write Ratio Value for Span

This command sets the Span correction level. This is an autocal feature.

Request data bytes

Data byte	#0	#1	#2	#3
	Span Corr. Level Setting MSB			Span Corr. Level Setting LSB
Data byte #0-3	Span Corr. Level Setting, IEE754			

Return data bytes

Data byte	#0	#1	#2	#3
	Span Corr. Level Setting MSB			Span Corr. Level Setting LSB
Data byte #0-3	Span Corr. Level Setting, IEE754			

Command #147 Read Ratio Level for Span

This command returns the Span correction level. This is an autocal feature.

Request data bytes

Data byte	#0	#1	#2	#3
	Span Corr. Level Setting MSB			Span Corr. Level Setting LSB
Data byte #0-3	Span Corr. Level Setting, IEE754			

Command #148 Write Ratio Value for Zero

This command sets the Zero correction level. This is an autocal feature.

Request data bytes

Data byte	#0	#1	#2	#3
	Zero Corr. Level Setting MSB			Zero Corr. Level Setting LSB
Data byte #0-3	Zero Corr. Level Setting, IEE754			

Return data bytes

Data byte	#0	#1	#2	#3
	Zero Corr. Level Setting MSB			Zero Corr. Level Setting LSB
Data byte #0-3	Zero Corr. Level Setting, IEE754			

Command #149 Read Ratio Value for Zero

This command returns the Zero correction level. This is an autocal feature.

Request data bytes

None

Return data bytes

Data byte	#0	#1	#2	#3
	Zero Corr. Level Setting MSB			Zero Corr. Level Setting LSB
Data byte #0-3	Zero Corr. Level Setting, IEE754			

Appendix B: Tables

Table A
Conversion

Range 0 - 100 %	Current in mA	Range 100 - 0 %
0	4.0	100
5	4.8	95
10	5.6	90
15	6.4	85
20	7.2	80
25	8.0	75
30	8.8	70
35	9.6	65
40	10.4	60
45	11.2	55
50	12.0	50
55	12.8	45
60	13.6	40
65	14.4	35
70	15.2	30
75	16.0	25
80	16.8	20
85	17.6	15
90	18.4	10
95	19.2	5
100	20.0	0

Table B

Total Loop Ω versus Supply Volts

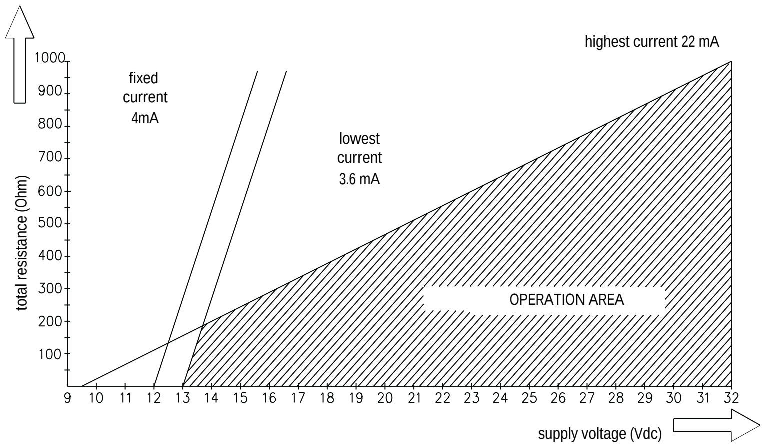
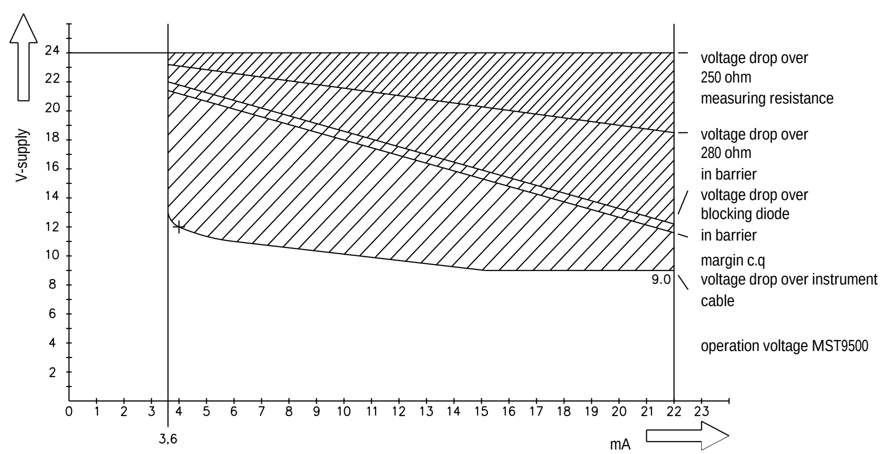


Table C

Voltage Drop Versus mA For Current Transmitter Operation



Appendix C: Approvals

CE Certificate

WRITTEN CE DECLARATION OF CONFORMITY

We, Siemens Milltronics Process Instruments B.V.
Nikkelstraat 10 - 4823 AB BREDA - The Netherlands

Declare, solely under own responsibility, that the product

Capacitance Level and Flow Measurement, Mercap

Mentioned in this declaration, complies with the following standards and/or normative documents:

Requirements	**Remarks**	**Certificate No.**
EMC Directive 89/336/EEC	Commercial, light Industrial, and industrial	48466-KCS/CE 94-4254 48466-KRQ/ECM 95-4797
EN 55011: 1991	Emission – Class B (EN 60555-2) Harmonic Distortions are not applicable (EN 60555-3) Voltage Fluctuations are not applicable	
EN 50082-2: 1992	Generic Immunity Standard, from which:	
• EN 61000-4-2: 1995:	Electrostatic Discharge (ESD) Immunity	
• EN 61000-4-3: 1996:	Radiated Electro-Magnetic Field Immunity	
• ENV 50204: 1995:	Digital Radio Telephones Immunity	
• EN 61000-4-4: 1995:	Electrostatic Fast Transient (EFT) Immunity	
• EN 61000-4-5: 1995:	Surge Transient Immunity	
• EN 61000-4-6: 1996:	Conducted Radio-Frequency Disturbances Immunity	
ATEX Directive 94/9/EC	Audit Report No. 2003068	KEMA 00ATEXQ3047
	Ex II 1 GD EEx ia IIC T6…T4 CE 0344 T 100 °C IP 66	KEMA 00ATEX1096X
EN 50014: 1992	General Requirements	
EN 50020: 1994	Intrinsic Safety “i”	
EN 50284: 1999	Special Requirements for Category 1G Equipment	
EN 50281-1-1: 1998	Dust Ignition Proof	

The notified body is: N.V. KEMA – Utrechtseweg 310 – 6812 AR Arnhem – The Netherlands

Location: Breda
Date: August 28, 2000

Named Representative: C.S. van Gils
Position: Managing Director

> **Note:** For specific safety specifications, please consult the instrument label.

Certificates and Approvals

The Intrinsical Safety Specifications of the MST9500 have been defined and approved as follows:

Application	Specifications
current loop insulated from the measuring circuit	3.6-22 mA
internal capacitance	can be neglected
internal inductance	10 µH
maximum supply voltage	30 Vdc
maximum current	200 mA
maximum power consumption	1.5 W

The MST9500 can be directly connected to an intrinsically safe supply for intrinsically safe applications. For non-intrinsically safe operations, such as explosion proof, a safety barrier must be used.

The operation of the MST9500 conforms to the following:

NAMUR recommendation NE 43

This recommendation describes rules with which analogue transmitters transfer their information to D.C.S. equipment. This information can be divided into the following types:

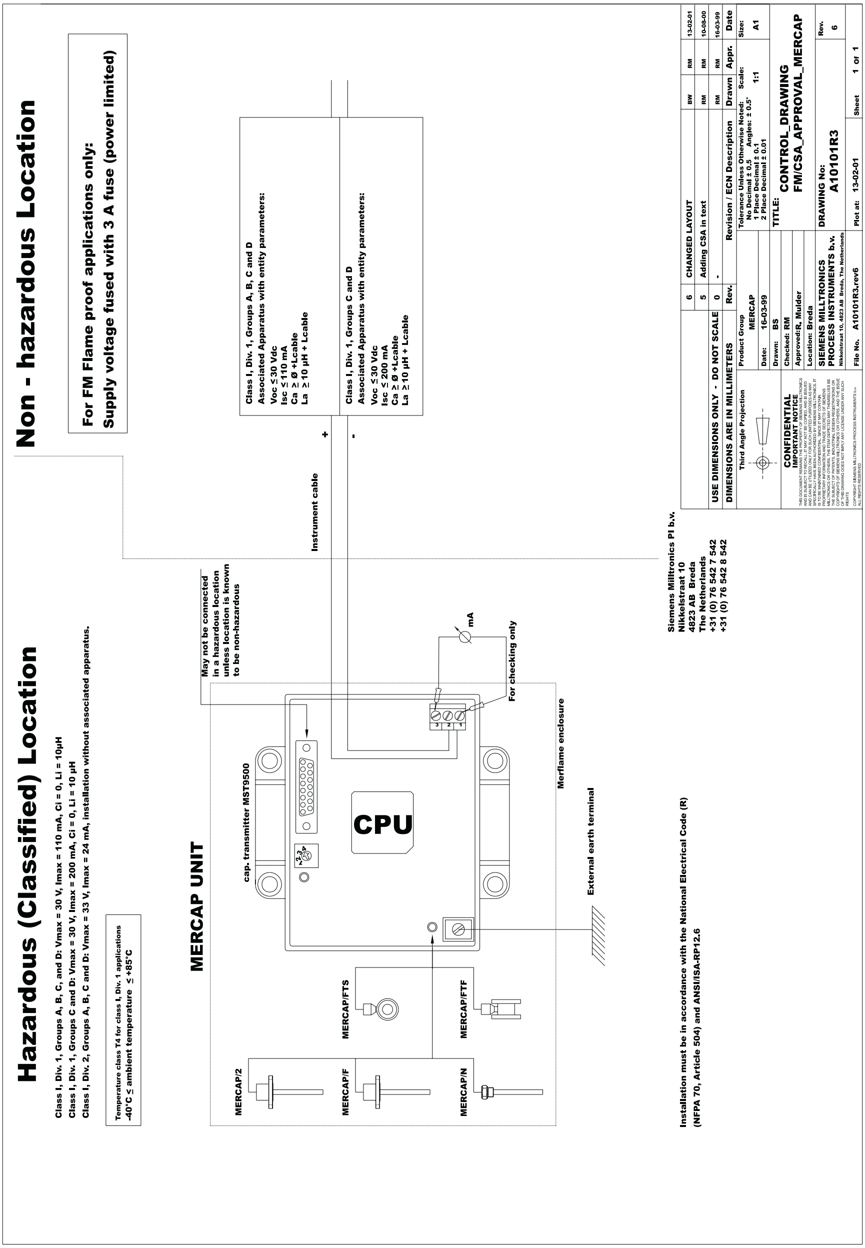
- measurement information and failure signalling

  As far as **measurement information** is concerned, it is indicated that the current signal should be in the range of **3.8** to **20.5 mA**.

- **Failure information** which indicates a failure in the measuring system applies to the current ranges of **0** to **3.6 mA** and **21 mA** or greater.

  The application will determine which of these two failure ranges is desirable. The MST9500 can be set for one of them as required.

Control Drawing FM/CSA Approval Mercap



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Printed in Canada