Honeywell

Model CET5000 Series SmartCET® Corrosion Monitoring Transmitter

Model CET5000 – M
Model CET5000 – G
Model CET5000 - P

Operator Manual

Doc. No.: 34-SC-25-01

Revision Date: 11/06

Copyright, Notices, and Trademarks

Rev. 3– November 2006

Warranty/Remedy

Honeywell warrants goods of its manufacture as being free of defective materials and faulty workmanship. Contact your local sales office for warranty information. If warranted goods are returned to Honeywell during the period of coverage, Honeywell will repair or replace without charge those items it finds defective. The foregoing is Buyer's sole remedy and is **in lieu of all other warranties, expressed or implied, including those of merchantability and fitness for a particular purpose**. Specifications may change without notice. The information we supply is believed to be accurate and reliable as of this printing. However, we assume no responsibility for its use.

While we provide application assistance personally, through our literature and the Honeywell web site, it is up to the customer to determine the suitability of the product in the application.

Trade Marks

HART®

Registered trademark of HART Communication Foundation, Austin, USA

Viton®

Registered trademark of the company E.I. Du Pont de Nemours & Co., Wilmington, USA

Honeywell International, Inc.

Industrial Measurement and Control

2500 W. Union Hills Drive

Phoenix, Arizona 85027

Notices

Safety Instructions

Designated Use

The SmartCET 5000 is a compact, 4-20 mA corrosion transmitter used to detect general or localized corrosion in a wide range of industries. The transmitter measures a general corrosion rate in mils per year or millimeters per year and provides an indicator of localized corrosion activity in the form of a Pitting Factor. The readings are taken in real time and a new measurement is available approximately every seven (7) minutes.

Installation, commissioning and operation

The SmartCET 5000 transmitter has been designed to operate safely in accordance with current technical, safety and relevant standards. If installed incorrectly or used for applications for which it is not intended, it is possible that application-related dangers may arise. For this reason, the instrument must be installed, connected, operated and maintained according to the instructions in this manual by suitably trained personnel. This manual must be read and understood and the instructions followed. Modifications and repairs to the device are permissible only when they are expressly approved in this manual.

Operational safety

[redacted]

Measurement systems used in a hazardous (classified) area must comply with all existing national standards. It must be assured that all technical personnel are sufficiently trained. All measurement and safety regulations that apply to the measuring points are to be observed.

Maintenance safety

[redacted]

The transmitter should always be mounted so that the safety warning label will at all times be visible to any employee or other person called upon to replace the electrodes or otherwise service the transmitter. The label is on every safety bracket that comes with adjustable probes.

About This Document

Abstract

This manual describes the installation and operation of the SmartCET 5000 Corrosion Transmitter.

Contacts

World Wide Web

The following lists Honeywell's World Wide Web sites that will be of interest to our customers.

Honeywell Organization	WWW Address (URL)
Corporate	*http://www.honeywell.com*
Industrial Measurement and Control	*http://www.honeywell.com/imc*
Process Solutions	*http://www.honeywell.com/ps*

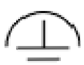
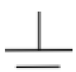
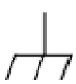
Telephone

Contact us by telephone at the numbers listed below.

Region	Organization	Phone Number	
United States and Canada	Honeywell	1-800-423-9883 1-800-525-7439	Tech. Support Service

Symbol Definitions

The following table lists those symbols that may be used in this document to denote certain conditions.

Symbol	Definition
	This **DANGER** symbol indicates an imminently hazardous situation, which, if not avoided, **will result in death or serious injury**.
⚠ WARNING	This **WARNING** symbol indicates a potentially hazardous situation, which, if not avoided, **could result in death or serious injury**.
⚠ CAUTION	This **CAUTION** symbol may be present on Control Product instrumentation and literature. If present on a product, the user must consult the appropriate part of the accompanying product literature for more information.
CAUTION	This **CAUTION** symbol indicates a potentially hazardous situation, which, if not avoided, **may result in property damage**.
	**WARNING** **PERSONAL INJURY:** Risk of electrical shock. This symbol warns the user of a potential shock hazard where HAZARDOUS LIVE voltages greater than 30 Vrms, 42.4 Vpeak, or 60 Vdc may be accessible. **Failure to comply with these instructions could result in death or serious injury.**
	ATTENTION, Electrostatic Discharge (ESD) hazards. Observe precautions for handling electrostatic sensitive devices
	Protective Earth (PE) terminal. Provided for connection of the protective earth (green or green/yellow) supply system conductor.
	Functional earth terminal. Used for non-safety purposes such as noise immunity improvement. NOTE: This connection shall be bonded to protective earth at the source of supply in accordance with national local electrical code requirements.
	Earth Ground. Functional earth connection. NOTE: This connection shall be bonded to Protective earth at the source of supply in accordance with national and local electrical code requirements.
	Chassis Ground. Identifies a connection to the chassis or frame of the equipment shall be bonded to Protective Earth at the source of supply in accordance with national and local electrical code requirements.

Contents

Tables

Figures

1. Introduction

1.1 Overview

Models CET5000G and CET5000P

The SmartCET® instrument utilizes state-of-the-art algorithms and data analysis techniques to accurately measure corrosion rate and pitting.

SmartCET executes on a 7-minute measurement cycle and performs an automated standard linear polarization resistance (LPR) technique or electrochemical noise (ECN) measurement. These techniques provide the corrosion rate (CET5000G) or an indication of localized (pitting) corrosion (CET5000P).

To further enhance the accuracy of the LPR technique, the default Stern-Geary constant (B value) is accessible to be changed in the transmitter better reflecting the actual process application.

At the completion of each measurement cycle, the respective corrosion rate or Pitting Factor in the form of a 4-20mA HART signal is produced and made available to the plant personnel.

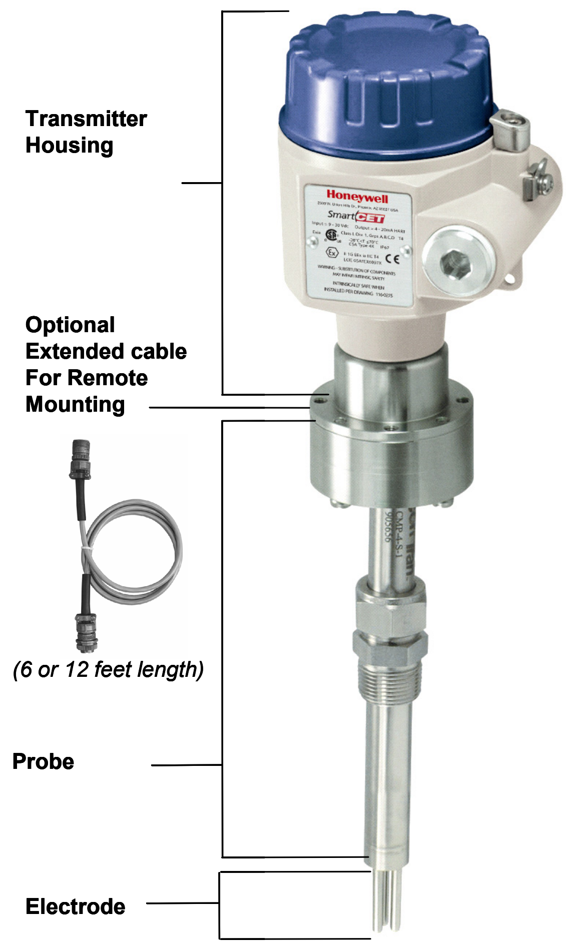


Figure 1-1 SmartCET5000 Transmitter

Model CET5000M

The SmartCET® multivariable transmitter (CET5000M) performs the same functions as the single variable versions above and more. The multivariable transmitter will detect both general corrosion and localized corrosion (pitting) in real-time, in one instrument.

The CET5000M model provides four outputs, which include general corrosion rate, an indicator for localized corrosion (Pitting Factor), a measured Stern-Geary constant (B value), and a corrosion mechanism indicator. These four outputs are accessible to a distributed control system or process knowledge system via a 4-20mA signal with HART® protocol.

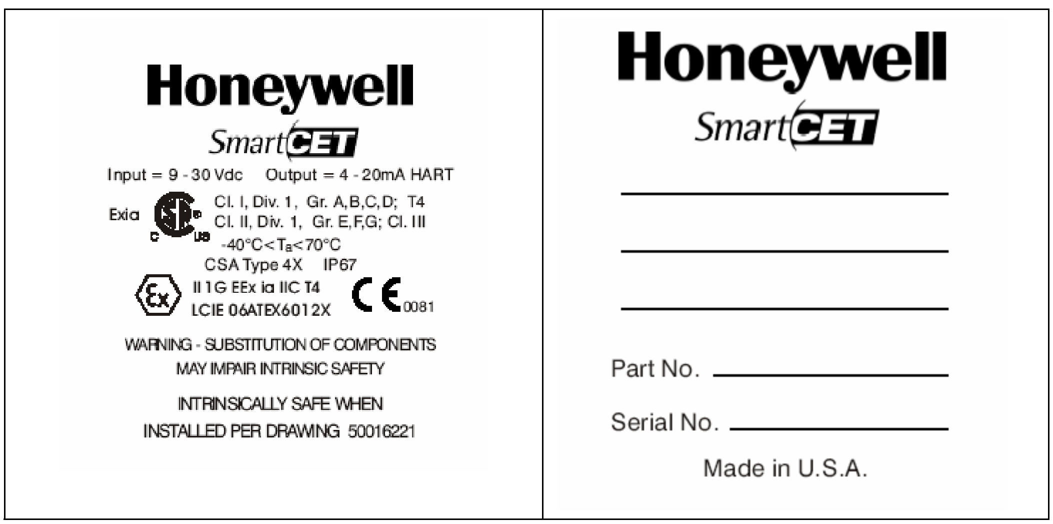
Any model of the SmartCET corrosion transmitter interfaces to the process environment through a process specific probe and electrode combination.

1.2 Features

- On-line, Real-Time Corrosion Monitoring
- Two-wire 4-20mA HART®Transmitter
- General or Localized Corrosion (Pitting) Monitoring
- Withstands 1500 psi (102 bar) Process Pressure (higher pressures can be accommodated through additional probe designs)
- Standard ¾" NPT Process Connection for Insertion Probe style, other connections supported
- Custom Configuration
- Multivariable Output (Model CET5000M) with general corrosion rate, localized corrosion indicator (pitting), dynamic B value, and an additional variable for corrosion mechanism analysis

1.3 Identification

The SmartCET transmitter has two labels on the transmitter housing. Shown on the left is the label with full CSA and ATEX certification. General purpose rated transmitters will not have the certification body references. The label on the right will contain a stamped model number and serial number.



2. Specifications and Model Selection Guides

2.1 Specifications

General Specifications	
Output signal	4-20mA signal (two-wire) with HART
Supply voltage	9-30 Vdc
Rated Operating Voltage	9 VDC minimum at max loop current 2-wire (4-20mA)
Max load with 24VDC power supply	680 ohms with high alarm capability 750 ohms without high alarm
Linearity	0.0015% non linear
Resolution	17 bit
B value (default)	25.6mV
Operating and Storage Conditions	
Operating Temperature	-40°F to +158°F (-40°C to +70°C)
Storage Temperature	-40°F to +185°F (-40°C to +85°C)
Process Conditions	
Process Temperature (Max.) **316 Stainless Steel Probe** ***Direct Mount:*** ***Remote Mount:*** **Glass Epoxy Probe**	Custom probes with higher ratings available 250°F (121°C) 500°F (260°C) peak, 400°F average 150°F (65°C)
Process Pressure (Max.)	3600 psi (245 bar) 316 stainless steel, retrievable probe double sealed 1500 psi (102 bar) 316 stainless steel probe double sealed 100 psi (7 bar) glass epoxy probe
O-Ring (set of 3)	Viton (Viton® is registered trademarks of DuPont Dow Elastomers)
Physical Specifications	
Protection	NEMA 4X (applies to transmitter with direct mount probe)
Enclosure Material	Aluminum
Process connection	¾"NPT (for insertion probes)
Electrical connection	¾"NPT
Wiring Terminal	Accept up to 1.5mm - 14AWG
Mounting	Probe mounts direct on process pipe, transmitter can be direct or remote mounted to probe.
Weight	1.1 lb (500g)
Certifications and Approvals	
Electrical Classifications	• CSA (Canada and US) Class 1 Div 2, Groups A, B, C, D • CSA Intrinsic Safety Class I, II, III; Div 1 Groups A, B, C, D, E, F, G • CE Mark • ATEX – Ex II 1G EEx ia IIC T4, -40C <Ta < 70C

2.2 Probe Specifications

2.2.1 Adjustable 316 Stainless Steel Probe

The adjustable 316 stainless steel probe (Figure 2-1) is an adjustable probe commonly used in most field applications. The assembly consists of a ¾" NPT compression fitting, an insertion rod with a hermetically sealed three-electrode end-cap, and a six-pin connector welded in place. The insertion length is adjustable using the compression fitting.

Electrodes shown in the picture are ordered separately.

Specifications:

Probe Body- 316 Stainless Steel

Endcap Seal- Glass

Fill Material- Epoxy

Temperature Rating- 500°F/260°C

Pressure Rating- 1500 psi/102 bar

Mounting- ¾" NPT fitting

Figure 2-1 Adjustable 316 Stainless Steel Probe

2.2.2 Fixed Length 316 Stainless Steel Probe

The fixed 316 stainless steel probe (Figure 2-2) is a fixed-length probe. The probe assembly consists of an insertion rod with a three-electrode end-cap, a hermetically sealed connector and a ¾" NPT pipe plug that is welded in place. The insertion length (I. L.) is calculated to the end of the electrode and can be specified by the customer.

Electrodes shown in the picture are ordered separately.

Specifications:

Probe Body- 316 Stainless Steel

Endcap Seal- Glass

Fill Material- Epoxy

Temperature Rating- 500°F/260°C

Pressure Rating- 3000 psi/204 bar

Mounting- ¾" NPT fitting

Figure 2-2 Fixed Length 316 Stainless Steel Probe

2.2.3 Epoxy Adjustable Probe

The epoxy adjustable probe (Figure 2-3) consists of a glass epoxy probe with a ¾" NPT nylon compression fitting for insertion into the system. The studs for mounting the electrodes and the six-pin connector are held in place by the epoxy fill material. This probe is available only in 11" length.

Electrodes shown in the picture are ordered separately.

Specifications:

Probe Body- Glass Epoxy

Endcap Seal- Epoxy

Fill Material- Epoxy

Temperature Rating- 150°F/65°C

Pressure Rating- 100 psi/7 bar

Mounting- ¾" NPT nylon fitting

Figure 2-3 Epoxy Adjustable Probe

2.3 Electrical Specifications

Supply	9-30 Vdc
Rated Operating Voltage	9 Vdc min at max loop current
Max Load with 24Vdc supply	680Ω with high alarm/750Ω without alarm
Linearity	0.0015% non-linear
Resolution	17 bit
B Value (default)	25.6 mV
High Alarm current	22.5 mA
Low Alarm current	3.7 mA

2.4 Mechanical Specifications

Transmitter Housing

Protection	4X
Enclosure Material	Aluminum
Electrical Connection	¾" NPT
Weight	1/1 lb (500g)
Operating Temperature	-40ºF to +158 ºF (-40 ºC to +70 ºC)

Model Selection Guide

Model Selection Guide
34-SC-16-01 Issue 1

SmartCET corrosion transmitter for Real-time, online corrosion measurement - corrosion is the new process variable

The SmartCET multivariable transmitter will detect general corrosion and localized corrosion (pitting) in real-time connecting to a distributed control system or process knowledge system.
The CET5000M model provides four outputs, which include general corrosion rate, an indicator for localized corrosion (Pitting Factor), Stern-Geary constant (B value), and fourth variable to help diagnose the corrosion mechanism. The transmitter connects to the process environment through a process specific probe and electrode combination.
Features include:

- 4-20mA signal and compatible HART protocol
- New corrosion measurements available approximately every seven minutes
- Flexible sensor configuration and design allows for process specific probe and electrode application.

This MSG produces a valid model number for ordering the transmitter. Probes and/or electrodes are ordered separately.

SmartCET CET5000

Instructions

- Select the desired key number. The arrow to the right marks the selection available.
- Make the desired selections from Tables I through VI using the column below the proper arrow. A dot (•) denotes availability.

Key Number		I		II		III		IV		V		VI
_ _ _ _ _ _ _ _ _	-	_ _ _	-	_ _ _ _ _ _ _	-	_ _	-	_ _ _ _ _ _	-	_ _	-	_ _ _

KEY NUMBER - SmartCET CET5000 Corrosion Transmitter

Description	Selection	Availability		
SmartCET single variable for General Corrosion	CET5000G	↓		
SmartCET single variable for Localized Corrosion (Pitting Factor)	CET5000P		↓	
SmartCET Multivariable Ouput	CET5000M			↓

TABLE I - Process Connection

		Selection			
Process Connection	3/4" NPT, 316L	N21	•	•	•
	3/4" NPT Nylon Adjustable Fitting	NP3	•	•	•
	1" - 150 lb Flange	A31	•	•	•
	1" - 300 lb Flange	A32	•	•	•
	1 1/2" - 150 lb Flange	A51	•	•	•
	1 1/2" - 300 lb Flange	A52	•	•	•
	2" 150 lb Flange	A61	•	•	•
	2" 300 lb Flange	A62	•	•	•
	Ring electrode	000	•	•	•
	No selection	XXX	•	•	•

TABLE II - Probe Material / Mounting / Length

		Selection			
Measurement / Probe Material	Inches 316 L	CB _ _ _ _	a	a	a
	Inches Epoxy Glass	CF _ _ _ _	b	b	b
	Millimeters 316L	DB _ _ _ _	a	a	a
	Millimeter Epoxy Glass	DF _ _ _ _	b	b	b
	Ring Electrode	NA _ _ _ _	c	c	c
	No selection	XX _ _ _ _	•	•	•

Table II continued next page

TABLE II - Probe Material / Mounting / Length (continued)

		Selection	Availability G	Availability P	Availability M
Probe Mounting and Style	Standard Insertion, Direct Mount, Fixed, SS, Viton	_ _ A _ _ _	d	d	d
	Standard Insertion, Remote Mount, Fixed, SS, Viton	_ _ B _ _ _	d	d	d
	Standard Insertion, Direct Mount, Adjustable, SS, Viton	_ _ C _ _ _	d	d	d
	Standard Insertion, Remote Mount, Adjustable, SS, Viton	_ _ D _ _ _	d	d	d
	Retractable Insertion, Remote Mount, Adjustable, SS, Viton	_ _ E _ _ _	d	d	d
	Special (Consult Factory)	_ _ F _ _ _	•	•	•
	Standard Insertion, Direct Mount, Fixed, SS, Kalrez	_ _ G _ _ _	d	d	d
	Standard Insertion, Remote Mount, Fixed, SS, Kalrez	_ _ H _ _ _	d	d	d
	Standard Insertion, Direct Mount, Adjustable, SS, Kalrez	_ _ I _ _ _	d	d	d
	Standard Insertion, Remote Mount, Adjustable, SS, Kalrez	_ _ J _ _ _	d	d	d
	Retractable Insertion, Remote Mount, Adjustable, SS, Kalrez	_ _ K _ _ _	d	d	d
	Flush Probe, Direct Mount, Fixed, SS, Triangle disks geometry	_ _ L _ _ _	d	d	d
	Flush Probe, Remote Mount, Fixed, SS, Triangle disks geometry	_ _ M _ _ _	d	d	d
	Flush Probe, Direct Mount, Adjustable, SS, Triangle disks geometry	_ _ N _ _ _	d	d	d
	Flush Probe, Remote Mount, Adjustable, SS, Triangle disks geometry	_ _ 0 _ _ _	d	d	d
	Retractable Flush, Remote Mount, Adjustable, SS, Triangle disks geometry	_ _ P _ _ _	d	d	d
	Flush Probe, Direct Mount, Fixed, SS, Interleaved	_ _ Q _ _ _	d	d	d
	Flush Probe, Remote Mount, Fixed, SS, Interleaved	_ _ R _ _ _	d	d	d
	Flush Probe, Direct Mount, Adjustable, SS, Interleaved	_ _ S _ _ _	d	d	d
	Flush Probe, Remote Mount, Adjustable, SS, Interleaved	_ _ T _ _ _	d	d	d
	Retractable Flush, Remote Mount, Adjustable, SS, Interleaved	_ _ U _ _ _	d	d	d
	High pressure insertion, Remote, Fixed, SS	_ _ V _ _ _	d	d	d
	High pressure flush, Remote, Fixed, SS, Triangle disks geometry	_ _ W _ _ _	d	d	d
	High pressure flush, Remote, Fixed, SS, Interleaved	_ _ X _ _ _	d	d	d
	Ring electrode, Remote Mount, Virgin PTFE gasket. (Specify electrode, flange, class and finish)	_ _ Y _ _ _	e	e	e
	Ring electrode, Remote Mount, Garlock Gylon gasket. (Specify electrode, flange, class and finish)	_ _ Z _ _ _	e	e	e
	Ring electrode, Remote Mount, other gasket material. (Specify electrode, size and pressure rating)	_ _ 1 _ _ _	e	e	e
	No selection	_ _ 2 _ _ _	•	•	•
Probe Length	8 inch for 316L or epoxy glass, NPT Process Connection	_ _ _ 080	f	f	f
	12 inch for 316L, NPT or Flange Process Connection	_ _ _ 120	g	g	g
	18 inch for 316L, NPT or Flange Process Connection	_ _ _ 180	g	g	g
	24 inch for 316L, NPT or Flange Process Connection	_ _ _ 240	g	g	g
	200 mm for 316L or epoxy glass, NPT Process Connection	_ _ _ 200	g	g	g
	300 mm for 316L, NPT or Flange Process Connection	_ _ _ 300	g	g	g
	450 mm for 316L, NPT or Flange Process Connection	_ _ _ 450	g	g	g
	610 mm for 316L, NPT or Flange Process Connection	_ _ _ 610	g	g	g
	Ring Electrode	_ _ _ RRR	c	c	c
	No selection	_ _ _ XXX	•	•	•

TABLE III - Electrode Material Guide

		Selection	Availability G	P	M
Electrode Material	1018 Carbon Steel	0A	●	●	●
	A53 Grade B Carbon Steel	0B	●	●	●
	AISI 304 (Check with factory)	0C	●	●	●
	AISI 304L	0D	●	●	●
	AISI 316 (Check vith factory)	0E	●	●	●
	AISI 316L	0F	●	●	●
	Carpenter 20 Cb3	0G	●	●	●
	Monel 400	0H	●	●	●
	CDA715 70-30 Cu-Ni	0I	●	●	●
	CDA 110ETP 99.9 Cu	0J	●	●	●
	CDA 706 90-10 Cu-Ni	0K	●	●	●
	CDA687 (Al Brass) (Check with factory)	0L	●	●	●
	CDA443(ARS AD. Brass)	0M	●	●	●
	Aluminum 1100	0N	●	●	●
	Aluminum 2024	00	●	●	●
	Titanium GR2	0P	●	●	●
	Hastelloy C-276	0Q	●	●	●
	ASTM A105 Carbon Steel	0R	●	●	●
	AISI 1010 Carbon Steel	0S	●	●	●
	AL6061 Aluminum	0T	●	●	●
	A106 GrB	0U	●	●	●
	A36	0V	●	●	●
	5LGrB	0W	●	●	●
	C2000	0X	●	●	●
	C22	0Y	●	●	●
	Ductile Iron Grade 65-45-12	0Z	●	●	●
	A182 F5, 5Cr 1/2Mo	1A	●	●	●
	A182 F9, 9Cr 1Mo	1B	●	●	●
	API5LX-65 Carbon maganese pipeline steel	1C	●	●	●
	Duplex 2205	1D	●	●	●
	A516 Gr70	1E	●	●	●
	API 5LX52 (STE 360.7)	1F	●	●	●
	317L stainless steel	1G	●	●	●

TABLE IV - Transmitter

Housing	Aluminum housing with 3/4" electrical	A2_ _ _	●	●	●
Electrical Output	Electronic Output - 4-20mA with HART	_ _ IH _	●	●	●
Transmitter Mount	Direct Mount (not for ring electrodes)	_ _ _ _1	h	h	h
	Remote 6 feet cable	_ _ _ _2	i	i	i
	Remote 12 feet cable	_ _ _ _3	i	i	i
	Special (Consult Factory)	_ _ _ _4	●	●	●

TABLE V - Approvals

Approvals	General Purpose	GP	●	●	●
	CSA, NI, Class 1, Div 2, Group A-D	D2	●	●	●
	CSA, IS, Class 1, Div 1, Group A-D; ATEX, FM	IS	●	●	●

TABLE VI - Insertion Length for Insertion Probes or Ring Flange Size+Class+Finish

		Selection	Availability G	P	M
Insertion length - inches	5.0 inches	050	j	j	j
	5.2 inches	052	j	j	j
	5.4 inches	054	j	j	j
	5.6 inches	056	j	j	j
	5.8 inches	058	j	j	j
	6.0 inches	060	j	j	j
	6.2 inches	062	j	j	j
	6.4 inches	064	j	j	j
	6.6 inches	066	j	j	j
	6.8 inches	068	j	j	j
	7.0 inches	070	j	j	j
	7.2 inches	072	j	j	j
	7.4 inches	074	j	j	j
	7.6 inches	076	j	j	j
	7.8 inches	078	j	j	j
	8.0 inches	080	j	j	j
	8.2 inches	082	j	j	j
	8.4 inches	084	j	j	j
	8.6 inches	086	j	j	j
	8.8 inches	088	j	j	j
	9.0 inches	090	j	j	j
	9.2 inches	092	j	j	j
	9.4 inches	094	j	j	j
	9.6 inches	096	j	j	j
	9.8 inches	098	j	j	j
	10.0 inches	100	j	j	j
	10.2 inches	102	j	j	j
	10.4 inches	104	j	j	j
	10.6 inches	106	j	j	j
	10.8 inches	108	j	j	j
	11.0 inches	110	j	j	j
	11.2 inches	112	j	j	j
	11.4 inches	114	j	j	j
	11.6 inches	116	j	j	j
	11.8 inches	118	j	j	j
	12.0 inches	120	j	j	j
	12.2 inches	122	j	j	j
	12.4 inches	124	j	j	j
	12.6 inches	126	j	j	j
	12.8 inches	128	j	j	j
	13.0 inches or mm	130	k	k	k
	13.2 inches	132	j	j	j
	13.4 inches	134	j	j	j
	13.6 inches	136	j	j	j
	13.8 inches	138	j	j	j
	14.0 inches or mm	140	k	k	k
	14.2 inches	142	j	j	j
	14.4 inches	144	j	j	j
	14.6 inches	146	j	j	j
	14.8 inches	148	j	j	j
	15.0 inches or mm	150	k	k	k
	15.2 inches	152	j	j	j
	15.4 inches	154	j	j	j
	15.6 inches	156	j	j	j
	15.8 inches	158	j	j	j
	16.0 inches or mm	160	k	k	k
	16.2 inches	162	j	j	j
	16.4 inches	164	j	j	j
	16.6 inches	166	j	j	j
	16.8 inches	168	j	j	j

Table VI continued next page

TABLE VI - Insertion Length for Insertion Probes or Ring Flange Size+Class+Finish

		Selection	Availability G	P	M
Insertion length - inches	17.0 inches or mm	170	k	k	k
	17.2 inches	172	j	j	j
	17.4 inches	174	j	j	j
	17.6 inches	176	j	j	j
	17.8 inches	178	j	j	j
	18.0 inches or mm	180	k	k	k
	18.2 inches	182	j	j	j
	18.4 inches	184	j	j	j
	18.6 inches	186	j	j	j
	18.8 inches	188	j	j	j
	19.0 inches or mm	190	k	k	k
	19.2 inches	192	j	j	j
	19.4 inches	194	j	j	j
	19.6 inches	196	j	j	j
	19.8 inches	198	j	j	j
	20.0 inches or mm	200	k	k	k
	20.2 inches	202	j	j	j
	20.4 inches	204	j	j	j
	20.6 inches	206	j	j	j
	20.8 inches	208	j	j	j
	21.0 inches or mm	210	k	k	k
	21.2 inches	212	j	j	j
	21.4 inches	214	j	j	j
	21.6 inches	216	j	j	j
	21.8 inches	218	j	j	j
	22.0 inches or mm	220	k	k	k
	22.2 inches	222	j	j	j
	22.4 inches	224	j	j	j
	22.6 inches	226	j	j	j
	22.8 inches	228	j	j	j
	23.0 inches or mm	230	k	k	k
	23.2 inches	232	j	j	j
	23.4 inches	234	j	j	j
	23.6 inches	236	j	j	j
	23.8 inches	238	j	j	j
	24.0 inches or mm	240	k	k	k
	24.2 inches	242	j	j	j
	24.4 inches	244	j	j	j
	24.6 inches	246	j	j	j
	24.8 inches	248	j	j	j
	25.0 inches or mm	250	k	k	k
	25.2 inches	252	j	j	j
	25.4 inches	254	j	j	j
	25.6 inches	256	j	j	j
	25.8 inches	258	j	j	j
	26.0 inches or mm	260	k	k	k
	26.2 inches	262	j	j	j
	26.4 inches	264	j	j	j
	26.6 inches	266	j	j	j
	26.8 inches	268	j	j	j
	27.0 inches or mm	270	k	k	k
	27.2 inches	272	j	j	j
	27.4 inches	274	j	j	j
	27.6 inches	276	j	j	j
	27.8 inches	278	j	j	j
	28.0 inches or mm	280	k	k	k

Table VI continued next page

TABLE VI - Insertion Length for Insertion Probes or Ring Flange Size+Class+Finish

		Selection	Availability G	P	M
Insertion length - millimeters	135 mm	135	m	m	m
	145 mm	145	m	m	m
	155 mm	155	m	m	m
	165 mm	165	m	m	m
	175 mm	175	m	m	m
	185 mm	185	m	m	m
	195 mm	195	m	m	m
	205 mm	205	m	m	m
	215 mm	215	m	m	m
	225 mm	225	m	m	m
	235 mm	235	m	m	m
	245 mm	245	m	m	m
	255 mm	255	m	m	m
	265 mm	265	m	m	m
	275 mm	275	m	m	m
	285 mm	285	m	m	m
	290 mm	290	m	m	m
	295 mm	295	m	m	m
	300 mm	300	m	m	m
	305 mm	305	m	m	m
	310 mm	310	m	m	m
	315 mm	315	m	m	m
	320 mm	320	m	m	m
	325 mm	325	m	m	m
	330 mm	33	m	m	m
	335 mm	335	m	m	m
	340 mm	340	m	m	m
	345 mm	345	m	m	m
	350 mm	350	m	m	m
	355 mm	355	m	m	m
	360 mm	360	m	m	m
	365 mm	365	m	m	m
	370 mm	370	m	m	m
	375 mm	375	m	m	m
	380 mm	380	m	m	m
	385 mm	385	m	m	m
	390 mm	390	m	m	m
	395 mm	395	m	m	m
	400 mm	400	m	m	m
	405 mm	405	m	m	m
	410 mm	410	m	m	m
	415 mm	415	m	m	m
	420 mm	420	m	m	m
	425 mm	425	m	m	m
	430 mm	430	m	m	m
	435 mm	435	m	m	m
	440 mm	440	m	m	m
	445 mm	445	m	m	m
	450 mm	450	m	m	m
	455 mm	455	m	m	m
	460 mm	460	m	m	m
	465 mm	465	m	m	m
	470 mm	470	m	m	m
	475 mm	475	m	m	m
	480 mm	480	m	m	m
	485 mm	485	m	m	m
	490 mm	490	m	m	m
	495 mm	495	m	m	m

Table VI continued next page

TABLE VI - Insertion Length for Insertion Probes or Ring Flange Size+Class+Finish

		Selection	Availability G	P	M
Insertion length - millimeters	500 mm	500	m	m	m
	505 mm	505	m	m	m
	510 mm	510	m	m	m
	515 mm	515	m	m	m
	520 mm	520	m	m	m
	525 mm	525	m	m	m
	530 mm	530	m	m	m
	535 mm	535	m	m	m
	540 mm	540	m	m	m
	545 mm	545	m	m	m
	550 mm	550	m	m	m
	555 mm	555	m	m	m
	600 mm	600	m	m	m
	605 mm	605	m	m	m
	610 mm	610	m	m	m
	615 mm	615	m	m	m
	620 mm	620	m	m	m
	625 mm	625	m	m	m
	630 mm	630	m	m	m
	635 mm	635	m	m	m
	640 mm	640	m	m	m
	645 mm	645	m	m	m
	650 mm	650	m	m	m
	655 mm	655	m	m	m
	660 mm	660	m	m	m
	665 mm	665	m	m	m
	670 mm	670	m	m	m
	675 mm	675	m	m	m
	680 mm	680	m	m	m
	685 mm	685	m	m	m
	690 mm	690	m	m	m
	695 mm	695	m	m	m
	700 mm	700	m	m	m
	705 mm	705	m	m	m
	710 mm	710	m	m	m
No Selection	No selection	XXX	•	•	•

RESTRICTIONS

Restriction Letters	Available Only With		Not Available With	
	Table	Selection	Table	Selection
a			I	NP3 000
b			I	N21 A31, A32 A51, A52 A61, A62 000
c			I	N21 NP3 A31, A32 A51, A52 A61, A62

RESTRICTIONS

Restriction Letters	Available Only With		Not Available With	
	Table	Selection	Table	Selection
d			II	CF _ _ _ _ DF _ _ _ _ NA _ _ _ _
e			I II II	N21 NP3 A31, A32 A51, A52 A61, A62 CB _ _ _ _ CF _ _ _ _ DB _ _ _ _ DF _ _ _ _
f			I II	A31, A32 A51, A52 A61, A62 000 NA _ _ _ _
g			I II	000 CF _ _ _ _ DF _ _ _ _ NA _ _ _ _
h			I II	000 NA _ _ _ _
i			II	_ _ A _ _ _ _ _ C _ _ _ _ _ G _ _ _ _ _ I _ _ _ _ _ L _ _ _ _ _ N _ _ _ _ _ Q _ _ _ _ _ S _ _ _
j			I II	NP3 000 CF _ _ _ _ DB _ _ _ _ DF _ _ _ _ NA _ _ _ _
k			I II	NP3 000 CF _ _ _ _ DF _ _ _ _ NA _ _ _ _
m			I II	NP3 000 CB _ _ _ _ CF _ _ _ _ DF _ _ _ _ NA _ _ _ _

CET5000 SmartCET Corrosion Transmitter Supplemental Accessories & Kits

Description	Part Number	List Price
Galvanic Isolator – 1 Channel	50022364-001	**
Galvanic Isolator – 2 Channel	50022364-002	**
Remote Probe Cable – 6 Ft	50022365-001	**
Remote Probe Cable – 12 Ft	50022365-002	**
Hart USB Modem	50022366-001	**
Hart Interface Module –no relays	50022367-001	**
Hart Interface Module –two relays	50022367-002	**

** Consult Honeywell Order Entry Systems for current parts pricing.

Table 2-1 Electrode Material Guide

Model Key#	UNS #	Electrode material	K value
A	G10180	1018 Carbon steel	11597.63
B	K03005	A53 Grade B Carbon Steel	11583.07
C	S30400	AISI 304	11334.57
D	S30403	AISI 304L	11342.80
E	S31600	AISI 316	11513.39
F	S31603	AISI 316L	11519.53
G	N08020	Carpenter 20 Cb3	11595.52
H	N04400	Monel 400	11077.87
I	C71500	CDA715 (Cu/Ni 70/30)	11337.86
J	C11000	CDA 110ETP 99.9Cu	11686.71
K	C70600	CDA 706 (Cu/Ni 90/10)	11513.44
L	C68700	CDA 867 (Aluminum Brass)	12411.53
M	C44300	CDA 443 (ARS AD Brass)	12324.74
N	A91100	Aluminum 1100	10940.96
O	A92024	Aluminum 2024	11400.51
P	R50400	Titanium GR2	8644.02
Q	N10276	Hastelloy C-276	11666.48

3. Installation

3.1 Contents of delivery

⚠ CAUTION

It is essential to follow the instructions concerning the unpacking, transport and storage of this instrument given in the section 3.2 "Pre-installation Information".

The contents of delivery consist of:

- Assembled instrument
- Stainless steel probe (for insertion style probes)
- 3-electrodes elements (attached loosely to insertion probes or could be standalone 3 ring electrodes)
- Cable (remote mount version only)
- Safety bracket
- Remote transmitter mount bracket (remote mount version only)
- Accessories (if any are ordered)
- Instruction manual (this document)

3.2 Pre-installation Information

Unpacking

If the transmitter has not been removed from its shipping carton, inspect the carton for damage then remove the transmitter.

- Inspect the unit for any obvious shipping damage and report any damage due to transit to the carrier.
- Make sure a bag containing mounting hardware is included in the carton with the controller.
- Check that the model number shown on the inside of the case agrees with what you have ordered.

Attention!

All probes are shipped with the insulating gaskets installed. Upon removing the protective cap, ensure that the O-rings are not loose. The O-rings are made of Viton® and if not installed the probe will not operate properly. Please refer to **Figure 3-11**.

Transport

⚠ CAUTION

Protect the transmitter electrodes from damage. Do not attempt to carry the transmitter by its electrodes.

Storage

Pack the instrument for storage or transport so it is protected against impact. The original packing material provides the optimum protection for the device. The permissible storage temperature is -40°F to +176°F (-40°C to +80°C).

3.3 Mounting

3.3.1 Dimensions

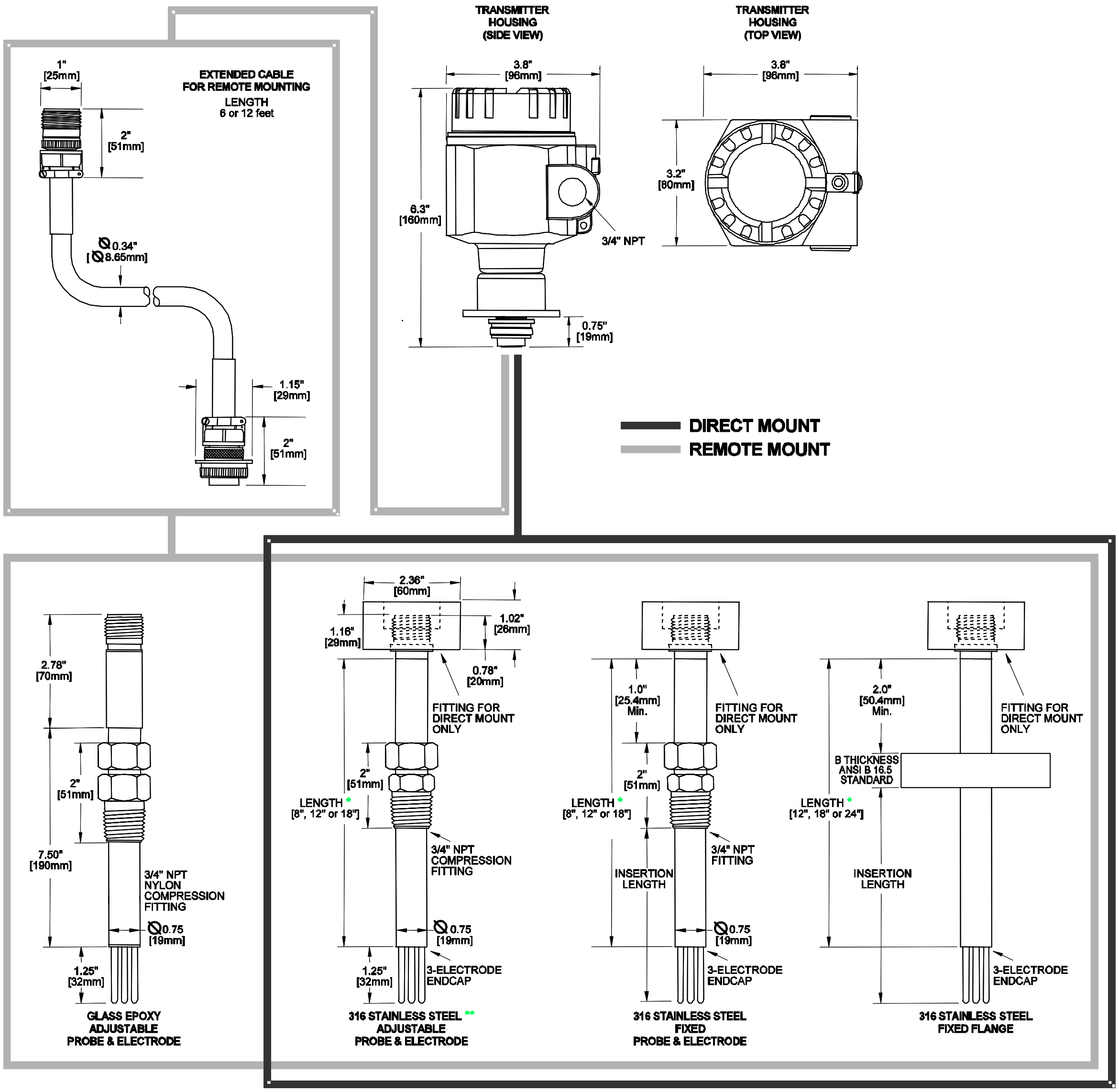


Figure 3-1 SmartCET5000 Transmitter and Probe Dimensions

3.3.2 Mounting safety procedures and hints

The corrosion probe must be installed in a location that is most susceptible to corrosion. In most cases, corrosion tends to occur where water is trapped or stagnant. However, it can also accelerate at the bend of the pipe or where corrosion has occurred previously, but is accelerated by high flow or turbulence.

The electrodes should be selected to reflect the same metal properties as the piping or other components that might be susceptible to corrosion. For example, in applications where the pipe is made of stainless steel and the water pump's impeller is made of carbon steel, the impeller will corrode faster than the pipe. In this case it is advisable to select the electrodes to be the same material as the pump's impeller.

Table 3-1 Mounting safety procedures and hints

Incorrect Transmitter Location

The transmitter **should not** be mounted in a pipe drop since the corrosive liquid may not be in full contact with the electrodes as shown in **Figure 3-2.**

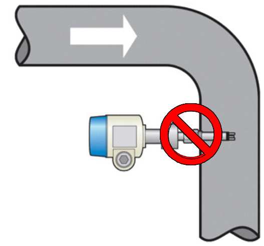


Figure 3-2 Incorrect SmartCET Transmitter Installation

Correct Transmitter Location

The transmitter **should** be mounted in the riser of a pipe near an elbow where the velocity is the highest. In general, SmartCET5000 should be mounted in pipes or tanks at locations of highest liquid velocity and constant immersion, shown in **Figure 3-3**.

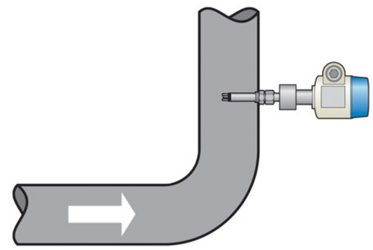


Figure 3-3 Correct SmartCET Transmitter Installation

Correct Pipeline Position

SmartCET5000 can be located at any point on the pipeline but should always be immersed in the corrosive material as shown in **Figure 3-4**.

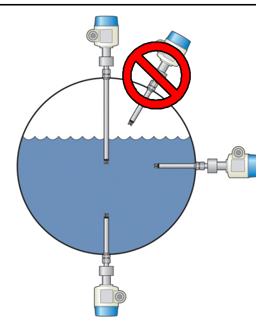


Figure 3-4 Correct SmartCET Pipeline Position

Located in Tee

SmartCET5000 can be located at any point on the pipeline but should always be immersed in the corrosive material as shown in **Figure 3-5**

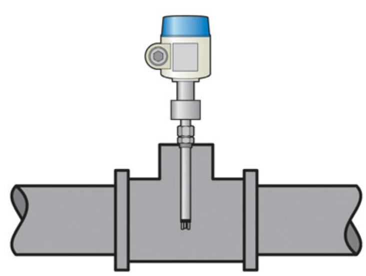


Figure 3-5 SmartCET Located in Tee

Located in Bypass Loop

SmartCET5000 should be located downstream of a control valve for best performance and can also be located in the deadleg portion of a by-pass.

Note that the transmitter located in the by-pass leg should be mounted before the valve for best performance. See **Figure 3-6.**

This guarantees the electrodes will always be immersed in the corrosive material.

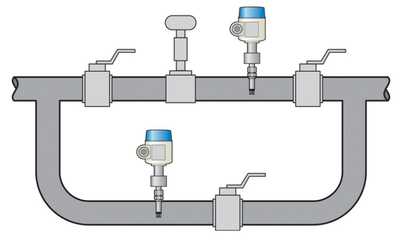


Figure 3-6 SmartCET Located in Bypass Loop

Mounted with Different Electrodes

Installing SmartCET5000 with different electrode materials on the suction side of the pump will ensure monitoring of the pump impeller and the pipe as shown in **Figure 3-7**.

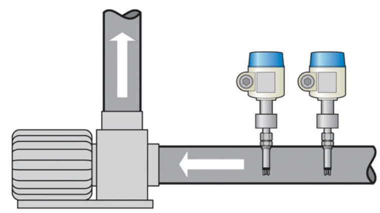


Figure 3-7 SmartCET Mounted with Different Electrodes

Installed in a Condensate Flash Tank

A condensate flash tank, shown in **Figure 3-8**, is also a good application.

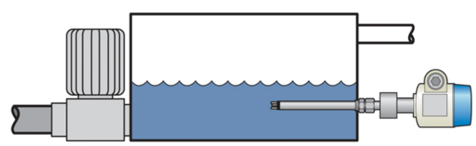


Figure 3-8 SmartCET Installed in a Condensate Flash Tank

Mounted in Y-Strainer

The transmitter is shown in the blow down of a Y-strainer in **Figure 3-9**.

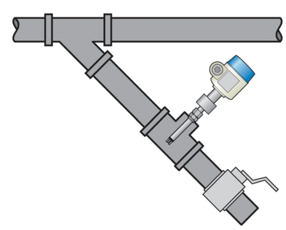


Figure 3-9 SmartCET Mounted in Y-Strainer

Mounted in Basket Strainer

The transmitter is shown in the discharge side of the basket strainer in **Figure 3-10**

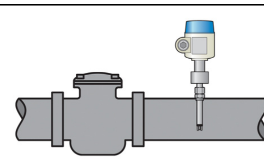


Figure 3-10 SmartCET Mounted in Basket Strainer

3.4 Installation

3.4.1 Introduction

⚠ CAUTION

A trained specialist must perform the necessary installation and commissioning of SmartCET5000. Recognized rules of the technology and setup requirements must be maintained both during and after installation. Safety requirements must be observed during all installation steps.

⚠ WARNING

If the pipe or vessel into which the SmartCET5000 is to be inserted is under pressure and/or contains any hazardous substance, such as steam, caustic solutions, acids, toxins or other substances specified by OSHA as physical or health hazards, the pipe or vessel must first be depressurized and any hazardous substance purged there from, and appropriate lockout/tagout procedures observed in accordance with Section 1910.147 of the OSHA Regulations, before SmartCET5000 can be installed. **Failure to follow these procedures may result in serious injury or death.**

3.4.2 Overview

SmartCET5000 consists of three basic components:

1. A **transmitter housing** that contains the electronics and provides the 4-20 mA HART output signal.
2. The **probe**. There are two basic options, direct mount and remote mount. The remote mount probe is supplied with a 6' or 12' cable. Note, for flange inserted electrodes, a probe may not be included.
3. The **electrodes**. This part of the probe will corrode in the same manner as the metal being investigated. Note: some custom probes may have electrodes that are integral to the probe assembly and will not be shipped loose as described in the next section.

3.4.3 Electrode installation

If the electrodes are shipped loose, the electrodes must be installed **hand-tight.** Ensure that the Viton® gaskets are in place prior to installing the electrodes. Depending upon the actual corrosion rate, it may be necessary to check or replace the electrodes every three months because the element might be too corroded or bent to give a correct reading. See **Figure 3-11**.

NOTE: Clean the electrodes with rubbing alcohol or another similar material prior to operation. This establishes a reliable baseline for the transmitter electronics.

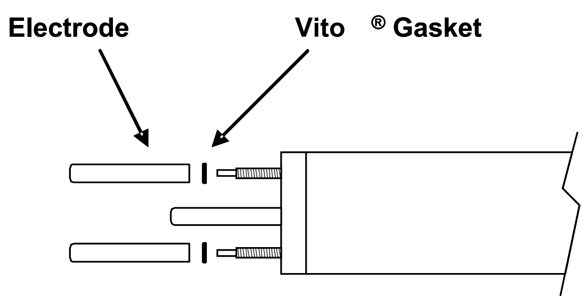


Figure 3-11 Electrodes and Viton Gasket

3.4.4 Probe installation

Insert the probe into the pipe, adjust the insertion to desired depth and apply 1and 1/4 turns from hand-tight to provide the seal as shown in **Figure 3-12**.

Please see safety bracket installation instructions below.

Some probes are supplied with an adjustable, compression NPT fitting (e.g. Swagelok). With this fitting, please follow the tightening sequence described next to ensure a tight seal.

1. The Swagelok fitting should be held onto place with a plastic zip-tie around the probe body. The zip-tie should be removed.
2. Determine the depth that the probe should extend into the pipe.
3. Tighten the larger upper nut until the tubing will not rotate freely by hand.
4. Make a mark on the nut. This mark will serve as a reference as the 6 o'clock position.
5. While holding fitting body steady, tighten the large upper nut 1 + 1⁄4 turns to the 9 o'clock position.
6. This tightening sequence will crimp the internal ring onto the probe body and should lock the fitting in place now.
7. Tighten the lower nut onto the pipe nipple or access point.

Note: For fixed type probes (without the adjustable compression fitting) only the 1 1/16 hex nut needs to be tightened and the safety bracket is not required **(below).**

Additionally, ensure the flow rate of the process fluid does not exceed 20 feet per second (fps). Stronger flow might damage probes with three finger electrodes and interfere with the reading. If the flow rate exceeds the recommendation, a different probe style may be required.

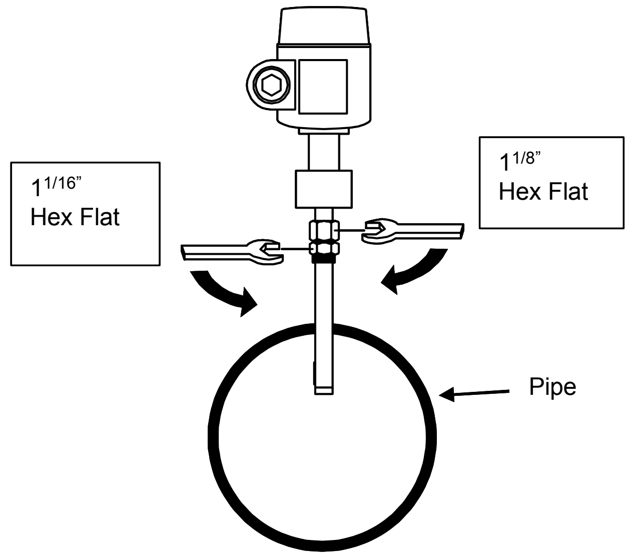


Figure 3-12 Probe Mounting

3.4.5 Safety Bracket installation

The adjustable version of the SmartCET5000 probe uses a compression fitting to provide the seal.

A safety bracket is provided with every adjustable probe and must be installed before the process is under pressure. See **Figure 3-13**. Please follow the assembly instructions below.

1. Screw nut (2) onto threaded rod (3).
2. Screw threaded rod (3) into base plate 1.
3. Tighten nut (2) to lock threaded rod (3) in place.
4. Slide top plate (4) onto threaded rods (3).
   Note: Top plate (4) must be assembled with label on top.
5. Place lock washer (5) and nut (6) onto threaded rod (3).
6. After sensor is mounted into pipe, slide safety bracket into place and tighten nut (6) to lock bracket into place.
   Note: If threaded rods (3) are too short for proper adjustment, contact the factory for replacements.

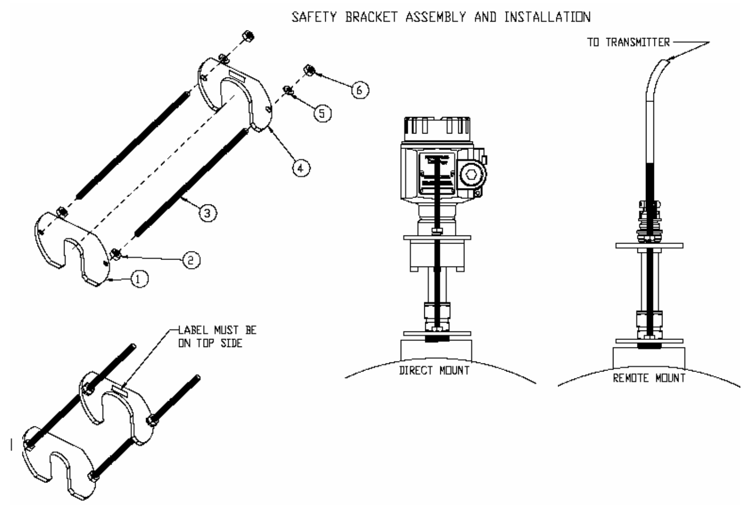


Figure 3-13 Safety Bracket Installation

3.4.6 Mounting Bracket Installation

A mounting bracket is available for use with the remote mount version of SmartCET5000. The assembly and installation is shown in **Figure 3-14**.

Please follow the assembly instructions below.

1. To assemble locking clamps (5) on to mounting bracket (2), angle clamp (5) out, slide tabs into holes and angle back in.
2. Secure mounting bracket to sensor housing using two screws (6) provided.

FOR PIPE MOUNT

1. Position mounting bracket (2) on pipe.
2. Using the U-bolt (1) provided, secure the mounting bracket (2) to the pipe using the lock washer (3) and nut (4) provided.

FOR WALL MOUNT

1. Secure mounting bracket (2) to the wall using a sturdy fastener (not provided).

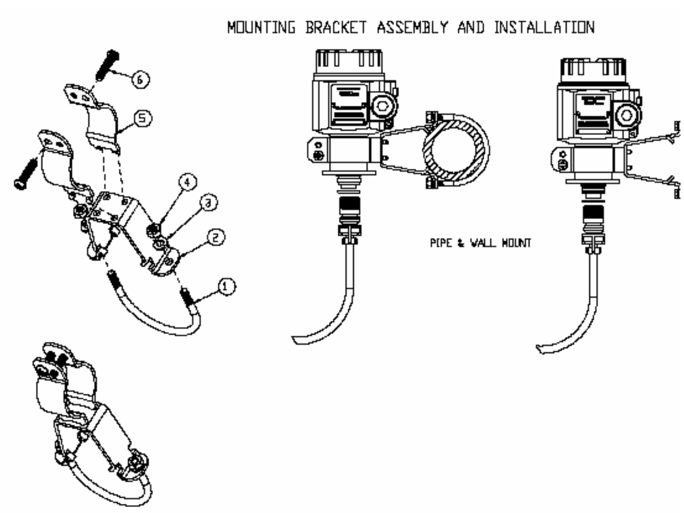


Figure 3-14 Mounting Bracket Installation

4. Wiring

4.1 Transmitter Wiring Guide

Before connection, please note the following:

- The power supply must be identical to the data on the nameplate.
- Switch off power supply before connecting up the device.
- Connect equipotential bonding to transmitter ground terminal before connecting the device.

Connect SmartCET as follows:

1. Unscrew housing cover.
2. Insert cable through one of the ¾” NPT electrical ports.
3. Make electrical connection. See terminal assignment in **Figure 4-1**.
4. If the cable has a shield, it should only be connected at one end. Please follow the convention at the plant site of whether to connect the cable shield at the field side (e.g. in the transmitter) or at the controller side. In general, most users elect to connect the cable shield in the control cabinet.
5. Screw on housing cover.

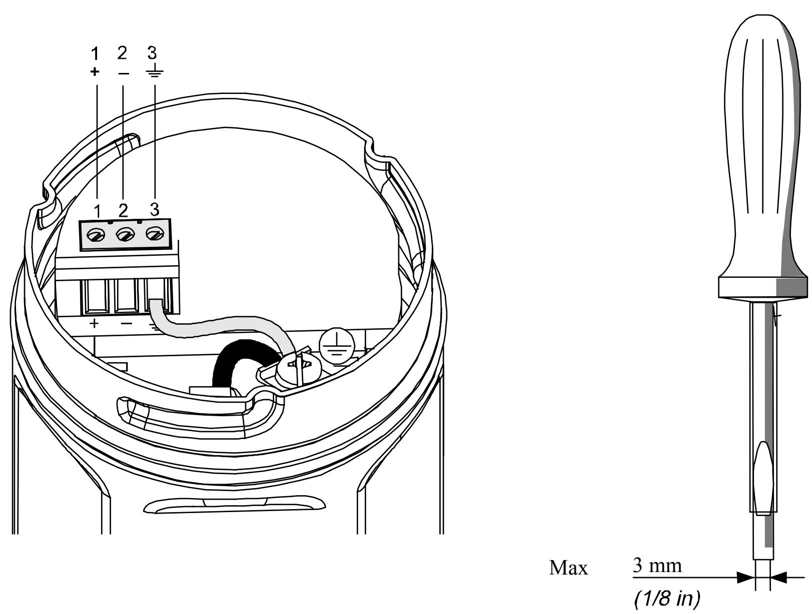


Figure 4-1 Transmitter Wiring

4.2 Galvanic Isolation

In general for Honeywell equipment, the negative side of the analog termination screw on the controller is connected to the MRG (Master Reference Ground). The SmartCET probe, being in contact with the process and plant equipment, could also be grounded. The existence of two grounds will cause errors in the SmartCET corrosion values. Therefore, a galvanic isolation module should be connected as shown in order to provide proper isolation.

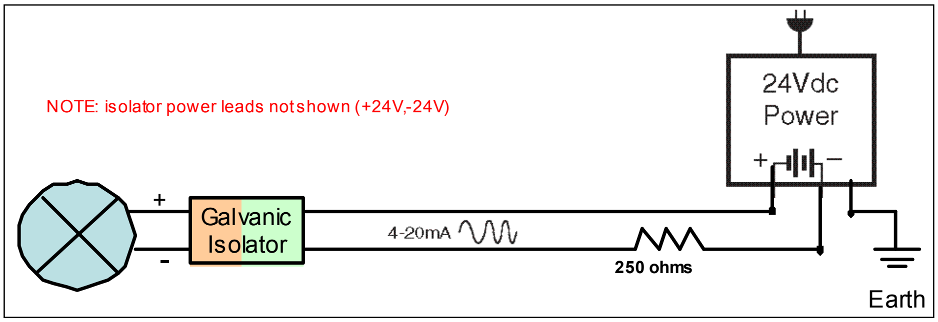


Figure 4-2 Galvanic Isolation connection

4.3 Wiring for HART

4.3.1 Introduction

The SmartCET5000 transmitter supports HART communication protocol. HART is an acronym for Highway Addressable Remote Transducer. The HART protocol makes use of the Bell 202FSK standard to superimpose digital signals at a low level on top of the 4-20 mA signal. The HART protocol enables two-way communication and makes it possible for additional information beyond just the normal process variable to be communicated to and from a smart field instrument.

4.3.2 Wiring

Due to the sensitive nature of corrosion measurement, it is important to provide good electrical isolation between the I/O system/power supply and each 4-20mA/HART signal from SmartCET. For this reason, isolators are required to be installed between the transmitter and the control system if the I/O card is not fully isolated from ground.

Please observe the following guidelines:

- **Always use a grounded power supply (on the AC side).**
- **Ensure that the I/O card is isolated from ground.**

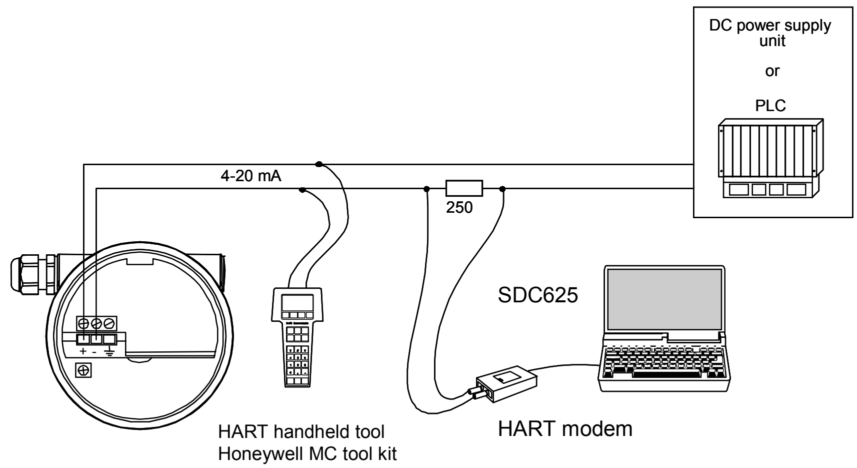


Figure 4-3 Connecting a HART Modem or a Hand-Held Device

4.4 Wiring for Non-HART Systems

For customer orders that require conversion of the HART digital signal to analog current loop signals, a HART Interface Module (HIM) is required. Typically, a Moore Industries HIM should have been provided. The HIM is CSA approved and rated for general/ordinary locations. It is certified for non-incendive Class 1, Division 2, Groups A – D. A suitable enclosure is required for hazardous locations.

The HIM device requires a loop resistor of at least 250 ohms and a maximum of 1100 ohms, as shown in Figure 4-4. The selected IS barrier must be able to operate within this range.

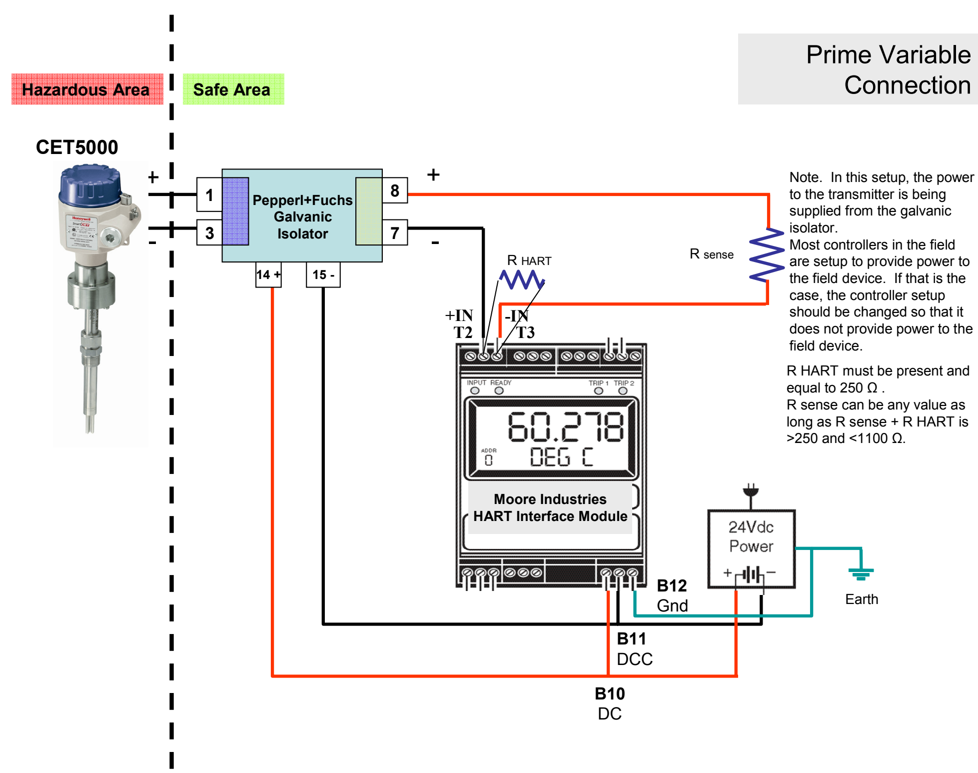


Figure 4-4 Wiring for Non-HART Systems

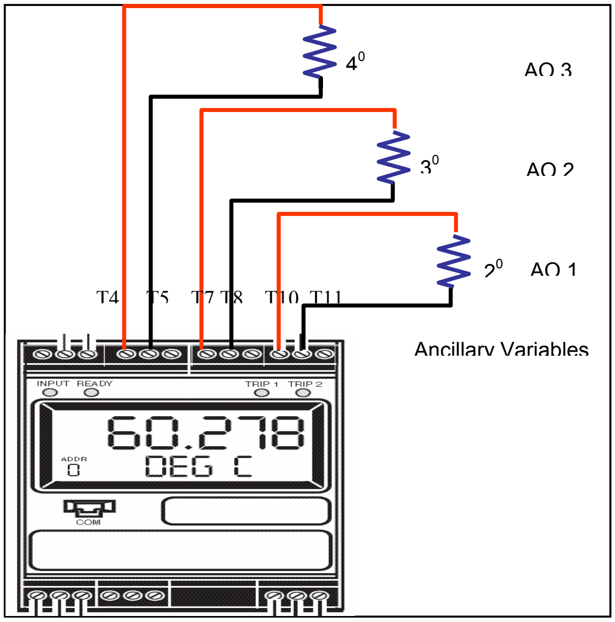


Figure 4-5 HIM Output Wiring

Figure 4-5 shows the wiring of the HIM device if it is providing power. If the controller is providing loop power, the HIM terminal pairs that should be used are 5 and 6, 8 and 9, and 11 and 12.

4.5 Wiring for Local Indicator

The diagram below shows the recommendation for wiring to a local indicator and using the HART interface module.

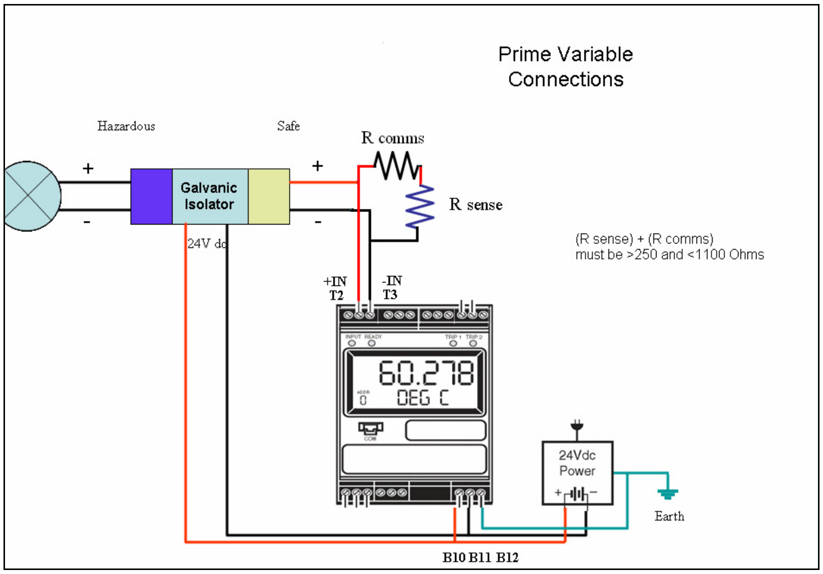


Figure 4-6 Wiring for Local Indicator

4.6 Surge Protection and IS Barriers

Using an intrinsically safe transmitter in a hazardous area requires an IS barrier. Depending upon the Honeywell controller, intrinsic safety protection system could be already present on the termination assembly; however, additional consultation with other suppliers for the required isolators, signal conditioners, surge barriers, intrinsic safety barriers, maybe required. Determination and implementation of proper surge protection and IS barriers are specific to the application and local codes. Each user should determine the level of protection that is required.

An intrinsic safety isolator used in combination with an intrinsically safe SmartCET mounted in a hazardous location meets this requirement so additional isolation is not required. For all other applications, a signal conditioner capable of repeating the 4-20mA/HART signals and providing at least 500V of isolation must be used.

Experion R300, R210 and R201 Systems
The Rail IO Modules - Series H are a Din-rail mounted solution that provides a compact Experion I/O interface, which can be mounted and operated in potentially hazardous locations. The Series H Rail IO Module provides corrosion protection to test level G3, according to ISA-S71.04-1985, is a standard feature of Series H I/O components.

In the US: Modules can be mounted in Class I, Division-1, Groups B, C, D. Devices can be located in Class I, II, III, Division-1, Groups A, B, C, D, E, F, G. In Europe: Modules can be mounted in Zone-1, Group IIC. Devices can be located in Zone-0, Group IIC.

For further information, please consult Experion publication EP03-420-300 or 210.

TPN Network

The Process Manager family of controllers offers field termination assemblies (FTA) built-in with galvanic isolators and intrinsic safety barriers. Please consult with your local HPS Systems Account Manager to determine correct FTA to order.

4.7 Post Installation Check

After wiring the transmitter and connecting the probes, perform the following checks:

- Is the probe secure and tightened to specified torque? (See section 3.4.4)
- Have the electrodes been cleaned? (See section 3.4.3)
- Is the terminal assignment correct? (See section 4.1)
- Is the housing cover screwed tight?
- Is the signal conditioner installed between the SmartCET5000 and the PLC or controller?

5. Configuration

5.1 Overview

Under standard delivery conditions, the SmartCET transmitter will be delivered pre-configured with user specific data. The user only needs to enter a tag name and descriptor if that information was not provided previously. Tag name and descriptor entry can be completed using a HART compatible handheld tool like the Honeywell MC Toolkit with SDC625 tool, or through a network software configuration tool like the Experion System Field Device Manager (FDM). Both of these configuration options use the SmartCET DD (Device Description) file. This file is provided with the product and can also be downloaded from the HART foundation website.

Either of the HART configuration options can be used to access and change the default transmitter setup parameters or the sensor parameters, which are detailed next.

5.2 SmartCET Default Setup

As shipped, the SmartCET corrosion transmitter will have the following default values already setup for use:

PV units: mpy

URV: 100 mpy

LRV: 0 mpy

Damping: N/A

Alarm config: Auto reset / high

Line Freq: 60Hz

B value: 25.6mV

Measurement: Meter

Method: Reflects the transmitter purchased, e.g. general (G), pitting (P), or multivariable (M)

5.3 Sensor Configuration

The sensing element of the SmartCET corrosion transmitter is the electrode. Specific electrode data must be configured into the transmitter for accurate corrosion measurement. Electrode specific data includes:

Electrode area (cm3)

Density (gm/cm3)

No. of electrons

Atomic mass (gm)

Resistance (ohms)

K comp (Table 2-1 contains a list of common values for specific electrode materials) Use this table to enter the K value for the electrode that is in service. The K value is a composite value that represents the density, # electrons, atomic# and resistance, all in a single constant K. The Honeywell factory will ship with the specific electrode data (matching the electrode ordered) configured into the transmitter.

Honeywell uses a three electrode setup as shown in **Figure 3-11**. The SmartCET corrosion transmitter will not work correctly with a probe using a two electrode configuration. Additionally, there is no universal standard for the internal wiring of three electrode probes so non-Honeywell supplied three electrode probes may or may not be compatible.

6. Operation

6.1 Overview

The multivariable version of the SmartCET corrosion transmitter outputs four corrosion measurements, which are:

- General Corrosion Rate
- Pitting Factor (also referred to as localized corrosion indicator)
- B value
- Corrosion Mechanism Indicator

The **General Corrosion Rate** is the average or general corrosion rate, and is generally expressed in mils per year (mpy) or millimeters per year (mmpy).

The **Pitting Factor** is a dimensionless number that indicates the presence of a pitting (localization) corrosion environment.

The **B value** is expressed in millivolts per decade, and is commonly also known as the Stern-Geary constant.

The measurement unit for the **Corrosion Mechanism Indicator** is $\mu F/cm^2$.

Details on each output, including a description of the technology used to calculate or measure the output, are given in **Section 9 - Appendix A - CET5000M Overview of Technology and Output Parameters**

A handheld HART communicator can access all operational data (e.g. process variables); however the more convenient and intended target for corrosion data access is connection to a distributed control system (DCS) or process knowledge system (PKS).

6.2 Variables and Definitions

The following are **examples** of screens and variables that are available **using SDC625 tool and a HART modem.**

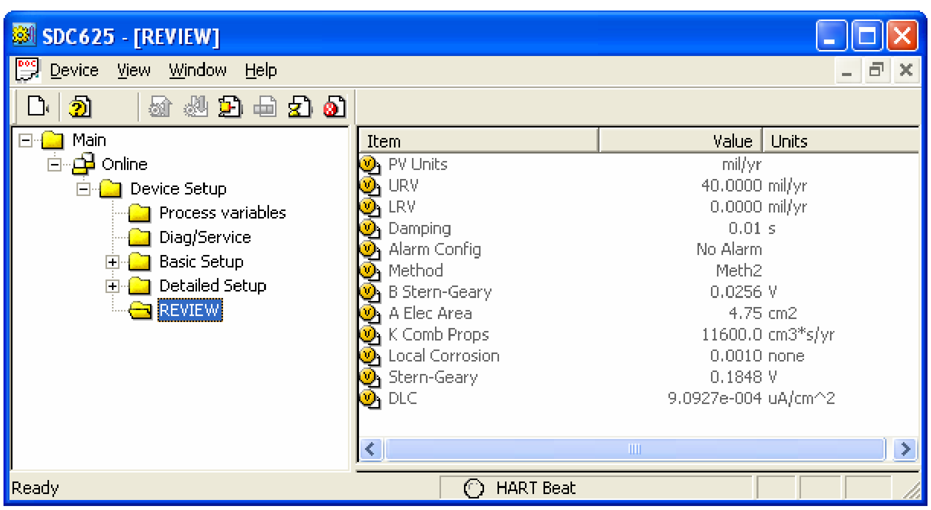


Figure 6-1 Device Setup Variables

PV Units: General corrosion rate can be expressed in either mil/year (1 mil = 0.001inch) or mm/year.

URV and LRV: Upper range value and lower range value for the corrosion rate. For example:

URV= 100 mil/year

LRV=0.000

The 4 mA would be the zero point at 0 mil/year and 20 mA would correspond to maximum corrosion rate at 100 mil/year in this case.

Damping: Determines how quickly the output will change with respect to the input. Because of long update time (7 minutes) there is no need to increase damping.

Alarm Config: Set the alarm preferences for certain corrosion rates (i.e., 0-110 mil) with this pull down menu. The alarm activates when corrosion goes beyond the URV and LRV range. The available options are:

High and Auto: Output goes to 22.5 mA. Alarm resets automatically after the next reading (~7 min)

Low and Auto: Output goes to 3.7 mA. Alarm resets automatically after the next reading (~7 min)

High and Manual: Output goes to 22.5 mA. Alarm is reset manually by sending another alarm command. For example, you can select a **No Alarm** option or select the same alarm option **High and Manual** from the pull down menu. The device will also reset automatically after the next successful reading.

Low and Manual: Output goes to 3.7 mA. Alarm is reset manually by sending another alarm command. For example, you can select a **No Alarm** option or select the same alarm option **Low and Manual** from the pull down menu. The device will also reset automatically after the next successful reading.

No Alarm: Alarm is turned off.

Method: Method 2 is the default setting. Do not change.

B Stearn-Geary: B value is expressed in mV and is typically 25.6 mV (set as default) for most reactions. For more information please contact the factory.

A Elec Area: All electrode lengths are standard from the factory 4.75 cm^2. This value should reflect the electrode style selected. The factory default applies the three finger electrode style used on insertion probes.

K Comb Props: A corrosion constant K is dependent on the metal properties and required for proper corrosion current measurement Reference Table 2-1 on page 14 provides a list of values already calculated for common materials. New materials can use the formula below.

Corrosion constant K [mm/year] is determined by:

$$K = \frac{3270.22 * (\text{Atomic mass of metal in grams})}{(\text{\# of e- in corrosion reaction}) * (\text{Density g/cm3})}$$

Local Corrosion – HART Secondary Measurement Output

Stearn-Geary: HART Tertiary Measurement Output

DLC: HART Quarternary Measurement Output

6.3 Online Parameters

Double click on “Main”, and then double click on “Online”.

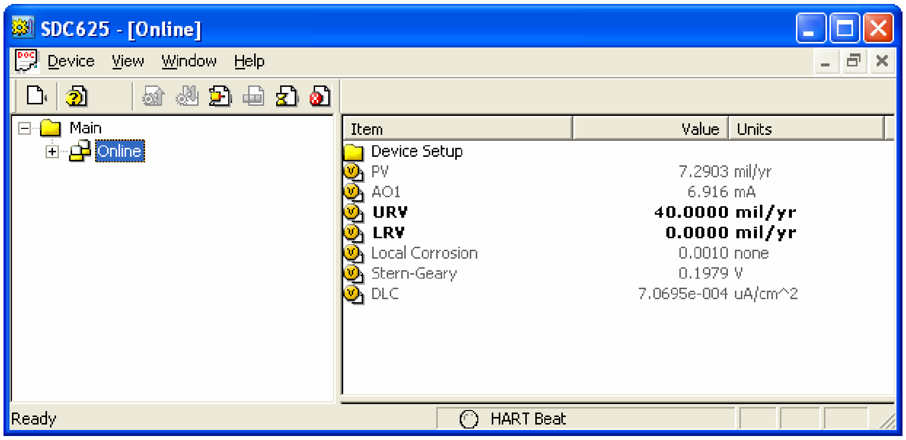


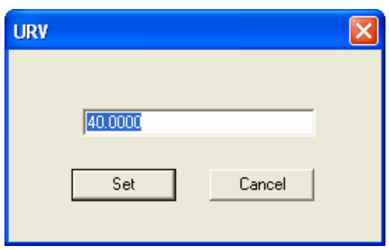
Figure 6-2 Online Parameters Dialog Box

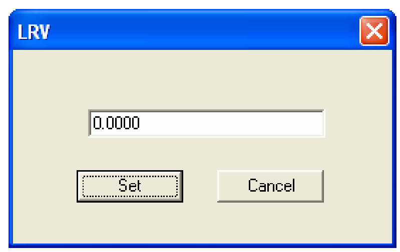
You can change the URV and LRV on this screen. Note, items in **bold** text are changeable.

URV: The upper range value is 100 mil/year maximum (default)

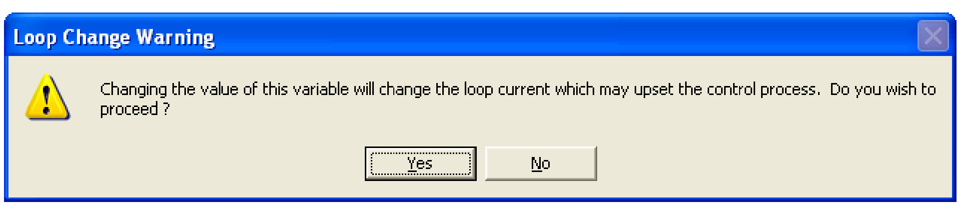
LRV: The lower range value is 0 mil/year minimum (default)

Double click on URV or LRV in the dialog box to call up the change dialog box.





High light the value and change, and then press “Set”. On the “Loop Change Warning” dialog box, select “Yes “to change or “No” to cancel.



6.4 Device Setup Parameters

Double click on "Device Setup". From the Device Setup menu, several tools are available for reviewing and adjusting information from the device. Double click on the desired topic and refer to the section shown below for details

- Process Variables – Section 6.4.1
- Diagnosis and Service – Section 6.4.2
- Basic Setup - Section 6.4.3
- Detailed Setup – Section 6.4.5
- Review – Section 6.4.6

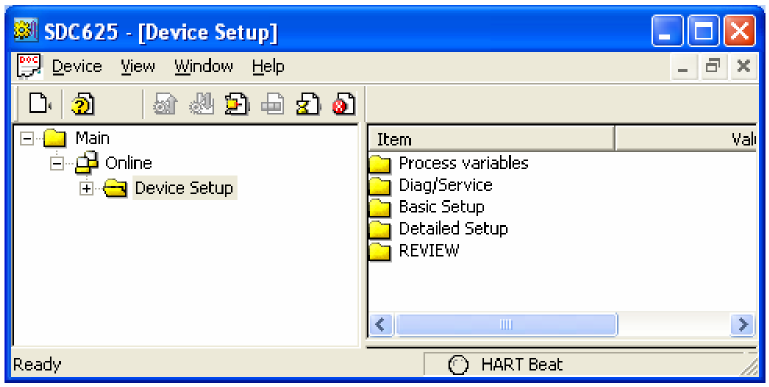


Figure 6-3 Device Setup Dialog Box

6.4.1 Process Variables

Double click on Process variables and the following screen appears. All parameters are read only.

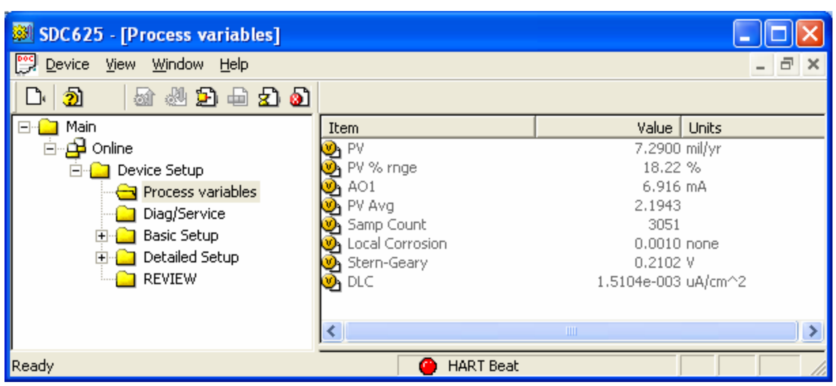


Figure 6-4 Process Variable Dialog Box

PV – The units used to measure general corrosion rates. General corrosion rate can be expressed in either mil/year or mm/year

PV % rnge - – (Percent of Range) Variable that tracks the Digital Value representation with respect to the range defined by the Lower Range Value and Upper Range Value, for normal operating modes. The units of this variable are always in percent.

AO1 – Analog output in current, 4 to 20 mA. This shows the current value output

PV Avg – Average of the selected measurement over the number of measurement cycles since these were last cleared.

Sample Count – The number of measurement cycles since these were last cleared.

Local Corrosion – HART Secondary Measurement Output

Stearn-Geary – HART Tertiary Measurement Output

DLC – HART Quarternary Measurement Output

6.4.2 Diag/Service

Double click on Diag/Service and the following screen appears:

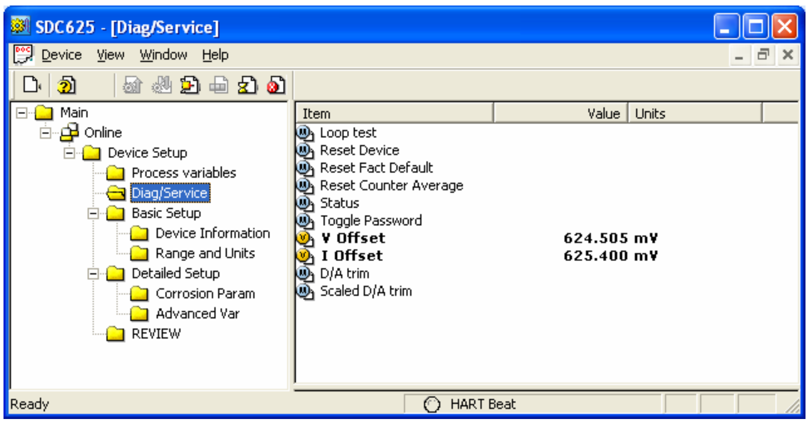


Figure 6-5 Diagnosis and Service Dialog Box

Loop Test – Allows you to manually manipulate the Analog output to a selected constant output value. There are several selections available: 4mA, 20mA, Other, End.
Right click on “Loop Test”, then select Execute and follow the prompts.

Reset Device – Resets the transmitter. “Right click on ‘Reset Device”, then select Execute and follow the prompts.

Reset Fact Default – Resets the transmitter to factory default. Right click on “Reset Fact Default”, then select Execute and follow the prompts.

Reset Counter Average – Resets Sample Count and PV Average to zero. Right click on “Reset Counter Average”, then select Execute and follow the prompts.

Status – The status of the device. Displays system errors if there are any present.

Toggle password – Proprietary

V Offset – Voltage Channel Offset Typically 625 mV ±6. Right click on “V Offset”, and then select Edit to call up the change dialog box. Highlight the value and change, and then press “Set”.

I Offset – Current Channel Offset Typically 625 mV ±6. Right click on “I Offset”, and then select Edit to call up the change dialog box. Highlight the value and change, and then press “Set”.

D/A Trim – (Digital to Analog Trim) – Allows the calibration of a selected Analog Output with an external reference at the operating endpoints of the Analog Output. Right click on “D/A Trim”, then select Execute and follow the prompts.

Scaled D/A Trim – (Digital to Analog Scaled Trim) Allows the calibration of the Analog Output with an external reference at the operating endpoints of the Analog Display. Right click on “Scaled D/A Trim”, then select Execute and follow the prompts.

6.4.3 Basic Setup

Double click on “Basic Setup” and the following screen appears:

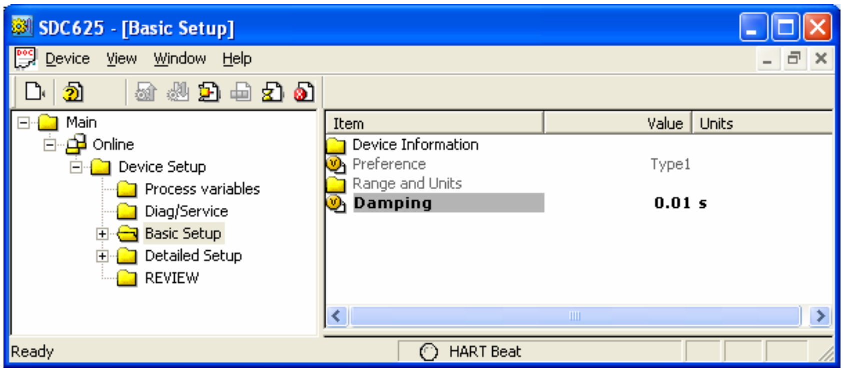


Figure 6-6 Basic Setup Dialog Box

Preference – Type refers to either general or localized (pitting) corrosion monitoring. The Type is set at the factory and cannot be changed.

Type 1 is general corrosion.

Type 2 is localized (pitting) corrosion.

Damping – Determines how quickly the output will change with respect to the input. Because of long update time (7 minutes) there is no need to increase damping. If you wish to change the value, right click on “Damping”, and then select Edit to call up the change dialog box. Highlight the value and change, and then press “Set”.

The two subsets of the Basic Setup menu are **Device Information**, and **Range and Units**. The Device Information screen is shown in **Figure 6-7**. Range and Units is represented in **Figure 6-8**.

6.4.3.1 Device Information

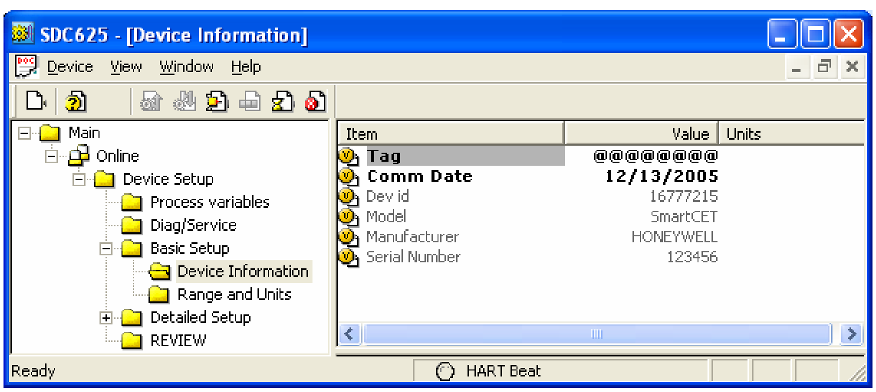


Figure 6-7 Device Information Dialog Box

Tag: Customer specified identification. If you wish to change the value, right click on “Tag”, and then select Edit to call up the change dialog box. Highlight the tag name and change, and then press “Set”.

Comm Date: Commissioning date

Dev Id: Field Device identification

Manufacturer: Honeywell

Serial Number: This serial number is used to identify specific customer requirements. It is also tagged on the outside of the transmitter head.

6.4.4 Range and Units

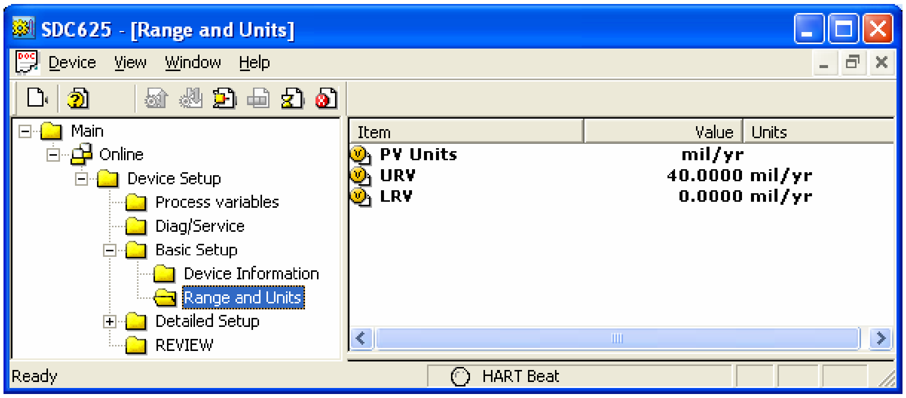


Figure 6-8 Range and Units Dialog Box

PV Units: General corrosion rate can be expressed in either mil/year (1 mil = 0.001inch) or mm/year. If you wish to change the value, right click on "PV Units", and then select Edit to call up the change dialog box. Highlight the tag name and change, and then press "Set".

URV and LRV: Upper range value and lower range value for the corrosion rate. For example:

URV= 100 mil/year

LRV=0.000

The 4 mA would be the zero point at 0 mil/year and 20 mA would correspond to maximum corrosion rate at 100 mil/year in this case.

Not applicable if "Preference" is set to type 2.
If alarm is enabled, the loop current will go to alarm condition if the measured value exceeds this limit.

6.4.5 Detailed Setup

Double click on "Detailed Setup" and the following screen appears:

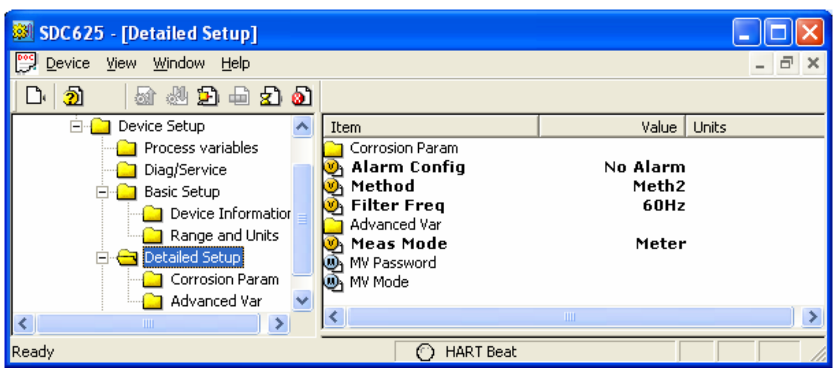


Figure 6-9 Detailed Setup Dialog Box

Alarm Config: Set the alarm preferences for certain corrosion rates, 0-110 mil, for example, with this pull down menu. The alarm activates when corrosion goes beyond the URV and LRV range. The available options are:

High and Auto: Output goes to 22.5 mA. Alarm resets automatically after the next reading (~7 min)

Low and Auto: Output goes to 3.7 mA. Alarm resets automatically after the next reading (~7 min)

High and Manual: Output goes to 22.5 mA. Alarm is reset manually by sending another alarm command. For example, you can select a ***No Alarm*** option or select the same alarm option ***High and***

Manual from the pull down menu. The device will also reset automatically after the next successful reading.

Low and Manual: Output goes to 3.7 mA. Alarm is reset manually by sending another alarm command. For example, you can select a ***No Alarm*** option or select the same alarm option ***Low and Manual*** from the pull down menu. The device will also reset automatically after the next successful reading.

No Alarm: Alarm is turned off.

If you wish to change the selection, right click on "Alarm Config", and then select Edit to call up the change dialog box. Pull down the menu and make a selection, and then press "Set".

Method:

Method 1 not used.

Method 2 default setting.

Filter Freq: 50Hz or 60Hz, in reference to line power frequency (120 vs. 220 VAC).
If you wish to change the selection, right click on "Filter Freq", and then select Edit to call up the change dialog box. Pull down the menu and make a selection, and then press "Set".

Meas Mode: The default is Meter. Other parameters require additional evaluation software.
If you wish to change the selection, right click on "Meas Mode", and then select Edit to call up the change dialog box. Pull down the menu and make a selection, and then press "Set".

The two subsets of the Detailed Setup Screen menu are **Corrosion Parameter** and **Advance Variable**. The Corrosion Parameter screen is shown in **Figure 6-10**, the Advance variable screen is represented in **Figure 6-11**.

6.4.5.1 Corrosion Parameters

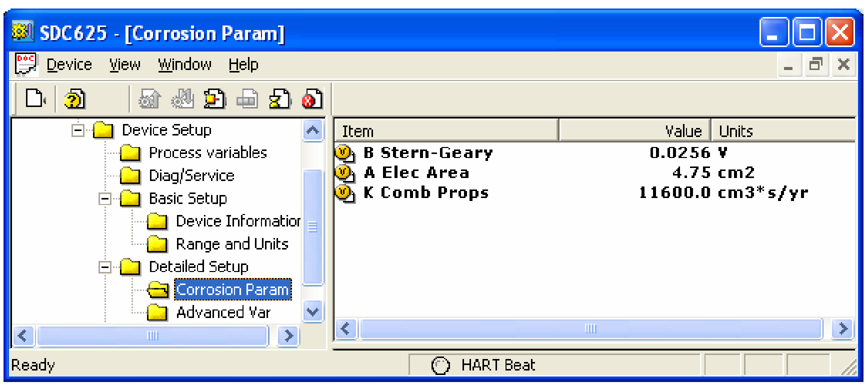


Figure 6-10 Corrosion Parameters Dialog Box

B Stearn-Geary: B value is expressed in mV and is typically 25.6 mV (set as default) for most reactions. For more information please see Section 9.3.

A Elec Area: The factory default is 4.75 cm^2 which is the value for finger electrodes.

K Comb Props: A corrosion constant K is dependent on the metal properties and required for proper corrosion current measurement. **Corrosion constant** K is determined by: referencing Table 2-1.

6.4.5.2 Advanced Variable

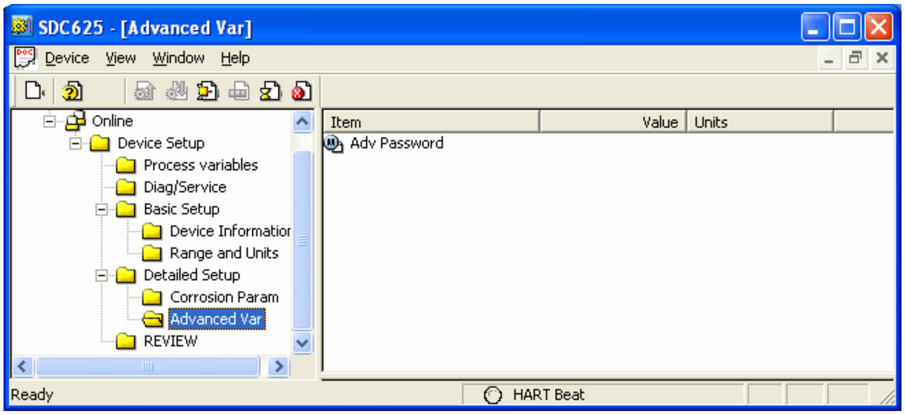


Figure 6-11 Advanced Variable Dialog Box

AdvPassword: N/A

6.4.6 Review

Click Review. The review screen shows all of the variables for corrosion measurement. The values shown in **Figure 6-12** are the default values.

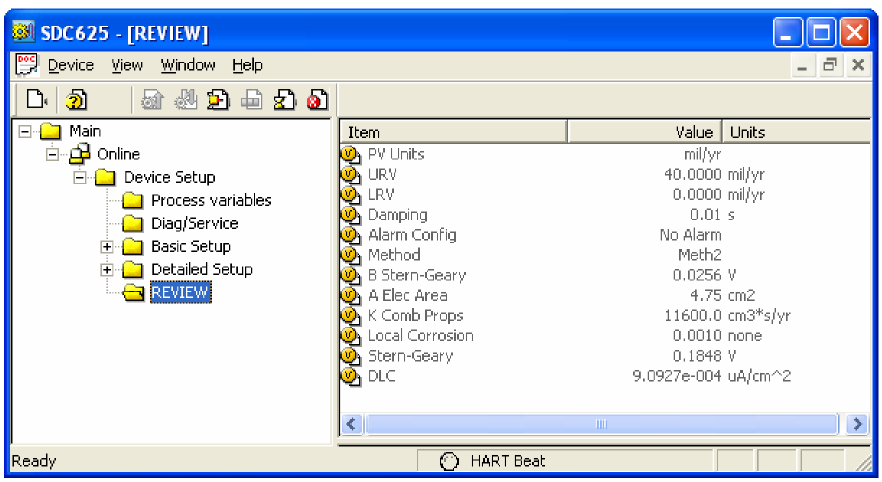


Figure 6-12 Review Screen

6.5 Initial Operation

Now that the probe and electrode is in the process fluid and the SmartCET corrosion transmitter is properly wired, the SmartCET should be ready for normal operation. The electrodes will require some residence time in the process fluid before corrosion can be accurately measured. SmartCET should also go through multiple measurement cycles, each cycle is approximately seven minutes long, before the corrosion measurements represent the true corrosive conditions. This waiting period is especially necessary if the SmartCET transmitter was powered up prior to being connected to a probe.

7. Replacement Parts and Accessories

7.1 SmartCET5000 Parts

Please submit the serial tag number and model number when ordering replacement parts for SmartCET5000.

7.1.1 Transmitter, Probe with Electrodes, or Electrode Replacement

The model number will have the following form factor:

CET5000 M - N21 CB A 080 - 0A - A2 IH1- D2 - 050

The combination of the model number and serial number will provide the necessary information to order a replacement transmitter, probe with electrode, or electrode only. Please specify which item is required since the model number contains information on the entire product.

If the pipe or vessel into which the SmartCET5000 is to be inserted is under pressure and/or contains any hazardous substance, such as steam, caustic solutions, acids, toxins or other substances specified by OSHA as physical or health hazards, the pipe or vessel must first be depressurized and any hazardous substance purged there from, and appropriate lockout/tagout procedures observed in accordance with Section 1910.147 of the OSHA Regulations, before SmartCET5000 can be removed or the electrodes replaced. **Failure to follow these procedures may result in serious injury or death.**

7.1.2 Transmitter Accessories

Common transmitter accessories which are supplied at the time of order placement are shown below.

Model No.	Description
50022362-001	Safety bracket for transmitters with direct mount probes
50022362-002	Safety bracket for probes remotely mounted
50022363-001	Remote mount transmitter mounting bracket
50022365-001	Remote cable – 6 foot
50022365-002	Remote cable – 12 foot

7.2 HART Accessories

Some installations include a HART interface module that converts the HART SV, TV, and QV parameters into three analog signals. This module is designed for those systems that do not natively support the HART protocol in the controller of the process control system. If a replacement is required, please contact your Honeywell representative to submit a replacement order.

8. Troubleshooting

8.1 Overview

This section describes various possible problems and the means to correct them.

WARNING

If the pipe or vessel into which theSmartCET5000 is to be inserted is under pressure and/or contains any hazardous substance, such as steam, caustic solutions, acids, toxins or other substances specified by OSHA as physical or health hazards, the pipe or vessel must first be depressurized and any hazardous substance purged there from, and appropriate lockout/tagout procedures observed in accordance with Section 1910.147 of the OSHA Regulations, beforeSmartCET5000 can be removed or the electrodes replaced. **Failure to follow these procedures may result in serious injury or death.**

8.2 Diagnosis of Transmitter Health from Measurement Data

The output from the SmartCET corrosion transmitter can provide insight into the health of the transmitter operation. Table 8-1 shows the output expected for each variable when the transmitter is operating properly and the table also shows an indication when a probe short condition exists and when no probe is connected.

Table 8-1 Diagnosis of Transmitter Health

Description	Transmitter output variable	General Corrosion	Pitting / Localized Corrosion	Probe short	No probe connected
Corrosion rate	PV	Across range	Across range	Maximum value Note 1.	~ 0 Note 3.
Pitting Factor	SV	<0.1	>0.1	<0.001	~ 1
B value	TV	(Stable) Note 2.	(Unstable) Note 2.	(Unstable) Note 2.	(Unstable) Note 2.
Corrosion Mechanism Indicator	QV	Across the range	Across the range	(~ 0) Note 2.	~ 0

Notes:

1. Corrosion rate maximum will depend on the material constants and surface area entered. From a measurement perspective, it relates to the absolute value of the polarization resistance of the working electrode. If the polarization resistance is very low (<10 ohms), the instrument will be close to current saturation. For optimal operation it is preferable to maintain the polarization resistance of the working electrode at values of >100 ohms. This may be achieved to some extent by changes to the surface area of the working electrode. Therefore, a specific threshold value in mpy cannot be applied generically. However, instead of using the corrosion rate reaching a max value as the indicator, it might be possible to use one of the command 48 indicators to provide the same thing, e.g. Corrosion rate out of range.

2. Items shown in brackets are general statements. No specific value can be provided.

3. An exact zero value will not be achieved. It will be essentially be zero or something very small, e.g. 0.001 mpy.

Under conditions when general corrosion is prevalent on the material being monitored, the measured corrosion rate observed as the primary variable (PV) may be expected to show evidence of being stationary for a short term. In these cases the corrosion rate will tend to exhibit only slight variation in the short term, perhaps over periods of hours or longer. Any slight process change, such as temperature variability is often reflected in the corrosion rate behavior. Larger excursions in the corrosion rate may be experienced if there are more pronounced changes to the environment, for example due to flow rates or changes in composition.

The secondary variable, Pitting Factor, will typically be a low value under these conditions (e.g. <0.01), although it may exhibit some short term response to abrupt changes in the environment, for example sudden changes in temperature, flow rate or fluid composition.

The tertiary variable (the B value) will usually fall in a range of 0.010 to 0.030 volts, and will be stable.

The quaternary variable (Corrosion Mechanism Indicator) is largely dependant on the type of material being studied, but generally, if active corrosion is being observed (>5mpy), it will tend to be significantly larger than the case for very low corrosion rates.

If low general corrosion rates are being observed, which are close to instrument baseline (< 0.05 mpy), the Pitting Factor may appear artificially high (e.g. > 0.01).

When localized corrosion is occurring, the observed general corrosion rate values may be in the range 0.1 to 10 mpy or higher, depending on the material and the environment. The Pitting Factor will tend to exhibit higher magnitude peaks of activity during pit initiation events, whereas propagating pits may be associated with a general increase in the observed corrosion rate and lower levels of pitting factor (<0.1). The general corrosion rate in the case of propagating pits often exhibits short term variation and is noticeably less stable than the case for general corrosion. Pitting is often accompanied by increased variability in the B value. With increasing degrees of pit propagation, the CMI values will also tend to increase.

8.3 General Troubleshooting Procedures

The CET5000 is designed to operate over a broad range of corrosion rates. However, most problems associated with the corrosion rate calculation arise when the actual corrosion rate is extremely high, and there is likelihood that the instrument is approaching or exceeding its stated operating limits. In some circumstances, this can be remedied by using sensors with a smaller surface area.

Another factor to be considered is severe diffusion limiting or mass transport control of the corrosion processes. In this case the B value determination may become difficult, and erratic behavior with very high values may be observed. Troubleshooting procedures that deal with this condition and general situations are shown in Table 8-2.

Table 8-2 Troubleshooting Procedures

Symptom	Possible Cause	Recommended Checks
No 4-20 mA output	Check voltage and compare it with the specifications on the nameplate	Connect the correct voltage
Measuring correct voltage but unit does not respond	Check polarity on the terminals.	See Section 4.1 – Transmitter Wiring Guide
HART communication does not function	The communication resistor is not installed properly	See Section 4.3: Wiring with HART

Symptom	Possible Cause	Recommended Checks
Corrosion rate values are very low and do not change	1.Probe or probe cable fault – bad connection to probe electrodes 2. Transmitter fault	1. Check continuity with test cell connected at probe end of cable. May be necessary to remove probe and carry out continuity checks between connecting pins and probe sensing elements. 2. Check with test cell connected directly to Amphenol connector on transmitter. Consult with the factory for additional information.
Corrosion rates are very high, Pitting Factor very low, and B values are very low.	This problem could be due to a shorting condition between probe sensing elements	1a. Disconnect probe and the corrosion rate should fall. 1b. Remove probe and physically check for electrode to electrode contact. 1c. May be caused by the presence of conductive corrosion deposits e.g. iron sulfide (B value very low). 2. Use probe with smaller surface area.
Corrosion rate switches abruptly from high to very low levels, Pitting Factor is very high, and the B value goes to the current default value.	This situation is symptomatic of when the (internal) polarization resistance calculation has apparently gone to a negative value, with the result that the corrosion rate is indeterminate and a default low value is returned. Apparent negative polarization resistances may occur in situations where the corrosion rates are very high and the electrode area is incorrect for the process situation.	1. The electrodes could be too large. Investigate using electrodes with a smaller area. 2. Another possible cause may be due to an asymmetrical response of the electrodes, for example due to crevice corrosion occurring on one of the electrodes. The electrodes should be inspected in this case. 3. All the variables being measured corrosion rate, Pitting Factor, B value and CMI are suspect and could be in error. Consult with the factory for additional information.

Symptom	Possible Cause	Recommended Checks
All corrosion variables are very unstable exhibiting one or more of the following: 1. Corrosion rate unstable, may drop to very low values 2. Pitting Factor low when corrosion rate high and vice versa. 3. B values unstable switching between ~0.02 and > 0.1 4. CMI unstable switching from very low value 1e-3 to large value e.g. > 0.5	These systems are typically caused by high and variable corrosion rates in the process environment, hard diffusion limiting processes, and/or electrode surface areas being too large for the application.	1. Disconnect probe. Corrosion values should return to baseline levels. 2. Check with test cell, transmitter should give a standard response. 3. Electrode surface area could be incorrect for the application. Contact a Honeywell corrosion specialist to review the application. Corroding systems with real diffusion / mass transport limiting scenarios are problematic monitoring situations.

8.4 Recommended Operating Conditions

SmartCET utilizes electrochemical techniques that are applicable for a wide range of corrosive conditions. The following table provides the applicable operating envelope for SmartCET with additional comments when the operating range is outside envelope.

Measurement	Range	Comments
Corrosion rate	0-250 mpy dependent upon the electrode surface area, typically in range of 1 to 10 cm^2. (Default URV setting is 100 mpy and the electrode area is 4.75 cm^2.)	• Higher sensitivity at low corrosion rates may be achieved by using larger electrodes - consult factory for additional information. • The higher corrosion rate range is achieved with appropriately sized electrodes (e.g. small areas). If symptoms listed in Table 8.2 occur, the B value should be fully reviewed and analyzed before providing a corrosion rate estimate. It is recommended to qualify the rate estimate against mass loss from electrodes – consult factory for additional information.
Pitting Factor	0.001 to 1.	With low corrosion rates, the Pitting Factor may appear artificially high due to very low observed general corrosion rates – consult factory for additional information.
B value	Expected range: 5 to 60mV (0.005 to 0.06V).	• Low values may be due to formation of surface films having redox behavior (e.g. Iron sulfide). The electrode essentially starts to become non-polarizable. • High values predominantly may be due to diffusion limiting processes. As the electrochemical processes become more diffusion limiting, the B value may not achieve a stable value. Applying the B value from this type of situation (e.g. updating the default value) is not recommended. Consult with the factory for additional information.
Corrosion Mechanism	Expected range: 0	Values are dependent on material and environment.

Measuremen t	Range	Comments
Indicator	to 2 μA/cm^2.	

8.4.1 SmartCET Use in Low Conductivity Environments

SmartCET uses electrochemical techniques to analyze and measure corrosion in process environments. The electrochemical measurements require a low level of ionic conductivity in the fluid to which the probe is exposed. Some compensation may be required using special probe arrangements when dealing with extremely low conductivity environments. Please consult with the Honeywell factory for additional information.

9. Appendix A - CET5000M Overview of Technology and Output Parameters

9.1 Introduction

The multivariable version of the SmartCET corrosion transmitter outputs four corrosion measurements, which are:

- General Corrosion Rate
- Pitting Factor
- B value
- Corrosion Mechanism Indicator

The **General Corrosion Rate** is the average or general corrosion rate, and is generally expressed in mils per year (mpy) or millimeters per year (mmpy).

The **Pitting Factor** is a dimensionless number that indicates the presence of a pitting (localization) corrosion environment.

The **B value** is expressed in millivolts per decade, and is commonly also known as the Stern Geary constant.

The measurement unit for the **Corrosion Mechanism Indicator** is $\mu A/cm^2$.

The values are all updated every 430 seconds, which is the total measurement cycle time of the instrument. The values for the General Corrosion Rate, the Pitting Factor and the Corrosion Mechanism Indicator are set to output the most recent values.

The B value is slightly different in that the output value is an average of the values over the last 2-3 hour period. This averaging provides a more stable representation of the B value. If there is a large change in the B value, for example, from a high value e.g. 0.15 volts to a low value e.g. 0.015V, the new value will be approached asymptotically over a period of approximately three hours. This is normal behavior and will only be noticeable if there are large sustained changes in the B value – such as may occur during commissioning of the device or when switching from a test cell to a corrosion probe.

Detail of each output parameter is presented in this appendix, including a description of the technology used to calculate or measure the output.

9.2 General Corrosion Rate

SmartCET uses the Linear Polarization Resistance (LPR) technique to calculate the General Corrosion Rate. This calculation is usually the prime variable of interest since it reflects the overall rate of metallic corrosion. Corrosion may be directly related to operational parameters such as temperatures, flow, chemical composition, etc.

SmartCET uses three electrodes that are referred to as the working, counter and reference electrodes. A low frequency sinusoidal voltage excitation is applied to the working electrode with respect to the reference electrode, and the current is measured and analyzed (on the counter electrode) synchronously with the applied signal.

Given a sinusoidal pattern, the working electrode becomes positively charged and then negatively charged (in other words, polarized positively and negatively). It is a DC voltage applied in a sinusoidal pattern and resembles an AC pattern. The peak-to-peak value of the sinusoidal wave is 50mV.

Strictly, this is a measurement of the real part of the low frequency impedance of the working electrode. This method of analysis is selected due to its superior noise rejection, which is particularly useful when studying corroding systems since they exhibit varying degrees of intrinsic noise. The result is equivalent to measuring the *linear polarization resistance* of the working electrode. With this measurement, the corrosion current (hence, the corrosion rate) is inversely proportional to the polarization resistance.

This measurement also employs the Stern-Geary approximation where the Stern-Geary constant (or B value) is the proportionality constant. In practice, with no prior knowledge of the system, the “default” value of B for this type of measurement is typically chosen to be in the range 25 to 30 mV; in reality, the value of B is system-dependent.

Use of the default B value may result in the absolute corrosion rate being somewhat in error, but in some instances, it is the general trend of the corrosion rate that could be of interest instead of the absolute value.

Working method summary:

There are three electrodes in use, which are designated working electrode (WE), counter electrode (CE) and reference electrode (RE). A sinusoidal DC voltage is applied on the WE (voltage is varied).

In turn, the current response is measured between the CE and WE. The ratio of voltage to current provides the polarization resistance. The polarization resistance is not a true resistance in the traditional sense, but can be treated as such in describing the LPR technology.

The corrosion current is inversely proportional to the polarization resistance.

How does LPR distinguish polarization resistance due to corrosion versus general resistance of the solution? How does an electrical model represent a corrosion process? What makes corrosion look like an electrical system?

First, SmartCET includes a measurement cycle where the solution resistance is measured and calculated. This allows the resistance due to the solution to be quantified.

Corrosion comprises an anodic process and a cathodic process, i.e. electrochemical processes that occur at anodic and cathodic sites on the metal surface. When corrosion is occurring, there is an increase of ionic flow between the anodic and cathodic sites (i.e. Faradaic process). A non-corrosive system would not exhibit any ionic flow. SmartCET applies a sinusoidal wave to facilitate an increase in flow. The sinusoidal wave is a very slight DC voltage to enhance the anodic sites during one part of the wave and then enhance the cathodic sites in the other half of the wave. SmartCET measures the polarization resistance during these cycles. A heavily corroding system would be characterized by greater ionic flow. The small DC voltage does not affect the naturally occurring corrosion process.

The anodic and cathodic sites exist on any of the three electrodes (versus one electrode being the anode and the other the cathode). It is the flow of current from the anodic site on one electrode to the cathodic site on the other electrode that is being measured.

Table 9-1 shows the relationship between corrosion rate, environment characterization and the recommendation for getting accurate General Corrosion Rate measurements.

Table 9-1 Corrosion Rate and Environment Characterization

Corrosion Rate	Environment	Comments
>200 mpy	Highly conductive, highly corrosive	This could be at upper level of SmartCET accuracy range. If used in this environment, electrodes with small area should be used (e.g. $1cm^2$).
1-200mpy	Average corrosion rate	Use correct probe type according to process application.
0.01-1mpy	Low conductivity or passive system	Electrodes with large area should be used (e.g. $10cm^2$).
<0.01mpy	Extreme passivity or low conductivity (e.g. organic medium)	This could be at lower level of SmartCET accuracy range. If used in this environment, electrodes with large area should be used (e.g. $10cm^2$).

9.3 The B value

The B value represents a correction factor 'constant' that is determined by the mechanism and kinetics of the corrosion process. In a dynamic process, research has shown that the B value is not constant. For example, the B value for a sour system with a microbiological influence on corrosion activity could be 4mV. The average "industry-accepted" default B value is typically between 25 and 30mV. Houston tap water gives a B value of 15mV. A severely scaled system (i.e. inorganic scale deposits on the metal surface) would show a B value of around 100 mV.

By evaluation of the non-linearities in the current response from the LPR measurement, it is possible to determine a B value for the system being studied. This involves the analysis of the higher order harmonic content of the current response, and computation of a value of B for the system being studied.

With knowledge of the B value it is possible to *refine* the LPR-generated corrosion rate estimate, since the uncertainty regarding the standard (default) B value is removed. The B value is directly related to the mechanistic properties of the component anodic and cathodic corrosion processes.

The anodic process is essentially the metal oxidation and the cathodic process is, for example, the oxygen reduction or hydrogen evolution. These are essentially non-linear processes, and the current will typically (but not always) have a logarithmic dependence on the applied voltage.

The B value is a composite of the individual anodic and cathodic Tafel slopes.

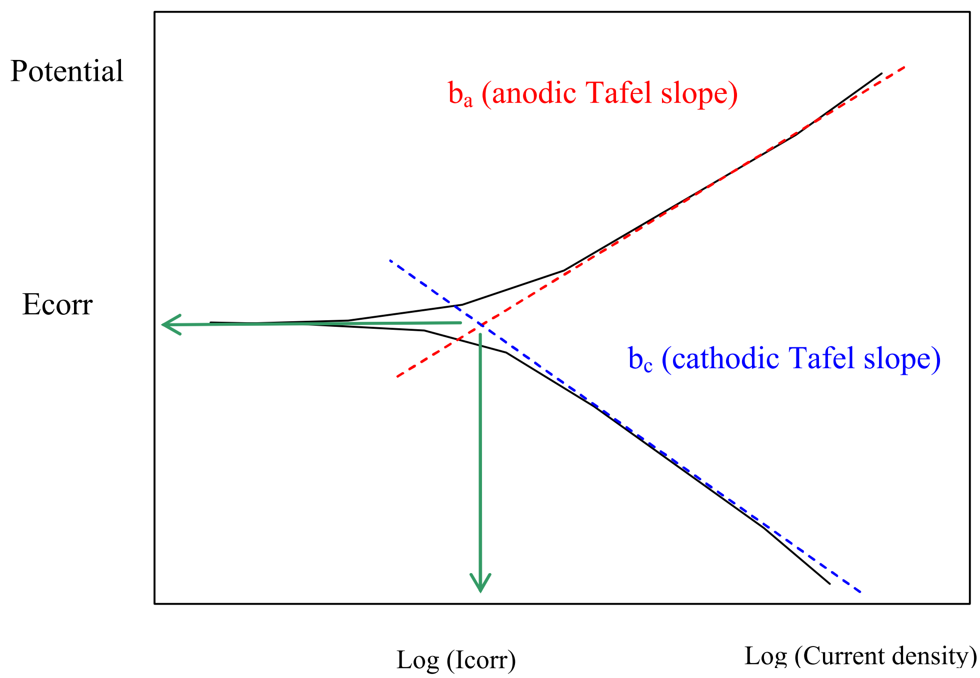


Figure 9-1 Individual Anodic and Cathodic Tafel Slopes

The B value is calculated using the following

B=ba*bc/2.303*(ba+bc)

So these individual slopes are representative of non-linear processes. In the calculation of the general corrosion rate, the B value approximation assumes that the processes are essentially linear for a small applied potential, for example: 10 – 20 mV away from the corrosion potential and only takes into account the first order (linear) processes. The harmonic distortion analysis takes into account the second and third order processes, i.e. it is similar to fitting a polynomial to x^3, but we use the higher frequency harmonic components to analyze rather than trying to fit a polynomial – it's a much better analysis route.

SmartCET uses Harmonic Distortion Analysis (HDA) to calculate the 'true' B value. With an accurately computed B value, the default B value used in the LPR calculation can be changed thus enabling a more accurate corrosion rate calculation to be made.

How does the technology work?

A low frequency AC voltage (10 mHz) is applied on the working electrode.

The current signals are analyzed at 10, 20 & 30 mHz (harmonics).

The response at each harmonic is used to calculate the B value.

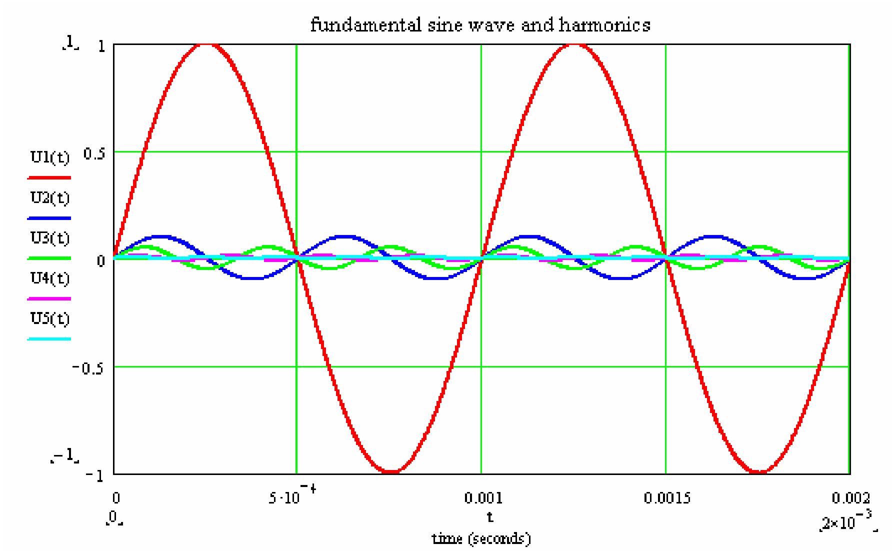


Figure 9-2 Fundamental Sine Waves and Harmonics

Table 9-2 provides analysis on the corrosion mechanism based upon the B value, and typical anodic and cathodic values.

Table 9-2 Corrosion Rate and Environment Characterization

ba	bc	B	Comments
60mV	60mV	13mV	Both processes activation controlled (e.g. sulfide film)
60mV	∞	26mV	Anodic process activation, cathodic diffusion, controlled (e.g. aerated system)
120mV	∞	52mV	Anodic process activation, cathodic diffusion, controlled (anodic slope different) – e.g. multiphase system
∞	∞	∞	Severe anodic and cathodic diffusion limiting – e.g. vapor phase. B value indeterminate.

9.4 The Pitting Factor

The Pitting Factor is a measure of the overall stability of the corrosion process, and is obtained from a measurement of the *intrinsic current noise* of the working electrode, and comparing this measurement to the *general corrosion current* obtained from the LPR measurement (e.g. general corrosion rate calculation).

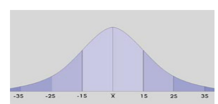
General corrosion processes typically have low levels of intrinsic noise, with the ratio of noise to the general corrosion current typically being ≤1% (Pitting Factor ≤0.01). With the onset of instability (pit initiation), localized corrosion occurrence leads to increasingly higher levels of current noise with respect to the general corrosion current such that the Pitting Factor may reach a value of 1. The Pitting Factor can be viewed as the probability that the corrosion mechanism is localized.

Spontaneous changes in the environment may also cause the instantaneous value of the Pitting Factor to approach a value of 1 in the short term; however, for localized corrosion, the Pitting Factor will remain unstable and secondary evidence may be observed in terms of the overall stabilities of both the general corrosion rate estimate and the B value.

SmartCET uses electrochemical noise (ECN) to calculate the Pitting Factor.

How does the technology work?

- No excitation is applied to the electrodes. The electrodes are at rest.
- SmartCET 'listens' for current noise between the working and counter electrodes.
    1. For general corrosion
        - Zero net current flow occurs between the working and counter electrodes.
        - The current signal can be represented by a normal bell curve distribution



    2. For localized corrosion
        - The electrodes exhibit a net current fluctuation
        - Current distribution will deviate from a standard bell curve.
        - Standard deviation (e.g. noise is present) of the signal will increase.
- Of interest is the amplitude of the signal. The generation of current is due to the material naturally corroding in the environment. If the ECN current measurement is the same as the current measured from LPR (100%) then the Pitting Factor equals 1 and pitting corrosion is present. If the ratio is 1% then the Pitting Factor is 0.001 and all corrosion present is due to general corrosion and not pitting.
- Final note, the probe electrodes are electrically isolated from the pipe and, hence, the measurement is unaffected by pipe noise. The noise detected is only related to the corrosion on the probe electrodes.

A useful analogy to explain the difference between general corrosion and localized corrosion (Pitting Factor) is that of a flashlight with its beam constantly ON (general corrosion) and one that is flickering (localized corrosion).

The interpretation of various Pitting Factor values is shown in Table 9-3.

Table 9-3 Pitting Factor Values

PF Value	Comments
0.1 or higher	Pitting/localized corrosion – initiation (Note: check corrosion rate value; if very low, PF could be misleading).
0.01 to 0.1	Intermediate level; general corrosion but check PF does not increase above 0.1.

0.01 or lower	General corrosion.

9.5 The Corrosion Mechanism Indicator

The metallic corroding interface is complex and dynamic. The general corrosion rate, the B value, and the Pitting Factor all help to characterize the *Faradaic* corrosion processes (current flow that is the result of electrochemical process) quite thoroughly. However, in order to be more complete in the analysis of the electrochemical response there is at least one more factor which needs to be taken into account.

During the measurement of the low frequency impedance, a *reactive*, phase shifted component of the current response may be detected. This is a consequence of the physical nature of the metal/environment (electrolyte) interface, and may reflect *mechanistic properties* such as the presence of films, film formation and surface adsorption processes.

The values obtained are likely to be characteristic of a particular system being studied. For example sulfide filming may cause the reactance to become more positive, whereas adsorption processes may cause the values to go negative. The absolute values obtained may provide the corrosion expert with extra knowledge regarding the corrosion behavior of any particular system.

Understanding CMI values

The CMI is a qualitative indicator of whether a surface film is present or not. If there is no film and only corrosion is present, the CMI will have an intermediate value. Inorganic scale, or thick passive oxide films with little or no conductivity, will show a low CMI value.

Analysis of the Corrosion Mechanism Indicator is shown in Table 9-4.

Table 9-4 CMI Values

CMI Value $\mu A/cm^2$	Comments
> 0.2	Possible redox film, e.g. sulfide
0.02-0.2	Freely corroding system
0-0.02	Passive material, e.g. Al, Zr, Ti
Negative	Adsorption processes, e.g. some corrosion inhibitors

CMI does not provide information on film thickness; however, it can be used to measure changes, for example, decreasing values may indicate that more filming or scaling is occurring.

The Corrosion Mechanism Indicator provides the most useful analysis when coupled with other corrosion information and/or process data. It is the combination of process data that provides a more complete view into the corrosion mechanism being measured.

Sales and Service

For application assistance, current specifications, pricing, or name of the nearest Authorized Distributor, contact one of the offices below.

ARGENTINA
HONEYWELL S.A.I.C.
BELGRANO 1156
BUENOS AIRES
ARGENTINA
Tel. : 54 1 383 9290

ASIA PACIFIC
HONEYWELL ASIA PACIFIC Inc.
Room 3213-3225
Sun Kung Kai Centre
N° 30 Harbour Road
WANCHAI
HONG KONG
Tel. : 852 829 82 98

AUSTRALIA
HONEYWELL LIMITED
5 Thomas Holt Drive
North Ryde Sydney
NSW AUSTRALIA 2113
Tel. : 61 2 353 7000
AUSTRIA

HONEYWELL AUSTRIA
G.m.b.H.
Handelskai 388
A1020 VIENNA
AUSTRIA
Tel. : 43 1 727 800

BELGIUM
HONEYWELL S.A.
3 Avenue de Bourget
B-1140 BRUSSELS
BELGIUM
Tel. : 32 2 728 27 11

BRAZIL
HONEYWELL DO BRAZIL
AND CIA
Rua Jose Alves Da Chunha
Lima 172
BUTANTA
05360.050 SAO PAULO SP
BRAZIL
Tel. : 55 11 819 3755

BULGARIA
HONEYWELL EOOD
14, Iskarsko Chausse
POB 79
BG- 1592 Sofia
BULGARIA
Tel : 359-791512/ 794027/ 792198

CANADA
HONEYWELL LIMITED
THE HONEYWELL CENTRE
300 Yorkland Blvd.
NORTH YORK, ONTARIO
M2J 1S1
CANADA
Tel.: 800 461 0013
Fax:: 416 502 5001

CZECH
REPUBLIC
HONEYWELL, Spol.s.r.o.
Budejovicka 1
140 21 Prague 4
Czech Republic
Tel. : 42 2 6112 3434

DENMARK
HONEYWELL A/S
Automatikvej 1
DK 2860 Soeborg
DENMARK
Tel. : 45 39 55 56 58

FINLAND
HONEYWELL OY
Ruukintie 8
FIN-02320 ESPOO 32
FINLAND
Tel. : 358 0 3480101

FRANCE
HONEYWELL S.A.
Bâtiment « le Mercury »
Parc Technologique de St Aubin
Route de l'Orme
(CD 128)
91190 SAINT-AUBIN
FRANCE
Tel. from France:
01 60 19 80 00
From other countries:
33 1 60 19 80 00

GERMANY
HONEYWELL AG
Kaiserleistrasse 39
D-63067 OFFENBACH
GERMANY
Tel. : 49 69 80 64444

HUNGARY
HONEYWELL Kft
Gogol u 13
H-1133 BUDAPEST
HUNGARY
Tel. : 36 1 451 43 00

ICELAND
HONEYWELL
Hataekni .hf
Armuli 26
PO Box 8336
128 reykjavik
Iceland
Tel : 354 588 5000

ITALY
HONEYWELL S.p.A.
Via P. Gobetti, 2/b
20063 Cernusco Sul Naviglio
ITALY
Tel. : 39 02 92146 1

MEXICO
HONEYWELL S.A. DE CV
AV. CONSTITUYENTES 900
COL. LOMAS ALTAS
11950 MEXICO CITY
MEXICO
Tel : 52 5 259 1966

THE NETHERLANDS
HONEYWELL BV
Laaderhoogtweg 18
1101 EA AMSTERDAM ZO
THE NETHERLANDS
Tel : 31 20 56 56 911

NORWAY
HONEYWELL A/S
Askerveien 61
PO Box 263
N-1371 ASKER
NORWAY
Tel. : 47 66 76 20 00

POLAND
HONEYWELL Sp.z.o.o
Ul Domainewksa 41
02-672 WARSAW
POLAND
Tel. : 48 22 606 09 00

PORTUGAL
HONEYWELL
PORTUGAL LDA
Edificio Suecia II
Av. do Forte nr 3 - Piso 3
2795 CARNAXIDE
PORTUGAL
Tel. : 351 1 424 50 00

REPUBLIC OF IRELAND
HONEYWELL
Unit 1
Robinhood Business Park
Robinhood Road
DUBLIN 22
Republic of Ireland
Tel. : 353 1 4565944

REPUBLIC OF SINGAPORE
HONEYWELL PTE LTD
BLOCK 750E CHAI CHEE ROAD
06-01 CHAI CHEE IND. PARK
1646 SINGAPORE
REP. OF SINGAPORE
Tel. : 65 2490 100

REPUBLIC OF SOUTH AFRICA
HONEYWELL
Southern Africa
PO BOX 138
Milnerton 7435
REPUBLIC OF SOUTH AFRICA
Tel. : 27 11 805 12 01

ROMANIA
HONEYWELL Office
Bucharest
147 Aurel Vlaicu Str., Sc.Z.,
Apt 61/62
R-72921 Bucharest
ROMANIA
Tel : 40-1 211 00 76/ 211 79

RUSSIA
HONEYWELL INC
4 th Floor Administrative
Builiding of AO "Luzhniki" Management
24 Luzhniki
119048 Moscow
RUSSIA
Tel : 7 095 796 98 00/01

SLOVAKIA
HONEYWELL Ltd
Mlynske nivy 73
PO Box 75
820 07 BRATISLAVA 27
SLOVAKIA
Tel. : 421 7 52 47 400/ 425

SPAIN
HONEYWELL S.A
Factory
Josefa Valcarcel, 24
28027 MADRID
SPAIN
Tel. : 34 91 31 3 61 00

SWEDEN
HONEYWELL A.B.
S-127 86 Skarholmen
STOCKHOLM
SWEDEN
Tel. : 46 8 775 55 00

SWITZERLAND
HONEYWELL A.G.
Hertistrasse 2
8304 WALLISELLEN
SWITZERLAND
Tel. : 41 1 831 02 71

TURKEY
HONEYWELL
Otomasyon ve Kontrol
Sistemlen San ve Tic A.S.
(Honeywell Turkey A.S.)
Emirhan Cad No 144
Barbaros Plaza C. Blok
Kat 18
Dikilitas 80700 Istanbul
TURKEY
Tel : 90-212 258 18 30

UNITED KINGDOM
HONEYWELL
Unit 1,2 &4 Zodiac House
Calleva Park
Aldermaston
Berkshire RG7 8HW
UNITED KINGDOM
Tel : 44 118 906 2600

U.S.A.
HONEYWELL INC.
INDUSTRIAL PROCESS CONTROLS
1100 VIRGINIA DRIVE
PA 19034-3260
FT. WASHINGTON
U.S.A.
Tel. : 1-800-343-0228

VENEZUELA
HONEYWELL CA
APARTADO 61314
1060 CARACAS
VENEZUELA
Tel. : 58 2 239 0211

Honeywell

Industrial Measurement and Control
Honeywell
1100 Virginia Drive
Fort Washington, PA 19034