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Setting the Standard for Automation™

CSE PE Exam Review: Measurement I and Signals/Transmission

EN00W2 Version 1.4

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Seminar Logistics

- Seminar materials
 - Downloadable presentation
 - Question and Answer session (audio and email)
 - Survey
 - Earn 1 Professional Development Hour (PDH)
- Seminar length
 - 60 minute presentation
 - Three 10-minute question and answer sessions



Audio Instructions

- As a participant, you are in a “listen-only” mode.
- You may ask questions via the internet, using your keyboard, at any time during the presentation. However, the presenter may decide to wait to answer your question until the next Q&A Session.
- If you have audio difficulties, press *0.



Audio Instructions for Q&A Sessions

- Questions may be asked via your telephone line.
- Press the *1 key on your telephone key-pad.
- If there are no other callers on the line, the operator will announce your name and affiliation to the audience and then ask for your question.
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Introduction of Presenter



- **Gerald Wilbanks, P.E.** Vice President of Documentation and Engineering Services in Birmingham, Alabama has over 40 years of experience in engineering, management, consulting, and design in heavy industry. He is a registered professional engineer in 4 states, a member of NSPE, ASQ, and an International Former President (1995) of ISA. Gerald is a graduate of Mississippi State University with a Bachelors Degree in Electrical Engineering and was recognized as the Engineer of the Year in 1991 by the Engineering Council of Birmingham. He is a Distinguished Engineering Fellow of Mississippi State University and is a Life Fellow member of ISA. He was appointed to the Alabama Board of licensure for Professional Engineers and Land Surveyors in 2009 and has served as an instructor in many courses, seminars, and other educational sessions for ISA and in his own business.



Key Benefits of Seminar

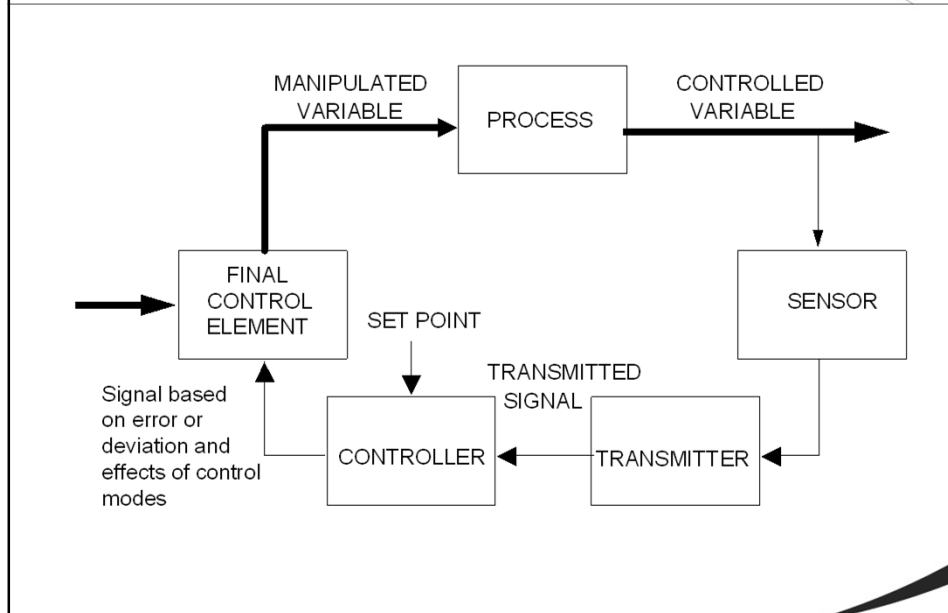
- Identify focus areas for more effective studying to assist you in passing the CS PE examination
- List transmission device terminology
- List measurement requirements and priority
- Identify Pressure applications
- Compare signal types and transmission methods
- This part of Domain I (Measurement) represents approximately 4 questions or 5% of the CS PE exam
- Domain II (Signals and Transmission) represents approximately 8 questions for 10% of the exam



Section 1: Pressure Measurement

- The CSE Professional Engineer Exam is based on the knowledge, skills and abilities in all facets of process control
- Each part of the control loop will be addressed according to the exam specification.
- Pressure is the basis for many of the process measurements.

The Process Control System (Loop)



Transmitter

A device which converts a physical process variable measurement (input) into a electronic or pneumatic output.

<u>INPUT:</u>	<u>OUTPUT:</u>
0-100 PSIG	4-20 mA DC (3-15 PSIG)
50-250 Deg. F.	4-20 mA DC (3-15 PSIG)
0-10 FT.	4-20 mA DC (3-15 PSIG)
0-200 GPM	4-20 mA DC (3-15 PSIG)



Range and Span

- **Range**
 - The region between the limits within which a quantity is measured, received, or transmitted, expressed by stating the lower and upper range values
- **LRV (lower range value)**
 - Lowest value of the measured variable that a device is adjusted to measure
- **URV (upper range value)**
 - Highest value of the measured variable that a device is adjusted to measure
- **Span**
 - Algebraic difference between the upper and lower range values



Transmitter Terminology

- Span [50 GPM, 100 Inches, 15 PSIG]
- Zero [True zero value of the process variable]
- Calibrated Range [0-50 GPM, 0-100 Inches, 0-15 PSIG]
- Output [4-20 mA DC, 3-15 PSIG, Contact Closure]
- Linearity [Equal Change in Output to Input Change]
- Hysteresis [Calibration Curve]
- Accuracy [Percent of Deviation From Absolute Value]

Suppressed and Elevated Zero Range

- Suppressed-zero range
 - A range in which the zero value of the measured variable is less than the lower-range value
 - Example : + 20 psig to 120 psig has a suppressed zero range
- Elevated zero range
 - A range in which the zero value of the measured variable, measured signal, etc., is greater than the lower range-value
 - Example: - 20 psig to 120 psig has an elevated zero range.

Performance Specifications

- Accuracy
 - $\pm 0.2\%$ of calibrated span
 - Includes combined effects of the following
- Repeatability
 - $\pm 0.05\%$ of calibrated span
- Linearity
 - $\pm 0.1\%$ of calibrated span
- Hysteresis
 - $\pm 0.05\%$ of calibrated span
- Dead band
 - None





Definition

- **Pressure is defined as the force exerted over a unit area.**
- Pressure can be determined by dividing the Force by the Area ($P = F/A$).
- **where:**
P = Pressure
F = Force
A = Area
- **A common term for pressure is pounds per square inch or psi.**
- **Hydrostatic head may also be used as inches of water for pressure units.**



Specific Gravity

Specific Gravity is a reference number that compares the weight of a specific volume of liquid to the same volume of water at 60 Deg. F, and the weight of a specific volume of gas at 60 Deg. F to the same volume of air at the same temperature.

- **Specific Gravity of Water** = 1.0 (62.4 lbs/cu. ft.)
- **Specific Gravity of Air** = 1.0 (.07649 lbs./cu. ft.)

Example:

- Density (petroleum) = 54.8 lbs/cu. ft.
Specific Gravity = $54.8/62.4 = .88$
- Density (Methane) = .04243 lbs/cu. ft.
Specific Gravity = $.04243 / .07649 = .555$



Pressure-Unit of Measurement

Units of Measurement

Two specific pressure units are used:

- pounds per square inch gauge (psig)
- pounds per square inch absolute (psia)

psig is referenced to atmospheric pressure.

- At sea level, this is 14.7 psia

psia is referenced to absolute zero.

Vacuum is measured:

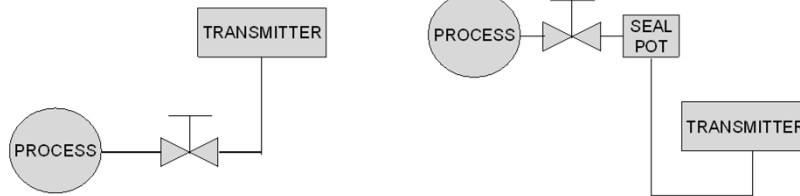
- inches of water (In H₂O)
- inches of mercury (In Hg).



Sensing Elements

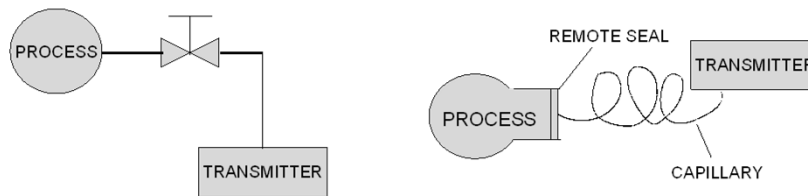
- Manometers
- Bourdon Tubes
- Pressure Helicals
- Capsule or Diaphragm
- Bellows
- Differential Pressure Bellows
- Strain Gauge
- LVDT

Installation



Instrument Above Process - Condensibles Run Back

Instrument Isolated from Process



Instrument Below Process - Downside Leg Filled

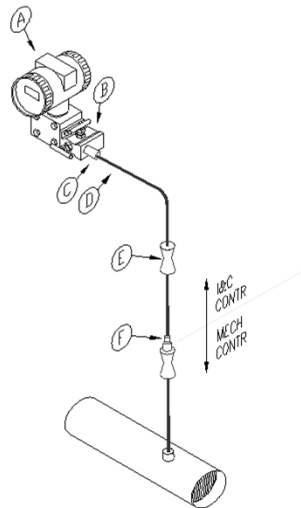
Instrument Completely Isolated from Process

Liquid or Steam Pressure

- Mount below the tap for liquid to vent gases back into the line or vessel
- For steam, this will give a liquid leg seal for the instrument.

Air or Gas Pressure

Transmitter



Mount the device above the pressure connection to allow condensibles to drain back into the line or vessel

Line or vessel – Pressure Source

Review of Key Points

- Pressure measurement can be accomplished using a variety of devices
- Conversion factors and units are the key elements in solving many measurement exam items
- The primary sensors and transmitters send the data to receivers and control systems
- Proper installation is required for accurate measurement
- Pressure is a base unit of measure for other variable measurements such as level and flow.



Live Question and Answer Session

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Section 2: Signals and Transmission

- Signals
- Transmission/Smart Transmitters
- Wiring Considerations

Signal Types

- Analog Electronic
 - 4 to 20 mA
 - 10 to 50 mA
 - 1 to 5 volts
 - -10 to + 10 volts
- Analog Pneumatic
 - 3 to 15 psig
 - 6 to 30 psig



Transmission Types

Electronic Analog

- Twisted Pair Copper Cable
- Twisted Shielded Pair Copper Cable
- Coaxial Cable
- Fiber Optic Cable
- Multi Cable Bundles
- Wireless Transmission



Wiring Considerations

- Electromagnetic Frequency Interference – Fiber Optic cable is immune from EMF pickup.
- Grounding Practices – Cables from transmitter to control room should only be grounded at one end to avoid ground loop currents.
- Physical Strength – Fiber Optic cable should not be installed with tight bends.
- Conduit and Cable Tray – Depends on type of industry and environment considerations.



Transmission Types

- Pneumatic Analog
- Copper or polyethylene tubing
- Nominal ¼ inch or smaller
- Multi Tube bundles from junction box





Installation Considerations

- Time Lag – Since the transmission medium is compressible, there will be a time lag in signal change.
- Delay Characterization – The time lag may be described as a dead time plus a first order lag.
- Limitations – Using ¼ inch tubing, 350 foot long will yield a time constant of about one second with a 1/3 second dead time.

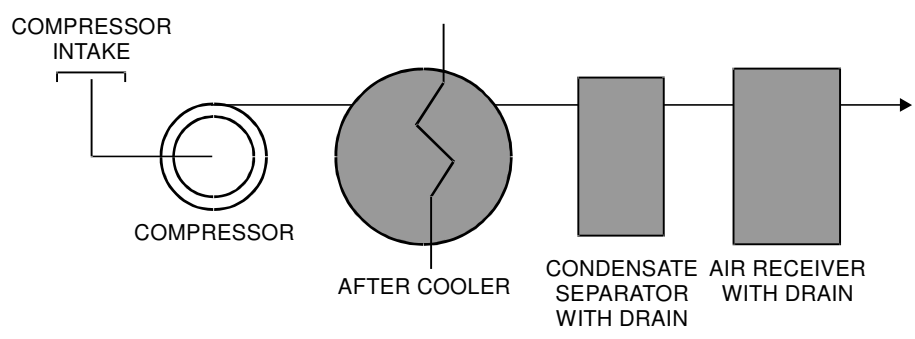


Instrument Air Quality Considerations

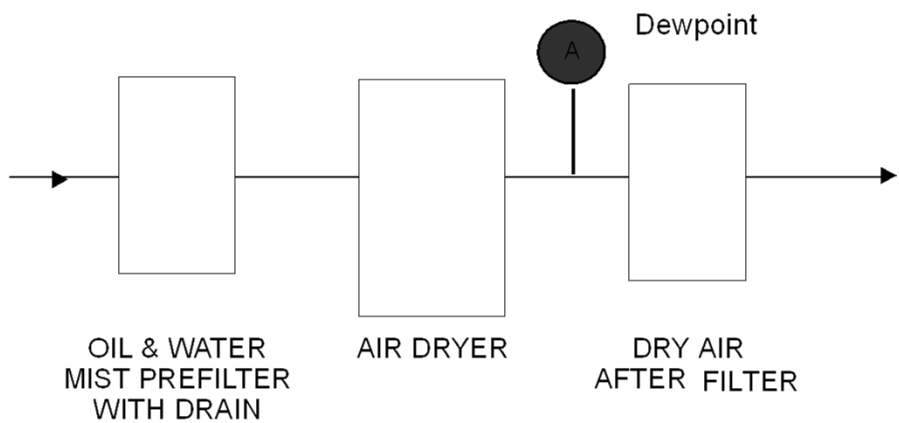
- Dew point - ANSI/ISA7.0.01-1996 establishes maximum allowable dew point (18 degrees F below minimum expected ambient temperature or 32 degrees F maximum)
- Oil content - same standard establishes maximum allowable oil content present when an oil lubrication compressor is used
 - Liquid oil - condensed oil vapor from compressor
 - Oil vapor - non-condensed oil aerosols
- Particulate matter - same standard establishes maximum particle size
- Other contaminants - chemical compounds toxic or corrosive or both
 - Air source is important



Instrument Air Supply System



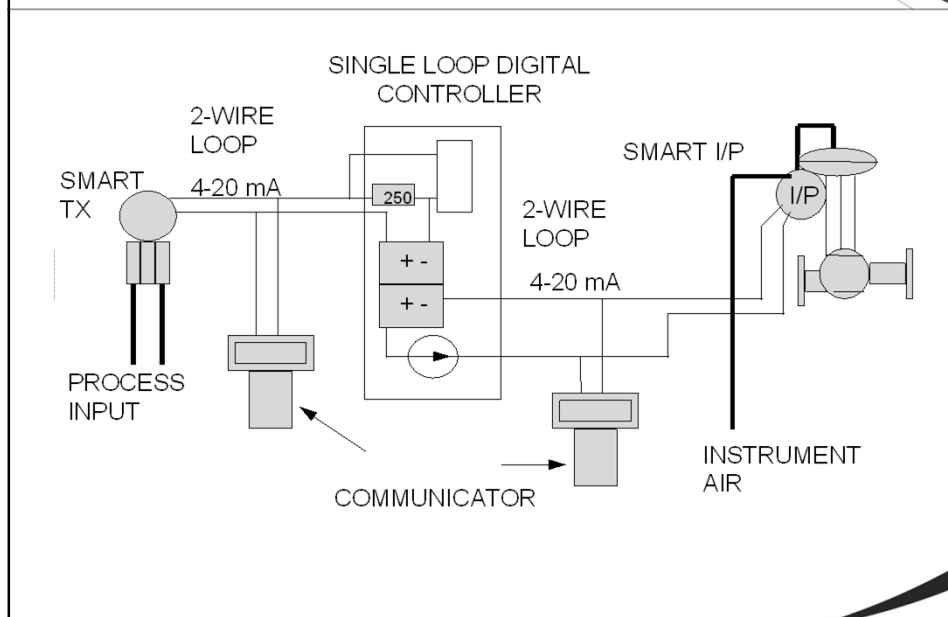
Instrument Air Quality Conditioning System



Smart Transmitters

- Current Practice
- Digitizing Signals
- Microprocessors
- Advantages
- Configuration

Smart Devices





Smart Transmitters

- Better accuracy
 - + .1% of span (smart) versus + .2% of span (analog)
- Linearity
 - No hysteresis, linearity is curve and temperature compensated (it is nice to have a microprocessor to perform a convenient algorithm)
- Better rangeability
 - 30 to 1 compared to 5 to 1
- Reliability
 - MTBF (electronics only) exceeds (typically) 50,000 Hrs



Wiring Considerations

- Fieldbus Defined
- Typical Installation
- System Architecture
- Interoperability



Field Bus

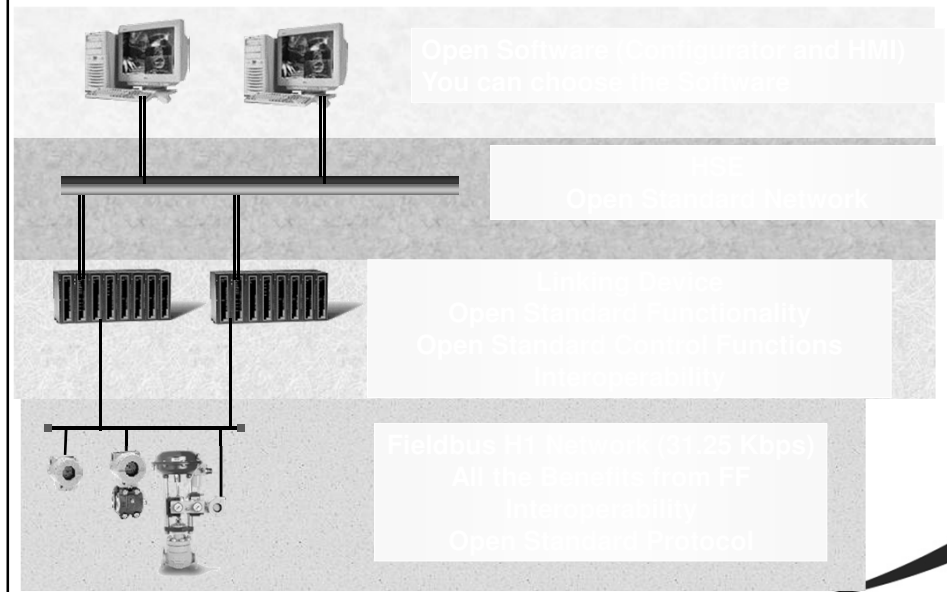
- Generic name for a data highway specifically designed for field devices
- Potential to reduce field wiring and I/O hardware costs for new installations
- Potential to move simple control functions to field devices



Field Bus Standards

- No single standard has delayed acceptance
- ISA SP50 - not yet a complete standard
- Foundation Fieldbus (FF) - USA (ISA/96)
- Profibus - Germany
- WorldFIP - France
- Some lower level standards (DeviceNet, Interbus-S, SDS, AS-I, Seriplex, etc.)
- All currently lack redundancy and speed

Foundation Fieldbus Control System



Foundation Fieldbus Standard

- Physical Layer for Devices and Components Installation
- Deterministic Digital Communication Protocol for Process Control
 - Publisher/Subscriber Model for Control Data
 - Client/Server Model for Supervision
 - Broadcast Model for Supervision and Events
- FF Function Block Language for Process Control Configuration
 - Standard Function Blocks
 - Enhanced Function Blocks
 - Manufacturer Specific Function Blocks
 - Flexible Function Blocks
- High Speed Ethernet Network for Data Exchange and Connectivity



High Speed Ethernet

- High-Speed Ethernet (HSE)
 - Based on Ethernet with IP and TCP/UDP (Protocol)
- Four basic HSE device categories:
 - Linking Device (LD)
 - Ethernet Device (ED)
 - Gateway Device (GD)
 - Host Device (HD)



Open Systems

- Originally meant very little other than connection to foreign devices
- Became a buzz word to help sell systems
- Ethernet and TCP/IP helped set standards
- Definition continues to change
- OSI Seven Layer Model helped to fuel this revolution.
- Link to Layered Communications Primer

- <http://www.semsim.com/ccna/tutorial/osi/osi.html>



Open Systems Today

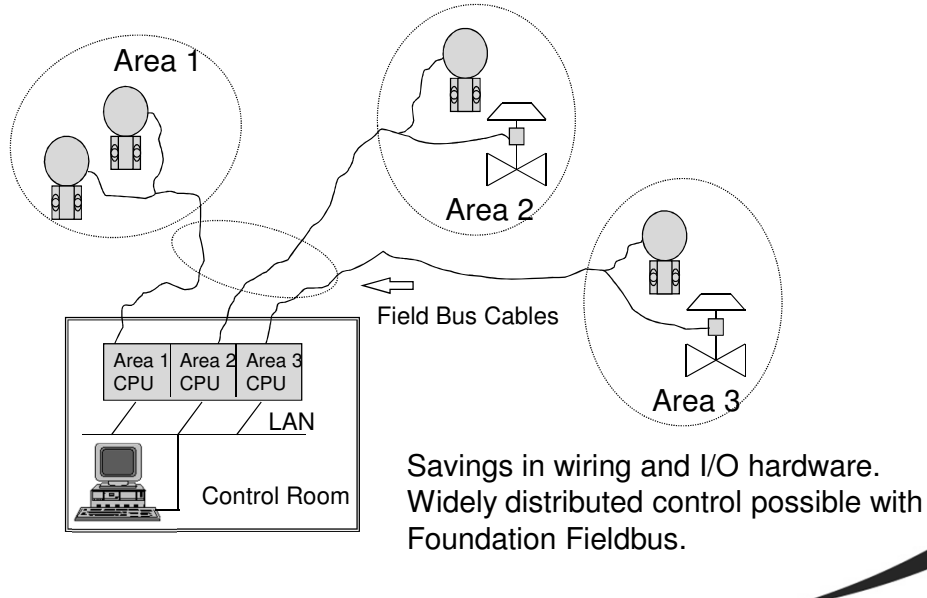
- Designed for easy interconnection of different computer systems
 - was RS-232 and Modbus
 - becoming Ethernet and TCP/IP based
 - built-in to some applications now
- One machine can serve as a bridge
- Generally used to move data



Open Systems Tomorrow

- Disconnect hardware from vendor software and services
 - can upgrade hardware at lower cost
- Web browser software able to provide view only capability to variety of DCS applications
- Field bus has the potential to radically change the shape of the DCS

Field Bus Distribution



Field Bus Today



- Products are available from multiple vendors for the most popular standards
- Begin using it on non-critical applications
- Purchase from a vendor who is committed to upgrade to ISA SP50 when that standard is finalized



Review of Key Points

- Care must be exercised in the installation and connection of the field wiring and tubing
- Instrument air supply must meet quality standards
- Fieldbus developments are changing the open systems of the past
- Smart transmitters and microprocessors have changed the current practice of device location and function



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How Many People Are at Your Site?

- Poll Slide
- Click on the appropriate number indicating the number of people that are at your site.



Sample Question - #1

- In an area of high electromagnetic disturbances, the computer data transmission medium with the least noise pickup is:
 - A. Fiber Optics
 - B. Twisted pairs of copper conductors with shielding
 - C. Twisted pairs of copper conductors in conduit
 - D. Coaxial cable



Sample Question - #2

- The output from a pressure transmitter is connected to a field junction box with a twisted, shielded pair of #18 wires. The same wiring is used to connect the junction box to a termination in the control room. The shield is attached to a ground connection in the control room and tied to the transmitter shield at the junction box. The shield at the transmitter should be:
 - A. Connected to a ground at the transmitter
 - B. Pulled back and taped at the transmitter
 - C. Tied to the power cable shield
 - D. Terminated with a field ground rod



Sample Exam Question - #3

- Approximately what is the pressure, in psig, on the bottom of a 20-foot tall tank filled with a fluid that has a specific gravity of 1.5?
 - A. 8.7
 - B. 12.99
 - C. 5.32
 - D. 30.0



Sample Exam Question - #4

- Which of the following practices is important in routing optic cable?
 - A. Laying cable in trays with high-horsepower motor wiring should be avoided.
 - B. Conduit fittings that require small radius bends should be avoided.
 - C. Overhead runs on messenger wires should be limited to 75 feet.
 - D. Underground fiber optic runs must be covered with concrete.



Related Courses from ISA

- Understanding Industrial Processes, Measurement and Control (FG05)
- Industrial Pressure and Level Measurement Engineering (EI05)
- All ISA courses are available any time as on-site training
- For more information: www.isa.org/training or (919) 549-8411



Other Related Resources from ISA

- *Instrument Engineers Handbook, 3rd Edition – Process Measurement & Analysis* (Bela Liptak)
- The ISA5.1-2009 Instrumentation Symbols & Identification standard
- ISA Membership is just \$100 per year, which includes free membership in two Technical Divisions (a \$20 value) - one from each Department: Automation and Technology and Industries and Sciences.
 - For more information: <http://www.isa.org/membership/meminfo> or (919) 549-8411



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