PALO VERDE
NUCLEAR GENERATING STATION

I&C Program

Classroom Lesson

I&C Program	**Date: 4/18/2012 3:55:30 PM**
LP Number: NIA97C000204	**Rev Author: THOMAS JEFFREY DE DEA**
Title: Pressure Measurement	**Technical Review:** Reed, Daniel R(Z08106) Digitally signed by Reed, Daniel R(Z08106) DN: cn=Reed, Daniel R(Z08106) Date: 2012.04.19 10:26:25 -07'00'
Duration : 12 HOURS	
	Teaching Approval:

INITIATING DOCUMENTS

None

REQUIRED TOPICS

None

CONTENT REFERENCES

Instrument Engineer's Handbook, Liptak 1969

Instrumentation for Process Measurement and Control, Anderson 1980

NRC Bulletin No. 90-01 "Loss of Fill Oil in Transmitters Manufactured by Rosemount"

NRC Information Notice 89-42 "Failure of Rosemount Models 1153 and 1154 Transmitters"

PCR 90-13-SI-001 "Safety Injection Transmitters Experience Oscillations"

Process Instruments and Controls Handbook, Considine 1974

PVNGS Specification 13-E-ZVG-007

CRDR 2579991 'Wrong Smoke Detector was smoked by I&C

VTD-I204-00024 ITT Barton Models 764

CRAI 3315837 add barton transmitter to initial training

REVISION COMMENTS

Apr 18, 2012 Jeff De Dea changed evaluation from LPE to Written Exam 03

added content per CRAI 3315837 for barton transmitters
04

Tasks and Topics Covered

The following tasks are covered in Pressure Measurement :

Task or Topic Number*	**Task Statement**

Lesson: Pressure Measurement

PRO06	Maintain manometer
PRO05	Maintain bourdon tube
PRO19	Maintain instrument diaphragm
PRO27	Maintain pressure switch
PRO31	Maintain pressure to current converter

Total task or topics: 5

TERMINAL OBJECTIVE:

1 Given the appropriate equipment and procedures, the I&C Technician will calibrate and maintain pressure detection instrumentation. The participant will demonstrate mastery by successful completion of a written Exam with a score of 80% or better .

1.1 Describe how Radiological Safety applies to calibrating pressure instruments

1.2 Define the term "pressure"

1.3 State the three ways of developing pressure

1.4 Convert between "PSIA", "PSIG", "Inches of Water Column" and other units of pressure

1.5 Describe the theory of operation of various pressure measuring device

1.6 Describe the theory of operation of a pressure to current transmitter/converter

1.7 Calibrate a pressure to current converter

1.8 Explain why head corrections are required for pressure transmitter calibrations

This class is divided into 6 major sections. They are:

Measurement Fundamentals

Pressure

Level

Flow

Temperature

Pneumatic instruments

Flow Control Valves.

This section is on measuring pressure.

TO: 1	**Given the appropriate equipment and procedures, the I&C Technician will calibrate and maintain pressure detection instrumentation. The participant will demonstrate mastery by successful completion of a written Exam with a score of 80% or better .**

EO: 1.1 Describe how Radiological Safety applies to calibrating pressure instruments

Main Idea

Radiological Safety

Pressure instruments on contaminated systems require special precautions during isolation, calibration, restoration, maintenance or replacement.

Ensure RP knows you will be breaking into a contaminated system. Ensure you follow postings and directions from RP. Wear proper protective clothing, catch any drips in a bag with absorbents. Treat hand tools that may be contaminated as such.

Be aware whether your pressure instrument is on a contaminated system, (RC, SI, RW, GR, LR, etc) or a potentially contaminated system, or a system you expect to be clean.

Be aware that some components in the secondary system must be released by RP due to previous contaminations of the secondary from primary to secondary leaks.

Optional Methods & Activities

Expectation: Apply appropriate techniques to ensure that you:

Maintain your exposure ALARA.

Minimize the spread of contamination.

Prevent the release of radioactive material.

(Reference: 75DP Series Procedures)

Standards

When: Entering, working in and exiting an RCA; working with equipment and tools on any system which may contain radioactive material; How:

Be aware of and comply with all

requirements of your REP.

Minimize items brought into and out of the Radiological Controlled Area (RCA), e.g., common hand tools, packaging material.

Always know the expected dose rates, and read your EPD frequently.

Immediately bring radiological alarms (area and personal dosimetry) to the attention of RP.

Control contamination at the source to

prevent it from spreading.

Ensure that RP has performed appropriate surveys in your work area before proceeding. RP leads (with surveys and analysis); you follow with your work.

Monitor yourself and personal hand carried items prior to release from the RCA.

Why: Prevent unnecessary radiation exposure and contamination to personnel in the plant, external and internal; and

prevent release of radioactivity to the environment.

EO: 1.2 Define the term "pressure"

Introduction

The 'big four' measurements in instrumentation are pressure, level, flow and temperature. While temperature is the most frequent measurement taken, pressure measurement is the star measurement of instrumentation because many other process variables can be inferred from pressure measurements. These include level, flow, density, specific gravity, and the condition of pumps and valves in a system.

Pressure and force are interrelated. Force is dependent on mass, velocity and acceleration, so a basic understanding of these concepts, as well as the behavior of fluids and gasses is important to understanding pressure measurement.

Main Idea

I. Pressure Definition

A. The application of force to something, by something else in direct contact with it

B. Formula

1. **Pressure = Force per Unit Area or**

2. **P = Force / Area**

Handout page 14

PPT slides on pressure

Sample Problems:

Instructor: A 100 pound man wearing, snow shoes with a surface area of 440 in^2, exerts a pressure of .227 pounds per square inch (psi)

Students: The same 100 pound man, wearing ice skates with a surface area of 10 in^2 exerts a pressure of **<u>10 psi</u>**

EO: 1.3 State the three ways of developing pressure

Main Idea

II. Methods of Developing Pressure

A. Hydrostatically - Pressure exerted by tank contents

1. The fluid contained by the tank has **<u>weight</u>** by the virtue of the fact that the water's molecules **<u>mass</u>** is acted upon by gravity. One gallon of gasoline weighs less than one gallon of water because it has less mass per unit volume, or **<u>density</u>**

2. "Water gauge"(WG) or "Inches of Water Column"(WC) are two ways to describe pressure of water hydrostatic "head".

   a. 27.73"WC = 1 psi

   b. 1.00"wc = .0361 psi

B. Mechanically - Pressure exerted by mechanical force

1. Pascals Law: Pressure to an enclosed fluid is transmitted undiminished to every portion of the fluid and the walls of the containing vessel

C. Temperature - Energy (heat) transferred to a liquid increased the molecular motion (kinetic energy) of the molecules, and expansion occurs with a corresponding density drop.

Optional Methods & Activities:

PPT slides on hydrostatic, mechanical and thermal pressure generation

Question: Vessel 2 has more mass in it, why doesn't the water flow from vessel 2 to vessel 1?

Answer: It has been found that the fluid in a container exerts force upon the entire vessel wall at perpendicular angle. Thus we find that the pressure applied to the common channel is identical in vessel 1 and 2.

Example:

10 pounds force applied to a 2 in^2 piston, generates 5 psi in the enclosed fluid system. If this pressure is then applied to a 20 in^2 piston, it will exert 100 pounds of force.

EO: 1.4 Convert between "PSIA", "PSIG", "Inches of Water Column" and other units of pressure

Main Idea

III. Converting Units of Measure

A. The Measured Pressure can be referenced in several ways

B. PSIA to PSIG or PSIG to PSIA

To convert between PSIA and PSIG, atmospheric pressure must be know.

C. PSIG ot Inches WC or WC to PSIG

To convert between PSIG and WC, the conversion factor of 27.73 must be known.

Optional Methods & Activities:

Use PPT slides on pressure conversions

Doing mathematical conversions is a great place for self checking and possibly even peer checking if the outcome of the calculation is going to be implemented in the plant or used to interpret a calibration result.

Example: Pressurizer pressure indicates 2250 psia, you connect a 0-3000 psig gauge. What is the indication on the test gauge? **PSIA – Atmospheric Pressure = PSIG**

2250 – 14.7 = 2235.3 PSIG

Convert 3 PSIG to Inches WC

3 x 27.73 = 83.19 "WC

Work several sample problems on the board to ensure students can convert from PSIG to WC and PSIA.

Emphasize attention to detail and self checking in calculations.

EO: 1.5 Describe the theory of operation of various pressure measuring device

Main Idea

IV. Methods of Pressure Measurement	Optional Methods & Activities:
A. Manometer - measures the amount of pressure necessary to raise a column of fluid, usually water or mercury. Unit of measure inches or feet of fluid in manometer	PPT slides on manometer Example: FWPT Lube oil reservoir Vapor Pressure 1. Discuss chemical use for manometer fluid. Know hazards of chemicals, and use chemicals properly.
B. Bourdon Tube - The flattened, hollow tube deforms under pressure in a non-linear fashion, compensated for by mechanical linkages	PPT slides on bourdon tube History of Bourdon tube/Ashcroft Gauge Example: Hiese Test Gauge
C. Diaphragm - Feels the process pressure on one side, and atmospheric pressure on the other side. the resultant motion is mechanically scaled to provide an indication for the range of pressure sensed	PPT slide on diaphragms Example:HVAC Pressure switches
D. Bellows - Sensing element more sensitive than the diaphragm or bourdon tube. Process pressure is sensed inside the bellows, the bellows expands or contracts, connected by mechanical linkage to drive an indicator	PPT slides on bellows Example:Foxboro Controller 43AP
E. Strain Gauge - Measures the change in electrical resistance of a conductor that is being stretched by a applied pressure	PPT slides on strain gauge Example:Crane Load cells

EO: 1.6 Describe the theory of operation of a pressure to current transmitter/converter

Main Idea

F. Pressure to Current Transmitter	PPT slides on Rosemounts
1. Example: Rosemount transmitter	Example: Rosemount transmitter. Manufacturers tag indicates circuit board side and termination side
a. Uses the principle of the diaphragm, but performs the measurement not by mechanical means, but by using the moving surfaces as plates of a capacitor	Show cut away sections of pressure capsules from rosemounts Discuss neck joint and what to do if it is found rotated.
b. The plate moves in one direction or the other due to differential pressure	Dis-assemble a Rosemount transmitter including the circuit boards and the head from the pressure capsule
c. Diaphragms and silicone oil isolate the plates from the process	Discuss the built in 'test' diode, test terminals and why we do not use them.
d. As plate moves toward one side, capacitance increases, while on the other side it decreases	
e. Capacitance is converted into 4 to 20 ma signal	
2. Force to electrical signal conversion is done by pressure varying an inductance, capacitance or resistance	

3. This parameter is then changed to a voltage or current proportional to process pressure

4. Barton Transmitter use a proven design to provide service under normal environmental conditions and those encountered during a design base accident .

Barton transmitters use a bourdon tube or bellows to apply force to a Silicon piezo resistive strain gauge .

Rugged housing that is seal to prevent steam penetration to electrical components.

Glass to metal gland seals for electrical connections.

Radiation resistant electronic components.

EO: 1.7 Calibrate a pressure to current converter

Main Idea

Using Laboratory Practical Exercise NIA97L000111, calibrate a pressure to current converter

Observe the precautions and general conditions on the LPE

During initial instructor lab demonstration and pre job brief PPE is not required as long as there are no actual safety hazards. During training, practice and evaluations simulating work in the field, personal protective equipment and electrical protective equipment are required in designated areas of the lab. PPE may be required in non-designated areas as deemed necessary by the instructor.

All requirements of the LPE must be met to satisfy this objective.

EO: 1.8 Explain why head corrections are required for pressure transmitter calibrations

Main Idea

V. Head Corrections

A. Transmitters are usually located below the point at which the pressure is to be measured to ensure no air in the sensing lines

PPT slides on head corrections

B. The weight of the water in the sensing lines would add to the pressure at the sensing tap giving a higher indicated pressure

Discuss calcs and how head corrections have been figured in by taking actual plant measurments.

C. Head corrections are used to eliminate this inaccuracy by subtracting the pressure that results from the column of water in the sensing from the input test pressures during calibration

Discuss that in PM data the head correction has been taken into account where needed.

VI. Industry Events

Prevent Events: Use Operating Events: *Cover CRDR2579991*

A. CRDR 2579991 01/23/2003

1. Incorrect fire detector was heated

Prevent Events: Pre-job Brief, Self Check/Peer Check, Two Minute Drill – *Verify correct EQID. Stress Importance of verifying instrument number*

2. Pre Act system actuated

3. Pre Act pipes were filled, but did not spray

4. No damage to system

B. QIR 85-10

Prevent Events: Use Operating Events – *Cover QIR 85-10*

1. Shift change

2. Oncoming technician was told where the switch was

3. Technician did not verify **FULL** instrument number

Prevent Events: Pre-job Brief, Self Check/Peer Check, Two Minute Drill – *Verify correct EQID. Stress Importance of verifying instrument number*

4. Lead lifted

5. Unexpected Control Room alarm

C. NRC Info Notice 89-42, "Failure of Rosemount Models 1153 and 1154 Transmitters"

Prevent Events: Use Operating Events – *Cover NRC Info Notice 89-42*

1. Failure of five transmitters at Millstone prompts investigation

2. Failure determined by vendor to be caused by a loss of fill oil

3. Vendor initially claims problem is isolated to "suspect lots" only

4. Symptoms include slow drift, lack of response, slowed response, and noise

5. Warning issued to utilities to be alert

D. NRC Bulletin 90-01, "Loss of Fill Oil in Transmitters Manufactured by Rosemount

Prevent Events: Use Operating Events – *Cover NRC Bulletin 90-01*

1. 91 failed transmitters identified by the vendor

2. Glass-to-metal seal failure

3. Vendor encourages owners to perform STs more often

4. Vendor indicates that failures of this type could occur on any of their transmitters, not just d/p type

5. Vendor cites improved manufacturing procedures to reduce problems

6. Beware of counterfeit devices or refurbishes

7. NRC makes recommendations to utilities to:

    a. Identify 1153 and 1154 transmitters that are installed in safety related

    All transmitters from suspect lots, except 1 in Unit 3, have been replaced. None from the bad lots were installed in RPS and ESFAS

    b. Determine if they are from suspect lots

    c. Review plant calibration records to find faulty transmitters

    d. Enhance the ST program for these transmitters

E. Memo 90-055-026-GRO/jrm, "Potential Failure of Rosemount Model 1153, and 1154 Transmitters due to Loss of Sensor Fill Oil"

Prevent Events: Pre-Job Briefs, Two Minute Drills, Post Job Critiques – *Cover Memo 90-055-026*

1. Outlines that training of Operations and I&C personnel onsite must be accomplished

2. Things to look for:

    a. Zero and/or Span Shift

    b. Sluggish response

    c. 20 % change >5 seconds = sluggish

F. IIR 3-1-89-111, "Incorrect Calibration of Temporary Rosemount 1152 Transmitter"

Prevent Events: Use Work Management Process – *Ensure work scope covers all equipment affected by changes.*

1. During flow testing, a flow orifice was determined to be the wrong size

2. The orifice was eventually machined to the desired size and installed permanently

3. The transmitter calibration WO issued for work was based on the old orifice dp, hence the cal resulted in "out of tolerance" readings in the control room

4. Resultant investigation determined that the calibration data was wrong and corrections were made

5. Concerns were raised regarding the loss of work control during operation of the Shutdown Cooling System

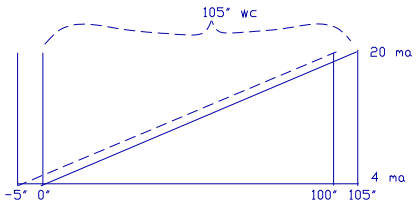
G. I&C Maintenance Report 86-02, "Short Spanning Rosemount Transmitters"

Prevent Events: Use procedures, Pre-job Briefs,- *Cal/check plant transmitters per procedures/work instructions, consult supervision when questions arise*

1. Three ways of calibrating a transmitter with a compound input range (i.e. "positive" or above atmospheric pressure on the high end, and "negative" or below atmospheric on the low end) exist:

   a. Standard Calibration: Referencing atmospheric pressure, inputting the positive pressure using a pressure source and inputting the negative pressure using a vacuum source

EXAMPLE: For a process range of -5"WC to 100"WC a transmitter would be adjusted for 20 ma out with an input pressure of 100"wc and adjusted for 4 ma out with an input pressure of -5"wc.



b. Low/High Side Calibration: By "exploiting" the differential characteristics of the instrument, adjusting the instrument for its 4 to 20 ma output for the differential inputs expected	EXAMPLE: For a process range of -5"WC to 100"WC, referencing atmospheric pressure with the low side of the instrument, a transmitter would be adjusted for 20 ma out with an input pressure of 105"wc and adjusted for 4 ma out with an input pressure of 0"wc. Following this Range adjustment, the Zero adjustment must be made. This may be done by inputting a +5"wc pressure to the low side of the transmitter (simulating a -5"wc pressure input to the high side), and adjusting for zero.
c. Short Span Calibration: By mathematically calculating the expected output of the transmitter, only calibrate a "section" of the operating range, trusting the linearity of the instrument to be adequate to maintain the output within acceptance criteria	EXAMPLE: For a process range of -5"WC to 100"WC, referencing atmospheric pressure with the low side of the instrument, a transmitter would be adjusted for 20 ma out with an input pressure of 100"wc and adjusted for 4.761 ma out with an input pressure of 0"wc.
2. Conversations with Rosemount indicate that they feel confident in the linearity of their instruments enough that short-spanning is allowed, with a limit that the transmitter be calibrated using at least 80% of its range	PVNGS work control indicates that short-spanning is performed on some PSIA instruments if the normal operating value is not in the vacuum region, i.e. pzr pressure, 0-2500 psia
H. IE Information Notice 85-100, "Rosemount Differential Pressure Transmitter Zero Point Drift"	***Prevent Events: Use Operating Events, Pre-Job Briefs –*** *Be aware of instrument limitations*
1. Rancho Seco, on 10-2-85 experienced a reactor trip, followed by a rapid cooldown that resulted in the initiation of HPI	
2. No flow conditions were indicated in the control room for one of the HPI injection lines	

3. Further operator actions resulted in recovery

4. Investigation identified shift in transmitter zero point to be the root cause of the erroneous control room readout

5. Shift occurred because the 1153 transmitter was calibrated with the system depressurized and then was brought to operating pressure

6. The zero shift can be in either direction and can be as much as 0.66 % of range for each 1000 psi of pressure change

7. Is necessary to refer to the tech manual to determine, for the transmitter in question, how much compensation must be made for the "off-normal" pressure to be encountered

I. PCR 90-13-SI-001

Prevent Events: Use Operating Events – *Cover PCR 90-13-SI-001*

1. Safety Injection Flow Transmitters had extreme oscillations

2. Changing circuit cards in transmitter to add electronic damping

J. O&MR 368, "Instrument Drift of ITT Barton Differential Pressure Switches"

Prevent Events: Use Operating Events, Pre-Job Briefs, Two Minute Drills, ***Self Check/Peer Check*** *– Cover O&MR 368*

1. Failure rate for Barton Models 288 and 289 is twice the industry average

These switches are common at PVNGS

2. Vendor recommendations include:

   a. Problems originate with switches rather than bellows

   b. Improper calibration methods and equipment cause problems

c. Failing to properly lock the microswitches after cal cause problems

d. Failing to check the device actuation following cal causes problems

SUMMARY OF MAIN PRINCIPLES

The following items are things to consider in your lesson summary. They are not mandatory. You should develop your own summary.,

Objectives Review

Review the Lesson Objectives

Topic Review

Restate the main principles or ideas covered in the lesson. Relate key points to the objectives. Use a question and answer session with the objectives.

Questions and Answers

Oral questioning

Ask questions that implement the objectives. Discuss students answers as needed to ensure the objectives are being met.

Problem Areas

Review any problem areas discovered during the oral questioning, quiz, or previous tests, if applicable. Use this opportunity to solicit final questions from the students (last chance).

Concluding Statement

If not done in the previous step, review the motivational points that apply this lesson to students needs. If applicable, end with a statement leading to the next lesson.

You may also use this opportunity to address an impending exam or practical exercise.

Should be used as a transitional function to tie the relationship of this lesson to the next lesson. Should provide a note of finality.