PALO VERDE
NUCLEAR GENERATING STATION

I&C Program

Classroom Lesson

I&C Program	**Date: 4/10/2012 4:49:50 PM**
LP Number: NIA97C000304	**Rev Author: DANIEL R. REED**
Title: Level Measurement	**Technical Review:** De Dea, Thomas J(Z31735) Digitally signed by De Dea, Thomas J(Z31735) DN: cn=De Dea, Thomas J(Z31735) Date: 2012.04.19 10:01:17 -07'00'
Duration : 14 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

Process Instruments and Controls Handbook, Considine 1974

QIR 86-12 "Operation of Magnetrol Model 402 Float Type Level Switches"

TCSAI 3100433 ADD OE23948 AND OE23984 TO NIA97 ADVANCED PROCESS Level section having to do with miscalibrated instruments due to reference leg issues

CRDR 3481882 :Heater drain transmitter back fill.

SOER 97-01 "Potential Loss of High Pressure Injection and Charging Capability from Gas Intrusion

REVISION COMMENTS

Apr 10, 2012	Dan Reed	Added content to cover SOER 97-01 "Potential Loss of High Pressure Injection and Charging Capability from Gas Intrusion.

Tasks and Topics Covered

The following tasks are covered in Level Measurement :

Task or Topic Number*	Task Statement
Lesson:	Level Measurement
PRO14	Maintain capacitance sensor
PRO12	Maintain float sensor
PRO55	Maintain ultrasonic level detector
PRO13	Maintain displacement sensor
PRO15	Maintain bubbler
PRO32	Maintain capacitance to current converter

Total task or topics: 6

TERMINAL OBJECTIVE:

1 Given the appropriate equipment and procedures, the I&C Technician will calibrate and maintain level instrumentation. Mastery will be demonstrated by successful completion of a Written Exam with a score of 80% or better.

1.1 Describe how using Self Checking applies to the calibration of level instruments

1.2 Contrast direct and inferred methods of measuring level, giving an example of each

1.3 Describe the theory of operation of a given level measuring device

1.4 Given an example of a hydrostatic head detector, calculate the transmitter calibration input pressure for a dry reference leg system using specific gravity and density corrections

1.5 Given an example of a hydrostatic head detector, calculate the transmitter calibration input pressure for a dry reference leg with zero suppression

1.6 Given an example of a hydrostatic head detector, calculate the transmitter calibration input pressure for a wet reference leg system

1.7 Check the capacitance level sensor for proper operation

1.8 Calibrate the capacitance to current transmitter

1.9 Calibrate the displacement sensor

1.10 Calibrate the bubbler tube level detector

1.11 Check a float sensor for proper operation

TO: 1 **Given the appropriate equipment and procedures, the I&C Technician will calibrate and maintain level instrumentation. Mastery will be demonstrated by successful completion of a Written Exam with a score of 80% or better.**

EO: 1.1 Describe how using Self Checking applies to the calibration of level instruments

Main Idea

Self-Checking Distinguish between critical and irreversible steps What are some critical steps when calibrating a level instrument? Verifying instrument Valving out the instrument Ensuring wet legs stay wet, dry legs stay dry Checking calibration values Restoring the instrument to service Checking that it reads as expected	**Optional Methods & Activities** **Expectation**: Review standard and expectations book with students covering self checking and at every critical step of a task. **Standards** When: Critical steps are those steps of a task that affect safety or quality of the end product. How: STAR Stop – Deliberate pause, focus attention on the task at hand. Think – Understand exactly what is to be done. Act – Perform the action. Review – Verify you get the intended results. STAR is a continuous process, which must be completed without break or interruption. Reset and start from the beginning if the process is interrupted. Why: Self-checking is used to prevent execution errors. We use this tool to ensure we are in the right unit; on the right train; on the right piece of equipment; performing the correct function; inserting data in the right place; in the right analysis; etc., to minimize the potential for making mistakes.
OE on Level	
OE23984 - 21 Steam Generator was Overfilled Due to Level Indication Inaccuracies Introduced Through Calibration Activities	**Have students read the event, then discuss.**
Discuss the following four items: 1. What happened?	**Summary:** During refueling outage activities, 21

2. Why did it happen? 3. Could it happen here? 4. What could we do to mitigate it?	Steam Generator was overfilled due to level indication inaccuracies introduced through calibration activities. This occurred due to calibration of steam generator wide range level transmitters while 21 Steam Generator was empty for secondary side inspections and inadequate response to indication anomalies.
OE23948 - Faulty Condensate Drain Tank Level Indication Resulted in a Power Reduction (Hope Creek)	**Have students read the event, then discuss.**
Discuss the following four items: 5. What happened? 6. Why did it happen? 7. Could it happen here? What could we do to mitigate it?	Summary: A condensate drain tank (CDT) level control valve responding to faulty level indication resulted in a plant power reduction.

EO: 1.2 Contrast direct and inferred methods of measuring level, giving an example of each

Main Idea

I. Direct and Inferred Methods of Level Measurement

A. Direct

1. Measurement device:

a. In direct contact with the fluid

b. Uses fluid surface as a variable

2. Fluid surface visible to be compared directly to a scale

B. Inferred

Optional Methods & Activities:

PPT on level instruments

Ask students to categorize the following level measurement devices:

Dipstick

Sightglass

float & chain

Rosemount transmitter

Bubbler tube

Capacitance level instrument (like on RCP oil reservoir level)

Ultrasonic

HJTC

Warrick conductivity level

Magnetrol robot head and R2D2 head

1. Fluid level measured by its effect on some type of device	Examples: Rosemount or other transmitters that measure level by pressure exerted by the fluid due to it's height, or bubbler tubes, or instruments that measure specific gravity or differential temperature to infer level
2. Fluid level is not actually visible	Level measurement can actually be further divided into two categories: continuous level measurement (rosemount level transmitters) and point level measurement (Heated Junction Thermocouples).

EO: 1.3 Describe the theory of operation of a given level measuring device

Main Idea

	Optional Methods & Activities:
II. Level Measuring Devices	
A. Direct	PPT series of various level measuring devices
1. Dipstick - Probe which is dipped into process fluid	
2. Sightglass - Transparent tube connected to process piping	Many places around site
3. Float / Linkage - Float connected through linkage to indicator	Examples: Main Lube Oil Storage, Diesel Lube Oil Sump
4. Magnetic Bond - Floating Magnet Exerts force on magnetic material mechanically linked to indication outside the tank	Example: Containment Sumps
B. Inferred	
1. Displacer - Based on **Archimedes Principle**: a body immersed in a fluid loses a portion of its weight equal to the weight of the fluid it displaces	Example: Magnetrol Level Switch
2. Hydrostatic Head - the weight of the water creates a pressure that can be converted using 1 psi = 27.73" Water	Many tanks including CST, RWT
3. Bubbler - Regulated air supply supplies air to vent tube at bottom of tank. By measuring pressure needed to overcome the head pressure, level can be obtained	Spray ponds
4. Differential Pressure Detector - Allows Reference to any pressure	CST, RWT, HUT
5. Capacitance - Contents of tank acts a dialectic. Probe one plate, Vessel wall other Plate	RCP oil reservoirs

6. Ultrasonic - Sound emitted; time for sound to be reflected can be interpreted for level (Can be mounted on top or bottom of tank)	Spent Fuel Pool, acid & caustic day tanks, many sumps
7. HJTC - Two TCs; one heated one not. Heat is dissipated when submerged. If uncovered the heated TC temperature increases, Delta T increases providing indication of uncovering	Example: Reactor Vessel Level Measurement System
8. Warrick Level Switch - Two conductive probes when both submerged current flows. Acts as Switch for on-off control	Spray Pond Backwash system (still installed but no longer used)
9. Delavel level switch - Magnetic float actuates Reed switches - provides 4-20 mA output	Example: Containment Sump Levels

EO: 1.4 **Given an example of a hydrostatic head detector, calculate the transmitter calibration input pressure for a dry reference leg system using specific gravity and density corrections**

Main Idea

Main Idea	Optional Methods & Activities:
III. Hydrostatic Head Detectors	
A. Factors affecting indication	PPT slide series on head correction Briefly list these factors, details to follow
1. Distance between taps	Discuss Calculations and how head correction should have already been figured in to calibration tables in PM work documents and STs.
2. Transmitter location in relation to the process	Head correction
3. Transmitter installation and capabilities (manufacturer)	Range of the transmitter
4. Specific Gravity - Ratio comparing the density of a fluid to the density of water at 68 degrees F	If your tank holds sulfuric acid, Specific Gravity would be higher than water. If it held gasoline, specific gravity would be lower.
5. Temperature - As a fluid is heated it expands and becomes less dense	Usually for open (atmospheric) tanks, no compensation for temperature is needed as water changes little in density. It stays very close to 1 over a wide range of temperatures. Steam tables can be used to find this number. This factor is more important for pressurized tanks.
B. Details	
1. Distance between taps is important as it determines limits of measurable range	Only a portion of this measurable range may be used.
2. Transmitter location relative to process important, determines possible error introduced	This error introduced may be calibrated out using the transmitter zero adjustment

3. Transmitter installation and capabilities important

Emphasize use of error reduction techniques when taking measurements and doing math. Emphasize need for self checking and possibly peer checking.

   a. Sensing line configuration may cause increasing <u>or</u> decreasing signal for increasing input

   b. Transmitter type may generate an increasing <u>or</u> decreasing signal for increasing input

Rosemount vs Barton

Illustrate these three factors using Figure III-14 thru 17 from the Student Handout pages 35-37, and PPT slide series

4. Specific Gravity - used in the calculation of the fluid's specific volume

5. Process Temperature - use ASME steam tables to determine the specific volume of the saturated liquid at the operating temperature and ratio it to specific volume of 68 degree water

Example:

H_2O at 400^oF - 53.65 lbm/ft^3

H_2O at 68^oF - 62.3 lbm/ft^3

Specific volume contains all the information you need both for density and specific gravity.

53.65/62.3 = 0.861

C. Calculations

Have students review example on Handout Figure III-18

1. Force = H x Sg x D

Work one rail road track calculation on board.

   a. H = Height of column of water

   b. Sg = Specific Gravity of the fluid

   c. D = Density Change from Temperature

EO: 1.5 Given an example of a hydrostatic head detector, calculate the transmitter calibration input pressure for a dry reference leg with zero suppression

Main Idea

D. Zero Suppression

Optional Methods & Activities:

Also known as Range Elevation. Illustrate the reason for the use of these terms using PPT slides, handout Figure III-15. Have students work example from PPT slides, handout Figure III-19

1. Compensation for a dry reference leg transmitter being located below the tank

2. When the LRV detected is greater that the measured variable, i.e. 60" of measured dp when the measured variable is at zero level it is referred to as "suppressed zero"

EO: 1.6 **Given an example of a hydrostatic head detector, calculate the transmitter calibration input pressure for a wet reference leg system**

Main Idea

E. Zero Elevation

Optional Methods & Activities:

Also known as Range Suppression. Illustrate the reason for the use of these terms using T016, handout Figure III-16. Have students work example from PPT slides, , handout Figure III-19

1. Used in wet reference legs when the full reference leg is tapped into the LP Connection

   NOTE: Rosemount Transmitters are all Connected with the variable pressure on the HP Connection

2. When the LRV detected is less than the measured variable, i.e. 0" of measured dp when the measured variable is at -96" level it is referred to as "suppressed zero"

F. During calibration, take into consideration:

1. Barton wet leg transmitters' hookup is reverse from Rosemount

   Review example in Handout, page 39

2. The capabilities of the instrument

   Review sample calculation in Handout, page 39

3. The test equipment configuration

   Review material from Appendix 3, 36MT-9ZZ03 and T020, Handout Fig III-20

   Prevent Events: Self Check/Peer Check, Two Minute Drill- Incorrect performance of Removing/Returning Transmitters from service will cause transfer of process between instrument legs.

G. Removing / Returning Transmitters from service

Refer student to Handout Appendix 3, procedure 36MT-9ZZ03. If necessary, draw on the whiteboard a transmitter configuration to illustrate the logic of the valving sequence

Removing Transmitter from service:

(Euphemistically referred to as "to H-E-L and back")

Prevent Events: Self Check/Peer Check, Two Minute Drill- *Never have H,E and L valves open at the same time.*

1. Wet Reference Leg

Emphasize self checking and peer checking as required by management expectations

   a. 'H' - Close HP isolation valve
   b. 'E' - Open equalizing valve
   c. 'L' - Close LP isolation valve

2. Remove test caps slowly to prevent spray
3. Close equalizing valve to perform calibration
4. Return to service
   a. Verify
      1) Both isolation valves shut
      2) Equalizing valve open
   b. 'L' - Open LP isolation valve
   c. 'E' - Shut Equalizing valve
   d. 'H' - Open HP isolation valve

2. Dry Reference Leg
   a. Close HP isolation valve
   b. Open equalizing valve
   c. Close LP isolation valve

3. Remove test caps slowly to prevent spray

4. Close equalizing valve to perform calibration

5. Return to service

   a. Verify

      1) Both isolation valves shut

      2) Equalizing valve open

   b. Open Reference isolation valve

   c. Shut Equalizing valve

   d. Open Process isolation valve

H. Water Bottles / Isolation Devices

1. The calibration tables are set up assuming that a dry side of a transmitter is empty and a wet side of a transmitter is full to the top of the test tap

2. Wet Reference Leg / Wet Process - use a water bottle on each test tap with an equal height of water in each bottle

3. Wet Process / Dry Reference Leg

   a. Ensure water is to the top of the test tap use an empty bottle on the process side

   b. Ensure the reference leg is dry by opening the drain on the bottom

4. Dry Reference Leg / Dry Process – ensure both sides of the transmitter are dry

IV. Industry Events

Prevent Events: Use Operating Events- *Cover QIR 86-12*

A. QIR 86-12 Magnatrol Float Switches

1. During Unit 2 Trip MSR level switches did not function properly

2. W.O.s issued to check MSR switches in Units 1 and 2

3. Approx. 50% would not function from set to reset

4. Insufficient travel to allow full actuation or reset

5. Only adjustment is switch in relation to the actuating arm/magnet beam

B. CRDR 3481882 Heater drain tank back fill

On 05/26/2010, during the performance of 40OP-9ED01 in Unit 1 to restore the "B" heater drain pump to service the Control Room Operator requested Instrumentation & Control (I&C) to fill and vent EDNFT514 flow transmitter and EDNLT532 level transmitter. In the course of communications between the Control Room, Work Control and I&C, the I&C Technician understood that both heater drain tank's transmitters needed to be filled.

The I&C technician received procedure steps from the Control Room Operator for only the "B" side transmitters, but took action to fill both "B" and "A" transmitters. When the "A" tanks transmitters were filled and vented the level in the "A" tank decreased and subsequent pump flow decreased to compensate, the resultant flow change caused a power change from 68.6 to 67.9 % and then an increase to 69.5% before stabilizing at 68.4% after flow resumed to normal. This resulted in a perturbation impact on reactivity. The I&C tech was contacted to stop, but had already completed the task

EO: 1.7 Check the capacitance level sensor for proper operation

Main Idea

Using Laboratory Practical Exercise NIA97L000211, calibrate a capacitance Level Sensor.

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 exercises 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 Calibrate the capacitance to current transmitter

Main Idea

Using Laboratory Practical Exercise NIA97L00111, calibrate a capacitance to current Rosemount transmitter and calibrate a Barton transmitter.

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: 1.9 Calibrate the displacement sensor

Main Idea

Using Laboratory Practical Exercise NIA97L000311, calibrate a displacement sensor

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: 1.10 Calibrate the bubbler tube level detector

Main Idea

Using Laboratory Practical Exercise NIA97L000411, calibrate a bubbler level instrument

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 Laboratory Practical Exercise must be met to satisfy this objective.

EO: 1.11 Check a float sensor for proper operation

Main Idea

Using Laboratory Practical Exercise NIA97L000511, calibrate a float level instrument.

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.

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.