PALO VERDE
NUCLEAR GENERATING STATION

I&C Program

Classroom Lesson

I&C Program	**Date: 2/25/2011 1:27:23 PM**
LP Number: NIA97C000403	**Rev Author: THOMAS JEFFREY DE DEA**
Title: Flow Measurement	**Technical Review:** Reed, Daniel R(Z08106) Digitally signed by Reed, Daniel R(Z08106) DN: cn=Reed, Daniel R(Z08106) Date: 2012.04.19 10:27:43 -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

Process Instruments and Controls Handbook, Considine 1974

TCS 2767928 OE18368 - Calvert Cliffs Unit 1 Automatic Trip Due to Low Steam Generator Water Level

REVISION COMMENTS

Feb 25, 2011	Jeff De Dea	changed evaluation from LPE to a Exam

Tasks and Topics Covered

The following tasks are covered in Flow Measurement :

Task or Topic Number*	**Task Statement**
Lesson:	Flow Measurement
PRO16	Maintain flow primary elements
PRO17	Maintain ultrasonic flow sensor

Total task or topics: 2

TERMINAL OBJECTIVE:

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

1.1 Describe how using pre-job briefs applies to calibration of flow instruments

1.2 Differentiate between flow rate and total flow

1.3 Describe the relationship between DP and flow across a flow restriction device

1.4 Given a percent range of DP sensed by an orifice plate, calculate the percent flow

1.5 Describe the theory of operation of a given flow measurement device

1.6 Describe the considerations for removing/restoring a rotameter from/to service

1.7 Rebuild or replace a rotameter

1.8 Set up or check an Ultrasonic Flowmeter for proper operation

1.9 Replace an Ultrasonic Flowmeter

TO: 1 **Given the appropriate equipment and procedures, the I&C Technician will calibrate and maintain flow 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 pre-job briefs applies to calibration of flow instruments

Main Idea

Using Pre-Job Briefs You will be expected to perform a pre-job brief before each lab practical evaluation. It will need to comply with the Site Standards & Expectations Handbook. It is pass/fail criteria for the evaluation.	**Expectation**: Every job begins with a pre-job brief. Every pre-job brief should end with a statement of what success looks like. For minor or simple repetitive task, a beginning of the work day, "Focus on Five" self-brief is sufficient.
	Standards When: Prior to task performance, or during turnover. How: Ensure all participants are present. Establish setting to minimize distractions. State objective and provide "big picture." Performer verbalizes what success looks like. **Focus on Five** **1. What is the task? What document describes it? Do I understand it?** Verify correct procedure and revision, or work instruction. Identify the critical steps of the task. (Steps that impact industrial, radiological, or nuclear safety. Identify Irreversible actions. **2. What is the worst thing that can happen and how can I prevent it?** Identify error-likely situations and errors at the critical steps. Consider the need to perform a formal hazard analysis. Identify the consequence to personnel or plant from errors and hazards. Identify the Prevent Events tool, PPE, or other barrier to prevent error and hazard consequence. **3. What else could go wrong?**

	Identify contingencies, abort points, and escape routes should the worst occur. Identify hazards to others or other work in the area. Identify where physical barriers, signs, other notifications to personnel are warranted. Discuss Operating Experience **4. What are the safety and/or radiation protection considerations?** Don or stage PPE based on hazards analysis, CUP, MSDS. Comply with REP, know cold areas, hot spots, dose and dose rate alarms. Gain permits needed for work and review for adequacy Consult with Leader, Safety Representative, or Radiation Protection as needed/ required **5. Is my training, and are my qualifications up to date?** Check SWMS to ensure team is qualified to perform task(s) associated with job scope. The Sensitive Issues Manual briefs certain sensitive evolutions and activities performed at Palo Verde. Consult the site manager if in doubt. Why: Provides an opportunity to orient the performer or team to the critical steps of the task and possible error/event scenarios. A well executed prejob brief identifies error-likely situations, barriers to those situations, and the roles and responsibilities of each task performer.

EO: 1.2 Differentiate between flow rate and total flow

Main Idea

Optional Methods & Activities:

PPT slide series on level

I. Flow Rate vs. Total Flow

A. Flow Rate

1. Amount of fluid that passes a given point at a **given instant**

   a. Lbm/hr

   b. Gpm

   c. Ft^3/min

2. The amount of flow past a point in a **given time period**

EO: 1.3 Describe the relationship between DP and flow across a flow restriction device

Main Idea

II. Relationship Between D/P and Flow

Optional Methods & Activities:

A. \/ % D/P = %Flow or $(\%F)^2 = \%$ D/P

1. Or in semi-normal English words, Flow is proportional to the square root of differential pressure

Mention Bernoulli and the bernolis theorem

As a fluid passes through a restriction, it accelerates, and the energy for this acceleration is obtained from the fluid's static pressure. Consequently, the line pressure drops at the point of constriction (Figure 2-1). Part of the pressure drop is recovered as the flow returns to the unrestricted pipe. The pressure differential (h) developed by the flow element is measured, and the velocity (V), the volumetric flow (Q) and the mass flow (W) can all be calculated

Pressure Drop Range 0 - 100" WC

Corresponds to 0 - 100 GPM

D/P = 25" Calculate Flowrate **50GPM**

Same Flow Loop Indicates 80 GPM Calculate D/P across orifice plate

64" WC

PPT flow slide series- Have Students Solve sample problems

Draw square root curve on white board

Discuss implications for very low flow – extremely high gain on the square root processor causing low signal to noise problems

Discuss implications of flow noise and turbulence on readings.

EO: 1.4 Given a percent range of DP sensed by an orifice plate, calculate the percent flow

Main Idea

III. Percent Range DP/Percent Flow Calculations for Orifice Plate

Optional Methods & Activities:

PPT Orifice flow calculation slide series

Give students the formula and allow them to perform calculation v%ÄP=%Flow

A. Example 1 (Solving for %Flow)

v25"/100"WC = %Flow

1. Pressure drop range: 0 to 100" WC

v.25 = %Flow

2. Flow: 0 to 100 gpm

.5 = %Flow

3. Currently read 25"WC

100gpm x .5 = **50 gpm**

B. Example 2 (Solving for ÄP)

Give students the formula and allow them to perform calculation $\%F^2$ = %ÄP

1. Same flow loop as example 1

$80/1000gpm^2$ = %ÄP

2. Indication of 80 gpm

.64 = %ÄP

100"WC x .64 = .64"WC

C. Methods of using measured ÄP signals

1. Indicator with a square root scale
2. Detector that can extract the square root
3. Pneumatic or electronic square root extractor

EO: 1.5 Describe the theory of operation of a given flow measurement device

Main Idea

Main Idea	Optional Methods & Activities:
IV. Theory of Operation	
A. Orifice Plate	PPT Flow slide series
1. Develops a high D/P	Inexpensive
2. Good Flow Measurement	
3. High permanent pressure drop = 60 to 80 % of D/P	
B. Venturi Tube	Example: Auxiliary Feedwater System
1. Develops less D/P	An American engineer, Clemens Herschel, invented the venturi tube and named it in honor of Giovanni Venturi.. Point out the vena contracta Possibly use website http://home.earthlink.net/~mmc1919/venturi.html which is a bernouli principle demonstrator on the web
2. Lower permanent pressure drop 25% of the D/P	Expensive
C. Flow Nozzle	Example: Steam Generator Secondary Outlet
1. Usually Steam Applications	Good for high velocity gasses
2. Inexpensive	Cost less than venture
3. Permanent Pressure Drop of 60 to 80% of D/P	
D. Elbow Taps	Example:Condensate Mini Flow Recirc
1. High Pressure on outside	
2. Low Pressure on Inside	
3. Small D/P not very Accurate	

4. Uses existing piping

E. Pitot Tube — Example: Circ water Piping

1. Impact opening faces upstream — invented by Henri Pitot in 1732 to measure the flowing velocity of fluids. Basically a differential pressure (d/p) flowmeter, a pitot tube measures two pressures: the static and the total impact pressure.

2. Static opening at 90^{o} Measures only static pressure

3. Error Prone from laminar flow, Eliminated by use of Annubar (Multiple Pitot)

F. Target Flow Sensor — Example:Air Flow Switches in HVAC

1. Flow causes deflection

2. Used as an actuator for a switch

G. Magnetic Flow Meter — Acid & Caustic system in secondary chemistry

1. Principle of **Faraday's Law of Induction:**Conductor moving through a magnetic field at right angles an electrical potential is developed — Use lab example if possible

2. Fluid acts as conductor

3. EMF changes as flow changes

H. Nutating Disc — Example: water meter in front of your home, gas pump flow meter

1. Flow causes disc to rotate

2. Mechanically connected to counting device

I. Ultrasonic Flowmeter — Example:**Controlotron -** clamp-on device - one application: Safety Injection

1. Principle: Sound travels through a given medium at rest at a constant rate

2. Sound transmitted through moving fluid travels at rate of speed of static fluid plus rate of fluid

3. Constants are programmed in for:

    a. Fluid

    b. Pipe material

2. Pipe thickness

Cover Operating Event OE18368 on loss of control of test leads at Calvert Cliffs

Read event in handout at the end of the ‘Flow’ section and discuss it:

Discuss:

What happened?

Could it happen here? Why or why not?

If it did happen, what can we do to mitigate it?

EO: 1.6 Describe the considerations for removing/restoring a rotameter from/to service

Main Idea

Rotameter

Optional Methods & Activities:

Prevent Events, Hazard Assessment: Pre-job Brief, Two Minute Drill *– Some Processes may be a hazardous, Example: H_2 Analyzers – you could open a hole into containment if not careful*

1. Flow Lifts Slug

Discuss rotameter clogging and how FME issues can impact rotameter operation

2. Considerations for Replacing a Rotameter

   a. Isolate

   b. Drain

   c. Verify part

   d. Install, verifying seal

   e. Unisolate slowly, prevent slamming float

   f. Check for leaks

Several shapes of float are available for various applications. One early design had slots, which caused the float to spin for stabilizing and centering purposes. Because this float rotated, the term rotameter was coined.

EO: 1.7 Rebuild or replace a rotameter

Main Idea

Using Laboratory Practical Exercise NIA97L000711, rebuild a rotameter

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 Set up or check an Ultrasonic Flowmeter for proper operation

Main Idea

Using Laboratory Practical Exercise NIA97L000811, set up and check an ultrasonic flowmeter for proper operation

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 Replace an Ultrasonic Flowmeter

Main Idea

Using Laboratory Practical Evaluation NIA97L000811, Install an ultrasonic flowmeter

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.