PALO VERDE
NUCLEAR GENERATING STATION

I&C Program

Classroom Lesson

I&C Program	**Date: 2/25/2011 1:42:48 PM**
LP Number: NIA97C000503	**Rev Author: DANIEL R. REED**
Title: Temperature 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 09:32:26 -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

OE15762 - Mercury Spill When Technician Cuts Ametek ICO7N Controller Capillary Tube

Plant Mod 2807626 substitute hot leg temperature input to CPC-B

TCS 2809286 temporary mod hot leg temperature input to CPC B

REVISION COMMENTS

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

Tasks and Topics Covered

The following tasks are covered in Temperature Measurement :

Task or Topic Number*	**Task Statement**

Lesson: Temperature Measurement

PRO02	Maintain RTD
PRO01	Maintain thermocouple
PRO04	Maintain volatile fluid sensor
PRO30	Maintain temperature switch
PRO29	Maintain temperature to pressure converter
PRO28	Maintain temperature 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 temperature instruments. Mastery will be demonstrated by successful completion of a Written Exam with a score of 80% or better.

1.1 Describe how Peer Checking applies to calibration and work on temperature instruments

1.2 Describe the theory of operation of Filled System Thermometers

1.3 Describe the theory of operation of a thermocouple

1.4 Draw a diagram of a three wire RTD bridge circuit and explain it's operation

1.5 Check a Volatile Fluid sensor for proper operation

1.6 Given thermocouple tables or graphs, a millivolt meter, and a thermometer, determine the temperature of the measuring junction of a thermocouple within two degrees

1.7 Given a known Resistance Temperature Detector (RTD), it's type and it's temperature coefficient of resistance, calculate the RTD resistance for a given temperature, then verify the results in the lab setting

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

EO: 1.1 Describe how Peer Checking applies to calibration and work on temperature instruments

Main Idea

Peer-Checking

Irreversible steps when working on temperature instruments may include:

Identifying instrument by DCID

Determinating the instrument

Removing an RTD or thermocouple, either in a hotwell or without a hotwell

Reterminating the instrument

Calibrations at the process racks

What are the elements of a peer check?

2 people

2 sets of eyeballs

Performed prior to the action

At least one communication event, and probably more than one communication events wherein both parties agree to the action before it takes place.

Optional Methods & Activities:

Expectation: Peer-checking will be used when performing steps or actions that are irreversible. The peer checker must always assume the performer is about to make a mistake.

Standards

When: An irreversible step is one that when performed incorrectly causes an immediate impact to nuclear, industrial or radiological safety.

How:

Have another knowledgeable individual check task or action for proper performance PRIOR to the action.

State intended action.

Prior to action peer-checker verifies action, understand reason and state agreement prior to taking action.

Proceed with the action.

Why: Peer-checking is a collaborative method of preventing inappropriate actions. Effective peer checking detects the errors of others and prevents the incorrect execution of irreversible steps.

EO: 1.2 Describe the theory of operation of Filled System Thermometers

Main Idea

I. Temperature

Optional Methods & Activities:

Page 56 in Handout. Illustrate the various differences in the scales. Reaumur Scale is archaic but is most likely to be seen in the brewing or liquor industries

A. Temperature is a measure of average kinetic energy of atom in a substance

PPT slide series Temperature monitoring

B. Temperature measurement

1. Process of determining temperature of object

2. Referenced to prescribed standards or units of measure

C. Temperature scales

1. Fahrenheit

a. Most common in US

b. based on 32 degree (freezing water) and 180 divisions to boiling water

c. Arbitrary points chosen

2. Celsius (Centigrade)

a. Common in Europe (metric system)

b. Freezing water = 0 and boiling = 100

3. Rankine

a. Uses scale of Fahrenheit

b. Sets absolute zero at zero degrees

4. Kelvin
    a. Similar to Rankine but uses Celsius scale
    b. Sets absolute zero as zero degrees

II. Filled System temperature sensors

A. Operating Principles

Mention mercury thermometers and how toxic mercury is. Discuss where we may have mercury thermometers on site: Met lab, chem. Labs, etc.

1. Sensor consists of a sealed bulb/capillary tubing
2. System is filled with a fluid which can be either:
    a. Liquid
    b. Gas
    c. Liquid and vapor
3. The fill fluid expands as its temperature increases
4. Expanding fluid raises pressure in the system
5. Change in pressure is sensed and is converted to a motion or visual output
6. Motion is used to operate an indicator, recorder, controller, etc.
7. System is completely sealed and any damage to the bulb, capillary tube, or bourdon will render the system inoperable or inaccurate
    a. Ensure tube is not kinked
    b. Avoid over-ranging system

B. Liquid in Glass Thermometer

Discuss what chemicals may be inside thermometers: Alcohol, mercury,

1. Simplest

2. Works on liquid volumetric expansion

3. Scale

   a. Determined by

      1) Boiling point of material

      2) Freezing point of material

   b. Limited by ability of glass to withstand temperature

4. Fill

   Draw example on board. May not be necessary based on experience level of class.

   a. Mercury - -38F to 1110 F

   Prevent Events, Hazard Assessment: Two Minute Drill – *Mercury is a toxic substance and an environmental hazard,*

   b. Organic liquids (alcohol) to -328 F

C. Filled System Thermometers

Prevent Events, Hazard Assessment,- *Some filled systems use toxic/environmentally harmful substances*

Prevent Events: Use Operating Experiences – *Cover OE15762 'Mercury spill when technician cuts Ametek Capillary'*

1. Class I (Liquid fill)

   a. Most common

   b. Operates on thermal expansion of the liquid to create pressure

   c. Usually employs a second thermal system to compensate for ambient temperatures along tube and in the case (may use a bimetallic element for case compensation)

   d. Liquids are usually inert hydrocarbons

1) Benzene

2) Ether

3) Alcohol

e. Offers: a narrow span, small sensor, uniform scales, high accuracy. Can also be used in dT measurements

2. Class II (Vapor filled)

H/O page 58

a. Sensing bulb partially filled with volatile fluid

b. Common fluids include: methylchloride, ether, butane, hexane, propane, toluene, sulfur dioxide

c. Based upon the principle that in a system containing only a liquid and its vapor, at a given temperature, a given pressure will exist in the system, regardless of system volume

Use analogy of pressure control in the primary system using the pressurizer where pressure is maintained by keeping the pressurizer at a certain temperature

d. Actual temperature measurement occurs at interface between liquid and vapor

e. May exhibit erratic operation when temperature being measured swings above and below ambient

f. Offers: good reliability, inherently accurate, non-uniform scales (non-linear)

3. Class III (Gas fill)

a. Utilizes perfect gas law

1) Absolute temperature = constant * pressure * volume

2) Volume does not remain constant, and perfect gasses do not exist

b. Helium approximates perfect gas, but tends to leak and is not often used

c. Nitrogen usually is used

d. Compensation generally not necessary if a large bulb is used

4. Class IV (Mercury filled) – not used at PVNGS

Prevent Events, Hazard Assessment: Two Minute Drill – *Mercury is a toxic substance and an environmental hazard,*

III. Bimetallic Switches

Refer to PPT slides on Bimetallic Indicator, also Handout Page 60

A. Two dissimilar metals expand at different rates

B. If fused together they will transform their expansion differential into motion

C. This motion may be used to generate a contact closure

1. Conventional contacts

2. Mercury switch

3. Indicator

EO: 1.3 Describe the theory of operation of a thermocouple

Main Idea

Thermocouples

A. Seebeck Effect of thermocouples - an EMF is generated in a closed circuit of two dissimilar metals when their junctions are at different temperatures.

Optional Methods & Activities:

Thermocouple PPT slide series

Demonstrate Seebeck effect by constructing a thermocouple and measuring with a fluke, the EMF generated when one junction is heated (optional) H/O page 64

B. Peltier Effect

Also show Peltier effect using the PPT slides

1. When a current is passed across a junction between two different metals a production or absorption of heat takes place

Build a thermocouple in class and demonstrate it using a volt meter

a. In direction of emf heat absorbed

b. In opposite direction of emf heat released

C. Thermocouple junctions

1. Measuring junction - A thermocouple consists of two dissimilar metals, such as chromel and alumel wires. The wires are fastened together at one end to form a <u>measuring junction</u> or <u>hot junction</u>

2. Reference junction - The free ends of the two wires are connected to the measuring instrument to form a closed path in which current can flow. The <u>point</u> where the <u>thermocouple wire</u> connects to the measuring instrument is designated as the <u>reference junction</u> or <u>cold junction</u>

D. Operation of a thermocouple circuit

1. The EMF of a thermocouple increases as the difference in junction temperatures increase (such as the measuring junction warming, while the reference junction remains the same)

2. If the measuring and reference junctions are at the same temperature, then the thermocouple EMF equals zero

3. If the measuring junction becomes warmer than the reference junction, then a positive EMF is measured at the reference junction

4. If the measuring junction becomes cooler than the reference junction, then a negative EMF is measured at the reference junction

E. Law of Intermediate Metals - the introduction of an intermediate metal into a thermocouple circuit will have no effect on the EMFs of the circuit, provided both junctions are at the same temperature

F. Law of Intermediate Temperatures

1. The thermal EMF developed by any thermocouple of homogenous metals with its junctions of any two temperatures is the algebraic sum of the EMFs

2. Different types of thermocouples available

3. Prominent at PVNGS is type K

4. Types can be identified by color of TC wire

G. Polarity of thermocouple wire - all thermocouple leads have a red lead which is the negative lead

H. Measuring thermocouple temperature

1. Thermocouple tables

Handout page 66 - refer students to tables section of handout

a. For the purpose of simplifying the temperature/EMF curve tables for thermocouples, a reference junction temperature of 32°F is assumed, and the millivoltages are given for the various measuring junction temperatures

b. Tables are available for the different types of TCs and of °C as well as °F

c. Important to remember that it is the difference in the EMFs for the two temperatures (reference temperature and measuring temperature)

2. Reading a thermocouple

   a. Read the millivoltage for the unknown measuring junction temperature

   b. Obtain the millivoltage for the reference junction temperature from the applicable table. (reference junction is where the TC wire goes to copper)

   c. Algebraically ADD the two millivoltages

   d. The sum may then be converted to temperature directly from the same table. This is the unknown measuring junction temperature

   e. The calculations are performed automatically whenever a thermocouple reading device is used. Usually done with a resistive temperature device

EO: 1.4 Draw a diagram of a three wire RTD bridge circuit and explain it's operation

Main Idea

Main Idea	Optional Methods & Activities:
V. Resistance temperature detectors (RTD)	
A. The resistance thermometer is based upon the inherent characteristic of metals to change resistance when they undergo a change in temperature	RTD PPT Slide series
1. RTDs have a positive temperature coefficient	Bring at least one RTD to class
2. Constructed of a pure metal such as:	Hook it to a DVM set for ohms
a. Platinum	Hold it in hand and watch the resistance value increase
b. Nickel	
c. Copper	
d. Tungsten	
3. Usually manufactured to be some multiple of 100 ohms at 0 °C.	Most here at PV are 100 ohm, but we have some 200 ohm and even 400 ohm
a. Some are multiples of 10 ohms, usually copper	
b. 0^0C (32^0F) is a standard reference point	
4. For pure metals - R/T ratio is fairly linear over a substantial range (This ratio is called alpha (α))	Draw wheatstone bridge on board and show how RTD works in the circuit
5. Determining the temperature of an RTD only requires the measurement of its resistance	Explain balancing the legs of the wheatstone bridge circuit with jumpers
B. Calculating RTD temperatures	
1. The formula for determining the temperature of an RTD is:	Handout page 68

$$\frac{R_{T2} - R_{T1}}{\alpha R_{T1}} + T_1 = T_2$$

R_{T2} = resistance @ temp T_2 (in Ω)

R_{T1} = resistance @ temp T_1 (in Ω)

α = temperature/resistance coefficient (°F^{-1} or °C^{-1})

T_2 = measurement temp (°F or °C)

T_1 = reference temp (°F or °C)

C. RTD Bridge Circuits

1. Two wire RTDs

H/O page 69

a. Used with a bridge circuit

b. Power supply taps determine which side at the bridge a resistance is on

c. Resistance of field wire is measured as part of RTD resistance,but may be "calibrated out

Give an example of 300' of field wire. Ask for estimate of resistance and how resistance might change with changes in ambient temperature

d. Resistance of field wire changes (e.g. if ambient temperature changes appreciably_), the reading of the RTD becomes erroneous

2. Three wire bridge

Draw 3 wire RTD circuit and show why the 3rd wire is needed.

a. This arrangement places one leg of the RTD field wire on each side of the bridge circuit, which cancels out the resistance of the field wire

Note position of power supply tap

D. Thermistors

Hook a thermistor to a DVM set for ohms, hold in hand and watch resistance change

1. Similar to RTDs – electrical resistance changes as temperature changes

2. Resistance to temperature relationship is negative (increase temperature, decrease resistance)

3. Less linear than RTD, but cheaper

1. Used in heat detection and compensation circuits

Much cheaper than RTDs

Operating Events

Discuss the t-mod and how it affects plant systems

Temperature element 2JRCBTE0122HB, which is the RCS Loop-2 Hot Leg temperature input to CPC-B, has failed. This temporary modification will wire in non-class 1E temperature element 2JRCNTE0121X as a substitute hot leg temperature input in order to restore CPC-B to OPERABLE status.

EO: 1.5 Check a Volatile Fluid sensor for proper operation

Main Idea

Using Laboratory Practical Exercise NIA97L000911, check a volatile fluid temperature sensor 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: 1.6 Given thermocouple tables or graphs, a millivolt meter, and a thermometer, determine the temperature of the measuring junction of a thermocouple within two degrees

Main Idea

Using Laboratory Practical Exercise NIA97L001011, determine a temperature using a thermocouple and thermocouple tables

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: 1.7 Given a known Resistance Temperature Detector (RTD), it's type and it's temperature coefficient of resistance, calculate the RTD resistance for a given temperature, then verify the results in the lab setting

Main Idea

Using Laboratory Practical Exercise NIA97L001111, determine a temperature using an RTD and a given RTD table.

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.