OALCF Tasks for the Apprenticeship Goal Path: Prepared for the Project, *Developing Best Practices for Increasing, Supporting and Retaining Apprentices in Northern Ontario (2014)*

OALCF Task Cover Sheet

Task Title: Calculating Linear Pipe Expansion

<table>
<tr><td colspan="2">Learner Name:</td></tr>
<tr><td colspan="2">Date Started: Date Completed:

Successful Completion: Yes___   No___</td></tr>
<tr><td colspan="2">Goal Path: Employment✓ Apprenticeship ✓ Secondary School____ Post Secondary✓ Independence___</td></tr>
<tr><td colspan="2">Task Description:
Understand and calculate linear pipe expansion when installing plumbing pipes.</td></tr>
<tr><td>Competency:
A: Find and Use Information
B: Communicate Ideas and Information
C: Understand and Use Numbers</td><td>Task Group(s):
A1: Read continuous text
A2: Interpret documents
B2: Write continuous text
B3: Complete and create documents
C3: Use measures</td></tr>
<tr><td colspan="2">Level Indicators:
A1.2: Read texts to locate and connect ideas and information
A2.2: Interpret simple documents to locate and connect information
B2.1: Write brief texts to convey simple ideas and factual information
B3.2a: Use layout to determine where to make entries in simple documents
C3.3: Use measures to make multi-step calculations; use specialized measuring tools</td></tr>
<tr><td colspan="2">Performance Descriptors: see chart on last page</td></tr>
<tr><td colspan="2">Materials Required:
Pen and Paper
Calculator - Scientific
Attached document - Understanding Linear Pipe Expansion
Attached document - Formula for Calculating Pipe Expansion</td></tr>
</table>

Task Title: Calculating Linear Pipe Expansion

Learner Information and Tasks

Plumbers will calculate the linear expansion of pipes when installing to ensure that the correct pipe size is used. Read the **Understanding Linear Pipe Expansion** and **Formula for Calculating Linear Pipe Expansion** documents.

Task 1: What do the following symbols mean?

a) ΔT
b) L
c) a

Task 2: a) Calculate the Coefficient of thermal expansion (a) for the following pipe material and enter it in the chart.

Material Type	Coefficient of thermal expansion (a)	(a)
ABS	73.8×10^{-6}	
Brass	18.7×10^{-6}	
CPVC	66.6×10^{-6}	
Copper	16.6×10^{-6}	
Iron	12.0×10^{-6}	
PEX 02 barrier	140×10^{-6}	
PEX-AL-PEX	24×10^{-6}	
PVC	110×10^{-6}	
Steel	13×10^{-6}	

b) Calculate the linear thermal expansion for the following linear pipe dimensions and temperature change. Use the formula for calculating pipe expansion and the coefficients you entered in the chart.

i. 5m length of ABS pipe with a 35° temperature change

ii. 25m length of PEX-02-barrier with a 45° temperature change

iii. 50m length of Steel with a 350° temperature change

c) Calculate the pipe expansion for the following types of pipes. Use this formula $\Delta L = a\ L\ \Delta T$. Refer to the document Formula for Calculating Linear Pipe Expansion and the answers you entered in the chart.

i. Iron - $\Delta T = 110°$, $L = 45m$, $(a) = ?$

ii. Copper - $\Delta T = 32°$, $L = 10m$, $(a) = ?$

iii. Brass - $\Delta T = 500°$, $L = 9m$, $(a) = ?$

Task 3: Other than pipes, list three examples of where thermal expansion can occur.

Understanding Linear Pipe Expansion

Linear expansion

When an object is heated or cooled, its length changes by an amount proportional to the original length and the change in temperature. It is the fractional change in length per degree of temperature change.

Thermal expansion

When a substance is heated, its particles begin moving more and thus usually maintain a greater average separation. The degree of expansion divided by the change in temperature is called the material's coefficient of thermal expansion and generally varies with temperature.

When water is heated it expands. For example, water heated from 90°F to a thermostat setting of 140°F in a 40 gallon hot water heater will expand by almost one-half gallon. This is because when water is heated, its density decreases and its volume expands. Since water is not compressible, the extra volume created by expansion must go someplace. During no-flow periods in a system, pressure reducing valves, backflow preventers, and other one-way valves are closed, thus eliminating a path for expanded water to flow back to the system supply. Hence, system pressure increases.

Coefficient of thermal expansion

The **coefficient of thermal expansion** describes how the size of an object changes with a change in temperature. Specifically, it measures the fractional change in size per degree change in temperature at a constant pressure. Several types of coefficients have been developed: volumetric, area, and linear.

Heat-induced expansion has to be taken into account in most areas of engineering. A few examples are:

- Metal framed windows need rubber spacers
- Rubber tires
- Metal hot water heating pipes should not be used in long straight lengths
- Large structures such as railways and bridges need expansion joints in the structures to avoid sun kink
- One of the reasons for the poor performance of cold car engines is that parts have inefficiently large spacings until the normal operating temperature is achieved.
- A gridiron pendulum uses an arrangement of different metals to maintain a more temperature stable pendulum length.
- A power line on a hot day is droopy, but on a cold day it is tight. This is because the metals expand under heat.
- Expansion joints that absorb the thermal expansion in a piping system.
- Precision engineering nearly always requires the engineer to pay attention to the thermal expansion of his product. For example when using a scanning electron microscope even small changes in temperature such as 1 degree can cause a sample to change its position relative to the focus point.

Thermometers are another application of thermal expansion — most contain a liquid (usually mercury or alcohol) which is constrained to flow in only one direction (along the tube) due to changes in volume brought about by changes in temperature.

Adapted from www.watts.com and wikipedia.com and plumbinghelp.ca

Formula for Calculating Linear Pipe Expansion

ΔT - (change in temperature) This is the difference between the initial temperature and the final temperature of the pipe

L -Initial length of the pipe

a - Coefficient of linear expansion for the material

The formula looks like this:

$\Delta L = a\, L\, \Delta T$

To use the formula, follow the steps below

10m length of copper pipe

40° change in temperature

0.000017 is the coefficient of linear expansion of copper

L = 10

a = 0.000017

$\Delta T = 40$

$\Delta L = 0.000017 \times 10 \times 40$

$\Delta L = 0.0068$m - rounded to 7mm

Calculating the Coefficient of thermal expansion (a)

Pipes are made of different material and require different calculations. Below is an example of a calculation for PET (Polyethylene terephthalate) pipe material. The required formula used in the calculation is always pre-determined through the engineering process. Always refer to specifications for each type of pipe used.

Pipe Material = Pre-determined number x 10-6

PET = 59.4 x 10-6 = 0.0000594

The coefficient of thermal expansion (a) is 0.0000594

Understanding Exponents

Positive Exponent

The positive exponent of a number indicates how many times to use the number in a multiplication.

For example: 6^3 - stated as 6 to the power of 3 or 6 to the third power or 6 cubed

Calculating the positive exponent

$6^3 = 6 \times 6 \times 6 = 216$

Negative Exponent

The negative exponent of a number indicates how many times to use the number in a division.

For example: 6^{-3} - stated as 6 to the negative power of 3 or 6 to the minus third power

Calculating the negative exponent

$6^{-3} = 1 \div 6 \div 6 \div 6 = 4.6296\text{-}03$

or $1 \div (6 \times 6 \times 6) = 1/6^3 = 1/216 = 4.6296\text{-}03$

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Task Title: Calculating Linear Pipe Expansion

Answer Key

Task 1: What do the following symbols mean?

a) ΔT : (change in temperature) This is the difference between the initial temperature and the final temperature of the pipe

b) L : -Initial length of the pipe

c) a : Coefficient of linear expansion for the material

Task 2: a) Calculate the Coefficient of thermal expansion (a) for the following pipe material and enter it in the chart.

Material Type	Coefficient of thermal expansion (a)	(a)
ABS	73.8×10^{-6}	**0.0000738**
Brass	18.7×10^{-6}	**0.0000187**
CPVC	66.6×10^{-6}	**0.0000666**
Copper	16.6×10^{-6}	**0.0000166**
Iron	12.0×10^{-6}	**0.000012**
PEX 02 barrier	140×10^{-6}	**0.000140**
PEX-AL-PEX	24×10^{-6}	**0.000024**
PVC	110×10^{-6}	**0.00011**
Steel	13×10^{-6}	**0.000013**

b) Calculate the linear thermal expansion for the following linear pipe dimensions and temperature change. Use the formula for calculating pipe expansion and the coefficients you calculated in question 2. If question 2 had errors, take those into account in the responses for this question and mark accordingly.

i. 5m length of ABS pipe with a 35° temperature change
Thermal expansion = Coefficient (a) x length of pipe x temperature change
Thermal expansion = 0.0000738 x 5 x 35
Thermal expansion = 0.012915m or 0.013m

The thermal expansion of the ABS pipe will be 0.013m

ii. 25m length of PEX-02-barrier with a 45° temperature change
Thermal expansion = Coefficient (a) x length of pipe x temperature change
Thermal expansion = 0.000140 x 25 x 45
Thermal expansion = 0.1575m or 0.16m

The thermal expansion of the PEX-02-barrier pipe will be 0.16m

iii. 50m length of Steel with a 350° temperature change
Thermal expansion = Coefficient (a) x length of pipe x temperature change
Thermal expansion = 0.000013 x 50 x 350
Thermal expansion = 0.2275m or 0.23m

The thermal expansion of the Steel pipe will be 0.23m

c) Calculate the pipe expansion for the following types of pipes. Use this formula $\Delta L = a\ L\ \Delta T$. If question 2 had errors, take those into account in the responses for this question and mark accordingly.

i. Iron - ΔT = 110°, L = 45m, (a) = ?
$\Delta L = 0.000012 \times 45 \times 110$
$\Delta L = 0.0594$

ii. Copper - ΔT = 32°, L = 10m, (a) = ?
$\Delta L = 0.0000166 \times 10 \times 32$
$\Delta L = 0.005312$

iii. Brass - ΔT = 500°, L = 9m, (a) = ?
$\Delta L = 0.0000187 \times 9 \times 500$
$\Delta L = 0.08415$

Task 3: What are three examples where thermal expansion occurs?

- **thermometers**
- **power lines**
- **railroad tracks**

There may other options

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Performance Descriptors		Needs Work	Completes task with support from practitioner	Completes task independently
A1.2	• scans text to locate information			
	• locates multiple pieces of information in simple texts			
	• makes low-level inferences			
	• makes connections between sentences and between paragraphs in a single text			
	• follows the main events of descriptive, narrative and informational texts			
A2.2	• performs limited searches using one or two search criteria			
	• extracts information from tables and forms			
	• uses layout to locate information			
	• makes connections between parts of documents			
	• makes low-level inferences			
B2.1	• writes simple texts to request, remind or inform			
	• conveys simple ideas and factual information			
B3.2a	• uses layout to determine where to make entries			
	• begins to make some inferences to decide what information is needed, where and how to enter the information			
	• follows instructions on documents			

C3.3	• calculates using numbers expressed as whole numbers, fractions, decimals, percentages and integers			
	• manages unfamiliar elements (e.g. context, content) to complete tasks			
	• makes estimates involving many factors where precision is required			
	• chooses and performs required operations; makes inferences to identify required operations			
	• selects appropriate steps to solutions from among options			
	• identifies a variety of ways to complete tasks			
	• interprets, represents and converts measures using whole numbers, decimals, percentages, ratios and fractions			
	• organizes and displays numerical information (e.g. graphs, tables)			
	• uses strategies to check accuracy (e.g. estimating, using a calculator, repeating a calculation, using the reverse operation)			

This task: was successfully completed___ needs to be tried again___

Learner Comments

______________________________ ___________________________

Instructor (print) **Learner Signature**