**OALCF Task Cover Sheet**

**Task Title:** Calculating Linear Pipe Expansion

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| **Learner Name:** | |
| **Date Started: Date Completed:**  **Successful Completion: Yes\_\_\_ No\_\_\_** | |
| **Goal Path:** Employment**✓** Apprenticeship **✓** Secondary School Post Secondary**✓** Independence\_\_\_ | |
| **Task Description:**  Understand and calculate linear pipe expansion when installing plumbing pipes. | |
| **Competency:**  A: Find and Use Information  B: Communicate Ideas and Information  C: Understand and Use Numbers | **Task Group(s):**  A1: Read continuous text  A2: Interpret documents  B2: Write continuous text  B3: Complete and create documents  C3: Use measures |
| **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 | |
| **Performance Descriptors:** see chart on last page | |
| **Materials Required:**   * Pen and Paper * Calculator - Scientific * Attached document - Understanding Linear Pipe Expansion * Attached document - Formula for Calculating Pipe Expansion | |

**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?

* + 1. ΔT
    2. L
    3. 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 x 10-6 |  |
| Brass | 18.7 x 10-6 |  |
| CPVC | 66.6 x 10-6 |  |
| Copper | 16.6 x 10-6 |  |
| Iron | 12.0 x 10-6 |  |
| PEX 02 barrier | 140 x 10-6 |  |
| PEX-AL-PEX | 24 x 10-6 |  |
| PVC | 110 x 10-6 |  |
| Steel | 13 x 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.

* + 1. 5m length of ABS pipe with a 35° temperature change
    2. 25m length of PEX-02-barrier with a 45° temperature change
    3. 50m length of Steel with a 350° temperature change

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

1. Iron - ΔT = 110°, L = 45m, (a) = ?
2. Copper - ΔT = 32°, L = 10m, (a) = ?
3. Brass - ΔT = 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](http://en.wikipedia.org/wiki/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:

ΔL = a L ΔT

**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

ΔT = 40

ΔL = 0.000017 x 10 x 40

ΔL = 0.0068m - 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: 63 - stated as 6 to the power of 3 or 6 to the third power or 6 cubed

Calculating the positive exponent

63 = 6 x 6 x 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 ÷ 6 ÷ 6 ÷ 6 = 4.6296-03

**or** 1 ÷ (6 x 6 x 6) = 1/63 = 1/216 = 4.6296-03

**Task Title:** Calculating Linear Pipe Expansion

**Answer Key**

**Task 1:** What do the following symbols mean?

* + 1. ΔT : (change in temperature) This is the difference between the initial temperature and the final temperature of the pipe
    2. L : -Initial length of the pipe
    3. 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 x 10-6 | **0.0000738** |
| Brass | 18.7 x 10-6 | **0.0000187** |
| CPVC | 66.6 x 10-6 | **0.0000666** |
| Copper | 16.6 x 10-6 | **0.0000166** |
| Iron | 12.0 x 10-6 | **0.000012** |
| PEX 02 barrier | 140 x 10-6 | **0.000140** |
| PEX-AL-PEX | 24 x 10-6 | **0.000024** |
| PVC | 110 x 10-6 | **0.00011** |
| Steel | 13 x 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.

* + 1. 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**

* + 1. 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**

* + 1. 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 ΔL = a L ΔT. If question 2 had errors, take those into account in the responses for this question and mark accordingly.

1. Iron - ΔT = 110°, L = 45m, (a) = ?

ΔL = 0.000012 x 45 x 110

**ΔL = 0.0594**

1. Copper - ΔT = 32°, L = 10m, (a) = ?

ΔL = 0.0000166 x 10 x 32

**ΔL = 0.005312**

1. Brass - ΔT = 500°, L = 9m, (a) = ?

ΔL = 0.0000187 x 9 x 500

**ΔL = 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\_\_\_

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| Learner Comments |
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#### Instructor (print) Learner Signature