Task Title: Calculating Linear Pipe Expansion

OALCF Cover Sheet – Learner Copy

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.

* Tasks 1 and 2 are complex and may require some prior knowledge of the trade to complete.

Main Competency/Task Group/Level Indicator:

- Find and Use Information/Read continuous text/A1.2
- Find and Use Information/Interpret documents/A2.2
- Communicate Ideas and Information/Write continuous text/B2.1
- Communicate Ideas and Information/Complete and create documents/B3.2a
- Understand and Use Numbers/Use measures/C3.3

Materials Required:

- Pen/pencil and paper and/or digital device
- Scientific calculator or digital device with scientific calculator functions

Learner Information

Plumbers will calculate the linear expansion of pipes when installing to ensure that the correct pipe size is used.

Read “Understanding Linear Pipe Expansion”, “Formula for Calculating Linear Pipe Expansion” and “Understanding Exponents”.

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.

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

Work Sheet

Task 1: What do the following symbols mean?

Task 1a) ∆T

Task 1b) L

Task 1c) a

Answer:

Task 2a: 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}	

Task 2b) 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.

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

Answer:

Task 2c) 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.

- **Iron - ΔT = 110°, L = 45m, (a) = ?**
- **Copper - ΔT = 32°, L = 10m, (a) = ?**
- **Brass - ΔT = 500°, L = 9m, (a) = ?**

Answer:

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

Answer: