Training Event 2020
Exercise 2 – Thermal Expansion

Linear thermal expansion

$$\Delta L = L \alpha \Delta T$$

METHOD

1. Get temperature of each layer
2. Calculate Thermal expansion of each layer (remember to convert from diameter to circumference)
3. Allow for expansion of shell
4. Decide how you might make thermal expansion allowance
   How might different methods work considering the service conditions of each example

EXAMPLE 1

Ladle for alloy steel in a foundry.
The ladle is used to contain steel for ingot casting. The working lining is fired magnesia, with a high alumina backup lining. The ladles are often allowed to cool between casts but are thoroughly preheated again.

The lining must not be allowed to move as the ladle is transported around the plant.

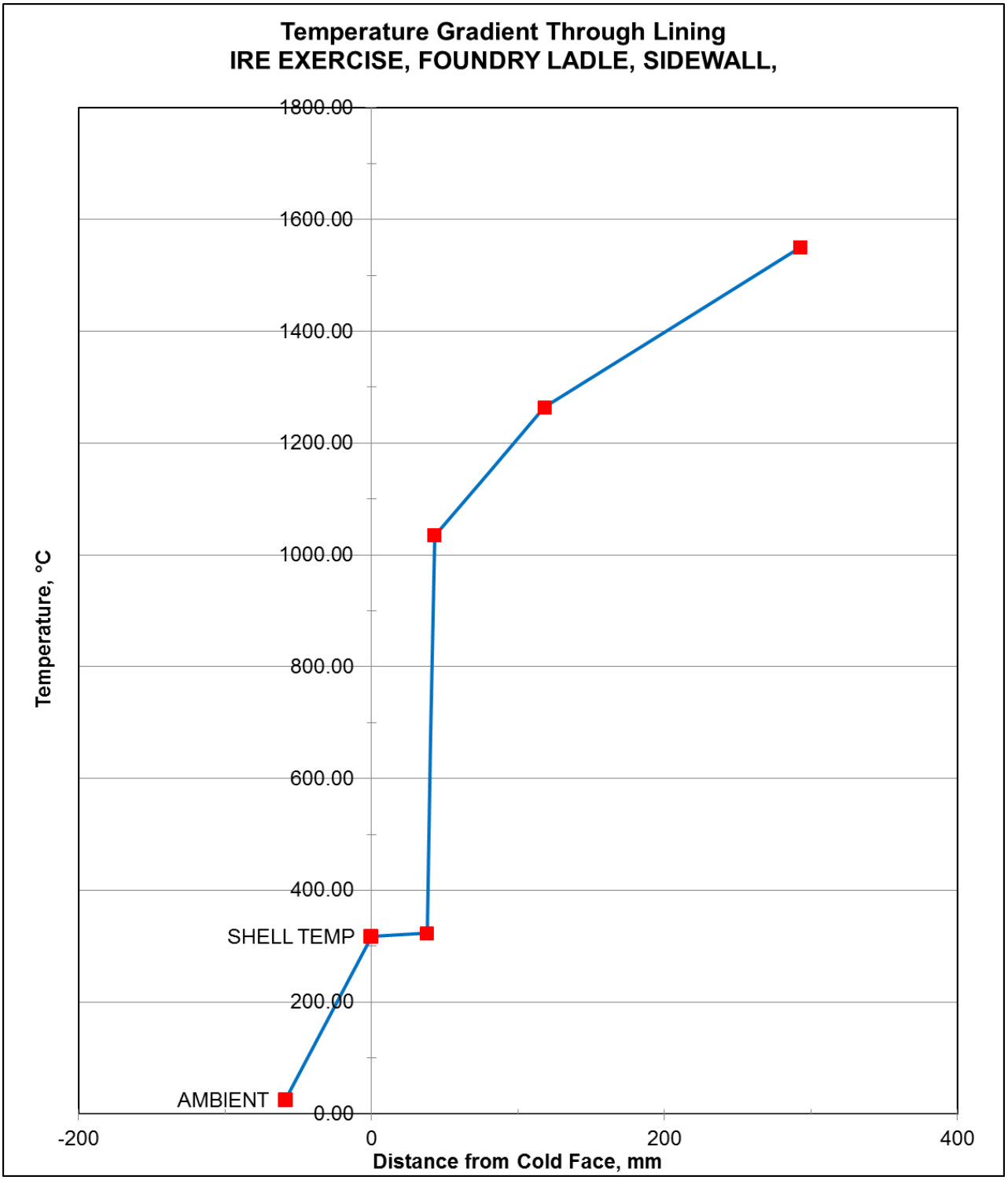
Ladle Diameter 1200mm inside new lining

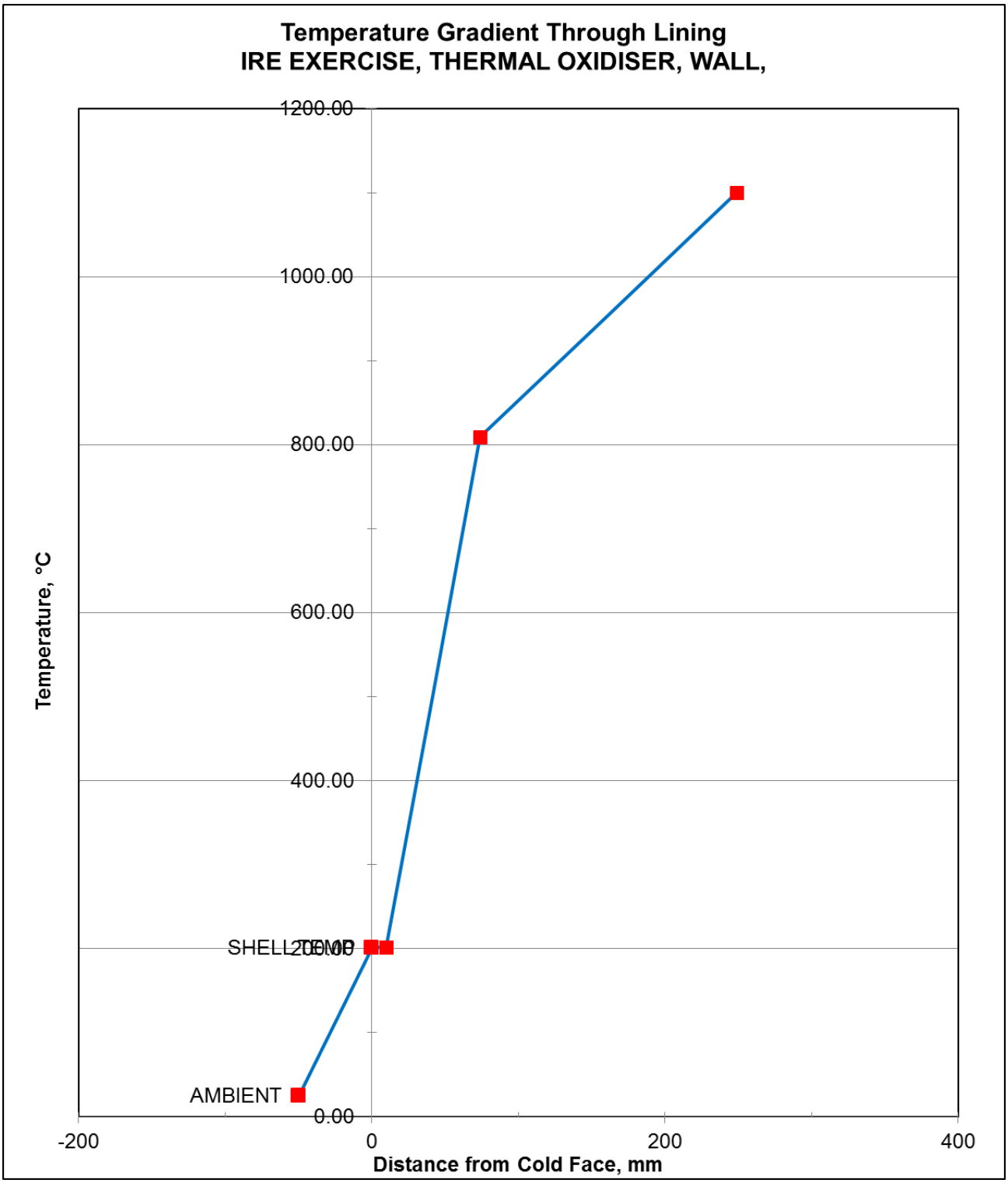
Shell – 38mm carbon steel, cte – 12×10^{-6} /°C
Insulation – 5mm high efficiency insulation panel. Do not include in expansion calculation
Safety Lining – 75mm Bauxite Brick, cte 5.2 $\times 10^{-6}$ /°C
Working Lining – 175mm Fired Magnesia Brick, cte 13 $\times 10^{-6}$ /°C

EXAMPLE 2

Thermal Oxidiser treating toxic liquid wastes
The lining is a vertical cylinder, 3.5m outside diameter and 8m tall.
It operates at 1100°C with occasional stoppages during which the lining is cooled to ambient
The combustion products include acid gases so the expansion design must not create additional insulation. Why not?

Shell – 10mm carbon steel, cte – 12×10^{-6} /°C
Insulation – 65mm Insulating Firebrick cte 5.2 $\times 10^{-6}$ /°C
Hot Face – 175mm Alumina-SiC Brick cte 4.8 $\times 10^{-6}$ /°C


Temperature Gradient Through Lining
IRE EXERCISE, FOUNDRY LADLE, SIDEWALL,
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
0.00
Temperature, °C
SHELL TEMP
AMBIENT
-200
0
200
400
Distance from Cold Face, mm


Temperature Gradient Through Lining
IRE EXERCISE, THERMAL OXIDISER, WALL,
1200.00
1000.00
800.00
600.00
400.00
0.00
AMBIENT
Temperature, °C
-200
0
200
400
Distance from Cold Face, mm