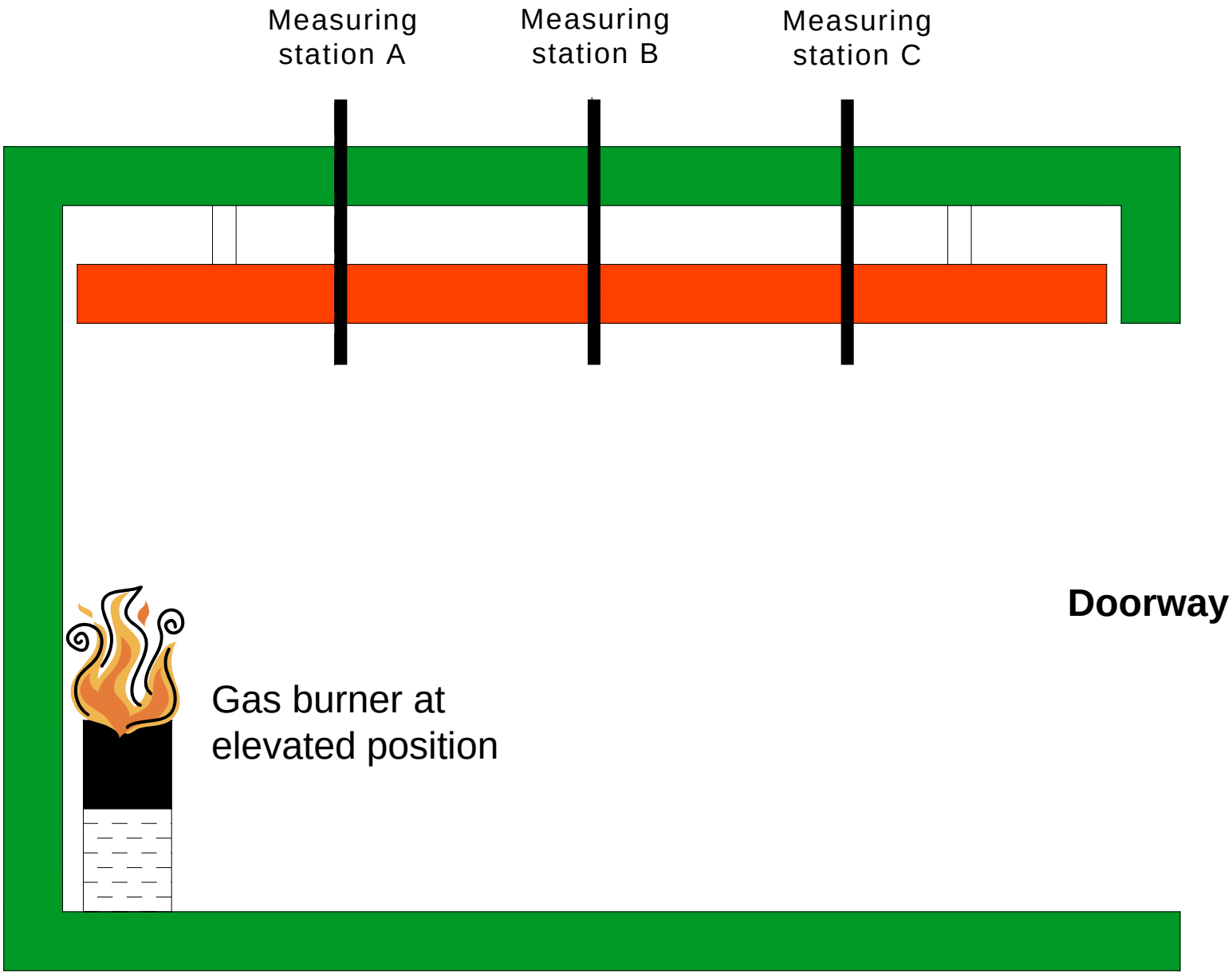
THE PLATE THERMOMETER, ADIABATIC SURFACE TEMPERATURE and SHADOW EFFECTS

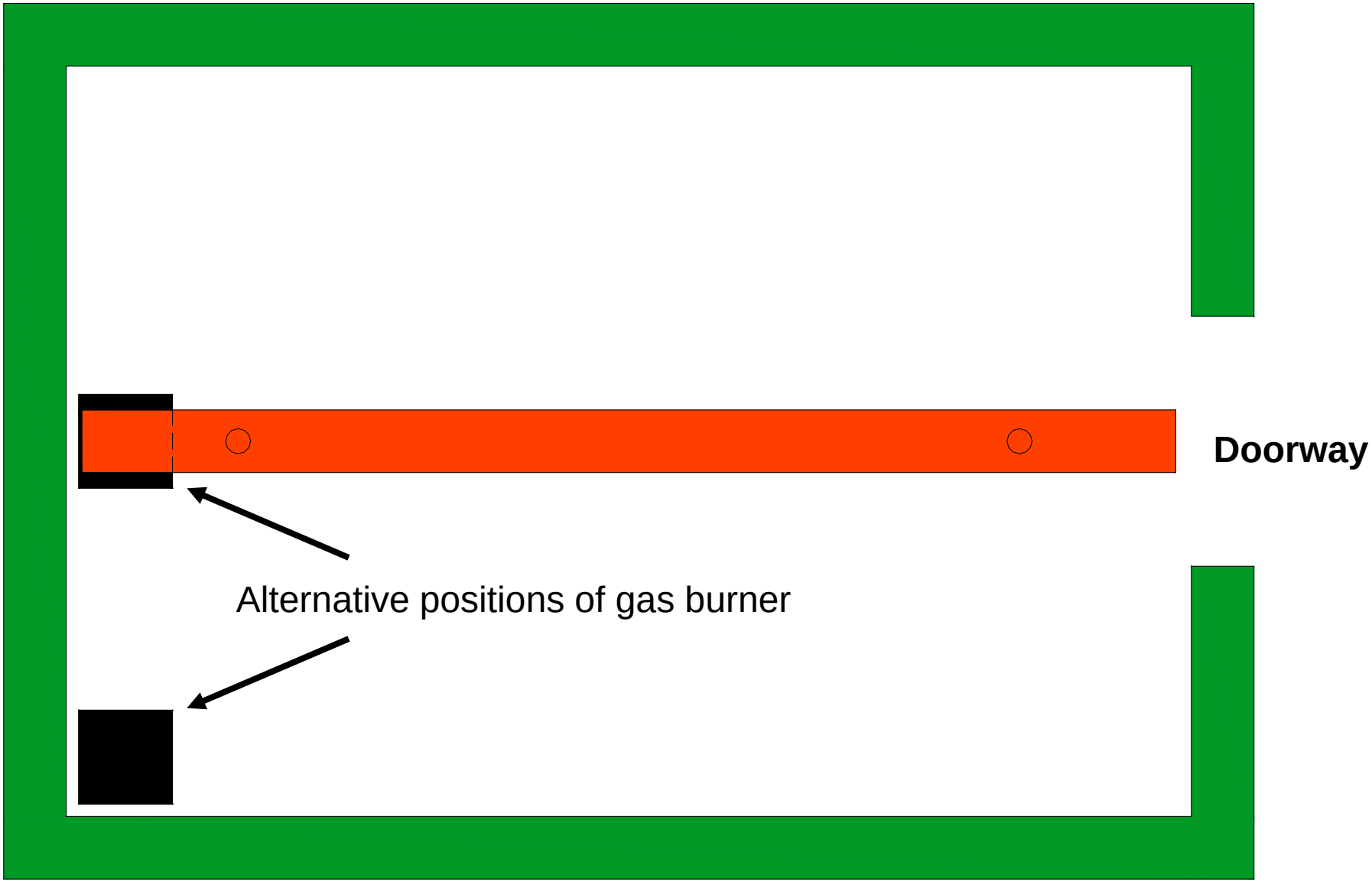
Ulf Wickström

SP Technical Research Institute of Sweden
Borås, Sweden

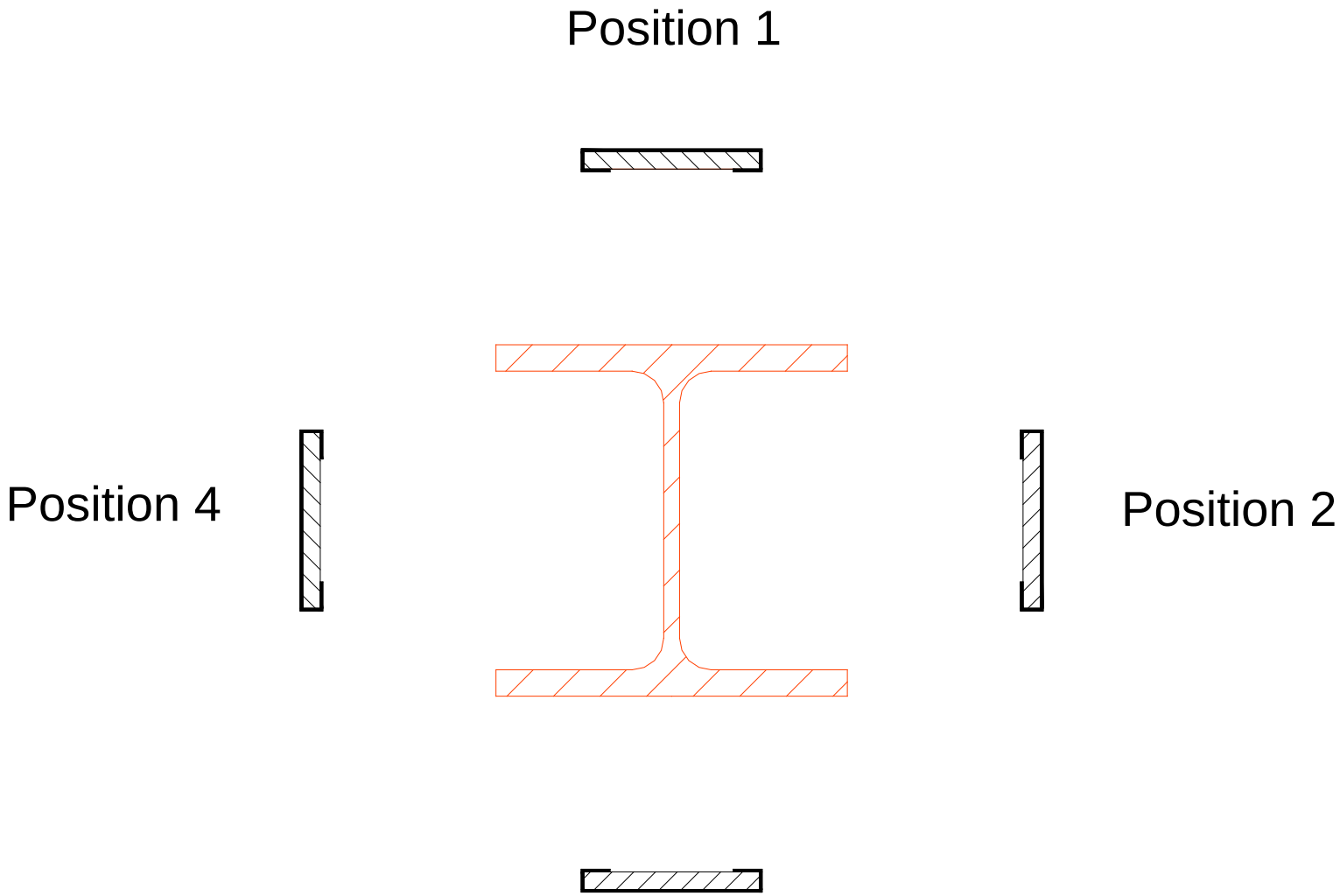
Side view of Room/Corner Test ISO 9705 burn room with steel beam



Top view of Room/Corner Test ISO 9705 burn room with steel beam



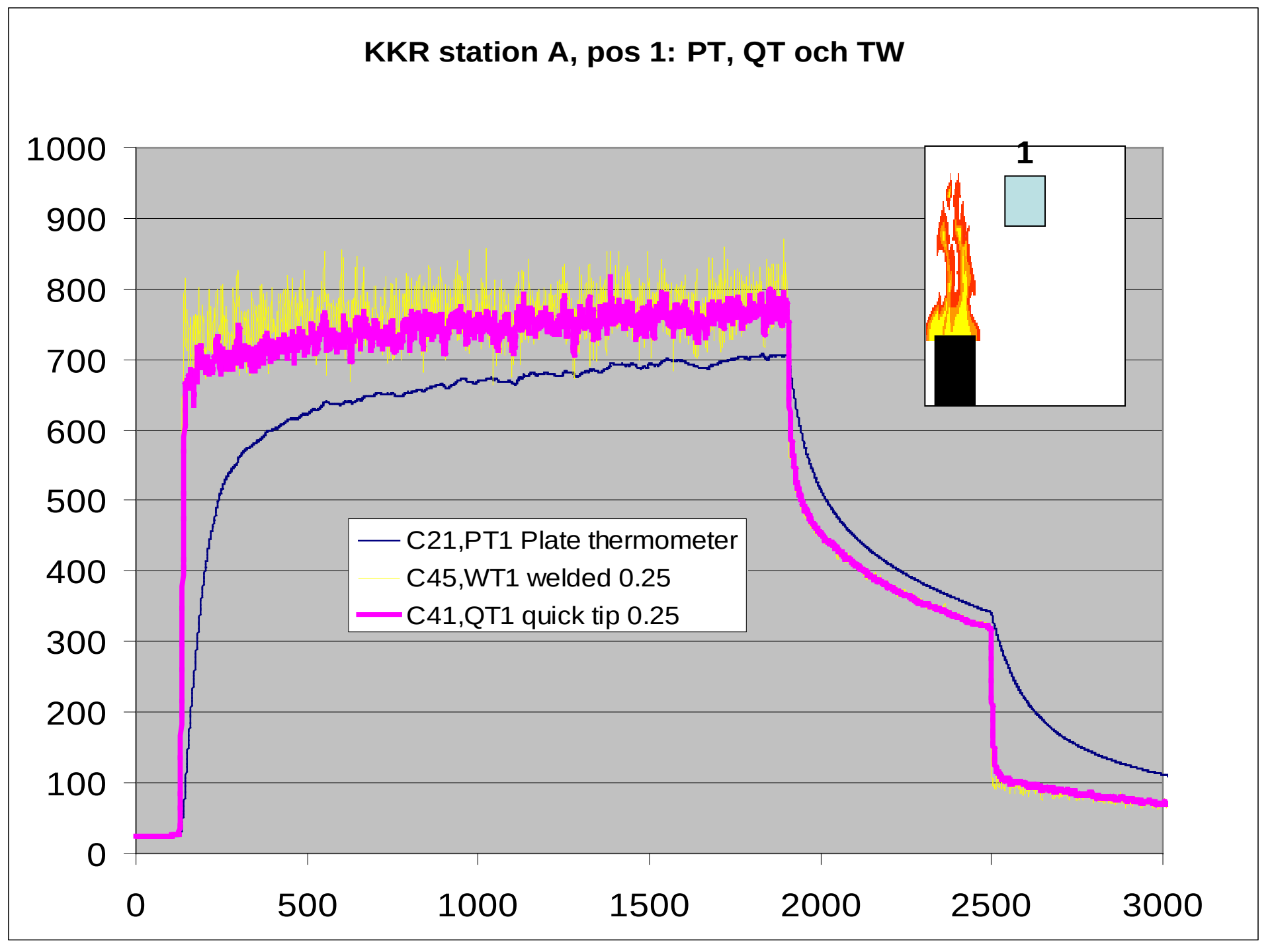
Gas phase measuring positions around I-section steel beam



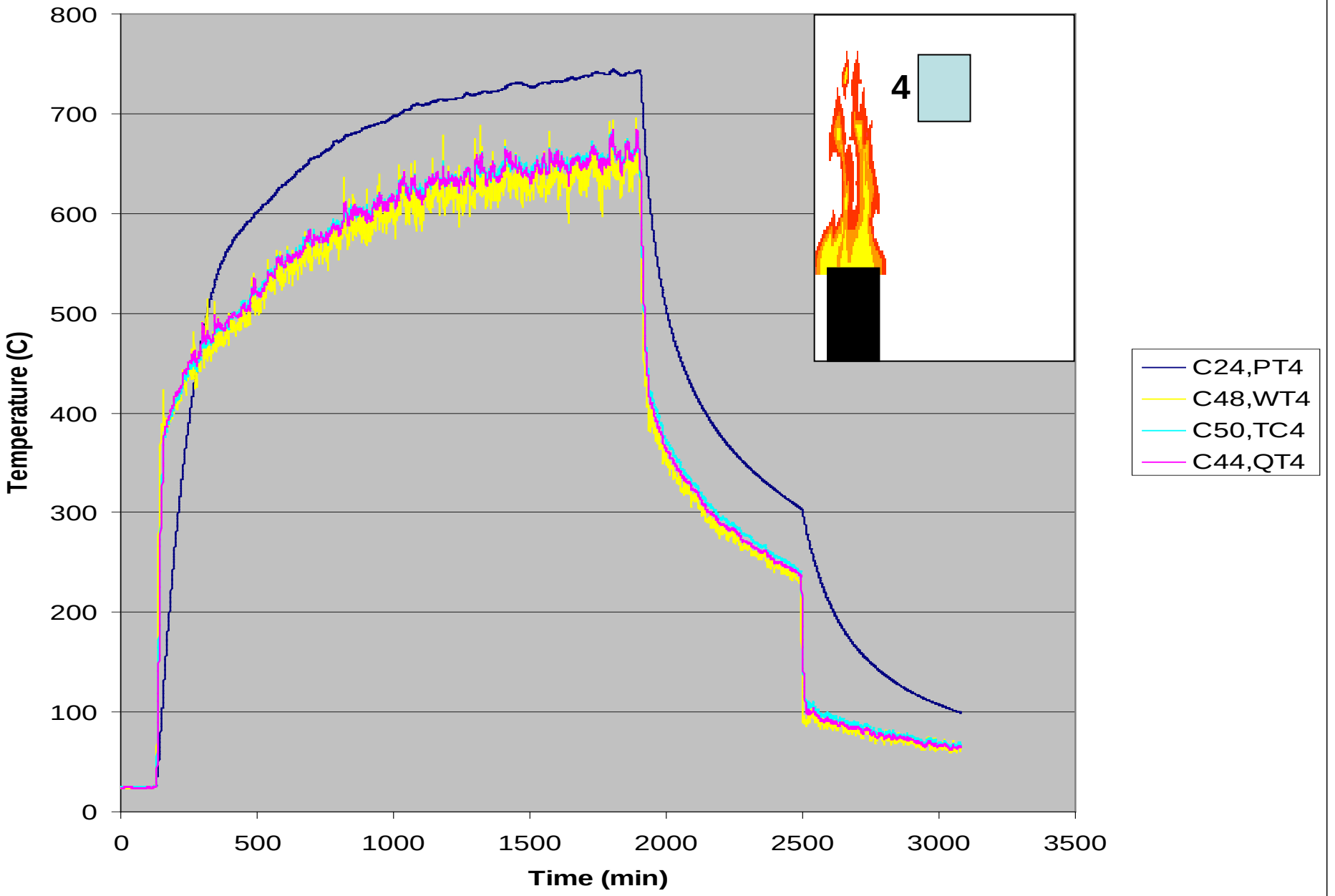

A2
A3
A4

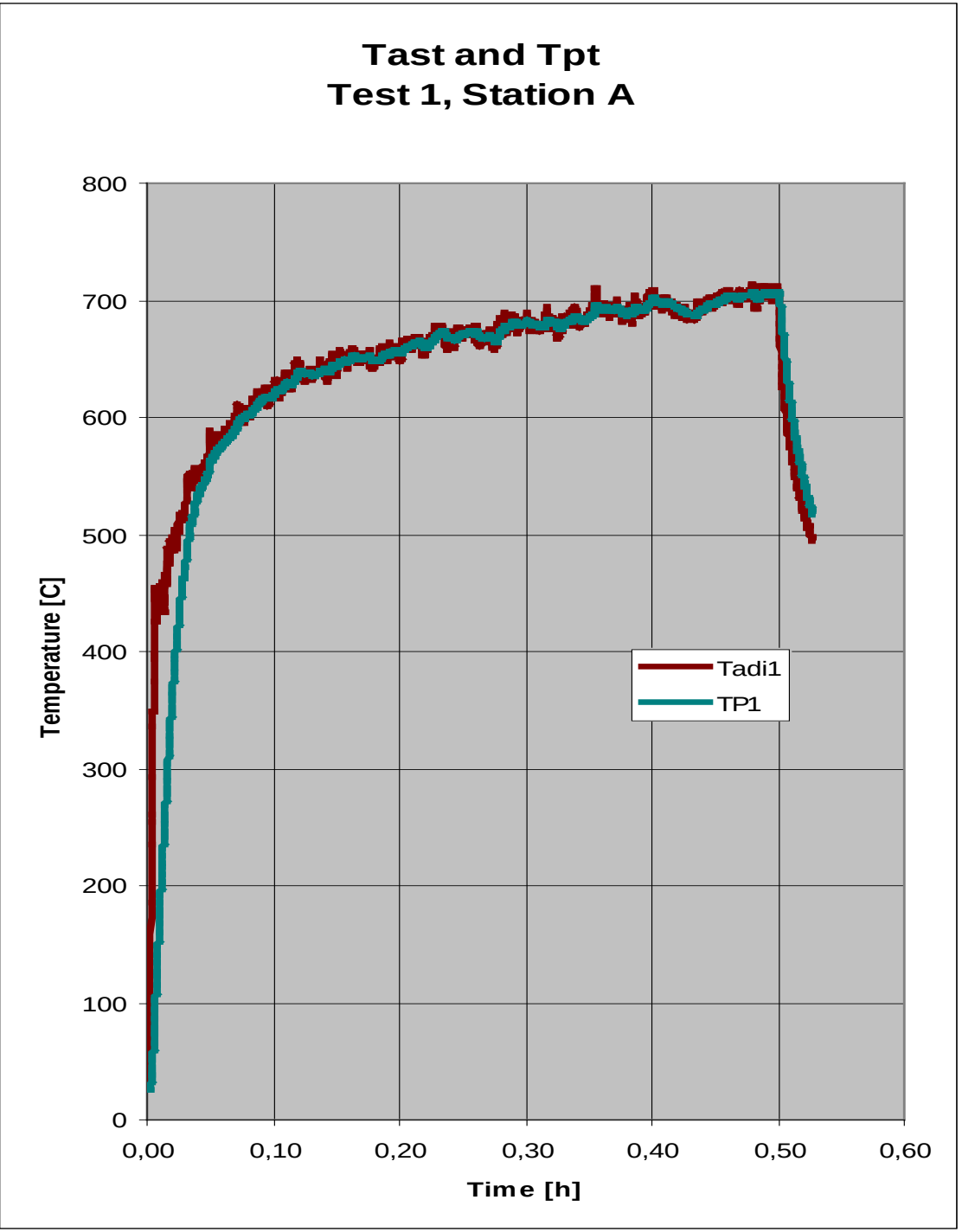

1
2
3
4
5
6
7
8

KKR station A, pos 1: PT, QT och TW

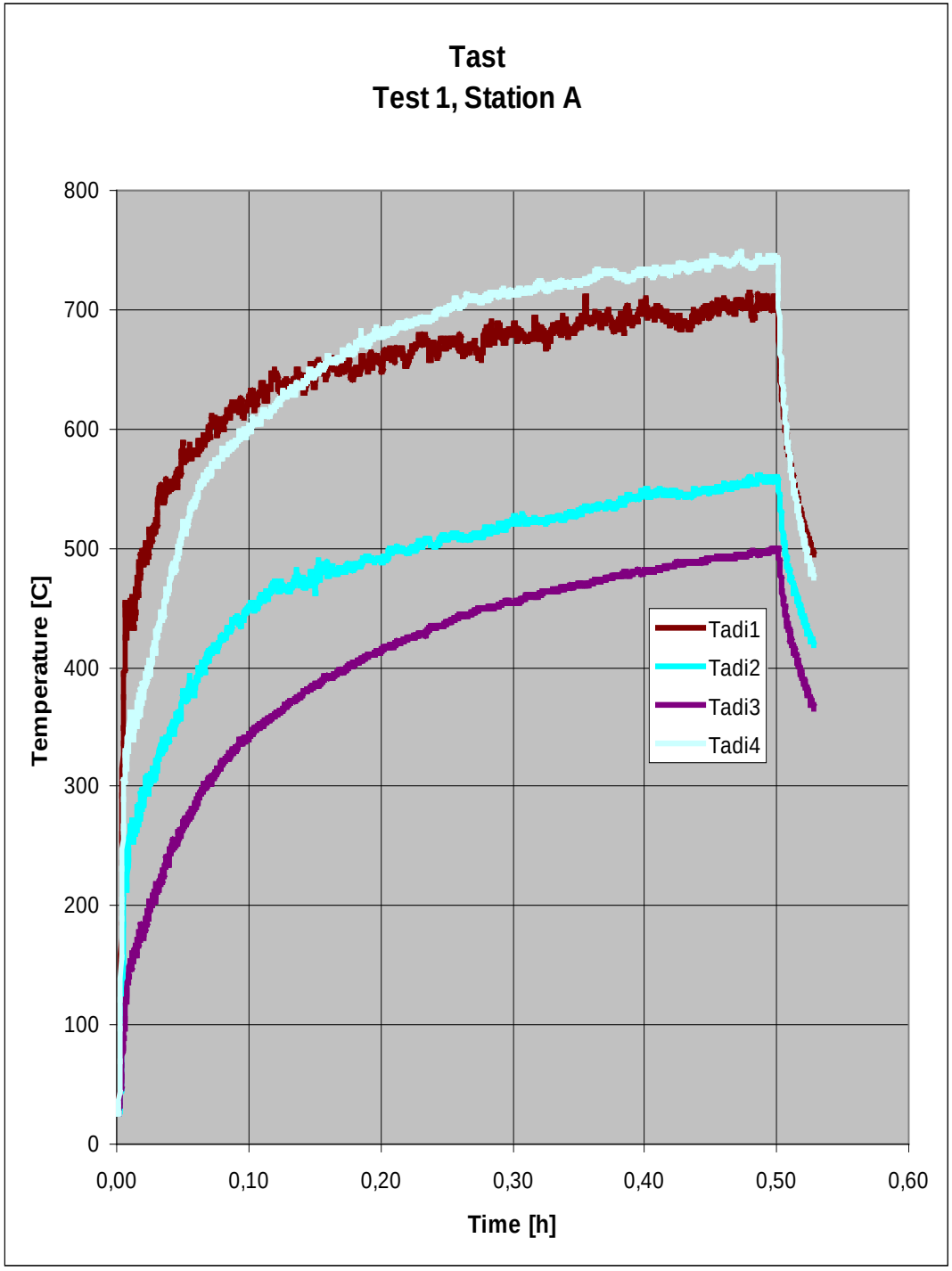


KKR station A, pos 4: PT, QT, TW och PS

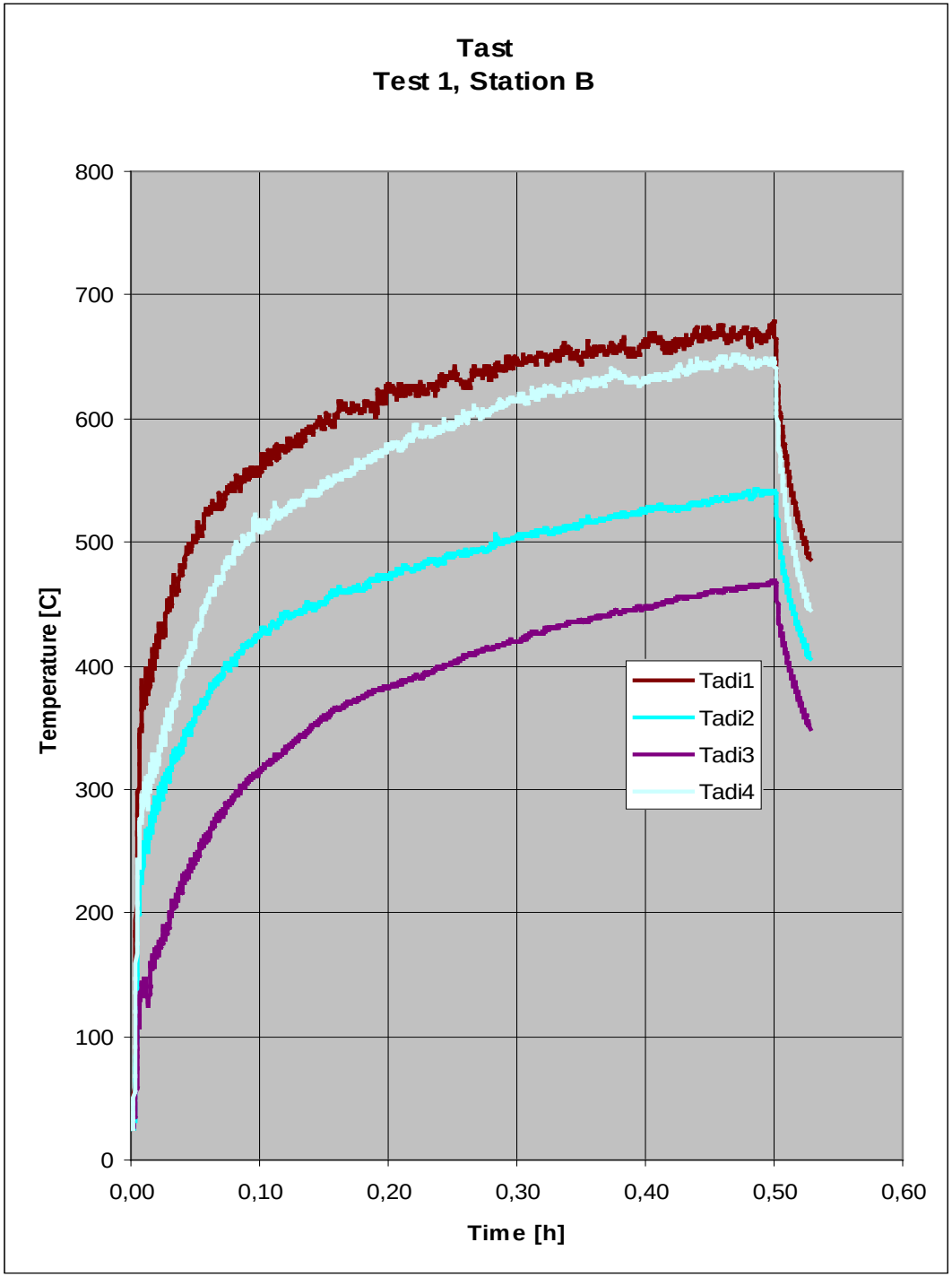




Adiabatic surface temperatures T_{AST} based on measured Plate thermometer T_{PT} temperatures at four positions



Adiabatic surface temperatures *Tast* based on measured Plate thermometer *Tpt* temperatures at four positions



Adiabatic surface temperatures *Tast* based on measured Plate thermometer *Tpt* temperatures at four positions

The concept of

Adiabatic Surface Temperature

AST

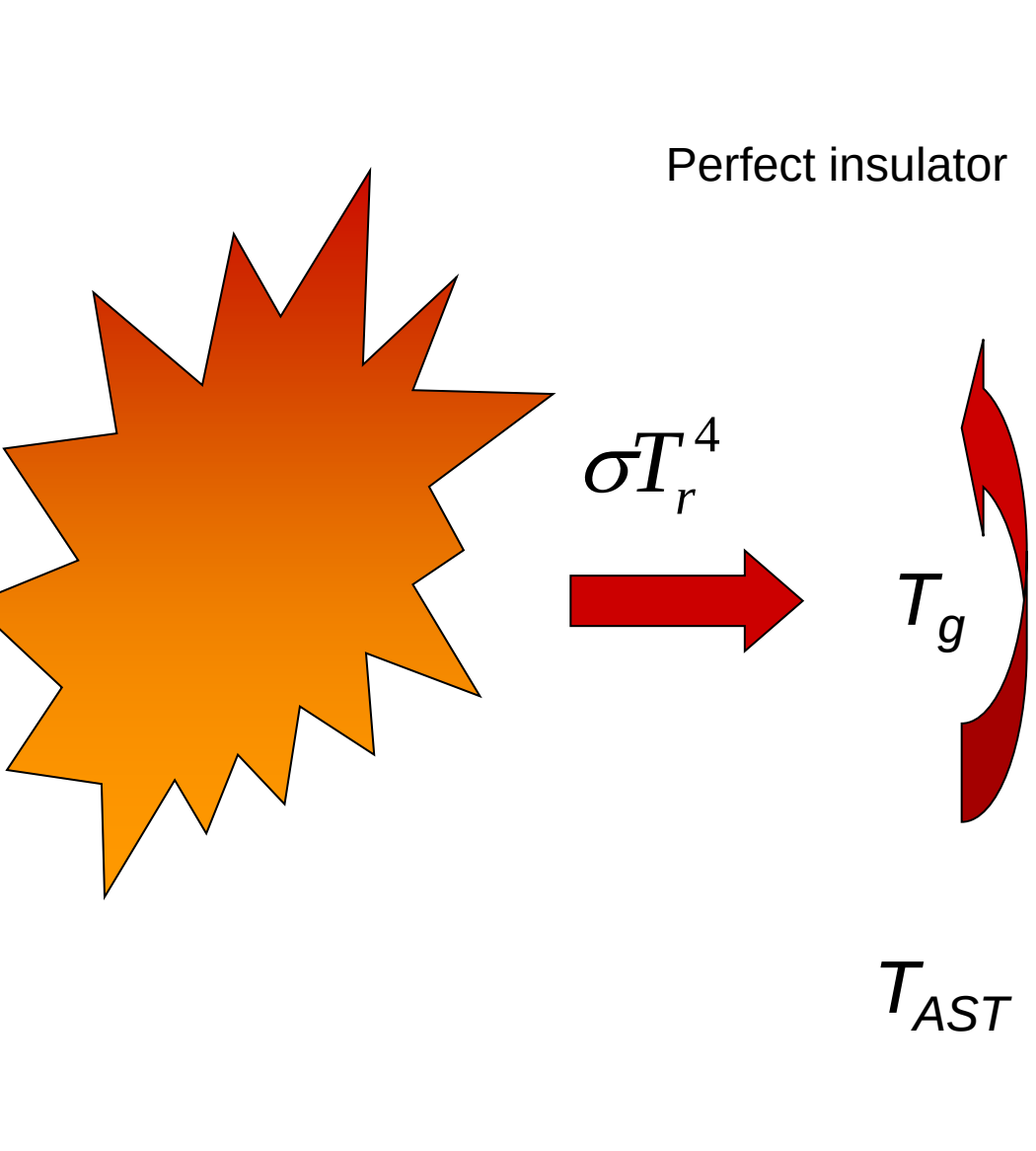
Heat transfer to a fire exposed surface

{Total heat transfer} = {Heat transfer by radiation} + {Heat transfer by convection}

$$\dot{q}''_{\text{tot}} = \dot{q}''_{\text{rad}} + \dot{q}''_{\text{con}}$$

$$\dot{q}''_{\text{tot}} = \varepsilon\sigma(T_r^4 - T_s^4) + h(T_g - T_s)$$

Adiabatic Surface Temperature, T_{AST}



Definition of AST:

$$\varepsilon_s \sigma (T_r^4 - T_{AST}^4)$$

$$+$$

$$h(T_g - T_{AST}) = 0$$

Use the Adiabatic Surface Temperature T_{AST} for calculating heat transfer

(+) $\dot{q}''_{\text{tot}} = \varepsilon\sigma(T_r^4 - T_s^4) + h(T_g - T_s)$ (heat transfer)

(-) $0 = \varepsilon\sigma(T_r^4 - T_{AST}^4) + h(T_g - T_{AST})$ (def. AST)

$$\dot{q}''_{\text{tot}} = \varepsilon\sigma(T_{AST}^4 - T_s^4) + h(T_{AST} - T_s)$$

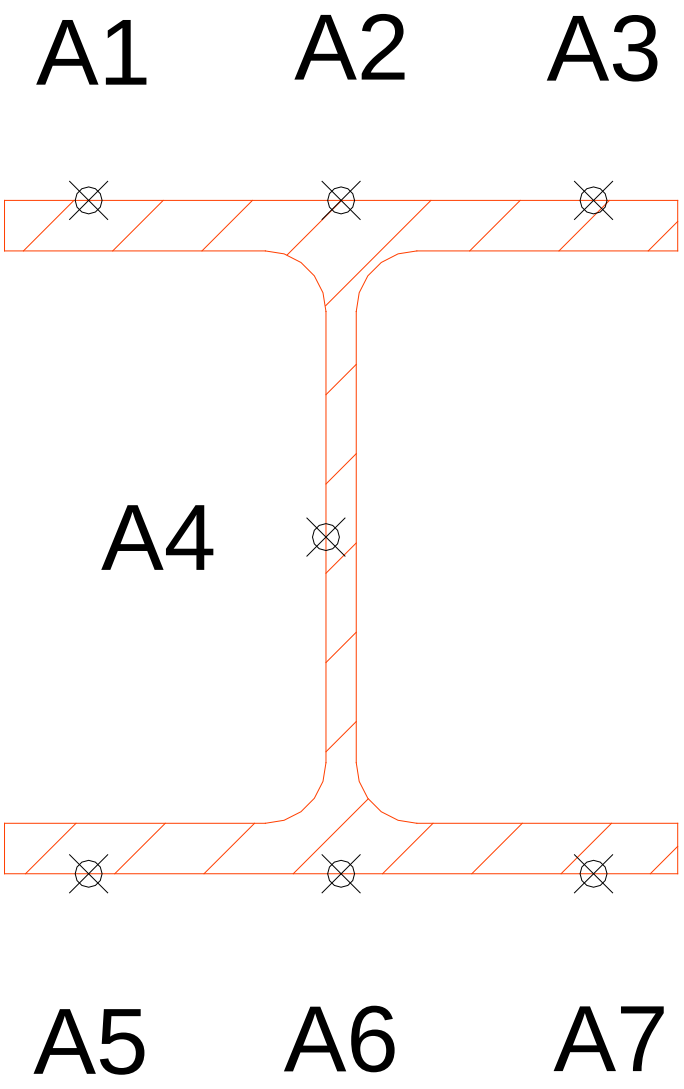
AST can be used for calculating heat transfer.

Will it work in practice ?

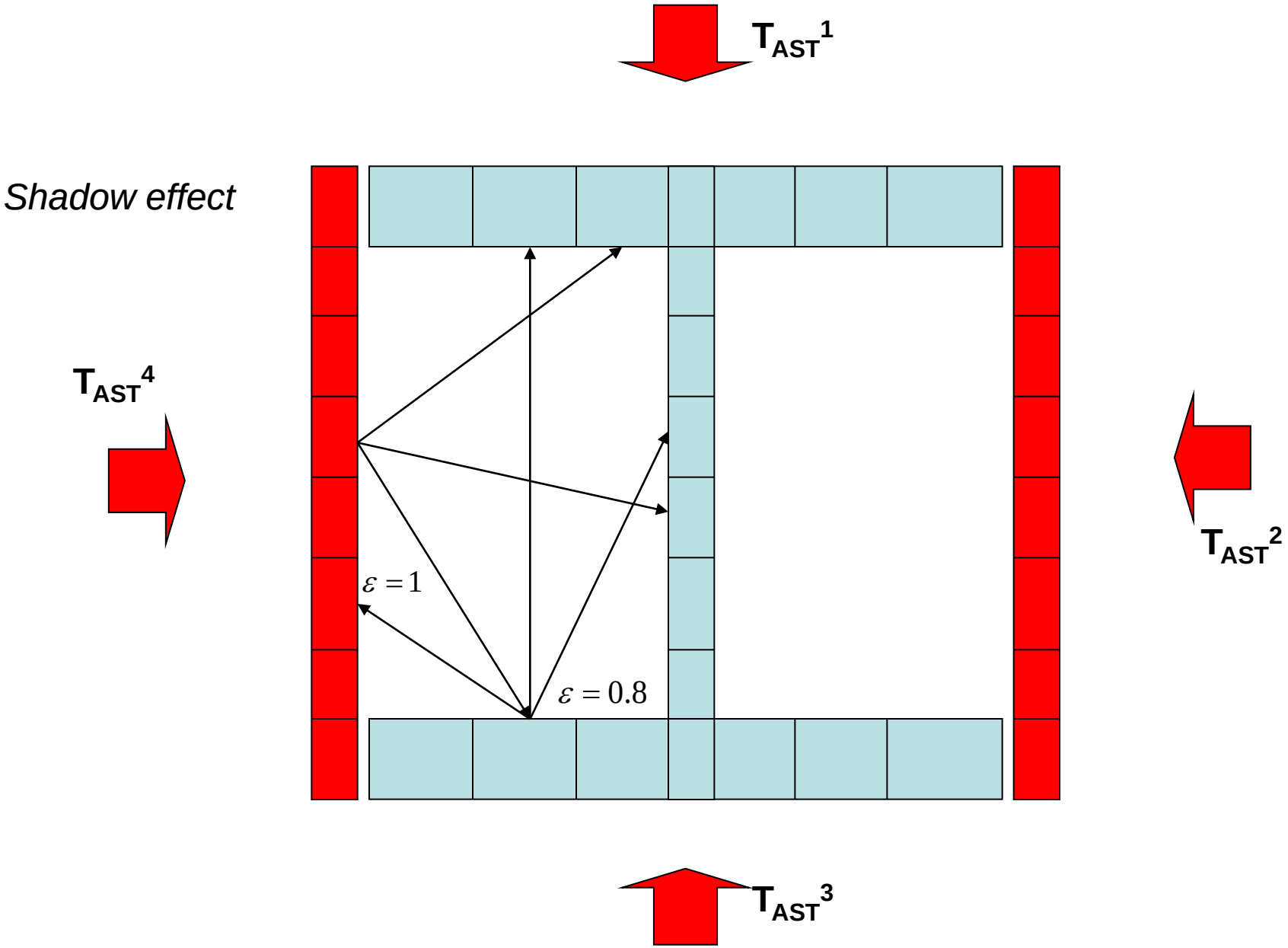
The heat flux depends on the adiabatic surface temperature T_{AST}

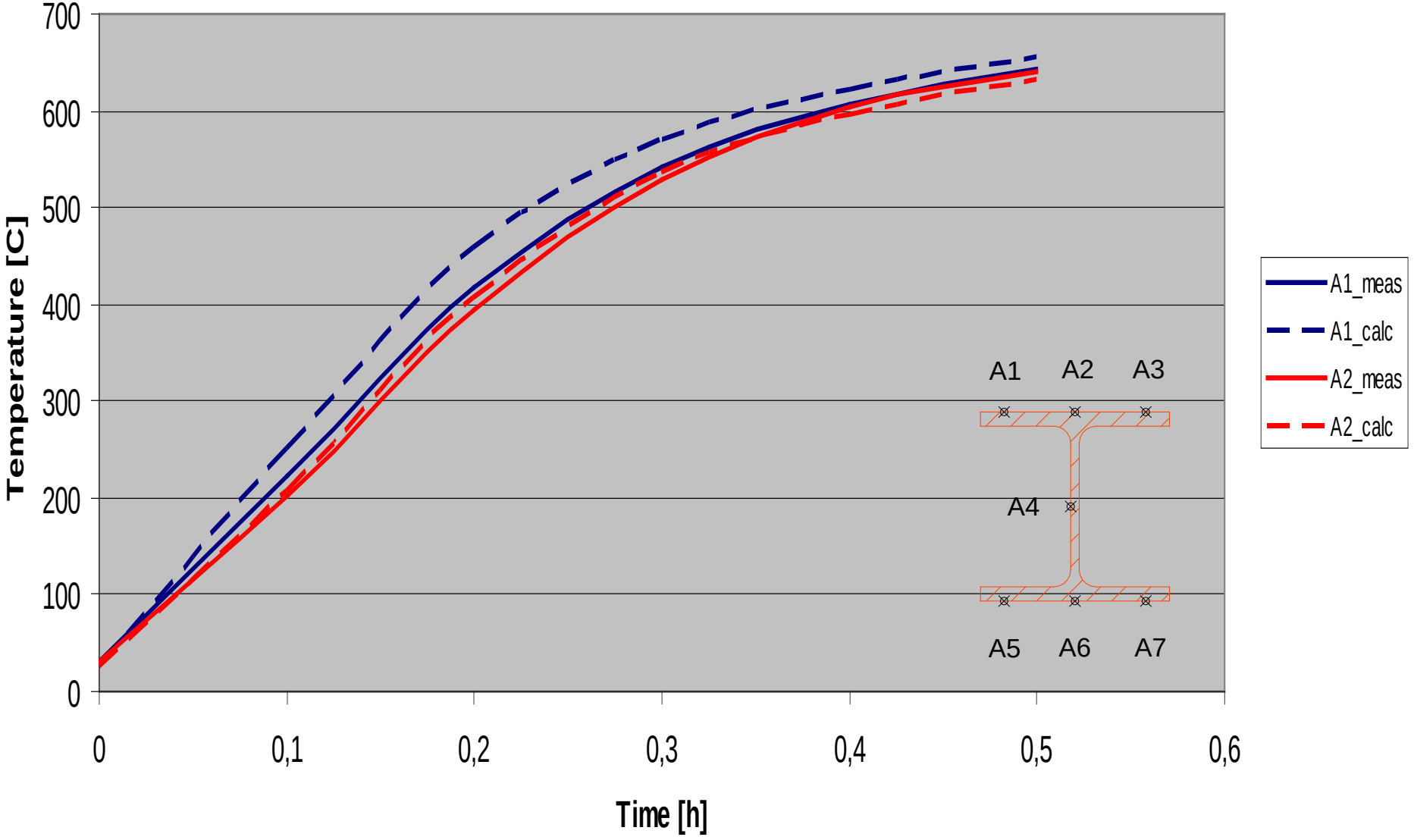
$$\dot{q}''_{\text{tot}} = \varepsilon\sigma\left(T_{AST}^4 - T_s^4\right) + h_c\left(T_{AST} - T_s\right)$$

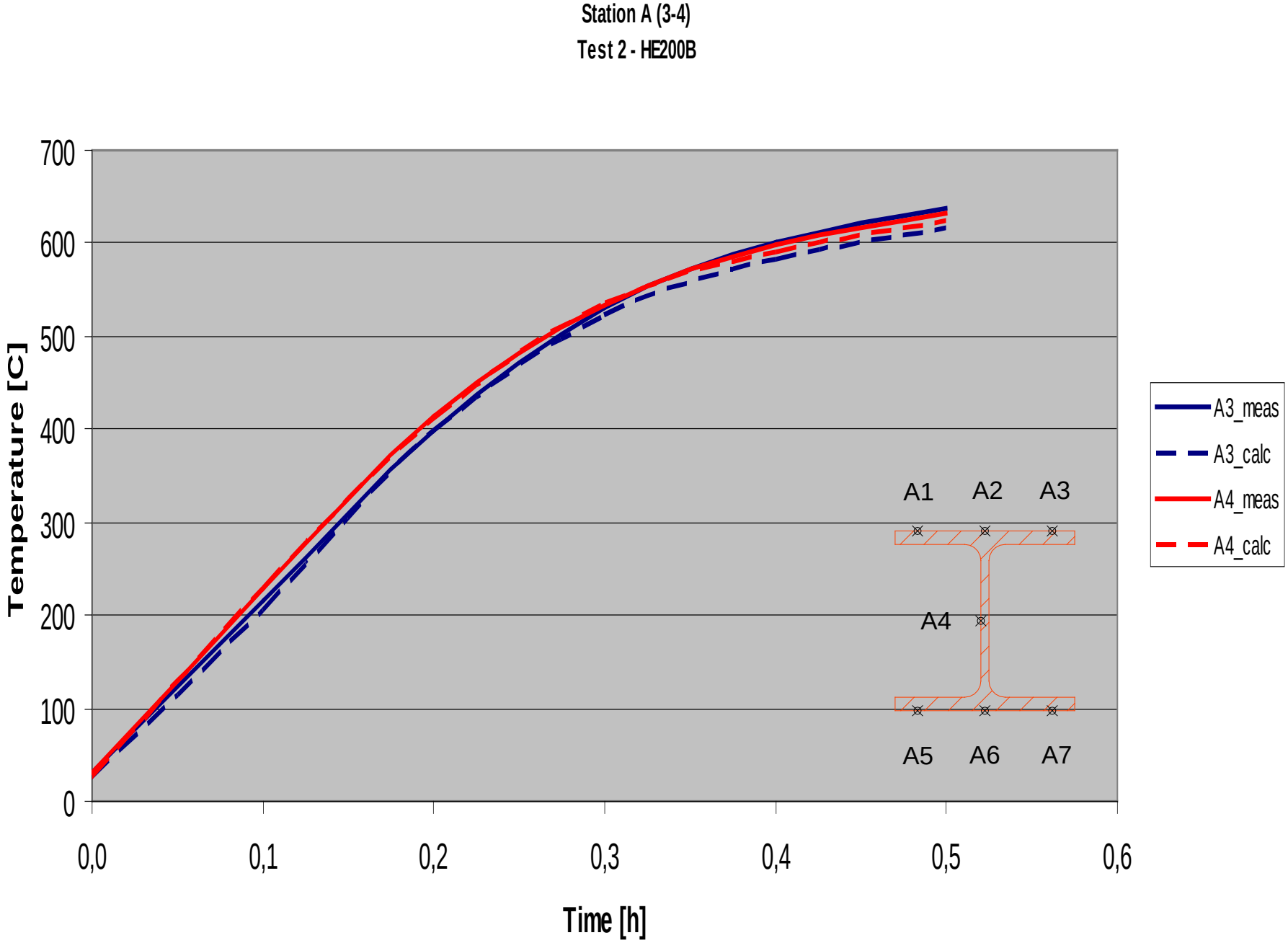
Steel thermocouple positions A1 to A7 in I-section



Finite element model




Station A (1-2)
Test 2 - HE200B
Temperature [C]
700
600
500
400
300
200
100
0
0
0,1
0,2
0,3
0,4
0,5
0,6
Time [h]
A1_meas
A1_calc
A2_meas
A2_calc
A1
A2
A3
A4
A5
A6
A7


Station A (3-4)
Test 2 - HE200B
Temperature [C]
700
600
500
400
300
200
100
0
0,0
0,1
0,2
0,3
0,4
0,5
0,6
Time [h]
A1
A2
A3
A4
A5
A6
A7
A3_meas
A3_calc
A4_meas
A4_calc

Station A (5-7)

Test 2 - HE200B