VALIDATING FDS AGAINST A LARGE-SCALE FIRE TEST FOR FACADE SYSTEMS

Markus Nilsson, Johan Nilsen and Axel Mossberg

Brandskyddslaget AB Consulting firm, Sweden

markus.nilsson@brandskyddslaget.se

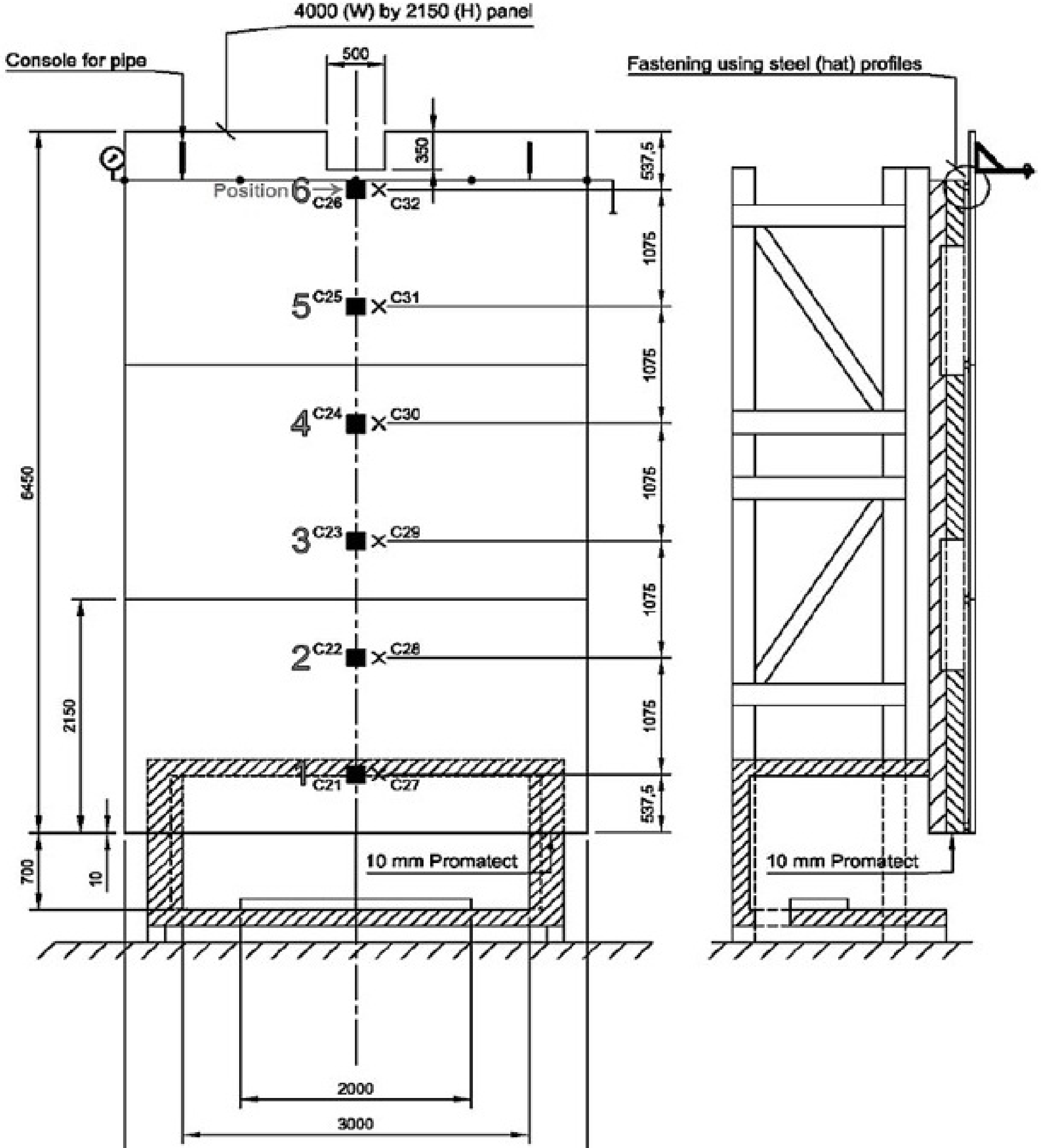
Introduction

Background

- Part of an MSc thesis at Lund University
- Need of a calculation tool for modelling external fire spread
- Evaluating the tool before performing the following analysis
- Previous numerical work on a large-scale fire test showed promising results
- SP FIRE 105 facade test - modified test
- An update in FDS $\neq$ every area is improved
- Investigate possible differences in the program versions (FDS 6.2.0 vs FDS 5.5.3)

Experimental setup

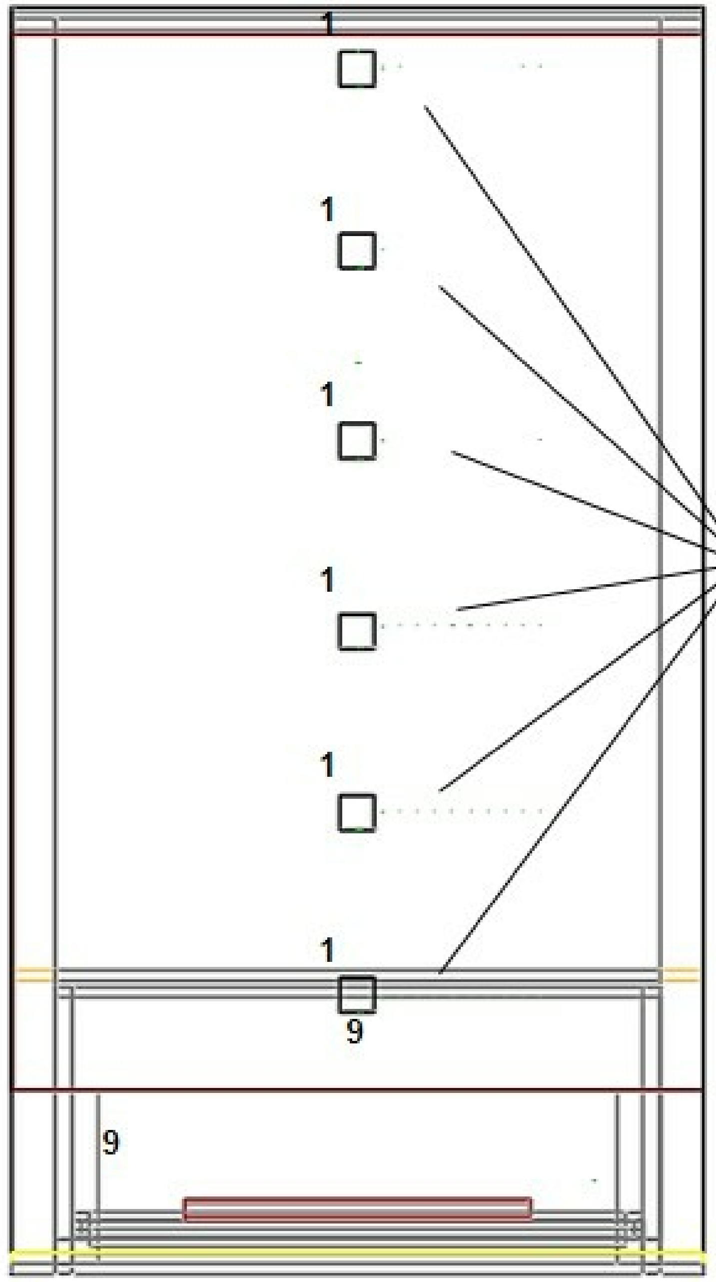
Modified SP FIRE 105 test rig

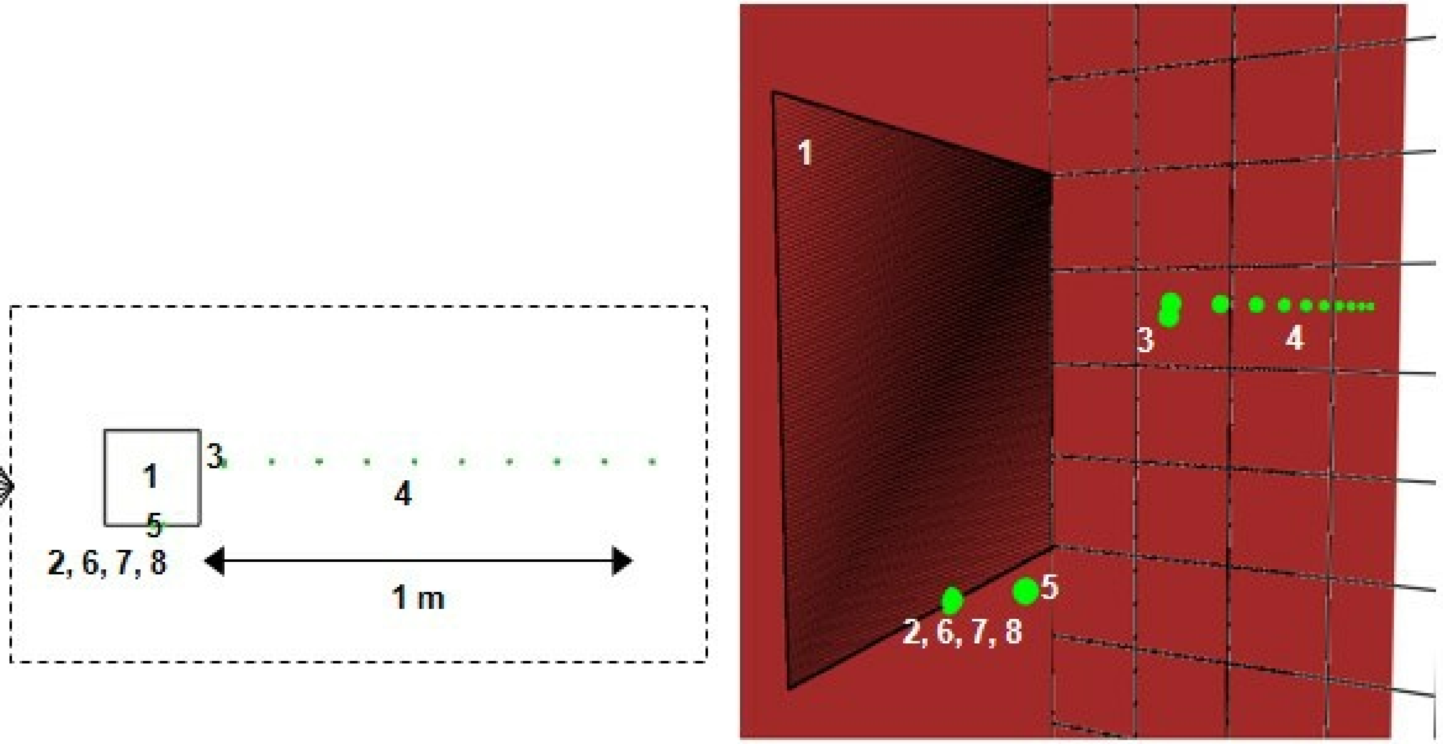


Fire development

t = 0 s t = 240 s t = 600 s t = 780 s

Setup in FDS





1. Inconel steel plate sheet (C21-C26)
2. Wall temperature device (C21-C26)
3. Thermocouple device as per position in drawing (C27-C32)
4. Thermocouple devices offset symmetry line (Sufix -1 to -10)
5. Velocity measurement device
6. Incident heat flux device
7. Convective heat flux device
8. Adiabatic surface temperature device
9. Oxygen level measurements

Processing the output data

$\dot{q}''_{IRHF}$ from the fire test

$$\dot{q}''_{inc} = \sigma T_s^4 - \frac{h_c(T_g - T_s)}{\epsilon} + \frac{dc\rho}{\epsilon} \cdot \frac{dT}{dt} \quad (1)$$

$$h_c = 2.4 T_f^{0.085} \cdot u_\infty^{1/2} \cdot x^{-1/2} \quad (2)$$

$$\dot{q}''_{inc} = \dot{q}''_{IRHF} \quad (3)$$

$$\epsilon_{PT}\dot{q}''_{inc} - \epsilon_{PT}\sigma T_{PT}^4 + h_{PT}(T_g - T_{PT}) + K(T_g - T_{PT}) = C\frac{dT_{PT}}{dT}$$

$$T_{PT} \sim T_{AST}$$

$\dot{q}''_{IRHF}$ in FDS

$$\dot{q}''_{inc} = \frac{\dot{q}''_{rad}}{\epsilon} + \sigma T_w^4 + \dot{q}''_c \quad (4)$$

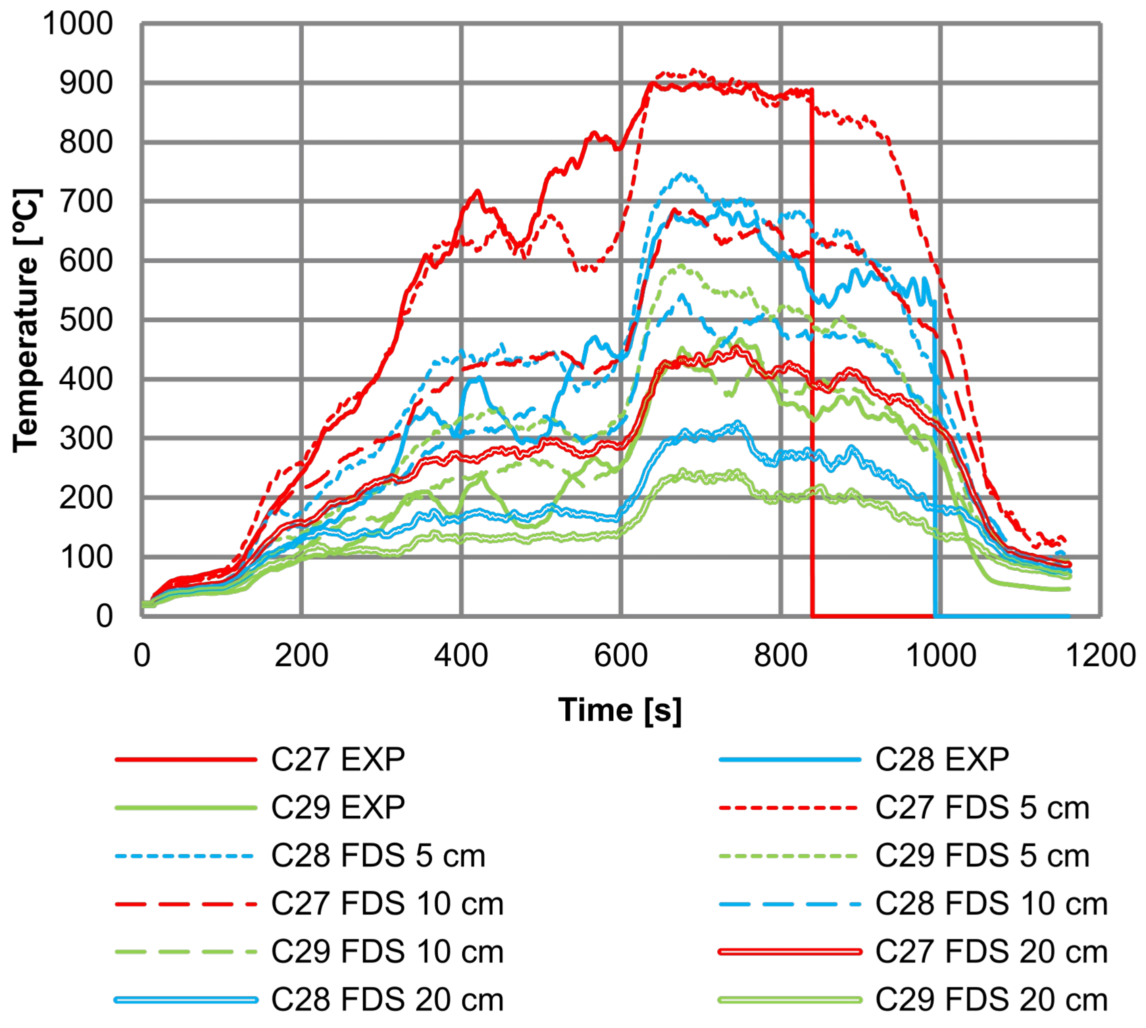
$$\dot{q}''_{rad} = \dot{q}''_{rad,in} - \dot{q}''_{rad,out} = \dot{q}''_{rad,in} - \epsilon\sigma T_w^4 \quad (5)$$

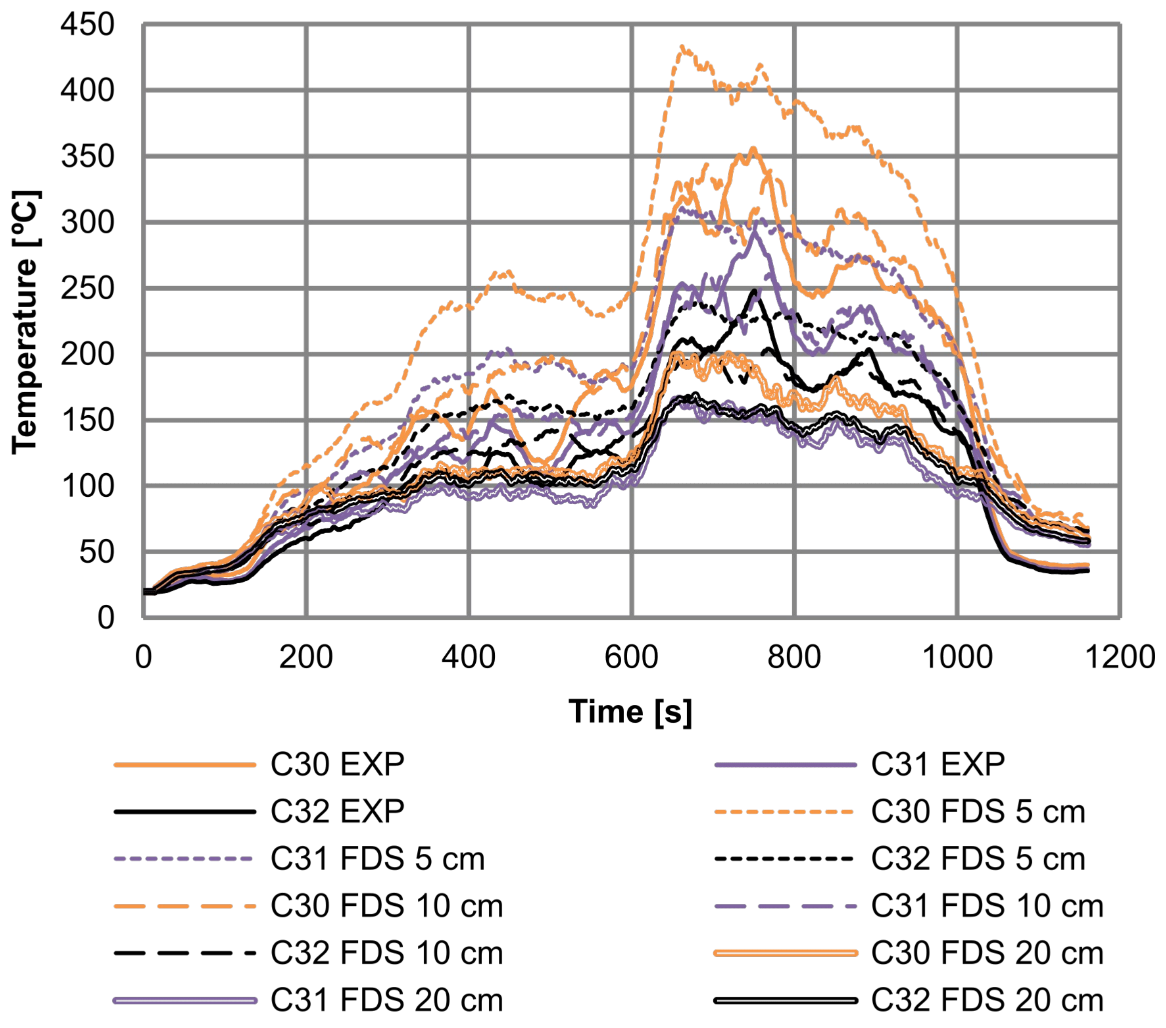
$$\dot{q}''_{inc} = \frac{\dot{q}''_{rad,in}}{\epsilon} + \dot{q}''_c \quad (6)$$

$$\dot{q}''_{IRHF} = \dot{q}''_{inc} - \dot{q}''_c = \frac{\dot{q}''_{rad,in}}{\epsilon} \quad (7)$$

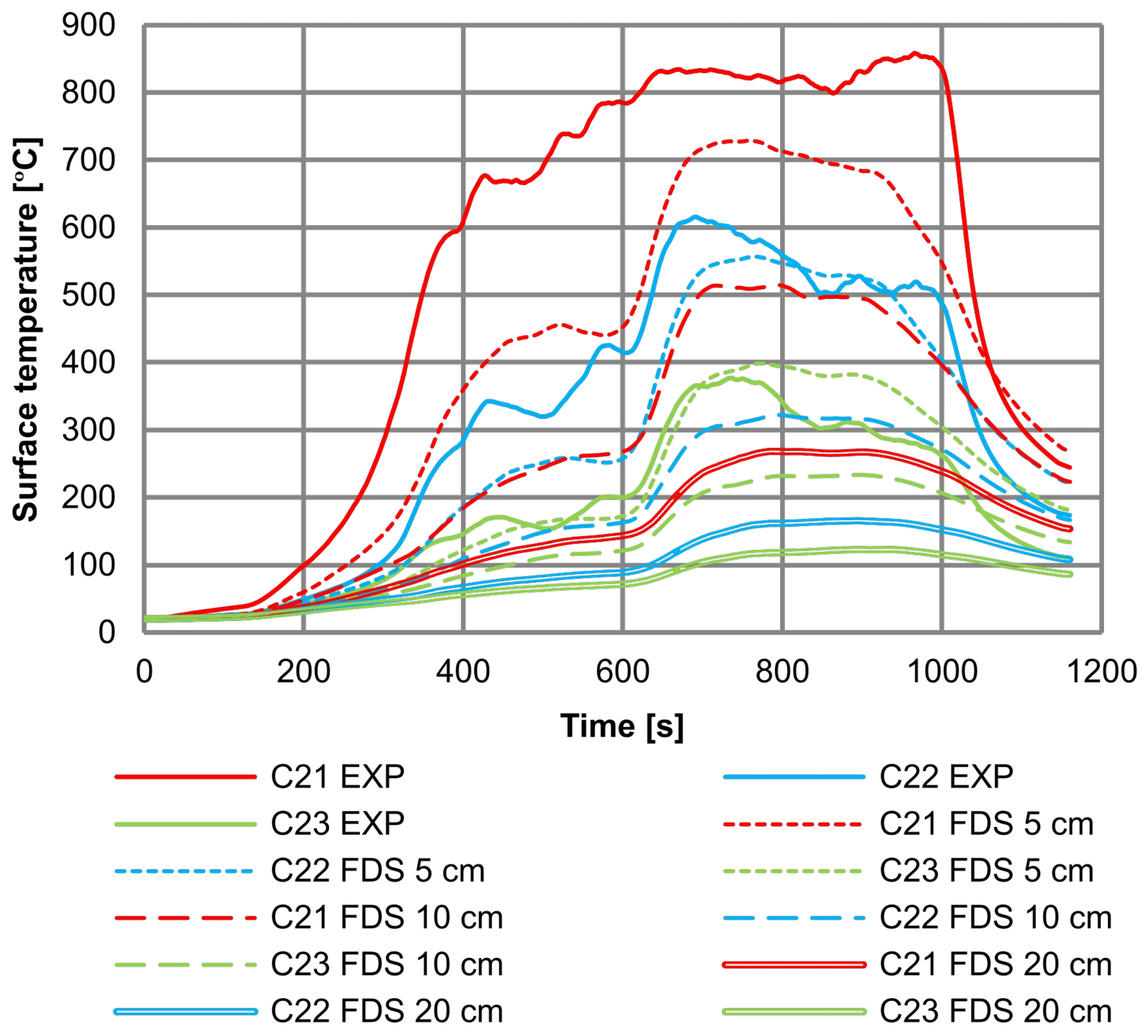
Results

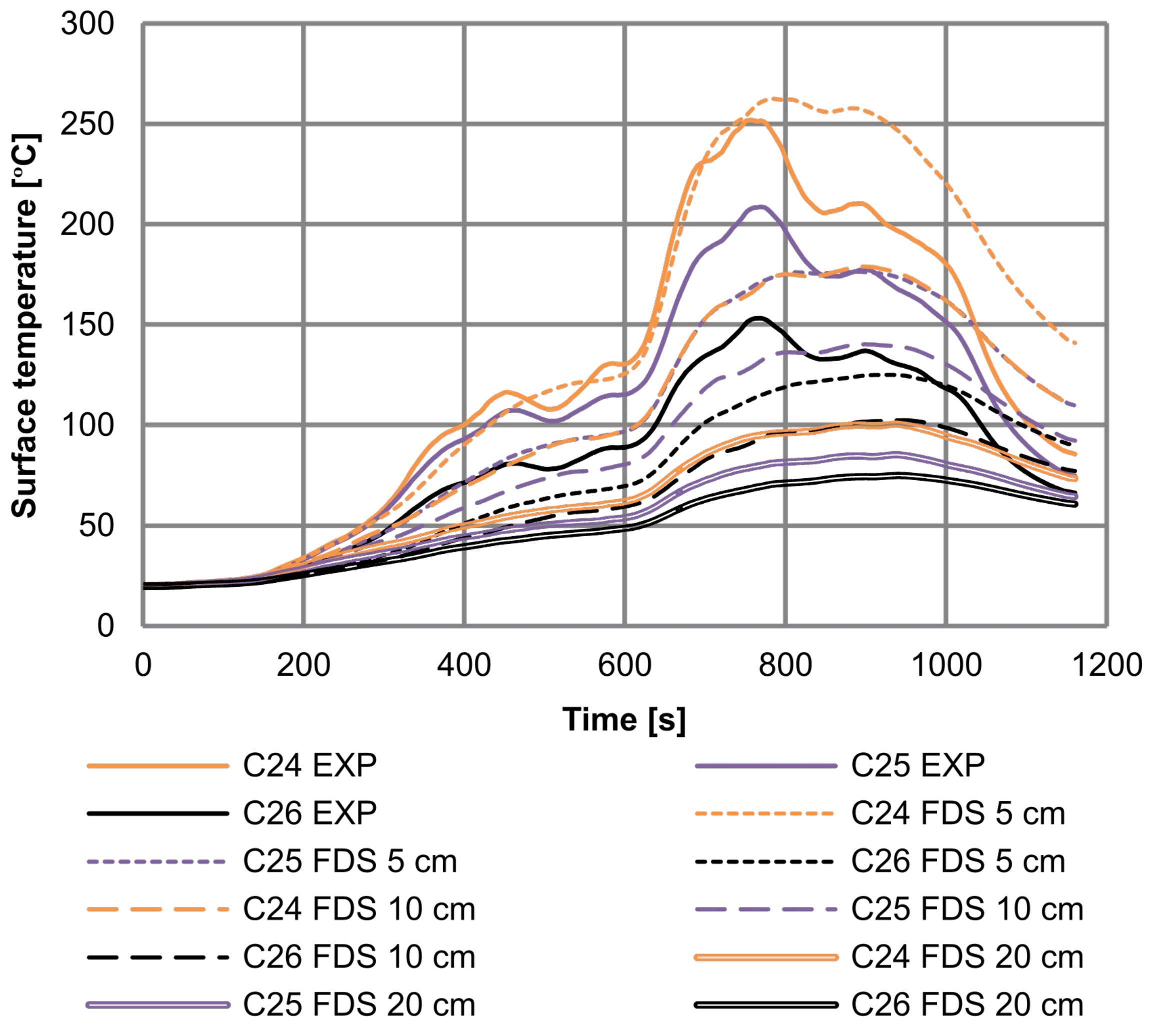
Grid sensitivity, thermocouples



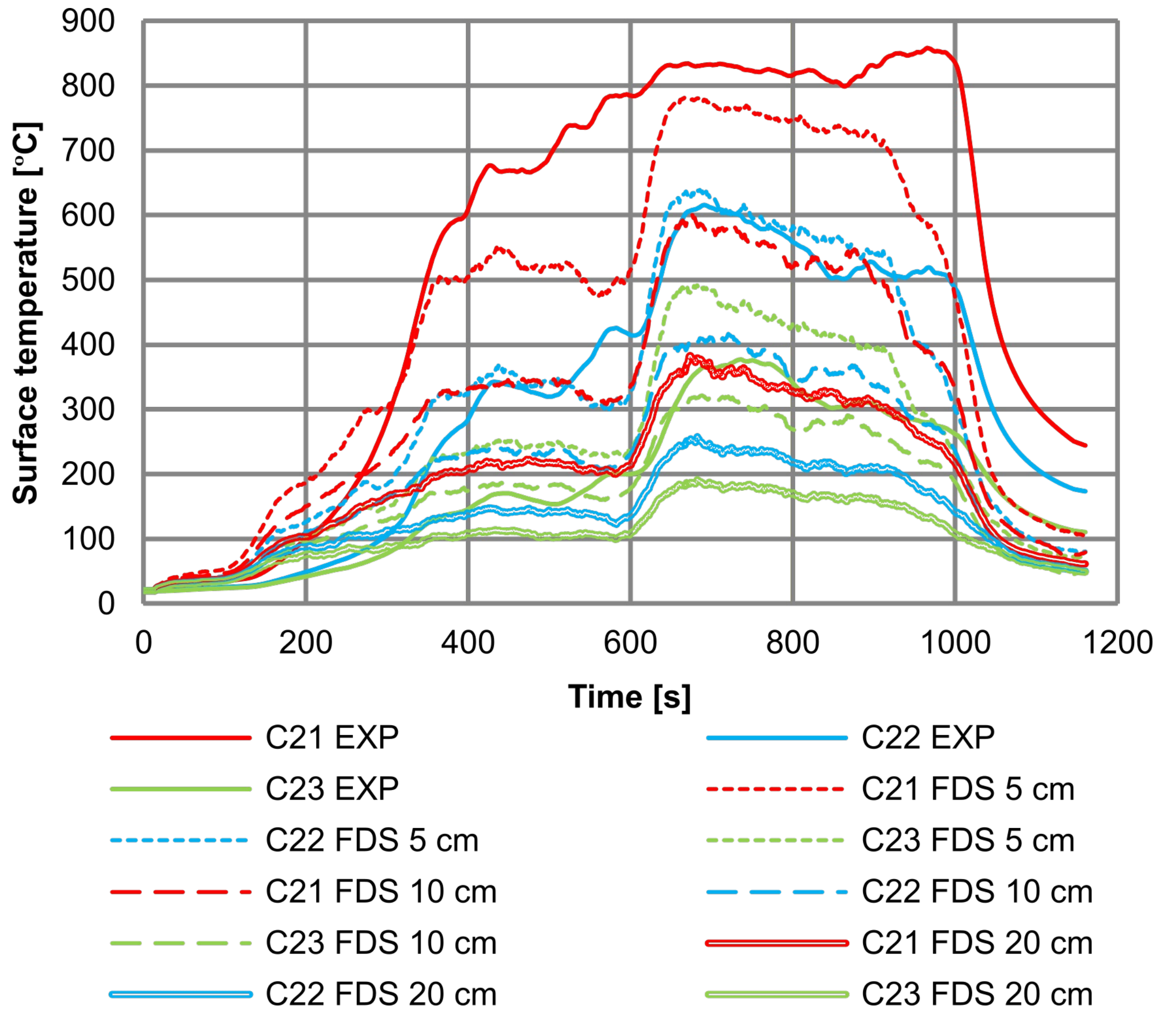


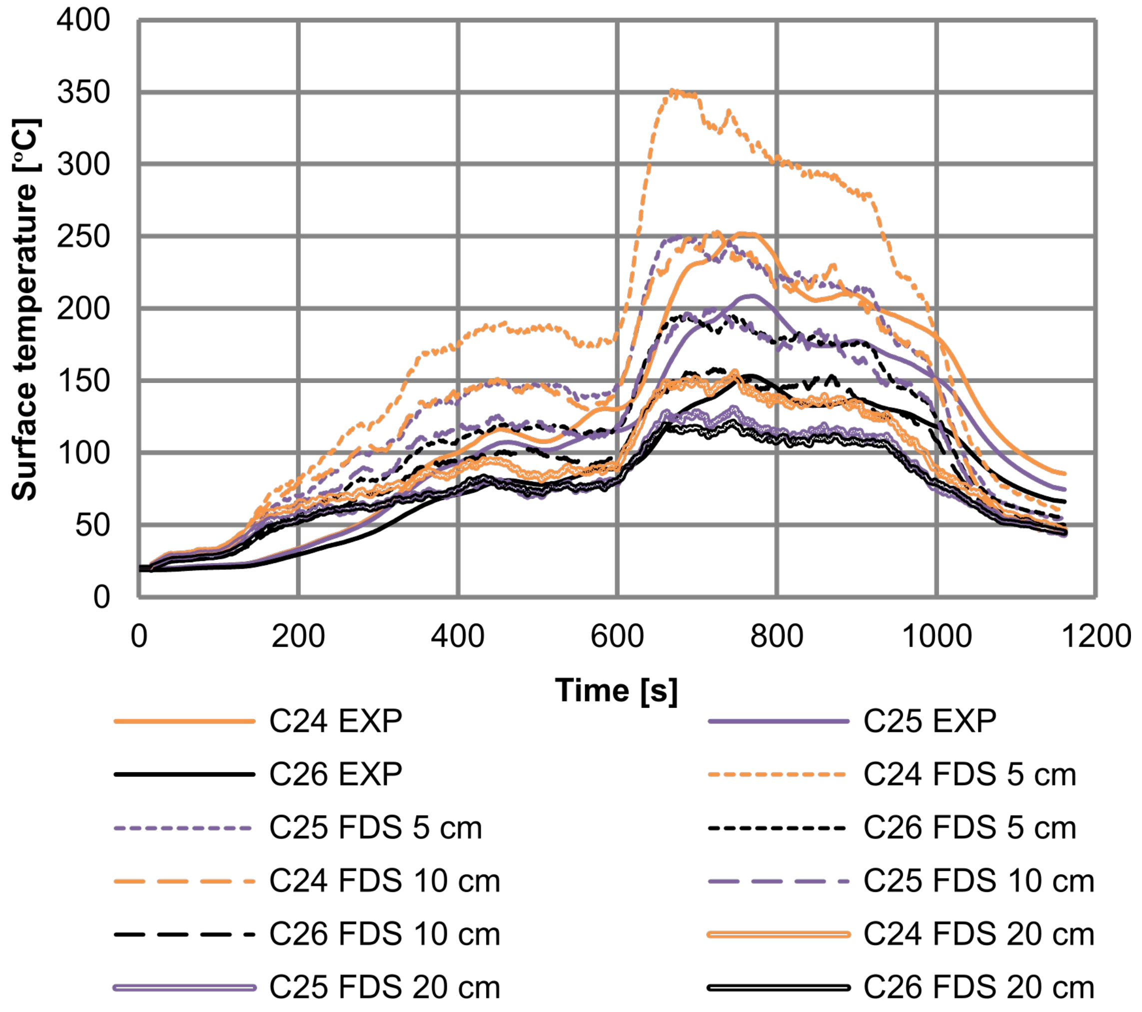
Grid sensitivity, thermometers





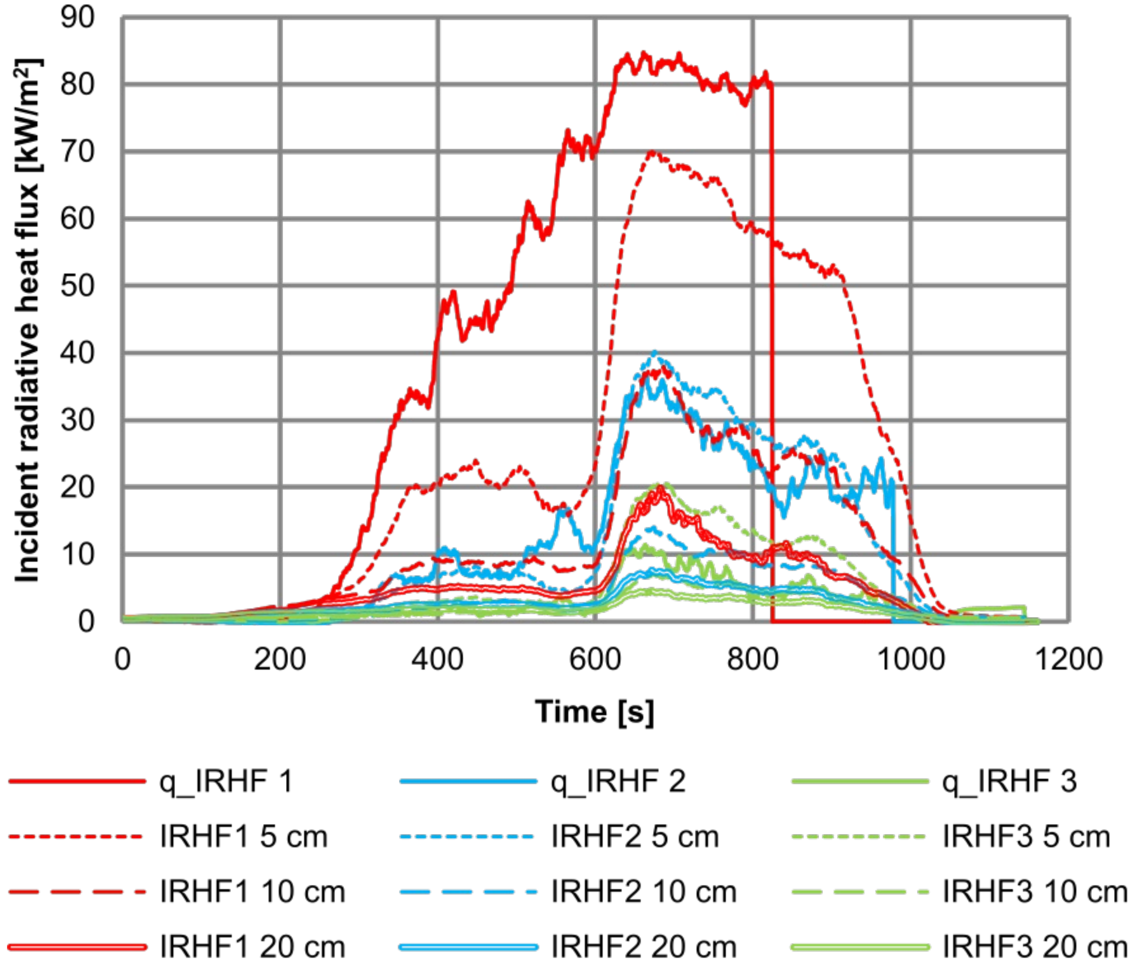
Grid sensitivity, T_{AST}

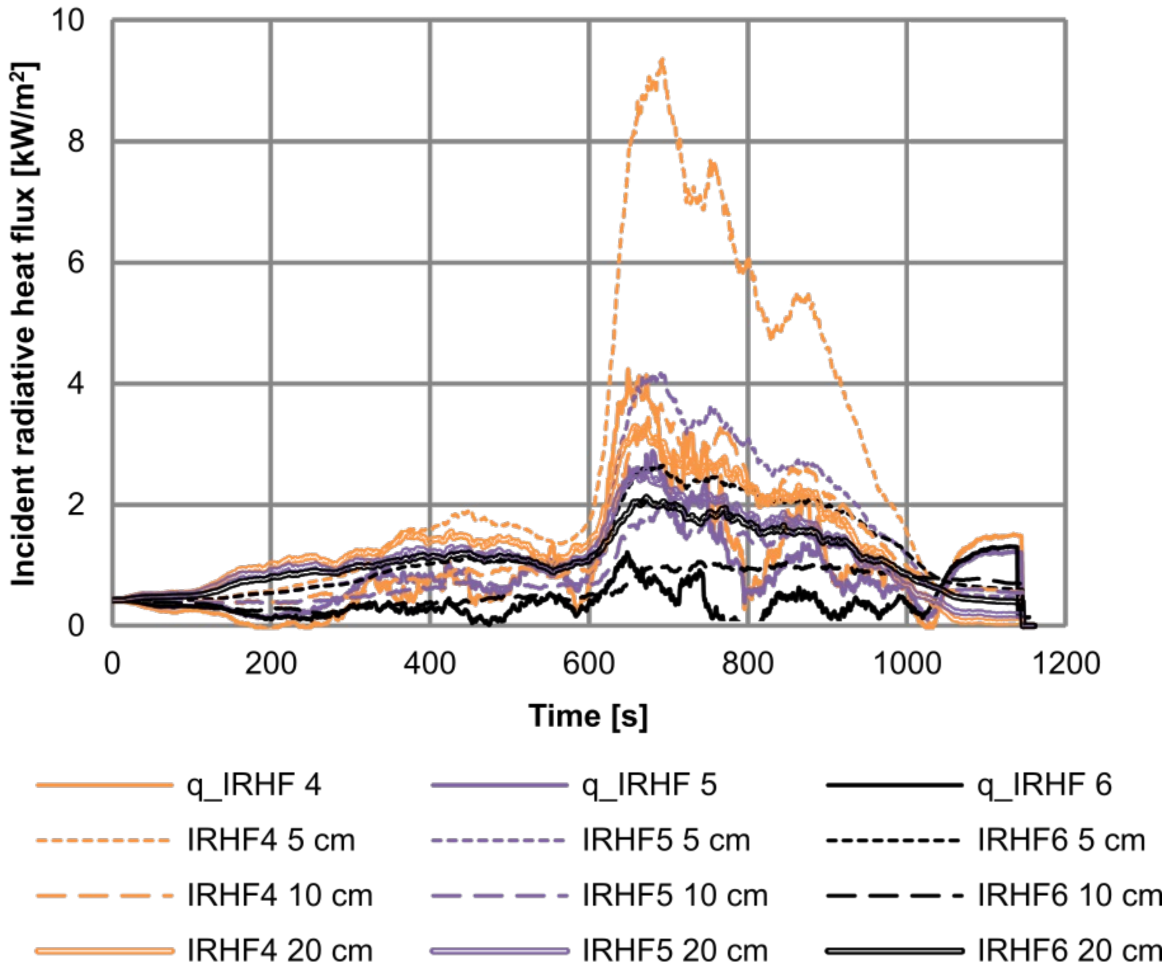




Facade damage

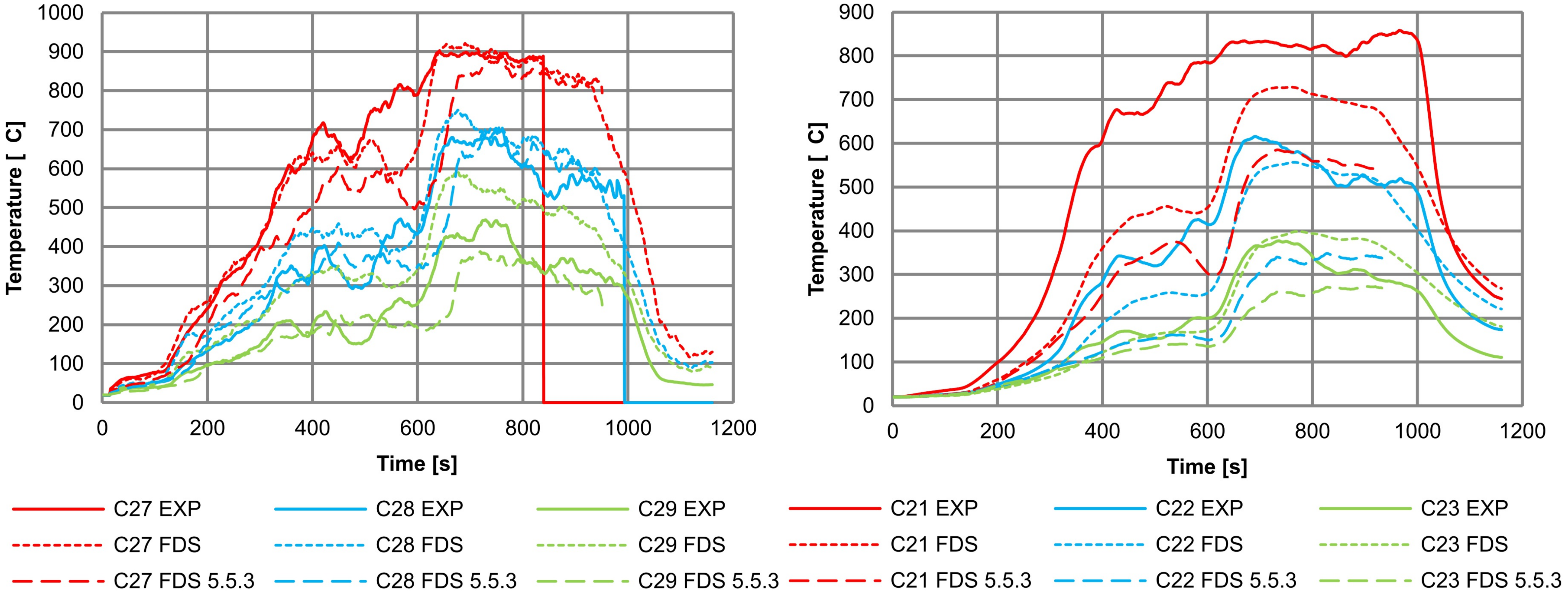
Grid sensitivity, $\dot{q}''_{IRHF}$



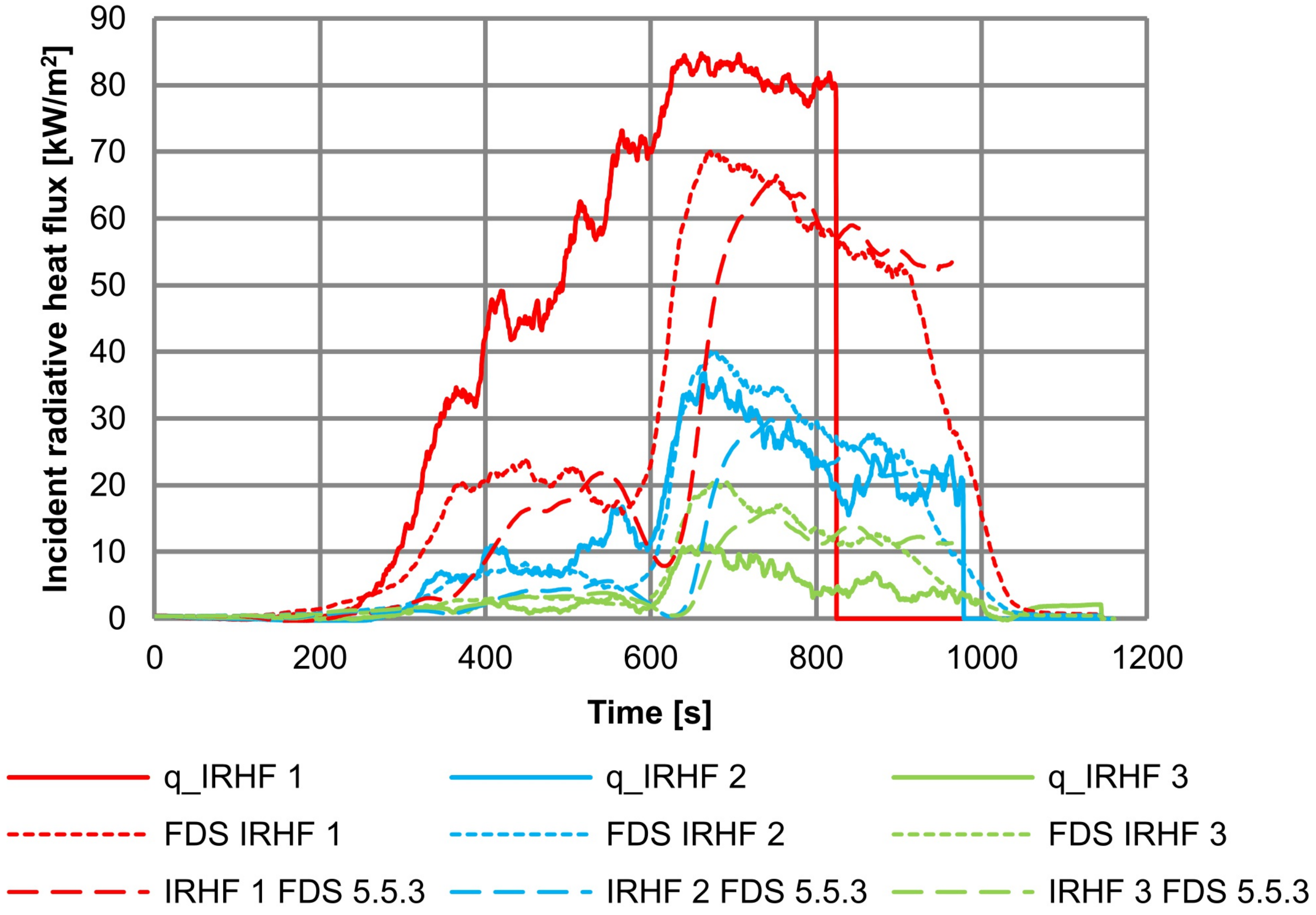


FDS 6.2.0 vs FDS 5.5.3

FDS 6.2.0 vs FDS 5.5.3, temperature



FDS 6.2.0 vs FDS 5.5.3, $\dot{q}''_{IRHF}$



Conclusions

- FDS 6.2.0 generally produce higher temperatures and $\dot{q}''_{IRHF}$ for the given setup compared to FDS 5.5.3
- FDS 6.2.0 produce results that are more in line with the test results compared to FDS 5.5.3
- To obtain credible results particularly close to the fire, a mesh resolution $D^*/\delta x$ of at least 30 is needed.
- Plenty of heat flux outputs in FDS – inadequate descriptions – confusing for the ordinary FDS-user
- T_{AST} can be used as an alternative means of expressing the thermal exposure to a surface in FDS

Thank you for listening