# Validating FDS Against a Large Scale Fire Test

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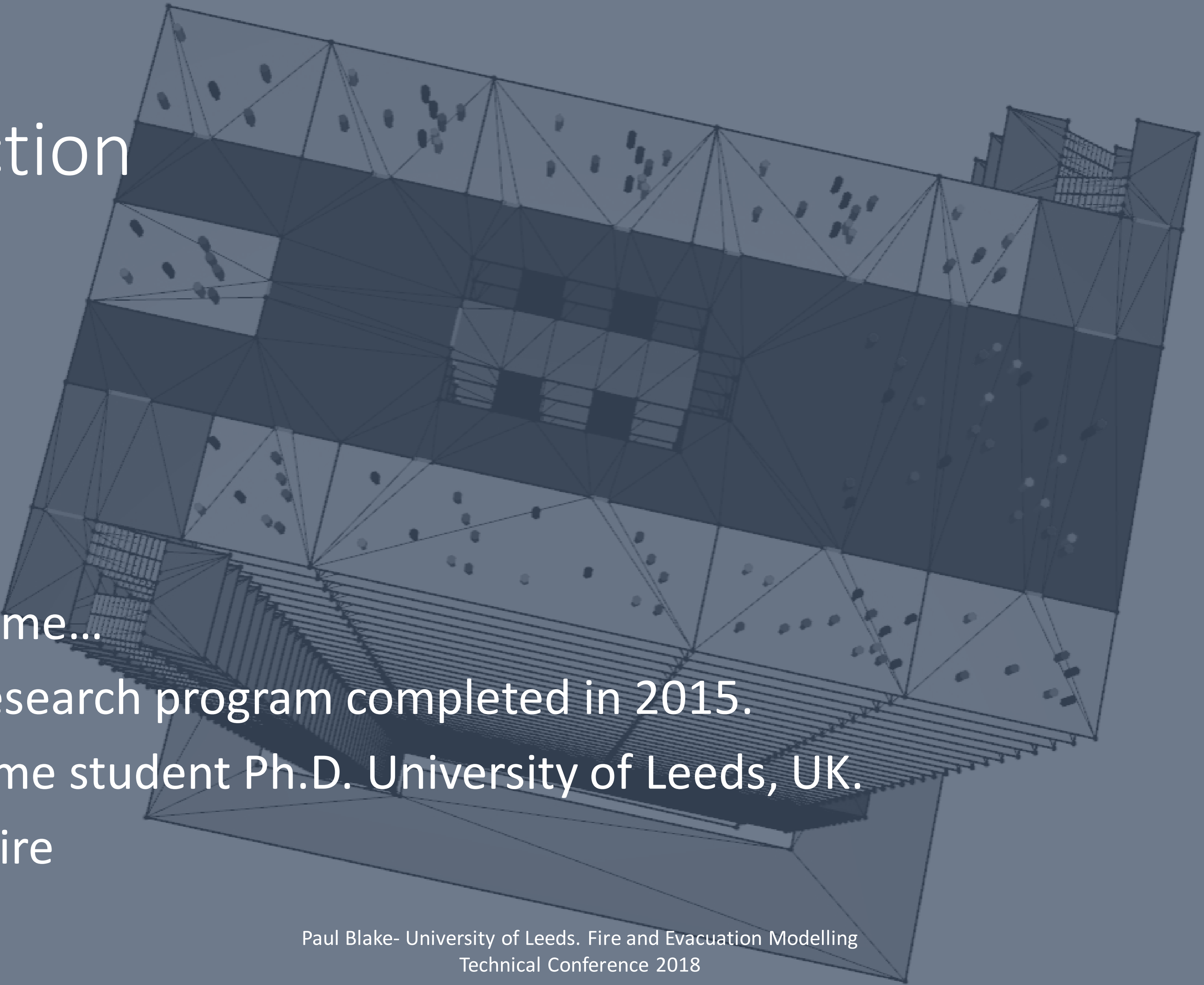
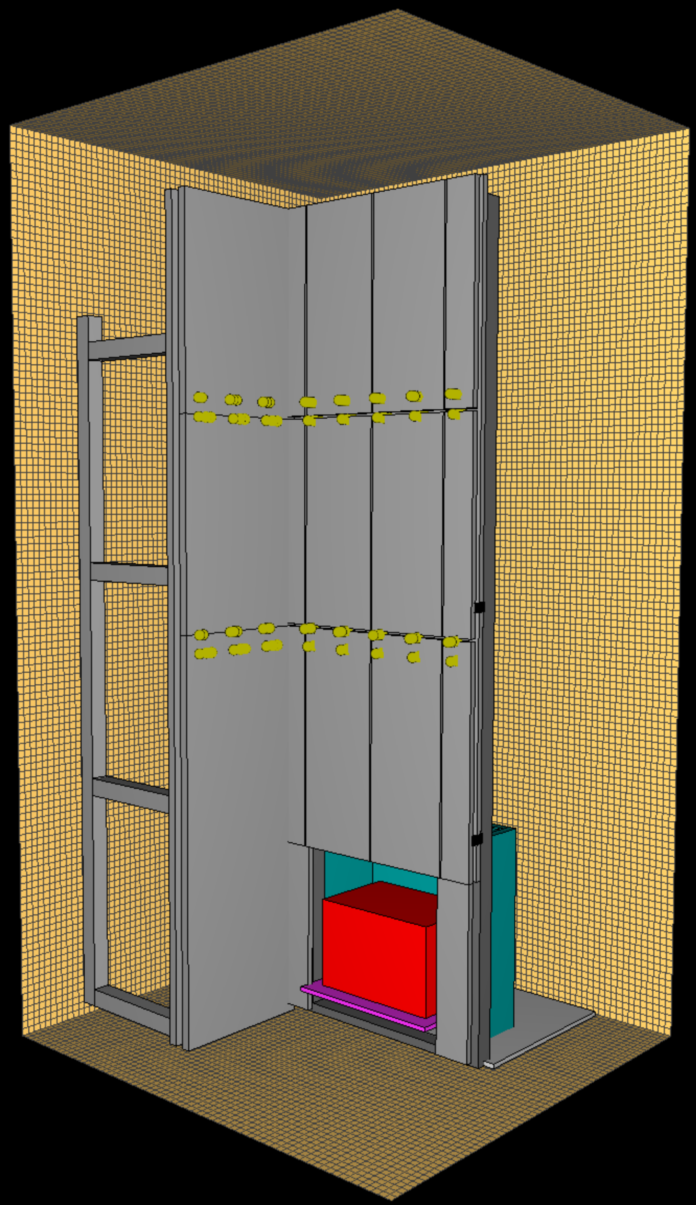
# Introduction



- About me…
- MSc research program completed in 2015.
- Part-time student Ph.D. University of Leeds, UK.
- Altor Fire



# Today…

- Replicate a full scale fire test in FDS 6.2.0
- Compare the material backing functions in FDS 6.2.0;
  - Void
  - Exposed
  - Insulated

# My ongoing research aims……

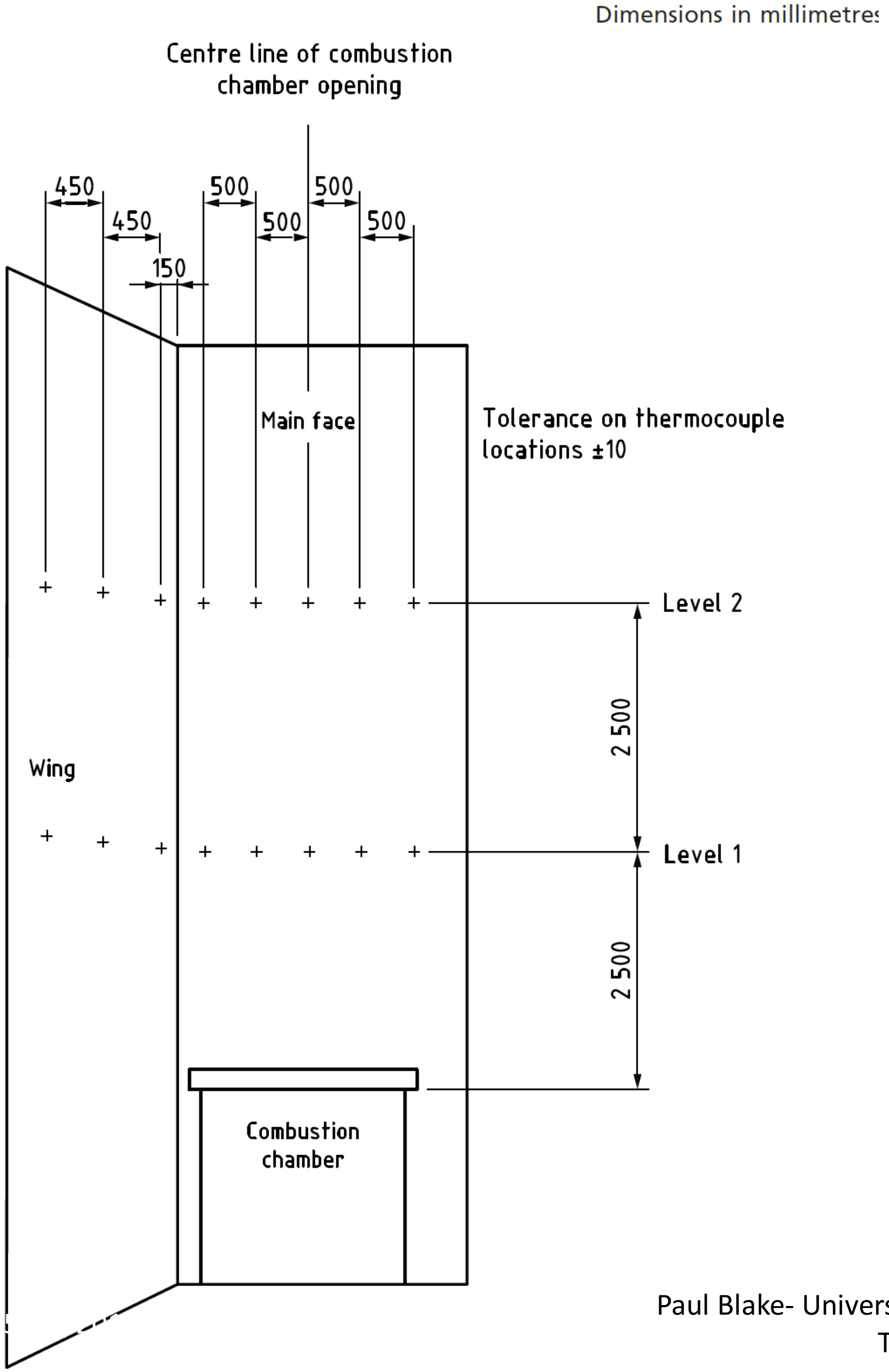
- Fire testing of external walling materials, conducted at the University of Leeds, then replicate the test results in FDS 6.2.0.
- Quantify the Heat Release Rate (HRR) of a full height fire. Determining if there is a correlation between the visible flame height of a fire height fire and the heat release rate.
- Use CFD (FDS) to accurately model the conditions that are evident during a full height fire.
- Assess the current fire test standards for external walling systems against actual fire conditions in tall buildings.
- Design evacuation models that can be applied to the conditions of a full height fire at the building including a simultaneous evacuation of buildings not designed for such a procedure.

# A Full Height Fire…

- External floor-to-floor travel
- Internal fire spread: ineffectual compartmentalisation
- Combustible external surfaces

The Tall Building Fire Safety Network

# External Walling Systems (Facades)




# BS8414-1:2015
# Full scale fire test

*Fire performance of external cladding systems. Test method for non-loadbearing external cladding systems applied to the masonry face of a building.*

- Main face (>2600mm x >6000mm)
- Wing face (>1500mm x >6000mm)
- Combustion chamber (2000mm)
- Wood crib fire
- Level 1 and Level 2 thermocouples
- 1800 seconds duration of test
- Narrative taken

# Test criteria….

The performance criteria and for the failure of a test is defined in BR 135;

*"Fire performance of external thermal insulation for walls of multi-storey buildings, third edition".*

and is as follows;

- The fire spread start time defined as the time when the temperature measured by an external thermocouple as Level 1 exceeds $200^0$C above ambient.
- A failure occurs due to external fire spread is determined when an external thermocouple at Level 2 exceeds $600^0$C for at least 30 seconds within 15 minutes of the fire spread start time.
- A failure due to internal fire spread is determined when any internal thermocouple at Level 2 exceeds $600^0$C above ambient temperature for at least 30 seconds within 15 minutes of the fire spread time.

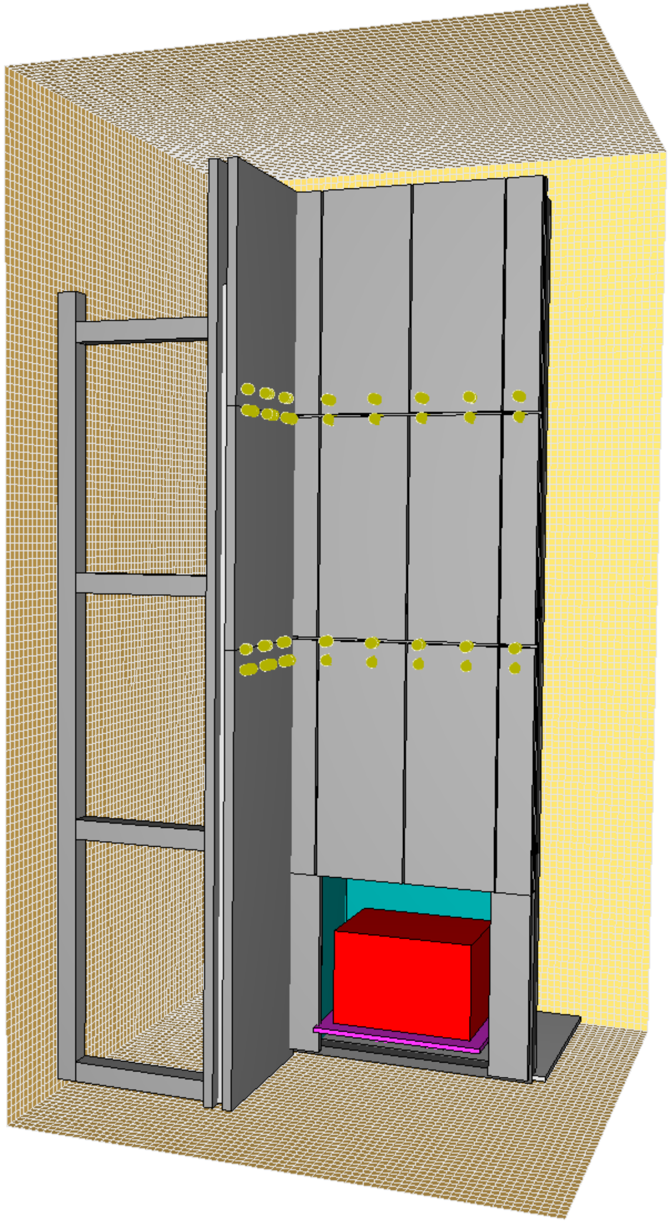
# BRE-DCLG Test-1 Results

Polyethylene (PE) cladding core
Polyisocyanurate (PIR) insulation

| Parameter | Result |
|---|---|
| $T_s$ Start temperature | 18.4$^0$C |
| $t_s$ Start time | 130 seconds after the ignition of the crib |
| Peak temperature/time at Level 2, External | 813.9$^0$C at 390 seconds after $t_s$ |
| Peak temperature/time at Level 2, Cavity | 410.4$^0$C at 380 seconds after $t_s$ |
| Peak temperature/time at Level 2, Insulation | 218.4$^0$C at 380 seconds after $t_s$ |

# Setup in FDS

- Thermocouples.
- Inside wall temperature devices.
- Heat Release Rate Per Unit Area: 2100kW.
- Mesh size is defined by the "EXPOSED" function.
- Surface front adjusted.



# Conductive Heat Flux in FDS (Eq1)

$$\dot{q}_c'' = h(T_g - T_w)$$

Where;

*h* is the convective heat transfer coefficient

$T_g$ is the gas temperature

$T_w$ is the surface wall temperature.

# Conductive Heat Flux in FDS (Eq2)

Where the radiation shape is unity, the radiative heat flux is given by:

$$\dot{q}_r'' = \varepsilon\sigma(T_w^4 - T_a^4)$$

Where:

- $\varepsilon$= emissivity
- $\sigma$= Stefan-Boltzmann constant (5.670x10-8 W/m$^2$·K$^4$)
- $T_w$= wall temperature
- $T_a$= ambient temperature

# Conductive Heat Flux in FDS (Eq3)

For steady state heat conduction through a uniform material with no internal heat generation, the conductive heat flux reads;

$$\dot{q}''_{conduction} = \frac{-k}{thick}(T_{back} - T_{front})$$

Where:
$k$= conductivity
$thick$= thickness of the material
$T_{back}$= wall temperature (back)
$T_{front}$= wall temperature (front)

# Materials, Layers and Surfaces

| Material | Depth (mm) |
|---|---|
| **Cladding** | |
| Aluminium | 0.5 |
| Polyethylene (PE) | 3.0 |
| Aluminium | 0.5 |
| **Insulation layer** | |
| Polyisocyanurate (PIR) | 80 |
| Air | 80 |

- Void: Air gap, open to heat fluxes.
- Exposed: Heat can be conducted through the material.
- Insulated: No heat is lost from the rear of the material.

# Results

Most reactive
Next most reactive
Against the three surface backings

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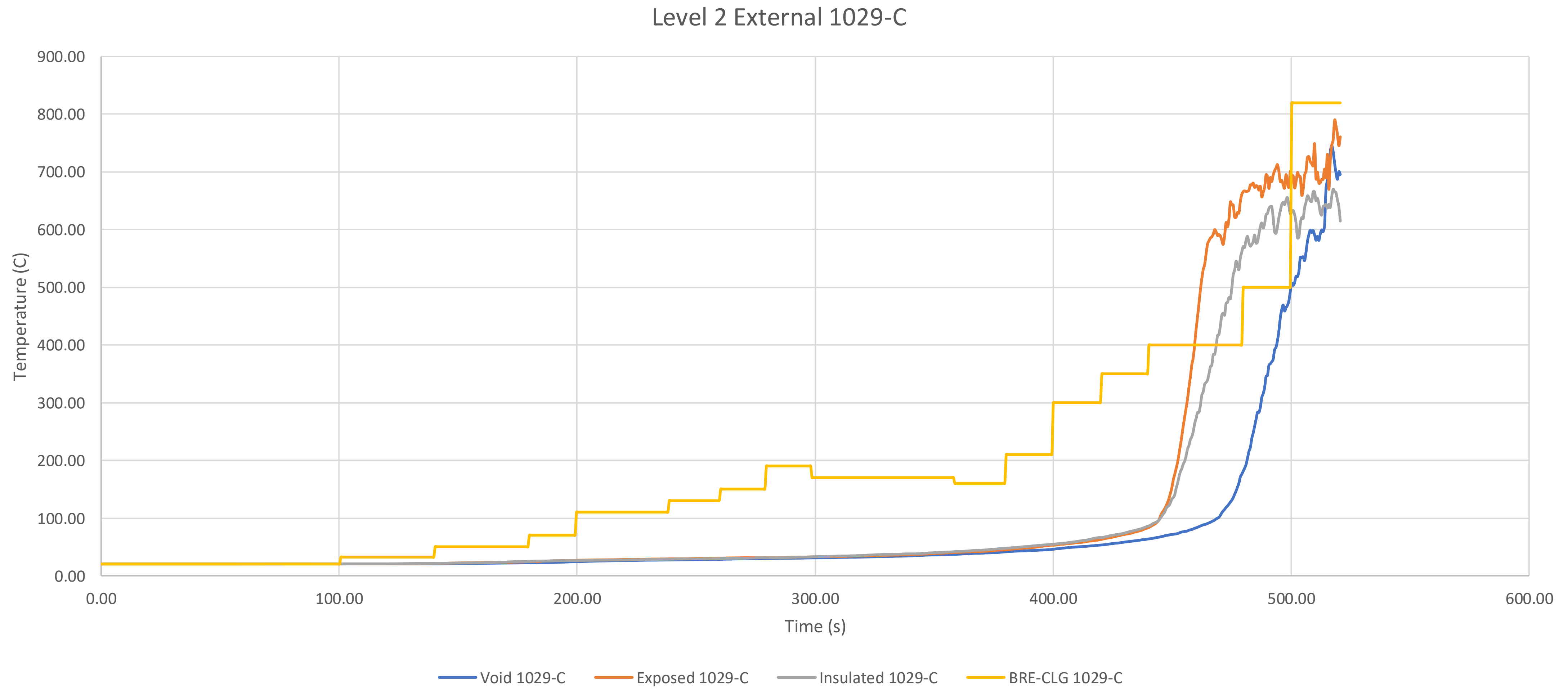
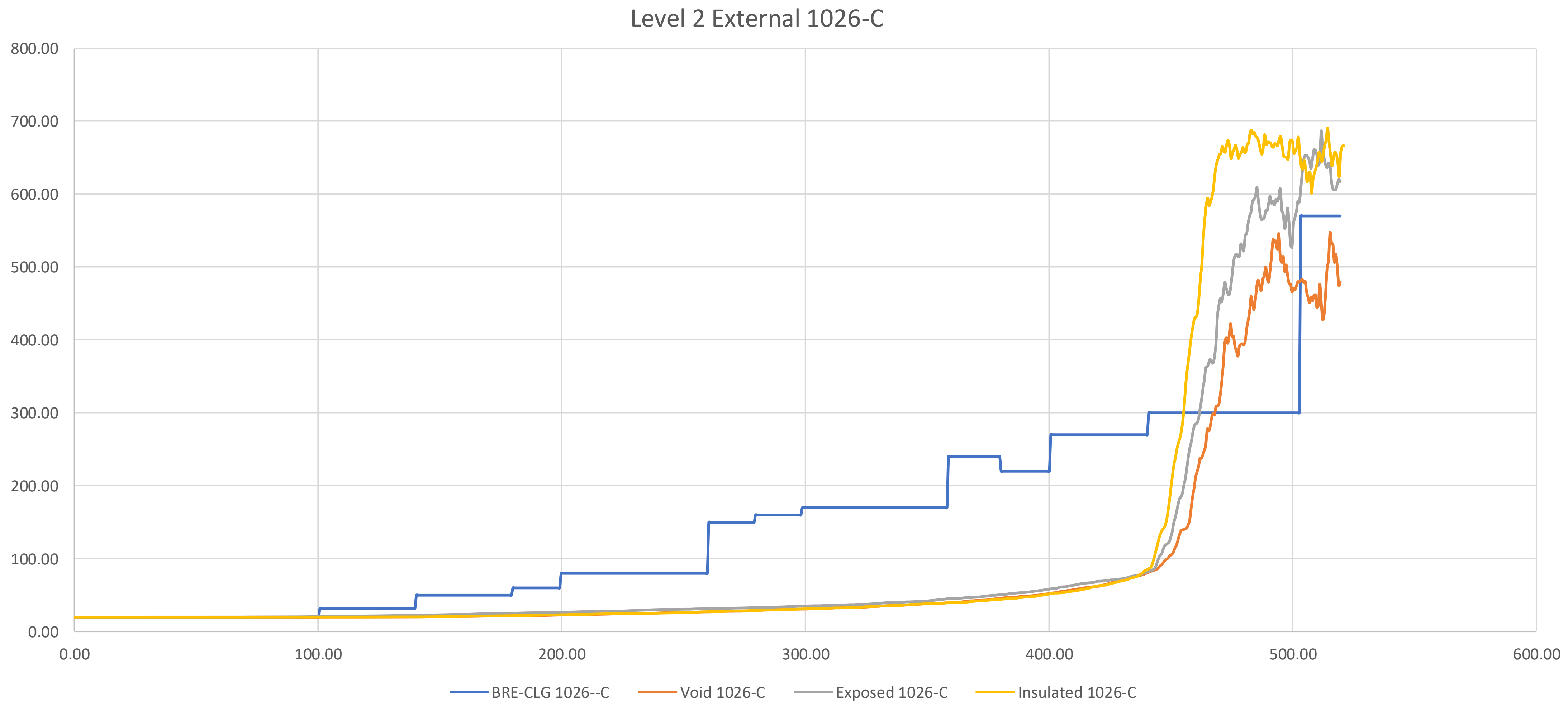
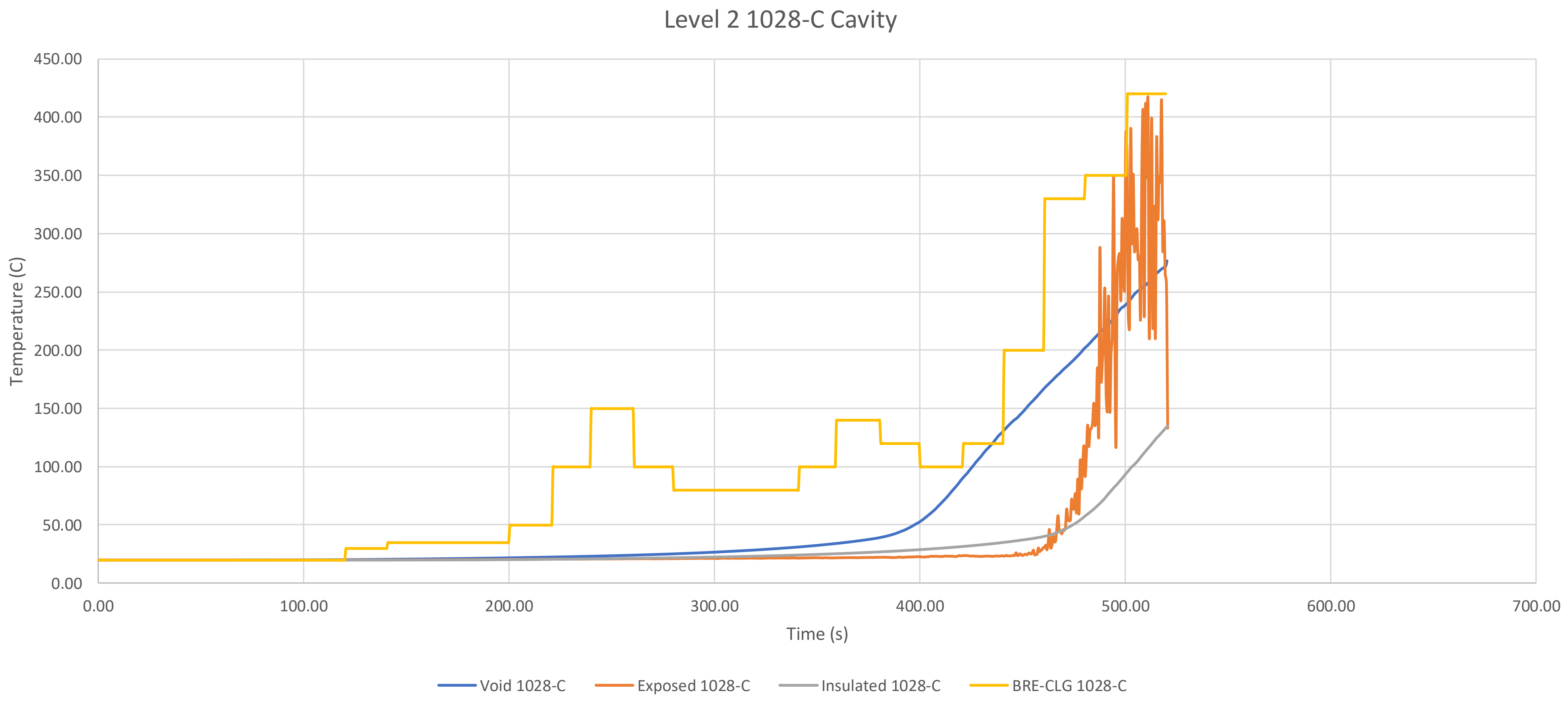
# Level 2– External: 1029-C



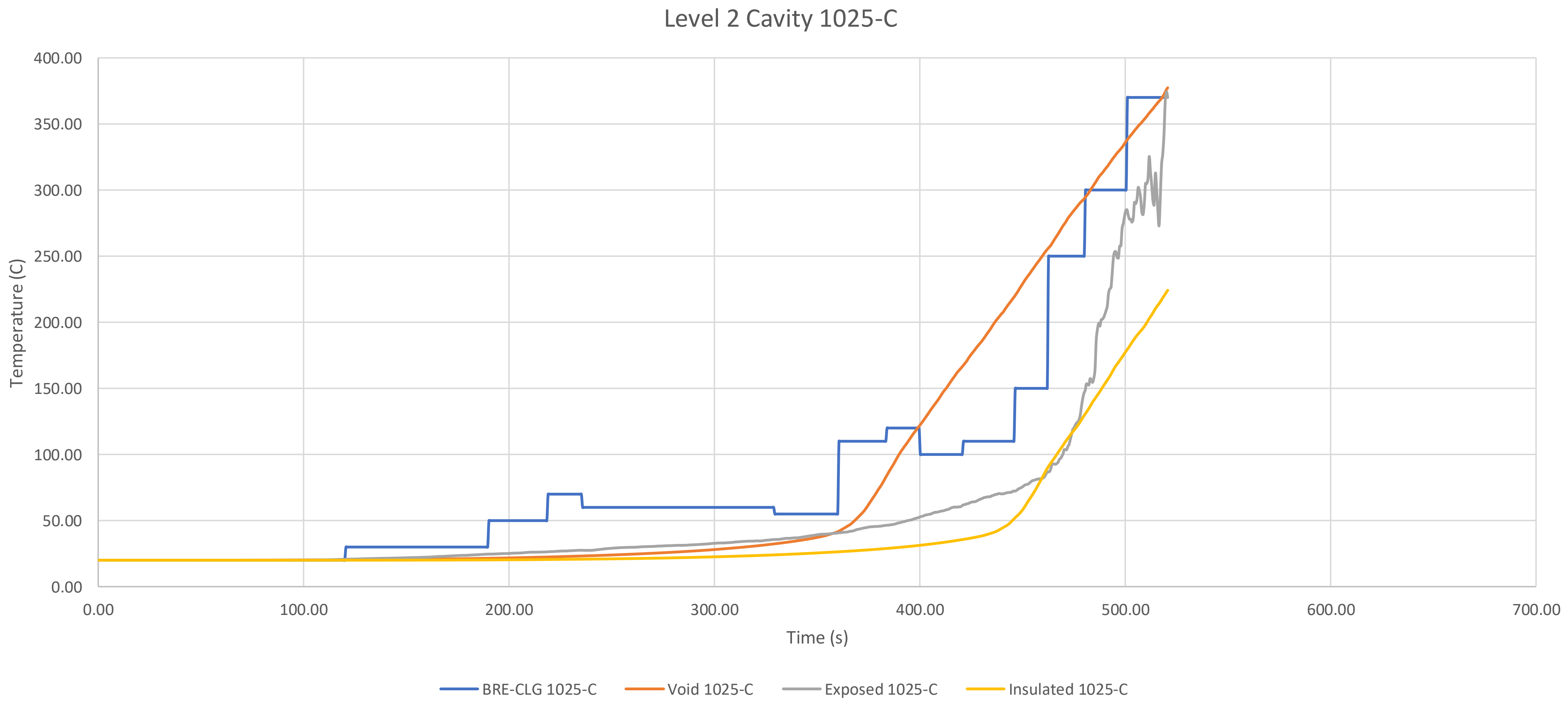
# Level 2– External: 1026-C



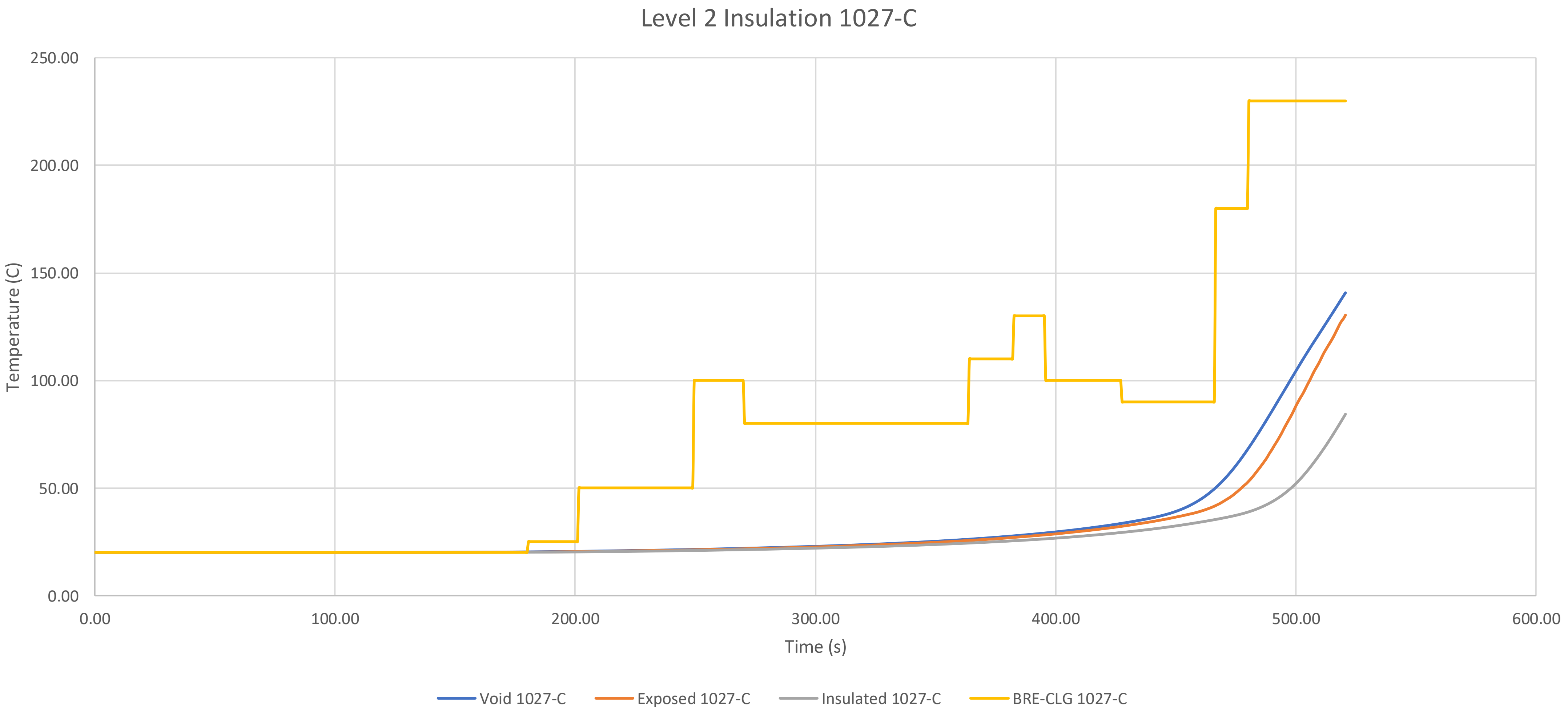
# Level 2- Cavity: 1028-C



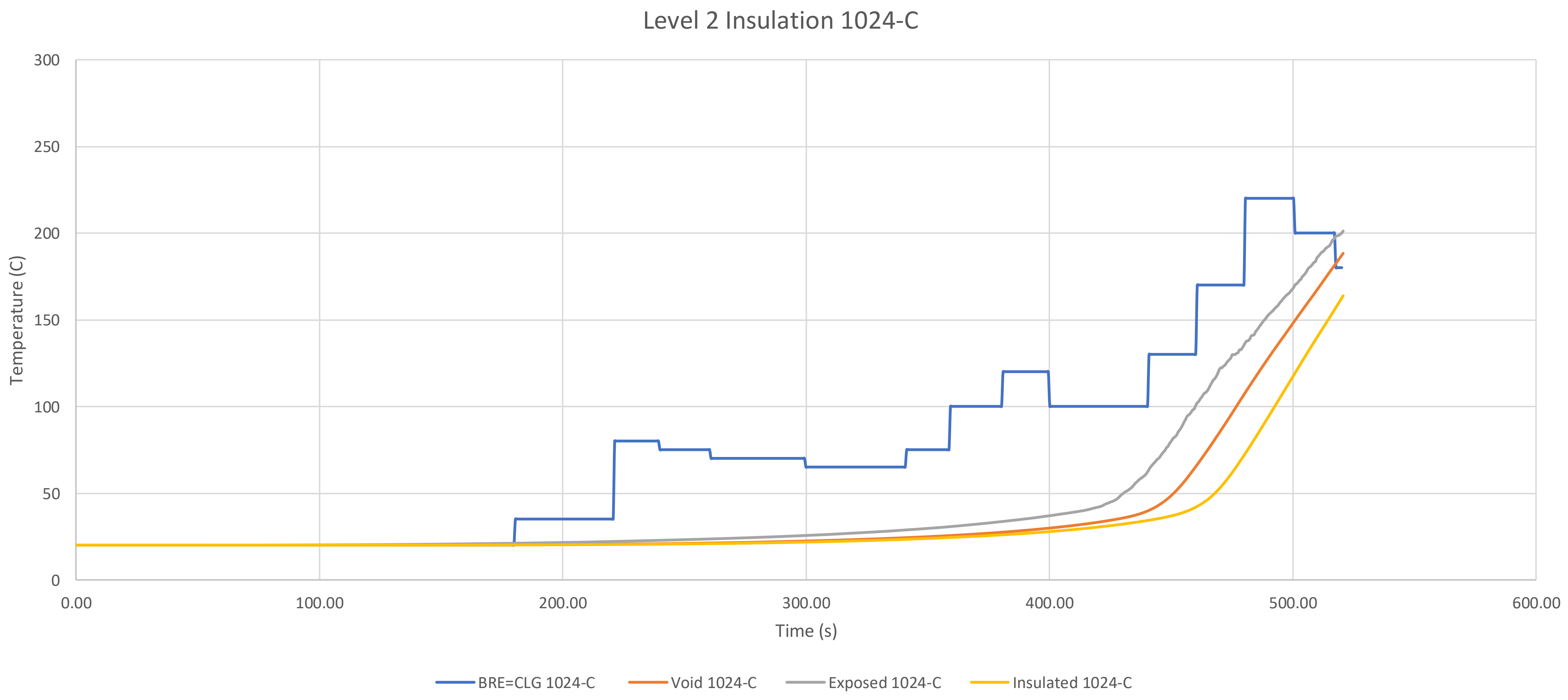
# Level 2- Cavity: 1025-C



# Level 2- Insulation: 1027-C



# Level 2- Insulation: 1024-C



# Conclusion & Progression

- The result of the modelling is based on a single test.
  - Modelling against a fixed temperature
  - Will complete the BRE-DCLG test reports
- Not all Polyethylene's are created equal.
- Adjustments to the ramp-up time.
- The insulation and cavities are hard to replicate post test.
- Void and Exposed material backing.
- Air channels

Any questions?

# Thank you