# The Effect of Applying Auto Ignition Temperature in FDS Simulation


By

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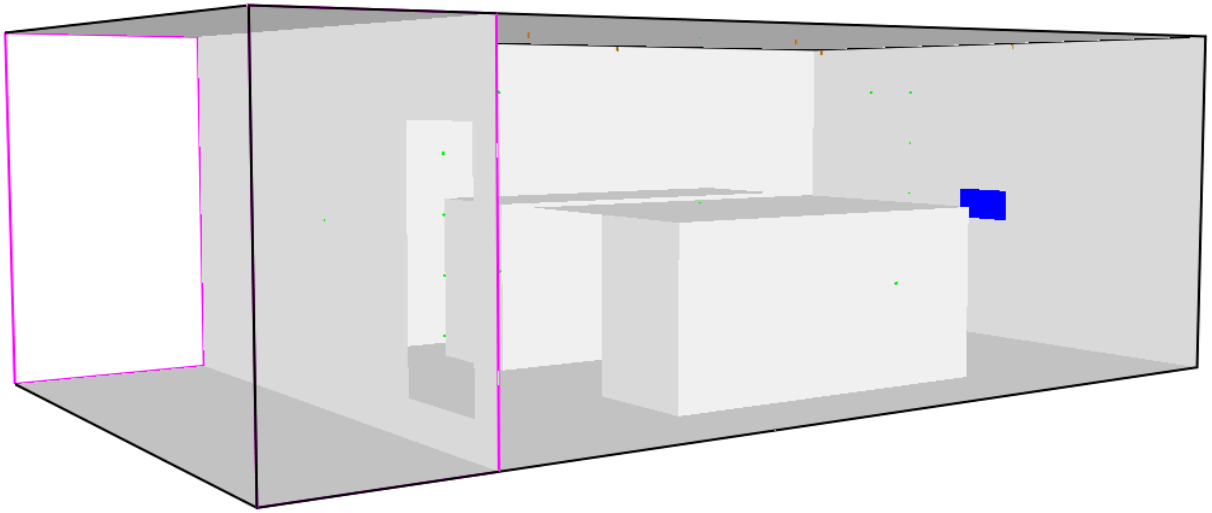
# Background

- FDS ability to predict extinguishing seems insuffisient.
- Auto Ignition Temperature(AIT) is by default zero Kelvin in FDS.
- The criteria for extinguishing is temperature and available fuel.
- Problem occurred during the master thesis.

# USCG - Case Study: Set Up

- The room is 7 m x 5 m x 3 m, a volume of 105 $m^3$
- Engine mook up, two engine block, one with a plate where the fire is beneath.
- 1 MW heptane spray fire



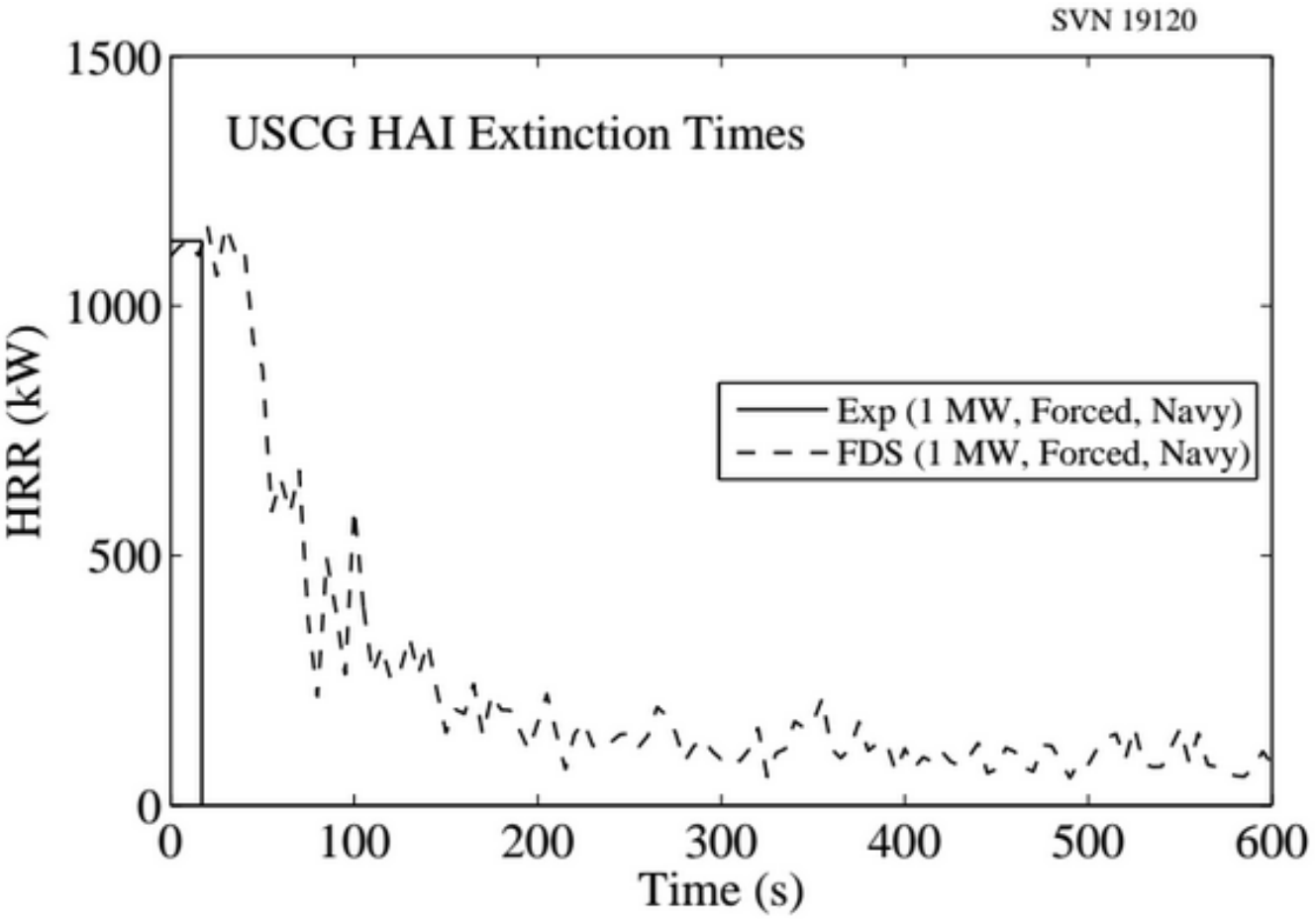
Blue square is the ventilation fan, there is an open door in the front.

# USCG - Case Study: Result of The Test

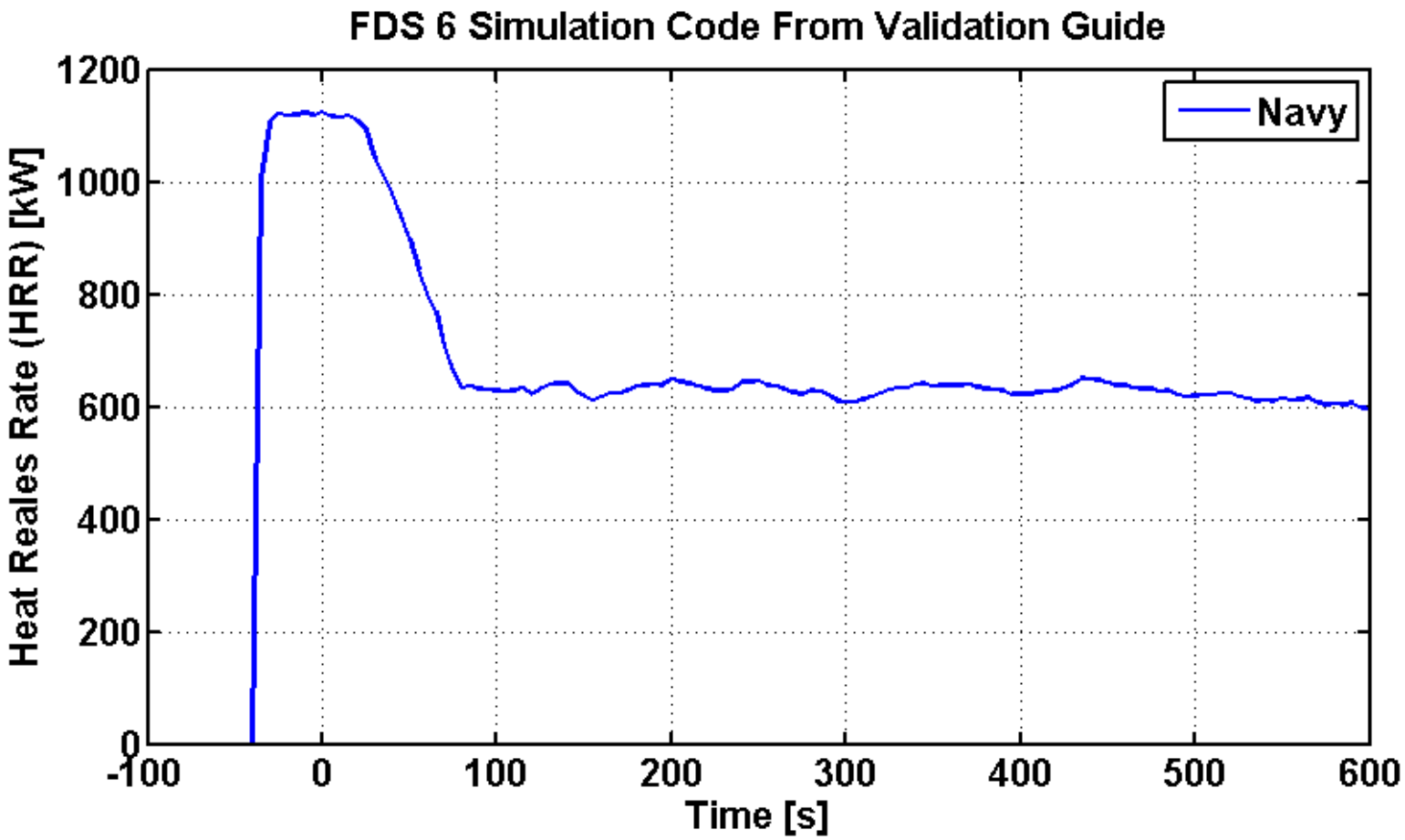
| System | | Navy | Grinnell | Fogtec | Chemetron | Fike |
|---|---|---|---|---|---|---|
| Number of Nozzles | | 6 | 6 | 6 | 15 | 6 |
| Operating Pressure (bar) | | 70 | 13 | 100 | 12 | 21 |
| Flow Rate (L/min) | | 68 | 75 | 22 | 70 | 48 |
| Assumed Median Drop Size ($\mu$m) | | 175 | 225 | 100 | | 200 |
| Assumed Initial Velocity (m/s) | | 75 | 32 | 90 | | 41 |
| Assumed Spray Angle (deg.) | | 120 | 90 | 120 | | 90 |
| Fire Scenario | Ventilation | Extinguishment Time (s) | | | | |
| 1.0 MW Spray | Closed | 15 | 26 | 21 | 27 | 21 |
| 1.0 MW Spray | Natural | 15 | 40 | 32 | 43 | 35 |
| 1.0 MW Spray | Forced | 17 | 55 | 76 | 357 | 133 |
| 0.5 MW Spray | Closed | 34 | 70 | 39 | 53 | 56 |
| 0.5 MW Spray | Natural | 41 | 117 | 67 | 158 | 140 |
| 0.5 MW Spray | Forced | 124 | No | No | No | No |
| 0.25 MW Spray | Closed | 157 | 360 | 169 | 314 | 277 |
| 0.25 MW Spray | Natural | 206 | No | 290 | 525 | 566 |
| 0.25 MW Spray | Forced | No | No | No | No | No |

Table from FDS validation guide.

# FDS Version of The Simulation



# Simulation From FDS Code

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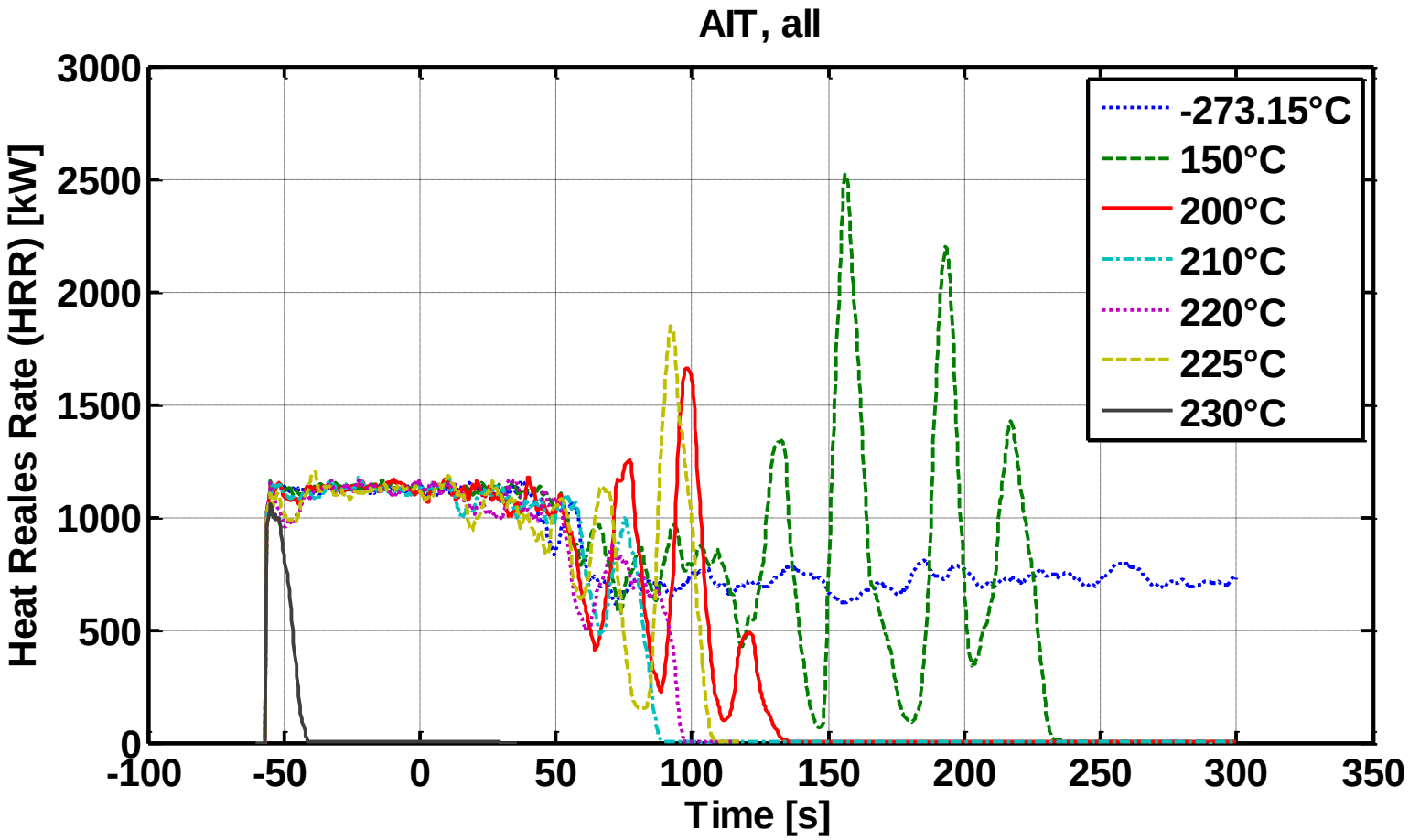
# Simulation With Change of AIT

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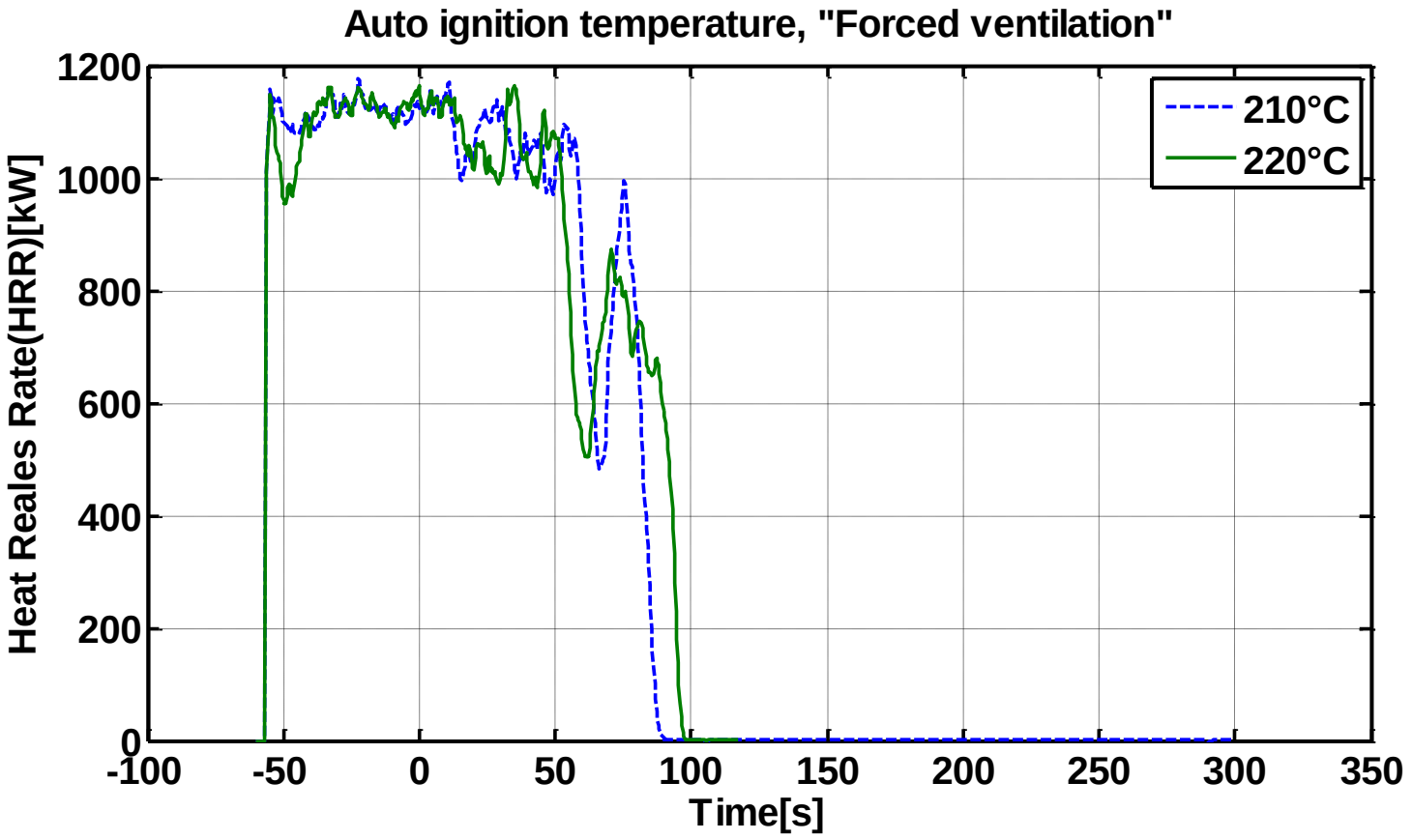
# AIT 210°C and 220°C

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# Extinction Time in FDS With AIT Applyed

- FDS did not predicted the extinction time very well.
  - FDS is a Fire Dynamic Simulator and does that pretty well.
  - FDS makes no representation that it is a good program to predict extinction.

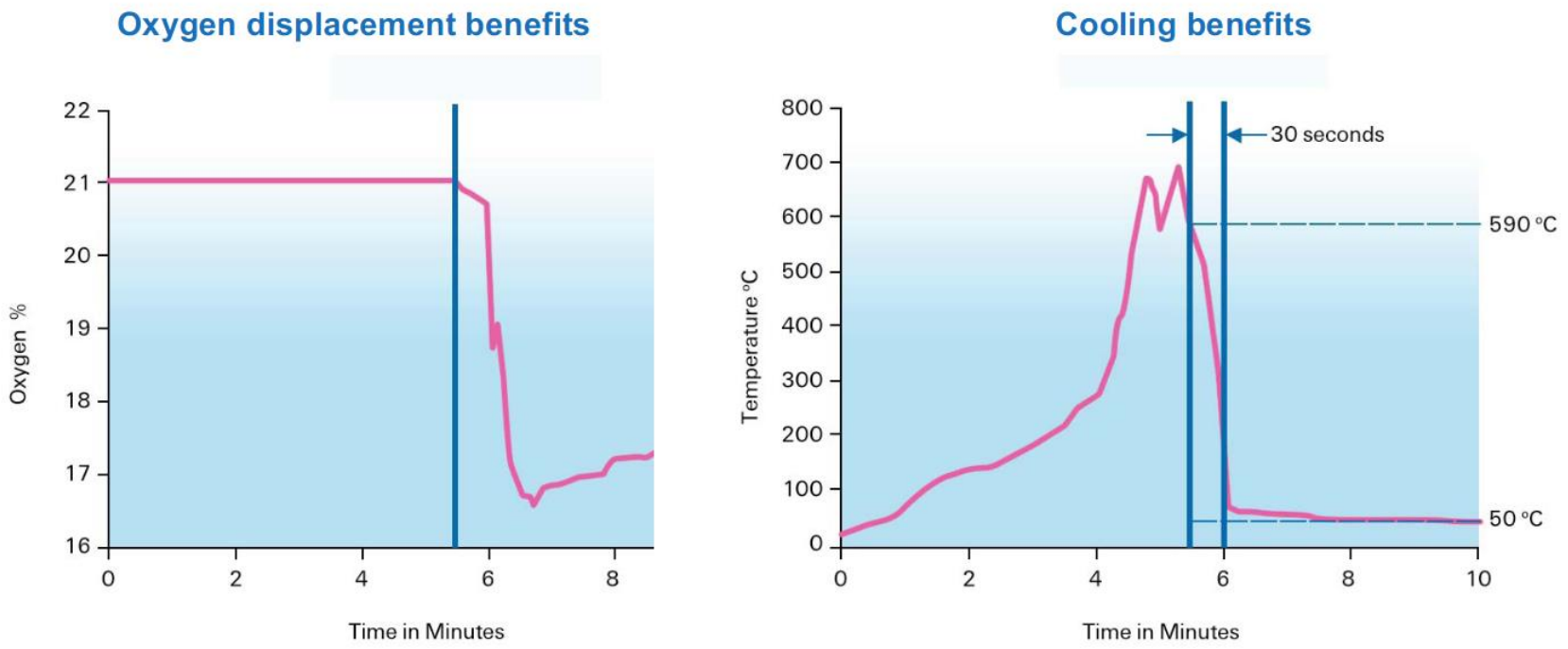
# Extinguishing Mechanism

- Strain:
  - The flow of the oxygen and fuel mixture become so high that combustion is not sustainable.
- Cooling:
  - This is the lower flame temperature. The energy released must be higher than the lowest possible heat release corresponding to the lower flame temperature. If the heat generated from the chemical reaction is too low it could not sustain combustion.
- Dilution:
  - When the oxygen/fuel mixture is to lean to burn.

# Water Mist

- The leading extinguishing mechanism in water mist is cooling
- Dilution give a contribution to extinguishing.

# Water Mist




The effect of oxygen displacement(dilution) vs cooling effect

*From: British Automatic Fire Sprinkler Association Ltd*

# Extinguishing Criteria in FDS

- If the cell temperature is below the AIT for all fuels in the cell, the combustion is suppressed.
- If the potential HRR from a local pocket of stoichiometric air-fuel-product can not raise the temperature in the pocket above the CFT(Critical Flame Temperature) , the combustion is suppressed.

# Extinguishing Criteria in FDS

$$\hat{Z}_F\left(h_F\left(T\right)+\Delta h_{c,F}\left(T\right)\right)+\hat{Z}_A h_A\left(T\right)+\hat{Z}_P h_P\left(T\right)<\hat{Z}_F h_F\left(T_{CFT}\right)+\hat{Z}_A h_A\left(T_{CFT}\right)+\hat{Z}_P h_P\left(T_{CFT}\right)$$

Basically this formula tells; Extinguishing occur when the temperature due to the HRR is lower than the CFT.

The FDS: Technical Reference Guide gives a short outline of this formula.

# Conclusion

- FDS can be used to predict extinguishing, but it is not straight forward.
- Applying AIT helps, but remember to Apply AIT for all fuel, or remove fuel(CO).