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# EVACUATION CONDITIONS IN SUBWAY STATIONS WITH PLATFORM SCREEN DOORS

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# INDEX

# 1.- Introduction

- Fire safety in subway stations ⟶ Big concern.
- Arson attacks in subway trains.
  - Firestarr Project ⟶ arson stated as the main cause of fire in rail and subway trains.
  - UK data: 2.911 fires in trains (from 1992 to 2000), 77,8% of which involving passenger trains ⟶ 56% due to arson attacks.
- Platform Screen Doors (PSD) ⟶ Effect on evacuation and safety?

# 1.- Introduction

- Platform Screen Doors (PSD).

# 2.- Subway stations

- Two kind of stations considered in this study:

  - Cut & Cover stations.

    Their main feature is their big volume ⟶ Escalators, stairs in the platform.
    Total volume: 135m (long) x 25,5m (wide) x 6,75m (high).
    Platform's surface: 135m (long) x 9m (wide).

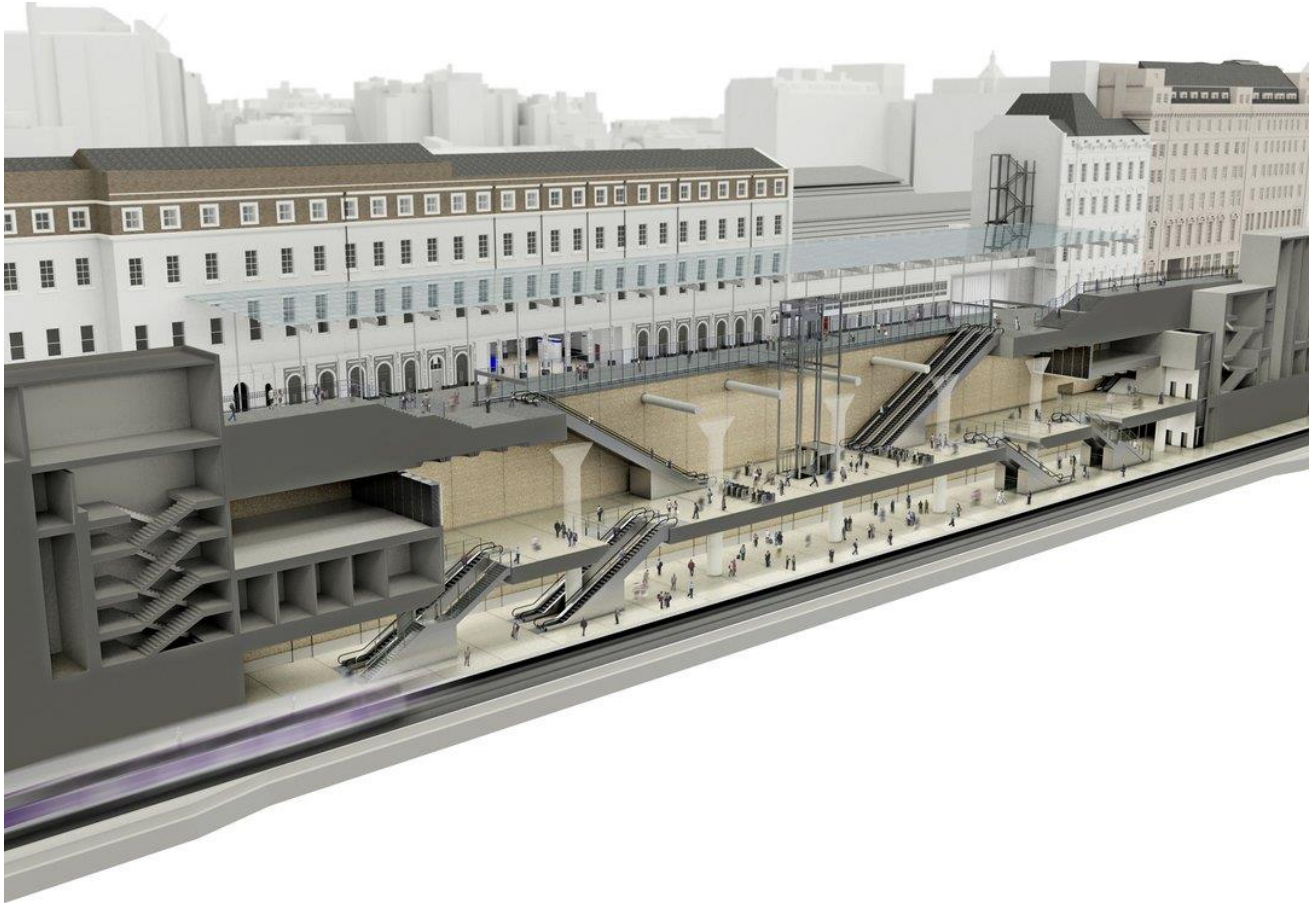
  - Cavern stations.

    Less volume than C&C ⟶ Escalators, stairs in access shaft and connected to the platform through passageways.
    Total volume: 135m (long) x 17m (wide) x 6m (high).
    Platform's surface: 135m (long) x 4,25m (wide).

# 2.- Subway stations

## 2.1.- Cut & Cover

- Cut & Cover station: Crossrail Paddington (London, UK)



# 2.- Subway stations

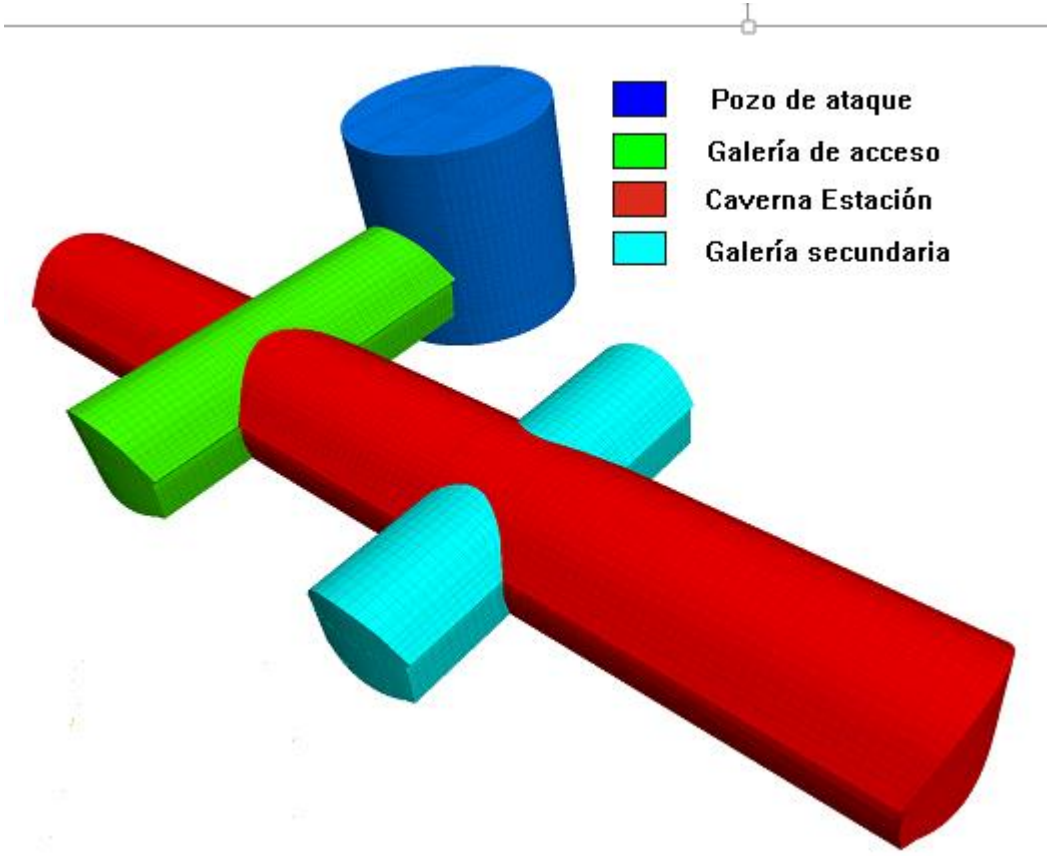
## 2.1.- Cut & Cover

- Cut & Cover station: Crossrail Paddington (London, UK)

# 2.- Subway stations

## 2.2.- Cavern

- Cavern station: design concept of Cavern stations in Line 6 subway in Santiago, Chile



# 2.- Subway stations

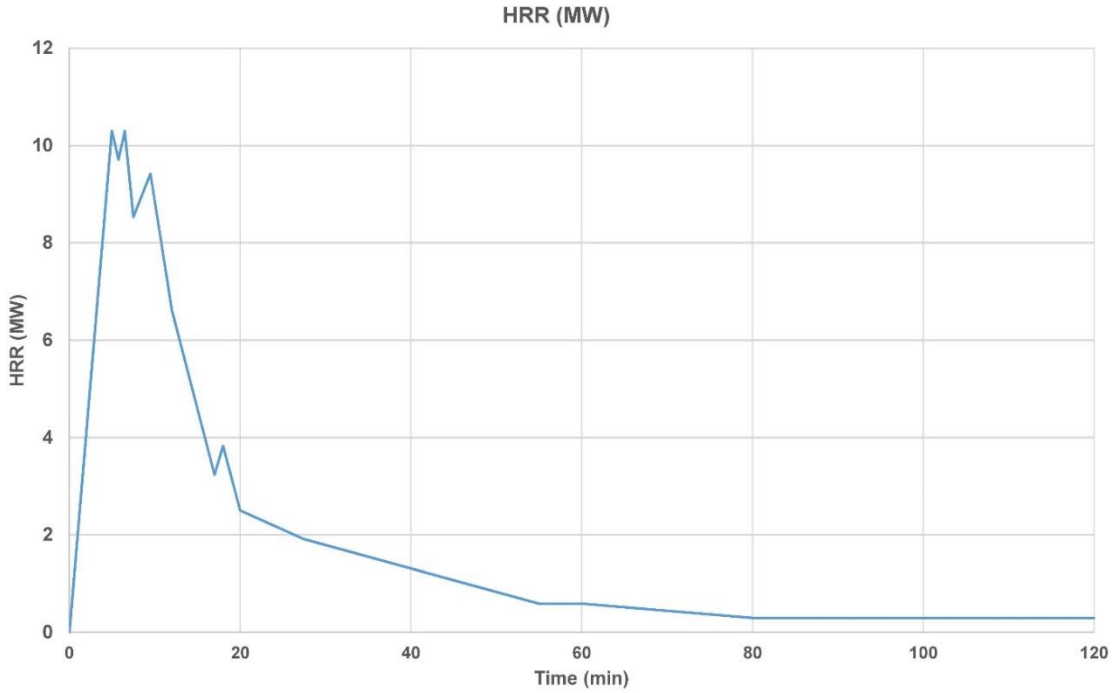
## 2.2.- Cavern

- Cavern station: Chueca station's platform in Line 5 (Madrid, Spain)

# 3.- Modeling of the fire event

## 3.1.- HRR fire curve

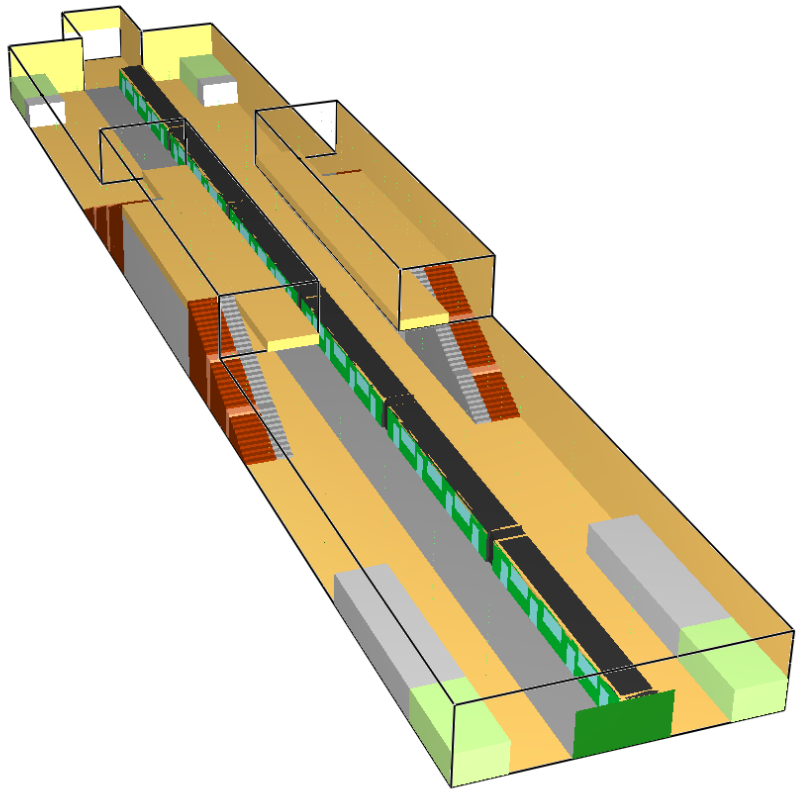
- HRR fire curve: Eureka project → Subway car.
- Reference documents: EN 45545, Subway Design Handbook, ASHRAE Handbook, Firestarr project.



# 3.- Modeling of the fire event

## 3.2.- Model for C&C and Cavern stations

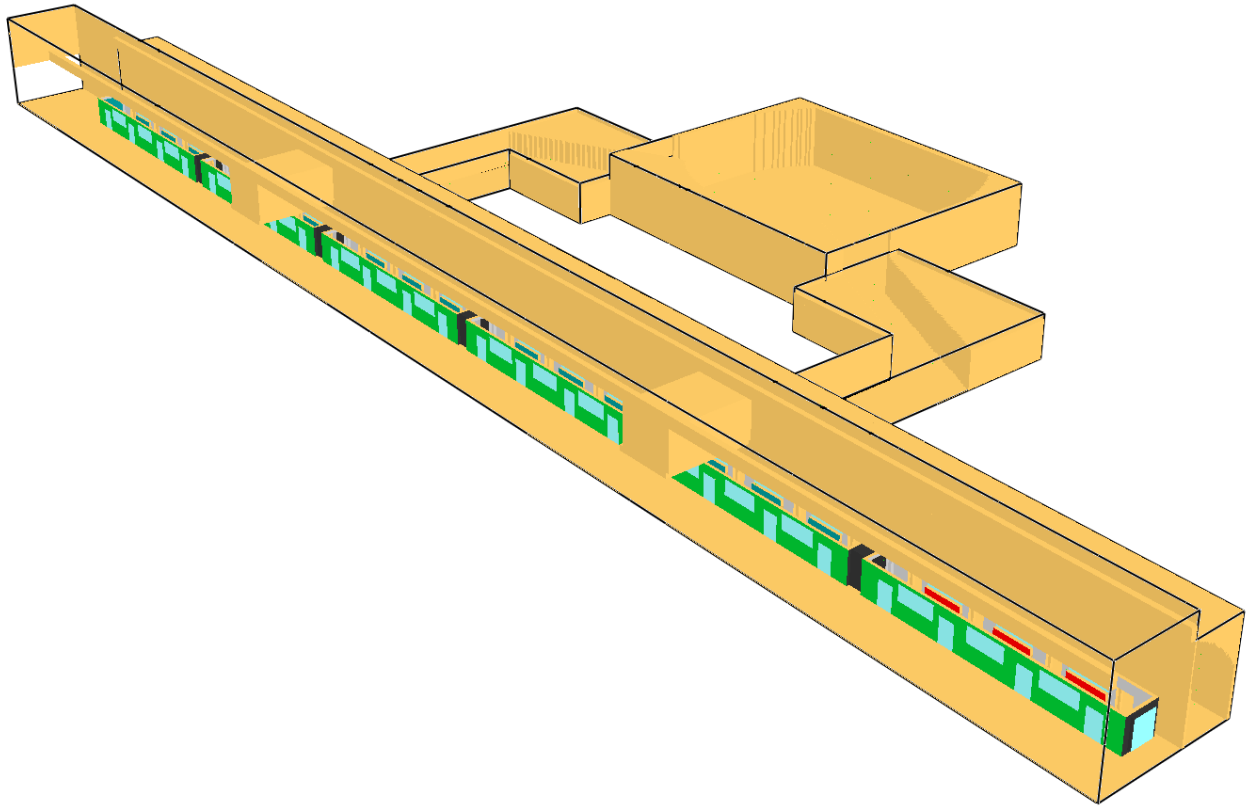
- Cut & Cover station



# 3.- Modeling of the fire event

## 3.2.- Model for C&C and Cavern stations

- Cavern station



# 3.- Modeling of the fire event

## 3.3.- Ventilation strategy

- Strategy A: with PSD
  - Exhaust ventilation from the station: 83,3 m3/s (CyC), 61,1 m3/s (Cavern)
  - Exhaust ventilation from the tunnel: 87,5 m3/s
  - It makes compatible exhausting from the station and from the tunnel simultaneously.
- Strategy B: without PSD
  - Exhaust ventilation from the tunnel: 87,5 m3/s.
  - Exhausting from the station and from the tunnel ⟹ not a good idea.

# 3.- Modeling of the fire event

## 3.3.- Ventilation strategy

- Strategy A: station in M5 subway line in Milan (Italy).

# 4.- Fire and evacuation simulations

- Fire simulation: reference standard → NFPA 130
  - Visibility: 10m (doors, walls).
  - Temperature: threshold time for incapacitation.
  - CO concentration: threshold time for incapacitation.

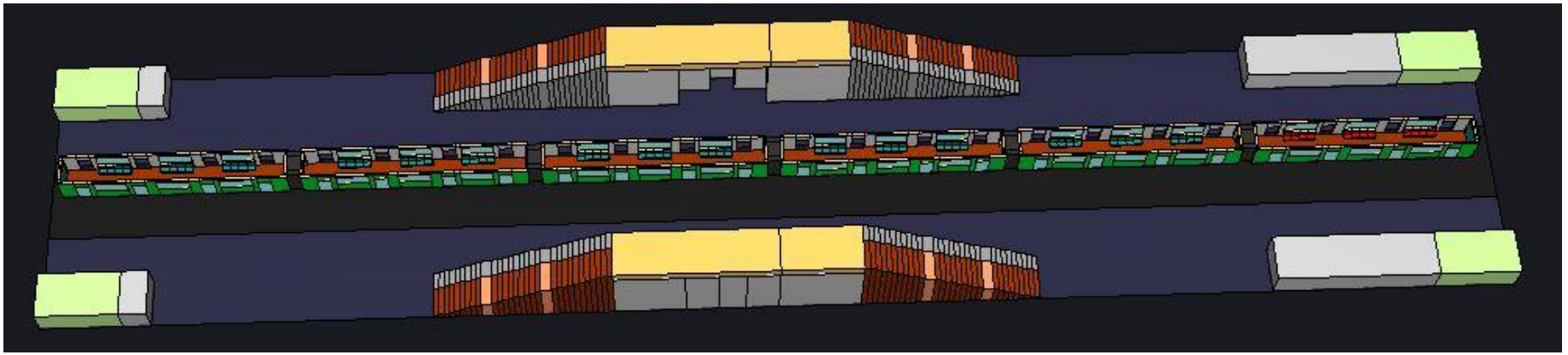
| Exposure temperature (ºC) | Without incapacitation (min) |
|---|---|
| 80 | 3.8 |
| 75 | 4.7 |
| 70 | 6 |
| 65 | 7.7 |
| 60 | 10.1 |

| Exposure CO content (ppm) | Without incapacitation (min) |
|---|---|
| 2000 | A few seconds |
| 1150 | 6 |
| 450 | 15 |

# 4.- Fire and evacuation simulations

## 4.1.- Cut & Cover stations

- Model created with Pyrosim.

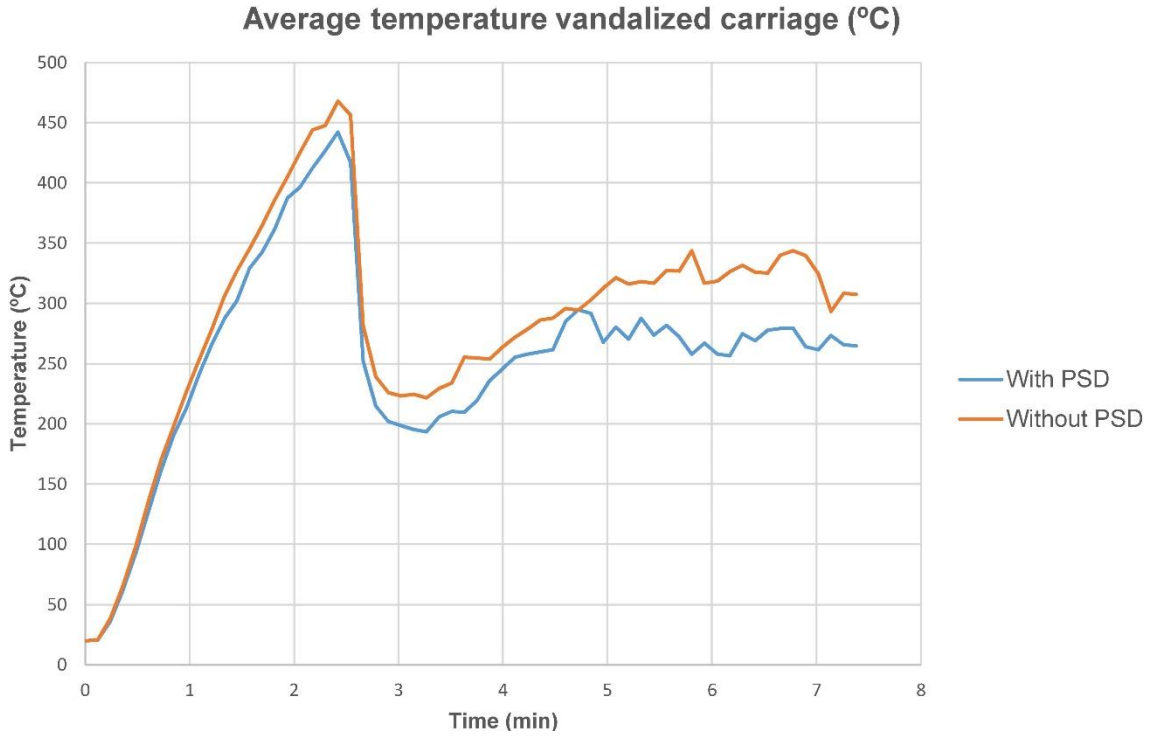


- Means of egress on each platform:
  - Emergency door on the right side.
  - Escalator + stairs on the right side.
  - Escalator + stairs on the left side.
  - Emergency door on the left side.

# 4.- Fire and evacuation simulations

## 4.1.- Cut & Cover stations

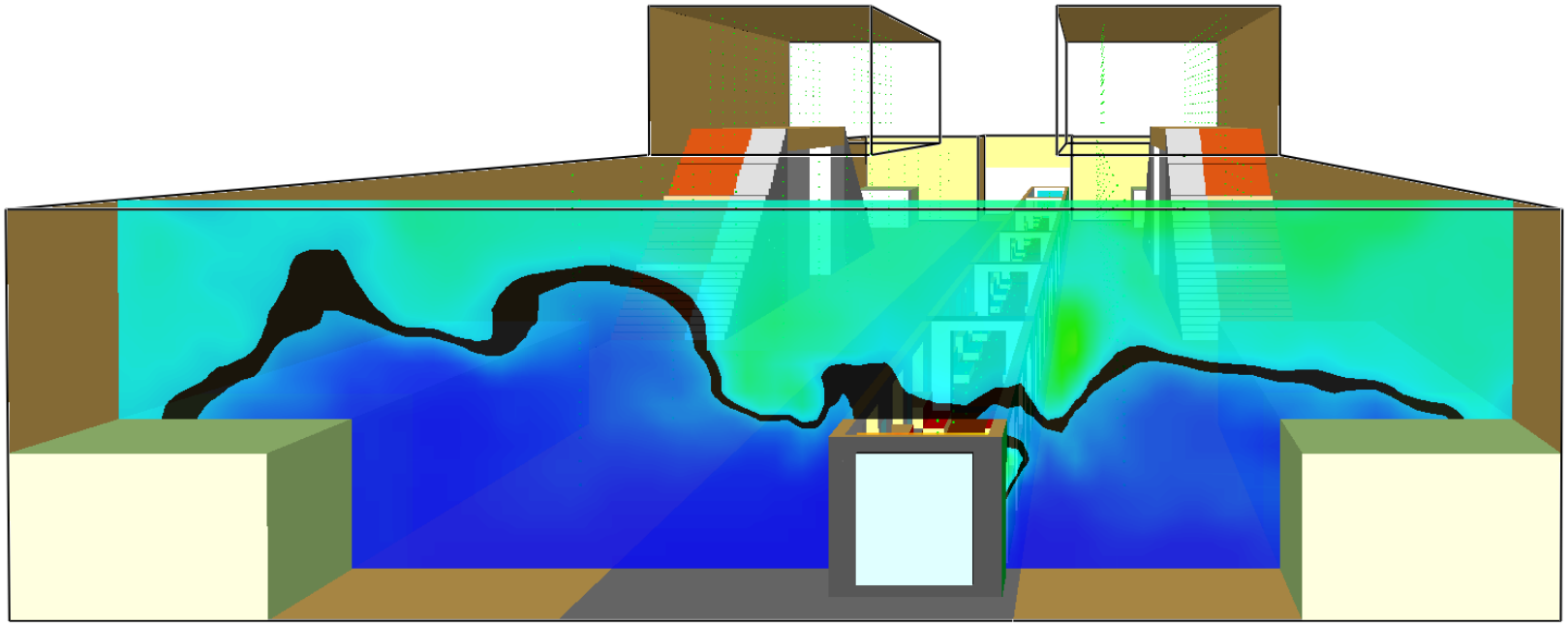
- Development of the fire.
  - The fire starts on the last carriage on the right.
  - Each carriage is connected to each other.
  - Each carriage has 6 windows, 3 per side, which break out when T=470ºC.



# 4.- Fire and evacuation simulations

## 4.1.- Cut & Cover stations

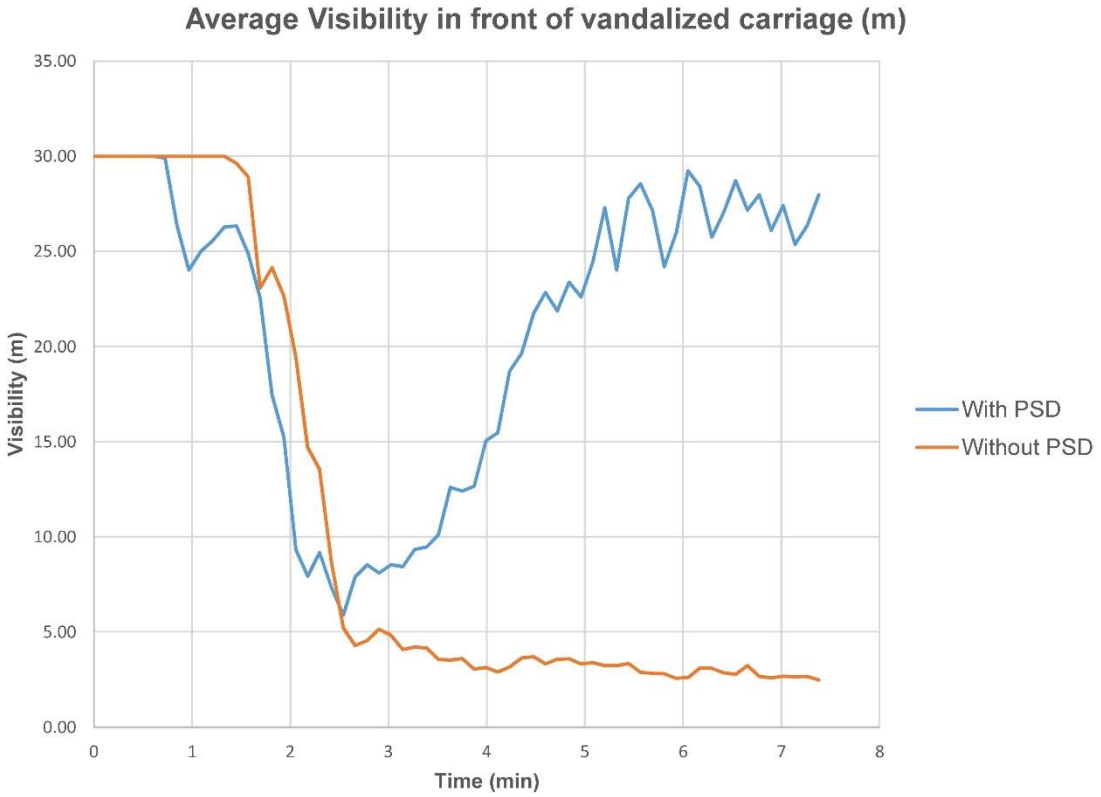
- Development of the fire.
  - Buoyancy: the smoke heads toward the upper part of the station (no PSD).
  - Figure: Temperature levels (t=6min, 80ºC in bold).



# 4.- Fire and evacuation simulations

## 4.1.- Cut & Cover stations

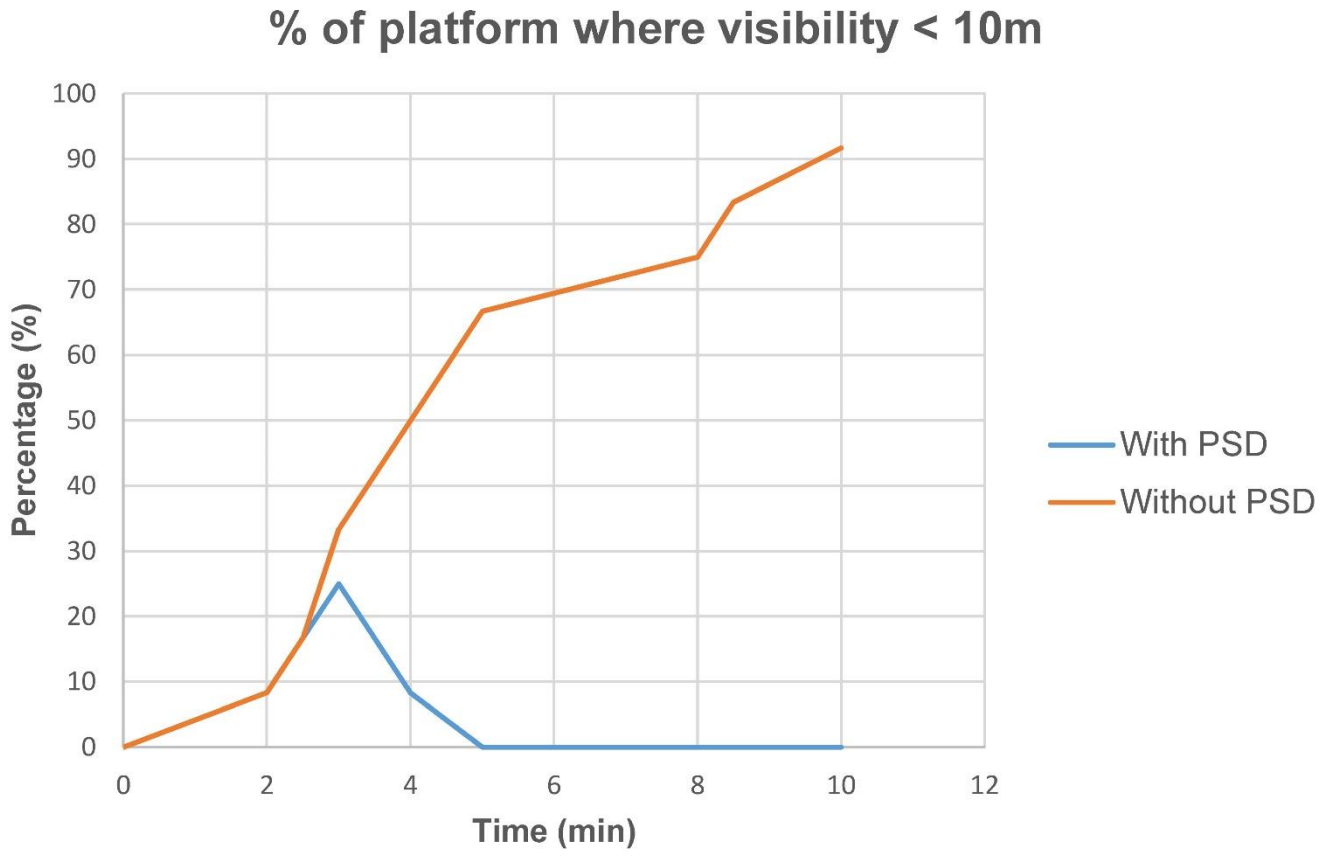
- Development of the fire.
  - Highest T users face: 80ºC in the stairs (no PSD), 80ºC close to PSD (with PSD).
  - Visibility: great differences, especially in front of the vandalized carriage.



# 4.- Fire and evacuation simulations

## 4.1.- Cut & Cover stations

- Development of the fire.
  - Visibility: great differences all along both platforms during the fire.



# 4.- Fire and evacuation simulations

## 4.1.- Cut & Cover stations

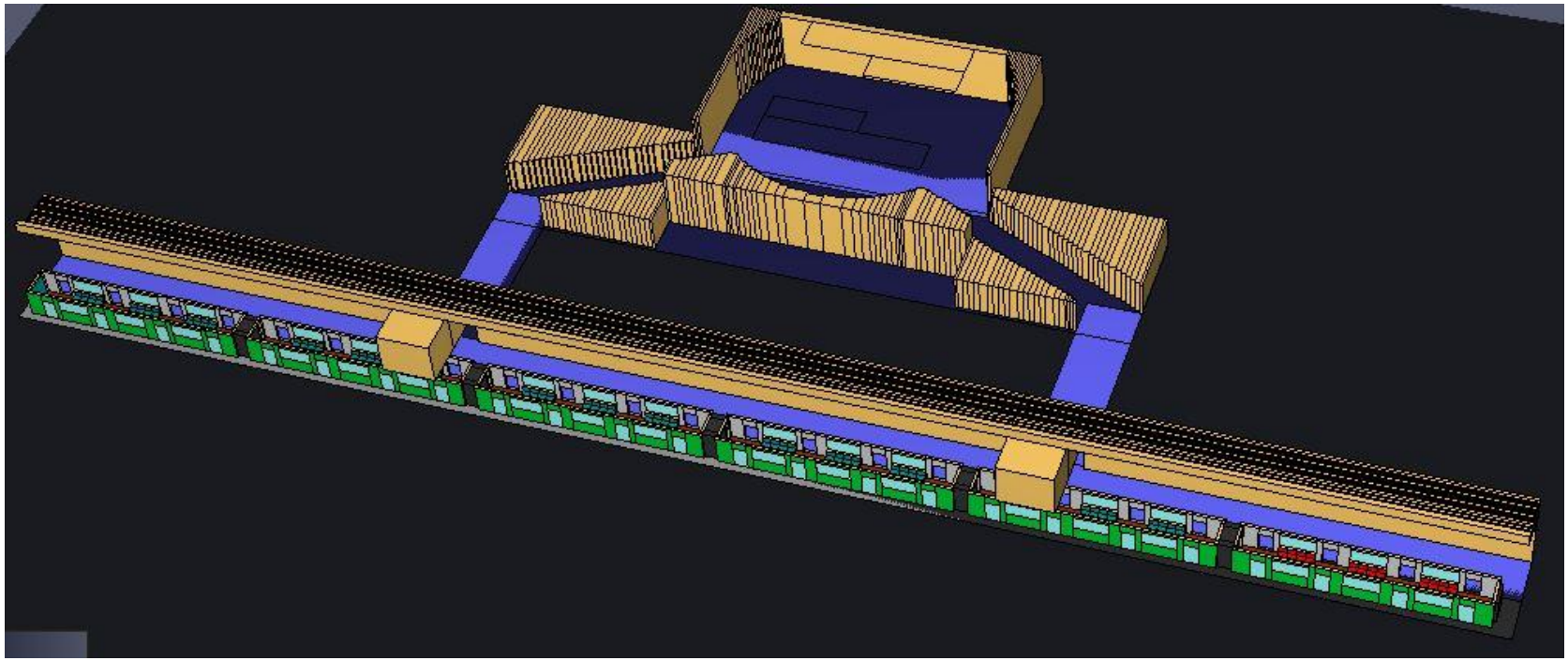
- Evacuation simulation with Pathfinder.
  - Occupation load: 380 passengers per platform, 60 passengers in the train.
  - Time to react: variable.
  - Smoke makes passengers move slower.
  - Escalator on the right side on the most affected platform: out of service.
  - Similar time needed for evacuation: 140s (with PSD) and 148s (without PSD).

    - Passengers react quickly, low occupation load ⟶ barely affected.
    - Harsh conditions: only without PSD, on the stairs.

# 4.- Fire and evacuation simulations

## 4.2.- Cavern stations

- Model created with Pyrosim.

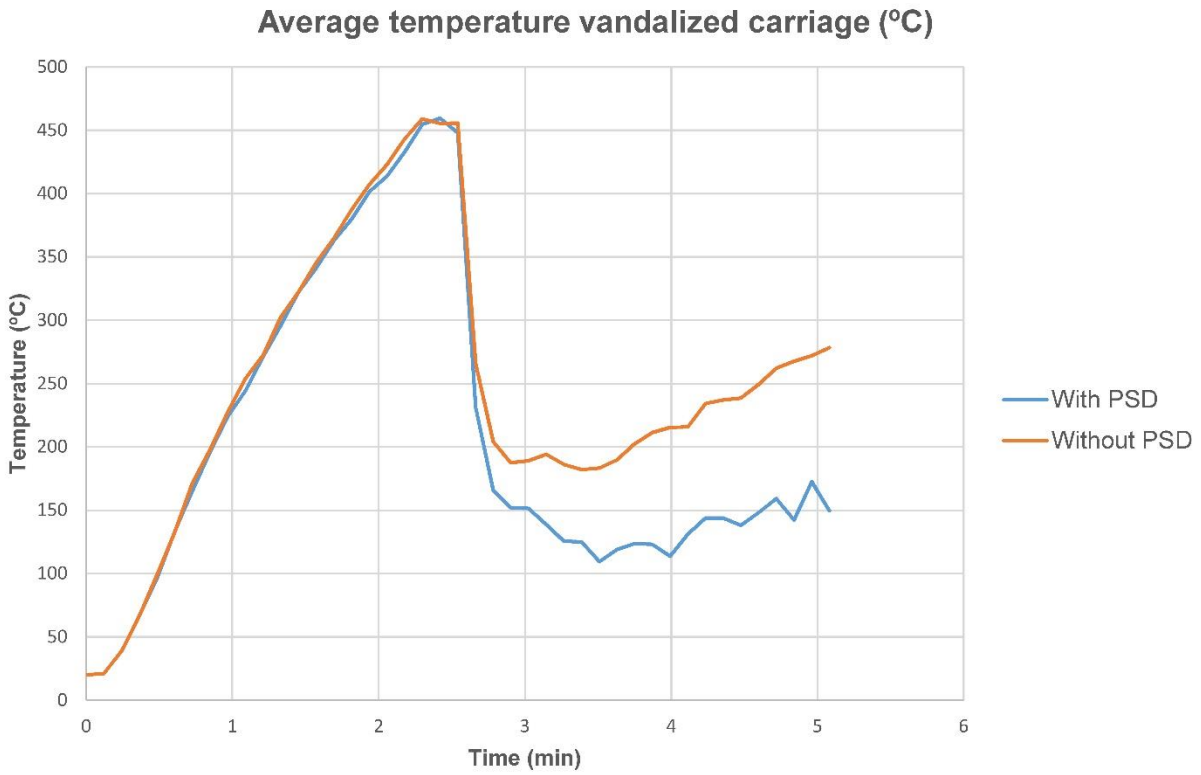


- Means of egress on each platform:
  - An emergency door on each side of the platform.
  - Two passageways.

# 4.- Fire and evacuation simulations

## 4.2.- Cavern stations

- Development of the fire.
  - The same conditions as in C&C stations.



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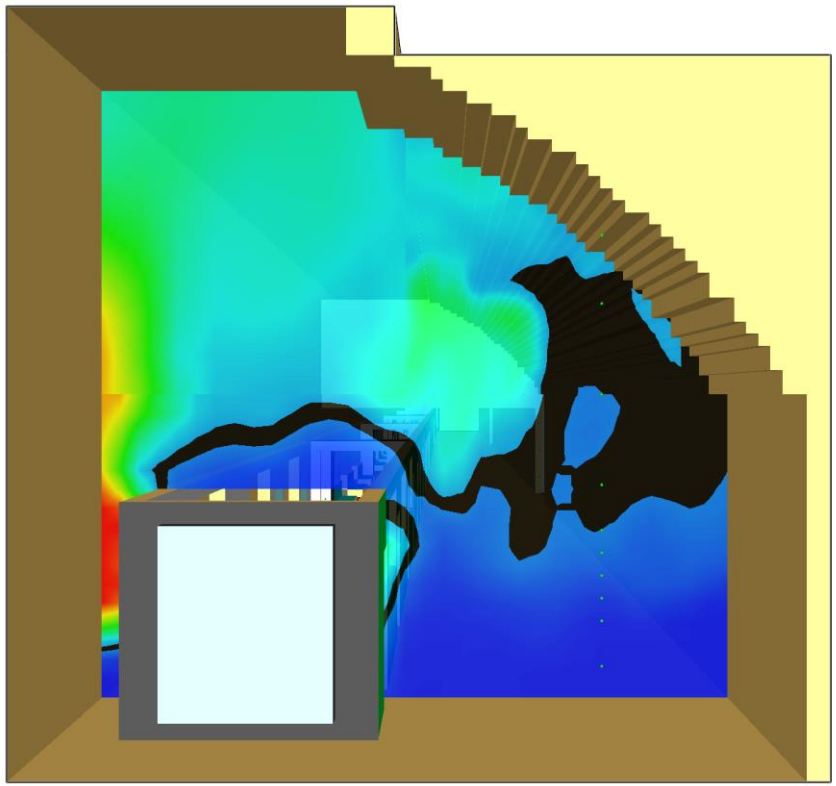

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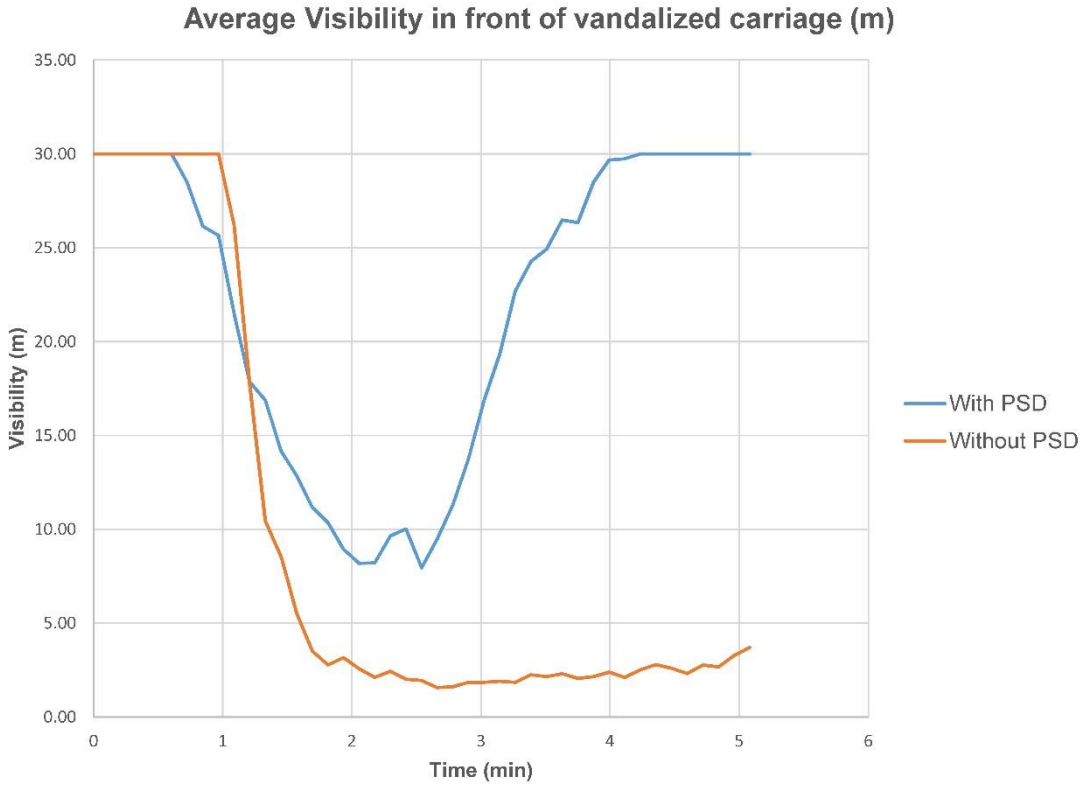

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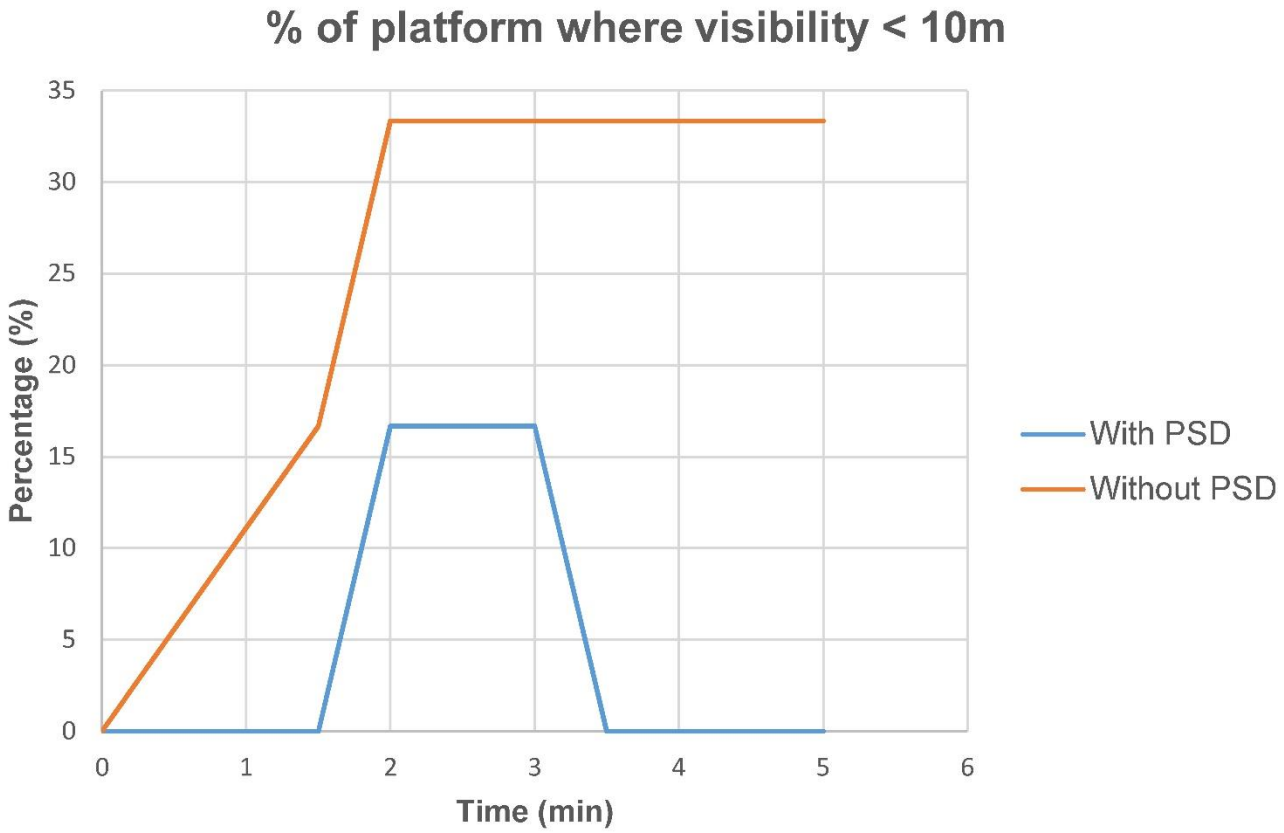
  - Visibility: great differences all along both platforms during the fire.



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## 4.2.- Cavern stations

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  - Time to react: variable.
  - Smoke makes passengers move slower.
  - Escalator on the right side on the most affected platform: out of service.
  - Similar time needed for evacuation: 121s (with PSD) and 116s (without PSD).

    - Passengers react quickly, low occupation load ⟹ barely affected.
    - Harsh conditions: only without PSD.

# 5.- Conclusions

- Occupation load: key factor.
- PSD offer better evacuating conditions.
- PSD make compatible exhaust from tunnel + station.
- Time for detection: great relevancy.