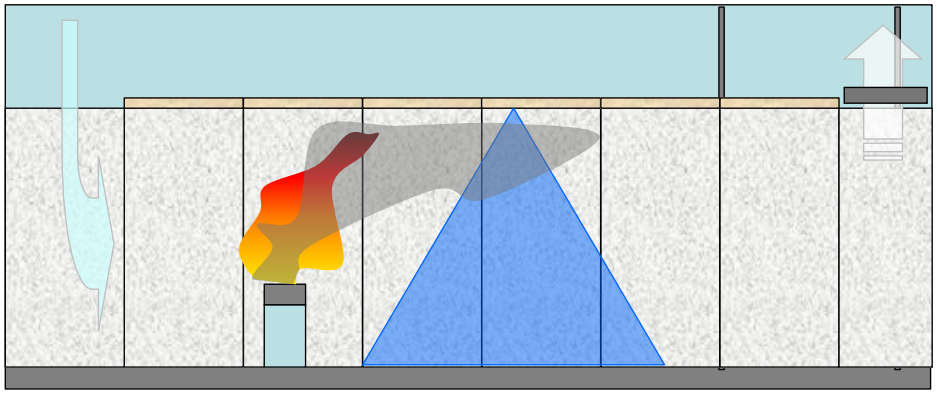


Shielding effects of watermist

Overview

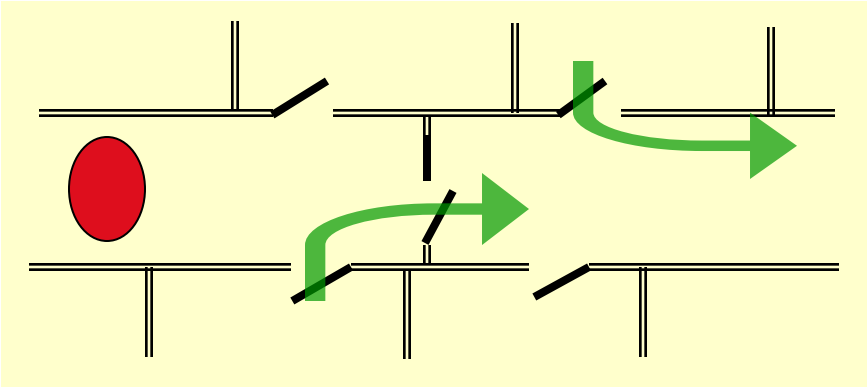
- Introduction
- Project background
- Design of test method
  - Scope
  - Tenability
- Test series
  - Physical set-up & instrumentation
  - Watermist characteristics
  - Procedure & programme
- Preliminary test results
- Directions for the near and far future

Introduction

- **Definition of watermist**
  - NFPA 750 – mean droplet diameter < 1 mm
  - Practice – mean droplet diameter < 0.1 mm
- **Application**
  - Suppression
    - 0.1-0.2 kg/m^3 to control fire
    - Cooling combustion zone, reduction of % O_2, inhibition of combustion reactions
  - Cooling effect on surroundings
    - Air temperature reduction, through rapid heat exchange between water and hot gases
    - Shielding of radiation
    - BUT very little experimental data
    - and NO applicable engineering knowledge

Project philosophy

- **Solid barriers impair rapid evacuation**
  - WM shield could be potential alternative
  - Set-up inspired by health care setting
    - Easy evacuation of people in beds/ wheelchairs
    - Limited smoke movement
    - In normal situation (no fire), often narrower passage because of fire doors



- **Long-term opportunities (not within project scope)**
  - Design freedom, equivalent solutions
  - Design of watermist for shielding applications

Project overview

- **Collaboration between Efectis and Saval**
  - Saval, member of SK Fire and Safety Group, is a European supplier of gaseous, watermist and sprinkler suppression systems

- **On going project**
  - Start up in September
  - Tests have been performed in previous 2 weeks
  - Today: preliminary results

Design of test method - scope

- **Investigation of shielding effects only**
  - For the purpose of life safety
  - Does not yet address the formal requirements for a conventional fire resistant barrier
    - Beginning fire vs. fully developed fire
    - Different values for temperature and radiation limits

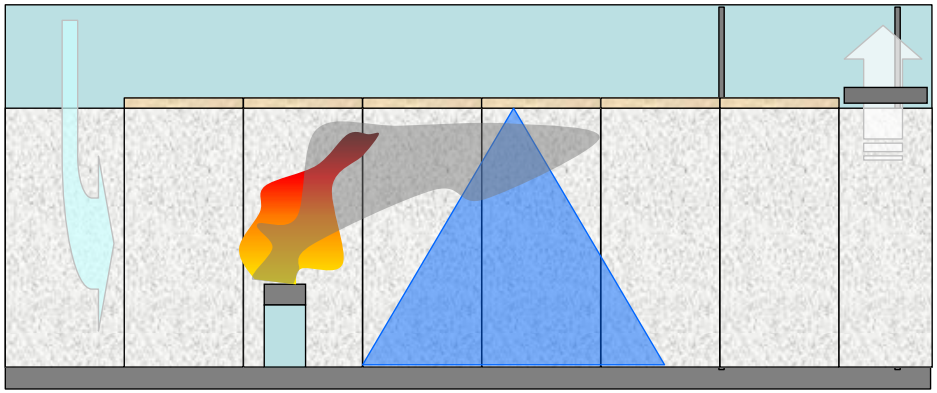
- **First exploration of practical use of shielding by watermist**
  - Application for specific
    - Building occupancy
    - Fire scenario
  - Gives focus for design of test method

Design of test method - tenability

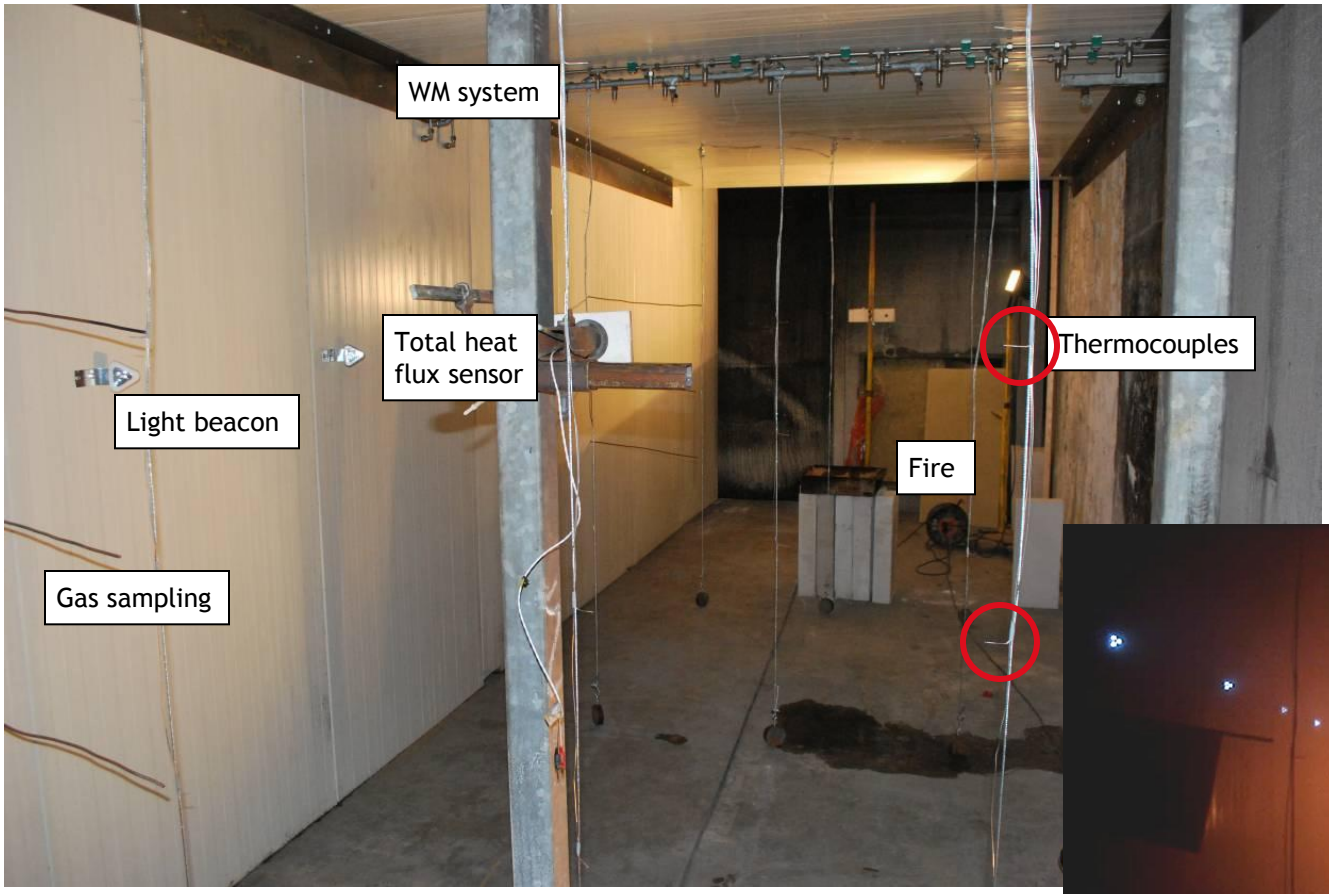
- **Non fatal or durable indefinitely?**
  - NOTE: no global consensus
- **Thermal factors**
  - Air temperature – humid environment!
  - Radiation intensity
- **Toxicological factors**
  - CO concentration
  - Soot concentration
  - Increases difficulty in measurements
  - NOTE: no global consensus on allowable concentrations
- **Visibility!**
  - Impairs evacuation, not-directly hazardous or lethal
  - Orientation should not be impaired

Test series - Set up

- **Corridor (length ca. 8 m, height 2.5 m, width 2.7 m)**
- **Air velocity, average 0,5 m/s -> representative of draught**
  - NOTE: prevents decent of smoke layer
- **No suppression of fire by spray cone (remarks)**
- **n-heptane fire, RHR 300-400 kW**
  - RHR Representative of chair or bed on fire (literature)
  - Fire scenario is representative but not worst case scenario!

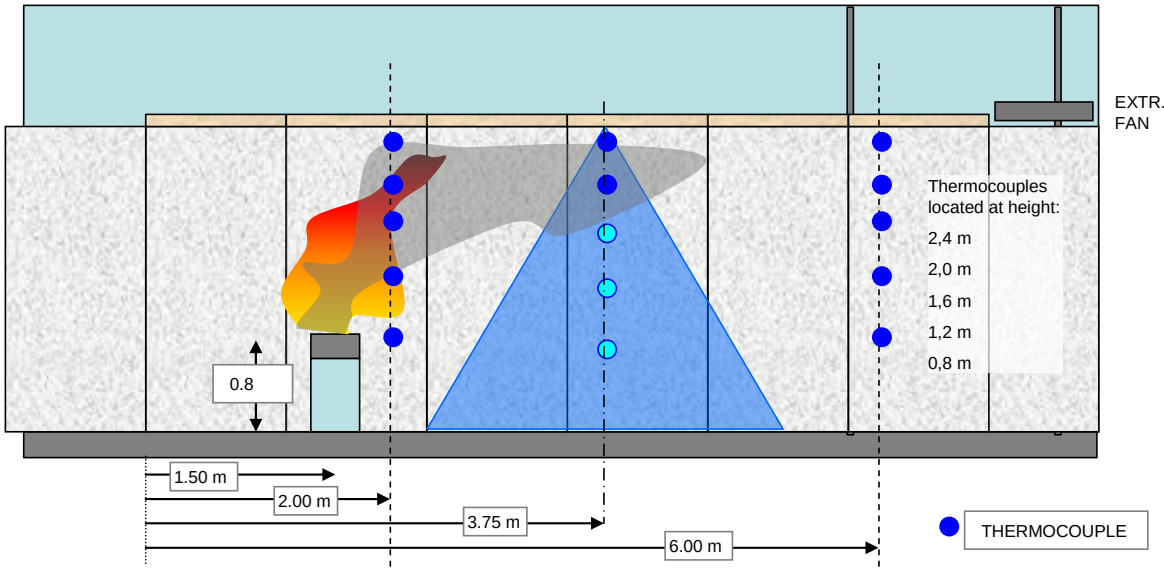


Test series - Set up



Test series - Instrumentation

- **Thermal measurements**
  - Thermocouples (3 measurement sections)
  - Plate thermocouple (representative of skin temperature)
  - Total heat flux sensors
- **Toxicological measurements (indicative)**
  - Gas sampling with gas meter and soot filter
- **Visibility is reviewed by**
  - Video-recording
  - Light beacons

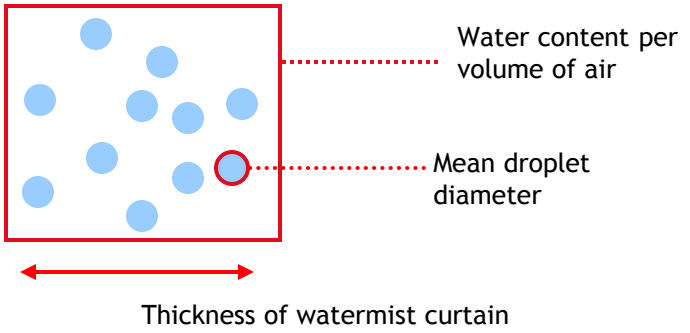


Test series - Watermist characteristics

- **Test program based on**
  - Wish for future design optimalisation ->
  - Reproducibility of results

- **High pressure (> 70 bar)**
  - Variance in nozzle flow capacity (1 – 3 L/min.)
    - Influence on mean droplet diameter
  - Single and double row
    - Variance in number of nozzles (13 vs. 26 nozzles)
    - Influence on thickness of watermist shield
    - Influence on water content per volume of air

- **Low pressure (< 13 bar)**
  - Small number of nozzles
  - Larger nozzle flow capacity (ca. 10 L/min.)
    - Influence on mean droplet diameter



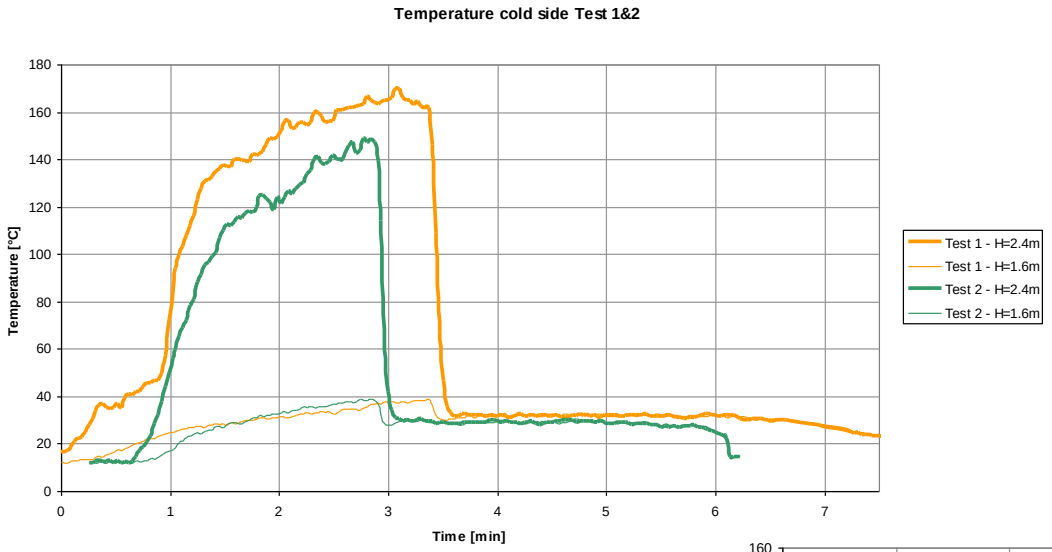
Test no.	LP/ HP	No. Nozzles	Av. nozzle flow [L/min.]	RHR [kW]
1	HP	26	<1.7	300-400
2	*HP*	*26*	*<1.7*	*300-400*
3	HP	26	<1.7	Ca. 800
4	HP	26	<1.3	300-400
5	HP	13	<3.0	300-400
6	*HP*	*13*	*<3.0*	*300-400*
7	LP	2	~10	300-400
8	*HP*	*13*	*<3.0*	*300-400*

Preliminary test results - overview

- **Test without watermist**
  - Max. Air temperature, between 50 and 170 °C (near ceiling)
  - Max. total heat flux, 1.5 kW/m^2 downstream, 3.5 kW/m^2 upstream

- **Thermal aspects (next slides)**
- **Toxicological aspects (indicative)**
  - No significant results
    - Highly influenced by test set up
  - No decent of smoke layer
- **Visibility reviewed by video recording of tests**
  - Light beacons were all visible
    - Ca 5m. Visibility from camera
  - Fire well visible through WM
    - helps people to evacuate away from the fire

Preliminary test results - reproducibility

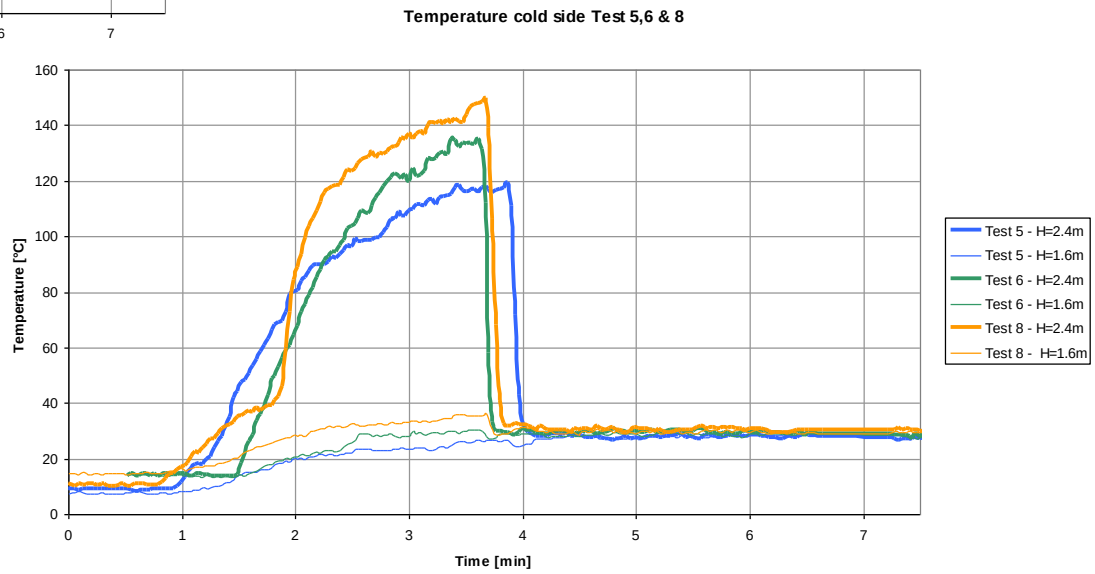


WM type 1

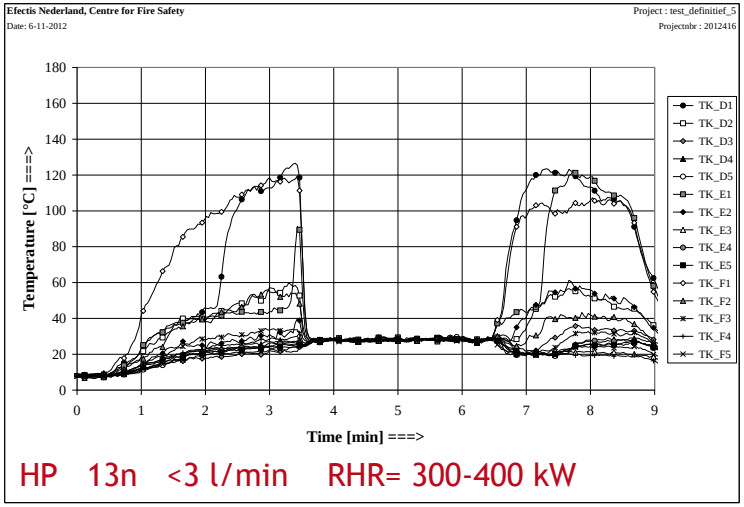
- high pressure
- 26 nozzles
- <1.7 L/min

WM type 3

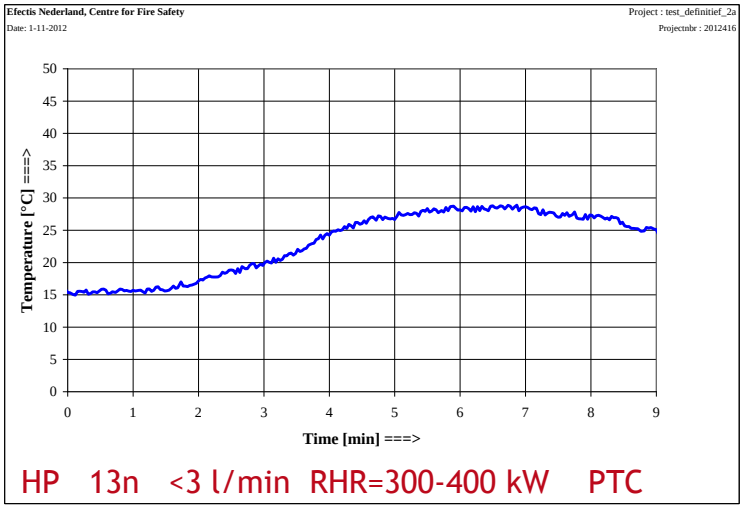
- high pressure
- 13 nozzles
- <3 L/min



Preliminary test results - temperature

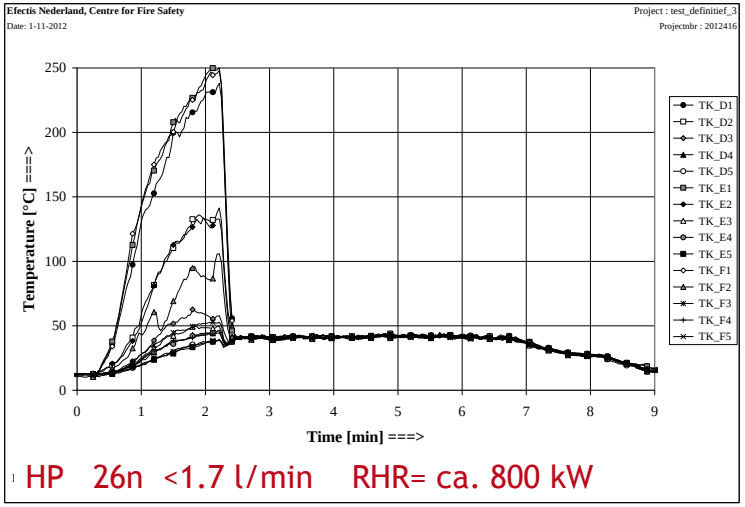


HP 13n <3 l/min RHR= 300-400 kW



HP 13n <3 l/min RHR=300-400 kW PTC

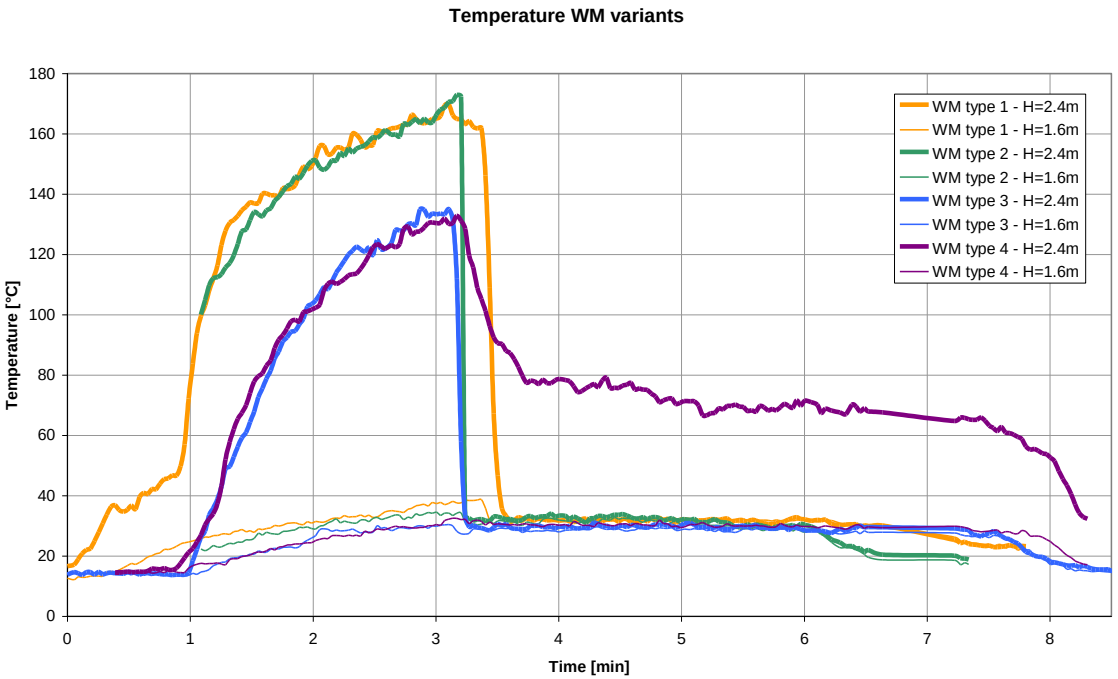
- **Significant drop in air temperature**
  - Also true for test with double RHR



HP 26n <1.7 l/min RHR= ca. 800 kW

- **Skin temperature**
  - Plate thermocouple, including all mechanisms
  - Ca. 28 °C < body temperature (37°C)

Preliminary test results - temperature



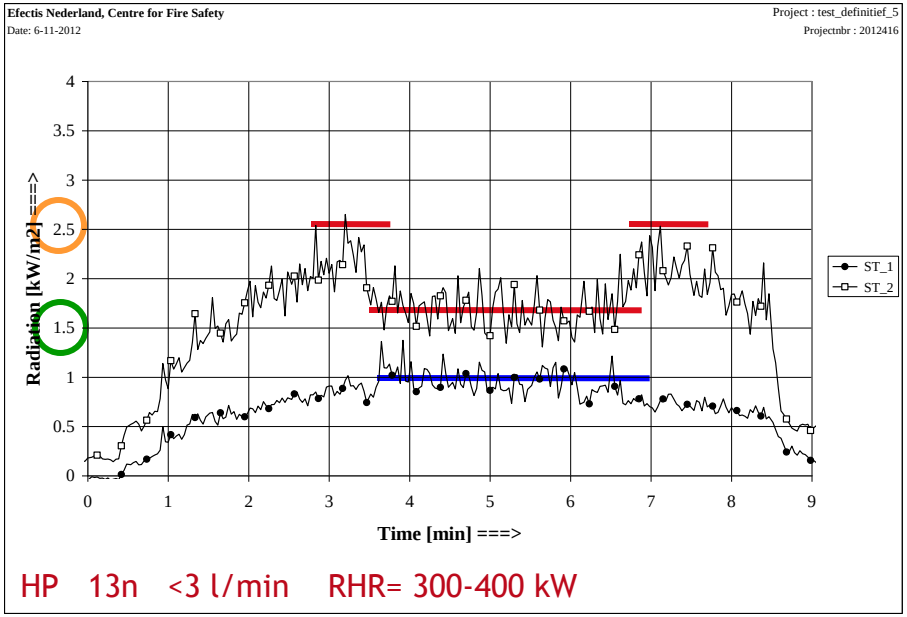
- **High pressure WM**
  - Different configurations give similar results
- **Low pressure WM**
  - Smaller temperature drop
  - Visible gaps in shield

WM type 1 = HP, 26 nozzles, <1.7 L/min.
WM type 2 = HP, 26 nozzles, <1.3 L/min.
WM type 3 = HP, 13 nozzles, <3 L/min.
WM type 4 = LP, 2 nozzles, ~10 L/min.

- **Additionally the measurement of:**
  - Temperatures in the section near the nozzles
  - Temperatures upstream, between shield and fire

Preliminary test results - total heat flux

- **Measurements performed with total heat flux meter**
  - Influence of additional mechanisms
    - Condensation heat transfer - order of magnitude similar to radiation



- **Cooling effect upstream**
  - Secondary influence on combustion process
  - Depends on distance between shield and fire
- **Total heat flux below important tenability values**

Directions for the future

- **Near future**
  - Investigate the different heat flux mechanisms
  - Larger range of watermist system configurations

- **Far future**
  - Smoke shielding properties
  - Large scale testing for equivalence to conventional fire resistant barrier
  - Develop empirical design rules

Summary

- **First exploration gives:**
  - Useful experience with the behaviour of a watermist shield
    - Effective reduction of air temperature
    - Visibility
    - Additional cooling effect upstream of shield
  - New directions for further research
    - Heat flux mechanisms
    - Toxicological aspects

The shielding effects of watermist present a new design possibility for innovative evacuation design