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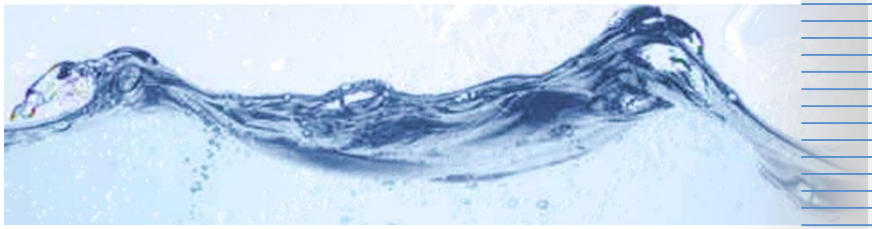
NOW

AOA

Properties of water mist and its characterization

8th Triennial International Fire- Cabin Safety Research Conference

K.Kirbach

27.10.2016

Overview

- AOA water mist fire suppression system
- Current water mist testing activities
- Parameters for water mist characterization
- Calculation of cooling efficiency
- Summary

Overview

AOA water mist fire suppression system

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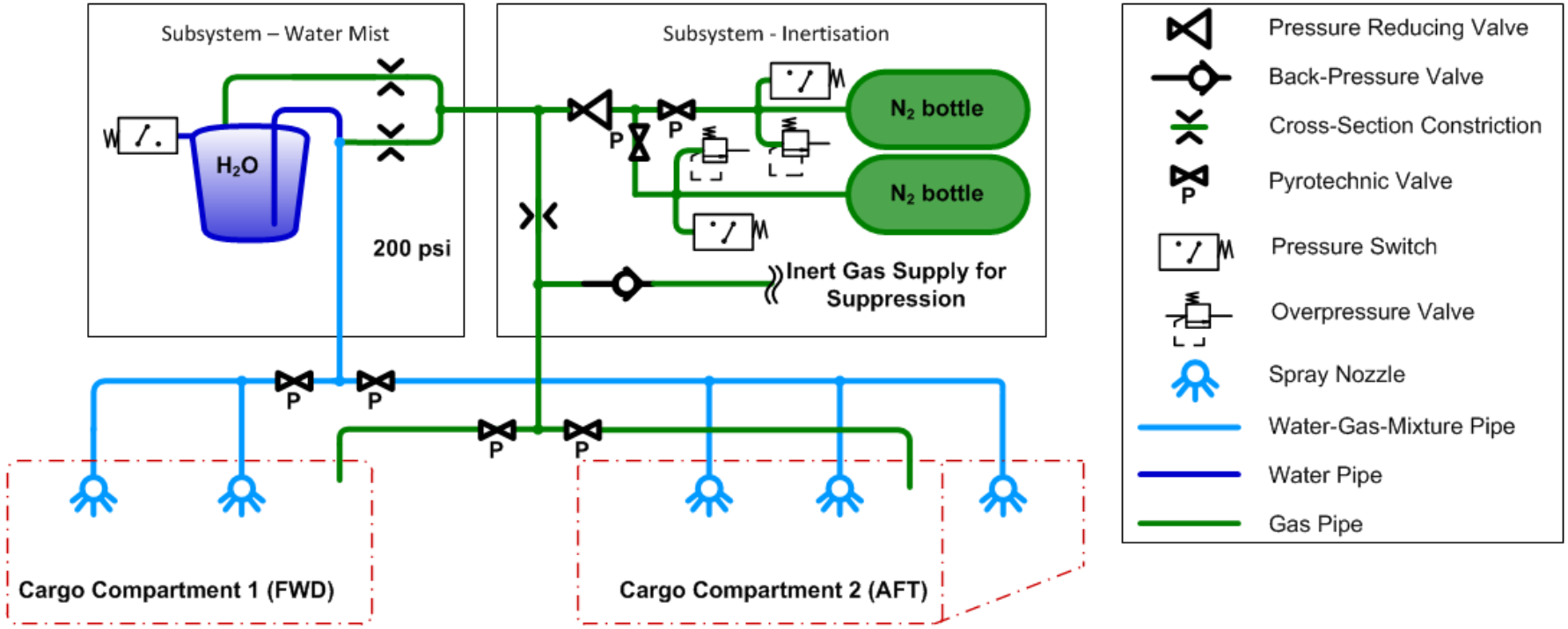
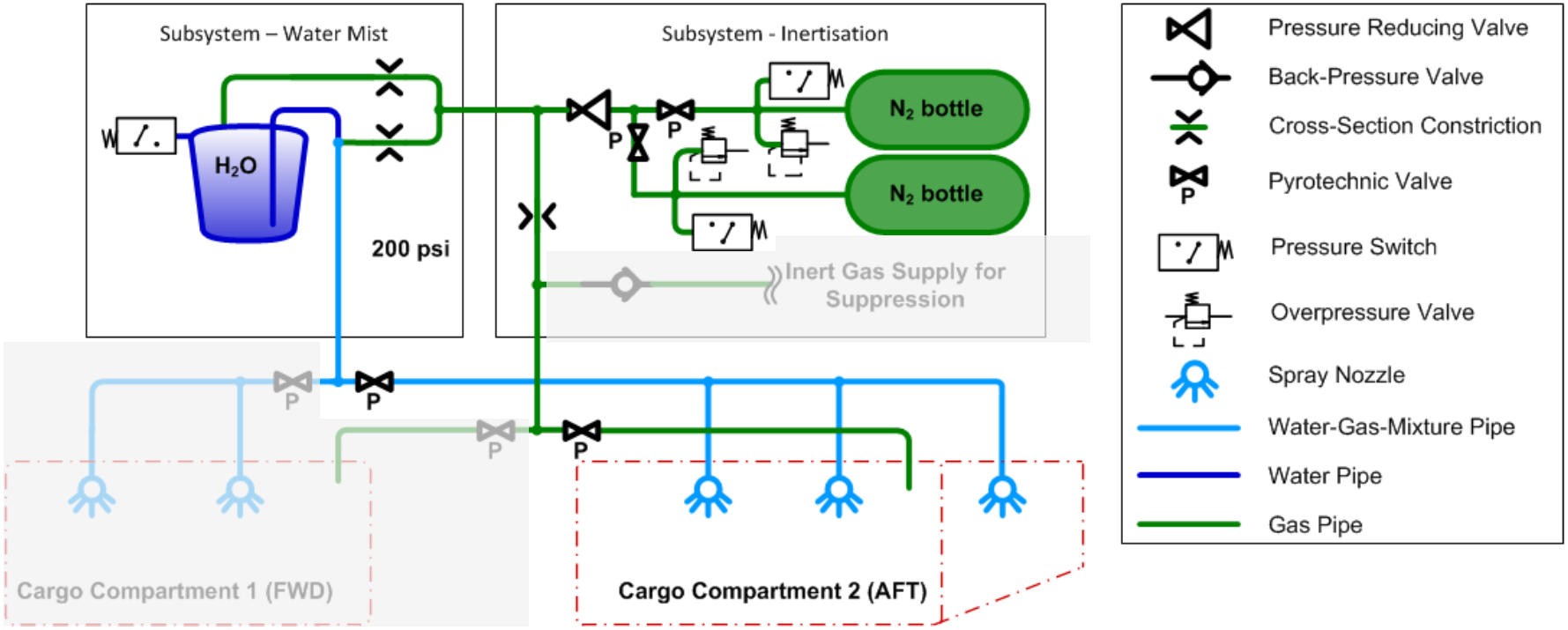
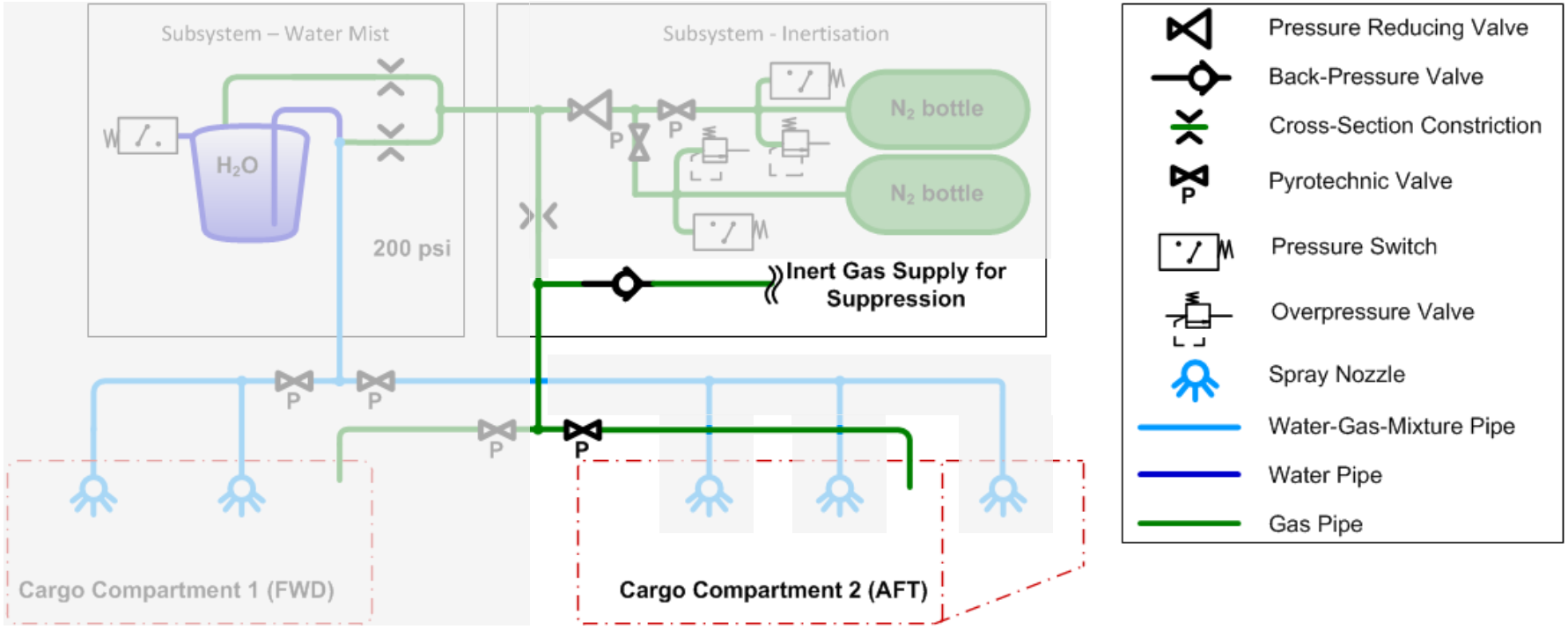
Schematic system concept



fire knock down

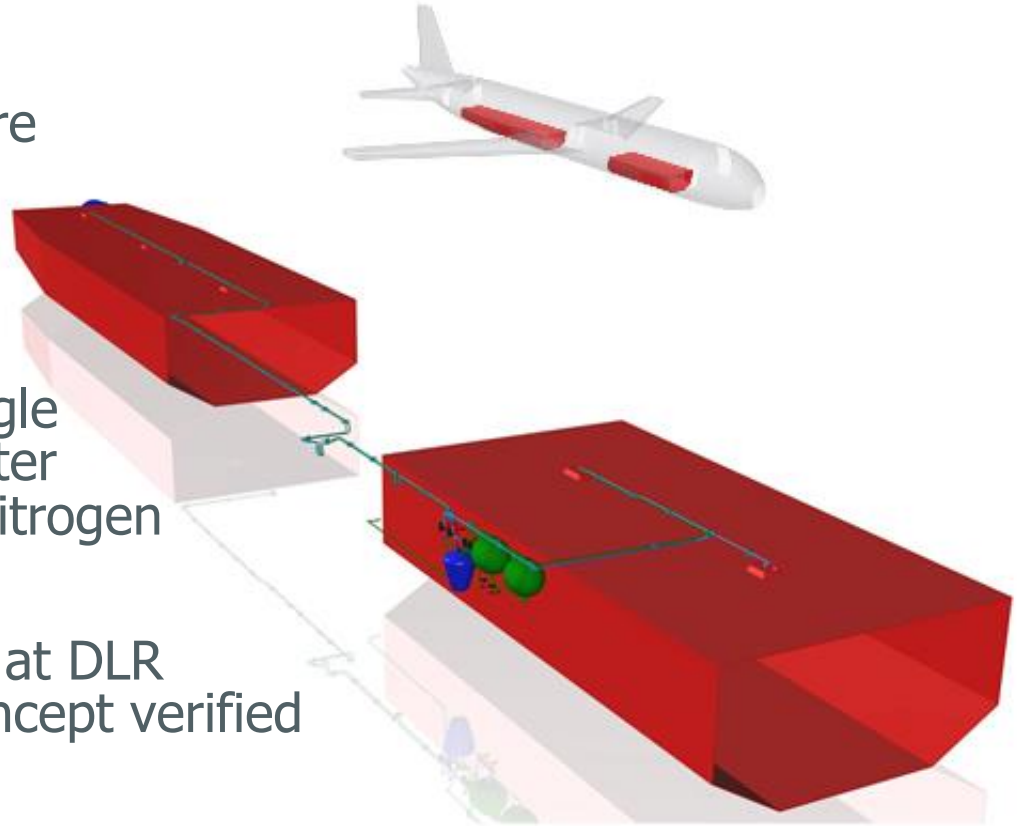


long term suppression



AOA water mist fire suppression system

- conducted more than 150 real fire experiments to optimize exting-uishing agent quantities for fire knock-down-phase
- required agent quantities for single aisle A/C → 13 lb (6kg) water
  33 lb (15 kg) nitrogen
- MPS tests sucessfully conducted at DLR
  → system concept verified



Current water mist testing activities

AOA water mist fire suppression system

Current water mist testing activities

Parameters for water mist characterization

Calculation of cooling efficiency

Summary

Current water mist testing activities

- Measurement instrumentation
  - →32 thermocouples mounted in ceiling and sidewalls
  - →Continuous oxygen analyzer
  - →Pressure transducer for compartment pressure
  - →6 aviation smoke detectors
  - →Video observation of the test compartment

- Full MPS Test capability
- Continuous testing for system and equipment development

Parameters for water mist characterization

AOA water mist fire suppression system

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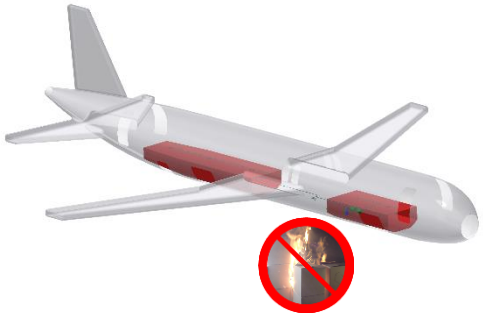
Parameters for water mist characterization

- Water mist and nitrogen extinguishing capability depending on key parameters:

1. O2 concentration
2. Cooling effect
3. Moisturization
4. Heat radiation shielding



Measurement of key parameter values during flight test

→ provide evidence of required key parameter levels for successful extinguishing

Parameters for water mist characterization

- Definition during MPS test campaign
- Verification during flight test

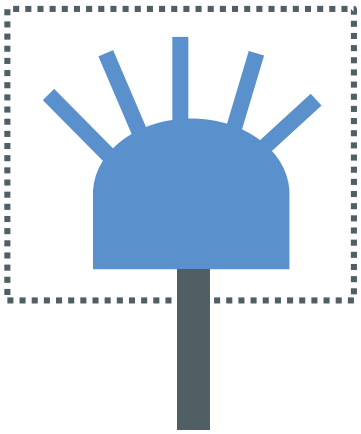
Parameter	Sensor	Range
O2 concentration	O2 sensor	< Vol.%
Cooling	Calorimeter	> kJ/m^2
Moisturization	Absorber	> ml/m^2
Radiation shielding	Light obscuration sensor	> %/m

Parameters for water mist characterization

- Parameter: cooling
- Sensor:

  Calorimeter

  1. Heat surface to stable 302 °F (150°C)
  2. Turn heater off with start of suppression
  3. Measure temperature

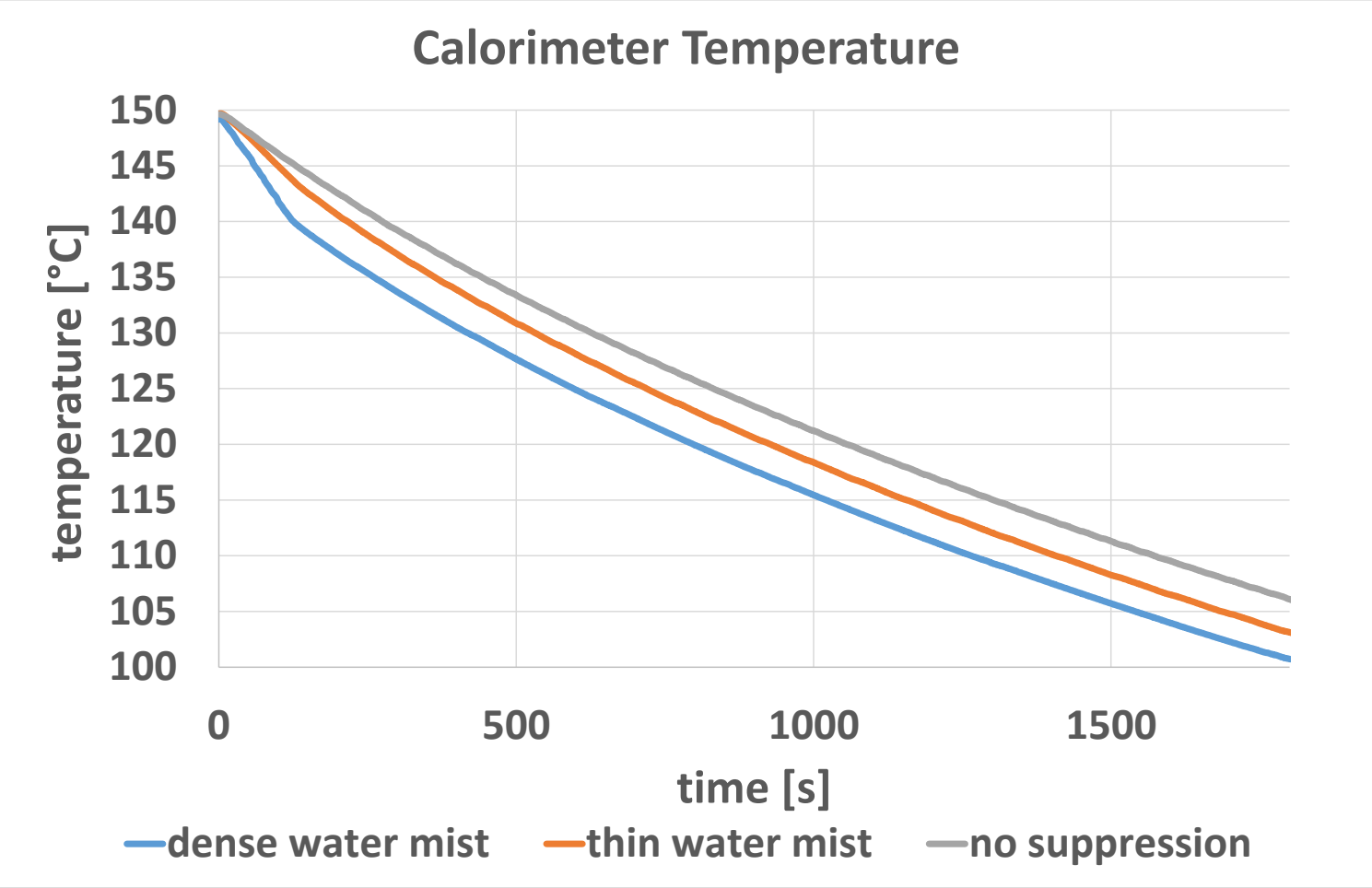


Hedgehog

Geometry possibilities

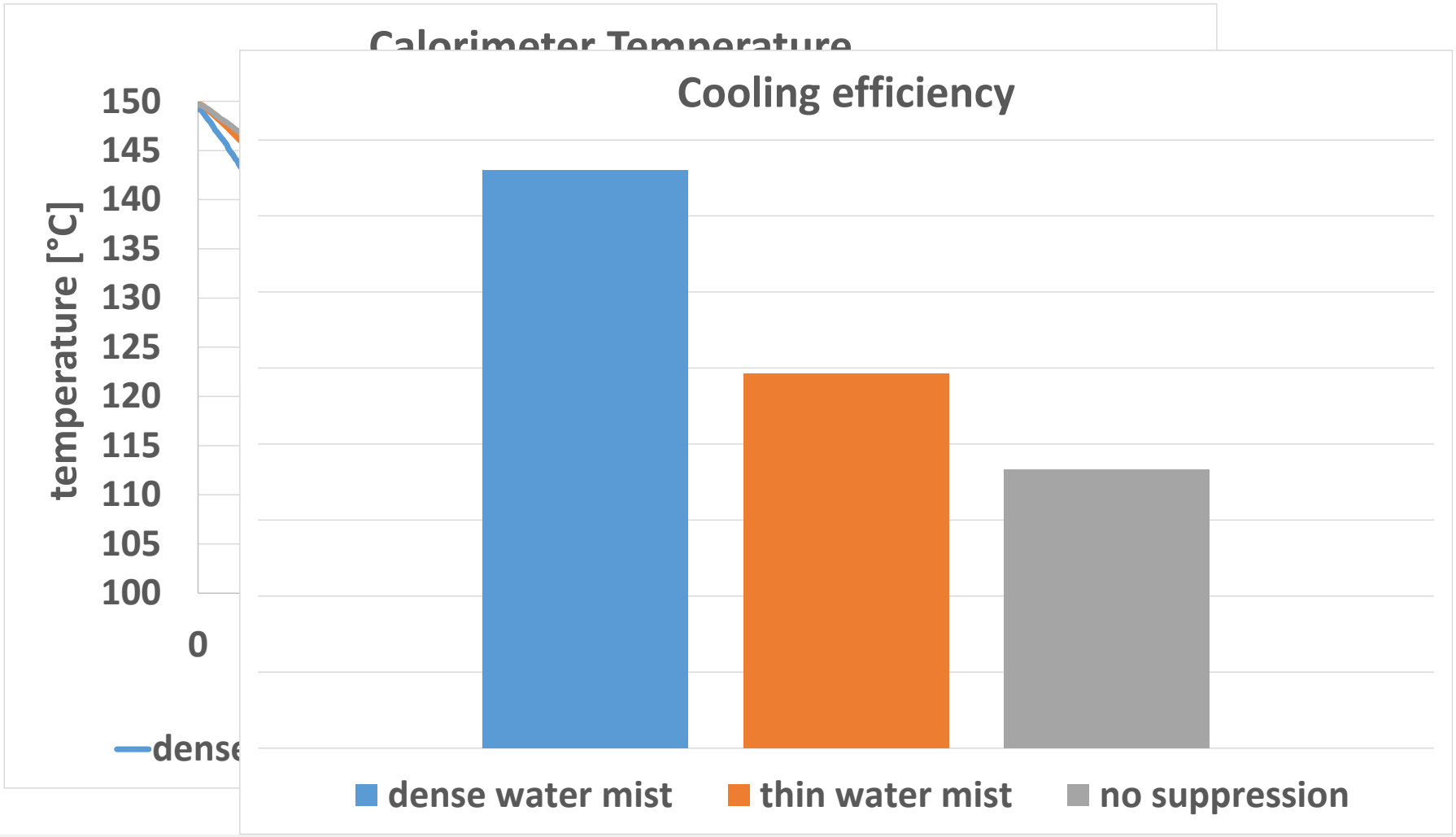
Parameters for water mist characterization

- Parameter: cooling



Parameters for water mist characterization

- Parameter: cooling



Parameters for water mist characterization

- Parameter: moisturization
- Sensor:

  Absorber

  1. Scale absorber before testing
  2. Distribute throughout the cargo compartment
  3. Scale after water mist suppression

  Absorbers tested:

  Sanity towel

  medical super absorber

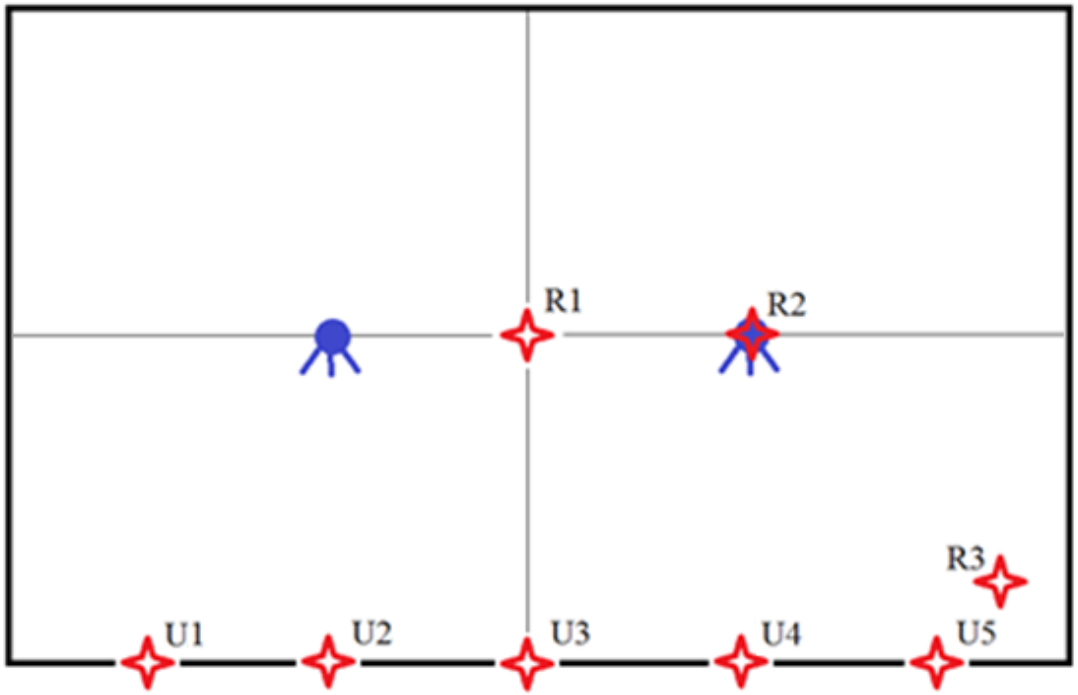
  baby sheet

Parameters for water mist characterization

- Parameter: moisturization
- Test cell:

  9 x 4,5 x 2,5 m (length x width x height)
- Test setup:

  two nozzles centered in the test cell



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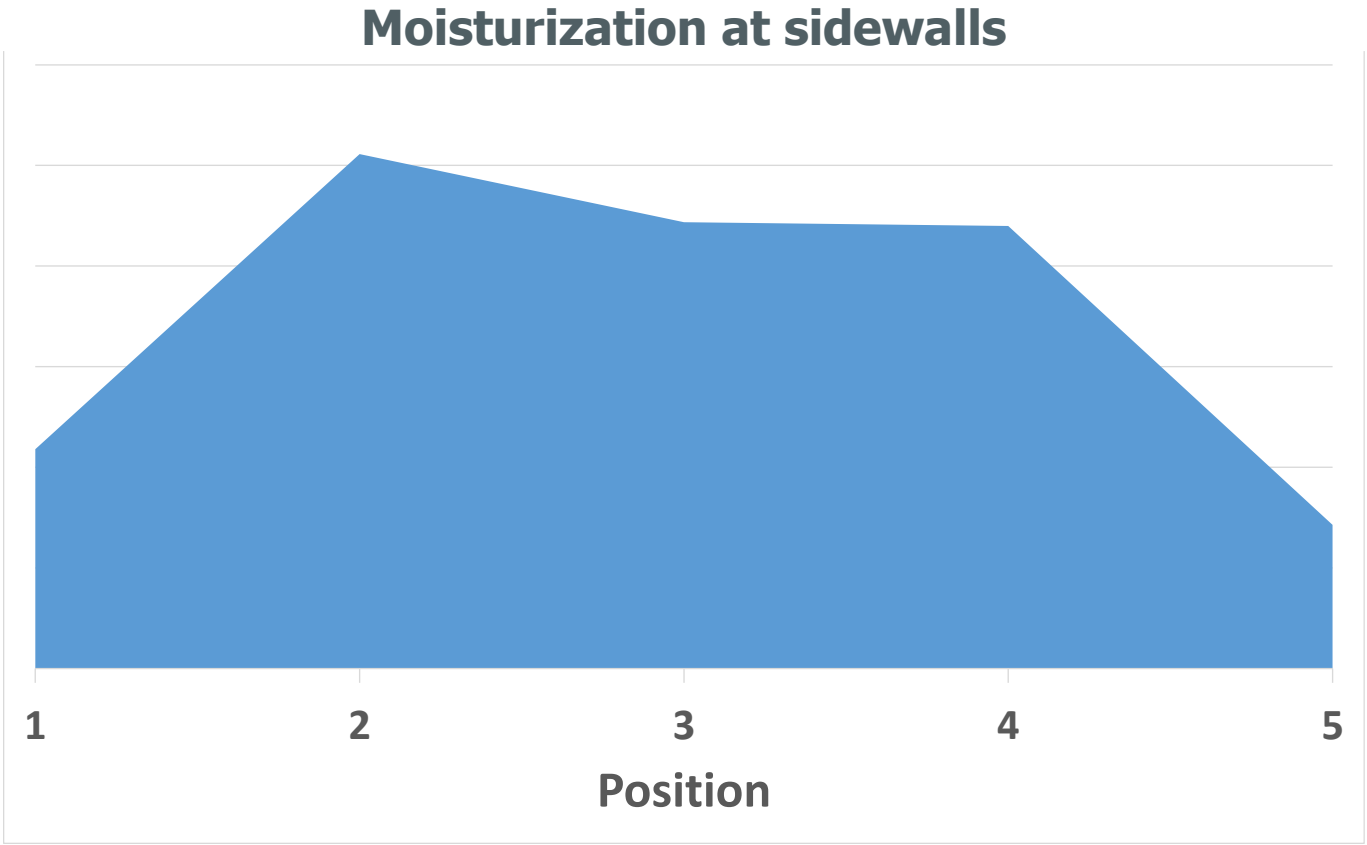

Parameters for water mist characterization

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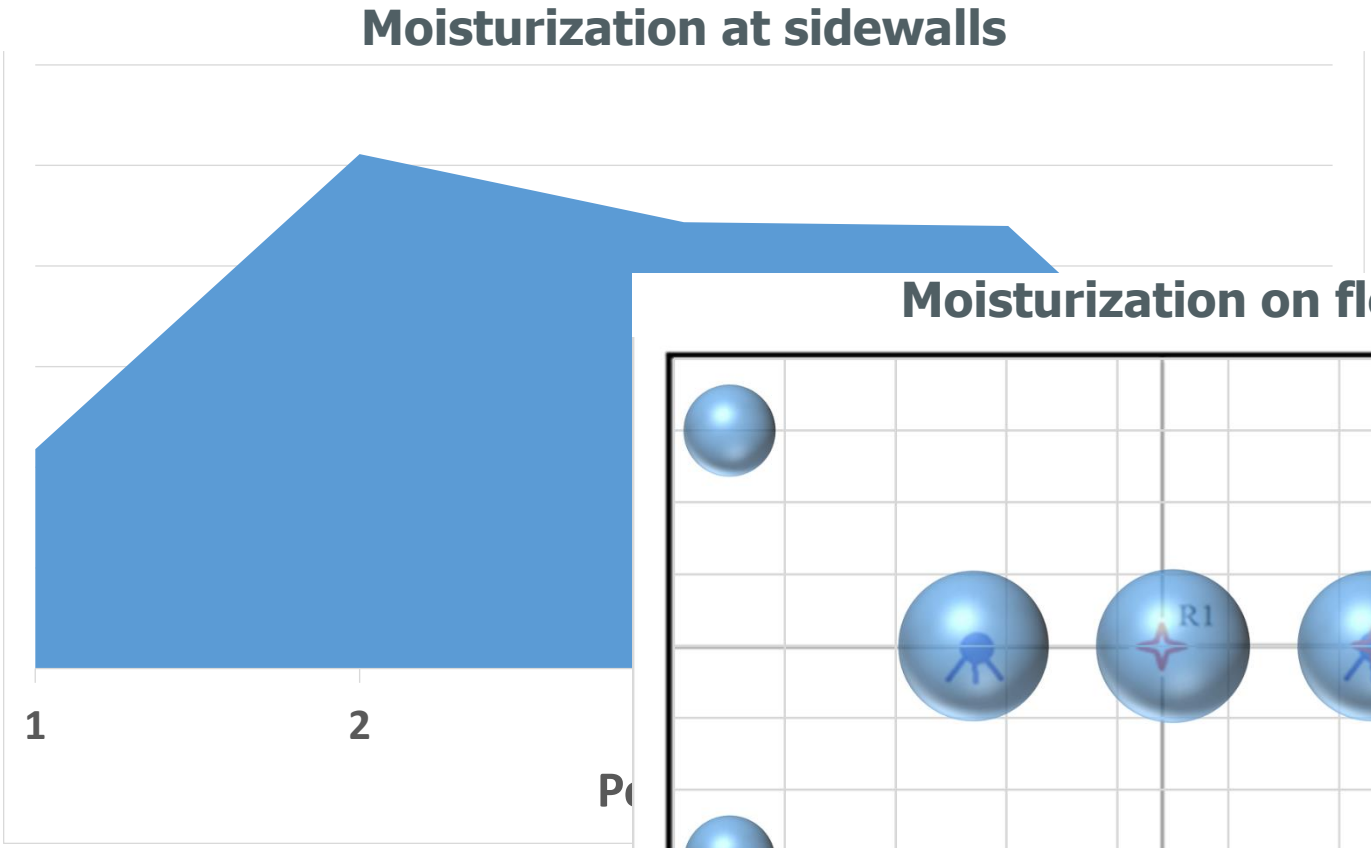


Parameters for water mist characterization

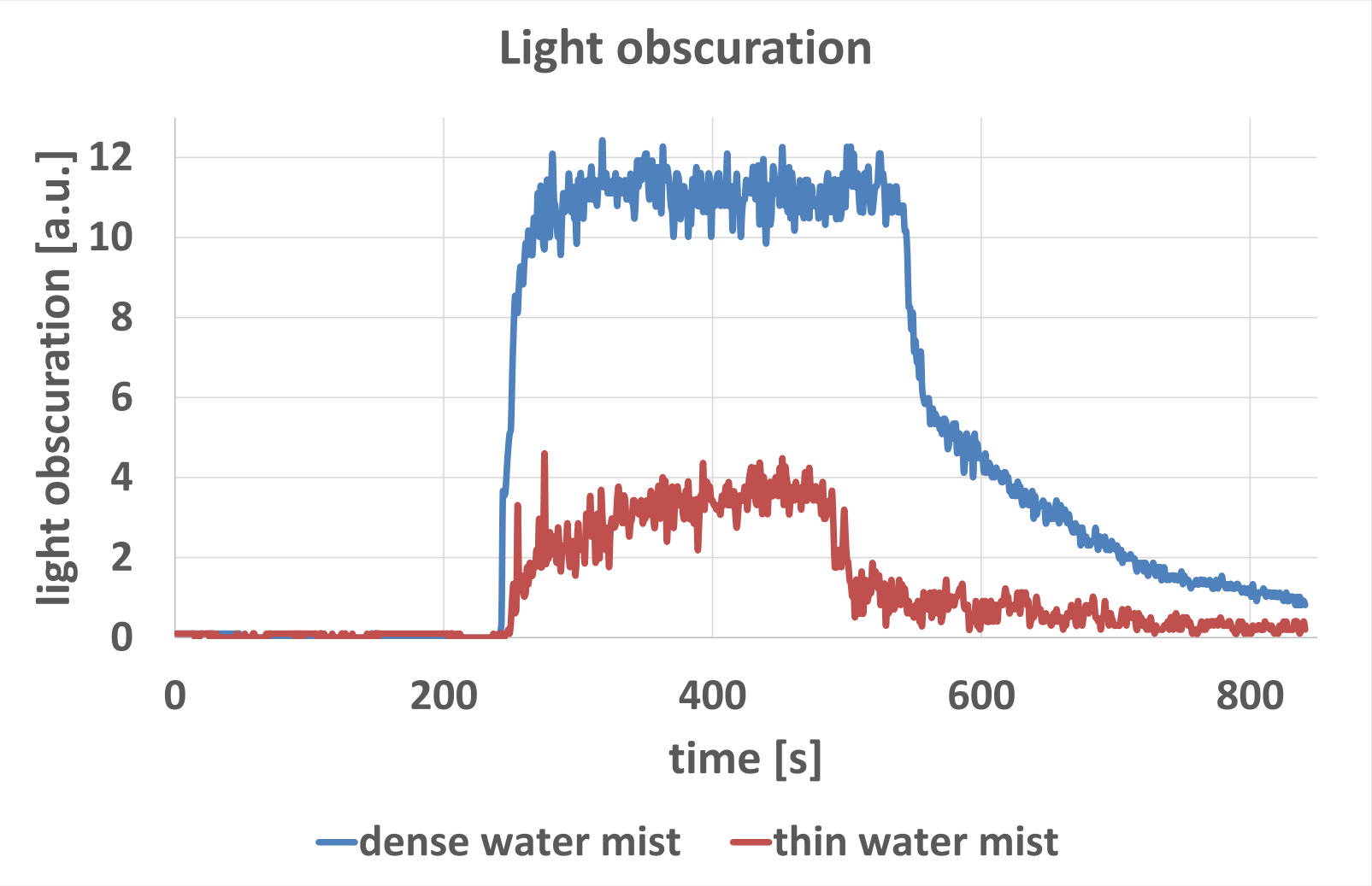
- Parameter: radiation shielding
- Sensor:

SICK VISIC620
Light obscuration sensor
(visual range)

CAPTRON Prototype device
Light obscuration sensor

Parameters for water mist characterization

- Parameter: radiation shielding/light obscuration



AOA water mist fire suppression system

Current water mist testing activities

Parameters for water mist characterization

Calculation of cooling efficiency

Summary

Calculation of cooling efficiency

- Isentropic expansion of 35 kg N_2
  @ 200 bar, 20 °C -> 20 bar, -125 °C

2: nitrogen: Specified state points

	Temperature (°C)	Pressure (bar)	Density (kg/m³)	Enthalpy (kJ/kg)	Entropy (kJ/kg-K)	Cp (kJ/kg-K)
1	20,000	200,00	218,54	270,14	5,1328	1,3179
2	-125,53	20,000	52,440	134,67	5,1328	1,3188

$$Q_{isentropic} = m_{N_2} \cdot c_{p,N_2} \cdot \Delta T_{N_2} = 6{,}78\ MJ$$

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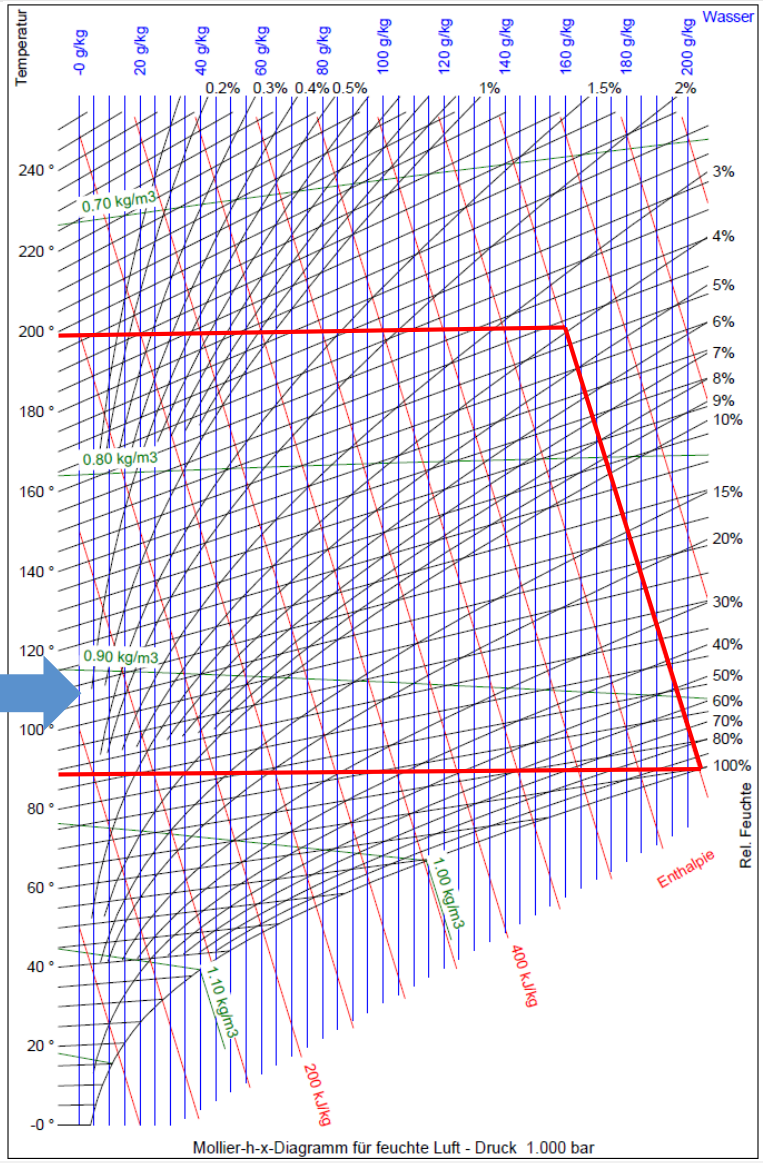
- Isenthalpic state change of 56 m³ cargo volume
  @ 200 °C, 4 % r.H. -> 87 °C, 100 % r.H.

4: Air (dry): Specified state points (75,57/1,2691/23,16)

	Temperature (°C)	Pressure (bar)	Density (kg/m³)	Enthalpy (kJ/kg)	Entropy (kJ/kg-K)	Cp (kJ/kg-K)
1	200,00	1,0000	0,73587	475,86	7,3320	1,0252
2	87,000	1,0000	0,96699	360,95	7,0546	1,0103

$$Q_{isenthalpic} = V_{air} \cdot \rho_{air} \cdot c_{p,air} \cdot \Delta T_{air} = 5{,}48\ MJ$$



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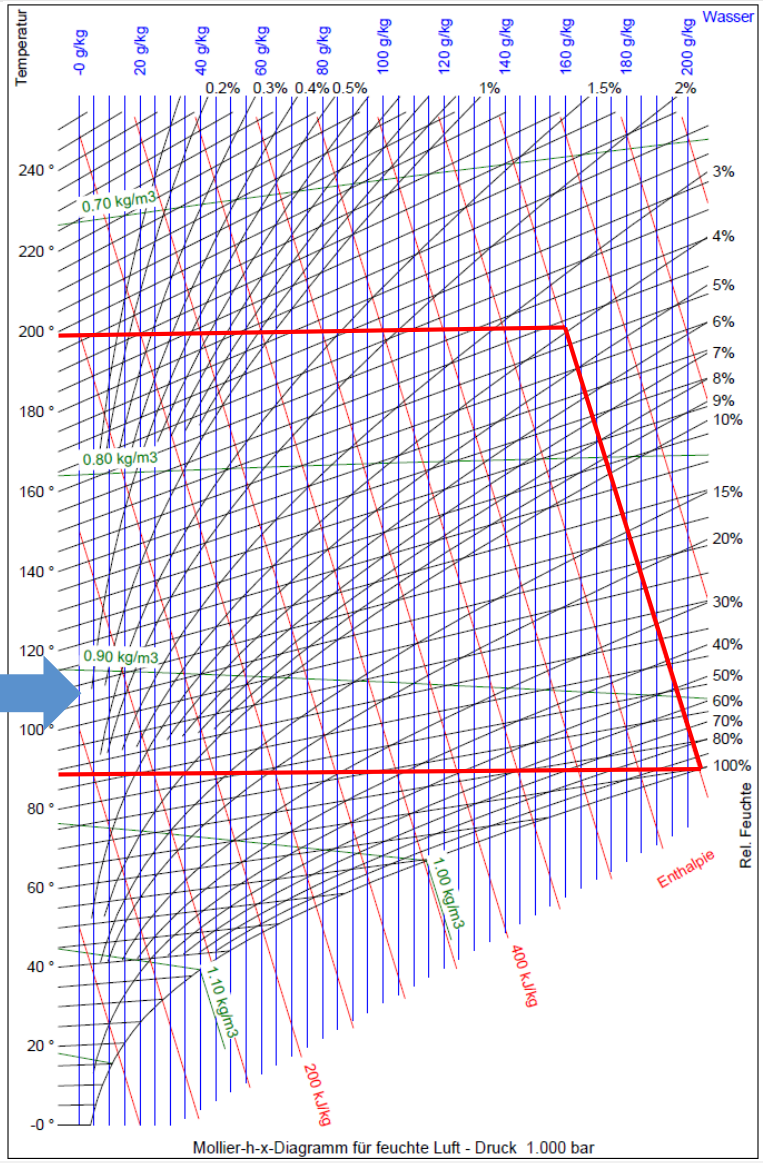
- Heat of evaporation @ 3 l H_2O, h_{evap}=2257 kJ/kg
  $Q_{evap} = m_{H_2O} \cdot h_{evap} = 6{,}77\ MJ$



Summary

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MPS passed water mist fire suppression system

Four paramters for water mist characterization

- Oxygen concentration
- Cooling
- Moisturization
- Radiation shielding

Cooling efficiency of water mist

Special Thanks to

- The AOA Team
- IBExU GmbH
- Fraunhofer IFAM Dresden
- our Students from Dresden University of Technology

Gefördert durch: Bundesministerium für Verkehr und digitale Infrastruktur

Koordiniert durch: NOW Nationale Organisation Wasserstoff- und Brennstoffzellentechnologie

Thank you for your attention!

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Questions?