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High Pressure Water Mist for the Protection of Risk of Oil Mist Explosions

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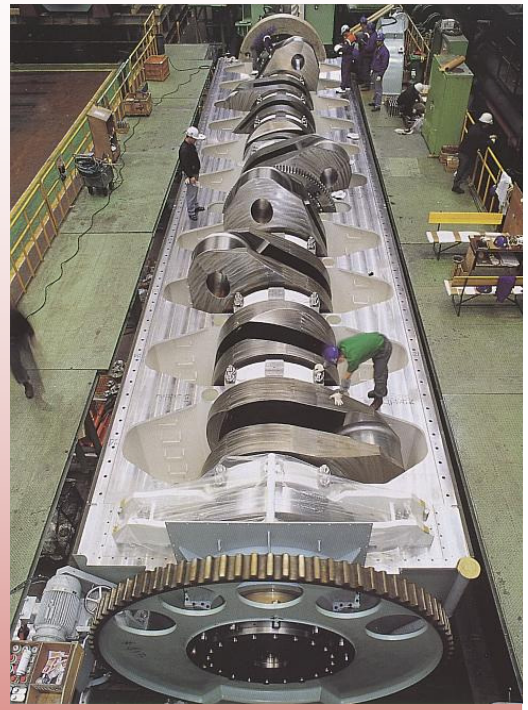
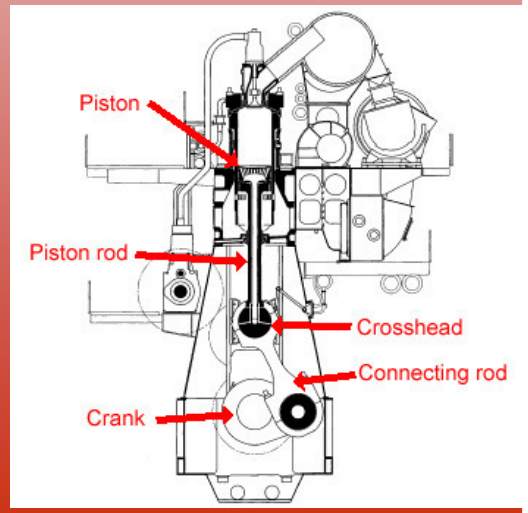
Background



- Oil mist causes fires and explosions in ship's engine rooms
- Creation of oil mists by mechanical and thermal processes

Example:
Lub oil evaporates on overheated surfaces due to installation failures of bearings in crank cases, explosion even with oil mist detection



Consequence:
- Repairs under thread of life
- Loss of the whole ship
- Thread of health by risk of cancer

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Aim of the whole project RedOMir

Research Project on behalf of the German government

In cooperation with the Institute of Safety Engineering, Rostock

Major Questions and Tasks for the project:

- Is it possible to influence an developing oil mist in a way that its thread of an explosion or as an health hazard can be rapidly reduced without endangering people?
- Is it possible to prevent the creation of explosible oil mists by cooling, dilution or reduction of ignition energy of oil mists?
- Reduction of oil mist explosion risks by the development of tests with:
  - Application of water mist
  - Application of cold air/pressurised air

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Targets of the Research Project (Subproject: Water Mist)

Prevention of the development of an *explosible* oil mist atmosphere with activation of water mist

Approach:

- ***Investigation of the physical properties of oil mists in explosion tests***
- ***Investigation of influence of HPWM on explosible properties of oil mists by condensation & coagulation of HPWM on oil droplets***

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Creation of explosible oil mists

Investigation of behaviour of oil mists

- Reasons for explosivity
- Comparable results

Test scenarios with and without igniter

- Development of
  - Temperatures
  - Overload pressure
  - Gases

Ignition with igniter and without igniter

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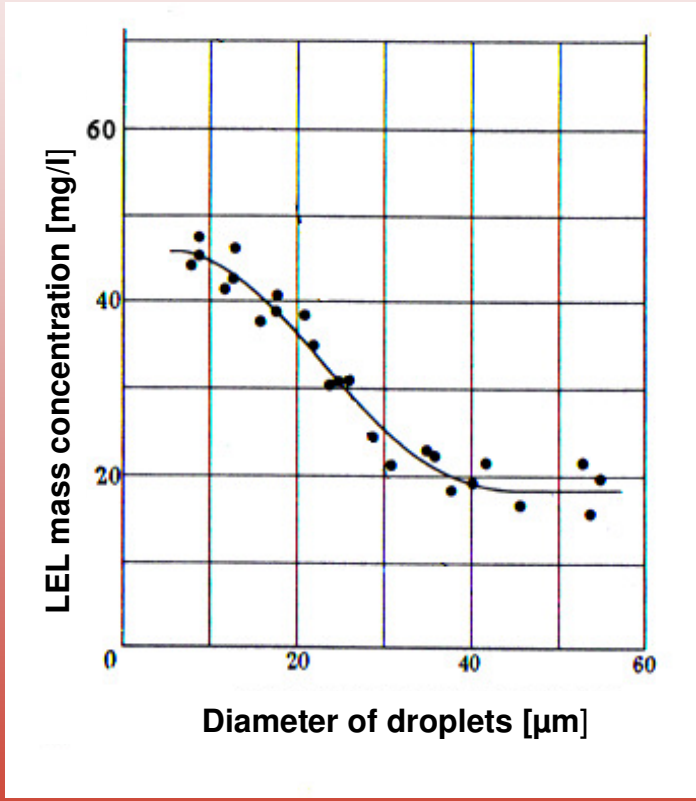
Method: Creation of explosible oil mists

Lower explosion limit of oil mist (LEL) in litererature:



- Burgyone et al.: basic experiments to determine the LEL of oil mist at about 50 g/m³ used in safety data sheets or safety guides until today
- LEL of oil mist depends on the droplet size and decreases with increasing droplet diameter

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Method: Creation of explosible oil mists

Attempts to create an explosible atmosphere

- Spraying of mechanical produced oil mist from an oil mist generator into a defined test volume ($1m^3$) with variation of the droplets diameter (from 1 to 5 µm), variation of the pressure and temperature, using 1 to 3 nozzles
- Inserting of thermal produced oil mist from an oil mist generator into a defined test volume ($1m^3$)

no success

- Heating of oil directly in the test volume ($1\ m^3$)

explosion

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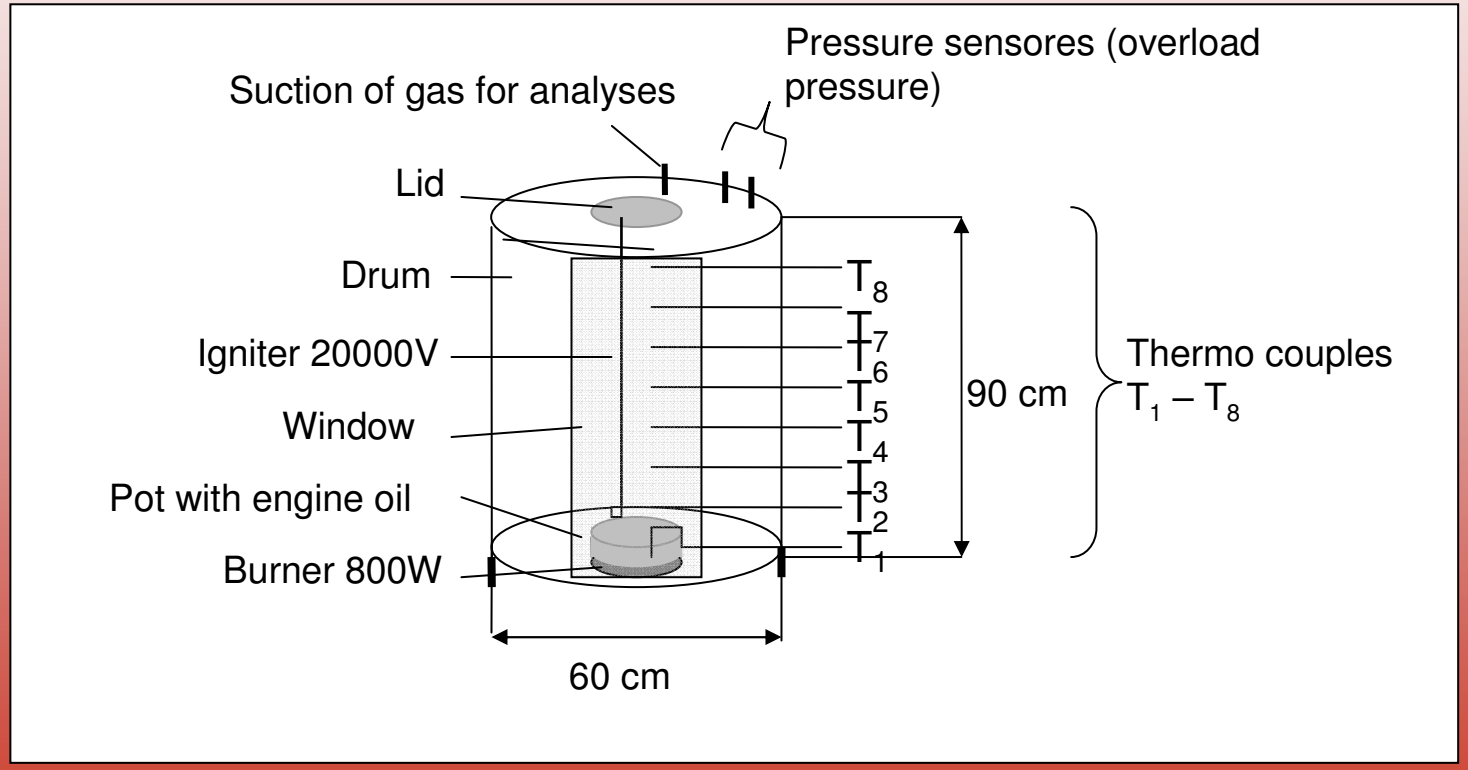
Method: Creation of explosible oil mists

Test set up



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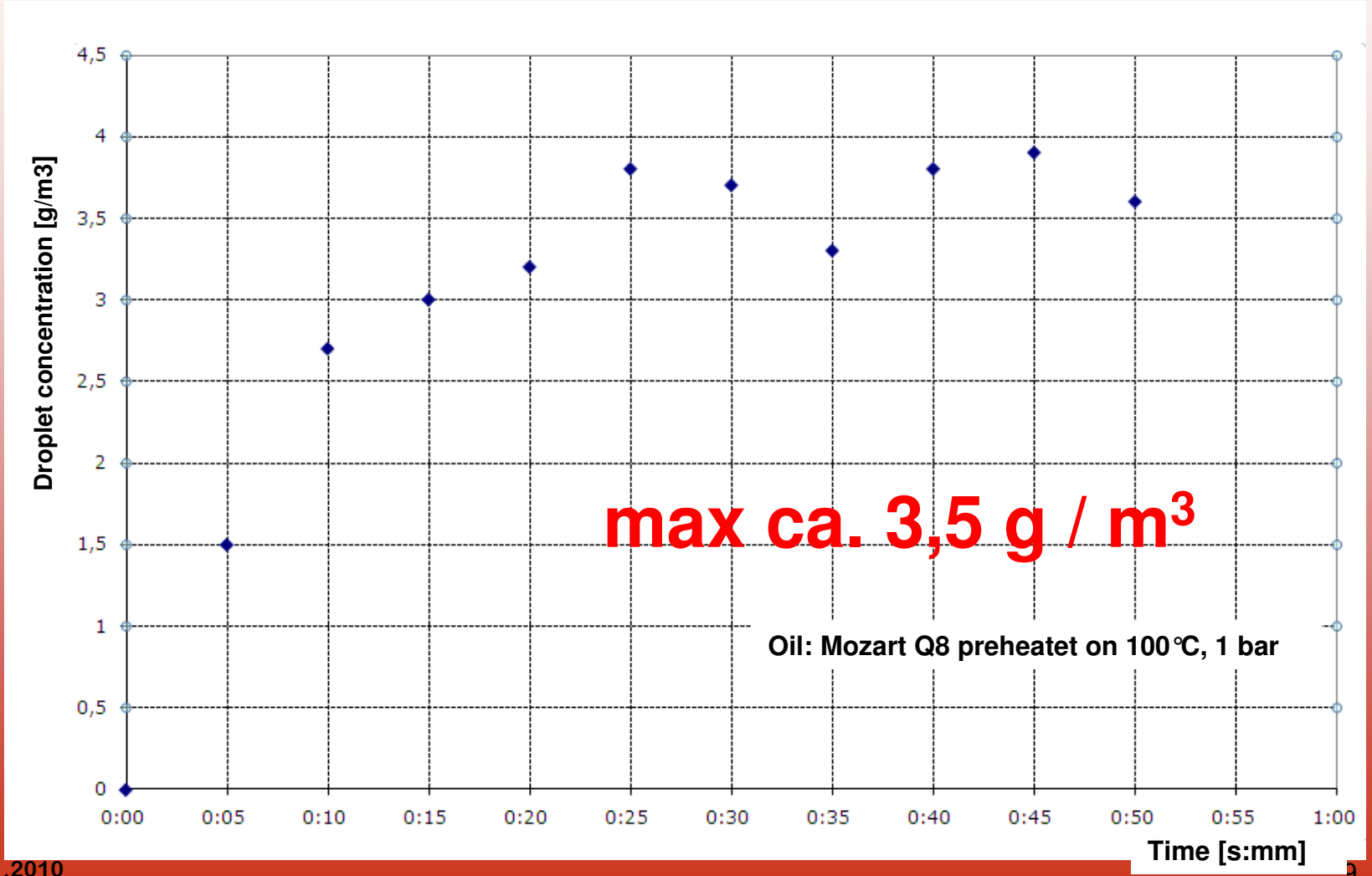
Creation of explosible oil mists



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Creation of explosible oil mists

- **Max. oil mist concentration 3 – 4 g/m³ (compared to literature 50 g/m³)**

Possible Reason: Adjusting equilibrium between new droplets and coagulating or sinking droplets

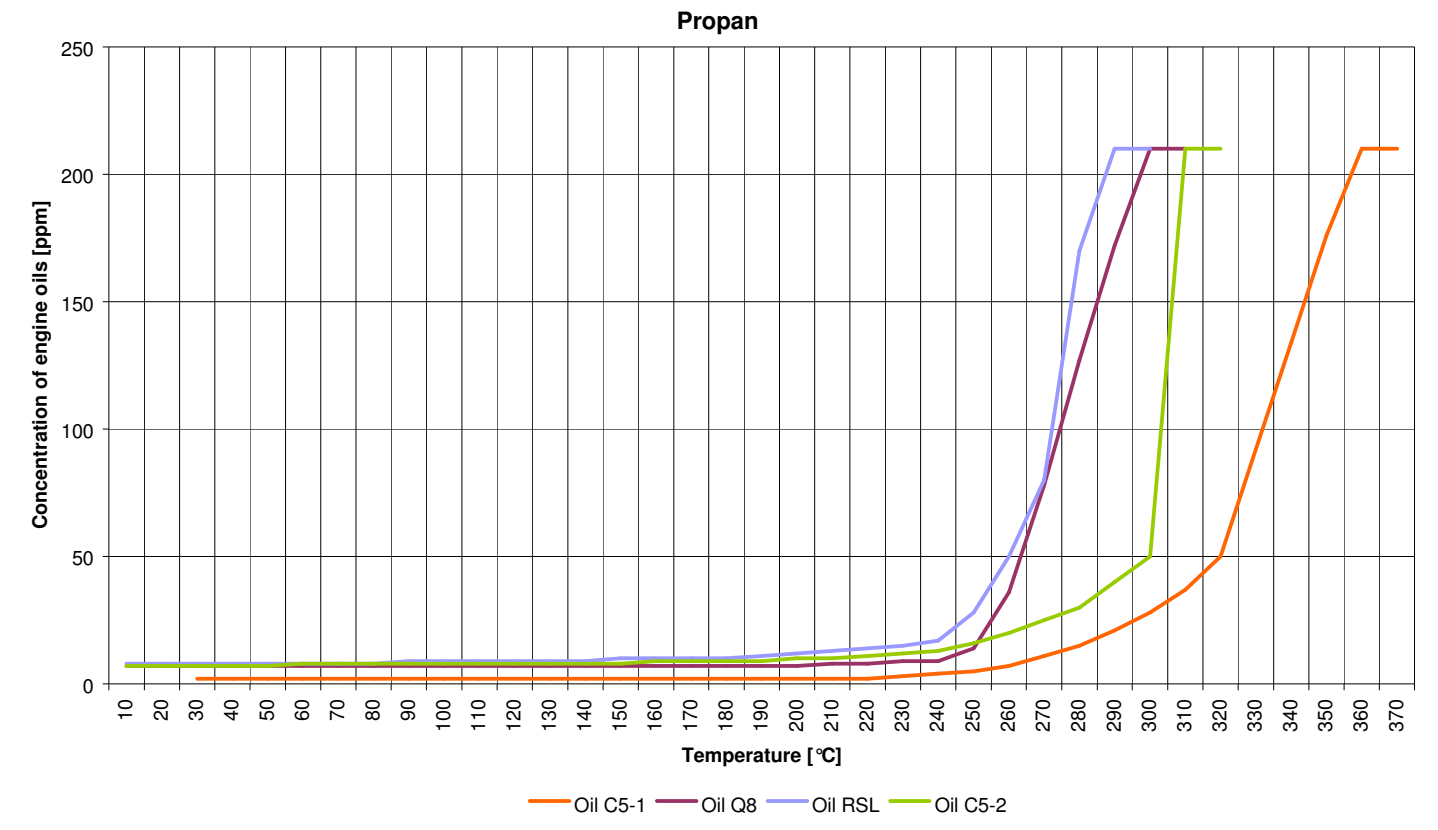
- **Explosivity of oil mists**
  - **Not caused by fine droplets**
  - **But caused by explosive decombustion gases**
  - **Oil mist detectors relay on a LEL of 50 g/m³**

Oil mist explosions happened in the past although no alarm by oil mist detectors

Creation of explosible oil mists

Example Graph : Propan

- Oil temperature during ignition 240°C – 330°C



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Creation of explosible oil mists

- **Explosivity and flamability of analysed gases:**

Gas	Flash point [°C]	Explosion limits [Vol.%]
Propane	-104	1,7 – 10,8
Formaldehyde	32	7 - 73
Hydrogen	-240	4 - 77

The thermal degradation of lubrication oil as a cause of crankcase explosions is considerably more probable as the assumed oil mist.

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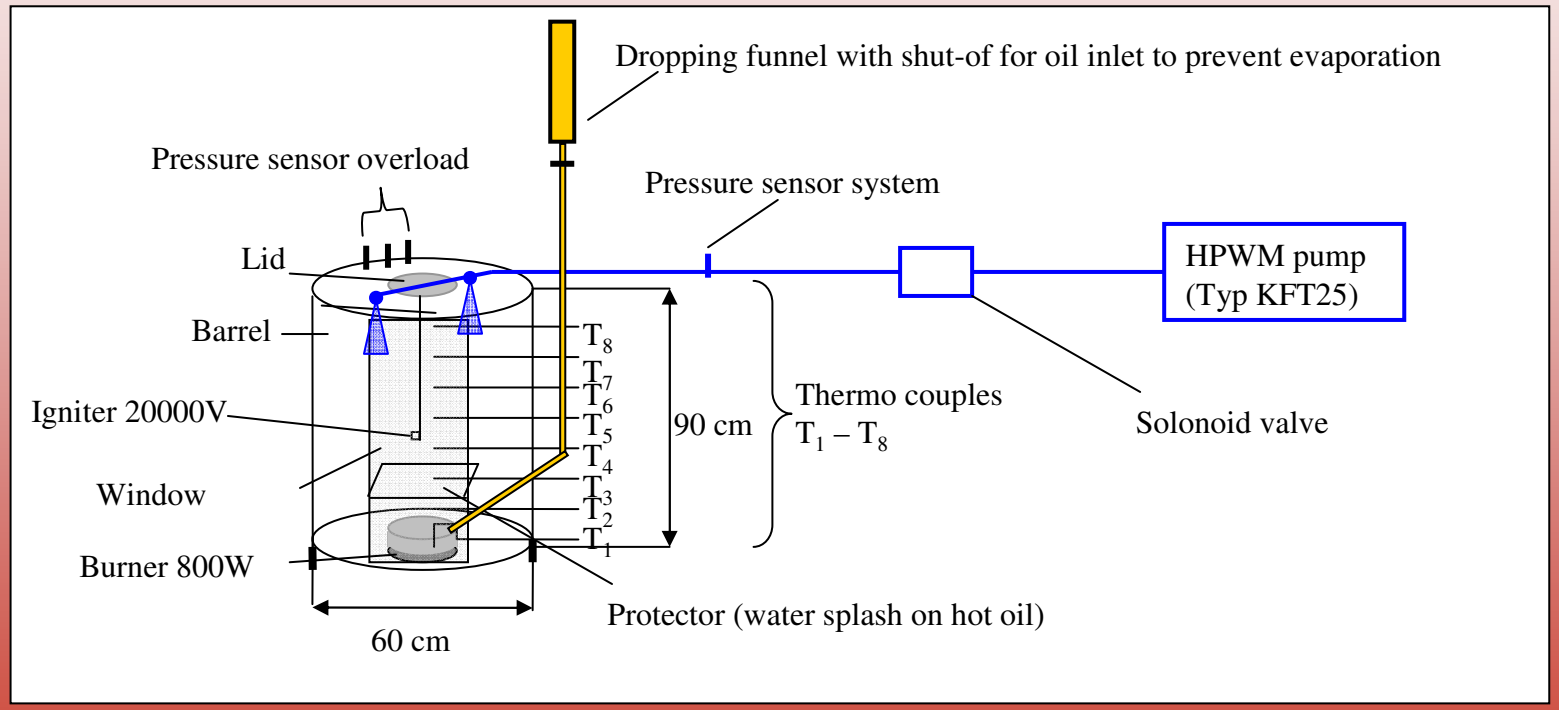
Reducing risk of explosion by activation of water mist

Prevention of the development of an explosible oil mist atmosphere:

- Not by condensation or coagulation processes between droplets of oil and water mist
- By decreasing of the ignition energy with water mist (cooling)

Method: Activation of HPWM

- **Test set up**



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Method: Activation of HPWM

Activation of water mist with variation of

- Flow rate
- System pressure
- Position of nozzles

Dimension of an explosion by the measurement of

- Overload pressure
- Explosible gases

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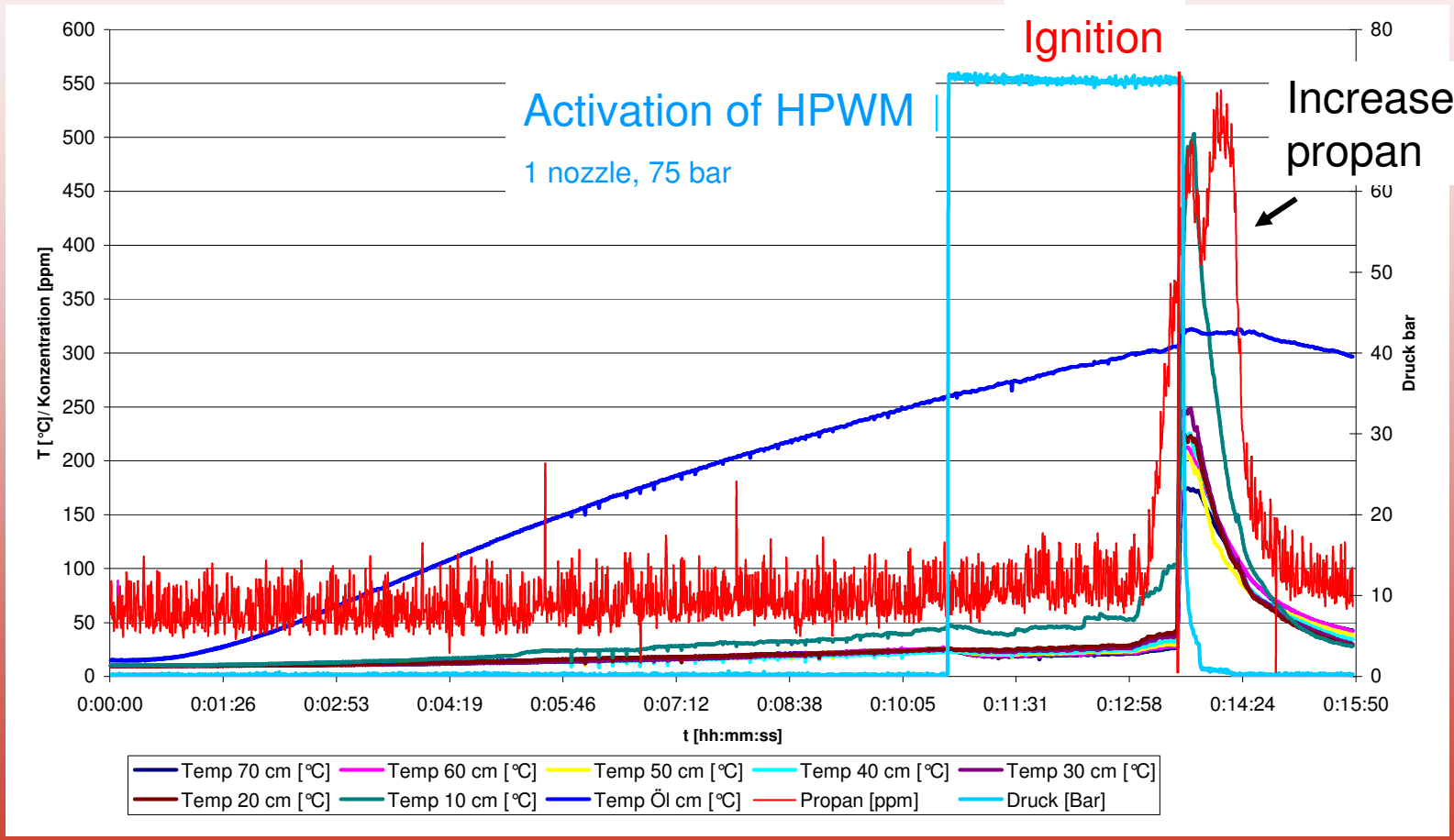
Results: Activation of HPWM



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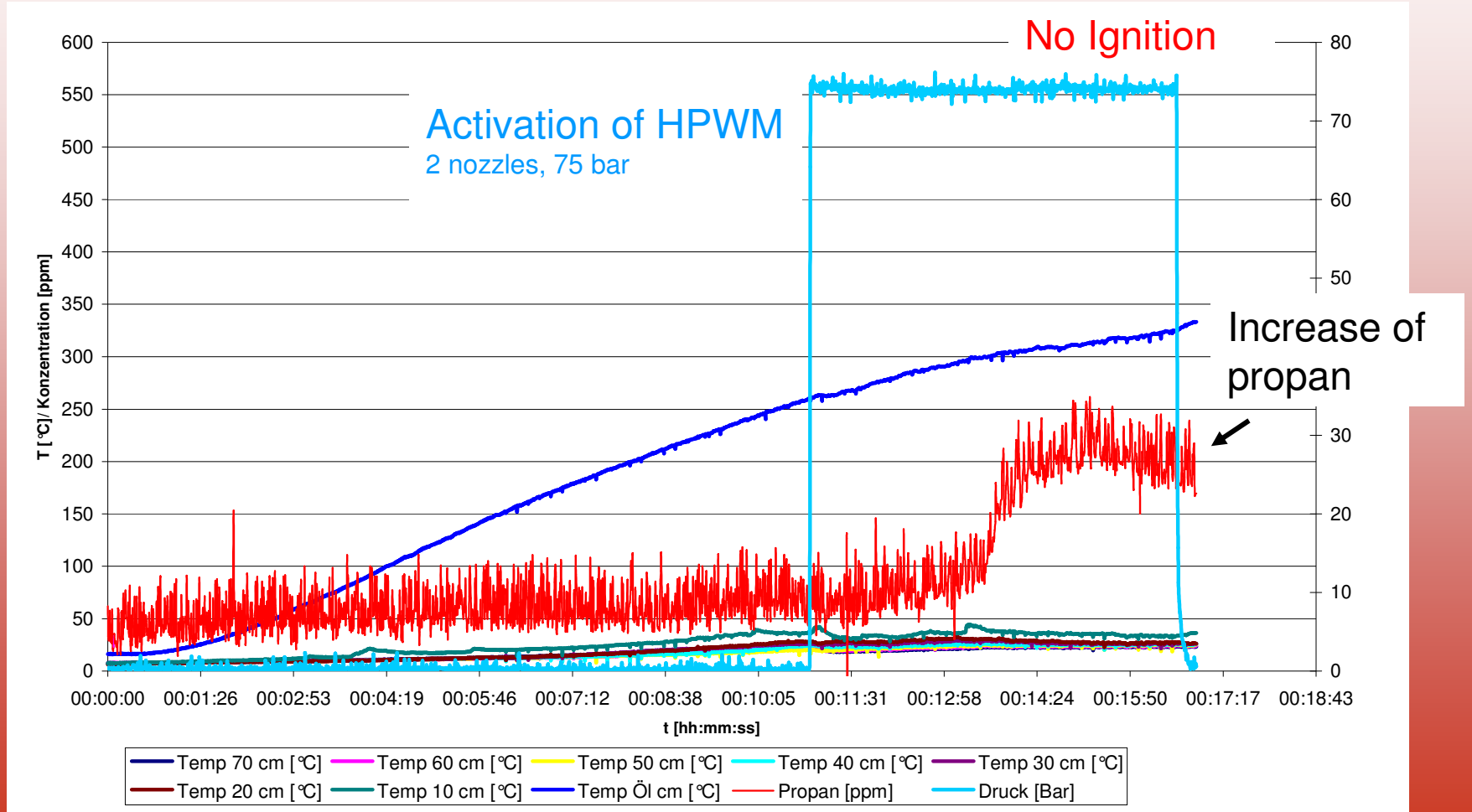
Results: Activation of HPWM



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Results: Activation of HPWM

Nr.	Test	K-Faktor	Flow rate [l/min]	Pressure HDWN [bar]	Overload pressure at ignition [mbar]
1	External ignition	2 x 0,01	0	0	13,77
2	Self ignition		0	0	29,91
3	Horizontal layout of 2 nozzles		0,1	25	21,01
4			0,122	37	4,24
5			0,141	50	-
6			0,173	75	-
7			0,2	100	-
8	vertical layout of 2 nozzles		0,173	75	4,63
9	vertical layout of 1 nozzle, 30 cm above protector	1 x 0,01	0,087	75	10,44
10	vertical layout of 1 nozzle, 10 cm above protector		0,087	75	7,31

Decrease of overload pressure by increase of HPWM by

- **Flow rate**
- **System pressure**
- **Optimised nozzle position**

Summary & Conclusion

Application of HPWM

- Prevention of ignition of explosible gases
  - By cooling of the surrounding atmosphere in the mock up
  - By decrease of ignition energy with HPWM
  - By dilution of concentration of explosible gases with HPWM

Application of Air (cooled/pressurised)

- No Prevention of ignition of explosible gases
  - Very slow cooling effect of the surrounding atmosphere in the mock up by use of cooled air
  - Acceleration of ignition by use of pressurised air

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Economical Benefits

- Use of present HPWM Systems in ships or other vessels to prevent oil mist explosions by ignition of explosible gases in combination with gas analyses
- Use of HPWM in crankcases as continuous running system to cool down hot surfaces that cause decomponsition of oil mists
- Development of new oil mist detectors that are not based on measuring the oil mist concentration rather than the gas concentration of developing explosible gases

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