Presented by

Kai Behle

Airbus Deutschland GmbH
BCECS2, Fire Protection

Contact: Kai.Behle@Airbus.com

Smoke Generation for Certification Ground and Flight Tests

Definition of Smoke Amounts

Overview

- Theoretical Background: Requirements and Guidelines
- Flashback: “FAA-Powder”
- Today: Paraffin Oil Smoke Generator
- Smoke Amounts - Airbus Method (linked to TSO C1d)
- Lab Test Campaign
  - Set-Up
  - Results (Smoke Generator and flaming Resin Block)
- Summary / Conclusion

Theoretical Background: Requirements

JAR's (FAR's are similar):

- JAR 25.0858 (a):

The detection system must provide a visual indication to the flight crew within **one minute** after the start of a fire.

- JAR 25.0858 (b):

The system must be capable of detecting a fire at a temperature significantly below that at which the **structural integrity** of the aeroplane is substantially decreased.

Theoretical Background: Guidelines

AC 25-9A - Extract about smoke amounts and generation:

§10 a

(2) A smouldering fire producing a **small amount** of smoke in conjunction with the applicable detection time (…) could be detected early enough to ensure that the fire and smoke procedures would be effective. **Subjective judgment**, considering the failure, size of compartment (…) is needed to assess the significance of a small amount of smoke.

(3) (…) **theatrical smoke** generators are acceptable for detection tests if the smoke generator is operated for limited intervals to limit the amount of smoke generated. (…)

Flash-Back: Smoke Generation with “FAA-powder“

- In FAA technical report FAA-ADS-73 (dated 1966) a mixture of each 50% potassium chlorate and lactose is proposed to be used for certification tests on smoke detection installations.

- Powder amounts to be used shall depend on:
  - Compartment **size**
  - Air **flow rate**

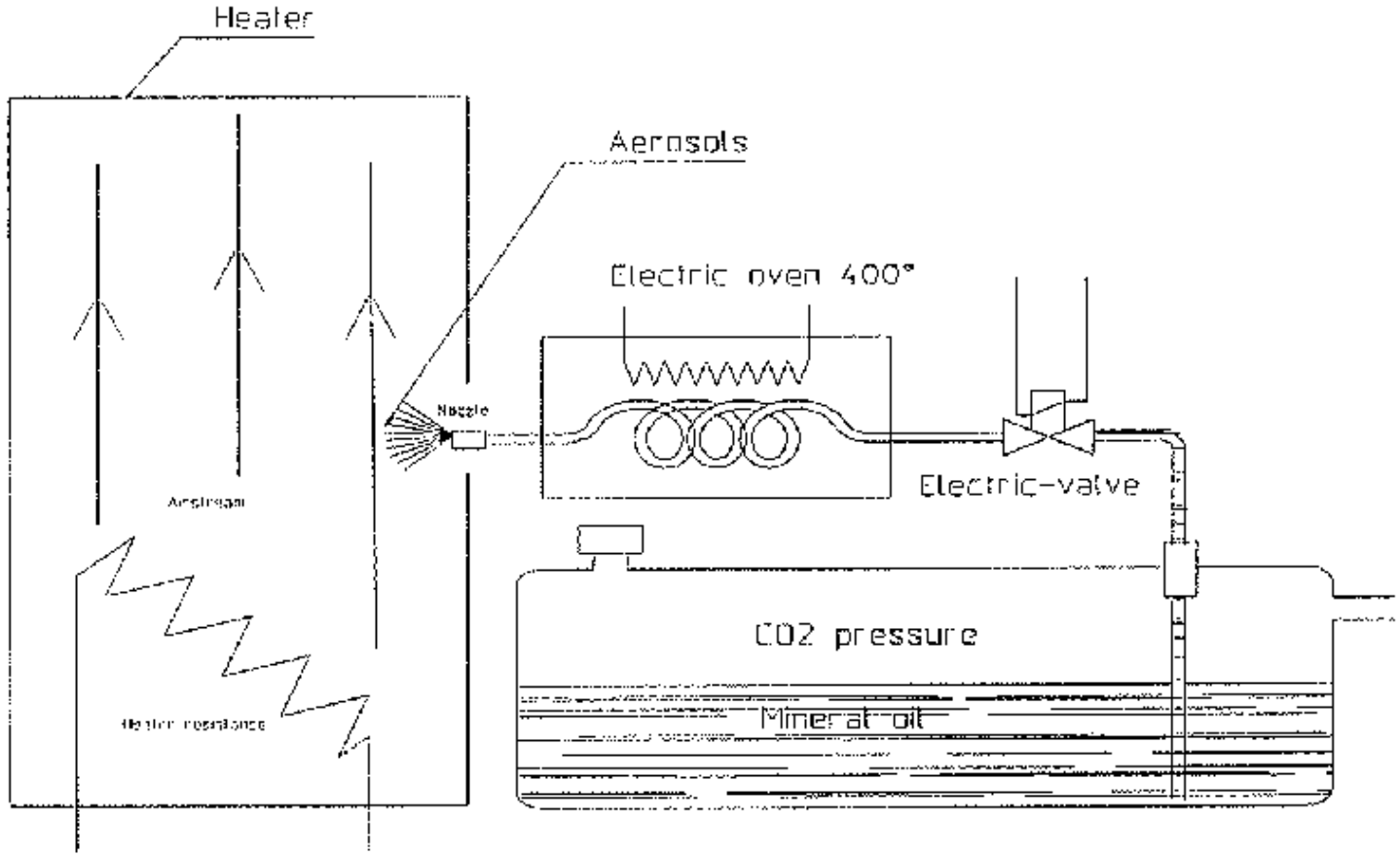
- This mixture was used within Airbus programs until mid of the nineties. For several **disadvantages**, in particular heavy sputtering and emission of toxic gases during the burning process, a new smoke generation method needed to be developed.

Today: Paraffin Oil Smoke Generator (used by Airbus)

A paraffin oil smoke generator was developed (Aerotec AX 1000 derivate ZZ103) in 1995 (refer to P26RP0301705 Edition 1)

Smoke Generator Functioning Principle

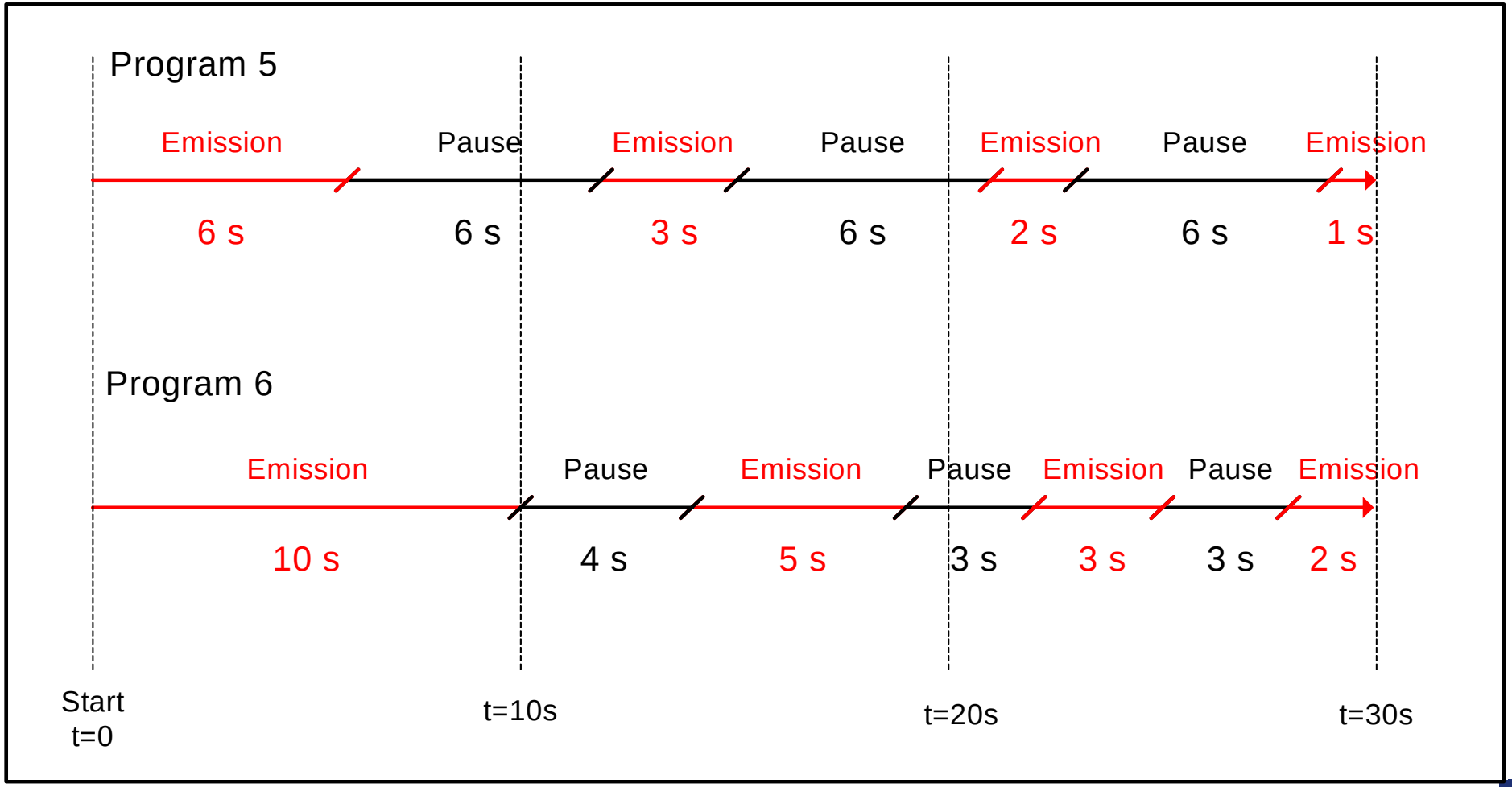
- Principle: Paraffine oil is pre-heated and directed towards a heated deflection plate directing the smoke upwards:



→ Upward deflection of simulated smoke is necessary to generate buoyancy

Paraffin Oil Smoke Generator (continued)

Different smoke generation programs were developed to represent various “FAA-powder“ amounts. E. g. the following programs were used during A318 ground- and flight-tests:



Paraffin Oil Smoke Generator (continued)

Smoke Generator Operation:

Both depicted sequences show that smoke is not permanently generated. In both cases, smoke generation is stopped after 30 seconds.

⇒ **Therefore, AC25-9A §10 a (3) is fulfilled.**

Smoke Amounts – Airbus Method (linked to TSO C1d)

- Light obscuration (in %/m or %/ft) is **the** physical parameter for assessing performance of optical smoke detectors
- TSO C1d requirement about required optical smoke detectors sensitivity:
  Alarm threshold setting: 12.5 %/m – 81 %/m light obscuration

→ Airbus method: use smoke amount leading to approx. 13%/m light obscuration (with ventilation switched off)
  - after 30s and
  - at one third of the compartment length (for LR and A380 compartments) with smoke generator located at FWD compartment wall

→ Determination of smoke generator setting in lab test campaign

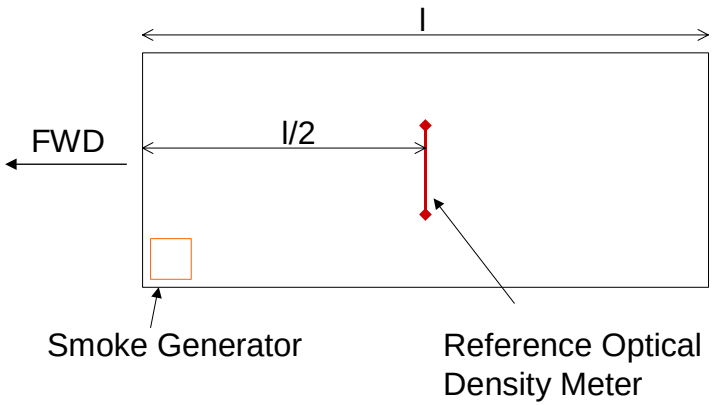
Smoke Amounts – Airbus Method (continued)

Airbus proposal as presented during Fire Protection Workshop held in Renton in Sep 2004

Proposal for Smoke Det. Response Time Tests

1. Step: Determine appropriate Smoke Amount and Smoke Generator Position in Lab- or Ground Test

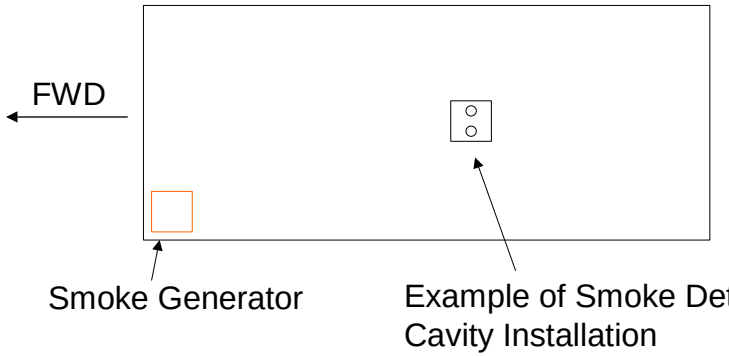
Example: Top View of Small Lower Deck Cargo Compartment



Proposal for Smoke Det. Response Time Tests

2. Step: Conduct Test on Aircraft with Smoke Amount and Generator Position determined in Step 1

Example: Top View of Small Lower Deck Cargo Compartment



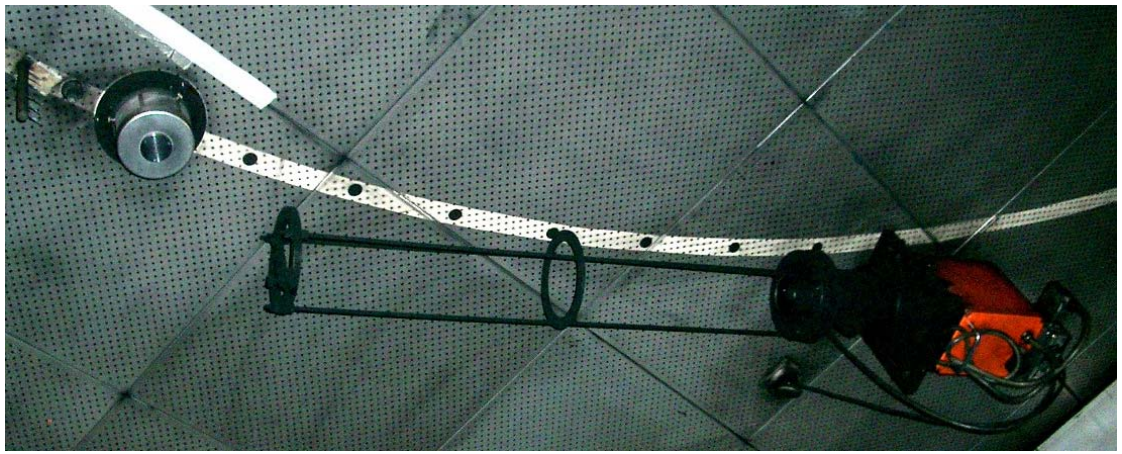
Note: Distance of l/2 between smoke generator and optical density meter was proposed for “small“ (e.g. single aisle airplane cargo compartments)

Lab Test Campaign – Set-Up

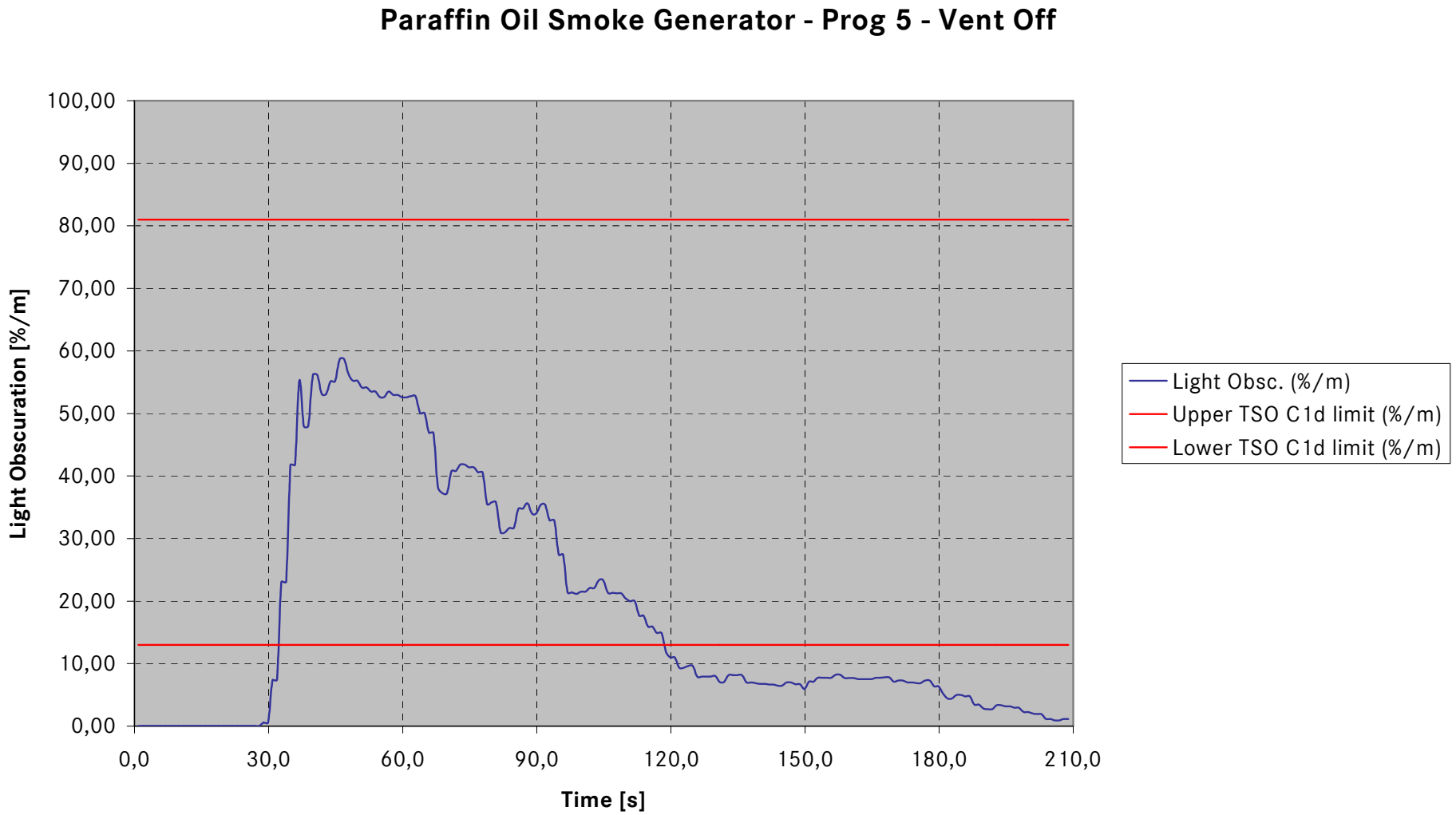
- Measurement campaign was conducted with smoke detector supplier Siemens/F
- Similar geometries of A380 FWD LDCC and Mock-up:

	A380 FWD LDCC	Mock-Up
Length	17.4m	14.4m
Width	4.2m	4.6m
Height	1.8m	1.8m

- Reference measurements taken by opical density meter



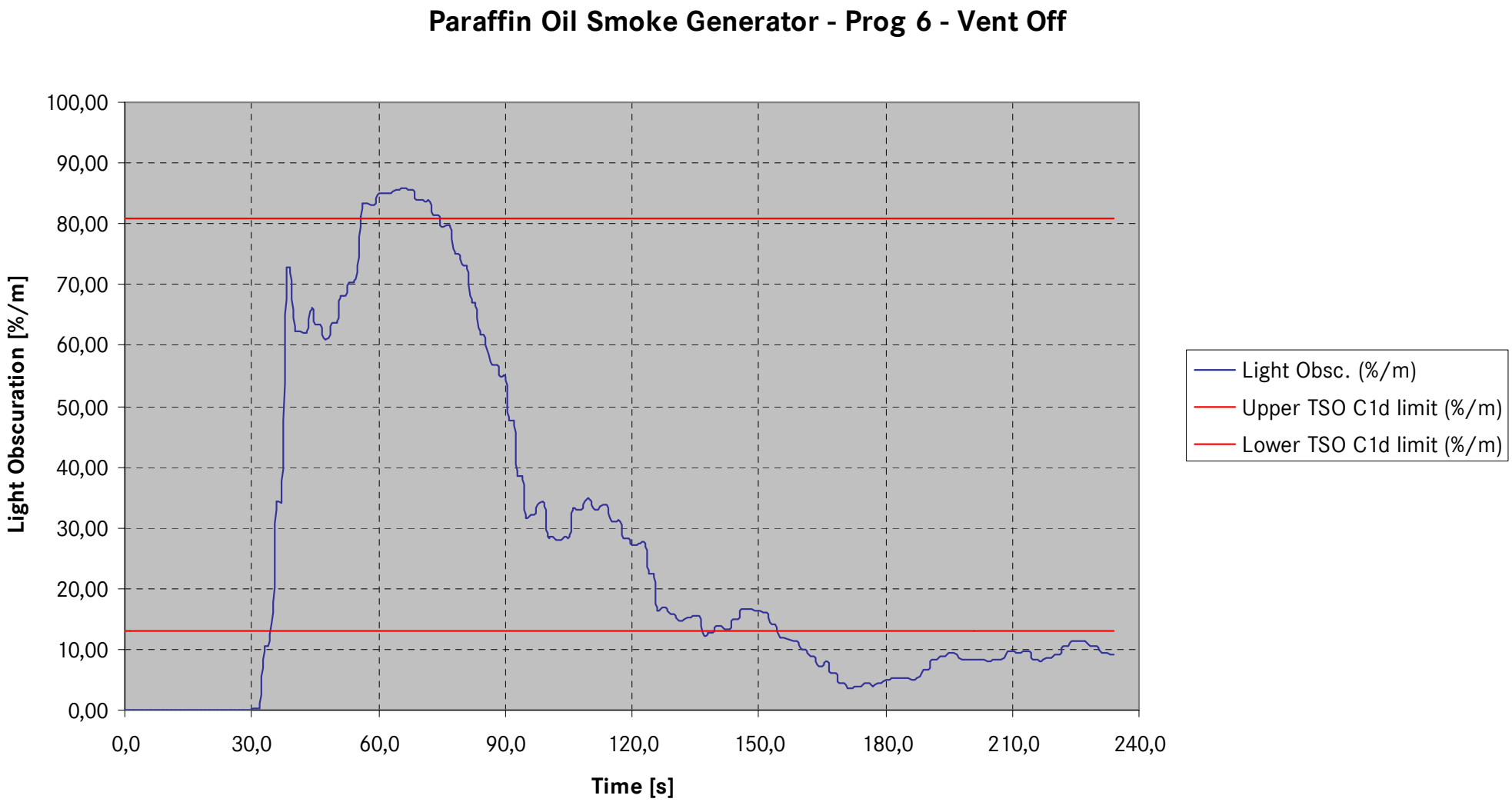
Results – Paraffin Oil Smoke Generator



- Light obscuration after 30s at ≈1%/m, ≈13%/m reached after 32s,
- Upper TSO C1d threshold not reached
- High dynamic due to upward deflection and sinking tendency of simulated smoke

→ **Smoke generator setting in accordance with Airbus proposal**

Results – Paraffin Oil Smoke Generator (cont'd)



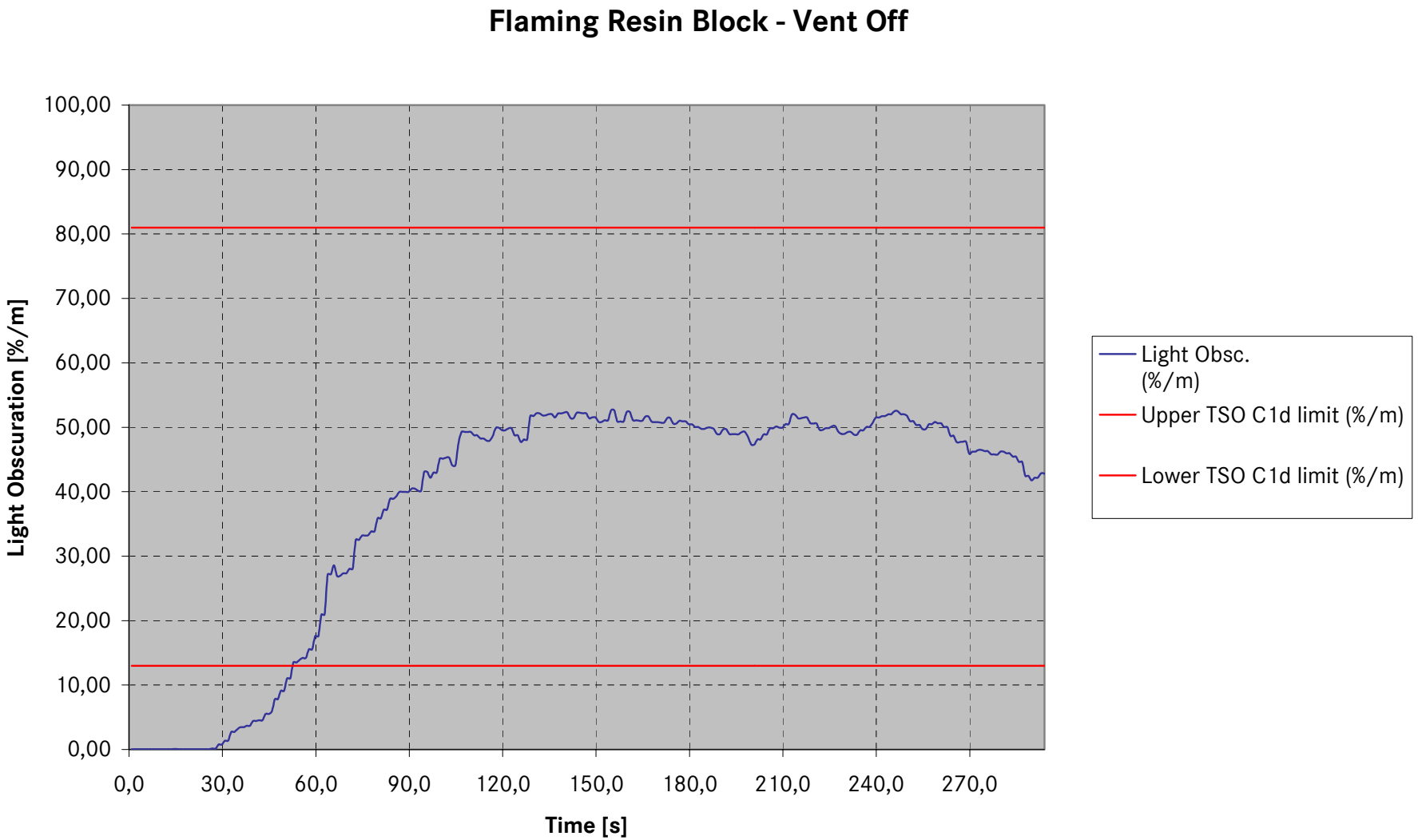
- Light obscuration after 30s at = 0%/m, ≈13%/m reached after 34s
- Upper TSO C1d threshold reached after 56s
- High dynamic due to upward deflection and sinking tendency of simulated smoke

Additional Tests – Flaming Resin Block

The “resin block” has been developed by FAA Technical Center with following targets:

- Reproducibility
- Detectability for multi-criteria fire-/smoke sensors
- Production of comparable smoke amount as “burning suitcase“

Additional Tests – For Reference Only



- Light obscuration after 30s at ≈1%/m, ≈13%/m reached after 52s
- Upper TSO C1d threshold not reached
- Max smoke density is maintained over 3 minutes → overall smoke amount higher than that generated by smoke generator prog. 5 and 6

Influence of Ventilation Rate

All shown test results were obtained with ventilation switched off.
The case with ventilation switched on might pose a serious challenge for detection of smoke generated by smoke generator program 5 or 6 as

- the smoke “plumes” generated by the interval mode of the generator might be extracted before the targeted homogenous smoke distribution is reached, and
- the smoke generator in program 5 or 6 stops smoke emission after 30 seconds.

→ When ventilation is switched on, the scenario simulated by “FAA-powder” and the paraffin oil smoke generator in program 5 & 6 might not represent a slowly evolving and continuing fire

Influence of Ventilation Rate (continued)

For the reasons mentioned above, a different smoke generator program might be chosen with ventilation switched on. This approach is considered justified as:

- It is common practice to base the smoke amount to be used on on air flow rates and compartment sizes (e.g. FAA report ADS-73 and FAA Technical Center Presentation held in Grenoble on 21 June 2004).
- Unlike the paraffin oil smoke generator in program 5 and 6, the flaming resin block – as well as a realistic fire scenario – continues generating smoke after 30s up to at least 180s (no generation of plumes)

The influence of ventilation will be verified in an A380 mock-up-test campaign beginning of 2006.

Summary / Conclusion

- It has been shown that AX1000 programs 5 and 6 are in line with AC25-9A
- Smoke generator program 5 comes closest to Airbus proposal about smoke amount determination
- Smoke emission by the flaming resin block continues for at least three minutes, whereas smoke generator in program 5 and 6 stops emission after 30s (crucial for case with ventilation switched on)
- Smoke generator programs 5 and 6 lead to higher signal dynamics and higher short-term maximum smoke density than flaming resin block
- Influence of ventilation needs to be investigated case by case

AIRBUS

AN EADS JOINT COMPANY
WITH BAE SYSTEMS

Backup: Dependence of Smoke Amounts on Comp. Sizes

- The key-criterion for the possibility to detect smoke is smoke concentration, i.e. a certain smoke amount per defined volume
  - The number of smoke detectors is irrelevant for detection if the smoke density corresponding to the alarm threshold (e.g. 12.5%/m) is not reached

  → Adaptation of smoke amount to compartment size/volume is necessary and reflected in Airbus proposal

  → Due to smoke propagation time, smoke detector number to be used to monitor compartments still needs adaptation to compartment size

Backup: Dependence of Smoke Amounts on Comp. Sizes

For the reasons mentioned above, it is necessary and common practice to vary smoke amounts in dependence of compartment sizes as mentioned in several FAA documents, for example

- FAA-ADS-73 and
- FAA Technical Center Presentation held in Grenoble on 21 June 2004 (refer to FAA Technical Center homepage).

Backup: Smoke Amounts Comparison – Ventilation On