BRAKE DUST

HORIBA´s input on the brake enclosure specification

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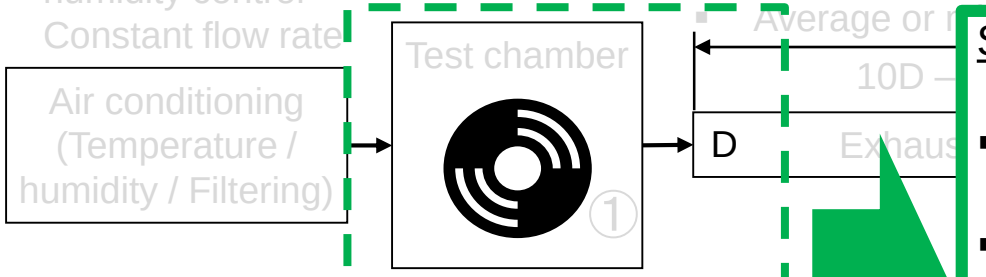
TF#24: Brake enclosure



- Brake temperature
- Utilization of a brake closure
- Enclosure design?
- Flow uniformity?
- Particle collection + transport efficiency?
- Interfaces to cooling air and exhaust duct

Scope of task force 2:

- Define **robust performance criteria** whereever this is applicable!
- Avoid **random design criteria** and restrictions based on assumptions and simplifications! PMP does not develop a system design!
- Always consider components and influencing factors upstream and downstream of the enclosure (cooling air duct/ exhaust duct)! **The brake enclosure is not an independent system!**

- **Existing requirement**
- **Topic still open!**

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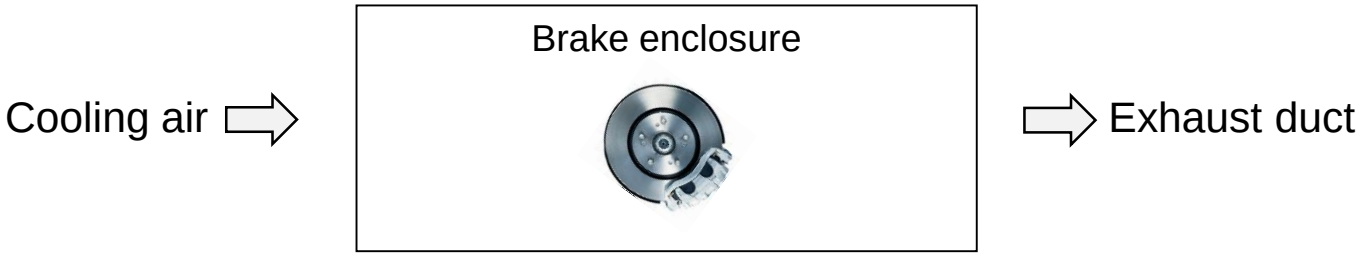
CPC= Condensation Particle Counter
PCRF= Particle Concentration Reduction Factor

Enclosure design

General design considerations: Outer dimensions and shape of the enclosure



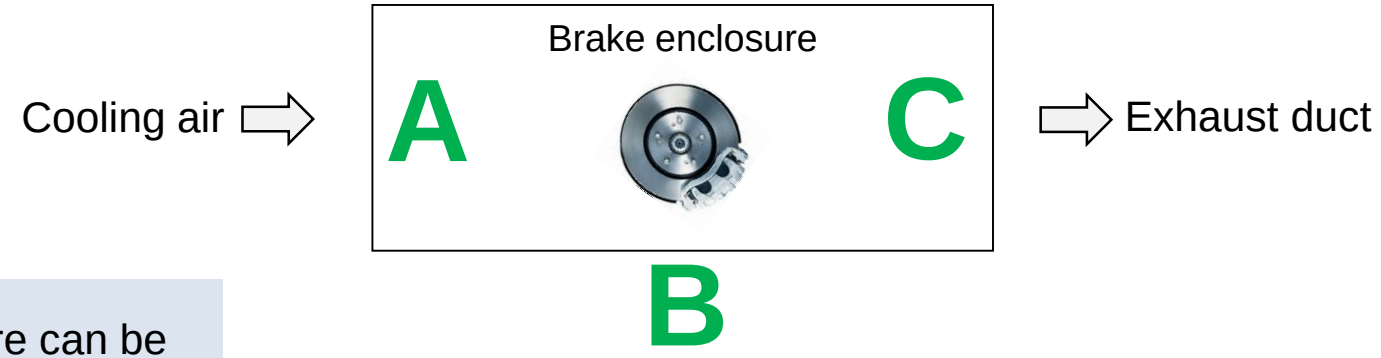
General design considerations:

- The outer dimensions of the brake enclosure are determined by the dimensions of the brake assembly!
- The brake enclosure should allow measurements of all the common sizes of LDV brake assemblies! One design for all brakes!
- The shape of the brake enclosure is dependent on duct dimensions upstream and downstream of the enclosure!
  - In an ideal world, the enclosure got the examt same dimensions as the cooling air and the exhaust duct to avoid any void areas, additional flow inhomogenities, cross section changes and so on…but: This is not realistic considering all the different brake dynos, laboratory space restrictions and duct works!

→ Geometric requirements shall NOT be introduced as they are mainly determined by the brake assembly itself and the duct work!

Enclosure design

General design considerations: Internal dimensions and shape of the enclosure



The brake enclosure can be separated into 3 areas:

- The cooling air supply section (A)
- The particle generation and collection area (B)
- The particle transport section (C)

The dimensions of these 3 areas are not constant and vary…

→ between different tests (due to brake dimensions, cooling air flow rates…)

→ different laboratories/ dynamometers (due to different duct dimensions, flow homogeneity…)

→ even within a single test (due to brake rotation speed, local turbulences, particle characteristics…)

→ Geometric requirements shall NOT be introduced as they are mainly determined by the operation conditions and the duct work! Simplified design restrictions do not consider the 3 variable sections within the enclosure!

Flow considerations

Purpose of the brake enclosure: Brake cooling, particle collection and particle transport

Brake cooling area:

- → Install the brake assembly in the center of the incoming air stream
- → Define brake temperature tolerances
- → Ensure homogenous flow distribution (by means of huge cross section, diffusers etc.)

Particle collection area:

- → Define caliper position and orientation
- → No performance or design criteria applicable due to changing rotational speeds and local flow turbulences
- → Maximize air exchange rate, ensure proper dilution

Particle transport area:

- → Minimize cross section changes (ideal: Brake enclosure= exhaust duct)
- → Provide sufficient dilution for particle stabilisation, while avoiding additional flow turbulences
- → Minimize residence time

- → **Performance/ design criteria for ensuring flow homogeneity around the brake assembly should not be introduced due to the huge variety of unpredictable influencing factors!**
- → **The best way to minimize additional flow inhomogeneities in the enclosure is by avoiding changes in the cross section downstream of the brake assembly as in case of the HORIBA design! BUT: This might be too restrictive**

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Excerpt of other criteria…

…and why they should not be specified in detail!

- Particle collection and transport efficiency

  → This needs to be specified for the entire system (incl. brake enclosure, ducts, sampling and measurement instruments) and not only for the brake enclosure!

- Particle distribution and uniformity within the enclosure

  → Considering the huge amount of influencing factors (brake sizes, brake particle characteristics, flow rates, rotational speed, flow distribution) there is no chance to agree on minimum requirements

- Reynolds numbers at the inlet/ outlet of the brake enclosure

  → A Reynolds number below 2300 (=laminar flow) can not be achieved with the current cooling air flow rate settings needed to meet the brake temperature requirements

- Specific design requirements (such as a max. 30° transitional angle downstream of the brake assembly)

  → This is a simplistic „work-around“ instead of tackling the root-cause of the issue (cross section change)

Summary

HORIBA´s recommendations for the brake enclosure

Minimum requirements

The brake enclosure shall incorporate good aerosol sampling practice that includes the avoidance of sharp bends and abrupt changes in cross-section and the use of smooth internal surfaces to reduce flow recirculation zones. Gradual changes in the cross-section are permitted; however, it is recommended to apply smooth transition angles to overcome these cross-section changes. The residence time within the enclosure should be ≤ 2 second.

Alternative, extended requirements

The brake enclosure shall incorporate good aerosol sampling practice that includes the avoidance of sharp bends. The cross-section ratio between the center and the exit of the enclosure should be close to 1; bigger/ smaller ratios are only permitted in case of technical equivalence. Smooth internal surfaces should be used to reduce flow recirculation zones. The residence time within the enclosure should be ≤ 2 second.

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Thank you

Cảm ơn

감사합니다

ありがとうございました

Dziękuję

धन्यवाद

Grazie

Merci

谢谢

நன்றி

ขอบคุณครับ

Gracias

Obrigado

Σας ευχαριστούμε

Děkuji

Teşekkürler

شكرا

Tack ska ni ha

Danke

Большое спасибо

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