PMP 54th session

9th Jan 2024, 14:30-17:30 CET

Palais des Nations (Room E XXII)

Introduction to BRL brake technology

Environmental sustainable Braking Systems

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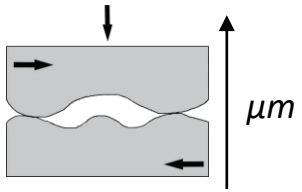
Summary

- 1. Foundation Technology
- 2. Liquid Cooling
  - Performance
- 3. Air Cooling
  - Performance
- 4. Actuation & Braking Torque
- 5. Friction Surface & Inertia
- 6. Packaging and Mass Distribution
- 7. Emissions [PM10 & PM2.5]
  - Liquid Cooled
  - Air Cooled

Foundation Technology

Technical fundamentals :

- *Use of friction technology for brake torque generation.*



- *The rotating element is the friction brake pads instead of the (current) brake disc.*

BRL's Technology Approach & Solving Emissions

Mechanical Brake

Liquid Cooled

Same Mechanical Operation

Air Cooled

Light vehicle < 7.5 tn

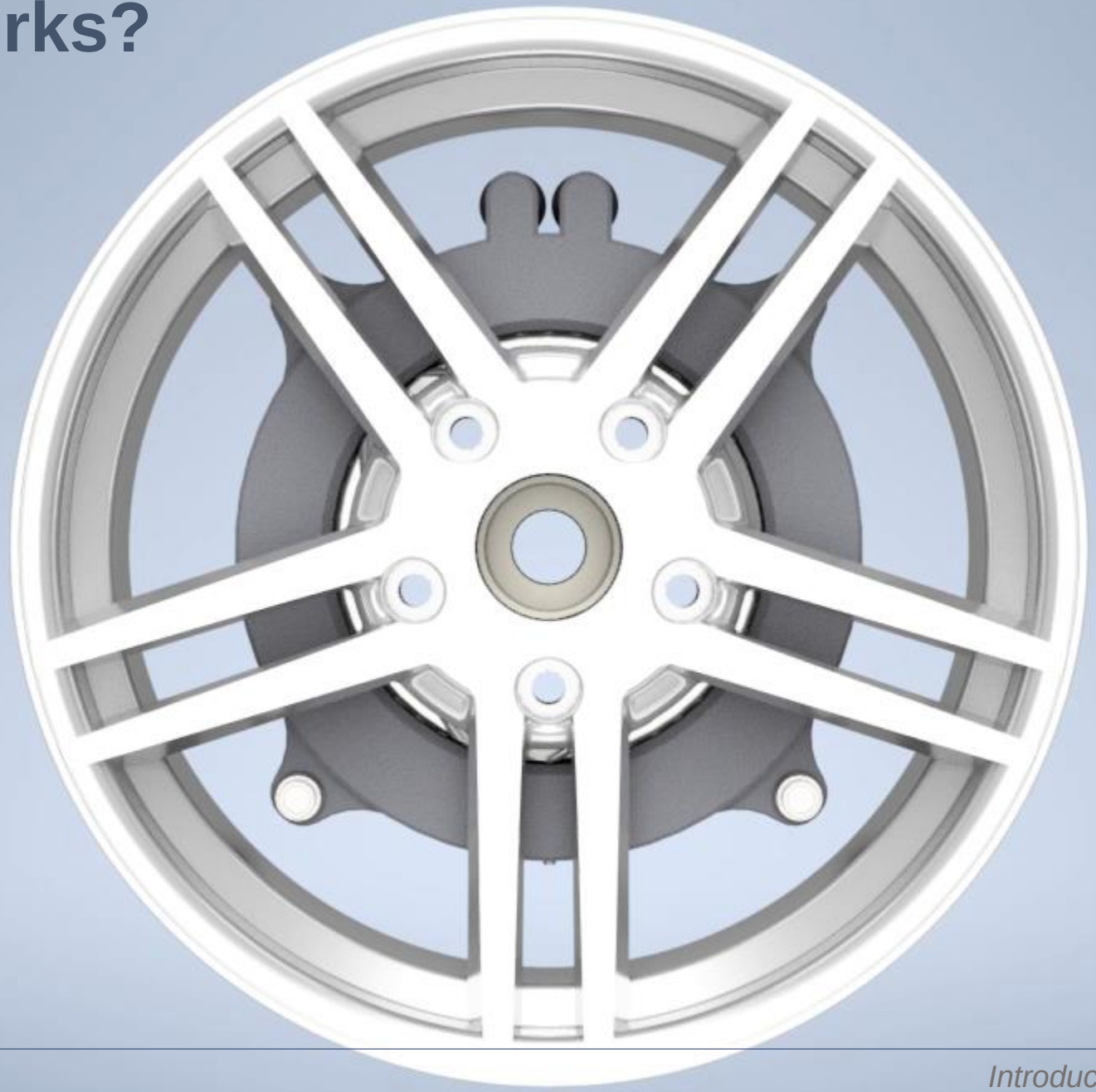
Commercial vehicle > 7.5 tn

- **Improve Thermal Management & Performance**
- **Increase the Life Cycle**
- **Improved Packaging**
- **Efficient, no residual friction torque.**

Capture fine particulates, eliminating emissions

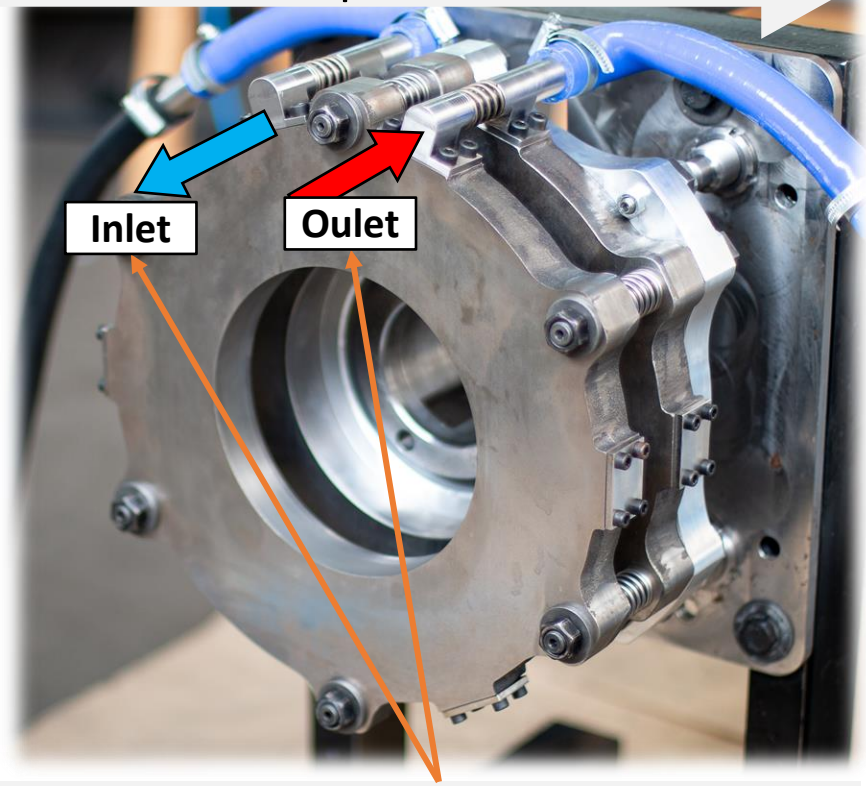
Without interfering with braking performance and safety

How BRL works?

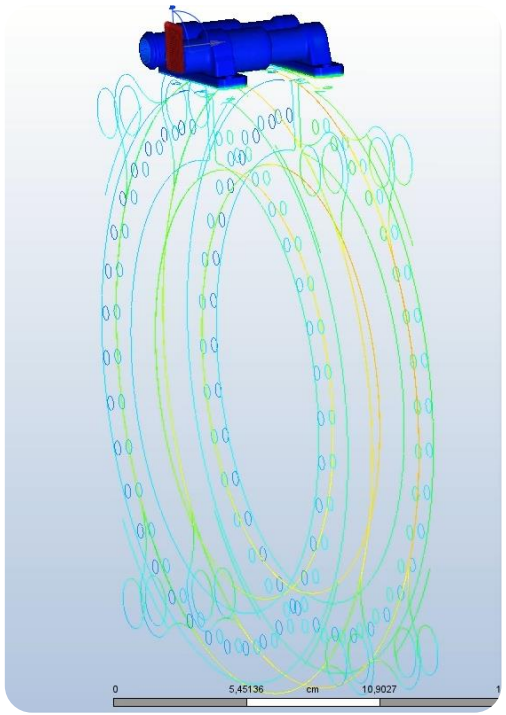


Liquid Cooling

How do we liquid cool the brake ?



Pressurized Chamber



- More efficient and higher boiling point of the coolant, no risk of leakage due to gassing.

Perfomance: Top performance with High cooling capacity

Materials: Use of cheap standard materials for highest performance.

Material	Thermal conductivity W/(m · k)	Specific heat J/ (G · ° C)	Density g/cm³
GJL-250 **(GCI)**	4,804E+01	0,450	7,395
Al-MC´s	[1,67-1,8]E+02	0,897	2,820

BRL Models For Passenger Cars in Al-MC´s	**[7-11] kg**

Set Up Packaging

- Use of the main radiator of the vehicle at **ICE ≈ [85-100]ºC & BEV ≈ [25-40] ºC**
- Use of separate radiator for brake circuit.

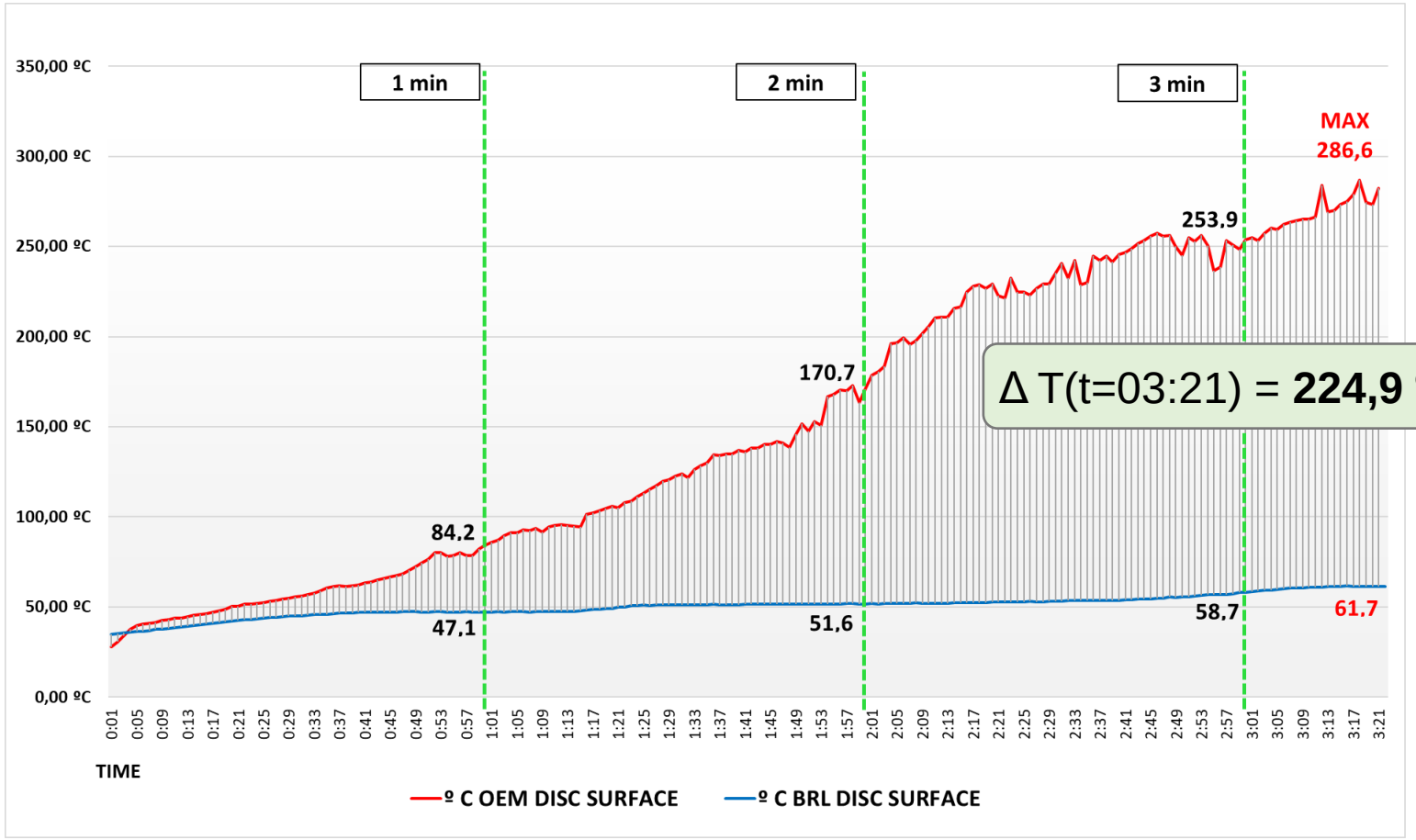
cm^2 Radiator — Cooling — m^3/s of Coolant — Cooling

Liquid Cooling Performance - *Test In House*

Vehicle / Testbench:
Audi A6 2.6 5V C4-ABC-2 150 cv
225 Nm / 3500 rpm

Register	UX120-014M Register HOBO
Sensors	TPK/E (Precision ➔ Clase 1 (+-1,5 K hasta 375 ºC, otherwise 0,004* (t))
Tubos refrigeración	Silicone pipe FDA 60 SH°(±5) Øe 18 mm X Øi 14 mm
Coolant	Ethyleneglycol 30%
Pump flow	20 l/min
Ambient temperature	28.1 ºC

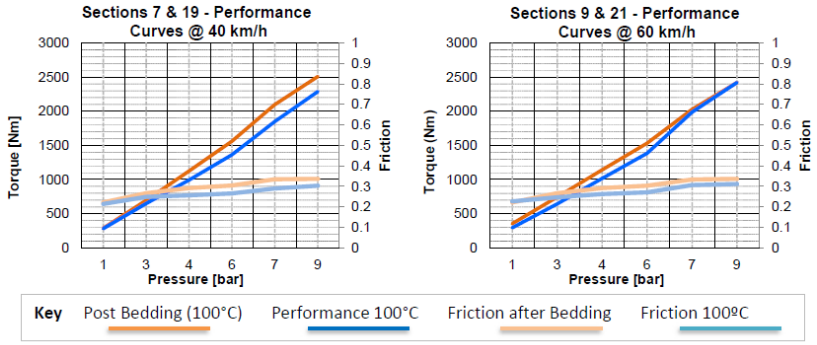
BRL vs OEM Disc Audi A6 (C4-ABC-2 series) – Drag Braking [3,250rpm to 2,500 - 2,750 rpm]

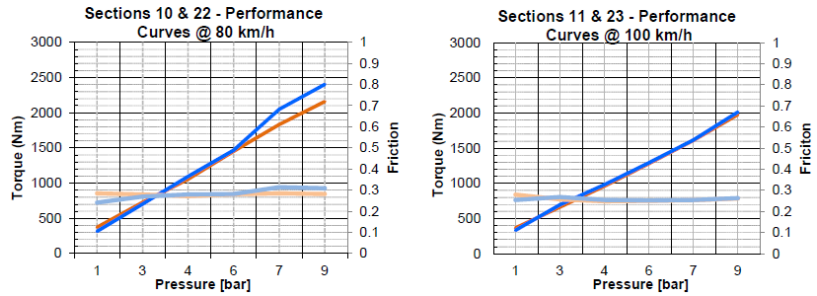


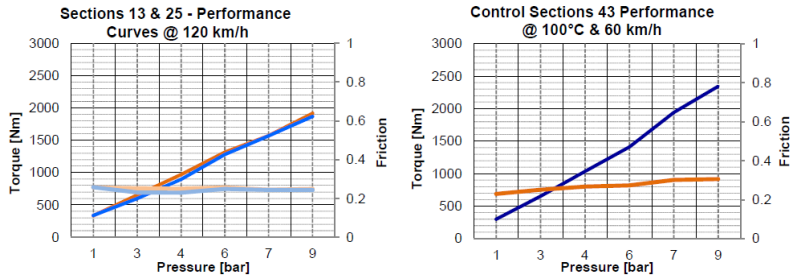
ISO 26865 - Liquid Cooling

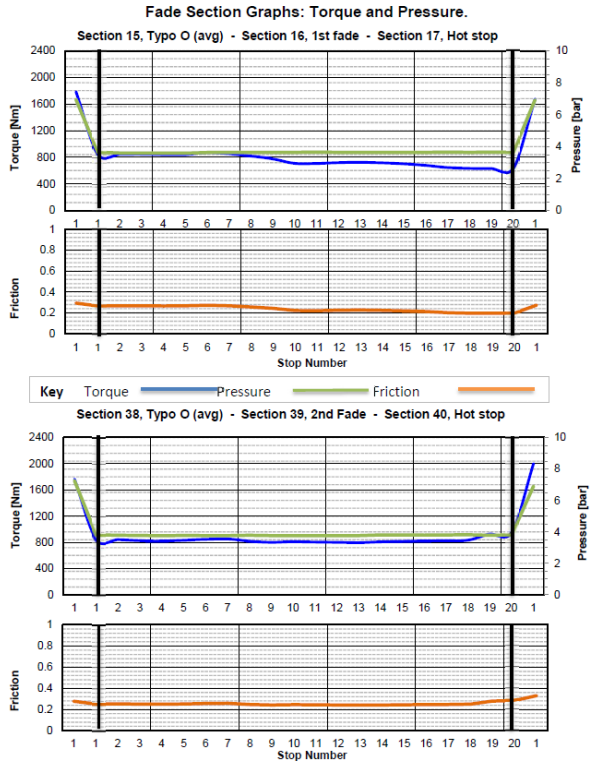
Extrated from IDIADA report: Report Number: R20110025-01
WO Number: WUK20110025

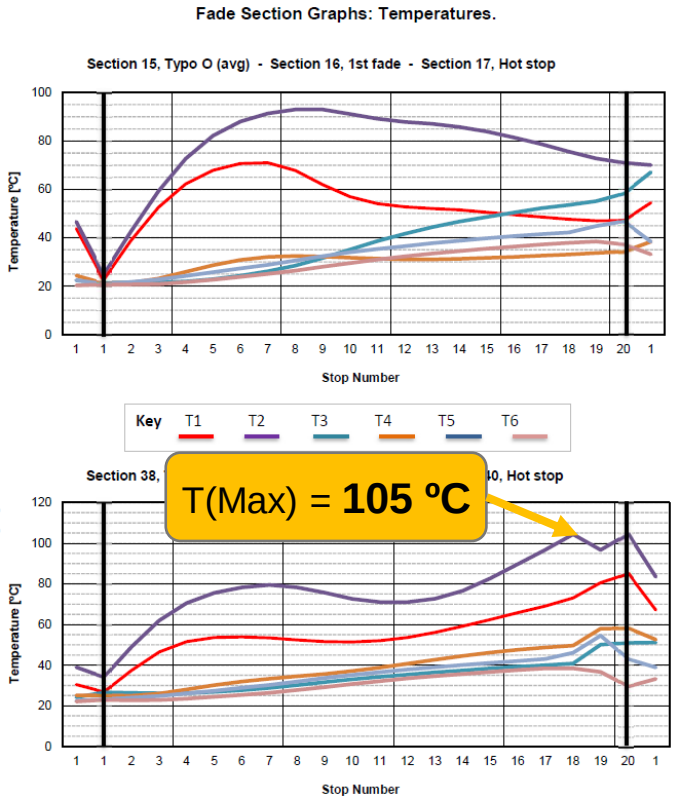
Applus IDIADA — UKAS TESTING 10369











Actuation type	Pneumatic
GVM	2,500 Kg
FAM 70% GVM	1,750 kg
Max Speed	120 Km/h
Pum Flow	[5-8] l/min

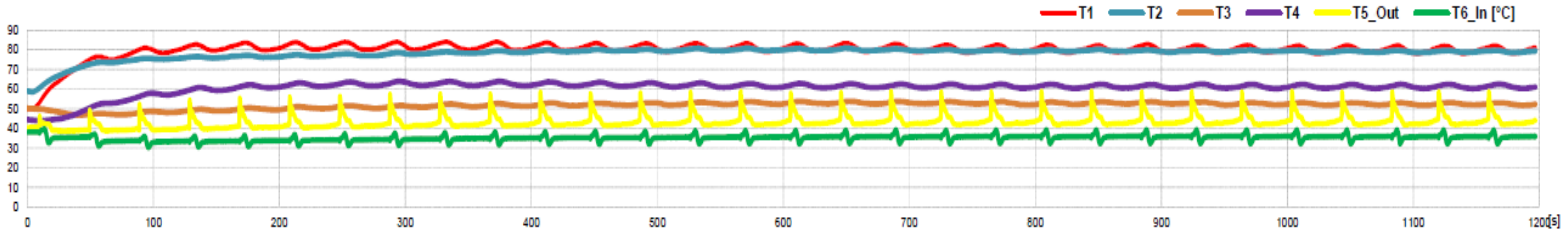
Direct drive, Pneumatically actuated P(max in test) = 9 bar

Repeatability: Great torque & friction stability at all Pressures & Speeds, both in performance and fade sections.

Downhill Thermodynamic Capacity - Liquid Cooling

Test 1 at 247 Nm

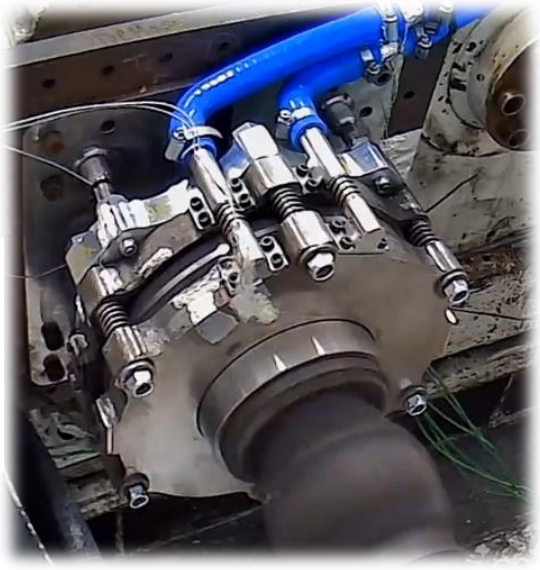
t(min)= 20:00



GVM	5,000 Kg
FAM 70% GVM	3,500 kg
Pump Flow	[5-8] l/min

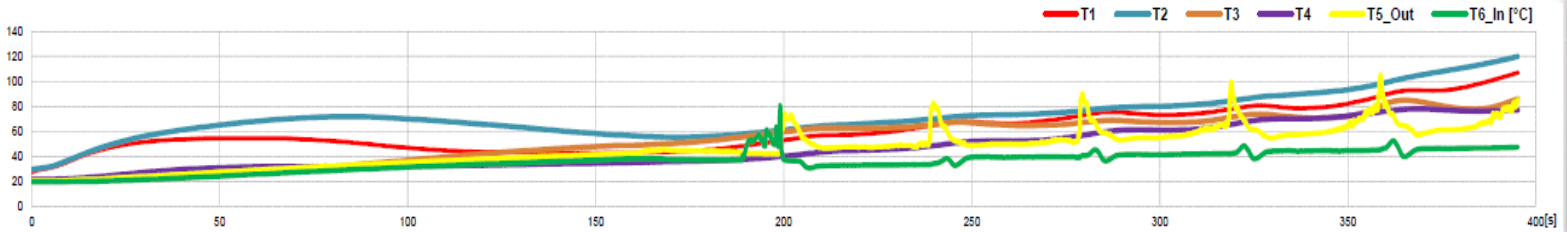
Max Temperature Friction face (T1,T2) = **80 ºC**

Max Temperature approach Coolant (T5) ≈ **50 ºC**



Test 2 at 670 Nm

t(min)= 6:40



Max Temperature Friction face (T1) = **120 ºC**

Max Temperature approach Coolant (T5) ≈ **65 ºC**

Extrated from IDIADA report: Report Number: R20110025-02
WO Number: WUK20110025

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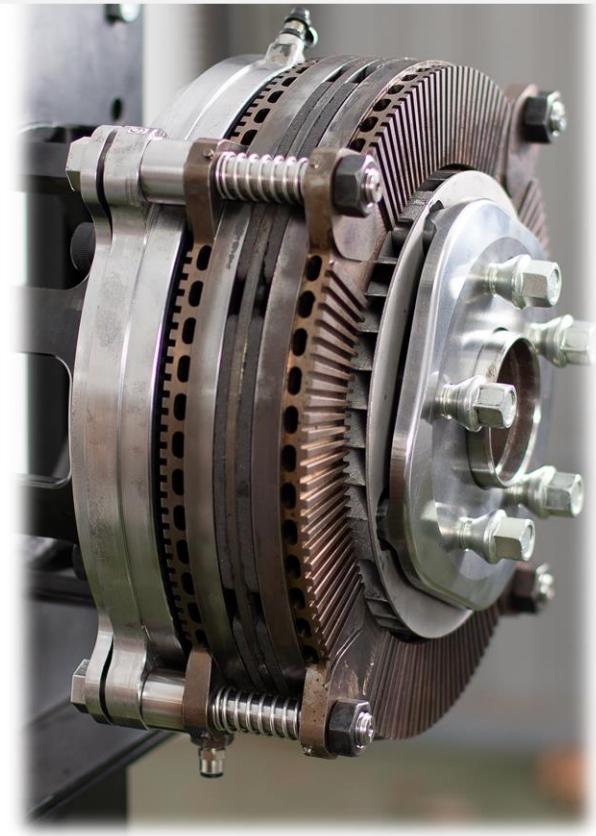
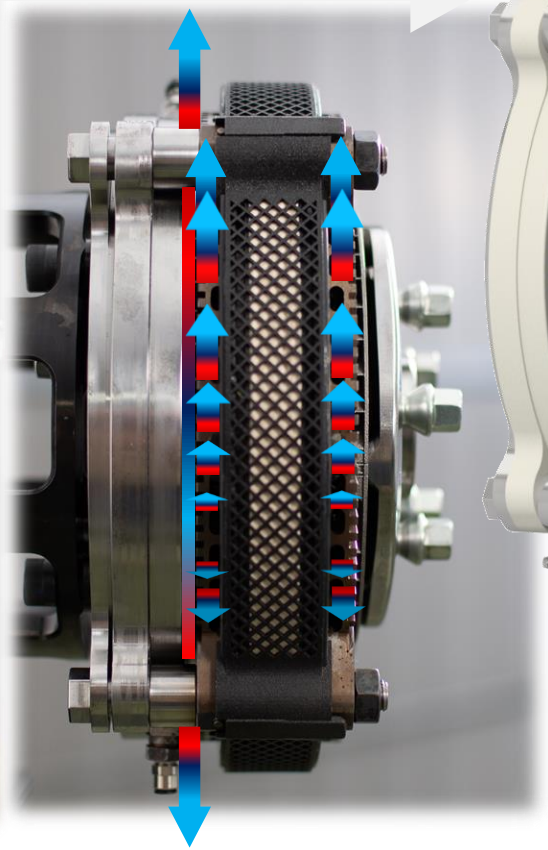
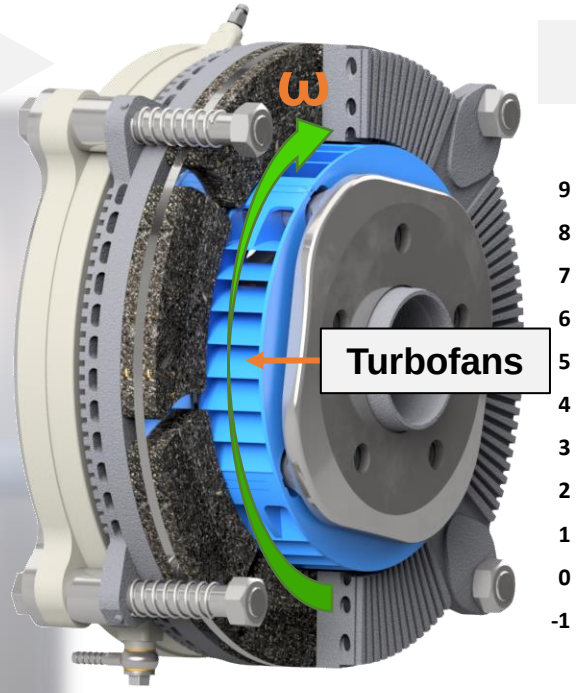
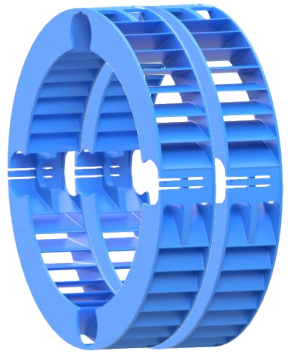
Air Cooling

How do we Air Cool the brake ?

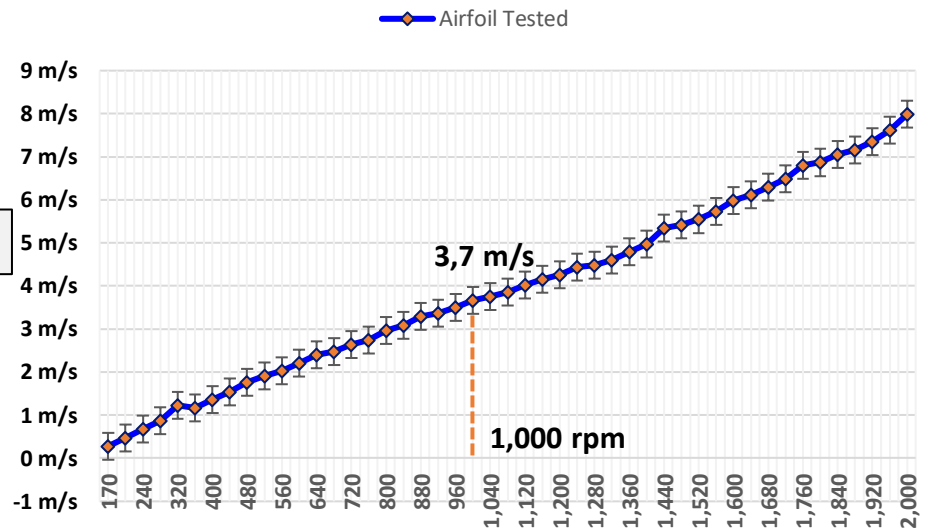








Forced Ventilation



≥2 turbofans

Airfoil Shape High efficiency

$$Q = A\ x\ v$$

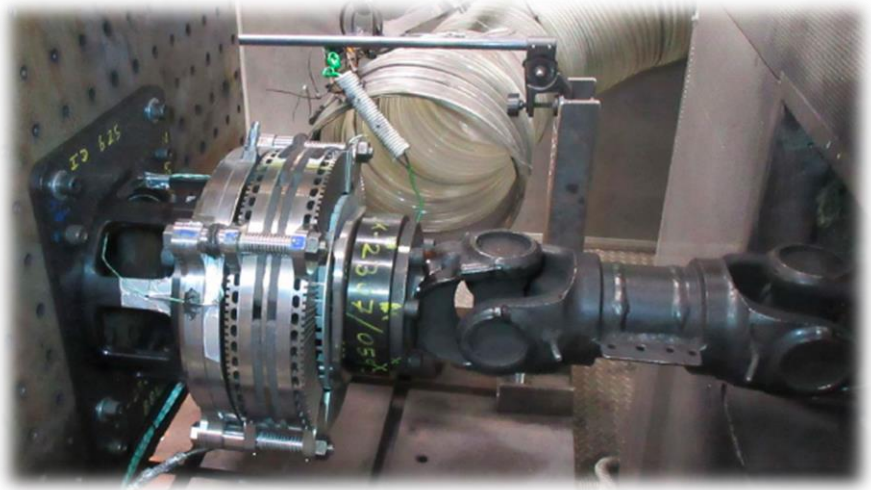
$$Q = \sum[A\ x\ v]$$

Min Ø 150 mm

32 mm Blade width

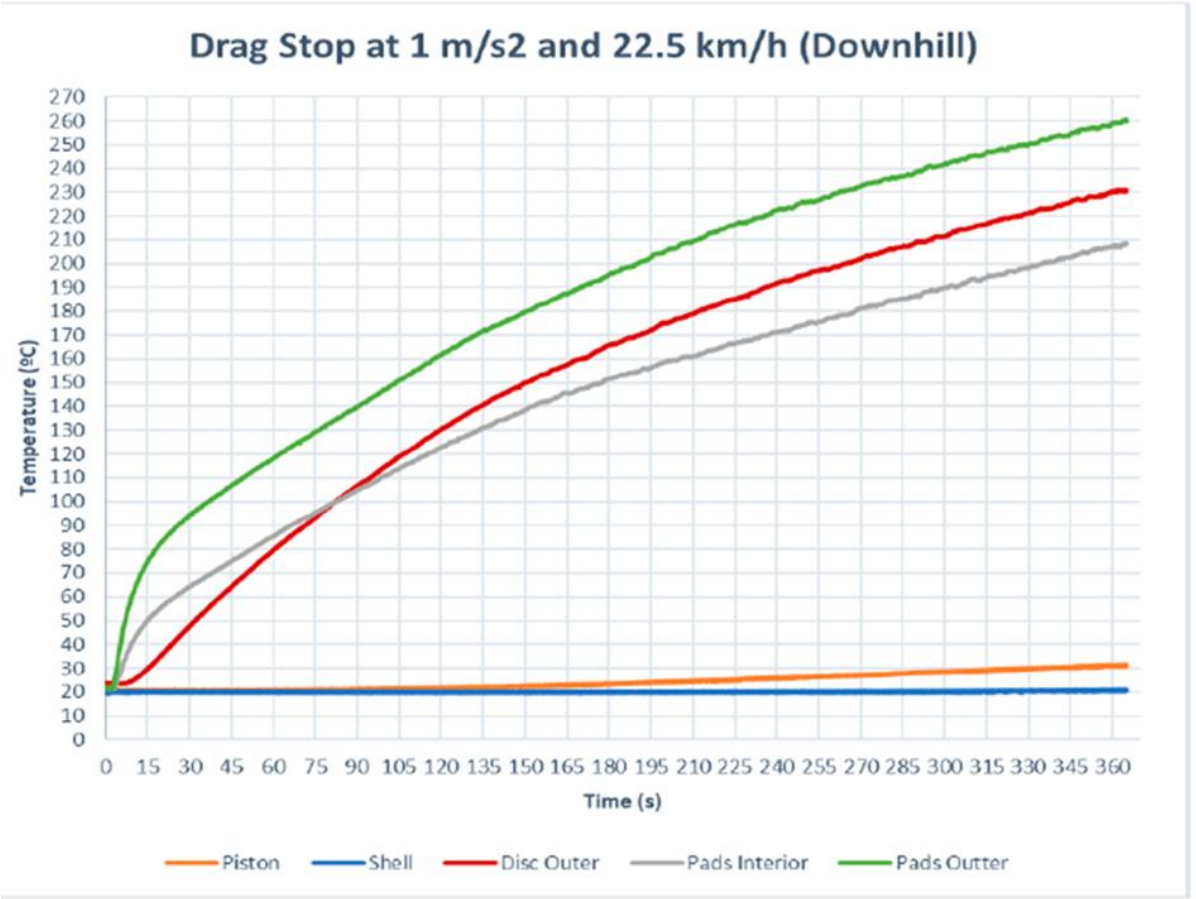
Air Cooled – High Fade Resistance

Applus IDIADA



High Fade Resistance

Downhill Simulation 2

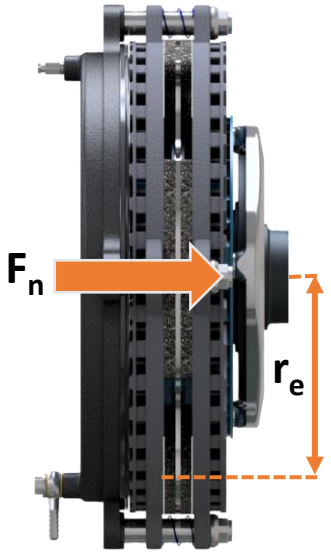


Conditions:

Constant Deceleration: 1 m/s^2
Constant Speed: 22.5 km/h
Time: 365 seconds

No external Ventilation in the Bench

Actuation & Braking Torque



$n = 2$

$$F_n = (\mathrm{p} - p_t) \cdot A_a$$

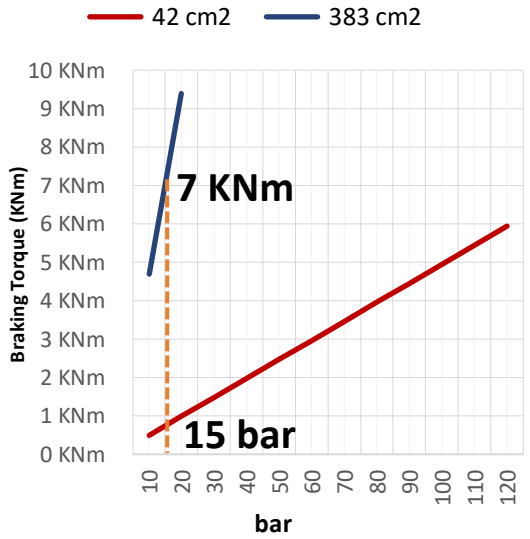
$$F_b = n\mu \cdot F_n$$

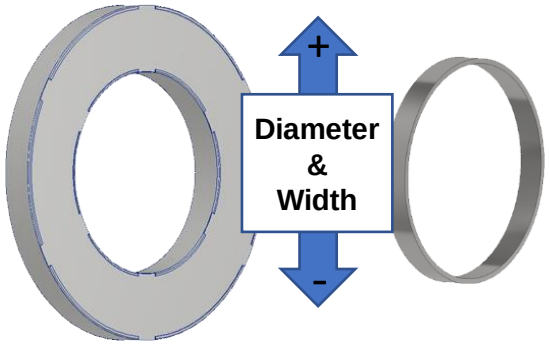
$$\tau_w = n\mu(p - p_t)A_a\eta r_e$$

$$\tau_w = BF \cdot F_n \cdot \eta \cdot r_e$$

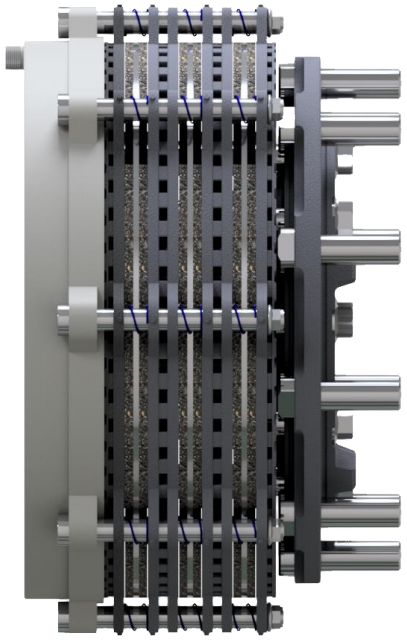
Example Passenger Vehicle

$n = 2 \quad r_e = 0.123\,m \quad \mu = 0.35 \quad \eta = 0.97$





Multidisc Packaging Option



$n = 6$

$$Axial\ Force\ req = \frac{Axial\ F\ Ouput}{n}$$

>n = Less Force to achive the braking torque required

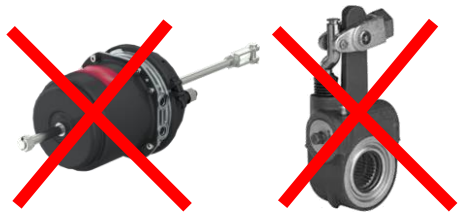
Compatible Actuations

HYDRAULIC / EHB

PNEUMATIC

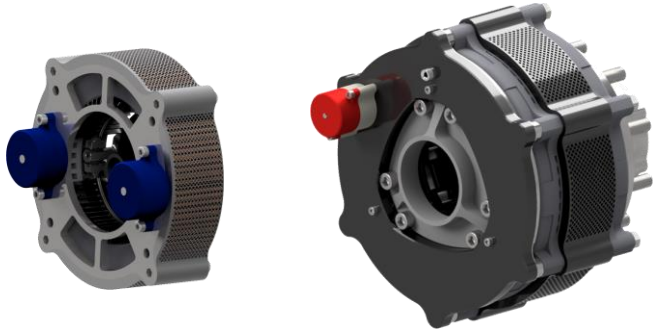
- Low Pressures
- High Axial Force
- Multidisc

For Commercial Vehicles Pneumatic Actuated



DRY EMB / EPB

- Less Energy

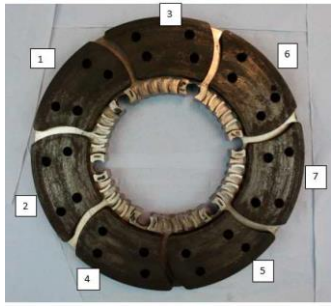


Increasing the Life Cycle of the brakes

Liquid Cooled

ISO 26865

Frictional Material:
Garben 506



	Loss Pad *[mm]*	Surface Pad *[mm²]*	Loss Volume *[cm³]*
Pad Set 1	-0,02	5427,9	-0,11
Pad Set 2	-0,04	5427,9	-0,22
Pad Set 3	0,03	5427,9	0,16
Pad Set 4	0,01	5427,9	0,05
Pad Set 5	0,03	5427,9	0,16
Pad Set 6	0,02	5427,9	0,11
Pad Set 7	0,01	5427,9	0,05
		TOTAL	**0,22**

Extrated from:

Report Number: R20110025-01
WO Number: WUK20110025

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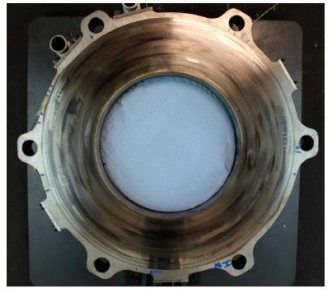
Inner face



Outer face

Friction Surface & Inertia

Friction Surface	
Type of Vehicle	
Passenger	**Commercial**
[180- 490]cm²	[890- 3,500]cm²

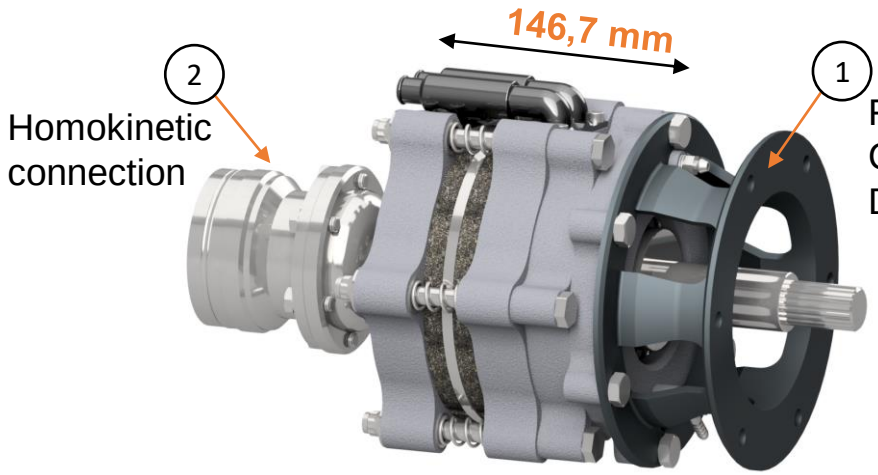
- **Lower Energy/Surface ratio than current industry standards**
- **Lower Inertia**

Packaging and Mass Distribution

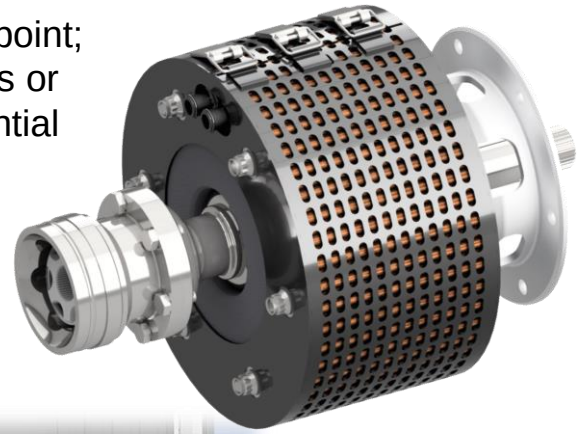
BRL - Unsprung weight

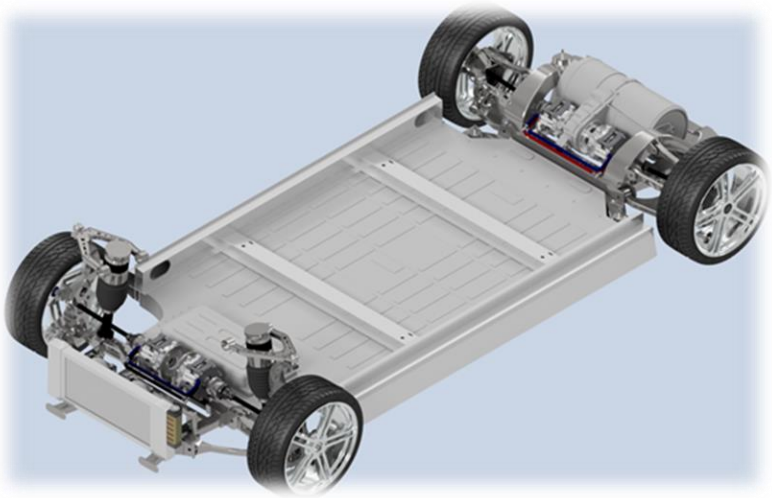
Compatible with
Assembly on-Block
On the production line

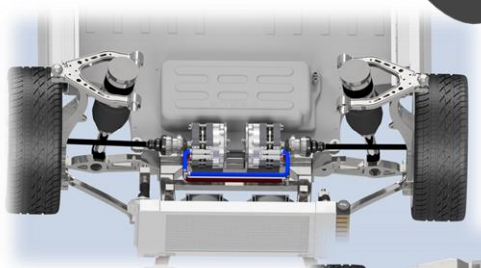
BRL - On Suspended weight



Total Ø = 212,16 mm

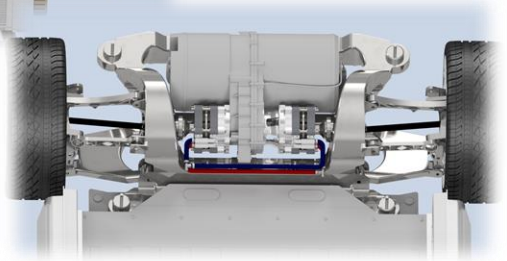






Front Axle RWD

Rear Axle RWD



Emissions [PM10 & PM2.5] – Liquid Cooled

Thermodynamic management:

- High heat dispersion
- With an External management

With an cheap solution, the BRL system ***uses a Passive particulate filter as an interchangeable accessory.***

As BRL can offer a brake with these thermal and dispersion capabilities, we can encapsulate the brake 100% without compromising performance or safety.

By encapsulating the brake we capture 100% of the friction material particles.

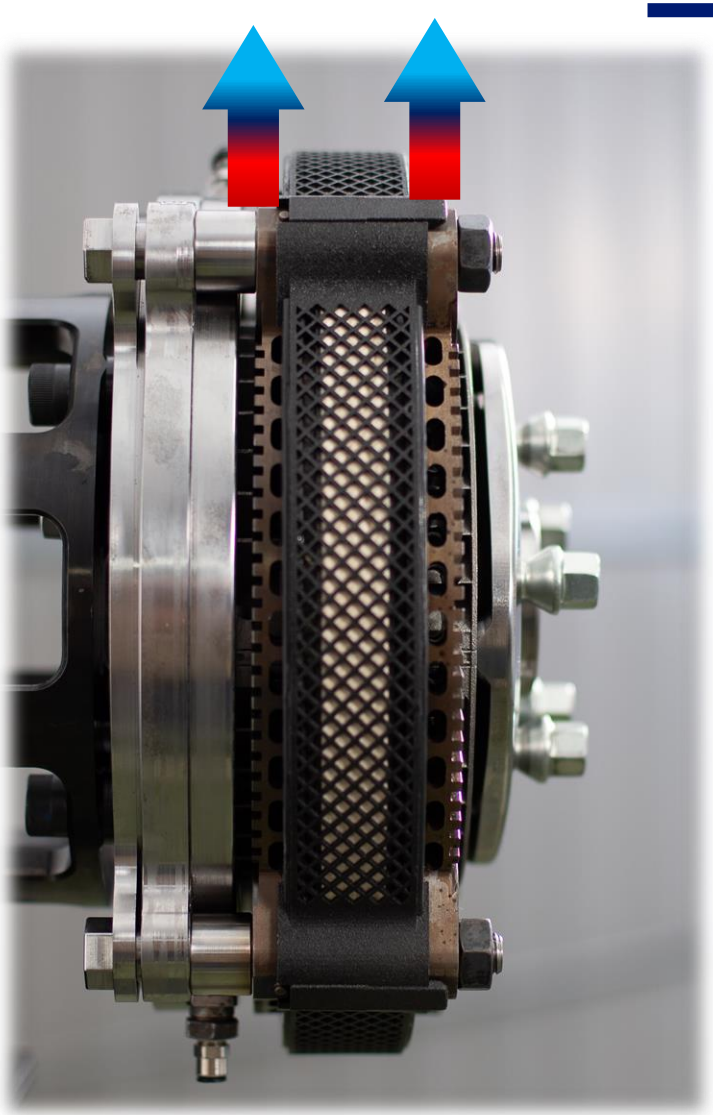
BRL - Unsprung weight

PM_{10} & $PM_{2.5}$

BRL - On Suspended weight

PM_{10} & $PM_{2.5}$

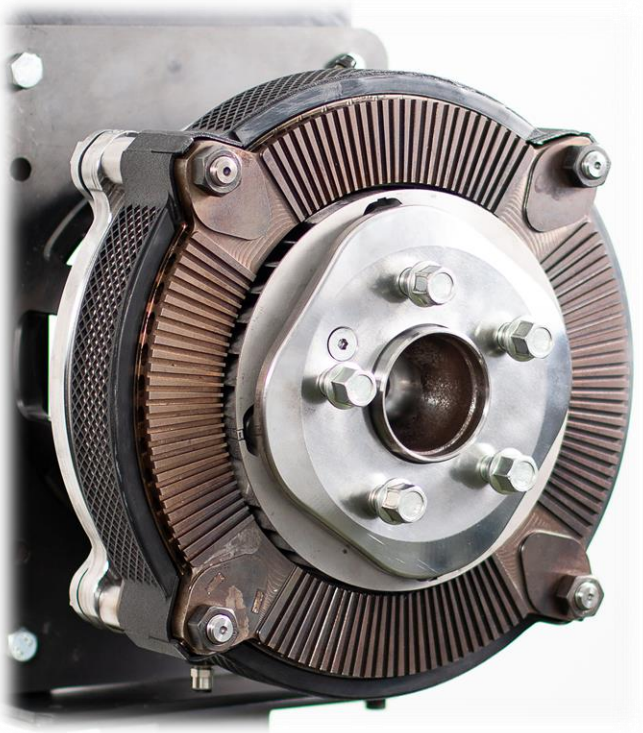
Emissions [PM10 & PM2.5] – Air Cooled



BRL's thermodynamic management is designed to filter out particulates and not alter the brake's cooling capabilities.

The high flow of the turbofans and the non-interference of the filter in the heat extraction area allows this feature.

Dyno Certified Results of Emissions expected:
2024 Q3



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Thank you for your time