



Views on HDV brake wear particles

22 November 2023

The Regulatory and Technical Differences Between HDV and LDV Braking Systems and Brake Emissions



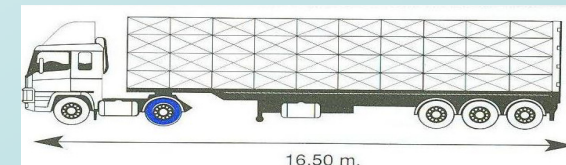
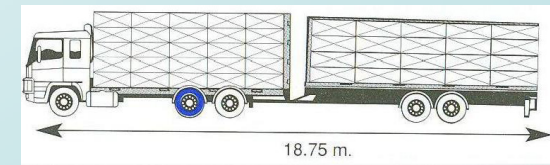
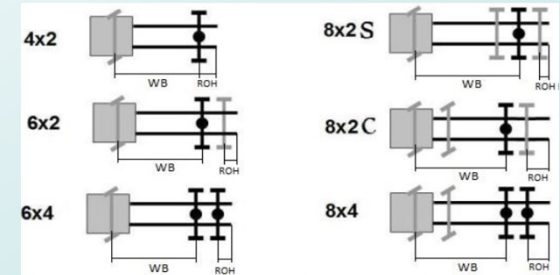
AGENDA

- 1. Summary of System Architecture Differences**
- 2. Legal Requirements & Temperatures**
- 3. Legal Requirements Endurance Brake**
- 4. Brake Load Distribution & Sizes**
- 5. Brake emissions – DISCUSSION POINTS**

SUMMARY OF SYSTEM ARCHITECTURE DIFFERENCES

Starting from physical differences LDV and HDV brakes have major differences, these differences may be summarised as below:

- HDV has front and rear brake split with air brake systems
- M2 vehicles may have hydraulic brake system and diagonal brake split
- Unladen and laden load margin is very high (for a two-axle vehicle weight range it can be 7 to 19 tonnes)
- Brake load distribution is monitored by EBS system and brake factor is adopted according to these values; axle load values are calculated with load sensor or air suspension sensors
- Brake wear ratios will vary across applications such as long haul, city distribution and construction uses
- Disc brake systems are mainly used for long haul, city traffic, road truck uses
- Tractor-trailer combination: full trailer combinations result in different brake system use between tractor/rigid truck and different type of trailers (mainly O3 and O4)
- Endurance braking (non-friction braking) is generally standard by engine braking, exhaust braking with ICE vehicles. Retarders are optional and have huge effect on brake wear reduction
- Regenerative braking is standard for BEV, Fuel Cell vehicles and brake resistor applications may be used to overcome the battery SOC regen. power downgrade
- Trailer manufacturer are also studying regen brake solutions (such as e-axle use on trailers)
- Speed limits and tests are different from LDV, maximum permissible testing limits 90kph
- Brake sizes are generally adopted to 22" wheel size for HDV over 18t, 430mm rotors and 410mm drum diameter sizes



LEGAL REQUIREMENTS & TEMPERATURES

- ECE R-13H → M1,N1 (8 Annexes)
- ECE R-13 → M2 & M3 , N1 to N3, O1 to O4 (22 Annexes)

- Type-I → M, N, O
- Type II → N3 & M3 (solo trucks, possibly with light trailers)
- Type IIA → special N3 & M3 vehicles (e.g. all N3 with O4 semi or full-trailers, solo ADR N3 trucks above 16t)
- Type III → O4 (alternatively O3)



R13 requires endurance brakes when the engine brake alone is deemed not enough to ensure sufficient retardation capacity (or when the goods are more “sensitive”, e.g. ADR):

- Solo trucks (non ADR) → endurance brake not required, engine brake is enough
- Solo trucks (ADR) > 16t → endurance brake required
- Heavy combinations → endurance brake required

R13 also requires endurance brakes for coaches, which are more likely to face long descents than city buses... (!)

- Due to high load conditions, HDV brake temperatures could be higher than LDV. Representative temperatures need to be investigated for HDV

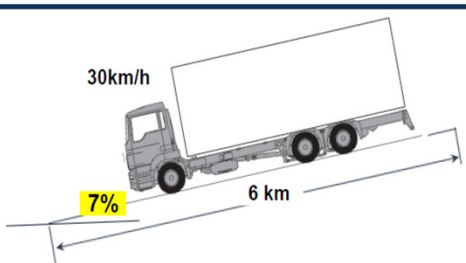


LEGAL REQUIREMENTS ENDURANCE BRAKE

Key words: Auxiliary Brakes, Secondary Brakes, Endurance Brakes, Retarder, Exhaust brake

- Definition of ECE-R13: "Endurance braking system" means an additional braking system having the capability to provide and to maintain a braking effect over a long period of time without a significant reduction in performance.

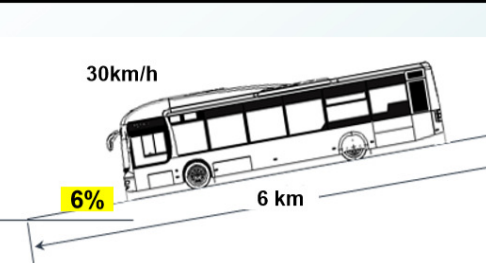
Type-IIA
Endurance Braking Performance Test



30km/h
7%
6 km

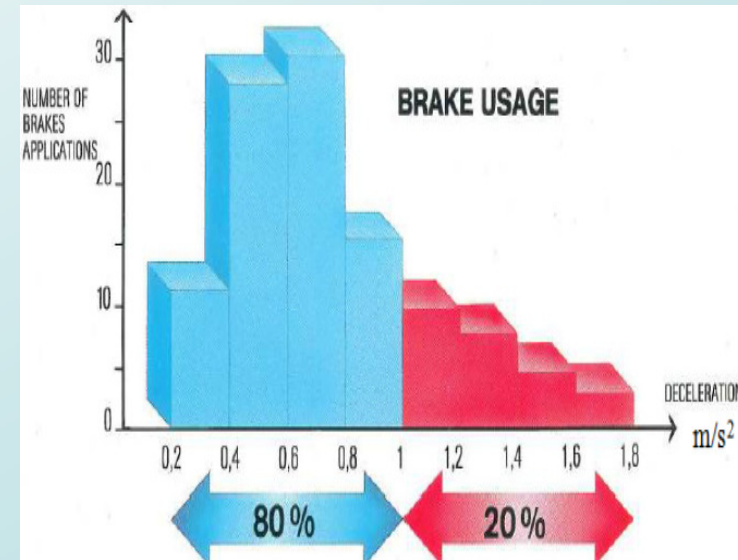
- **Scope**
 - M3 class II, III & B
 - N3 ADR and/or authorized to tow cat. O4
- **Service brake: prohibited**
- **Pass criteria:** Average speed of 30km/h (+/- 5 km/h)

Type II



30km/h
6%
6 km

- **Scope**
 - M3 and N3
 - Except vehicles submitted to Type-IIA
- **Service brake:** no restriction
- **Pass criteria:** Hot-stop performance after Type-II
 - N3: 3.3 m/s²
 - M3: 3.75m/s²



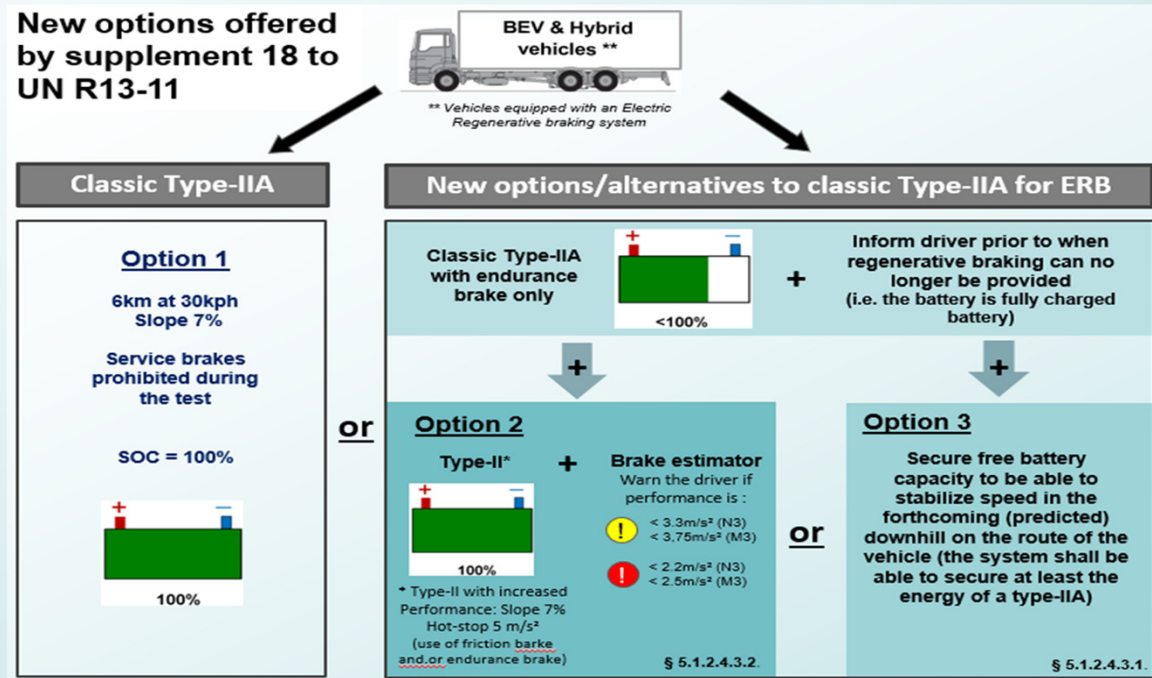
Blue: "covered by endurance brake"
Red: "friction brake is required"



LEGAL REQUIREMENTS ENDURANCE BRAKE

Key words: Auxiliary Brakes, Secondary Brakes, Endurance Brakes, Retarder

- BEV for Category A regen brake: not part of service brake system
- BEV for Category B regen brake: part of service brake system











Selected homologation method shall be considered



DIFFERENT HDV SEGMENTS (BUS, TRACTOR-TRAILER, RIGID-TRUCK) AS WELL AS PAYLOADS AND TOWING OF TRAILERS

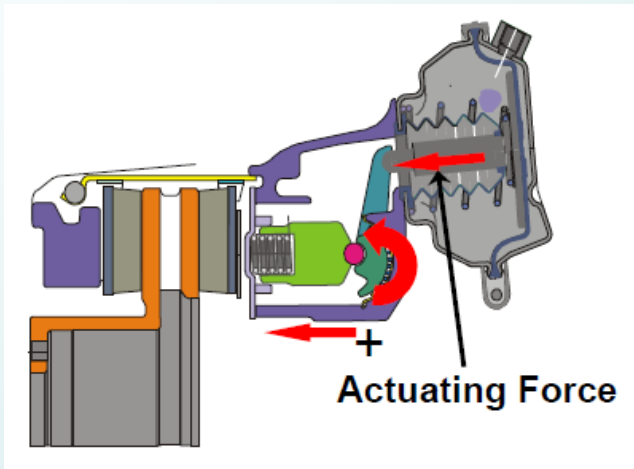
Categories	Europe
Passenger Car	Passengers of 9 or less (M1)
Bus	Passengers of 10 or more M2:GVM≤5t M3:GVM>5t
Truck	Qualitative Definition ("designed and constructed for the carriage of goods") N1:GVM≤3.5t N2:GVM≤3.5t–12t N3:GVM>12t *Each country has different criteria.

Axle Configurations		Chassis Config.	Vehicle Configuration & Usage Profile
2 Axle 3 Axle 4 Axle		Rigid Truck Tractor Full Trailer	Long Haul Regional Delivery Urban Delivery Municipal Utility Construction
Buses and coaches	M ₂		Vehicle comprising more than eight passenger seats plus one driver's seat and having a total weight not exceeding 5 tonnes
	M ₃ A B		Vehicle comprising more than eight (but not more than 22) passenger seats plus one driver's seat and having a total weight of 5 tonnes or more (inclusive)
	M ₃ I–III		Vehicle comprising more than 22 passenger seats plus one driver's seat
Road goods vehicles and their combinations	N ₁		Up to 3.5 tonnes (inclusive) total weight
	N ₂		From 3.5 tonnes to 12 tonnes (inclusive) total weight
	N ₃		From 12 tonnes of maximum permitted total weight
	N ₁ –N ₃		Up to 16 tonnes (inclusive) of maximum permitted total weight, when the owner of the vehicle is an agricultural entity
Special purpose road vehicles	M ₂ –M ₃ N ₁ –N ₃		Designed for performing specific operations but not for the carriage of goods

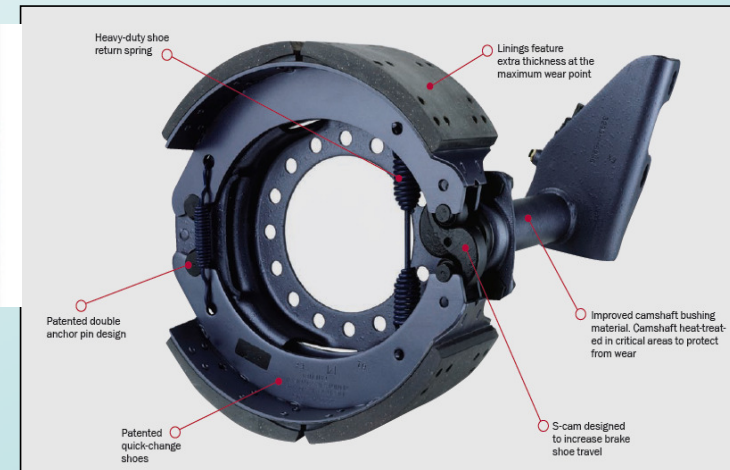
Category O: Trailers (including semi-trailers)
O1-O2-O3-O4 → ≤7,5t ≤3,5t ≤10t >10t

① BRAKE LOAD DISTRIBUTION & SIZES

1. Axle loads are distributed over a large band with dynamic load changes
2. Braking ratio is sensitive loading condition and needs some sort of control of the braking ratios
3. EBS functions are being operated on the brake wear compensation when high differences are being occurred with the help of continuous wear monitoring.
4. Brake actuator size is main contributor to brake force distribution
5. Vehicles of Category M2 has split brake distribution with hydraulic brakes and brake sizes shall be considered



Sample dimension:250x130x30



Sample dimension:190x15x200

BRAKE EMISSIONS – DISCUSSION POINTS

1. Particle measurement: Robust and applicable test procedure shall be established by considering segment differentiation, same procedure for drum brakes and disc brakes?
2. Measurement procedure for regenerative and endurance braking (engine brake, engine brake + retarders) for different segmentation
3. Trailer brake loading and brake differences must be taken into consideration
4. Endurance brake effect – calculated or tested?
5. Brake family and vehicle level emission calculation methods must be clarified for different axle configurations and segments