

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J1489

REV.
MAY2000

Issued 1987-06
Revised 2000-05

Superseding J1489 JUN1987

Submitted for recognition as an American National Standard

(R) Heavy Truck and Bus Retarder Downhill Performance Mapping Procedure

- 1. Scope**—The procedure covers the estimation of the total retardation capability available to a specific vehicle from:

- a. Natural retardation (rolling resistance, aerodynamic drag, etc).
- b. Engine drag
- c. Engine, integral automatic transmission, driveline or trailer-axle retarders

It assumes that foundation brakes are not used for maintaining speed on long mountain descents. Retardation is rated in terms of the maximum grades on which stable control speeds can be maintained for each gear over the range of highway speeds appropriate to that gear. For each gear, the calculation procedure determines maximum grades for at least four values of control speed ranging from the vehicle velocity corresponding to full load governed engine rpm, to the vehicle velocity corresponding to the engine rpm at minimum (idle) speed. In addition, the calculation procedure provides information on the total retarding power available for each gear.

- 1.1 Purpose**—This procedure provides a uniform method for calculating and reporting the steady-state control speed maintainable by either engine, integral automatic transmission, driveline, or trailer-axle retarders employed by heavy trucks and buses operating on downgrades. It provides a practical method of predicting retarder performance in a specified vehicle installation using data describing retarder performance characteristics and other vehicle design variables. It is intended to assist in the proper selection of a retarder by matching stated retarder performance capabilities with particular vehicle functional requirements.

2. References

- 2.1 Applicable Publications**—The following publication forms a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

- 2.1.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, Pa 15096-0001.

SAE J1252—SAE Wind Tunnel Test Procedure for Trucks and Buses

SAE Technical Standards Board Rules provide that: "This report is published by SAE to advance the state of technical and engineering sciences. The use of this report is entirely voluntary, and its applicability and suitability for any particular use, including any patent infringement arising therefrom, is the sole responsibility of the user."

SAE reviews each technical report at least every five years at which time it may be reaffirmed, revised, or cancelled. SAE invites your written comments and suggestions.

TO PLACE A DOCUMENT ORDER: (724) 776-4970 FAX: (724) 776-0790
SAE WEB ADDRESS <http://www.sae.org>

Copyright 2000 Society of Automotive Engineers, Inc.
All rights reserved.

3. Definitions

3.1 Weight Factors

W total vehicle weights kg (lb)

3.2 Vehicle Dimensions

A Vehicle frontal area m^2 (ft^2) (see Table 1 for listing of typical values.) (Product of vehicle's maximum height and width.)

R_M Number of power unit tire revolutions per kilometer (mile) (see Table 2 for a listing of typical values.)

R_{MTR} Number of trailer tire revolutions per kilometer (mile).

TABLE 1—TYPICAL VALUES FOR VEHICLE FRONTAL AREAS (A) (REF. SAE J1252)

Vehicle Type	Frontal Area
Vans (Both conventional and cab-over engine power units)	10.0 m^2 (108 ft^2)
Tankers & Flatbeds	
Conventional cab power unit	7.0 m^2 (75 ft^2)
Cab-over-engine power unit	7.9 m^2 (85 ft^2)
10-Wheel Dump	6.8 m^2 (73 ft^2)
Intercity Motor Coach	7.9 m^2 (85 ft^2)
Suburban Bus	7.4 m^2 (80 ft^2)
Motor Home	7.4 m^2 (80 ft^2)
School Bus	7.0 m^2 (75 ft^2)

**TABLE 2—SOME TYPICAL VALUES FOR TIRE REVOLUTIONSPER KILOMETER, R_K
(REVOLUTIONS PER MILE R_M) BY TIRE SIZE**

Size	Rev/kilometer	Size	Rev/Mile
215/75RR 17.5	418	6.50–20	602
225/70R 19.5	397	7.00–15	710
245/70R 19.5	383	7.00–16	685
265/70R 19.5	378	7.00–17	628
445/65R 19.5	305	7.00–17.5	685
365/80R 20.0	298	7.00–20	602
245/75R 22.5	347	7.00–22.5	602
255/70R 22.5	352	7.15–17	628
255/80R 22.5	336	7.50–15	670
265/75R 22.5	334	7.50–16	670
275/80R 22.5	319	7.50–20	561
295/75R 22.5	319	8.00–17.5	670
295/80R 22.5	311	8.00–19.5	628
315/80R 22.5	305	8.00–22.5	561

**TABLE 2—SOME TYPICAL VALUES FOR TIRE REVOLUTIONS PER KILOMETER, R_K
(REVOLUTIONS PER MILE R_M) BY TIRE SIZE (CONTINUED)**

Size	Rev/kilometer	Size	Rev/Mile
385/65R 22.5	305	8.25–20	542
425/65R 22.5	291	9.00–20	520
445/65R 22.5	285	9.00–22.5	542
275/80R 24.5	311	10.00–20	504
285/75R 24.5	309	10.00–22	482
305/75R 24.5	304	10.00–22.5	520
		11.00–20	492
		11.00–22	470
		11.00–24	457
		11.00–22.5	504
		11.00–24.5	482
		12.00–20	482
		12.00–24	443
		12.00–22.5	492
		12.00–24.5	470
		13.00–20	457
		14.75–17.5	581
		14.00–20	439
		14.00–24	403
		15.00–19.5	521
		15.00–22.5	481
		16.5–19.5	504
		16.5–22.5	467
		18.00–19.5	491
		18.00–22.5	456
		19.50–19.5	467

3.3 Dimensionless Coefficients

- C_d wind averaged aerodynamic drag coefficient—(see Table 3 for a listing of typical values, or SAE J1252.)
- C_R Road surface coefficient—(Used in determining the influence of road surface properties on rolling resistance, see Table 4 for a listing of typical values.)
- C_T Rolling resistance coefficient—(Used in defining the influence of tire properties and vehicle velocity on rolling resistance, see Table 5 for listing of typical values.)
- C_{AL} Altitude correction coefficient—(Used to determine the effects of altitude on air density and the effects of aerodynamic drag reduction devices; see Table 6 for a listing of typical values.)

**TABLE 3—TYPICAL VALUES FOR VEHICLE AERODYNAMIC WIND
AVERAGED DRAG COEFFICIENTS (C_d)**

Trucks	Coaches/Buses
0.80 for a vehicle not equipped with aerodynamic aids on its roof.	0.45 for an intercity coach or suburban bus
0.64 for a vehicle equipped with aerodynamic aids.	0.55 for a motor home or school bus

**TABLE 4—TYPICAL VALUES FOR HIGHWAY SURFACE COEFFICIENTS
ON CLEAN DRY PAVEMENT (C_R)**

<u>Road Type</u>	<u>C_R</u>
Smooth concrete	0.000
Worn Concrete, Brick, Cold Blacktop	0.002
Hot Blacktop	0.005

TABLE 5—TYPICAL VALUES FOR ROLLING RESISTANCE COEFFICIENT (C_T)

<u>Tire Type</u>	<u>C_T (km/h)</u>	<u>C_T (mph)</u>
Bias Ply	$(6.6 + 0.029 V) \times 10^{-3}$	$(6.6 + 0.046 V) \times 10^{-3}$
Radial Ply	$(4.1 + 0.026 V) \times 10^{-3}$	$(4.1 + 0.041 V) \times 10^{-3}$

**TABLE 6—TYPICAL VALUES FOR ALTITUDE
CORRECTION COEFFICIENTS (C_{AL})**

<u>Altitude - m (ft)</u>	<u>C_{AL}</u>
0 (0)	1.0
500 (1639)	0.96
1000 (3279)	0.92
1500 (4918)	0.88
2000 (6557)	0.84
2500 (8197)	0.80
3000 (9836)	0.76
3500 (11 475)	0.72
4000 (13 115)	0.68
4500 (14 754)	0.64
5000 (16 393)	0.60

3.4 Subscripts

- i Subscript used to denote each gear with $i=1$ corresponding to the highest numerical transmission gear ratio (that is, the lowest gear).
- j Subscript used to denote the combined ratio of drive axle(s) and auxiliary transmissions, if present, with $j=1$ corresponding to the highest numerical combined ratio (that is, the lowest axle/transmission range).

3.5 Speeds

$N_{e_{ij}}$	Engine speed in revolutions per minute (rpm) with transmission in gear i and the rear axle/auxiliary transmission in ratio j .
$N_{e_{gov}}$	Full load governed engine speed (rpm)
$N_{e_{min}}$	Engine idle speed (rpm)
V	Vehicle velocity in kilometers per hour - km/h (miles per hour - mph)
$V_{gov_{ij}}$	Vehicle velocity, km/h (mph) corresponding to the full load governed engine speed ($N_{e_{gov}}$) with the transmission in gear i and the rear axle/auxiliary transmission in ratio j .
$V_{min_{ij}}$	Vehicle velocity, km/h (mph) corresponding to the engine idle speed ($N_{e_{min}}$) with the transmission in gear i and the rear axle/auxiliary transmission in ratio j .
N_{D_j}	Driveline speed (rpm)
N_{TR}	Trailer-axle retarder speed (rpm)
V_C	Control speed (equilibrium speed on a downgrade), km/h (mph)

3.6 Gear Ratios

R_t	Transmission gear ratio for the i^{th} gear
R_{a_j}	Combined drive axle and, if appropriate, auxiliary transmission gear ratio
R_{TR}	Trailer axle ratio (gear ratio determining the rotational speed of a retarder installed on a trailer axle)

3.7 Efficiencies—(See Table 7 for a listing of typical values.)

E_D	Power-unit drive axle efficiency
E_{TR}	Trailer axle efficiency
E_O	Overall drive system efficiency

TABLE 7—TYPICAL VALUES FOR DRIVETRAIN EFFICIENCIES (E_D , E_O , E_{TR}) EFFICIENCY COEFFICIENT

Vehicle Configurations	E_D	E_O Transmission Manual	E_O Transmission Automatic	E_{TR}
4x2 Tractor	0.94	0.92	0.90	—
6x4 Trailer	0.90	0.88	0.86	—
Retarder equipped trailer axle	—	—	—	0.95

3.8 Power

P_N	Natural retardation power, kW (hp)
P_E	Engine retarding power, kW (hp) (see Figures 1 and 2)
P_{RE}	Retarder power from an engine-speed retarder, kW (hp)
P_{RD}	Retarder power from a driveline-speed retarder, kW (hp)
P_{TR}	Retarder power from a trailer axle retarder, kW (hp)
P_S	Total retarding power available, kW (hp)
P_G	Grade power demand, kW (hp)

TYPICAL VALUES FOR ENGINE FRICTION POWER (Figures 6 and 7)—(Does not include radiator fans, alternators, power steering pumps, etc.)

In lieu of specific engine friction data, the attached typical graphs may be used for obtaining friction levels as a function of displacement for typical 2- and 4-cycle diesel engines.

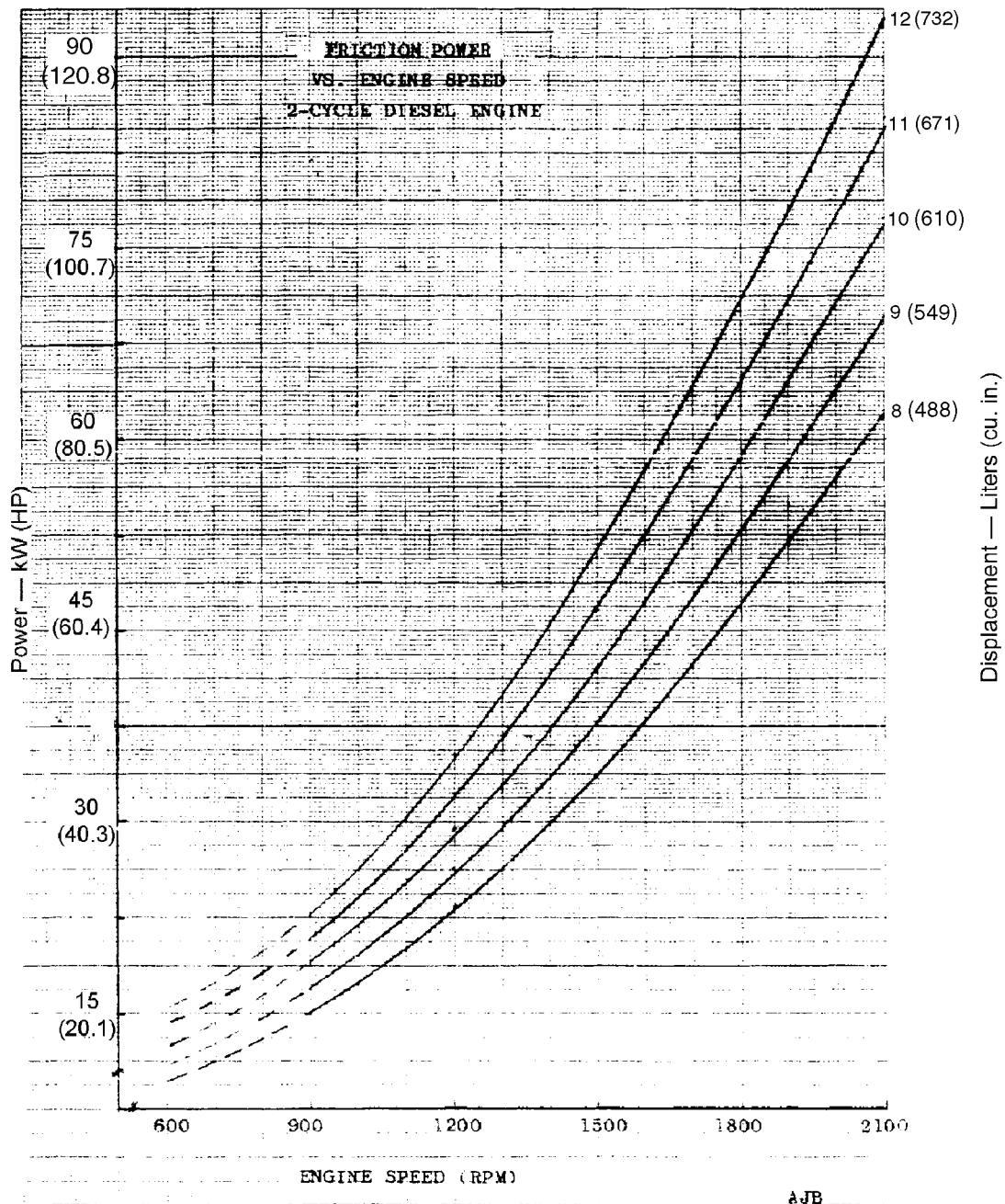


FIGURE 1—ESTIMATES OF 4 CYCLE DIESEL ENGINE FRICTION POWER