

15 CO₂ Emissions and Vehicle Performance

CO₂ emissions for the ULSAB-AVC Program were calculated using both the NEDC 2000 and the US Combined driving cycle requirements.

15.1 BACKGROUND

The following vehicle performance targets as shown in Table 15.1-1 were set based on engineering judgement and to achieve the primary program objectives.

Table 15.1-1 Main performances

Main Performances	C-Class	PNGV-Class
Acceleration 0-62 mph (0-100 km/h)/sec	≤ 14	≤ 14
Top Speed Continuous / mph / km/h	100 / 160	100 / 160
CO ₂ Emissions (g/km)	≤ 140	≤ 140
Aerodynamic Drag Coefficient (c _w)	≤ 0.25	≤ 0.25

15.2. Calculation of CO₂ Emissions

For the calculation of CO₂ emissions, two procedures were applied.

- NEDC (New European Driving Cycle) 2000 requirement with the test mass defined as:
Test mass = Vehicle curb weight + 100 kg
 - A) Manual shift mode
 - B) Automatic shift mode
- US Combined Driving Cycle (FTP 75, Highway) with the test mass defined as:
Test mass = Vehicle curb weight + 300 lb.

For the calculation of CO₂ emissions, the following formula applies for vehicles with semi-automatic transmission (manual and automatic shift mode possibilities).

$$\frac{\text{CO}_2 \text{ emissions}}{\text{US Combined}} = \frac{\text{US Comb. manual} + \text{US Comb. auto.}}{2}$$

US Comb. manual = CO₂ emissions US Combined manual shift mode

US Comb. auto. = CO₂ emissions US Combined automatic shift mode

15.3. Calculation of Vehicle Acceleration

For the calculation of the vehicle acceleration, the vehicle mass is calculated according to DIN 70020 (3) where the driving performances are calculated with the following vehicle mass.

$$\text{Vehicle Mass} = \text{Vehicle Curb Weight} + (\text{Payload} / 2)$$

For each vehicle C-Class and PNGV-Class variant, this procedure was used for calculation of vehicle performance and to determine the gear ratios to achieve the 14 sec. target for acceleration (0-100 km/h).

15.4. Calculation Parameters

15.4.1. General

Table 15.4.1-1 General calculation parameters

General Calculation Parameters	C-Class		PNGV-Class	
	Gasoline	Diesel	Gasoline	Diesel
Curb Weight (according to DIN Leer) [kg]	933	966	998	1031
Maximum Payload [kg]	450		500	
Calculated Test Mass (emissions) NEDC 2000 [kg]	1035	1065	1100	1130
Calculated Test Mass (emissions) US Combined [kg]	994	1024	1059	1089
Calculated Test Mass (acceleration) 0-62 mph/100 km/h [kg]	1160	1190	1250	1280
Vehicle Frontal Surface Area [m ²]	2.03	2.03	2.03	2.03
Dynamic Roll Radius (tire) [m]	0.275	0.275	0.275	0.275
Aerodynamic Drag Coefficient	0.25	0.25	0.25	0.25
Rolling Resistance Coefficient	0.12	0.12	0.12	0.12
Transmission Efficiency Coefficient	0.95	0.95	0.95	0.95

15.4.2. Engine Parameters

For the CO₂ emissions calculation, the engine characteristics (e.g. power and torque), shown in Table 8.5.1-1 and fuel specifications were used.

Gasoline has an average fuel density of 0.756 kg/L (at 15 degrees Celsius). Gasoline specification is according to:

- UTG 96 (US), premium unleaded fuel octane rating (antiknock index) of 93 ((R+M)/2) method,
- EU 3RF (Europe), super unleaded fuel with ROZ minimum 95

Diesel fuel has an average density of 0.84 kg/L (at 15 degrees Celsius).

15.4.3. Transmission Parameters

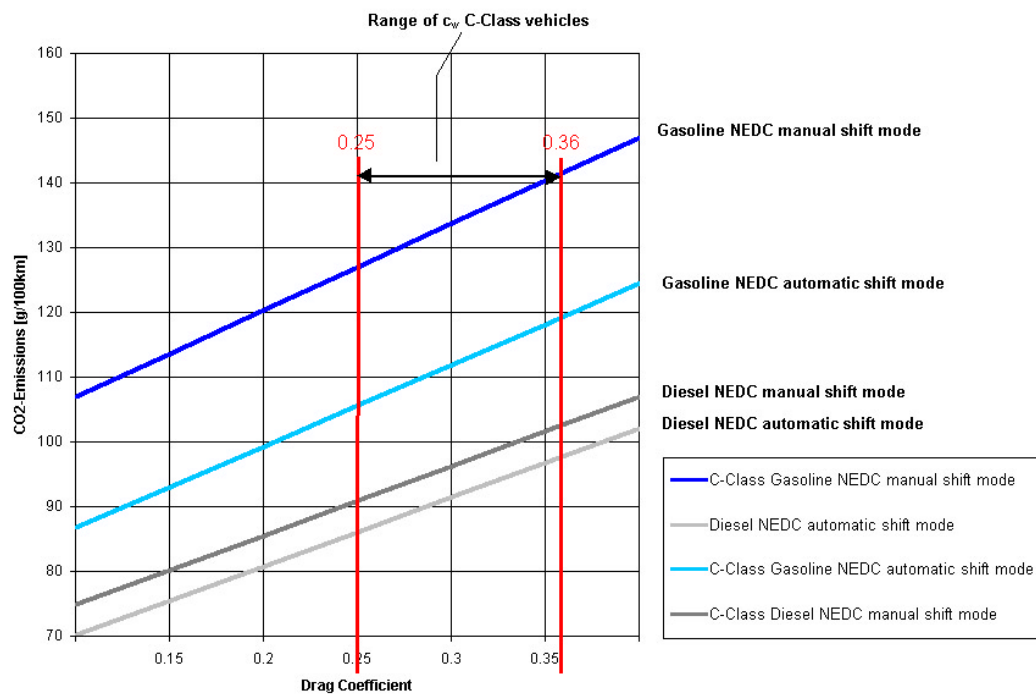
In the calculation, the program adjusts either automatically or offers the possibility for manually adjusting the gear spread ratio to achieve the desired results for acceleration time (0-100 km) or CO₂ emissions under the given boundary conditions of engine characteristics and vehicle mass. The transmission characteristics for the C-Class and PNGV-Class for an aerodynamic drag coefficient of 0.25 can be found in Tables 15.4.3-1 and 15.4.3-2.

Table 15.4.3-1 Transmission characteristics - C-Class

Transmission	C-Class Gasoline		C-Class Diesel	
	Total Ratio	Single Ratio	Total Ratio	Single Ratio
Gear 1	12.444	3.111	13.296	3.324
Gear 2	7.2	1.8	5.596	1.399
Gear 3	5.068	1.267	3.544	0.886
Gear 4	3.908	0.977	2.592	0.648
Gear 5	3.18	0.795	2.044	0.511
Primary Transmission	1:4		1:4	
Final Drive	1:1		1:1	

Table 15.4.3-2 Transmission characteristics - PNGV-Class

Transmission	PNGV-Class Gasoline		PNGV-Class Diesel	
	Total Ratio	Single Ratio	Total Ratio	Single Ratio
Gear 1	13.272	3.318	13.836	3.459
Gear 2	7.172	1.793	6.148	1.537
Gear 3	4.916	1.229	3.952	0.988
Gear 4	3.74	0.935	2.912	0.728
Gear 5	3.004	0.751	2.308	0.577
Primary Transmission	1:4		1:4	
Final Drive	1:1		1:1	

15.5. C-Class Vehicle CO₂ Emissions Calculation ResultsFigure 15.5-1 C-Class NEDC 2000 - CO₂ emissions over aerodynamic drag coefficient rangeTable 15.5-1 C-Class NEDC 2000 CO₂ emissions summary

C-Class Results		Manual shift mode		Automatic shift mode	
Aerodynamic Drag Coefficient $c_w = 0.25$		Gasoline	Diesel	Gasoline	Diesel
CO ₂ emissions (NEDC 2000)	[g/km]	127	102	106	86
Fuel Consumption (NEDC 2000)	[L/100 km]	5.3	3.8	4.4	3.2

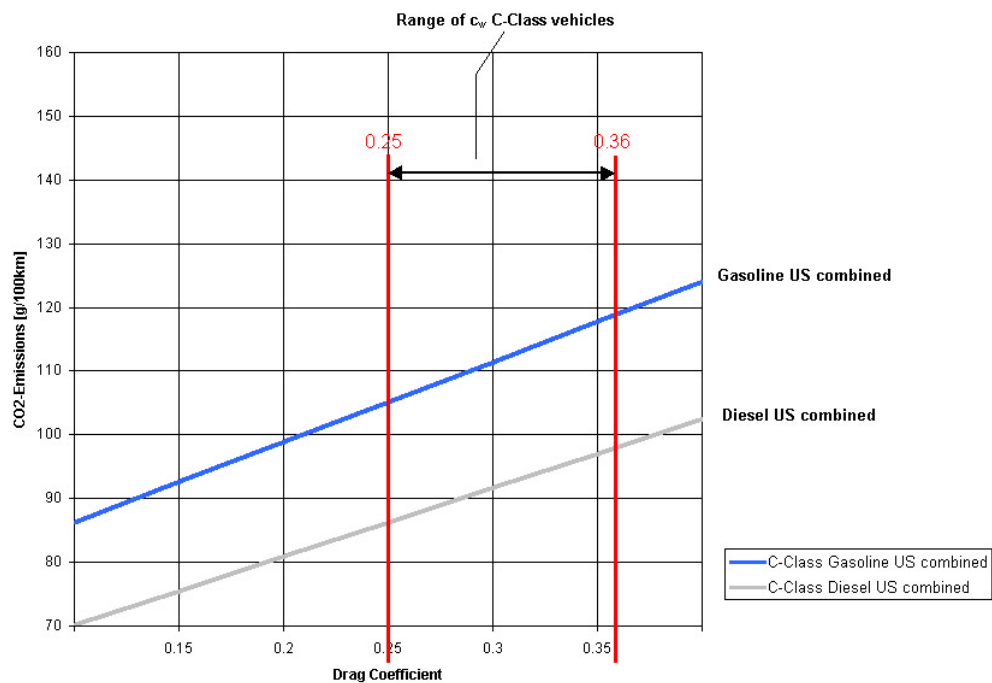


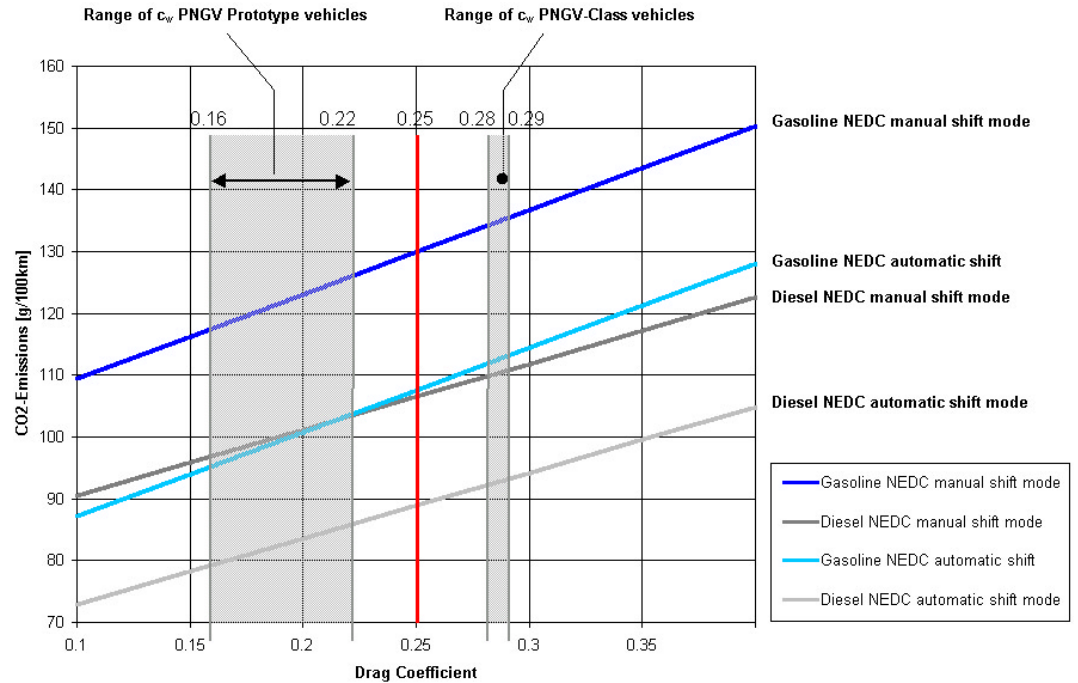
Figure 15.5-2 C-Class US Combined - CO₂ emissions over aerodynamic drag coefficient range

Table 15.5-2 C-Class US Combined - CO₂ emissions summary

C-Class Results		Gasoline	Diesel
Aerodynamic Drag Coefficient $c_w = 0.25$			
CO ₂ emissions (US Combined)	[g/km]	105	86
Fuel Consumption (US Combined)	[mpg]	53.4	72.7

Table 15.5-3 C-Class performances summary

C-Class Performances		Gasoline	Diesel
Aerodynamic Drag Coefficient $c_w = 0.25$			
Acceleration (0-100 km/h) (0-62 mph)	[sec]	13.5	13.4
Intermediate acceleration (80-120 km/h)	[sec]	17.9	16.8
Top speed continuous	[km/h]	194	184

15.6. PNGV-Class Vehicle CO₂ Emissions Calculation ResultsFigure 15.6-1 PNGV-Class NEDC 2000 - CO₂ emissions over aerodynamic drag coefficient rangeTable 15.6-1 PNGV-Class NEDC 2000 CO₂ emissions summary

PNGV-Class Results		Manual shift mode		Automatic shift mode	
Aerodynamic Drag Coefficient $c_w = 0.25$		Gasoline	Diesel	Gasoline	Diesel
CO ₂ emissions (NEDC 2000)	[g/km]	130	106	108	89
Fuel Consumption (NEDC 2000)	[L/100 km]	5.4	4.0	4.5	3.4

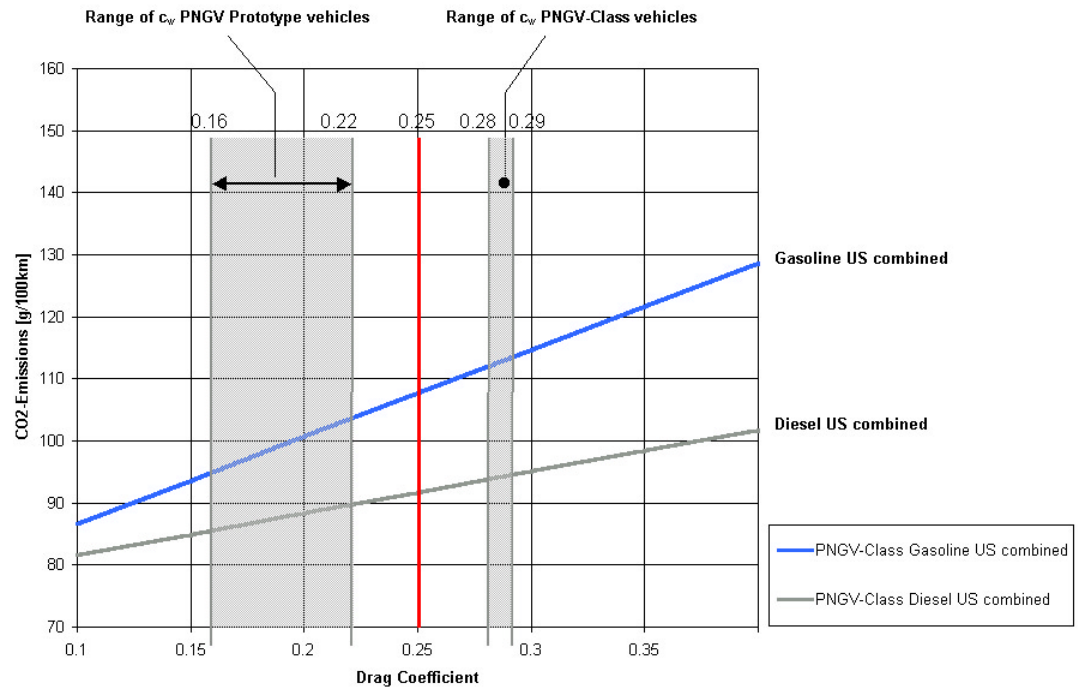


Figure 15.6-2 PNGV-Class US Combined - CO₂ emissions over aerodynamic drag coefficient range

Table 15.6-2 PNGV-Class US Combined CO₂ emissions summary

PNGV-Class Results		Gasoline	Diesel
Aerodynamic Drag Coefficient $c_w = 0.25$			
CO ₂ emissions (US Combined)	[g/km]	108	92
Fuel Consumption (US Combined)	[mpg]	52.4	68.0

Table 15.6-3 PNGV-Class performances summary

PNGV-Class Performances		Gasoline	Diesel
Aerodynamic Drag Coefficient $c_w = 0.25$			
Acceleration (0-100 km/h) (0-62 mph)		13.9	13.9
Intermediate acceleration (80-120 km/h)		18.0	17.4
Top speed continuous	[km/h]	193	184

15.7. Other Exhaust Emissions

As noted in Chapter 2, the achievement of the EU4 Exhaust Emissions targets by 2005 are dependent upon developments being undertaken by automotive companies and their suppliers. The results achieved by the ULSAB-AVC Program provide an excellent basis for such related developments.