SUMMARY OF U.S. EPA LIGHT-DUTY MY2027 PROPOSAL

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Ameya Joshi, May 2023

Benefits of this rule

Greenhouse Gas (GHG) Reduction

Light-duty vehicles today account for 15.5% of total GHG emissions in the US. (Overall transport sector emits 27.2% of GHG emissions)

The proposal is expected to cumulatively reduce CO_2 emissions by 7.3 billion metric tons over 2027 – 2055. Emissions of other GHGs – methane and N_2O are reduced by 0.12 and 0.13 million metric tons, respectively. Compared to the no-action scenario, the proposal will result in cumulative reduction of 25% CO2, 17% CH_4 and 25% N_2O over 2027 - 2055.

Criteria Pollutant Reduction

This proposal is projected to reduce criteria pollutants through reduced fuel consumption and advanced emission control technologies:

	PM2.5	NOx	NMOG	SOx	CO
Annual reduction in 2055 (million tons)	15	66	220	12	1,800
% Reduction in 2055	35%	41%	50%	42%	49%

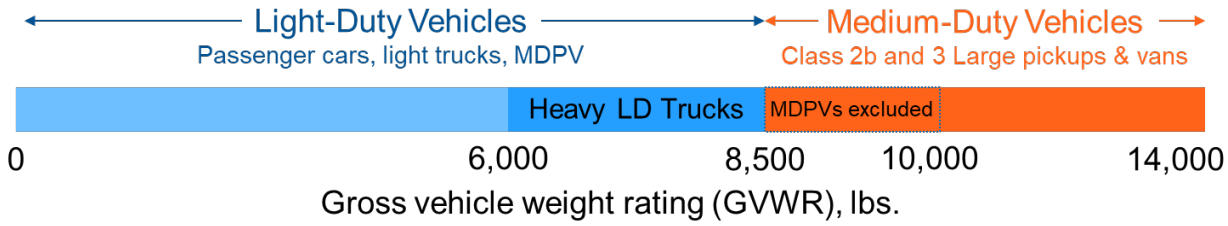
These reductions include the net effect of changes at the tailpipe, electricity generation and refineries. So for example, PM emissions associated with electricity generation actually increase (due to fleet electrification), but these are more than offset by tailpipe reductions through the use of gasoline particulate filters (GPFs) and reduced fuel consumption. SOx reductions are only due to reduced fuel consumption (no change in fuel sulfur specifications).

Other air toxics are also reduced. For example, carcinogenic polyaromatic hydrocarbons (PAHs) are reduced by 4.7 million tons per year by 2055, due to the use of GPFs.

PM2.5 reductions are estimated to result in $16 – 34 billion (2020$) due to reduced health & mortality risks.

Vehicles regulated

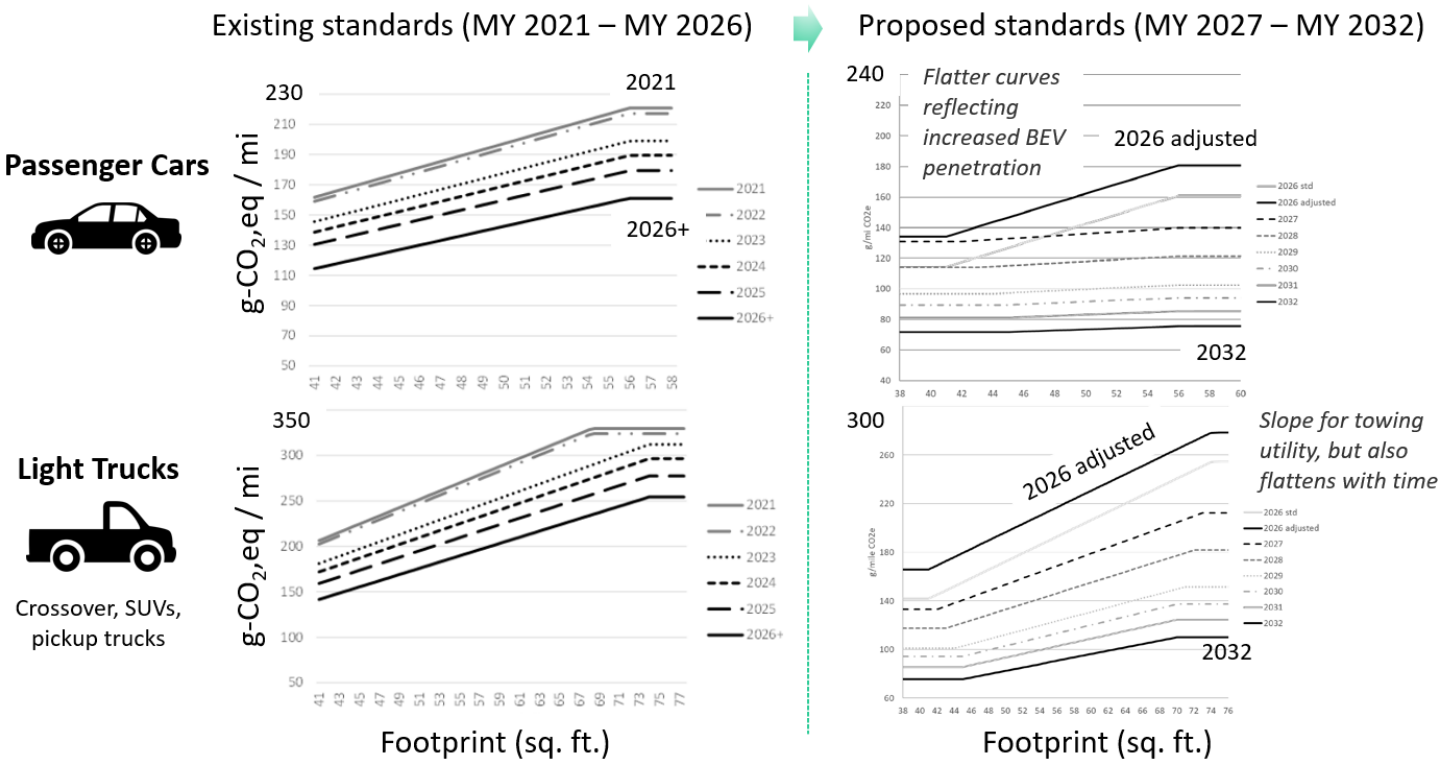
The proposal applies to light-duty and medium-duty (Class 2b and 3) vehicles. Passenger vehicles in the 8,501 – 10,000 lbs. GVWR group are not considered medium-duty vehicles.



PROPOSED LIGHT-DUTY VEHICLE MY 2027 – MY 2032 CO_2 STANDARDS

- The standards continue to be based on tailpipe emissions and do not account for upstream emissions from electricity or fuel production
- This proposal retains the footprint-based CO_2 standards.
- For each model year, a slope and intercept is provided which allows calculation of the CO_2 target
- The equations are different for cars and light trucks, with higher targets for light trucks

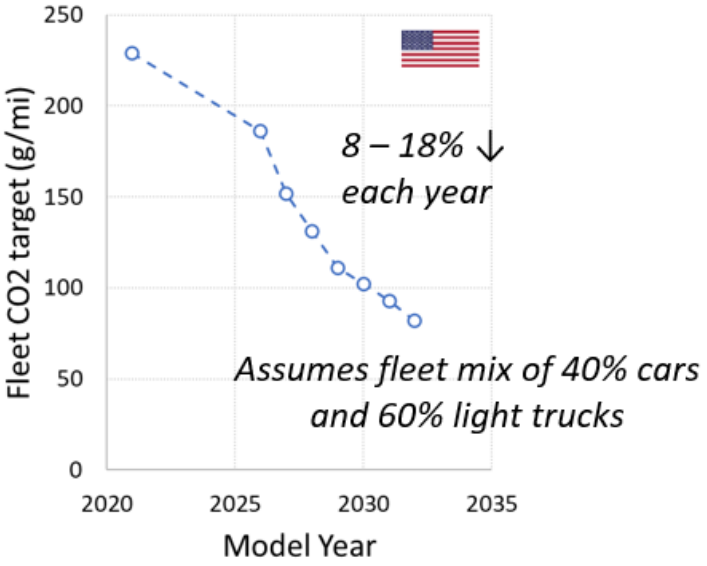
Figure below shows the existing standards and the proposed standards. For MY 2026, an "adjusted" curve is included: the A/C and off-cycle credits are reduced starting MY 2027, so the MY2026 curve is adjusted upward to provide an apples-to-apples comparison.



Some observations

1. The proposed curves are much flatter for passenger cars – that is, unlike previous standards, CO_2 targets are similar for smaller and larger cars. This follows from the assumption that a high degree of electrification will be required to meet the targets. Since the tailpipe emissions of a battery electric car is zero irrespective of its size, the targets are independent on the vehicle footprint.
2. The curves do retain a slope for light trucks, and this provides an allowance for towing for the larger trucks. The slope of trucks also reduces with time, corresponding to increased ZEV share.
3. The lower cutpoint (below which CO_2 targets remain the same) is increased by 1 square foot for the first three years, to encourage more offerings in the smaller vehicle segments. Also, the upper cutpoint is reduced from 74 to 70 sq. ft. to discourage vehicle upsizing.

4. Across the footprint range, CO_2 emissions will have to reduce by ~ 45% from 2027 to 2032. Compared to the 2026 curve, however, it is seen that significantly higher reduction is required for the heavier vehicles.
5. Average target for the light-duty fleet is estimated at 82 g/mi in MY 2032. This assumes a mix of 40% passenger cars and 60% light trucks. On average, this will require 13% CO_2 reduction each year relative to MY2026, higher (14 – 18%) reduction in the first three years and lower (8 – 12%) in the last three.



Alternatives

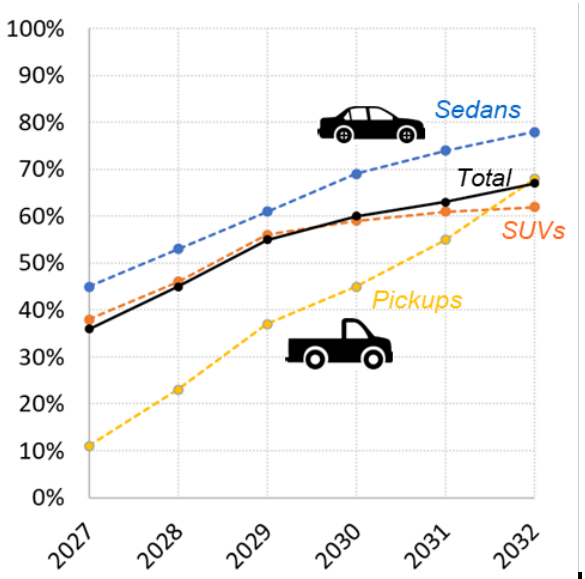
Other than the proposed CO_2 standards covered above, the EPA has also proposed two alternatives, one less and another more stringent, leading to an increase or decrease, respectively of CO_2 limits in 2032 by 10 g/mi.

Estimated Electrification

While the CO2 targets are technology neutral and can be met using a combination of various propulsion technologies, the EPA has provided an estimate of the market share of BEVs.

By 2030, the EPA projects a 60% overall share of BEVs, with a higher share for sedans (69%) and lower for pickup trucks (45%).

These estimates do not include any penetration of plug-in or full hybrids and will be revised in the final rule.



Credits

- Air conditioning system efficiency credits, currently capped at 5 g/mi for cars and 7.2 g/mi for trucks, and to be limited to IC engine powered vehicles starting MY 2027
- Credits for AC refrigerant leakage control to be removed starting MY 2027
- For medium-duty, the refrigerant-related provisions are to be phased out

Model Year	Off-cycle Menu Credit Cap (g/mi)
Current through MY 2027	10.0
2028	8.0
2029	6.0
2030	3.0
2031 +	0.0

- Off-cycle credits*:
  - Eligibility proposed for vehicles with IC engines only starting MY 2027. For PHEVs, the credits will be proportional to their utility value (% IC operation)
  - Menu-based credits to be phased out by MY 2031 with caps of 10 g/mi today, 8.0/6.0/3.0/0.0 g/mi over MY 2028 – 2031
  - Elimination of 5-cycle based credits starting MY 2027

*Background on off-cycle credits: These are available for a menu of advanced technologies, currently capped at 10 g/mi for cars and light trucks, and through 5-cycle testing to demonstrate additional GHG reductions on read-world driving conditions beyond the 2-cycle test. In 2021, the industry has used on average 8.7 g/mi of off-cycle credits, mostly menu-based.

Averaging, Banking and Trading

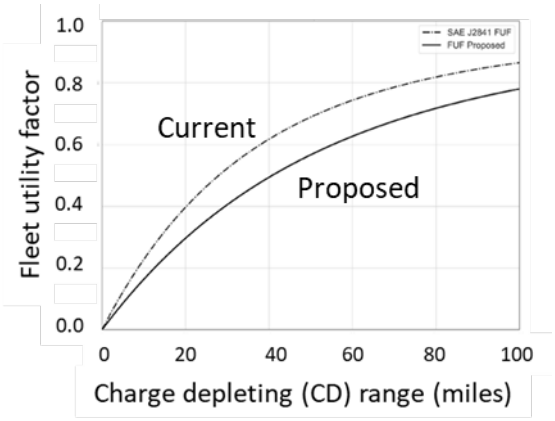
No change proposed to the existing ABT provisions which allows manufacturers to earn credits for overcompliance with the standards and use these for up to five model years, transfer across passenger car and light trucks, or trade to other companies.

Compliance & Test Procedure

Vehicle will have to comply with the standards over their useful life.
Testing will involve the 2-cycle procedure over the Federal Test Procedure (FTP or "city" test) and the Highway Fuel Economy Test (HFET or "highway" test).
Testing to be done using Tier 3 fuel starting MY 2027 (already used for criteria pollutant standards), which is representative of market E10 fuel. This replaces the Tier 2 test fuel Indolene. The change from Tier 2 to Tier 3 fuel is expected to result in 1.5% lower CO_2 emissions during the test. Tier 2 fuel can be used for testing up to MY 2029, and the GHG emission results can be adjusted downward by 1.66%.

Plug-in hybrids

The utility factors – that is the fraction of vehicle operation in electric mode – have been revised downwards. This effectively increases the CO_2 compliance values for PHEVs.



PROPOSED MEDIUM-DUTY VEHICLE MY 2027 – MY 2032 CO_2 STANDARDS

The MD vehicle standards were previously included in HD Phase 2 standards. Unlike light-duty, these medium-duty vehicle standards are not footprint, but work-factor based. The current proposal retains this work-factor approach and chassis dynamometer testing.

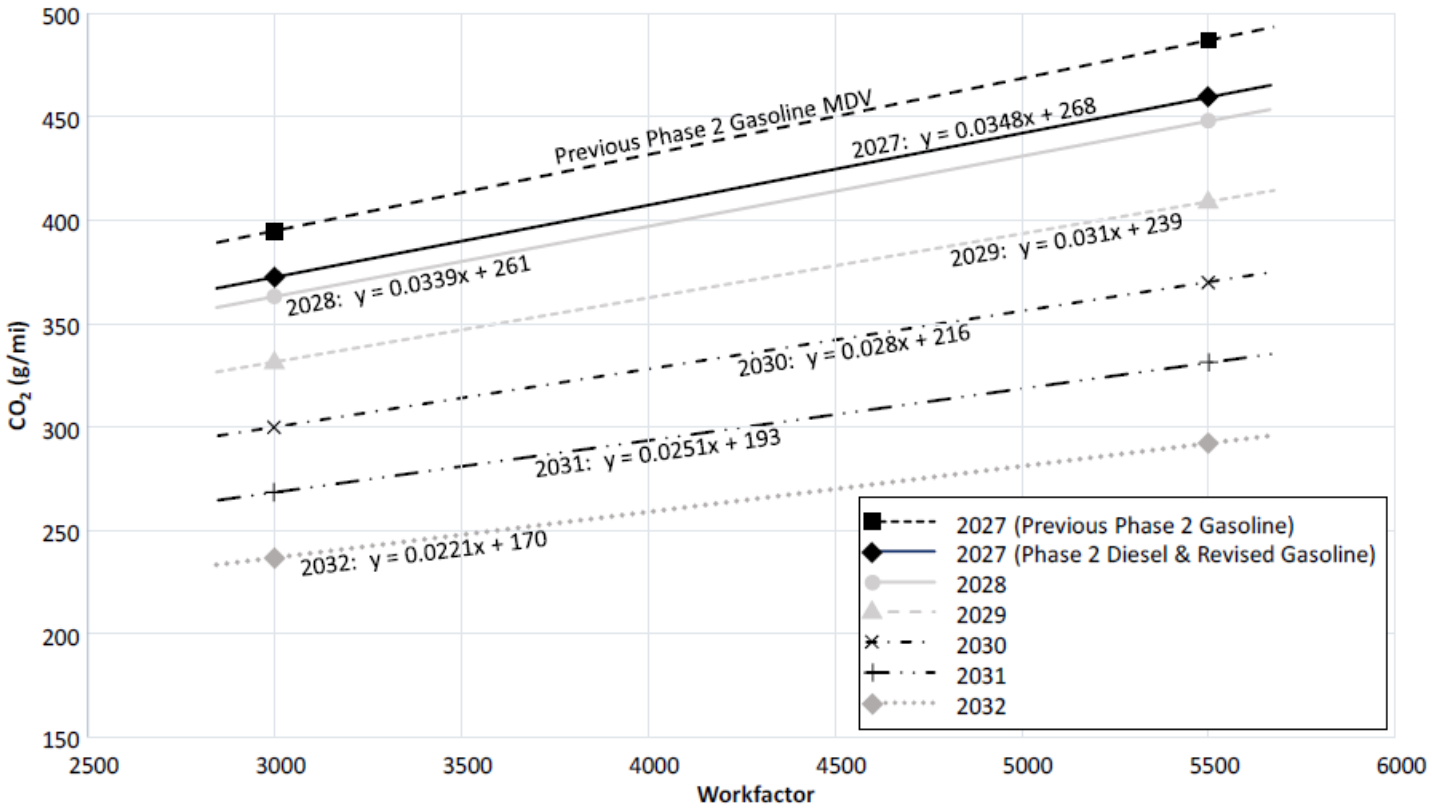
Work factor (WF) is defined as:

WF = 0.75 × [Payload Capacity + xwd] + [0.25 × Towing Capacity], where xwd = 500 lb. for 4WD, otherwise 0 lb.

Payload capacity = GVWR – Curb weight | Towing capacity = GCWR – GVWR

Beyond MY 2027, the standards are fuel-neutral (gasoline, diesel, electric, …)

The figure below shows the proposed standards:



The fleet averaged CO_2 targets, combining for vans and pickups is projected to reduce from 438 g/mi in 2027 to 275 g/mi in 2032, a 37% reduction.

MD Electrification: The GHG Phase 2 rule provided advanced technology multipliers of 3.5, 4.5 and 5.5 for BEV, PHEV and FCEVs, respectively. The multipliers were intended to promote adoption of these technologies. Given the rapid innovation and adoption of ZEVs, the EPA is proposing to remove these multipliers starting from MY 2027, and possibly phasing out the multipliers in the previous two years.

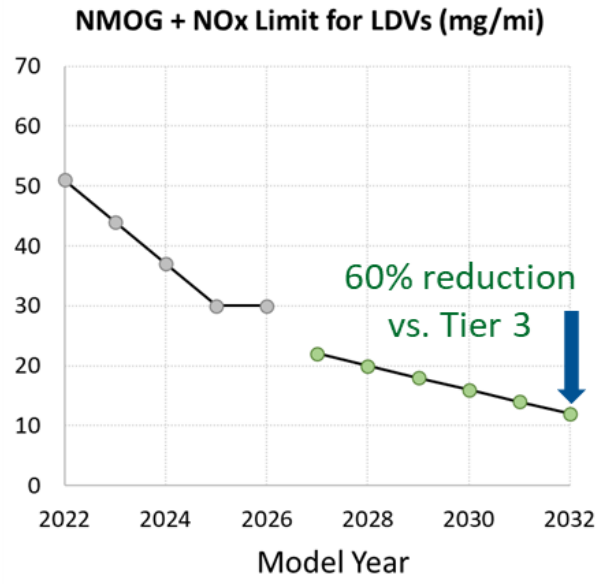
Gas Emissions – Light-Duty Vehicles

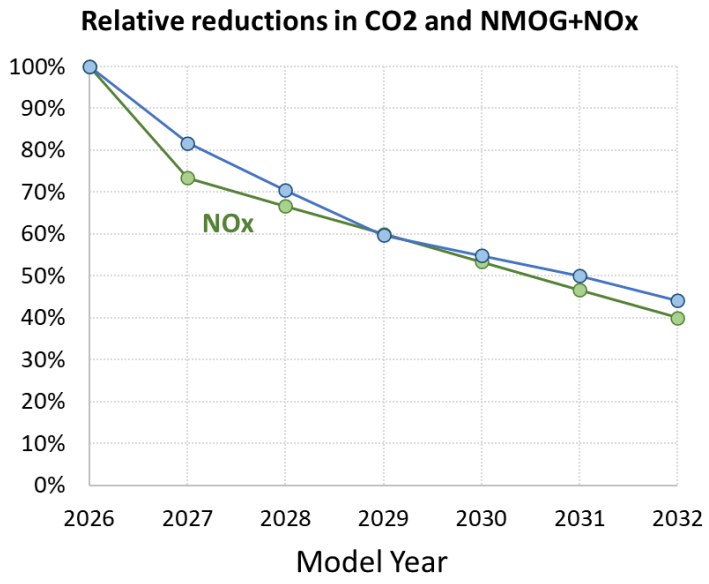
NMOG + NOx Standards for LDVs

Limits

The NMOG + NOx standards continue to reduce each year, down to 12 mg/mi for MY 2032. This is a 60% reduction compared to the fully phased-in value of 30 mg/mi for Tier 3.

The fleet averaged standards are proposed to be proportional to the GHG standards, assuming that these will be met primarily through the increased electric vehicle share of the fleet. The plots below show the actual limits on the left, and a normalized comparison of the CO_2 and NMOG+NOx limits. The latter shows that the GHG and NMOG + NOx reductions are closely aligned.





Revised Bins

The two highest bins – Bin 160 and Bin 125 are removed – and new ones are added: Bins 60, 40 and 10. The highest individual vehicle NMOG + NOx emissions are therefore capped at 70 mg/mi corresponding to Bin 70.

Testing & Compliance

- The limits apply to all tests individually: FTP at 25 °C, HFET, US06 and SC03. This is more stringent compared to Tier 3 in which vehicles had to meet a weighted average limit over the composite FTP cycle.
- At - 7 °C, vehicles will have to meet a combined NMOG + NOx fleet averaged limit of 300 mg/mi. ZEVs cannot be used to meet this limit (i.e. the averaging does not include ZEVs)
- Both ambient and low temperature standards must be met over the Tier 3 useful life
- The standards must be met at high altitude, without any compliance relief provisions from Tier 3

Adoption of CARB ACC II provisions for NMOG + NOx

EPA will adopt other provisions for reducing real world NMOG + NOx emissions as included in the CARB Advanced Clean Cars II program. These include emissions associated with:

(1) High-powered cold starts for plug-in hybrids
(2) Early driveaway
(3) Intermediate soak mid-temperature starts

Averaging, Banking and Trading (ABT) for NMOG + NOx

EPA is proposing to allow LDV NMOG + NOx credits (both from the 25 °C and -7 °C tests) to be transferred up to the end of the Tier 3 five-year credit life.

CO and Formaldehyde (HCHO) Standards for LDVs

Proposed limits and applicable test cycles are listed in this table. The CO limit applies to all light-duty vehicles, a change from Tier 3 which had a higher limit for LDT2 to MDPVs.

	25 °C	-7 °C
CO	1.7 g/mi limit on 25 °C FTP, HFET, US06, SC03	10.0 g/mi on - 7 °C FTP
HCHO	4 mg/mi limit on 25 °C FTP	-

Elimination of fuel enrichment

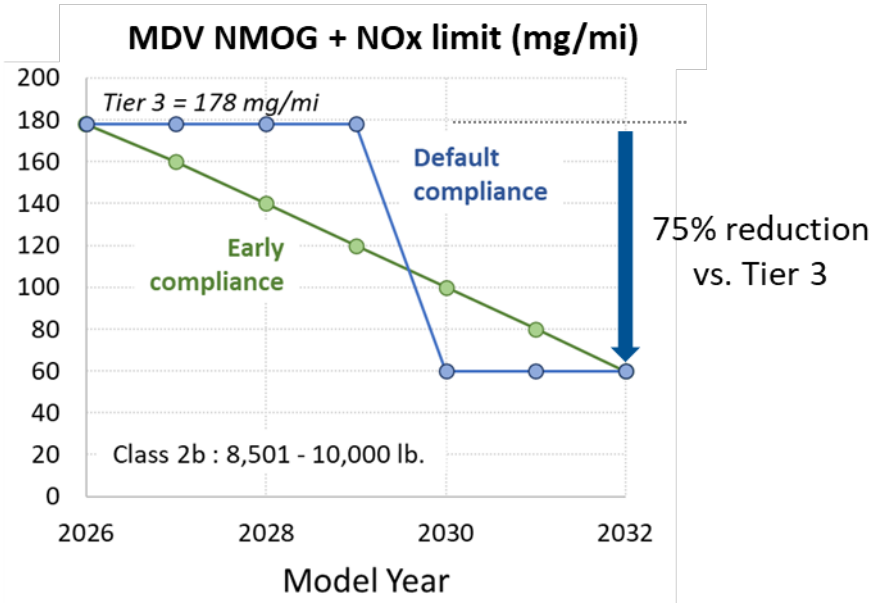
Commanded fuel enrichment, used for component protection from thermal damage, will be disallowed under normal operating conditions. This also applies to MDVs.

Gas Emissions – Medium-Duty Vehicles

NMOG + NOx Standards for MDVs

The NMOG + NOx limit for MDVs reduces from the Tier 3 phased-in limits for MY 2022 of 178 mg/mi for Class 2b and 247 mg/mi for Class 3, to 60 mg/mi. The default compliance pathway requires a step reduction in the emissions starting MY 2030 (providing a 4-year lead time), but there is also an early compliance pathway, as shown in the figure below, which allows a gradual reduction to 60 mg/mi in 2032.

The net reduction in NMOG + NOx of 75% compared to Tier 3, is much higher than the ~ 37% reduction in GHG emissions for MDVs over MY 2027 – 2032, which suggests that ICE improvements will play an important role in meeting the new standards. The EPA mentions ICE developments will enable 100 mg/mi NMOG + NOx tailpipe values.



Like LD, the MDV limits also apply over all 4 test cycles (25 °C FTP, HFET, US06 and SC03), with same limits at high altitudes and over useful life. For MDVs, a new FTP test at - 7 °C is introduced, with limit at 300 mg/mi (same as LD), and with the provision that ZEVs cannot be used in the fleet average.

CO and Formaldehyde (HCHO) Standards for MDVs

Proposed limits and applicable test cycles are listed in this table. The CO limit applies to all light-duty vehicles, a change from Tier 3 which had a higher limit for LDT2 to MDPVs.

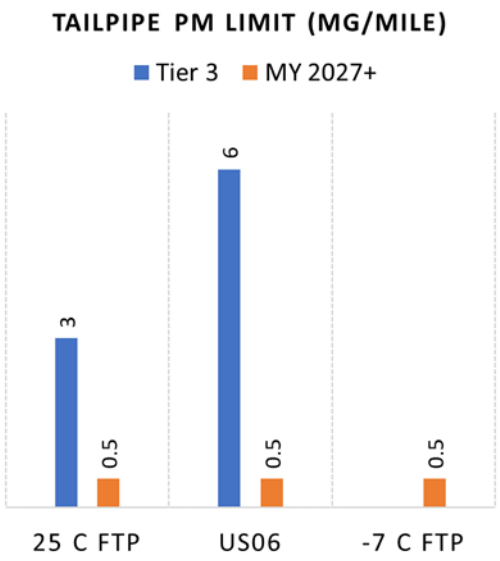
	25 °C	-7 °C
CO	3.2 g/mi limit on 25 °C FTP, HFET, US06, SC03	10.0 g/mi on - 7 °C FTP
HCHO	6 mg/mi limit on 25 °C FTP	-

Averaging, Banking and Trading (ABT) for NMOG + NOx

EPA is proposing to allow MDV NMOG + NOx credits to be transferred up to the end of the Tier 3 five-year credit life, only if the manufacturer selects the early compliance schedule.

Particulate Matter (PM) Standard

The proposal tightens the PM limit to 0.5 mg/mi on the existing 25 °C FTP and US06 cycles, and introduces for the first time for a -7 °C FTP test cycle, also set at 0.5 mg/mi. These apply to both light and medium duty vehicles.



- Tailpipe particle mass standard is proposed at 0.5 mg/mi for light- and medium-duty vehicles
- The standard must be met across 3 test cycles: FTP at 25 °C, FTP at - 7 °C and US06
- Unlike NMOG + NOx, the PM standard is a per vehicle cap, not fleet averaged.

The new standards will likely require the addition of a gasoline particulate filter (GPF), especially to reduce tailpipe emissions during the cold ambient test. Data collected by the EPA through a multi-lab study shows that GPF-equipped vehicles emit well below 0.5 mg/mi and that the current measurement procedures are robust and precise to support the standard. The addition of a GPF was found to reduce PM and polyaromatic hydrocarbons (PAHs) by > 95% and > 99%, respectively, without a measurable impact on GHG emissions when the GPF was properly sized.

Certification and Compliance:

- The EPA is proposing pre-production certification for PM on the various test cycles, a change compared to Tier 3 which required PM certification only at the durability group level. A worst-case test vehicle is to be selected from each test group from the -7 °C FTP test.
- In-use compliance will require PM emissions to be below the 0.5 mg/mi limit as tested using 25 °C FTP and US06 tests. No testing is required by manufacturers at - 7 °C, but the EPA can perform the tests.

OBD

The OBD system must detect GPF system tampering and malfunctions, store trouble codes and alert operators. This could be done using pressure sensors as example.

Phase-in of Criteria Pollutant Standards

A phase-in period is proposed for all criteria pollutant standards, including for NMOG+NOx, PM, CO, HCHO, CARB ACC II NMOG+NOx provisions, and elimination of enrichment.
The proposal provides eight phase-in scenarios from which manufacturers can choose.
The default compliance scenario is shown in the table.

- For vehicles at or below 6,000 lbs GVWR, 40% of the fleet must comply starting with MY2027, increasing to 100% in MY 2029.
- Vehicles > 6,000 lbs. require a 4-year lead time according to the Clean Air Act, and accordingly have been proposed a compliance start date of MY 2030. There is no phase-in period for these heavier vehicles.
- Chassis cert vehicles between 8,501 – 14,000 lbs GVWR cannot carry forward Tier 3 NMOG + NOx credits.

The early compliance scenario is also shown. In this case, manufacturers will calculate the same phase-in percentages for all weight classes. The incentive provided is that the Tier 3 NMOG + NOx credits for chassis cert vehicles between 8,501 – 14,000 lbs GVWR can be carried forward. The proposal also provides six other compliance scenarios from which manufacturers can choose.

Model Year	≤ 6,000 lb. GVWR	6,001 – 8,500 lb.	8,501 – 14,000 lb.*		≤ 8,500 lb. GVWR	8,501 – 14,000 lb.*
	Default scenario				Early phase-in scenario (one of several)	
2027	40%	0%	0%		40%	40%
2028	80%	0%	0%		80%	40%
2029	100%	0%	0%		100%	100%
2030+	100%	100%	100%		100%	100%

*Applies to both chassis or engine cert.

For PM, the EPA is requesting comment on accelerating the PM phase-in to 50% or 80% in MY 2027 and 100% in MY 2028 given the maturity of GPF technology and wide adoption in other markets.

Durability, Warranty

IC Engines

Current standards specify a warranty period for "major emission control components" of 8 years or 80,000 miles. The components included are catalytic converters, ECU and OBD device. In this proposal, the EPA is adding DPF/GPF, components of diesel SCR system (pumps, injectors, NOx sensors, DEF sensors, etc.) and diesel EGR system to the list.

Warranty period is 5 years or 50,000 miles for medium-duty vehicles (same as light HD vehicles)

Batteries

Considering the known degradation of batteries with time, EPA is proposing new battery durability monitoring and performance requirements beginning with MY 2027.

- Manufacturers must provide a state-of-health (SOH) monitor which will estimate the usable battery energy and provide the state-of-certified-energy (SOCE) that can be read by the vehicle user. This applies to LD, Class 2b and Class 3 BEVs and PHEVs.
- For LD vehicles only, the information from the monitor will be used to demonstrate compliance with a minimum percentage retention of the original usable battery energy for the new vehicle: > 80% at 5 years or 62,000 miles and > 70% at 8 years or 100,000 miles

For light-duty and medium-duty BEVs and PHEVs, EPA is proposing a warranty period of 8 years or 80,000 miles for the battery and associated electric powertrain components.