

Derivation of A/C Credits in the Light-Duty Greenhouse Gas Rule

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Rulemaking Process

- What is the “effect” of the pollutant on human health and welfare?
- What is the “inventory” of the pollutant in the atmosphere? (both current and future levels)
- What is the “impact”, or contribution, of vehicle use on pollutant levels in the atmosphere?
- What are the technologically-feasible methods available to reduce the pollutant?

Pollutants Related to Mobile A/C Use

1. Direct emissions (refrigerant leakage)
2. Indirect emissions (CO₂ emissions resulting from combustion of fuel to provide power needed operate the vehicle's A/C system)

Direct Emissions

- 5.1 % of CO₂eq GHGs are due to the refrigerant in MAC systems (includes leakage, maintenance, servicing, and disposal at end of vehicle life)
- Derived average per-vehicle per-year leakage rate from 2005 & 2006 emissions inventory data
- Scaled by MY 2016 vehicle sales
- Divided by total MY 2016 VMT (vehicle miles travelled)
- Multiplied by 0.8 to account for 20% gap between actual emissions and emissions on the certification test:
 - If alternative refrigerants are used, full credit is available
 - If R-134a is used, no credit is available for end of life (9%)
- Resulting CO₂eq “impact” of R-134a direct emissions is **12.6** g/mi for cars, and **15.6** grams/year for trucks

Direct Credits

- Credit earned for reducing refrigerant leakage
- Based on **SAE I-MAC Team 2** Final Report, a 50% reduction in refrigerant leakage can be attained
- EPA concurred with the SAE report, and used a 50% reduction in leakage to establish the maximum direct credit for cars and trucks (i.e. 0.5 * impact)

TABLE III.C.1-1—MAXIMUM LEAKAGE CREDIT AVAILABLE TO MANUFACTURERS

	Car (g/mi)	Truck (g/mi)
R-134a refrigerant with belt-driven compressor	6.3	7.8
R-134a refrigerant with electric motor-driven compressor	9.5	11.7
Lowest-GWP refrigerant (GWP=1)	13.8	17.2

Direct Credits ... cont'd

- Amount of direct credit is based on a formula which incorporates the **SAE J2727** Refrigerant Leakage score and the GWP of the refrigerant

$$\begin{aligned} \text{A/C Leakage Credit} = & (\text{MaxCredit}) * \\ & [1 - (\text{LeakScore}/\text{AvgImpact}) * \\ & (\text{GWPRefrigerant}/1430)] \end{aligned}$$

- Higher credits are available for sealed electric compressors (which can achieve leakage reductions >50%) and low-GWP refrigerants

Indirect Emissions

- An additional 3.9% of CO₂eq GHGs are due to power consumed to operate MAC systems
- CO₂ “impact” of indirect emissions is **14.2** g/mi
- Same impact for cars and trucks, as system power requirements are similar

Indirect Credits

- Credit earned for improving MAC system efficiency
- Based on **SAE I-MAC Team 2** Final Report, a 34% reduction in compressor energy can be achieved using “best-of-best” components and technologies
- EPA concurred with the SAE report, and when allowing for additional efficiency improvements for electric loads, used a 40% potential improvement in efficiency to establish the maximum indirect credit of **5.7 g/mi** (i.e. $0.4 * \text{impact}$, or $0.4 * 14.2 \text{ g/mi}$)

Indirect Credits ... cont'd

- EPA chose a defined credit “menu” approach for specific efficiency-improving technologies, as it is difficult to establish the absolute contribution of these technologies using a vehicle-based test procedure
- EPA used many of the technologies studied by SAE I-MAC Team 2, and the relative contribution of each technology to the overall efficiency improvement was used to “apportion” the 5.7 g/mi of credit available

Indirect Credits ... cont'd

TABLE III.C.1-2—EFFICIENCY-IMPROVING A/C TECHNOLOGIES AND CREDITS

Technology description	Estimated reduction in A/C CO ₂ emissions (%)	A/C efficiency credit (g/mi CO ₂)
Reduced reheat, with externally-controlled, variable-displacement compressor	30	1.7
Reduced reheat, with externally-controlled, fixed-displacement or pneumatic variable-displacement compressor	20	1.1
Default to recirculated air with closed-loop control of the air supply (sensor feedback to control interior air quality) whenever the ambient temperature is 75 °F or higher (although deviations from this temperature are allowed if accompanied by an engineering analysis)	30	1.7
Default to recirculated air with open-loop control air supply (no sensor feedback) whenever the ambient temperature 75 °F or higher lower temperatures are allowed	20	1.1
Blower motor controls which limit wasted electrical energy (<i>e.g.</i> , pulse width modulated power controller)	15	0.9
Internal heat exchanger	20	1.1
Improved condensers and/or evaporators (with system analysis on the component(s) indicating a COP improvement greater than 10%, when compared to previous industry standard designs)	20	1.1
Oil separator (with engineering analysis demonstrating effectiveness relative to the baseline design)	10	0.6

- For MY 2014-through-2016, result from an **A/C Idle Test** will be used to determine eligibility for credits, and/or scale the credit amount

Indirect Credits ... cont'd

- Unique or innovative technologies not on the credit list are eligible for “off-cycle” credits:
 - Manufacturer must demonstrate the efficiency improvement of the new technology relative to baseline technology (e.g. SAE I-MAC Team 2 approach, or equivalent)
 - Off-cycle credit will be determined based on apportionment of 5.7 g/mi max. indirect credit
- Since no defined test procedures exist for determining the efficiency improvement for “off-cycle” technologies, each will be evaluated on a case-by-case basis
- Methodology for establishing the “off-cycle” credit amount for a particular technology, and the analysis of its expected efficiency improvement, will be published in a Federal Register notice

Questions/Comments?

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