State of California
AIR RESOURCES BOARD

PRELIMINARY DISCUSSION PAPER –

PROPOSED AMENDMENTS TO CALIFORNIA'S LOW-EMISSION VEHICLE REGULATIONS FOR GHG EMISSIONS –

MOBILE AIR CONDITIONING – LEV III

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1. Introduction

Modern mobile air conditioning (MAC) systems enhance travel comfort and safety through features such as integrated cooling, heating, demisting, defrosting, air filtering, and humidity control. However, MAC systems contribute to greenhouse gas (GHG) emissions through direct refrigerant releases and indirect emissions which are tailpipe emissions associated with an increased load on the engine due to AC operation and the system's mass. The predominant refrigerant currently in use is HFC-134a, a hydrofluorocarbon (HFC) and a powerful GHG. It can slowly leak out of the MAC system in a manner that may occur with any closed high-pressure system such as permeation through hoses, and leakage due to compromised connections and deterioration of parts, seals, and fittings. Larger leaks may occur during accidents, maintenance and servicing, and vehicle disposal at the end of useful life. The use of a low GWP refrigerant in MAC would greatly reduce the GHG impact associated with direct emissions.

Emission reductions can also be gained through efficiency measures applied to MAC systems. Such efficiency measures include more efficient compressors, fans and motors, and systems that avoid over-chilling then re-heating the air. Technologies to reduce the heat gain within the passenger area can also be employed. These may include solar control glazing, solar reflective paint, passive or active parked-car ventilation, use of insulating material, and other innovative technologies.

In 2004, the California Air Resources Board (CARB) adopted limits on GHG emissions from new light-duty vehicles of model years 2009 and later. An AC credit scheme was developed to offset GHG emissions attributed to carbon dioxide, methane, and nitrous oxide. The regulation, known as Pavley, encourages, but does not require auto manufacturers to improve the leak-tightness of new systems that use HFC-134a, and/or use low-GWP refrigerants in new vehicles. Through the credit scheme manufacturers are also encouraged to reduce indirect emissions through a number of proven technologies such as efficient variable displacement compressors, condensers and evaporators with improved heat transfer, and reduce the amount of outside air that must be cooled. Thirteen other states and the District of Columbia adopted this California standard. This ARB regulation served as a template for a US EPA rulemaking to establish a national program for light-duty vehicle GHG emission standards.

Air conditioning credits associated with reduced emissions from MAC systems were also included in the calculation for the Environmental Performance Label (EPL). The EPL is required on all new vehicles sold in California and manufactured after January 1, 2009. To enable consumers to make informed decisions, two scores are provided on the EPL, a smog score and a global warming score. The global warming score reflects the emissions of GHG from the vehicle's operation and fuel production. Similar to the Pavley regulation, the

score calculation allows credits for reducing both direct and indirect AC emissions.

2. Proposed Requirements to Reduce GHG Emissions Associated with MAC

This regulation proposes to eliminate the AC credit scheme currently in use and replace it with mandatory requirements beginning with model year 2017 for all passenger cars, light-duty trucks, and medium-duty passenger vehicles. The proposed regulation has 3 elements:

- require a refrigerant with a GWP less than or equal to 150,
- require that the fleet average leak rate of new vehicles not exceed 9 grams per year, and
- require that the fleet average indirect emissions of new vehicles meet a performance test standard for indirect emissions.

2.1 Refrigerant Must Have a Low GWP

The proposed regulation would require a refrigerant with a GWP less than or equal to 150 for all passenger cars, light-duty trucks, and medium-duty passenger vehicles beginning with model year 2017.

The current refrigerant, HFC-134a, is a potent GHG with a GWP of 1,300[1]. It replaced the refrigerant R-12, a chlorofluorocarbon identified as an ozone depleting substance (ODS) under the Montreal Protocol. The global HFC emissions from MAC are estimated to be around 86 $MMTCO_2E$ in 2002 and are projected to grow rapidly to approximately 281 $MMTCO_2E$ in 2015 under business-as-usual[2]. A global opportunity exists to reduce GHG emissions associated with MAC by eliminating the use of HFC-134a in this application. Switching from the current refrigerant with a GWP of 1,300 to an alternate with a GWP of 150 would immediately reduce direct GHG emissions by about 90%.

The threshold of 150 allows for use of three alternative refrigerants that have draft or final approval under the Significant New Alternative Policy (SNAP) Program by the US EPA.

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[1] IPCC, 2007. Climate Change 2007: The Physical Science Basis, IPCC Working Group 1 Fourth Assessment Report, 2007. ("Global Warming Potential Value" or "GWP Value" for this regulation means the 100-yr GWP value first published by the IPCC in it's Second Assessment Report (SAR) (IPCC, 1995); or if a 100-yr GWP value was not specified in the IPCC SAR, it means the GWP value published by the IPCC in it's Fourth Assessment Report (AR4) (IPCC, 2007). Both the 1995 IPCC SAR values and the 2007 IPCC AR4 values are published in table 2.14 of the 2007 IPCC document. The SAR GWP values are found in column "SAR (100-yr)" of Table 2.14.; the AR4 GWP values are found in column "100 yr" of Table 2.14. If the compound is not listed in Table 2.14, then the GWP value will be determined by the Executive Officer).http://ipcc-wg1.ucar.edu/wg1/wg1-report.html

[2] Clodic et al., 2004. Determination of Comparative HCFC and HFC Emission Profiles for the Foam and Refrigeration Sectors until 2015, Report Prepared with Support from U.S. EPA and ADEME, April 2004. http://www.epa.gov/spdpublc/snap/emissions/index.html.

An alternate refrigerant must be approved by the US EPA SNAP Program. This program requires the US EPA to review and list acceptable refrigerant substitutes for ozone depleting substances (ODS). There are currently two SNAP-approved substitutes with a GWP less than 150 and another one with a draft SNAP approval. On October 19, 2009, EPA published a proposed rule to find HFO-1234yf acceptable, subject to use conditions, as a substitute for HFC-134a in MAC. Many in industry anticipate that this compound will be the world's next mobile refrigerant. It has a highly desirable GWP of 4 and its physical properties are similar to those of HFC-134a so system performance should be similar. As of this writing, the EPA is responding to comments and is expected to revise some of the conditions for use related to mitigating the mild flammability properties.

Other SNAP-approved refrigerants with low GWP included carbon dioxide (R744) with a GWP of 1 and HFC-152a with a GWP of 140. It is feasible to use either refrigerant in a MAC system. The CO_2 operates at a higher pressure necessitating significant equipment redesign and also heavier equipment. Also, because CO_2 can make a person drowsy, the system must be designed so that the concentration in the passenger compartment will never go above an upper limit in case of an accidental release. HFC-152a, like HFO-1234yf, has a mild flammability threshold, and a system using it must be designed so that concentrations in the passenger area do not exceed the flammability threshold.

The US EPA GHG emission standards finalized in 2010 and ARB's Environmental Performance Label (EPL) provide credits for using a low GWP refrigerant. However, widespread introduction of a low GWP refrigerant has not yet occurred. The US EPA rulemaking should accelerate transition to a low GWP refrigerant on a national scale by the use of credits through 2016, with the intent that a gradual transition will be occurring in the 2012 to 2016 timeframe. The proposed regulation harmonizes with EU Directive 2006/40/EC that requires all new vehicles have a refrigerant with a GWP less than 150 beginning January 1, 2017. This proposal harmonizes with that directive and allows adequate lead time for a complete transition.

2.2 Limit Direct Emissions

The proposed regulation would require that the fleet average leak rate should not exceed 9 grams per year per vehicle. The leak rate will be assessed by a model that assembles leak rate estimates assigned to each component of the AC system. Maintaining a low leak rate is important, irrespective of the refrigerant in use. Refrigerant containment not only maintains efficiency by avoiding insufficient refrigerant charge, but also helps reduce the need for AC service, thus improving the customer experience and overall cost-effectiveness of the requirement. During the past decade, manufacturers have tightened MAC systems and reduced the charge volume to reduce direct GHG emissions.

A refrigerant leak rate less than or equal to 9 g/yr is achievable and demonstrated by several sources of information. The US EPA estimates that MAC leakage is about 18 g/yr[3]. Furthermore, the cooperative industry and government Improved Mobile Air Conditioning (IMAC) Program demonstrated that new vehicle leakage can be reduced by 50%[4]. Manufacturers demonstrate achievement of a 9 g/yr leak rate in their documentation for AC credits under the Pavley and EPL certification with current commercial AC platforms using premium technologies. Lastly, it is likely that the electric compressor market share will grow with growth of hybrid and electric vehicles, leading to reduced leakage for vehicles with this type of compressor.

SAE International led a voluntary consensus standard body to develop the SAE Surface Vehicle Standard J2727 which assigns a leakage-score system to each component of a MAC system. US EPA used this scoring system in the GHG vehicle emissions standards, section 86.166-12, to calculate emissions due to air conditioning leakage. This method has a specific formula to sum the leakage associated with rigid pipe connections, service ports, flexible hoses, heat exchangers, mufflers, receiver/driers, and compressors. The proposed regulation would utilize a similar standard for calculating direct emissions; however, in this application it is mandatory that the emissions not exceed 9 g/yr rather than using reduced emissions for a GHG emissions credit.

Maintaining long-term refrigerant containment is very important. Therefore, technologies that ensure adequate lubrication during colder seasons of the year should be used to provide a better guaranty for long-term refrigerant containment. During colder months, the AC generally does not operate, resulting in lack of system lubrication. This can lead to increased leakage by drying out sealing parts and increased failure of moving parts, mainly the compressor. From a life-cycle climate performance (LCCP) perspective, this is an issue that should be addressed. Some manufacturers have voluntarily employed technologies such as having the AC operate under defrosting/dehumidifying functions to ensure adequate lubrication. This technology would increase annual indirect emissions and likely increase the production cost for the models that are not currently using this technology, but could achieve long-term benefits from reduced leakage and compressor failure. The benefits include maintaining efficiency by maintaining sufficient refrigerant charge and reduced need for service and repair.

ARB is seeking comments on technologies and procedures to ensure adequate lubrication in colder months.

[3] US EPA, 2010. Final Rulemaking to Establish Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards, Regulatory Impact Analysis, EPA-420-R-10-009, April 2010. http://www.epa.gov/oms/climate/regulations/420r10009.pdf.

[4] IMAC Team 1 – Refrigerant Leakage Reduction: Final Report to Sponsors, SAE, 2007.

2.3 Limit Indirect Emissions

The proposed regulation would require that manufacturers meet a fleet-averaged CO_2 standard for AC indirect emissions. This standard would be evaluated through a whole-vehicle performance test procedure designed to imitate realistic driving conditions and solar loads. US EPA has also expressed interest in developing a comprehensive test evaluating indirect MAC emissions to replace the AC Idle Test in place for model year 2014-2016 vehicles. As such, ARB staff will work with the US EPA and industry to develop a harmonized test procedure. Although staff has worked with industry to develop a similar test procedure for a complementary regulation, we understand there are complexities involved in determining a standard and test procedure. As such, it is unlikely that these will be developed in time for the LEV III Fall 2010 Board hearing. Therefore, staff will propose continuation of the US EPA Idle Test procedure and AC Efficiency Credits scheme as a placeholder while the standards and test procedure are developed. By 2012, staff will revise the regulation and propose for adoption the MAC indirect emissions standard and test procedure, which would be applicable for model year 2017 and later vehicles.

At this time, staff is proposing that the whole-vehicle performance test procedure evaluate the efficiency of the vehicle cooling system by soaking the vehicle under metal halide lamps for a period of two hours, followed by running the vehicle through a test cycle with the AC on and with the AC off. The CO_2 emissions would be measured during the test cycle and the difference between the AC on and AC off would need be less than or equal to the standard. By initially soaking the vehicle and running the test cycle for a sufficiently long period of time, the test would evaluate not only energy used during the initial cool down period but also during steady state operation.

Staff believes this type of test is the most appropriate way to evaluate indirect MAC emissions because it can accurately assess benefits from all types of vehicle cooling technologies and evaluates all technologies under realistic solar load and driving conditions. In addition, a whole-vehicle performance test procedure can readily account for the benefits of new technologies as they are developed without requiring a redesign of the test and would allow for a readily enforceable standard. Staff recognizes the increase in testing burdens that will result from the adoption of such a test procedure and is proposing to allow the use of broad AC test groups and the use of existing OEM test facilities in an effort to reduce these burdens.

ARB is soliciting OEM input on this test procedure including the appropriateness of using back-to-back SC03 cycles to measure indirect emissions and ways to minimize test burdens through the use of vehicle test groups (e.g., MAC system based, platform based, footprint). Any data or information on baseline MAC indirect emissions is also welcome.