ADDENDUM

Proposal to Provide Non-Methane Organic Gas Credits for Passenger Cars, Light-Duty Trucks and Medium-Duty Vehicles Utilizing an Ozone Reducing Catalyst Coating on the Radiator or Other Supporting Substrates

Background
In March 1995, Engelhard Corporation, a major supplier of catalysts to the automobile manufacturers, announced the development of a catalytic coating (PremAir) effective in reducing ambient ozone that could be applied to vehicle radiators. Subsequently, Engelhard approached the Air Resources Board and requested consideration of NMOG credits for vehicles using this technology. In addition, several vehicle manufacturers have expressed an interest in obtaining NMOG credits by equipping their vehicle radiators with this catalyst coating. Accordingly, staff have identified several issues relevant to the analysis of the air quality benefits of this technology. The relevant issues and a possible framework to provide the appropriate NMOG credits to this technology are outlined below. Staff proposes that NMOG credits allotted to this technology be applied to manufacturers’ fleet average emissions. Staff solicits comments on these issues and the framework proposed to provide NMOG credits.

Air Quality Benefits of PremAir
The unique nature of this technology presents a significant challenge to quantifying the air quality benefits attributable to its use on motor vehicles. Two analysis methods have been proposed, the Urban Airshed Model (UAM) and a mass based method using the federal test procedure and the specific reactivity of phase 2 gasoline.

Using the UAM, Systems Applications International (SAI) has compared the ozone reductions from treated radiators for the South Coast Air Basin (SCAB) fleet against the ozone reductions achieved by removing a select portion of the inventory for volatile organic compounds. For calculation purposes, SAI used a single radiator size for the vehicle fleet. SAI then calculated the per vehicle benefits on a high ozone episode day for a variety of indicators; a reduction in the 1 hour peak ozone, a reduction in the SCAB 8 hour ozone peak, and the reduction in population exposure to ozone. The estimated benefits ranged from an equivalent tailpipe VOC reduction of 0.01 g/mi for the change in the 1 hour peak ozone to a maximum of 0.024 g/mi for reductions in population ozone exposure.

The second method calculates the ozone reduction from a vehicle equipped with the radiator catalyst coating over the federal test procedure (FTP). The g/mi ozone reduced by the catalyst can then be converted to tailpipe FTP g/mi NMOG using the specific reactivity of a low-emission vehicle for phase 2 gasoline. The estimated benefits for a high ozone episode day using this method result in a tailpipe NMOG offset on the order of 0.01 g/mi.

Regardless of the analysis method ultimately chosen, the following issues must be resolved before the NMOG credits for this technology can be determined with confidence.
Ozone Indicator Used to Calculate PremAir Benefits
A manufacturer of the catalyst coating has proposed that NMOG credits be derived from the benefits calculated from the reductions in population exposure to ozone. As noted above, this would result in a maximum value for NMOG credits. Since California is required to meet a peak ozone standard, it seems logical that the benefits for this technology be calculated for ozone concentrations near the ozone standard. This would also help assure that the ozone attainment plan would not be compromised by overestimating the benefits.

Titration of Ozone by Vehicle Nitric Oxide (NO) Emissions
Vehicle emissions of NO are readily reactive with ozone thereby reducing the amount of ambient ozone available for treatment by coated radiators. A 1995 report outlining the results of a test program in the Cincinnati area confirms this scavenging effect, demonstrating on average a 40% reduction in roadway ozone concentrations compared to fixed site measurements. SAI has suggested that the scavenging effect of vehicle NO is limited by a number of factors and in all cases may be no higher than 30 ppb. The resolution of this issue is non trivial and may not be fully resolved without an extensive and lengthy test program. Therefore, until more definitive data are available, staff recommends that the more conservative estimate from the Cincinnati study (40% reduction of ambient ozone concentration) be used to adjust the ambient ozone concentrations used to calculate NMOG credits.

Radiator Airflow
The volume of ambient air processed by the vehicle radiator is another parameter critical to assessing the air quality benefits of this technology. Manufacturers are generally designing their vehicles to optimize vehicle aerodynamics in order to achieve fuel economy improvements. Consequently, on many vehicles, manufacturers are reducing the volume of air flowing through the radiator to a level sufficient for cooling purposes only. In addition, the volume of air impacted by the vehicle radiator is unique to each vehicle model depending on vehicle design and radiator size. Accordingly, the radiator airflow for each vehicle model must be quantified in order to determine the applicable NMOG credit.

Other Issues
Catalyst Durability
Another concern is durability of the catalyst coating on the radiator. The effects of time, road grime, and weather on the catalyst coating are unknown at this time. Although some durability tests have been conducted on this technology, more data are needed to determine whether the catalyst deteriorates over time. Therefore, when certifying vehicles equipped with this technology, the manufacturer should submit data demonstrating catalyst durability over the full useful life of the vehicle.
On-Board Diagnostics (OBD)
Although this technology is not strictly an emission control component, under this proposal it would receive NMOG credits as if it was. The OBD regulation requires monitoring of all emission control components. Currently, staff is not aware of any technology that would facilitate in-use monitoring of the performance of this technology. Furthermore, although manufacturers would be required to replace the radiator under warranty, many radiator failures occur beyond the warranty period when, absent OBD for the catalyst coating, there would be no assurance that the replacement radiator would be treated with the catalyst. Similar concerns apply to any substrate (e.g., mounted behind the radiator, rather than utilize the radiator itself) used to support the catalyst coating. Accordingly, until adequate OBD technology is available and to be protective of air quality, staff recommends that the NMOG benefit for this technology be reduced an appropriate factor.

Maintenance and Warranty
Radiator are subject to damage and deterioration requiring their replacement during the lifetime of a vehicle. Therefore, for vehicles receiving an NMOG emission credit for this technology, the manufacturer should warrant replacement of the radiator as required for other high price emission control components, for 7 years or 70,000 miles, whichever first occurs. Radiators on vehicles certifying to the 150,000 mile option available in LEV II should be warranted for ten years or 90,000 miles, whichever first occurs. This warranty requirement would also apply to any substrate used to support the catalyst coating.

NMOG Credit Proposal
Staff is proposing that an NMOG credit be assigned to vehicles equipped with this technology that would be used to adjust a manufacturer’s fleet average NMOG emissions. Accordingly, for vehicles equipped with this technology, manufacturers would subtract the applicable NMOG credit from the emission standard to which a vehicle is certified when calculating their fleet average NMOG emissions.

As noted above, two methodologies have been proposed to quantify the NMOG credit for this technology. Outlined below is a proposed framework to determine NMOG credits for each method.

NMOG Credits Calculated Using The Specific Reactivity for Phase 2 Gasoline
Using the specific reactivity for phase 2 gasoline, the manufacturer would submit the following data to receive NMOG credits for vehicles equipped with this technology:

1) The volume of ambient air passing through the vehicle radiator, or substrate used to support the catalyst coating, during a driving cycle equivalent to the FTP. This data must be supported by data demonstrating the airflow rate over the vehicle radiator at the speeds encountered in the FTP.

2) Data demonstrating the efficiency of the catalyst coating at the speeds encountered in the FTP.
3) Data demonstrating the durability of the catalyst coating over the full useful life of the vehicle.

4) In addition, the manufacturer would need to warrant replacement of the radiator, or any substrate used to support the catalyst coating, for any significant deterioration during the full useful life of the vehicle.

The NMOG credit would be calculated according to the following formula:

\[
NMOG\ Credit = \left[ \frac{\sum_{i=1}^{FTP(sec)} V_i + E_i + O_i}{\sum_{i=1}^{N} D_i} \right] \div C \div OBD_f
\]

Where:
- \(V\) = Volume of air passing through the radiator
- \(E\) = Efficiency of the catalyst
- \(O\) = Ozone concentration (corrected for NO titration)
- \(D\) = Distance traveled over the FTP
- \(C = 2.94\) g ozone/g NMOG (specific reactivity of phase 2 gasoline)
- \(OBD_f\) = OBD factor

**NMOG Credits Calculated Using the UAM**

Using the UAM to determine the air quality benefits for the catalyst, the manufacturer would submit similar data to receive NMOG credits for vehicles equipped with this technology.

1) The volume of ambient air passing through the vehicle radiator, or substrate used to support the catalyst coating, during a driving cycle equivalent to the FTP. This data must be supported by data demonstrating the airflow rate over the vehicle radiator at the speeds encountered in the FTP.

2) Data demonstrating the efficiency of the catalyst at the speeds encountered in the FTP.

3) Data demonstrating the durability of the catalyst over the full useful life of the vehicle.

4) Again, the manufacturer would need to warrant replacement of the radiator, or any substrate used to support the catalyst coating, for any significant deterioration during the full useful life of the vehicle.

The vehicle radiator size and the demonstrated efficiency of the catalyst would be used to adjust
the NMOG credit calculated by the UAM for peak ambient ozone concentrations at the state ambient ozone standard for each vehicle model. The NMOG credit would be calculated according to the following formula:

\[
\text{NMOG Credit} = \frac{UAM \times \frac{R_v}{R_{UAM}} \times \frac{E_v}{E_{UAM}}}{OBD_f}
\]

Where:

- **UAM** = Benefit calculated by UAM (g/mi)
- **R_v** = Frontal area of vehicle radiator
- **R_{UAM}** = Frontal area of vehicle radiator used for UAM calculations
- **E_v** = Conversion efficiency of vehicle catalyst
- **E_{UAM}** = Conversion efficiency of catalyst used in UAM calculations
- **OBD_f** = OBD factor