

State of California  
California Environmental Protection Agency

## AIR RESOURCES BOARD

# Mobile Source Emission Reduction Credits

Guidelines for the Generation of  
Mobile Source Emission Reduction Credits  
Through Purchase and Operation of  
New, Reduced-Emission Heavy-Duty Vehicles

A Proposed Addition to the Guidelines  
Previously Approved by the  
Air Resources Board  
on November 18, 1993

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This report has been reviewed by the staff of the California Air Resources Board. Publication does not signify that the contents necessarily reflect the views and policies of the Air Resources Board.

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# INTRODUCTION

This document provides local air pollution control and air quality management districts with additions to the Air Resources Board's (ARB or "Board") guidelines for the development and implementation of mobile source emission reduction credit programs entitled "Mobile Source Emission Reduction Credits - Guidelines for the Generation and Use of Mobile Source Emission Reduction Credits", most recently approved by the Board on November 18, 1993. The additional program, presented as an appendix to this document, covers the generation of emission reduction credits through the purchase of new, reduced-emission heavy-duty vehicles in lieu of purchasing conventional heavy-duty vehicles emitting at more typical rates. If approved by the Board, the guidelines for this additional program will be incorporated into the existing guideline document. Close adherence by districts to the ARB guidelines will facilitate ARB review and approval of the resulting mobile source credit rules and the state implementation plans (SIP's) which contain those rules.

## **Mobile Source Emission Reduction Credits Guidelines Development**

In July 1992, the Air Resources Board (ARB or "Board") staff released a paper entitled "Mobile Source Emission Reduction Credits: A Concept Paper on the Generation of Emission Reduction Credits from Mobile Sources." This paper was subsequently presented to the Board as an informational item at the August 1992 Board meeting. At the Board's direction, the ARB staff subsequently held public workshops and solicited written and oral comments on the paper. A document was written to address the comments raised during the comment period and to formalize the concept paper into the ARB's guidance to air pollution control and air quality management districts (districts) for development and implementation of mobile source emission reduction credit programs. That guideline document was approved by the Board on February 19, 1993. At a following board meeting (November 1993), the Board approved the addition of two more sets of program guidelines to the complete guidelines document. That complete document contains information on the following three areas:

- 1) Overall program development and implementation;
- 2) Uses for mobile source emission reduction credits;
- 3) Specific guidelines for generation of credits using:
  - a. Accelerated retirement of older vehicles;
  - b. Purchase of low-emission transit buses;
  - c. Purchase of zero-emission vehicles;
  - d. Low- emission retrofit of existing light- and medium-duty vehicles;

e. Low-emission retrofit of existing heavy-duty vehicles.

In the continuing development of mobile source emission reduction credit guidelines, the ARB has developed additional specific guidelines for generating credits through the purchase of new, reduced-emission heavy-duty vehicles, in a manner similar to the transit bus guidelines noted above. In developing these additional guidelines, the ARB staff held a public workshop to present the proposed guidelines and receive comments from interested parties. The ARB has also received written comments on the draft guidelines. Where appropriate, responses to public comments were incorporated in these guidelines.

### **Background on the ARB's Motor Vehicle Program**

In California, mobile sources<sup>1</sup> account for about 60 percent of all ozone-forming emissions<sup>2</sup> and for over 90 percent of all carbon monoxide emissions (CO) from all sources. The ARB continues to develop and implement a comprehensive motor vehicle emissions control program. Some of the major elements of the motor vehicle program include stringent certification and emissions standards that will decrease ROG emissions by 80 percent and NOx emissions by 50 percent<sup>3</sup> over time. Other important state motor vehicle programs include in-use compliance, inspection and maintenance, emissions warranties, and clean and reformulated fuel regulations. Similar motor vehicle emissions programs are being developed and implemented for off-road vehicles and engines. Because mobile sources are the leading cause of urban air pollution, achieving additional emission reductions from mobile sources is attractive. However, it is important that any mobile source emission reduction credit program to be created meets existing air quality requirements and does not sacrifice the programs already in place.

### **Background on Emission Reduction Credit Programs**

In 1977, the concept of emission reduction trading was introduced in the federal Clean Air Act. As a result, districts developed and implemented New Source Review programs which included the concept of offsets. New Source Review programs regulate the siting of new industrial sources of air pollution and the expansion of existing industrial sources. In general, offsetting means a new company can build, or an existing company can expand, emission producing activities only if it secures emission reduction credits (offsets) from another existing company with the end result being no net increase in emissions.

Since the adoption of the emission trading concept in New Source Review rules, considerable interest has been expressed in expanding the concept of emission reduction trading to programs other than New Source Review. The creation and use of mobile source emission reduction

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<sup>1</sup> Mobile sources include vehicles such as passenger cars, trucks, buses, trains, ships, motorcycles, and construction and farm equipment.

<sup>2</sup> Reactive organic gases (ROG) and oxides of nitrogen (NOx) react in the presence of sunlight to form ozone.

<sup>3</sup> When 1990 model year light and medium duty vehicles are replaced with the models sold in 2000.

credits presents an opportunity to provide flexibility to industry to meet air quality goals. The concept is that a company can have the flexibility to comply with the specific requirements of a district rule or regulation, or it can comply by supplying mobile source emission reduction credits that ensure there is no net increase in emissions. The ARB-approved guidelines are to be used by districts in designing emission reduction credit trading programs that generate credits by reducing mobile source emissions.

### **Mobile Source Emission Reduction Credit Programs**

By adopting and implementing a mobile source emission reduction credit program, the district creates an opportunity for businesses and industry to create and use mobile source emission reduction credits. Participation in such a program is voluntary on the part of businesses wishing to use mobile source emission reductions for emission reduction credits.

Mobile source emission reduction credits are created when reductions in emissions from cars, buses, or other mobile sources exceed the reductions required by federal, state, and local laws. In addition, mobile source emission reduction credits must exceed the requirements of district rules and regulations as well as the requirements of the district's air quality attainment plans. Mobile source emission reduction credit programs need to be carefully designed so that they do not exacerbate a district's air quality problem by allowing credit for emission reductions that are already required by other programs, rules, or laws.

These programs provide flexibility to industry in meeting requirements for emission reductions. Such a program does not necessarily benefit air quality--unless the emission reduction credits are purchased specifically to benefit air quality. For example, districts along with environmental groups might choose to obtain mobile source emission reduction credits to help meet air quality goals.

Examples of how such credits could be produced include the purchase of low-emission transit buses and the elimination of old, high-emitting cars through an accelerated retirement program. Some possible uses of mobile source emission reduction credits include delaying compliance with prohibitory rules, offsetting emissions from temporary sources, improving air quality in general, and using them as an alternative to controls otherwise required of industrial sources.

### **Potential Benefits of Mobile Source Emission Reduction Credit Programs**

Mobile source emission reduction credit programs provide several benefits including generation of emission reductions at a competitive or lower cost than other strategies, especially when emission reductions from stationary sources have limited availability, or helping districts to attain the state and federal ambient air quality standards. Mobile source emission reduction credits may also help industry find emission reduction credits to mitigate emission increases. Additionally, the development of mobile source emission reduction credit programs may encourage the advancement of low-emission technologies, such as the advancement of electric-powered vehicles and fuel cell technology.

## **Criteria Which Mobile Source Emission Reduction Credits Must Satisfy**

For emission reductions to qualify as mobile source emission reduction credits, several specific fundamental criteria must be met. These criteria include:

- 1) The reductions must not be required by law or regulation, or otherwise assumed to occur as part of a regional air quality plan.
- 2) The reductions must be real, and quantified to an acceptable degree of certainty.
- 3) To be used as stationary source offsets or to replace other emission reduction requirements, the mechanism used to obtain mobile source emission reduction credits must be enforceable and legally binding.
- 4) The life of the reduction must be reasonably established, and commensurate with the proposed use of the credit.

## **Examples of Potential Mobile Source Emission Reduction Credit Programs**

Various opportunities for generating mobile source emission reduction credits exist. The current document, dated February 1994, presents guidelines for the implementation of five of the most widely discussed programs. The additional guidelines based on new, reduced-emission heavy-duty vehicle procurement will supplement this list. All programs are voluntary and they are meant to be used as an additional means of flexibility for industry to meet emissions requirements. The programs described in the current guideline document include:

- 1) The accelerated retirement of older, higher emitting cars from the vehicle fleet. This results in reductions beyond existing regulations and the normal retirement rate of older vehicles.
- 2) The purchase of low-emission transit buses. Methanol (M100), compressed natural gas (CNG), and electric buses have demonstrated the capability to achieve exhaust emission levels significantly below the levels of current diesel technology. Any bus that is certified to a low-emission standard would be eligible to be used in a mobile source emission reduction credit program.
- 3) The purchase of zero-emission vehicles (ZEVs).
- 4) The retrofit of existing light- and medium-duty vehicles.
- 5) The retrofit of existing heavy-duty vehicles.

The following chapter of this report describes an additional credit program that is based on the procurement of new, reduced-emission heavy-duty vehicles, in a manner similar to the guidelines for generating credits from the purchase of new, low-emission urban transit buses. These

new, heavy-duty vehicle credit guidelines utilize the regulations governing certification of heavy-duty engines and vehicles as the basis for certifying those reduced-emission engines and vehicles that a proponent wishes to use to generate emission reduction credits. Those regulations also give the credit programs enforcement and recall provisions should any certified engine or vehicle prove defective. The necessary credit standards and certification regulation changes have already been approved by the Board at the June 1995 Board hearing.

To be eligible for use in a credit-generating program, a heavy-duty vehicle and engine must be certified to one of the described credit standards. The resulting emission reduction, taken over the remaining vehicle life, is the credit amount, subject to any discount factor the responsible district may impose.

An examination of the general cost-effectiveness of new, heavy-duty vehicle credit programs is difficult. Depending on the types of vehicles involved, the fleet size and the type of operation conducted, the cost and the amount of credit-producing emission reductions would vary widely. Because of this variability, the proposed credit guidelines do not include cost-effectiveness estimates or projections of potential credit amounts. The ARB believes that such issues are best addressed by the individual proponents on a specific, case-by-case basis.

## **SUMMARY OF NEW HEAVY-DUTY VEHICLE CREDIT GUIDELINES**

This chapter summarizes the proposed guidelines for generating NOx emission reduction credits by purchasing new, reduced-emission heavy-duty vehicles. The new proposed guidelines are incorporated as an appendix to this report. The appendix is formatted such that it can be inserted into the "Mobile Source Emission Reduction Credits" document most recently revised in February 1994, as chapter 10 of that document. Upon approval of the proposed guidelines, this insertion will be completed and additional minor modifications of the final document will be made to accommodate this new chapter.

### **New Heavy-Duty Vehicle Purchase Credit Guidelines**

The new heavy-duty vehicle purchase guidelines are intended to allow heavy-duty vehicle operators to generate NOx emission reduction credits by purchasing and operating heavy-duty vehicles whose engines are certified to emit NOx at levels significantly below the mandatory NOx emission standards. It is assumed that the operator otherwise would have obtained a vehicle which just meets the mandatory emission standards. The difference in emission standards between the clean vehicle and the vehicle which just meets the existing mandatory standard, determines the credit amount. For example, if an operator forgoes the purchase of a conventional heavy-duty diesel vehicle that meets a 5.0 gram/bhp-hr mandatory NOx standard (the "ceiling" standard) and instead purchases an alternative fuel vehicle which is certified to an optional standard of 2.0 gram/bhp-hr (the "credit" standard), that vehicle could receive credit for the 3.0 gram/bhp-hr difference. Making some assumptions about the type of vehicle and operating cycle, and assuming a lifetime mileage of 750,000 miles, the total lifetime tonnage NOx reduction available for use as credits could be about 3 tons.

## ISSUES

The ARB staff held a public workshop on January 13, 1994, to present the draft of the new heavy-duty vehicle credit guidelines and to receive public comments. This section describes and discusses the major issues raised in those comments.

The workshop brought out several issues of concern regarding the new heavy-duty vehicle purchase guidelines. The draft credit guidelines have been modified to accommodate those issues wherever possible. The three major issues are discussed below.

The first issue is a request to allow credits for engine replacement in existing vehicles (known as "repowering"), as opposed to purchasing a complete new vehicle. The requestors suggest that the ceiling standard for such repowering credits be the original engine's certification standard when it was new. This would result in higher calculated emission reductions than would be obtained by using the current mandatory standard as the ceiling. The ARB is concerned that this scenario would result in credits being given for diesel engine replacements which would have occurred anyway. Such emission reductions could not be considered surplus and therefore cannot be used as a basis for generating credits. Instead, the draft guidelines provide for repowering credits if the replacement engine is significantly cleaner than the current mandatory standard. The ceiling standard used in the credit calculations would be the current mandatory standard and not the original engine's certification standard, regardless of age.

The second issue involves the structure of the optional NO<sub>x</sub> certification standards. Commenters wanted smaller increments between optional standards and to set the maximum optional standard to be closer to the mandatory standard. The ARB continues to believe that the optional standard increments and maximum values chosen are necessary to provide adequate certification compliance margins to account for test and manufacturing variabilities. The optional standards, as described in Appendix A were approved by the Board in June 1995, after more public discussion of these issues was conducted. The Board directed the staff to reexamine the optional credit standards structure as data and experience with optional certification is gained.

The final major issue that the draft responds to is the inclusion of a specific procedure for calculating a vehicle conversion factor. (The conversion factor or "CF" relates engine specific emission values in grams/bhp-hr to vehicle values in grams/mile.) Commenters requested more specific guidance than previous guidelines have given. This draft provides an equation for determining the CF, with instructions on the specific data required, while also allowing other approaches to be considered, based on ARB and district acceptance. One commenter requested that the ARB specify use of a CF based solely on the Federal Test Procedure (FTP) engine certification test emissions and simulated mileage driven. However, the ARB staff believes that this does not provide enough flexibility to cover the many different types of vehicles and applications which may be affected by these guidelines.

# CONCLUSIONS

## Mobile Source Emission Reduction Credit Programs

The ARB's general conclusions regarding the implementation of mobile source emission reduction credit programs in California bear repeating here.

- 1) Opportunities exist to create and use mobile source emission reduction credits. The creation of these credits provides districts and industry with an additional mode of flexibility in meeting air quality goals.
- 2) Districts wishing to establish mobile source emission reduction credit programs are encouraged to adopt regulations covering the generation and use of credits which are consistent with these guidelines. Districts should use great care in designing mobile source emission reduction credit programs so that they do not create false credits that would exacerbate air quality problems.
- 3) Any regulation adopted to create and use mobile source emission reduction credits needs to ensure that the credits meet the following criteria: surplus, real and quantifiable, enforceable, and with an established life span.
- 4) Relative to many existing control programs, mobile source emission reduction credits can produce cost-effective emission reduction credits.
- 5) At this time the best uses of mobile source emission reduction credits appear to be:
  - allowing industry an alternative method of obtaining emission reductions otherwise required by district rules
  - offsetting emission increases from temporary sources
  - providing a source of additional emission reductions for use in market-based emission reduction trading programs
  - potentially using credits as mitigation of emissions from stationary sources through an extended life credit program
  - providing a substitution for meeting average vehicle ridership requirements
  - improving air quality

## **New Heavy-Duty Vehicle Purchase Credit Guidelines**

o Purchasing and operating new, reduced-emission heavy-duty vehicles can provide NOx emission reductions and these emission reductions could be used to help offset the extra cost of purchasing the vehicles through the sale of mobile source emission reduction credits.

o These guidelines are intended to provide a starting point for local air quality districts to design workable new heavy-duty vehicle credit programs. These guidelines are an extension and adaptation of the previously issued guidelines for new urban transit bus credits. Since there are many different types of heavy-duty engine and vehicle combinations, it would be difficult to develop detailed guidelines that would be completely applicable to all of them. Specific programs should be developed on a case-by-case basis as proponents come forward with proposals. The ARB staff is available to work with districts and program proponents to build a workable program.

## Appendix A

### GENERATION OF EMISSION REDUCTION CREDITS THROUGH THE PURCHASE OF NEW HEAVY-DUTY VEHICLES

(To be inserted as an addition to the Air Resources Board's Mobile Source Emission Reduction Credits Guidelines)

This chapter presents guidelines for generating mobile source emission reduction credits through the purchase and operation of reduced-emission heavy-duty vehicles. It is an extension and expansion of those guidelines presented in Chapter 6, "Generation of Emission Reduction Credits Through The Purchase of Low-Emission Buses". For information on generating credits through the purchase of clean urban buses and engines, the reader is referred to that chapter. For generating credits through the purchase of new, clean heavy-duty vehicles other than urban buses, the guidelines in this chapter should be used.

#### **Introduction**

Heavy-duty trucks and urban buses emit significantly more oxides of nitrogen (NO<sub>x</sub>) on a per-vehicle basis than any other category of motor vehicle in California. There are opportunities to reduce these and other heavy-duty vehicle emissions by replacing existing vehicles with new vehicles powered by reduced-emission engines. These reductions can then be used to generate emission reduction credits. The following guidelines enhance the potential to create emission reduction credits by the purchase of new, reduced-emission heavy-duty vehicles while simultaneously safeguarding air quality. Emission reduction credit programs would be developed and implemented by the local air pollution control districts and air quality management districts (districts) following the Air Resources Board's (ARB or Board) guidelines.

Programs designed to generate emission reduction credits must comply with the current Federal Emission Trading Policy, which requires that credits only be allowed for emission reductions that are surplus to federal, state, and local regulations. In February of 1993, the Board approved guidelines for the generation of emission reduction credits through the purchase of new urban transit buses. This document presents proposed guidelines to extend the applicability of the emission reduction credit program in a similar manner to all new, reduced-emission heavy-duty vehicles. The guidelines in this document are very similar to those approved by the ARB for urban buses, but broader in scope to accommodate a variety of operating scenarios.

The State Implementation Plan (SIP), approved by the Board in November 1994, is the state's basic blueprint for reaching air quality attainment goals in many areas of California. Several of the mobile source measures in the SIP call for major reductions of emissions from on-road heavy-duty vehicles operating in the state. The requirements of such SIP measures may conflict in some instances with the desire of vehicle operators to generate mobile source credits in accordance with these guidelines. Since emission reductions used as mobile source emission reduction credits have

little or no direct beneficial effect on air quality, this conflict could hamper the SIP attainment goals. Care must be exercised to ensure that any mobile source credit programs developed are balanced with reasonable progress toward air quality attainment.

The amount of credit available through the use of these guidelines will decrease as the ARB adopts more stringent emission standards for heavy-duty vehicles in the future. Currently, there is an opportunity to generate credits based on existing heavy-duty emission standards. As those emission standards are tightened in the future, and manufacturers are required to produce engines with lower emissions, fewer opportunities for credits will be available.

### **Program Guidelines**

The guidelines presented in this chapter are designed to allow air pollution control districts and credit program operators to calculate emission reductions resulting from the purchase and use of reduced-emission heavy-duty vehicles in lieu of vehicles that just meet the emission standards. As used in this document, the heavy-duty designation includes those vehicles with a gross vehicle weight (GVW) greater than 14,000 pounds and engines certified in the heavy-duty category, as indicated on the certification Executive Order (EO), and not in the light-duty or medium-duty classifications. The heavy-duty category also can be broken into light heavy-duty (14,001 to 19,499 pounds GVW), medium heavy-duty (19,500 through 33,000 pounds GVW) and heavy heavy-duty (over 33,000 pounds GVW). The guidelines presented here consider a fleet operator faced with the need to replace a large number of heavy-duty vehicles simultaneously, possibly due to retirement of a large number of worn-out vehicles. The operator could buy new vehicles that meet the current applicable emissions standards, or opt for reduced-emission vehicles that emit below the current standards by a significant amount. For the latter case, the difference between the emission standards to which the two types (current-standard and reduced-emission) of engine were certified would constitute an emission reduction that could be used or sold as credits.

At present, diesel-fueled engines are capable of emission levels only slightly below the current NO<sub>x</sub> emission standard. To generate credits by purchasing "clean" vehicles instead, the fleet operator likely would have to procure vehicles that operate on an alternative fuel (such as methanol, natural gas or electricity). Generally, using such alternative fueled vehicles is more expensive than using conventionally powered vehicles, either because of increased capital costs for the engines themselves, the cost of fuel, the additional fueling infrastructure cost, or combinations of these factors. The extra funding required for reduced-emission vehicle purchase and operation could potentially be obtained from the sale of credits for the emission reductions.

According to the following guidelines, the amount of the emission reduction credit is based on the difference between the certification standards of the current-standard engine and reduced-emission engine. In addition, the credit life is based on the expected operating life of the substitute reduced-emission vehicle being purchased.

The ARB did not include a cost-effectiveness evaluation in this guideline document. However, the capital and operating costs for reduced-emission vehicles can be calculated in a manner similar to the costs described in the February 1993 emission reduction credits document. Potential credit program participants will analyze the costs involved and the value of the potential emission reductions in determining whether to participate in an emission reduction credits program.

### **Pollutants for Which Credits Can Be Granted**

NO<sub>x</sub> is the only pollutant considered in these guidelines as a reasonable candidate for credit generation. NO<sub>x</sub> emissions from diesel vehicles are very close to the current certification standard. Particulate matter (PM), reactive organic gas (ROG), and carbon monoxide (CO) levels from current diesel engines are already quite low. This means that any PM, ROG or CO emission reductions from the use of reduced-emission engines would have to be even smaller (indeed, some alternative fuel engines show increases in CO emissions relative to the diesel engine from which they are derived). Due to the lack of extensive data regarding in-use emissions, the relative uncertainties associated with the lifetime PM, ROG and CO emission values of alternative fueled heavy-duty vehicles are quite large. This greatly reduces the confidence that credits generated for these three pollutants meet the "real and permanent" criteria for emission reduction credits.

Although ROG and CO exhaust emissions from gasoline-powered vehicles are greater than the ROG and CO emissions from comparable diesel vehicles, and although there are evaporative and marketing emissions associated with the use of gasoline powered vehicles, it is not possible to determine which engine category (gasoline or diesel) would be appropriate as the basis for calculating emission reductions from the use of alternative fueled engines. Virtually all heavy heavy-duty engines are diesel engines, while light heavy-duty and medium heavy-duty engines can be gasoline powered or diesel powered. These two different types of powerplants are fungible to a great degree, and it would not be possible to make a determination on the type of "in-lieu" engine that was being replaced by an engine that was a candidate for earning emission reduction credits. Therefore, no credits should be granted for pollutants other than NO<sub>x</sub>.

### **Calculation of Credits**

The following sections describe the factors and procedures used to calculate the emission reduction credit associated with purchasing a reduced-emission heavy-duty vehicle.

#### **Calculation of Vehicle Emission Reductions**

The magnitude of the credit-generating emission reduction is calculated based on the difference between the "ceiling" standard and an optional reduced-emission (or "credit") standard, to be discussed below. A conversion factor is used to convert the emission standard to a gram per mile emission rate. It is necessary to use standards rather than actual measured emission levels in calculating the emission reduction credit to ensure that production variability and emission control system deterioration are taken into account. The credit standard establishes an enforceable level with

which vehicles that are purchased to generate credits must comply. (A more detailed discussion of compliance responsibility for the duration of vehicle life is presented later in this appendix).

Certification Standards

The applicable mandatory emission standard should be used as the ceiling standard for credit calculations. The current mandatory heavy-duty vehicle emission standard for NOx is 5.0 gram/brake horsepower-hour (g/bhp-hr). This is the ceiling standard used for credit calculation examples in these guidelines. Federal law establishes a 4.0 gram/bhp-hr standard nationwide in 1998. The Board, in June 1995, adopted the standard to go into effect at the same time for California. Once the lower NOx standard becomes effective, credits will be calculated based on that lower ceiling standard. The credit standard, to which a potential reduced-emission engine must be certified to generate credits, may be selected by the engine manufacturer from the multi-tier optional standards presented in Tables 1 and 2. These optional standards were adopted by the Board in June 1995.

Table 1: Heavy-Duty <i>Diesel-Cycle</i> Engine NOx Optional Certification Standards		
Standard Type	1995-1997	1998-later
	(gram/bhp-hr)	(gram/bhp-hr)
Ceiling Standard:	5.0	4.0
Credit (Optional) Standard:	3.5	---
	3.0	---
	2.5	2.5
	2.0	2.0
	1.5	1.5
	1.0	1.0
	0.5	0.5

Table 2: Heavy-Duty <i>Otto-Cycle</i> Engine NOx Optional Certification Standards		
Standard Type	1995-1997	1998-later
	(gram/bhp-hr)	(gram/bhp-hr)
Ceiling Standard:	5.0	4.0
Credit (Optional) Standard:	2.5	---
	2.0	---
	1.5	1.5
	1.0	1.0
	0.5	0.5

This multi-tier approach is used to allow the engine manufacturer and purchaser the maximum flexibility possible in certifying and selecting an engine family. As noted previously, these standards were approved by the Board in June 1995 and are currently available for use in certifying reduced-emission engines.

These tables show that the highest credit standard in each category is well below the applicable ceiling standard. An engine must be significantly cleaner than the ceiling standard to assure that a real emission reduction is achieved. It is of interest to note that there is no zero-emission optional standard included in this table. The conventional certification procedures would not be applicable for use on a zero-emission heavy-duty vehicle, due to the nature of such a vehicle. However, zero-emission heavy-duty vehicle designs would be certified through other procedures, primarily based on engineering evaluations of the basic design, as opposed to measurements made during engine dynamometer runs. Zero-emission heavy-duty vehicles would be eligible to participate in the same credit and incentive programs as other reduced-emission heavy-duty vehicles.

Credit Life

Duration of the credit life for a newly purchased vehicle is dependent on the expected vehicle life. Because there are so many different types of vehicles and applications that could be used to generate credits, it is impossible, a priori, to specify meaningful credit life values in these guidelines. Therefore, the expected vehicle/credit life should be determined by the credit proponent from historical fleet records of similar vehicles in similar operation with similar histories. Historical records should be available to support the lifetime claims. During the credit life, the responsible district should conduct periodic checks of each vehicle's operating records to ensure that the vehicle is being operated for the mileage and in the manner claimed in the pertinent credit application.

### Conversion Factor

A conversion factor (CF) is used to convert the emission rate expressed in terms of mass of pollutant per unit of engine work, to units of pollutant mass emitted per unit distance a vehicle is driven. A vehicle's emissions per mile are obtained by multiplying the emissions expressed as g/bhp-hr by the CF expressed as work (bhp-hr) expended per mile a vehicle travels.

The work required to move a heavy-duty vehicle over a given distance is a function of several factors, including the vehicle configuration and its load. For urban transit buses, this value is relatively well established because the duty requirements of most transit buses (stop-and-go, low speed driving) are similar. This is not the case for other heavy-duty vehicles. For example, heavy-duty trucks or charter buses may be used primarily on freeways with infrequent stops or idling, while trucks used in waste hauling or ready-mix concrete delivery might have completely different duty cycles and work per mile requirements. This lack of homogeneity makes it difficult to generalize the operation of heavy-duty vehicles. Since there are so many different types of heavy-duty vehicles and applications, the ARB has not developed specific conversion factors for all of them. The credit applicant should submit an appropriate and justified conversion factor value when applying for credits. This submitted value is subject to district and ARB approval. One possible approach to determining the conversion factor is to use the following formula:

$$CF = \frac{(fuel\ density)}{(vehicle\ fuel\ economy) \times (engine\ brake\ specific\ fuel\ consumption)}$$

where CF is the conversion factor in bhp-hr per mile, fuel density is in pounds per gallon for liquid fuels or pounds per standard cubic foot for gaseous fuels, vehicle fuel economy is in miles per gallon or miles per standard cubic foot, as appropriate, and engine brake specific fuel consumption is in pounds per bhp-hr. The engine and vehicle manufacturers should be consulted for these data. Other sources for the conversion factor, such as actual engine dyno to chassis dyno correlation data, conceivably could be acceptable depending on such factors as how closely the test configurations correspond to the actual vehicle and engine configurations as well as on other factors.

### Calculation Procedure

The following procedure is used to calculate the amount of credit to be generated by reduced-emission heavy-duty vehicle procurement.

- Step 1: Calculate the gram/mile equivalent emission rate for the ceiling standard vehicle and the credit standard vehicle. This is done by multiplying the appropriate standard from Table 1 or 2 (based on the applicable ceiling standard and the engine's credit certification level) by the appropriate conversion factor.

Step 2: Calculate vehicle lifetime emissions. For both the ceiling standard and credit standard vehicles, multiply the gram/mile results of Step 1 by the credit lifetime mileage. Convert measurement units from grams to tons.

Step 3: Calculate the lifetime pollutant reduction. Subtract the Step 2 lifetime tonnage result for the credit standard engine from that of the ceiling standard engine. This is the lifespan emission tonnage reduced per vehicle. Note that this is not an annualized, tons per year value. To determine the annual tons per year, divide the lifetime tonnage value by the vehicle life in years.

This process is summarized in the following equation:

$$\text{lifetime reduction} = \text{ceiling standard} \times CF_1 \times \text{lifetime mileage}_1 - \text{credit standard} \times CF_2 \times \text{lifetime mileage}_2$$

where subscript "1" refers to the conventional vehicle which is certified to the mandatory ceiling standard, and subscript "2" refers to the vehicle certified to the optional credit standard.

### **Repowering**

Repowering is the practice of replacing a vehicle's engine with another engine rather than rebuilding the existing engine. Repowering with a clean engine that meets the criteria presented in this document can provide for emission reduction credits. Emission reduction credits are calculated in the same way that credits are calculated for the purchase of an entirely new vehicle, that is, to qualify for credits the engine should be certified to one of the credit standards shown in Tables 1 and 2. The ceiling standard will be the mandatory standard in effect at the time the repowered engine is installed. Credits for repowered vehicles can be granted initially for the expected life of the engine, assuming the entire vehicle is expected to remain in service at least that long. These credits may be renewed at the time of rebuild. During the credit life, the responsible district should conduct periodic checks of each repowered vehicle's operating records to ensure that the vehicle is being operated for the mileage and in the manner claimed in the pertinent credit application.

### **Credit Emissions Testing and Compliance Responsibility**

To generate credits by purchasing reduced-emission vehicles, operation of the vehicles should result in real emission reductions throughout the credit life. A means of verifying that low emissions are maintained throughout the credit life is needed to ensure that real emission reductions occur.

Historically, heavy-duty vehicles have not been routinely tested for in-use emissions compliance since many studies have shown that heavy-duty diesel engines are reasonably stable with respect to emissions deterioration over time. However, as reduced-emission engines that use

alternative fuels and add-on control equipment, such as catalytic converters, are developed and put into use, emission deterioration rates may increase significantly. The district that implements a credit program should require the implementation of an appropriate in-use testing program to ensure that the reduced emission levels associated with reduced-emission vehicles that participate in a credit program are maintained in customer use. The cooperation of the credit-generating vehicle operator and the credit user is expected in any effort deemed necessary to verify in-use compliance. At a minimum, it will be necessary for a small number of vehicles to be made available for chassis dynamometer emission tests, along with the funds necessary to conduct the tests. The parties seeking credits should demonstrate that they have plans and contracts in place to meet these obligations before credit can be granted. The ARB staff will work with all involved parties to ensure that an effective testing program is implemented. As with any ARB-certified vehicle, the ARB has the authority to recall reduced-emission vehicles that do not comply with the optional emission standard to which they are certified.

It is expected that more than one district could have similar credit programs. In this case, the combination of testing resources and results between districts for like engine families and vehicles could result in reduced test costs for all those involved. The ARB encourages participating districts to consider such pooling of resources.

### **Compliance During Certified Engine Life**

For credit generation purposes, the operator's vehicle should use a reduced-emission engine for which the engine manufacturer has obtained ARB certification to one of the credit standards listed in Table 1 or Table 2, as appropriate. To certify an engine to an optional standard, the engine manufacturer must demonstrate through the normal certification procedures that the engine emits below the level of the chosen optional standard throughout its statutory useful life. The engine manufacturer must also accept responsibility for the in-use emissions of the engine-family through the statutory useful life and be subject to recall if the engine-family systematically exceeds the credit standard certification level. (The statutory useful life mileage is 290,000 miles for heavy heavy-duty diesel and diesel-derived engines. It is 185,000 miles for medium heavy-duty diesel and diesel-derived engines. It is 110,000 for light heavy-duty diesel and diesel-derived engines, and for Otto-cycle heavy-duty engines except those derived from diesel engines. The useful life time period for NOx emissions is 8 years through 1997 and 10 years beginning in 1998. In practice, the end of the statutory useful life is determined by whichever of the mileage or time requirements is met first.)

In addition, during the first 5 years or 100,000 miles or 3,000 hours of operation of a heavy-duty diesel engine's life, or the first 5 years or 50,000 miles for the life of all other heavy-duty engines, the manufacturer must provide a warranty to cover each individual engine's emission control equipment, as required by current certification procedures. During this period, the manufacturer is responsible for the repair of any faulty piece of engine or emission control equipment that causes emissions to exceed the credit certification standard.

In the past, responsibility for random, non-systematic parts failure in the period between the end of the emission control warranty and the end of the useful life has not been formally assigned to anyone. But to generate credits, the vehicle operator should accept responsibility for maintaining the vehicle to proper, reduced-emission operation conditions throughout the life of the vehicle, for any period and any failure not covered by the engine manufacturer.

### **Compliance After Rebuild**

While engine life is considered complete at the end of the useful life period, many heavy-duty engines are rebuilt and put back into operation to yield a significantly higher mileage total vehicle life. It is assumed that a rebuild restores an engine to zero-mile conditions (and new engine certification levels) and that emissions therefore remain below the certification level throughout the remainder of the vehicle life. To generate credits, the vehicle operator should take responsibility for engine emissions compliance during the post-rebuild period. The engine should be rebuilt to the original equipment manufacturer's specifications, including all equipment on the emissions critical parts list. The operator should also maintain each individual vehicle so that emission control equipment failures are readily detected and corrected. Vehicles with rebuilt engines should be included in the in-use testing program required by the district. To detect systematic errors in the rebuild process, the district program should contain provision for the ARB, in cooperation with the district and vehicle operator, to test some of the rebuilt fleet in each engine family to determine post-rebuild emission levels. If ARB determines that such testing is necessary, the operator should make vehicles available to ARB for emissions testing.

In summary, responsibility should be taken for ensuring in-use compliance with the applicable credit certification standards at all times during the life of an individual vehicle.

### **Regional Emissions**

A district that implements a program offering emission reduction credits for the purchase and use of reduced-emission heavy-duty vehicles should include in the requirements appropriate safeguards to ensure that the emission reductions occur within the district for which they were intended. An enforcement program to check records of routes and miles driven should be included in the rules that implement these guidelines. Heavy-duty vehicles that qualify for the appropriate credit programs in two or more districts may earn credits for travel in more than one of those districts, with district consent. The credits would be prorated according to miles driven in each area.