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TCRP Synthesis 8

Retrofit of Buses to Meet Clean Air Regulations

A Synthesis of Transit Practice

Transportation Research Board
National Research Council

TRANSIT COOPERATIVE RESEARCH PROGRAM

Synthesis of Transit Practice 8

Retrofit of Buses to Meet Clean Air Regulations

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TRANSIT COOPERATIVE RESEARCH PROGRAM

The nation's growth and the need to meet mobility, environmental, and energy objectives place demands on public transit systems. Current systems, some of which are old and in need of upgrading, must expand service area, increase service frequency, and improve efficiency to serve these demands. Research is necessary to solve operating problems, to adapt appropriate new technologies from other industries, and to introduce innovations into the transit industry. The Transit Cooperative Research Program (TCRP) serves as one of the principal means by which the transit industry can develop innovative near-term solutions to meet demands placed on it.

The need for TCRP was originally identified in *TRB Special Report 213--Research for Public Transit New Directions,* published in 1987 and based on a study sponsored by the Federal Transit Administration (FTA). A report by the American Public Transit Association (APTA), *Transportation 2000,* also recognized the need for local, problem-solving research. TCRP, modeled after the longstanding and successful National Cooperative Highway Research Program, undertakes research and other technical activities in response to the needs of transit service providers. The scope of vice configuration, equipment, facilities, operations, human resources, maintenance, policy, and administrative practices.

TCRP was established under FTA sponsorship in July 1992. Proposed by the U.S Department of Transportation, TCRP was authorized as part of the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). On May 13, 1992, a memorandum agreement outlining TCRP operating procedures was executed by the three cooperating organizations: FTA, the National Academy of Sciences, acting through the Transportation Research Board (TRB), and the Transit Development Corporation, Inc. (TDC), a nonprofit educational and research organization established by APTA. TDC is responsible for forming the independent governing board, designated as the TCRP Oversight and Project Selection (TOPS) Committee.

Research problem statements for TCRP are solicited periodically but may be submitted to TRB by anyone at anytime. It is the responsibility of the TOPS Committee to formulate the research program by identifying the highest priority projects. As part of the evaluation, the TOPS Committee defines funding levels and expected products

Once selected, each project is assigned to an expert panel, appointed by the Transportation Research Board. The panels prepare project statements (requests for proposals), select contractors, and provide technical guidance and counsel throughout the life of the project. The process for developing research problem statements and selecting research agencies has been used by TRB in managing cooperative research programs since 1962. As in other TRB activities, TCRP project panels serve voluntarily without compensation.

Because research cannot have the desired impact if products fail to reach the intended audience, special emphasis is placed on disseminating TCRP results to the intended end-users of the research: transit agencies, service providers, and suppliers. TRB provides a series of research reports, syntheses of transit practice, and other supporting material developed by TCRP research. APTA will arrange for workshops, training aids, field visits, and other activities to ensure that results are implemented by urban and rural transit industry practitioners.

The TCRP provides a forum where transit agencies can cooperatively address common operational problems. TCRP results support and complement other ongoing transit research and training programs.

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Each report is reviewed and accepted for publication by the technical panel according to procedures established and monitored by the Transportation Research Board Executive Committee and the Governing Board of the National Research Council.

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PREFACE

A vast storehouse of information exists on many subjects of concern to the transit industry. This information has resulted from research and from the successful application of solutions to problems by individuals or organizations. There is a continuing need to provide a systematic means for compiling this information and making it available to the entire transit community in a usable format. The Transit Cooperative Research Program includes a synthesis series designed to search for and synthesize useful knowledge from all available sources and to prepare documented reports on current practices in subject areas of concern to the transit industry.

This synthesis series reports on various practices, making specific recommendations where appropriate but without the detailed directions usually found in handbooks or design manuals. Nonetheless, these documents can serve similar purposes, for each is a compendium of the best knowledge available on those measures found to be successful in resolving specific problems. The extent to which these reports are useful will be tempered by the user's knowledge and experience in the particular problem area.

FOREWORD

By Staff
Transportation
Research Board

This synthesis will be of interest to transit agency general managers, as well as operations, maintenance, and planning personnel. It will also be of interest to environmental agency officials, equipment suppliers, consultants, and others concerned with bus operations planning and design. This synthesis summarizes the options available under the Environmental Protection Agency's (EPA) Urban Bus Retrofit/Rebuild Program for heavy-duty diesel bus engines and clarifies the information in the regulations for transit agencies developing their own strategies for compliance. This synthesis also provides an overview of transit agency programs already in place to reduce particulate matter (PM) emissions.

Administrators, practitioners, and researchers are continually faced with issues or problems on which there is much information, either in the form of reports or in terms of undocumented experience and practice. Unfortunately, this information often is scattered or not readily available in the literature, and, as a consequence, in seeking solutions, full information on what has been learned about an issue or problem is not assembled. Costly research findings may go unused, valuable experience may be overlooked, and full consideration may not be given to the available methods of solving or alleviating the issue or problem. In an effort to correct this situation, the Transit Cooperative Research Program (TCRP) Synthesis Project, carried out by the Transportation Research Board as the research agency, has the objective of reporting on common transit issues and problems and synthesizing available information. The synthesis reports from this endeavor constitute a TCRP publication series in which various forms of relevant information are assembled into single, concise documents pertaining to a specific or closely related issue or problem.

This report of the Transportation Research Board strives to familiarize transit agency staff with EPA's Retrofit/Rebuild Program, which is designed to reduce the amount of PM emissions in metropolitan areas with 1980 populations of 750,000 or more,

beginning on January 2, 1995, and ending when all pre 1994 model year engines are retired. This synthesis provides a concise summary of the EPA program requirements, including two specified options.

To develop this synthesis in a comprehensive manner and to ensure inclusion of significant knowledge, available information was assembled from numerous sources, including a number of public transportation agencies. A topic panel of experts in the subject area was established to guide the researchers in organizing and evaluating the collected data, and to review the final synthesis report.

This synthesis is an immediately useful document that records practices that were acceptable within the limitations of the knowledge available at the time of its preparation. As the processes of advancement continue, new knowledge can be expected to be added to that now at hand.

CONTENTS

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The Principal Investigators responsible for the conduct of the synthesis were Sally D. Liff, Manager, Synthesis Studies, and Donna L. Vlasak, Senior Program Officer. This synthesis was edited by Linda S. Mason.

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Information on current practice was provided by many transit agencies. Their cooperation and assistance were most helpful.

RETROFIT OF BUSES TO MEET CLEAN AIR REGULATIONS

SUMMARY

The Environmental Protection Agency (EPA), as directed by the Clean Air Act Amendments (CAAA) of 1990, has issued a regulation affecting pre 1994 model year (MY) urban buses when their engines are rebuilt or replaced after January 1, 1995. Known as EPA's Urban Bus Retrofit/Rebuild Program, the requirement applies only to those urban buses powered by heavy heavy-duty diesel (HHDD) engines operating in metropolitan areas with 1980 populations of 750,000 or more. The intent of the regulation is to reduce particulate matter (PM) emissions from urban buses. *Transit agencies affected by the program have a legal obligation to comply with all requirements set forth in the program and are subject to civil penalties for noncompliance.* The program ends when all pre 1994 MY HHDD engines have been retired from a transit agency's fleet.

Congress passed major Clean Air Act amendments in 1966, and shortly afterward EPA was established, which began promulgating emissions standards for both gasoline- and diesel-fueled engines. Of all emissions generated from diesel engines, EPA is especially concerned with PM emissions. A probable human carcinogen, PM emissions exacerbate lung disease, soil the environment, and contribute to airborne pollution.

Urban transit buses have received special attention from EPA because they typically operate in congested areas and have a high degree of public exposure. As a result, EPA has applied separate, more stringent PM emissions standards to diesel-powered urban buses. Since 1988, the allowable level of PM emissions for urban buses has been reduced by 88 percent. Additionally, the Clean Air Act (CAA) requires EPA to revise the standards to require the use of low-polluting fuels if 1994 and later urban buses fail to meet PM emissions standards while they operate in service. Such fuels include natural gas, propane, methanol, ethanol, or any comparably low-polluting fuel.

EPA's Retrofit/Rebuild Program encourages the application of new technology and allows transit agencies to choose between two options. Option 1 requires transit agencies to meet a specified PM emissions level for all pre 1994 MY engines in their fleet once those engines are rebuilt or replaced. Achieving the PM emissions levels for each engine, however, depends upon the availability of EPA-certified equipment that meets specified lifecycle cost (LCC) limits. The LCC of equipment includes the initial purchase price, as well as any additional costs or savings that may result from operating the equipment throughout its useful life. Option 2 offers greater flexibility because it does not require every pre 1994 engine in the fleet to meet a specific PM emissions level when rebuilt or replaced. Instead, Option 2 is a fleet-averaging approach. It is designed to achieve the same level of PM emissions reduction as Option 1, but allows those results to be obtained through an emissions-averaging process.

Transit agencies must comply with at least one of the two options available under the program. The agencies are allowed to switch from one option to another other as long as they have been in compliance with both options since the beginning of the program. Once

an agency fails to comply with a particular option, it may never return to that option again. Adequate records must be kept showing compliance with all relevant aspects of the program. To enforce its program, EPA is allowed to audit a transit agency's facilities and levy fines up to $25,000 for each engine not in compliance.

An important element of this synthesis involved a survey of transit agencies affected by EPA's program. The survey revealed that many agencies are overwhelmed by the complexity of EPA's program and do not fully comprehend all of its requirements. An encouraging aspect of the survey was the large number of agencies that already have emissions-reduction programs in place and have made initial preparations to comply with EPA's program. This activity indicates a willingness by transit agencies to participate in programs designed to improve the environment.

The synthesis summarizes the options available under the program in a simplified manner, clarifies much of the misunderstanding created by EPA's Final Rule, and allows transit agencies to develop their own strategies for compliance. *Because of the amount of flexibility offered by EPA's program, transit agencies should become thoroughly familiar with both options.* It may not be advantageous to decide on one particular strategy early in the program because most of the equipment will not be known until the program is well underway. Regardless of the option selected, gaining a complete understanding of EPA's program will allow transit agencies to maximize their resources while reducing the amount of airborne emissions that can affect our environment.

CHAPTER ONE

INTRODUCTION

BACKGROUND

Heavy-Duty Diesel Standards

In response to growing concerns over air quality, Congress passed major Clean Air Act amendments in 1966. This legislation was amended over the years leading up to the Clean Air Act Amendments (CAAA) of 1990, which affect all forms of on-highway transportation today. To administer and enforce the Clean Air Act (CAA) and other environmental legislation, the Environmental Protection Agency (EPA) was established in 1970. Shortly afterward, EPA began to promulgate emissions standards for both gasoline and diesel-powered engines.

Beginning in the mid 1980s, EPA became increasingly concerned with particulate matter (PM) emissions generated by diesel engines. Originally regulated as smoke, particulates are extremely small and can become easily trapped in the lungs. A probable human carcinogen, PM emissions exacerbate lung disease, soil the environment, and contribute to airborne pollution.

The first PM emissions standard for heavy-duty diesel (HDD) engines was promulgated by EPA on March 15, 1985 *(1J.* The requirement established a PM emissions standard of 0.60 grams per brake horsepower hour (g/bhp-hr) for all 1988 through 1990 model year (MY) HDD engines. EPA was especially concerned with HDD engines used in urban buses because they typically operate in congested areas and have a high degree of public exposure. As a result, EPA's March 1985 rule applied a separate, more stringent PM emissions standard of 0.10 g/bhp-hr to HDD engines used in urban buses. The 0.10 PM emissions standard was originally scheduled to begin 6 years later with the 1991 model year.

The American Public Transit Association (APTA), on behalf of the transit industry, petitioned EPA to delay implementation of the 0.10 urban bus PM emissions standard until 1994 (2). Before EPA was able to take final action on APTA's petition, Congress took up the issues raised in that petition as part of the debate regarding the CAAA of 1990.

Clean Air Act Amendments (CAAA) of 1990

The CAAA of 1990 delayed the 0.10 PM emissions standard for urban buses until 1993, allowing manufacturers additional time in which to develop emission-reduction technology. In the interim, a PM emissions standard of 0.25 g/bhp-hr was established for 1991 and 1992 MY urban bus engines *(3).* For model years 1994 and 1995, the urban bus PM emissions standard was lowered to 0.07 g/bhp-hr (4). The PM emissions standard for 1996 MY and later urban buses was reduced even further to a certification level of 0.05 g/bhp-hr, while the inuse standard remains at 0.07 g/bhp-hr *(5).* Since 1988, the inuse level of PM emissions for urban buses has been reduced by 88 percent. Table 1 shows emissions standards for oxides of nitrogen (NOx), hydrocarbons (HC), carbon monoxide (CO), and PM established for heavy-duty urban bus engines from 1988 to 1998. Smoke standards established by EPA in 1970 for all HDD engines are set at 20 percent for acceleration, 50 percent for peak, and 15 percent for lug emissions, and remain in effect at least until 1998.

TABLE 1
URBAN BUS EMISSIONS STANDARDS, 1988--1998 (in g/bhp-hr)

Model Year	Nox	HC	CO	PM
1988*	10.7	1.3	15.5	0.60
1990	6.0	1.3	15.5	0.60
1991	5.0	1.3	15.5	0.25
1993**	5.0	1.3	15.5	0 10
1994	5.0	1 3	15 5	0.07
1996	5.0	1.3	15.5	0.05 ***
1998	4.0	1.3	15.5	0.05 ***

*Prior to 1988, only smoke standards applied to HDD diesel engines
**Beginning in 1993, a separate, more stringent emission standard was applied to urban buses.
***Beginning in 1996, the certification level for PM emissions falls to 0 05, while the in-use level remains at 0.07.
Source: EPA

In addition to establishing lower emission standards, section 119(c) of the CAAA of 1990 requires EPA to conduct random in-use testing of 1994 and later MY urban buses. The purpose of the testing is to determine whether 1994 and later bus engines actually comply with the 0.07 PM emissions standard for their full, useful life of 10 years or 290,000 miles. If buses do not comply, regulations must be established requiring the phase-in or purchase of new buses that operate on low-polluting fuels. These fuels include natural gas, propane, methanol, ethanol, or other comparably low-polluting fuel.

Retrofit/Rebuild Requirement

The CAAA of 1990 also require EPA to implement one additional program to reduce PM emissions from urban buses. Section 219(d) requires EPA to develop regulations that reduce PM emissions from 1993 MY and earlier urban buses whose engines are rebuilt or replaced after January 1, 1995. The requirement affects urban buses operating in metropolitan areas with 1980 populations of 750,000 or more. EPA is authorized to establish a program that reflects the best retrofit technology and maintenance practices that are reasonably achievable.

Notice of Proposed Rulemaking (NPRM), September 1991

In its interpretation of section 219(d) of the CAAA of 1990, EPA published an NPRM on September 24, 1991, proposing regulations for its Urban Bus Retrofit/Rebuild Program

(6). EPA received a variety of comments to its original program announcement from several sources including suppliers, manufacturers, transit agencies, and others. Many expressed concern over the cost, durability, and availability of equipment needed to meet EPA's requirements.

Program Revision, July 1992

In response to comments received to their September 1991 notice, EPA published a subsequent notice in July 1992 that described two new options for its program (7). The revised options gave transit agencies greater flexibility in choosing a variety of technologies and approaches to meet the intent of the CAA. The amended options also established cost limits for emissions-reduction technology to help ensure the program would be reasonable and cost effective.

Final Rule Issued, April 1993

After considering all comments concerning its Retrofit/Rebuild Program, EPA issued a Final Rule on April 21, 1993 *(8).* The program is extremely detailed and defines the responsibilities of transit agencies and equipment suppliers. Transit agencies affected by the program have a legal obligation to comply with all requirements set forth in the Final Rule, and are subject to the penalty provisions of the CAA for noncompliance.

EPA URBAN BUS RETROFIT/ REBUILD PROGRAM

Overview

EPA's Urban Bus Retrofit/Rebuild Program is designed to reduce the amount of PM emissions in metropolitan areas. The program, which applies to pre 1994 MY urban buses when their engines are rebuilt or replaced, is meant to reflect the best retrofit technology and maintenance practices that are reasonably achievable.

EPA's program only applies to urban buses operating in metropolitan areas with 1980 populations of 750,000 or more. The program begins on January 2, 1995, and ends when all 1993 and earlier MY engines are retired. To provide transit agencies with increased flexibility in meeting CAA requirements, EPA's program contains two options. Figure 1 provides a summary of the steps required to comply with the Retrofit/Rebuild Program.

Option 1

The primary requirement of Option 1 is to meet a 0.10 g/bhp-hr PM emissions level for all pre 1994 MY engines once they are rebuilt or replaced after January 1, 1995. However, meeting the 0.10 PM emissions level depends on the availability of EPA-certified equipment for a life-cycle cost (LCC) of no more than $7,940 (1992 dollars). The LCC takes into account the overall cost to purchase and operate emissions-reduction equipment for its useful life. If equipment is not available that meets a 0.10 PM emissions level within the LCC limits at time of rebuild, transit agencies must install equipment to achieve a minimum 25 percent reduction in PM emissions for an LCC of less than $2,000 (1992 dollars). If this equipment is not available, transit agencies can elect to rebuild or replace engines to their original configuration, or to a configuration certified with lower emissions characteristics.

Responsibility for calculating the LCC under Option 1 lies primarily with the equipment supplier. The LCC includes equipment, fuel, installation, and maintenance costs that are incremental to (above and beyond) those needed for a standard rebuild. A 45-day public review period will be provided for all certification applications within which transit agencies and others can challenge the data supplied by the certifier. Once equipment becomes certified, EPA will make the appropriate announcement in the *Federal Register*. EPA is working with APTA to disseminate this information directly to transit maintenance personnel. Transit agencies then have a 6-month grace period after certification is granted in which to plan their equipment purchases. After the 6-month period has expired, agencies complying with Option 1 must install certified equipment on all affected pre 1994 MY engines when they are rebuilt or replaced. Transit agencies will have a choice of equipment only when more than one type of equipment is certified as meeting the appropriate standards for a particular engine.

Option 2

Option 2 is designed to give transit agencies greater flexibility because it does not require every pre 1994 MY engine in the fleet to meet a specific PM emissions standard at time of rebuild. Instead, Option 2 is a fleet-averaging approach. It requires transit agencies to make PM emissions calculations for each calendar year of the program beginning in 1996, and ending when all pre 1994 MY engines have been retired. Option 2 is designed to achieve the same level of PM emissions reduction as Option 1, but allows those results to be achieved through an emissions averaging process.

Option 2 allows transit agencies to use any of the following approaches to reduce PM emissions from their fleets: install any equipment certified by EPA for costs above, below, or at the LCC limits established under Option 1; retire bus engines before they reach 15 years of age; take credit for emissions-reduction equipment placed in service before January 2, 1995 (i.e., existing or repowered engines with upgrade kits, exhaust aftertreatment devices, alternative fuels, and fuel additives); and take credit for PM reductions resulting from the use of certified clean diesel fuels as defined by EPA.

Under Option 2, transit agencies can apply any of the emissions-reduction approaches described above to show that their actual fleet level attained (FLA) for PM emissions is equal to or below the target level for the fleet (TLF). To be in compliance with Option 2, the FLA must be equal to or below the TLF for each year of the program.

Averages of FLAs and TLFs are calculated using equations developed by EPA. The calculations include 1993 MY and older engines only. *Buses added to the fleet with 1994 MY and newer engines are not included in the averaging process.*

However, when a pre 1994 MY engine is replaced with a 1994 or newer engine, the older engine is treated like a retired bus and receives a substantial benefit under the program. The

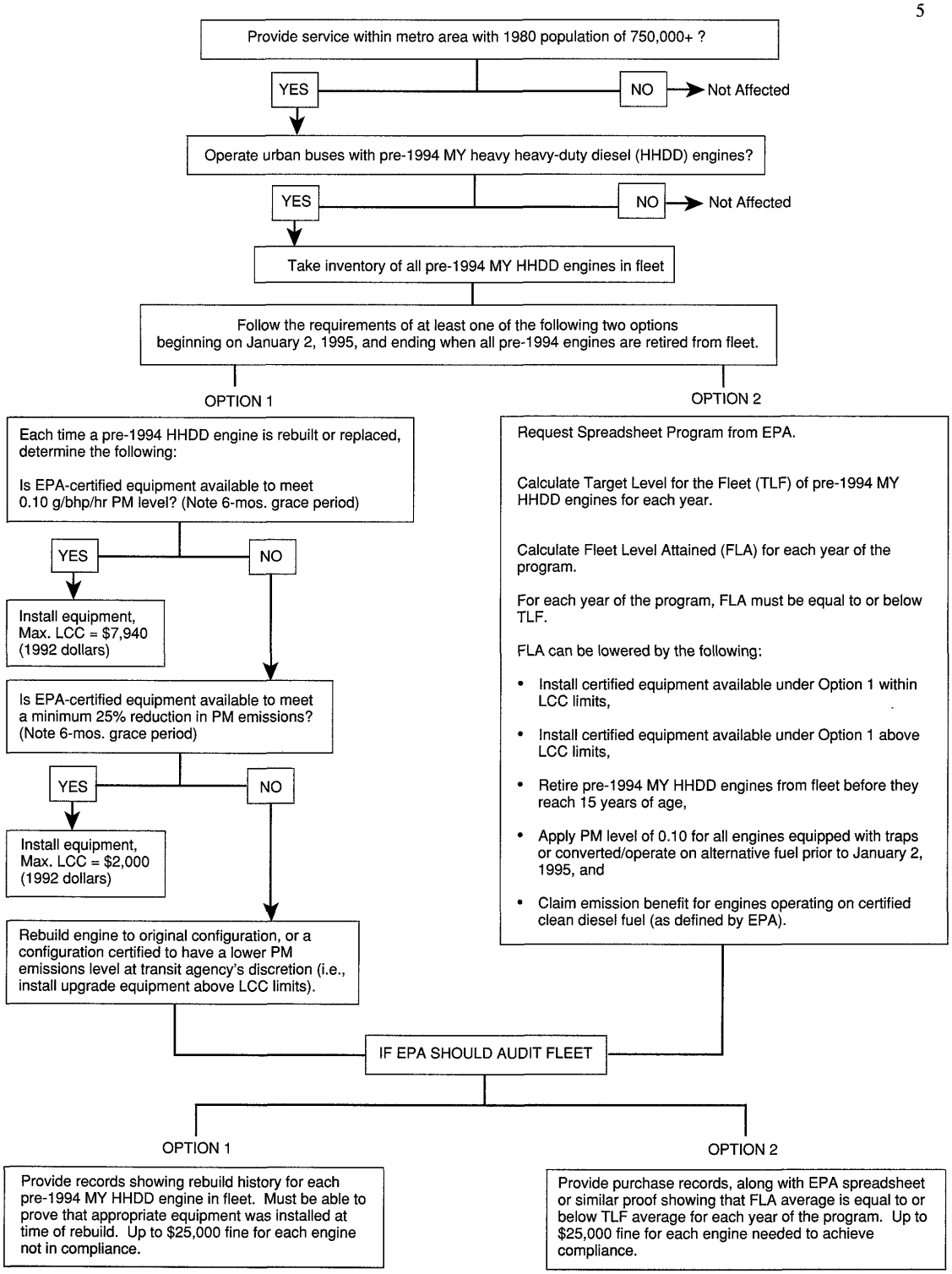

FIGURE 1 EPA Urban Bus Retrofit/Rebuild Program.

benefit continues until the replaced engine would have reached 15 years of age. The TLFs change on January 1 of each year and reflect emissions reductions expected during the previous calendar year. Likewise, FLA averages are based on emissions reductions achieved during the previous calendar year.

Switching Options

Agencies are allowed to switch from one option to another as long as they have been in compliance with both options since the beginning of the program. Once a transit agency fails to comply with a particular option, it may never choose that option again for compliance purposes.

Record Keeping

Adequate records must be kept on file for each pre 1994 MY engine to verify compliance with either of the two options. Records include purchase records, receipts, and part numbers used to rebuild the engine. All records must be maintained for 5 years, or until the engine is rebuilt again. Agencies must install and maintain certified equipment according to written instructions provided by the equipment supplier.

Enforcement, Penalties, and Warranties

EPA is authorized to audit records and conduct in-use emissions testing to verify compliance with the program. EPA can require agencies to pay a fine up to $25,000 for each engine not in compliance with the program.

For all equipment certified under the program, suppliers will be responsible for providing an emissions performance warranty for 150,000 miles and an emissions defect warranty for 100,000 miles. Both warranties are provided without time limitations and include all certified components.

EQUIPMENT AND COSTS

Although several emissions-reduction technologies are expected to apply for EPA certification, no equipment had been certified while this synthesis was being prepared. Therefore, the synthesis does not specifically address equipment costs. Within the program itself, cost ceilings have been established for equipment certification. Additionally, costs are addressed on a limited basis in the case study examples.

It would also not be appropriate to speculate on which equipment may become available. In fact, particulate traps, which EPA originally believed would be the retrofit technology most likely to meet its program requirements, are being withdrawn from service by some transit agencies *(9,10).* While the removal of traps does not preclude their use in the future, it does highlight the uncertainty of equipment that may become certified for use under the Retrofit/Rebuild Program.

A list of certification applications expected by EPA is included in Appendix C. Because of the competitive nature of the aftermarket business, one can only speculate as to which equipment included on this list may actually qualify for and receive EPA certification.

The first company to formally apply for certification under EPA's Retrofit/Rebuild Program is Engelhard with a catalytic converter muffler *(11).* The muffler, which is considered an aftertreatment device because it treats the exhaust after it has left the engine, contains an oxidation catalyst and is intended to replace the original muffler. Engelhard's catalytic converter muffler is expected to provide a 25 percent reduction in particulates for an LCC within the ceiling of $2,000 (1992 dollars). This muffler is said to fit all HDD engines not already equipped with an aftertreatment device.

The Manufacturers of Emission Controls Association (MECA) indicates that several of its members have been communicating with EPA concerning the certification of exhaust aftertreatment equipment (personal communication with Bruce Bertelsen, MECA, July 1994). MECA referred to an EPA list, which includes certification applications that EPA expects to receive (see Appendix C). A status report prepared by MECA provides an overview of exhaust control technologies that may have an application submitted for EPA certification *(12).* The report highlights two exhaust aftertreatment devices in particular.

The first is a flow-through oxidation catalytic converter, which essentially represents the technology that Engelhard has submitted to EPA for certification. An oxidation catalyst consists of a stainless steel canister mounted in the exhaust stream, much like a muffler. The canister contains a honeycomb-like structure called a substrate, coated with precious metals such as platinum or palladium. As pollutants come in contact with the substrate, they are oxidized and transformed into harmless gases. Catalytic converters have no moving parts and, according to MECA, require limited maintenance.

The second device is a diesel particulate filter, commonly known as a trap oxidizer. Traps consist of a filter positioned in the exhaust stream, designed to collect a significant amount of PM while allowing exhaust gases to pass through the system. As the solid PM is collected and becomes trapped, some means of disposal must be provided. The most promising means of disposal is to oxidize (or burn) the PM in the trap itself, thereby regenerating the filter in a continuous cycle. This is done either by restricting the filter to a point where the exhaust backpressure produces enough heat to oxidize the PM, by using a catalyst or a supplementary heat source. Other trap systems use compressed air to remove soot.

In addition to certification applications expected from suppliers of aftertreatment devices, engine manufacturers are also expected to submit equipment for EPA certification. The Detroit Diesel Corporation (DDC) plans to certify an upgrade kit for all mechanical unit injector 6V92TA engines during the last quarter of 1994 (personal communication with Mark Johnston, DDC, July 1994). The upgrade kit will bring all mechanically controlled DDC 6V92TA engines to an 1989 MY configuration. Although the kit will not be certified to a 0.10 PM emissions level, it is expected to achieve more than a 48 percent reduction in PM emissions. DDC's kit is expected to meet the $2,000 LCC limit (1992 dollars) established for equipment achieving a 25 percent or greater reduction in PM emissions.

The Cummins Engine Company plans to certify an upgrade kit for all eight versions of its L10 engines with mechanical fuel delivery systems manufactured from 1985 to 1992 (personal communication with Carl Koontz, Cummins Engine Company, July 1994). The upgrade kit will achieve a

reduction in PM emissions greater than 25 percent. Cummins expects the incremental cost for the upgrade kit will be substantially less than the $2,000 LCC limit established under the Option 1 fallback requirement.

The Society of Automotive Engineers (SAE) has several papers available that address the reduction of PM emissions from urban bus engines. Many of the most recent issues published by SAE are listed in the Bibliography.

PURPOSE AND METHODOLOGY

The purpose of this synthesis is twofold. First is to provide a concise summary of EPA's Urban Bus Retrofit/Rebuild Program for 1993 and Earlier Model Year Urban Buses as presented in the *Federal Register* on April 21, 1993 *(8).* Second is to review the experiences of transit agencies as they prepare to comply with EPA's program.

As presented in the *Federal Register*, EPA's Retrofit/Rebuild Program is extremely detailed and has led to some confusion among readers not accustomed to such documents. This synthesis summarizes the options available under the program in language that may promote a better understanding of the program and allow transit personnel to develop their own strategies for compliance.

As a summary, this synthesis does not claim to include every detail about the program and is not intended to replace EPA's Final Rule as a reference source. Transit agencies affected by EPA's program must use the Final Rule issued on April 21, 1993, to determine the full extent of their responsibilities. Although this synthesis clarifies many of the complex issues raised in the program, it should be used as a companion to EPA's Final Rule. Compliance with the Retrofit/Rebuild Program will be based on information contained in EPA's Final Rule issued on April 23, 1993, not in this synthesis.

This synthesis summarizes the following aspects of EPA's Urban Bus Retrofit/Rebuild Program:

- Conditions for compliance,
- Option 1,
- Certification requirements,
- Option 2,
- Record-keeping requirements,
- Enforcement procedures, and
- Penalties for noncompliance.

An important element of this synthesis was a survey of transit agencies expected to comply with EPA's Retrofit/Rebuild Program. The survey consisted of a questionnaire mailed to 87 transit agencies, and telephone interviews conducted with several of the 45 agencies responding to the questionnaire. A copy of the questionnaire, along with a list of agencies responding, is contained in Appendix B. The intent of the survey was to determine the level of understanding transit agencies had concerning the program, which aspects of the program presented the most difficulty, which option were transit agencies most likely to comply with, and the level of emissions-reduction activity currently taking place at transit agencies.

Of those responding to the questionnaire, three transit agencies were chosen as case studies in this synthesis report. The agencies selected each have extensive programs already in place to reduce PM emissions, and are well underway in planning their compliance strategies. The experiences demonstrate how individual agencies have approached this program in relation to their own fleet mix, engine rebuilding program, and future plans. The approaches selected by the three agencies will help others to develop their own strategies.

The sources of information used for this synthesis include a review of the Urban Bus Retrofit/Rebuild Program as contained in EPA's Final Rule published in the *Federal Register* on April 21, 1993 *(8).* A review was also made of background material leading up to the Final Rule, along with literature concerning diesel emission reduction and clean air legislation.

EPA CONTACTS

Transit agencies needing additional information pertaining to the regulatory requirements of EPA's Retrofit/Rebuild Program are requested to contact the Environmental Protection Agency, Regulation Development and Support Division, 2565 Plymouth Road, Ann Arbor, Michigan 48105.

For information pertaining to implementation, guidance, certification, enforcement, and liability, contact the Environmental Protection Agency, Manufacturers Operations Division, 401 M Street, S.W., Mail Code: 6405--J, Washington, D.C. 20460.

Information about TLF and FLA calculations required for Option 2, including a spreadsheet program, can also be obtained from EPA's Washington office.

CHAPTER TWO

DETAILED OVERVIEW OF EPA'S URBAN BUS RETROFIT/REBUILD PROGRAM

CONDITIONS FOR COMPLIANCE

EPA's Urban Bus Retrofit/Rebuild Program affects 1993 and earlier MY buses whose engines are rebuilt or replaced after January 1, 1995. The program is limited to urban buses operating in metropolitan areas with 1980 populations of 750,000 or more. Transit agencies affected by the program have a legal obligation to comply with all relevant aspects of the program and are subject to penalties for noncompliance.

Definition of Urban Bus Operator

EPA defines urban bus operator as a transit agency, state, city department, private, or public entity controlling the use of one or more urban buses. Since issuing its Final Rule, EPA has clarified this definition *(13)*. EPA intends "controlling the use of" to refer to the organization that controls or is responsible for two essential elements of an urban bus system:

(1) general scheduling of routes and

(2) setting the maintenance policy (controlling when and what maintenance is to be performed on urban bus engines) for pre 1994 MY engines used in urban buses.

In most cases, EPA expects that one organization can be identified as the party responsible for both route scheduling and maintenance policy. When a transit agency has a department for maintenance and a department for scheduling, the agency is clearly the operator responsible for complying with the program Likewise, when a transit agency contracts for all of its bus services, the contractor is assumed to be the operator because it is responsible for route scheduling as well as setting maintenance policy.

In some cases, the organization that performs the actual maintenance (i.e., private contractor) may be different from the organization that sets maintenance policy (i.e., transit agency). EPA expects that regardless of the party that performs the actual maintenance (i.e., rebuilding of bus engines), it is the organization responsible for setting maintenance policy that will be responsible for complying with EPA's program. When route scheduling and the setting of maintenance policy are handled by separate and independent parties, responsibility can be determined by EPA on a case-by-case basis. If there is a question regarding who is responsible for complying with this program, contact EPA at the Washington, D.C. address shown at the end of Chapter 1.

Definition of Urban Bus

EPA defines urban bus as a passenger-carrying vehicle powered by an HHDD engine, with a load capacity of 15 or more passengers, and intended primarily for within-city operation. According to EPA, an urban bus is distinguished by short rides and frequent stops, is normally equipped with two sets of doors and a farebox, and is not normally equipped with rest rooms and luggage storage.

The definition applies to several makes of 30-ft, 35-ft, and 40-ft transit buses; articulated transit buses; and suburban style buses powered by HHDD engines. Applicable vehicles include active and spare buses in the fleet but do not include emergency contingency vehicles. Electric buses are not included in the program, although electric retrofits are allowed.

EPA did not intend to include charter and inter-city type buses normally equipped with three axles and under-floor luggage storage in the Retrofit/Rebuild Program *(14)*. However, buses in this category may be required to comply with EPA's program, especially if they are intended primarily for transit operation. Operators of inter-city and charter buses used in transit service are requested to contact EPA for further clarification.

Definition of Heavy Heavy-Duty Diesel (HHDD) Engine

EPA's program applies to 1993 and older MY HHDD engines. HHDD engines have sleeved cylinder liners, a design for multiple rebuilds, and a rated horsepower that generally exceeds 250 *(15)*. Vehicles in this group normally exceed a gross vehicle weight rating of 33,000 pounds. Examples of DDC engines affected by the program include its 6V53N, 6V71N, 6V71T, 6L71TA, 6L71TA DDEC, 6V92TA, 6V92TA DDEC I, 6V92TA DDEC II, and Series 50 engines. The regulation also affects pre 1994 MY HHDD engines manufactured by the Cummins Engine Company, including its L10, 6C-8.3, NT-300, NT-350, and VTB-903 engines Several other pre 1994 MY HHDD engines are affected by the program, including those manufactured by Caterpillar, MAN, Saab-Scania, Volvo, and others.

The program does not include medium heavy-duty diesel (MHDD) engines such as DDC's 8.2 liter and Cummins' 6B5.9 engines.

Model Year of Bus/Model Year of Engine

When developing its program, EPA assumed that the model year of the bus and the model year of the engine are the same. This has led to some confusion because, unlike passenger automobiles, the model year of an urban bus does not necessarily coincide with the model year of its engine. Often, engines have been certified a year before or after the bus was actually assembled. In other cases, engines are exchanged with a different model year engine (e.g., during a rebuild).

The intent of EPA's Retrofit/Rebuild Program is to reduce PM emissions from the engines used in 1993 and earlier MY

buses (14) . *Therefore, it is the model year of the engine that will be used to determine compliance. With EPA's program.* When the model year of the engine and model year of the bus do not coincide, it is the pre 1994 MY engine that must comply with EPA's program, regardless of the bus model year.

In some cases, transit agencies receive spare engines that are negotiated as part of the original bus order. These engines are typically placed in storage until needed. EDP did not consider these spare engines in their Final Rule, however, they have since clarified this issue (11). EPA has determined that all HHDD engines, even those stored as long-term spares, must meet applicable standards before they can be installed in urban buses. Therefore, new engines placed in storage must be upgraded with certified equipment (if such equipment becomes certified under the LCC limits) before they are installed in buses. *Transit agencies essentially have 6 months from the time equipment becomes certified to install the spare engines before upgrade equipment is required.*

Identifying an Engine's Model year

The mode year of an urban bus engine can be determined either by an identification plate affixed to the engine or by the engine's serial number. For 1970 MY and later engines manufactured by DDC, the model year of the engine is listed on a certification label attached to the valve cover (see Figure 2). The label certifies that the engine conforms to all federal and state emission regulations for its particular application. Combined with the certification label is an option label containing all original optional equipment used on the engine along with pertinent tune-up information.

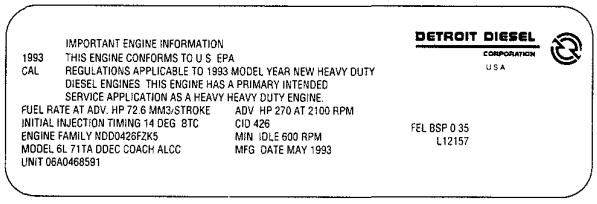

FIGURE 2 DDC engine certification label. (Source: Detroit Diesel Corporation)

For 1970 and earlier MY DDC engines that did not require EPA PM emissions certification, the model year cannot be found on the engine. The model year of these engines must be determined by the engine's serial number. Transit agencies with 1970 and earlier MY DDC engines are requested to contact their local distributor, or DDC directly, to obtain this information. The engine serial number is stamped on the cylinder block. When viewed from the front of the engine, the information is found in the following locations: V-71, L-71 Series: machined pad on the left side, upper front corner just below the fire deck (see Figure 3); and V-92 Series: machined pad on the right side, upper front corner just below the fire deck.

The engine model year for Cummins L10 engines can be found on the Engine Dataplate. This plate is mounted vertically in front of the air compressor, or horizontally above the air compressor/fuel pump area (see Figure 4). Cummins' Dataplate contains the engine's serial number and a control parts

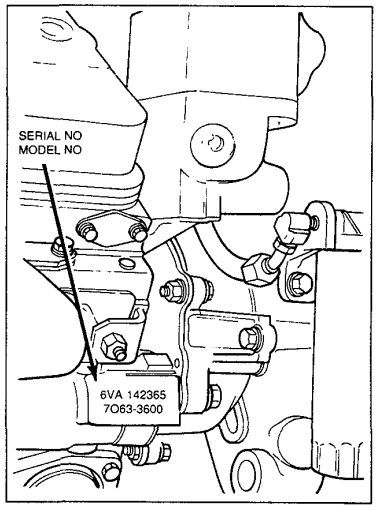

FIGURE 3 Location of DDC engine serial and model numbers (6V-71 shown). (Source: Detroit Diesel Corporation)

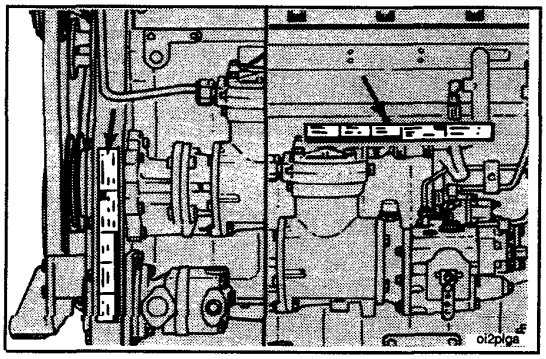

FIGURE 4 Location of Cummins Engine Dataplate, L10 series. (Source: Cummins Engine Company)

list used for ordering spare parts. It also includes tune-up information, engine specifications, vehicle emissions control information, and the engine's model year designation.

Overview of Affected Engines

When the Retrofit/Rebuild Program begins, HHDD engines affected by the program will fall into four general categories:

(1) Pre 1988 MY engines that did not require EPA certification but essentially have a PM emissions level at or about 0.60 g/bhp-hr,

(2) 1988 to 1990 MY engines that were actually certified to a 0.60 PM emissions standard,

(3) 1991 and 1992 MY engines certified to a 0.25 PM emissions standard, and

(4) 1993 MY engines certified to a 0.10 PM emissions standard.

Because 1990 MY was the final year urban buses were certified to a 0.60 PM emissions standard, most of the older, higher-emitting engines will already have received at least one rebuild when the program begins. Additionally, most of the engines scheduled to be rebuilt for the first time in 1995 and later will be cleaner engines certified at either 0.25 or 0.10 g/bhp-hr (i.e., 1991 MY and later engines).

The transit agency's mix of pre 1994 MY engines, together with equipment that actually becomes certified for the engines, will play a significant role in determining a strategy--and the extra costs incurred--for meeting EPA's requirements. *By evaluating all pre 1994 MY engines in the fleet and the rebuild plans for those engines, transit agencies can maximize the program's effectiveness while keeping additional costs associated with emissions-reduction equipment to a minimum.*

Metropolitan Areas With 1980 Populations of 750,000 or More

EPA's program affects pre 1994 MY urban buses operating in Consolidated Metropolitan Statistical Areas (CMSAs) and Metropolitan Statistical Areas (MSAs) with a 1980 population of 750,000 or more. Metropolitan areas are defined by the Office of Management and Budget, with technical assistance from the Census Bureau.

EPA has compiled a listing of the individual counties affected by the program, which is included in Appendix
A. While the list is accurate to the best of EPA's current knowledge, it is the responsibility of each transit agency to determine whether it is affected by the regulations.

When the Program Begins ... And When it Ends

Transit agencies affected by the program are required to comply with EPA's program beginning on January 2, 1995. Each option has its own requirements for when an agency must actually reduce PM emissions from its bus fleet to be in compliance. Regardless of the option taken, agencies must comply with the program beginning on January 2, 1995. A transit agency's responsibility to upgrade equipment ends when all pre 1994 MY HHDD engines have been retired from its urban bus fleet.

OPTION 1

Overview

Option 1 is the easier of the two options to understand and implement. It requires each pre 1994 MY HHDD engine to meet a specified level of PM emissions *only when that engine is rebuilt or replaced after January 1, 1995.* Upgrading the engine is only required if the following conditions apply: equipment has been certified by EPA as meeting a specific level of PM emissions; the equipment has been certified for a minimum of 6 months; and the LCC of that equipment does not exceed specified amounts established by EPA.

Definition of Engine Rebuild and Engine Replacement

EPA defines engine rebuild as an activity occurring over one or more maintenance events involving the disassembly of the engine, including removal of the cylinder head(s), and the replacement or reconditioning of more than one major cylinder component (i.e., piston assembly, cylinder liner, connecting rod, or piston ring set) in more than half of the cylinders.

The phrase "occurring over one or more maintenance events" is a key element to the definition because when some engines are rebuilt, they require the replacement or reconditioning of major components in all cylinders. Other engines, upon disassembly and inspection, may only require attention to those cylinders with damaged components. According to EPA, a rebuild occurs when major cylinder components are replaced or reconditioned in more than half of the cylinders during one or more maintenance events. This applies if more than half of the cylinders are reconditioned or replaced all at once, or during several teardowns that take place throughout the engine's life.

Engine replacement is defined as the removal of an engine from the bus followed by the installation of another engine. This applies to engines that are replaced with new, previously unused engines, as well as those engines exchanged from an inventory of rebuilt engines. Any engine installed in an urban bus after January 1, 1995, including spare engines taken from storage, must meet the retrofit/rebuild standards applicable to that engine.

Primary Requirement of Option 1

Option 1 requires all urban buses with pre 1994 MY engines rebuilt or replaced after January 1, 1995, to meet a 0.10 PM emissions level. Transit agencies are expected to meet this requirement only if the following three conditions can be met:

1) EPA-certified equipment that meets a 0.10 PM emissions standard is available,

2) The equipment has been certified for 6 months or more before the rebuild date, and

3) The equipment has an LCC of less than $7,940 (in 1992 dollars), incremental to (above and beyond the cost of) a standard rebuild.

Once equipment for a specific engine meets all the conditions described above, it then becomes a trigger (requires PM emissions reduction) under Option 1.

Fallback Requirements of Option 1

If equipment that meets a 0.10 PM emissions level with the conditions described above is not available, Option 1 contains fallback requirements that must be addressed in a specific order. If equipment meeting a 0.10 PM emissions standard is not available at the time of rebuild, transit agencies must comply with the first fallback requirement. If the first fallback requirement cannot be satisfied, the second fallback applies

and so on, until all fallback requirements have been exhausted.

The first fallback requirement states that a rebuilt or replacement engine must achieve a 25 percent or greater reduction in PM emissions only if the following conditions can be satisfied: certified equipment is available that achieves a 25 percent or greater reduction in PM emissions; the equipment has been certified for 6 months or more before the rebuild date; and the equipment has an LCC of less than $2,000 (1992 dollars), incremental to a standard rebuild.

If equipment is not available at the time of rebuild that meets either a 0.10 PM emissions standard or achieves a 25 percent or greater reduction in PM emissions, the second fallback requirement applies. It allows engines to be rebuilt to their original configuration, or to a configuration certified to lower PM emissions level at the operator's discretion.

Default Provision of Option 1

If there is no equipment available as of July 1, 1996, that has been certified to either a 0.10 PM emissions level or that achieves a 25 percent or greater reduction in PM emissions for the applicable LCC limits, EPA will eliminate the LCC requirements of Option 1. However, Option 1 will require engines affected by the program to achieve a 25 percent reduction in PM emissions *regardless of cost*, provided the certified equipment does not require a switch from mechanical control to electronic control, installation of exhaust aftertreatment equipment, or the use of a fuel different from the fuel on which the engine currently operates.

Adoption of any of the fallback requirements will depend upon equipment that actually becomes certified for pre 1994 MY engines. If certified equipment becomes available that meets a 0.10 PM emissions standard at the time of rebuild, the fallback requirements will not come into play. Until 6 months after equipment becomes certified, transit agencies can rebuild engines to their original configuration and still be in compliance with Option 1.

The requirements listed under Option 1 are minimum requirements intended to protect transit agencies against excessive costs, and to allow them sufficient time in which to purchase the equipment. The requirements are not intended to discourage the installation of any certified equipment that lowers PM emissions. At their discretion, agencies may install certified equipment at costs above the LCC limits, or within the 6-month lead time period.

EQUIPMENT CERTIFICATION REQUIREMENTS

Before any equipment can become a trigger under Option 1, the equipment must be certified by EPA for a minimum of 6 months prior to the engine rebuild or replacement.

Who Can Certify Equipment

Anyone, including original equipment manufacturers, aftermarket suppliers, and even transit agencies can certify equipment. The equipment must be certified in the manner described by EPA, and all certifiers will be held responsible for the liability provisions of the program.

Public Notice of Equipment Certification

Once a certification application has been submitted and reviewed by EPA, the public will be given a 45-day review period in which to examine the data and offer comments. A complete copy of the application will be placed in a public docket and a summary will be published in the *Federal Register*. EPA will review all comments, make a final decision, and inform the equipment supplier in writing whether such equipment may be certified. Copies of the decision will be sent to all interested parties, who will be given a 20-day period in which to appeal the decision. If an appeal is not filed within 20 days, EPA's decision will be final and will be published in *the Federal Register*.

Test Procedures Allowed for Certification

In general, equipment must be certified using the heavy-duty federal test procedure (FTP) test cycle. EPA will allow the use of chassis-based tests for demonstrating a percent reduction in PM emissions if approved in advance by EPA. All new certification testing requires the use of low-sulfur diesel test fuel. When a retrofit brings an engine to a configuration that has already been certified, EPA will accept the existing test data for certification purposes. When retrofit equipment is being certified for use with more than one engine family, EPA requires testing to be conducted on the engine family with the highest level of PM emissions. EPA could require the testing of other engines as well.

Retrofit/Rebuild Equipment Installed Before 1995

EPA is allowing the use of certain equipment installed before January 1, 1995, without requiring actual certification of that equipment. Under this provision, trap-equipped and alternatively fueled engines put into service before January 1, 1995, are assumed to be operating at a PM emissions level of 0.10 g/bhp-hr. Diesel engines upgraded to a later configuration (i.e., pre 1988 MY DDC engines upgraded to the latest mechanical configuration) are assumed to be operating at the most recent certification level.

Engines that are trap-equipped, alternatively fueled, and upgraded before January 1, 1995, also have an impact under Option 2 where they could be used to lower FLA averages. Additional information concerning Option 2 is provided later in this chapter.

Determining The Life-Cycle Cost (LCC)

Before any equipment can qualify as a trigger under Option 1, the equipment must meet LCC ceilings. For equipment

certified to a 0.10 PM emissions level, the maximum LCC allowed is $7,940. For equipment certified to achieve a 25 percent or greater reduction in PM emissions, the maximum LCC allowed is $2,000. All LCCs are incremental to (above and beyond) the cost of a standard rebuild and are indexed to the 1992 consumer price index (CPI). EPA will determine what constitutes a standard rebuild during the certification process based on several factors, including manufacturer's recommendations, transit agency experience, and practice.

An equipment certifier has two options for certifying equipment as a trigger. The equipment manufacturer can offer the equipment to all transit authorities for less than the LCC ceiling (national trigger) or it could offer the equipment for less than the LCC ceiling to selected transit authorities and trigger the rebuild requirements only for those authorities (local trigger).

The LCC limits established by EPA ensure that the Retrofit/Rebuild Program is reasonable and cost effective. Responsibility for calculating LCCs lies primarily with the equipment certifier and is done as part of the certification process. The public will be given a 45-day review and comment period in which to examine all data provided by the supplier. During this period, transit agencies can challenge the LCC data.

Included in the LCC are only those costs which are incremental to (above and beyond) the cost of a standard rebuild. Included are the initial purchase price of the equipment, as well as potential fuel penalties or savings resulting from use of the equipment, the cost of fuel additives, maintenance costs, and other incremental costs. The LCCs are established by EPA at time of certification, not by individual transit agencies.

Incremental Equipment Cost

Equipment costs include the purchase price of parts incremental to a standard rebuild, as well as any additional parts needed to install and operate the upgrade equipment. Equipment costs, however, exclude special requirements such as bid bonds, performance bonds, or special warranties. The purchase price does not include reasonable shipping and handling fees or taxes.

Incremental Installation Cost

Incremental installation cost is defined as the additional cost of labor needed to install upgrade equipment on a bus. This cost is based on a labor rate of $35 per hour (1992 dollars) for all transit agencies and is revised annually based on the CPI.

Incremental Maintenance Cost

Incremental maintenance cost reflects the additional cost of parts needed to maintain the PM emissions-reduction equipment for scheduled maintenance up to 150,000 miles (without time limitations). Incremental maintenance cost does not include labor.

Incremental Fuel Cost

Incremental fuel cost is defined as the increase or savings in fuel economy that results from the use of PM emissions-reduction equipment. The calculation will depend on the type of equipment being installed and whether the equipment operates on diesel fuel, a fuel requiring an additive, or an alternative fuel. Upgrade equipment that is certified for use by all transit agencies (national trigger) is treated differently than equipment intended for individual transit agencies on a case-by-case basis (local trigger).

Although somewhat involved, the calculations to determine incremental fuel costing are done as part of the certification process by the equipment certifier. It may be necessary for transit agencies to provide fuel costing information to the certifier, depending on the equipment. The public will be given a 45-day review period in which to offer comments and challenge the fuel costing data used to determine overall LCC.

For retrofit equipment requiring the use of an additive or alternative fuel to become a trigger under Option 1, the equipment supplier must provide a contract to the transit agency. The contract must specify the maximum cost at which the fuel additive or alternative fuel will be sold for the life of the engine being retrofitted. Additionally, the equipment supplier must cover all facility costs associated with the additive or fuel. Additional costs include facility modifications needed to store and dispense the fuel or additive, along with modifications required to meet all applicable fire code and safety requirements. Operational costs associated with the fueling facility, such as the cost of electricity needed to power natural gas compressors, are also the responsibility of the equipment supplier. The provisions ensure that any equipment requiring the use of additives or alternative fuels remains cost effective throughout the life of the retrofit.

$10,000 Engine Replacement Credit

In addition to certifying add-on equipment to reduce PM emissions, suppliers may offer complete replacement engines under Option 1. For equipment that replaces an existing urban bus engine with a new, previously unused engine, the certifier may include a credit of $10,000 (1992 dollars) when calculating the LCC. EPA believes that $10,000 is a reasonable estimate of the savings realized from not having to rebuild the original engine.

Before a replacement engine meeting a 0.10 PM emissions level can become a trigger under Option 1, the price of that engine, plus any incremental installation, fuel, and maintenance costs, cannot exceed $17,940 (1992 dollars). The price of $17,940 represents the sum of $7,940 (maximum LCC allowed for a 0.10 PM emissions level) and $10,000 (the engine replacement credit).

The $10,000 engine replacement credit also applies to the 25 percent or greater PM emissions-reduction fallback requirement under Option 1. The maximum price (including incremental installation, fuel, and maintenance costs) for a new replacement engine achieving a 25 percent or greater reduction in PM cannot exceed $12,000 (1992 dollars). The price of $12,000 represents the sum of $2,000 (maximum LCC allowed for a 25 percent reduction in PM) and $10,000 (the engine replacement credit). As with all certification applications, transit agencies will have a 45-day review and comment period in which to challenge the LCC calculations made for the replacement engine.

In-Use Performance Warranty

As part of the certification process, equipment suppliers must provide an in-use emissions performance warranty of 150,000 miles (without time limitations). This warranty is valid only if the equipment is installed and maintained properly by the transit agency per written instructions provided by the supplier. The emissions performance warranty is a guarantee that the equipment will meet emissions requirements without the need for significant maintenance, and that the engine will not exceed original certification levels. Any maintenance required of the equipment will be reviewed as part of the certification process and supplied in writing to the transit agency. At the end of the 150,000 mile in-use compliance period, the equipment could either be replaced to maintain warranty coverage, or the transit agency could accept responsibility for maintaining the equipment in proper operating condition. Agencies who fail to maintain equipment beyond the in-use compliance period would be subject to penalties.

Emissions Defect Warranty

In addition to the in-use performance warranty, EPA requires a 100,000 mile emissions defect warranty to be provided with all certified equipment. This warranty guarantees that the equipment certifier will replace all defective components free of charge for 100,000 miles (without time limitations) from when the equipment was originally installed. The certifier is obligated to honor the warranty only if the equipment was installed and maintained according to written instructions provided with the equipment.

Secondary Failures Caused by Certified Equipment

EPA's Final Rule did not specifically address whether the warranty requirements of its program would include coverage of secondary failures, which refer to any damage resulting from the use of certified equipment. Since issuing its Final Rule, EPA has confirmed that neither of the two warranties required by the program cover any costs or repairs associated with secondary failures *(16).* EPA's program does not prevent equipment suppliers from providing a separate warranty that covers secondary failures as long as the cost is included in the overall LCC.

EPA is concerned with secondary failures that may result from the use of certified equipment and has requested that any information regarding the potential for secondary failures be presented during the 45-day public comment and review period. EPA will review all comments thoroughly, including those regarding secondary failures, and will consider all information before making a final decision on equipment certification. If EPA determines that the use of certified equipment is causing extensive secondary failures, EPA has the authority to revoke certification.

Transferring Equipment

Transit agencies are allowed to transfer certified equipment from one engine to another as long as the donor engine is being retired. The equipment being transferred must also be certified for use on the engine receiving the equipment.

All manufacturer's warranties are voided once the equipment is transferred. Transit agencies must ensure that equipment is functioning properly at time of transfer and continues to function properly after it has been transferred. Agencies are subject to penalties for equipment that fails to function properly.

Equipment Labeling

Certifiers of equipment must supply a single label that can be affixed to the engine. The label must contain the statement "Certified to EPA Urban Bus Engine Rebuild Standards." In addition, the label must include the model and serial number of the equipment, the PM emissions certification level, and the name of the party responsible for all warranty claims. All parts included in the kit must be identified by part number at time of certification to allow transit agencies to determine if the kit contains the same components originally certified by EPA.

OPTION 2

Overview

Option 2 is designed to provide transit agencies with increased flexibility in that it does not require every pre 1994 engine to meet a specific PM emissions level. Instead, Option 2 is an emissions-averaging approach designed to achieve the same level of PM emissions reduction as Option 1. Transit agencies choosing to comply with Option 2 can use the following emissions reduction strategies: install any equipment that becomes certified regardless of its LCC; retire pre 1994 MY engines before they reach 15 years of age; claim PM emissions reductions from all pre 1994 engines operating with upgrade kits, exhaust aftertreatment devices, alternative fuels, and fuel additives before January 1, 1995; and claim PM emissions reductions from the use of certified clean diesel fuel as defined by EPA.

For each year of the program, transit agencies choosing to comply with Option 2 essentially compare two averages: (1) the average level of PM emissions that the pre 1994 fleet has actually attained in a given year (expressed as FLA), and (2) a target level of PM emissions expected from the pre 1994 fleet during the same year (expressed as TLF).

For each year of the program, the FLA must be equal to or below the TLF. Emissions averages for a given calendar year are based on emissions results attained (FLA) or expected (TLF) during the previous year. For example, the TLF for 1996 reflects the average level of PM emissions expected from the fleet during 1995. Likewise, the FLA for 1996 reflects the average level of PM emissions attained during 1995.

The TLF and FLA calculations can be made manually using the equations found in EPA's Final Rule. The equations are rather complex, however, and many transit agencies may find them difficult and cumbersome to work with. To simplify the calculations, transit agencies can request floppy disks from EPA. The software program from EPA allows transit agencies to enter data in the appropriate columns while the computer

program makes all of the necessary TLF and FLA math calculations on a spreadsheet. Excel and Lotus versions are both available. For transit agencies with access to a computer, the EPA spreadsheet program available for Option 2 may achieve more accurate results than manual math calculations.

CALCULATING TARGET LEVEL FOR FLEET (TLF) AVERAGES

The purpose of calculating TLF averages under Option 2 is to establish a target level that transit agencies can use every year to compare their FLA of PM emissions to. The TLF represents the PM average that pre 1994 engines in the fleet would have achieved in a given year if they were rebuilt with equipment available under Option 1. Because each transit agency's pre 1994 engine mix is different, the TLF must be calculated separately for each agency. For those using EPA's spreadsheet program, TLF averages are calculated automatically.

Information Required For TLF Calculations

To calculate the TLF for a given calendar year, the following information is required: an inventory of all pre 1994 engines in the fleet (excluding those older than 15 years of age); EPA's Adjusted Rebuild Schedule; and pre-rebuild and post-rebuild emissions levels established by EPA for each engine.

Inventory of Pre 1994 Engines

To calculate TLF averages, transit agencies must first identify all pre 1994 engines in their fleet affected by the program. Pre 1994 engines should be grouped by model designation, the engine's model year, and quantity (i.e., 24--1979 DDC 6V92TA, 16--1985 Cummins L10, etc.). The TLF calculations do not include engines older than 15 years of age. The model year of the engine is determined by its serial number and does not necessarily reflect the model year of the bus.

EPA's Adjusted Rebuild Schedule

Because each transit agency's engine mix and rebuild schedules are unique, EPA's Adjusted Rebuild Schedule is used to place everyone on a level playing field when calculating TLFs. This schedule assumes that transit agencies will rebuild engines in the fifth, eighth, and eleventh years of their life regardless of the agency's actual rebuild schedule. The schedule reflects an assumption made by EPA that agencies will expedite some rebuilds before the start of the program and delay others to minimize the extra costs associated with the upgrade equipment.

Once all pre 1994 engines affected by the program have been identified, EPA's Adjusted Rebuild Schedule is then used to determine which emissions level to use (pre-rebuild or post-rebuild) during any given year of the program. EPA's Adjusted Rebuild Schedule, as shown in the Final Rule, may be difficult to use *(17).* Therefore, a simplified version of how to determine the years in which post-rebuild levels are used is provided in Table 2.

TABLE 2

WHEN TO USE POST-REBUILD LEVELS WHEN CALCULATING TLF AVERAGES

For Calendar Year Emissions Levels	Start Using the Post-Rebuild for These Engine Model Years
1996	1984, 1987
1997	1985
1998	1986, 1991
1999	1988, 1992, 1993
2000	1989, 1990

*For all other MY engines, use pre-rebuild emissions levels

Source: EPA

Pre-Rebuild And Post-Rebuild Emissions Levels

Once transit agencies have determined when to use pre-rebuild levels and when to use post-rebuild levels, the appropriate PM emissions level is then assigned to each engine. For example, Table 2 indicates that for calendar year 1996, post-rebuild levels are used for 1984 and 1987 MY engines only. All other engines are assigned pre-rebuild levels. Pre-rebuild levels reflect the engine's original configuration, while post-rebuild levels reflect the installation of PM-reduction equipment certified for less than the LCC limit under Option 1.

The pre- and post-rebuild emissions levels are included in a table in EPA's Final Rule entitled "Urban Bus Engine PM Levels for use with Option 2," which is shown as Table 3 of this synthesis.

Table 3 is used to determine PM emissions averages in two specific phases. The first phase applies to TLF calculations made for calendar years 1996 and 1997 and is based on equipment certified by July 1994. Because no equipment had received EPA certification by this date, Table 3 can be used "as is" to calculate TLF averages for calendar years 1996 and 1997. For 1996, post-rebuild levels will be used for 1984 MY and 1987 MY engines only to determine TLF averages (all other MY engines in the fleet will be assigned pre-rebuild levels). For 1997, 1985 MY engines are the only additional engines assigned post-rebuild levels (see Table 2).

The second and final phase will be based on equipment certified by July 1996, and applies to PM emissions calculations made for calendar years 1998 and later. EPA will revise Table 3 and publish it in the *Federal Register* shortly after July 1996. For those using EPA's spreadsheet program, a revised version must be used after July 1996 to reflect the updated emissions levels.

TLF Equation

Once the correct PM emissions level (pre-rebuild or post-rebuild) has been assigned to each pre 1994 MY engine, that

TABLE 3

URBAN BUS ENGINES LEVELS FOR USE WITH OPTION 2

Engine Model	Model Year Sold	Percent of Affected Population	Pre-rebuild PM Level (g/bhp-hr)	Post-rebuild PM Level (g/bhp-hr)
DDC 6V92TA	1979-1987	32	0.50	0.30
	1988-1989	<1	0.30	0.10
DDC 6V92TA DDECI	1986-1987	4	0.30	0.30
DDC 6V92TA DDECII	1988-1991	21	0.31[2]	0.10
	1992	6[1]	0.25	0.10
	1993 (no trap)	6[1]	0.25	0.10
	1993 (trap)	6[1]	0.07	0.07
DDC Series 50	1993	–	0.16	0.10
DDC 6V71N	1973-1987	8	0.50	0 50
	1988-1989	<1	0.50	0.10
DDC 6V71T	1985-1986	3	0.50	0.50
DDC 8V71N	1973-1984	<1	0.50	0.50
DDC 6L71TA	1990	<1	0.59	0 10
	1988-1989	<1	0.31	0.10
DDC 6L71TA DDEC	1990-1991	<1	0.30[2]	0.10
Cummins L10	1985-1987	1	0.65	0.65
	1988-1989	3	0.55	0.10
	1990-1991	4	0.46[2]	0.10
Cummins L10 EC	1992	2[1]	0.25	0 10
	1993 (trap)	2[1]	0.05	0.05
Alternatively-fueled Engines	Pre-1994	–	0.10	0.10
Other Engines	Pre-1988	8	0.50	0.50
	1988-1993	–	–[3]	0.10

[1] Estimate based on current sales
[2] 1991 PM standard of 25 g/bhp-hr was met using emission credits under EPA's banking and trading program
[3] Certification level

Source: EPA, Final Rule, 58 FR 21373 (April 21, 1993)

level (expressed in g/bhp-hr) is multiplied by the appropriate number of engines in the fleet. The total emissions number is then divided by the number of pre 1994 engines in the fleet that are 15 years old or less. The TLF values should be rounded off to two decimal places.

For example, if a transit agency is calculating its TLF for calendar year 1996, 1984 and 1987 MY engines are assigned post-rebuild levels while the remaining pre 1994 engines (15 years old or less) are assigned pre-rebuild levels. If the agency has 25 1984 DDC 6V92TA engines in its fleet, the post-rebuild level expected from those engines in 1996 would be: 0.30 x 25 = 7.50 g/bhp-hr. If the same agency also has 25 1985 DDC 6V92TA engines, the pre-rebuild level expected from those engines would be: 0.50 x 25 = 12.50 g/bhp-hr. If the 50 engines described here represent the only pre 1994 MY engines in the fleet, the TLF would be calculated as follows:

1996 TLF =

$$\frac{\text{Total Emissions}}{\text{Total Buses}} = \frac{(7.50 + 12.50)}{50} = 0.40 \text{ g/bhp-hr} \qquad (1)$$

The example shown here has been simplified. When calculating TLF averages manually, transit agencies must use the TLF equation found in EPA's Final Rule.

Exceptions To TLF Calculations

There is an exception to the general rule that emissions levels used to calculate TLFs under Option 2 shall equal the certification levels of Option 1. The level used for determining the TLF under Option 2 shall never be less than 0.10 g/bhp-hr, regardless of any equipment certified under Option I that achieves a lower PM emissions level. This is because Option I only requires retrofit equipment be certified to a level of 0.10 g/bhp-hr.

CALCULATING FLEET LEVEL ATTAINED (FLA) AVERAGES

Once the TLF has been determined for a given calendar year, the FLA must be calculated for the same period. Those using EPA's spreadsheet program enter information in the appropriate columns, and math calculations for both TLF and FLA averages are done simultaneously.

The FLA average is calculated by taking the level of PM emissions generated from pre 1994 MY engines in the fleet and dividing it by the total number of pre 1994 MY engines still operating in the fleet. Unlike TLF averages, FLA averages *include* those engines in the fleet that are 15 years of age and older unless the engines have been upgraded to a 0.10 PM emissions level. By keeping engines in service that are 15 years or older and do not meet a 0.10 PM emissions level,

transit agencies will have higher FLA averages, thereby making it difficult to meet TLFs. Engines that meet a 0.10 PM emissions level will not be penalized for remaining in service beyond 15 years because they are treated as retired and not included in the calculations.

Information Required For FLA Calculations

To calculate FLA averages, the following information is required: an inventory of all pre 1994 MY HHDD engines in the fleet (engines 15 years or older that do not meet a 0.10 PM emissions level are included in the FLA averages, engines 15 years or older that do meet a 0.10 PM emissions level are not included); a listing of all pre 1994 MY engines that have been upgraded before January 1, 1995; and any certification information pertaining to the use of clean diesel fuels, as defined later in this chapter.

Lowering FLA Averages

For every year of the program, a transit agency's FLA average must be equal to or below its TLF. The level of emissions assigned to each pre 1994 MY engine depends on whether the engine is in its original configuration, or whether emissions-reduction equipment has been installed. Engines that have not been upgraded are assigned a PM emissions level reflecting the engine's original configuration. For engines upgraded with emissions-reduction equipment, the PM emissions level assigned to those engines will depend on the equipment installed.

Agencies choosing to comply with Option 2 can use the following strategies to reduce FLA averages: the installation of any equipment certified under the program (regardless if it meets LCC limits established for Option 1 or not); the early retirement of bus engines that are less than 15 years old; any upgrades made to pre 1994 MY engines before January 1, 1995 (for certain DDC 6V92TA engines, upgrades made after January 1, 1995 may also be used to reduce FLA averages. See the discussion on Default Provisions later in this chapter); and the use of certified clean diesel fuel as defined by EPA.

Equipment Certified Under Option 1

To lower FLA averages under Option 2, agencies can use any of the certified equipment available under Option 1 when rebuilding or retrofitting pre 1994 MY bus engines after January 1, 1995. All equipment certified under Option 1 will be assigned a post-rebuild PM emissions level, which agencies can then apply when calculating their FLA averages.

Equipment Certified Above Cost Ceilings

Option 1 contains cost ceilings to protect agencies against excessive costs. However, equipment may become certified for a price that exceeds the LCC limits. For those complying with Option 1, this equipment would not serve as a trigger for compliance (although operators could choose to install it at their own discretion). Under Option 2, this equipment could be installed as a way to lower FLA averages.

Early Retirement of Engines

The most significant FLA reduction allowed under Option 2 involves the early retirement of pre 1994 MY engines that are less than 15 years old. There is a strong incentive for transit agencies to retire these engines because they can assume a PM emissions level of zero when calculating FLA averages. Agencies may continue to include the zero level in their FLA averaging until the engine(s) would have been 15 years old, thereby substantially reducing its FLA average. The emissions-reduction benefit applies only if the pre 1994 engine being retired is replaced with a 1994 MY or newer engine (or by a complete bus with a 1994 MY or newer engine).

Upgrades Performed Before January 1995

Transit agencies can claim emissions reductions for certain retrofits and upgrades performed before January 1, 1995. For retrofitted or repowered engines currently operating with particulate traps or equipment operating on an alternative fuel, the level of PM emissions is assumed to be 0.10 g/bhp-hr for calculating FLA averages. Regardless of whether the equipment was actually certified, operators using this equipment before January 1, 1995, can include a 0.10 PM emissions level for the engines until they reach 15 years of age. After that, agencies can continue to use the engines and not include them in their total count of pre 1994 MY engines when making FLA calculations.

Additionally, agencies can claim PM emissions reductions from certain upgrade kits installed before January 1, 1995. Before an emissions reduction can be claimed, however, the kits must upgrade the engine to a configuration that has already been certified as achieving a specific PM emissions level. For example, operators who have rebuilt their mechanically controlled DDC 6V92TA engines to an exact 1989 MY configuration (the last year for a federally certified mechanical configuration) can assume the 1989 PM emissions level regardless of the engine's actual model year. The lower PM emissions level assigned to these engines will help to reduce FLA averages.

The Use of Clean Diesel Fuel

Under Option 2, agencies can lower their FLA averages by using certified clean diesel fuel. Before an operator can claim the reduction, several conditions must be satisfied.

Beginning in October 1993, the sulfur content of diesel fuel is required by law to be below 0.05 weight percent. Because of this requirement, agencies are only allowed to claim emissions reductions that are above those already achieved with federally required fuel.

Furthermore, agencies claiming a PM emissions reduction resulting from clean diesel fuel must provide emissions test data for each engine family operating on the fuel. Before an agency can claim PM emissions reductions, all pre 1994 MY

engines must have supporting test data showing the amount of PM emissions achieved from the fuel use. The testing could be performed by the transit agency, a fuel supplier, a fuel manufacturer, or any other party.

In addition to showing the amount of PM emissions reduction, the testing performed on the clean diesel fuel must show that the levels of hydrocarbons (HC), carbon monoxide (CO), and oxides of nitrogen (NOx) have not increased. If these levels have not increased, agencies using the clean diesel fuel could then claim an additional reduction in PM emissions on a percentage basis when determining their FLA average. Agencies must keep records showing the amount of clean diesel fuel purchased. During an audit, EPA could request to see such records to verify that the buses are in fact being operated on clean diesel fuel.

FLA Calculations

The FLA represents the average level of PM emissions that an agency's fleet has actually attained during the previous year To be in compliance with Option 2, the FLA of PM emissions must be equal to or below the agency's TLF.

Using the example given previously for TLF calculations, the agency's FLA must be equal to or below 0.40 g/bhp-hr. The TLF average calculated in the example was based on EPA's Adjusted Rebuild Schedule (see Table 2), which assumed all 25 of the 1984 engines were rebuilt with equipment available under Option 1. Therefore, each had a PM emissions level of 0.30. The remaining 1985 engines in the fleet were assumed to be operating at pre-rebuild levels (i.e., the engine's original configuration).

If the agency actually rebuilt all 25 of its 1984 engines in 1995 with equipment available under Option 1, the FLA for the calendar year would be identical to the TLF, as shown below.

1996 FLA =

$$\frac{\text{Total Emissions}}{\text{Total Buses}} = \frac{(7.50 + 12.50)}{50} = 0.40 \text{ g/bhp-hr} \qquad (2)$$

In the examples provided here, the transit agency is in compliance with both Option 1 and Option 2 for calendar year 1996. The agency could also apply other approaches available under Option 2. For example, it could apply a level of zero for any engines retired before 15 years of age. If traps had been installed on engines before January 1, 1995, a level of 0.10 could be used for those engines.

The examples shown here are simplified. When calculating FLA averages manually, transit agencies must use the FLA equation found in EPA's Final Rule.

Because no equipment had received EPA certification by July 1994, meeting TLFs for calendar years 1996 and 1997 should be relatively easy to accomplish. However, as more equipment becomes certified by July 1996, meeting the target levels for the second phase of Option 2 (1998 and beyond) may become increasingly difficult. Agencies should be aware of this as they develop their strategies for Option 2.

Default Provisions

EPA's program assures some minimum level of PM emissions reduction if no equipment becomes certified for any engine model. Because no equipment had been certified by July 1994, EPA will retain the technology availability assumptions shown in Table 3.

EPA believes that agencies will be able to meet the post-rebuild requirements under Option 2 for calendar years 1996 and 1997. EPA's assumptions are based on currently available upgrade kits or on the engine's original configuration.

As mentioned above, the only engines expected to be rebuilt under EPA's Adjusted Rebuild Schedule during 1986 and 1987 will be 1984, 1985, and 1987 MY engines (see Table 2). Although no equipment had been certified by July 1994, Table 3 shows that DDC 6V92TA engines are expected to achieve a post-rebuild level of 0.30 g/bhp-hr, instead of the 0.50 level that the engine was originally certified at.

EPA is expecting this reduction because emissions upgrade kits are currently available from DDC that bring 1979 MY through 1987 DDC 6V92TA engines to a 1989 MY certification level of 0.30 *(11)*. (The actual new engine certification level for a 1989 MY DDC 6V92TA engine is 0.31. However, due to an error in Table 3, the 0.30 level will be used for consistency purposes). In addition to using the 0.30 PM emissions level for calculating TLF averages, EPA is allowing transit agencies to claim a 0.30 PM emissions level for calculating FLA averages when DDC upgrade kits are installed in any 1979 through 1987 DDC 6V92TA engines. Under Option 1, installation of the kit is not required until 6 months after DDC actually receives certification from EPA. Under Option 2, however, emissions reductions achieved from the DDC upgrade kit may assist transit agencies to reduce their FLA average.

Transit agencies should note that the use of uncertified upgrade kits available from DDC for 1979 through 1987 6V92TA engines includes the standard warranties offered by DDC and does not include either the emissions defect or emissions performance warranties required by EPA's Retrofit/Rebuild Program. Additionally, transit agencies are only allowed to take credit for rebuilds that use the uncertified DDC upgrade kits until 6 months after a rebuild kit is certified for these engines. For example, if a rebuild kit for 1979 through 1987 MY 6V92TA engines is certified in February 1995, transit agencies cannot claim emissions reductions for using the uncertified DDC upgrade kits after August 1995 (6 months after a rebuild kit was certified for these engines).

ENFORCEMENT AND PENALTIES

Transit Agency Responsibilities

Transit agencies must comply with at least one of the two options available under the program. They are allowed to switch options if they have been in compliance with both options from the start of the program. Once an agency fails to

comply with either option, the agency can never go back and claim compliance to that option again.

Transit agencies are required to install and maintain certified equipment per written instructions supplied by the manufacturer. For certified equipment transferred from one engine to another, agencies will be responsible for ensuring that the equipment is functioning properly at time of transfer and continues to function properly afterwards. Equipment can only be transferred if it has been certified for use on the engine receiving the equipment. Those who continue to operate equipment beyond the 150,000 mile in-use warranty period are responsible for maintaining that equipment in proper operating condition. Engines with equipment not maintained properly are assumed to be operating at a pre-rebuild level (i.e., emissions level of the original configuration engine). Agencies that fail to maintain equipment as specified by the manufacturer are subject to the enforcement penalties of EPA's program.

Record Keeping

Beginning January 2, 1995, transit agencies must keep adequate records showing that they have been in compliance with all provisions of EPA's program. Once a pre 1994 MY engine is rebuilt, the agency must keep all records concerning that rebuild for 5 years, or until the engine is rebuilt again. Records include purchase records, receipts, and all part numbers used in the rebuilding activity.

EPA is also requiring transit agencies to keep a brief history of each pre 1994 MY engine. The engine history, maintained manually or through a computerized management information system (MIS), must show when each engine was rebuilt or replaced, along with all equipment used. Records must be detailed enough to show how the major cylinder components in the engine were treated. This documentation will be used to determine whether the maintenance activity performed on the engine meets the criteria of EPA's definition for engine rebuild. Agencies must also keep records for each pre 1994 MY engine retired from the fleet, as well as any pre 1994 MY engines added to the fleet.

Records are required for the purchase of certain fuels, including any fuel for which additional emissions reduction is being claimed (e.g., diesel fuel with a sulfur content below 0.05 weight percent). Purchase records are also required for any fuel additive that may be needed to operate retrofit equipment. Additionally, purchase records are required for fuels, other than diesel, used with dual-fueled engines.

Audits and Enforcement

To enforce its Retrofit/Rebuild Program, EPA is allowed to inspect and audit a transit agency's records, facilities, buses, and all related equipment. EPA is also allowed to inspect facilities where the engine rebuilding or replacement takes place. EPA has the right to inspect and make copies of records, to inspect and photograph engines, and to inspect and monitor any activity related to the rebuilding of engines.

EPA is authorized to conduct random in-use testing of rebuilt engines to ensure that the equipment certified under the program meets all emissions and durability requirements. If EPA determines that an engine is not meeting emissions requirements, EPA can choose to identify the cause of the failure. Determinations will be handled on a case-by-case basis. If EPA determines the failure was due to the retrofit equipment, it will require the supplier to replace the equipment (assuming the 150,000 mile emissions performance warranty is still in effect). If EPA determines that other engines have failed as a result of the equipment, EPA can recall the equipment and have it repaired or replaced by the certifier EPA can also withdraw certification if necessary.

If EPA determines that the failure was caused by the transit agency (i.e., equipment was not installed or maintained properly), the agency would be in violation of the CAA and subject to penalties. Transit agencies can voluntarily submit information to EPA at any time to verify compliance. Such information should be sent to EPA's Washington, D.C. address listed at the end of Chapter 1.

Penalties for Noncompliance

Under the enforcement provisions of the CAA, transit agencies are subject to a fine of up to $25,000 for each violation. Under Option 1, the penalty will apply to each engine rebuilt or replaced without the appropriate equipment. Penalties also apply to each engine with improperly installed equipment.

Under Option 2, penalties would apply if the FLAs are not equal to or below the fleet's TLF. EPA will determine the minimum number of engines needed to be upgraded/retrofitted to comply with the TLF, and impose the penalty based on that number of engines. Equipment delivery delays beyond the control of transit agencies will be considered when determining penalties.

CHAPTER THREE

A SUMMARY OF PRACTICE

An important component of this synthesis project was a survey of transit agencies affected by EPA's Urban Bus Retrofit/Rebuild Program. The survey consisted of a questionnaire (see Appendix B) mailed to 87 transit agencies, and telephone interviews conducted with several of the 45 agencies responding to the questionnaire. A list of respondents is also included in Appendix B.

The intent of the survey was to determine the following:

- The level of understanding that transit agencies had concerning EPA's program,
- The aspects of the program most difficult to understand,
- The emissions-reduction programs already being implemented by transit agencies,
- The option offered by the program that transit agencies were most likely to comply with, and
- The determination of which transit agencies would be candidates for case study examples.

Overall, the survey revealed that many agencies affected by the program were overwhelmed by its complexity and had not spent sufficient time trying to understand it. Many who felt they understood the program were actually misinformed and did not fully comprehend all of its aspects. Of the 45 transit agencies responding to the questionnaire, only two claimed to have a very good understanding. These two agencies represented an average of 115 hours each reviewing EPA's Final Rule and other material on the subject. Table 4 summarizes question nine of the questionnaire, which asked how familiar transit agencies were with EPA's Retrofit/Rebuild Program. This table also includes the average time agencies spent in hours preparing for the program.

TABLE 4

TRANSIT AGENCY FAMILIARITY WITH EPA PROGRAM

Response	Number of Questionnaires With This Response	Average Number of Hours Spent Preparing
Very good understanding	2 (5%)	115
Good understanding	18 (40%)	40
Clarification desirable	16 (35%)	25
Detail required	9 (20%)	--

Source: Transit Agency Questionnaire

An encouraging aspect of the questionnaire was the fact that many transit agencies had begun preparing for EPA's program. Of those responding, 27 (60 percent) indicated they had made preliminary calculations and preparations. Slightly more than half of those responding indicated they were prepared to implement EPA's program by January 2, 1995. Of the 45 transit agencies responding to the questionnaire, 16 (35 percent) indicated they would most likely comply with Option 1; 8 (20 percent) indicated they would comply with Option 2; while 19 (40 percent) were undecided.

Another encouraging aspect of the questionnaire was that a number of transit agencies already have emissions-reduction programs in place. Of the 45 respondents, 30 (67 percent) indicated they were upgrading their engines at time of overhaul. Table 5 summarizes the type and quantity of upgrades being performed by the 30 transit agencies that have programs in place.

TABLE 5

EXAMPLES OF ENGINE UPGRADES BEING PERFORMED

Type of Upgrade	Total Indicated by Questionnaire
Upgrade kits: mechanical engines	27
Upgrade kits: electronic engines	12
Methanol conversions	0
CNG/LNG conversions	3
Ethanol conversions	0
Particulate trap conversions	4
Catalyst conversions	2
Others:	
Ceramic coatings	2
Clean diesel use (undefined)	1

Source: Transit Agency Questionnaire
Note: Some of the agencies responding were uncertain as to the exact number of upgrades being performed

In addition to programs that upgrade existing engines, several transit agencies are involved in programs to replace older engines with new engines that have lower PM emissions characteristics. Of the 45 agencies responding, 12 (27 percent) indicated they were replacing (repowering) original equipment engines with new engines designed to reduce PM emissions.

The survey revealed that the majority of operators responding to the questionnaire already have emissions-reduction programs in place and have started to prepare for EPA's program. This activity indicates a willingness by transit agencies to improve air quality.

ISSUES MOST FREQUENTLY RAISED IN THE SURVEY

Many valid issues were raised in the questionnaire, and during telephone interviews made to transit agencies as a follow-up to the questionnaire. The issues, many of which have been addressed in Chapters 1 and 2, have been grouped in categories. Brief clarifications are provided to further assist transit agencies with their understanding of the program.

Certification

- *Requirement for all equipment to be EPA certified*—To serve as a trigger (require PM emissions reduction) under Option 1, all equipment must be certified by EPA for less than the LCC ceilings established for each level of PM emissions reduction. For Option 2, a certain level of emissions reduction must be established through certification for transit agencies to take credit for using the equipment.
- *The certification of in-house rebuild components (i.e., blowers, injectors, fuel pumps, etc.)*--All emissions related equipment used in the Retrofit/Rebuild Program must be certified by EPA. Once equipment is certified, the certifier will be held liable for the emissions performance of the engines. The certifier will also be responsible for the penalty provisions contained in the program for noncompliance. *In general, in-house rebuilding of emissions-related components will not be allowed unless the transit agency becomes the certifier of the equipment, or makes special arrangements with the supplier.*

If transit agencies make special arrangements with the certifier, that information would need to become part of the certification application. Transit agencies that become involved in equipment certification accept responsibility for the emissions performance throughout the engine's useful life (150,000 miles).

- *Ceramic coatings as a viable technology under the program*--It is difficult to determine which technologies will be certified for use under the program at this time. A list of expected certification applications and the steps for certification are included in Appendix *C*. EPA will publish a summary of all certification applications in the *Federal Register,* followed by a 45-day public review and comment period. Interested parties may receive direct mailings by contacting APTA or the EPA office in Washington, D.C.
- *The certification process for equipment suppliers, such as those attempting to certify an alcohol fumigation process*--The certification process is the same for everyone, regardless if the certifier is an original equipment manufacturer, a supplier, a transit agency, or an individual. Anyone certifying equipment for use under EPA's program must follow the certification process established by EPA and will be held liable for the penalty provisions contained in the program for noncompliance.
- *Informing transit agencies of certified equipment available for specific engines*--EPA will publish a summary of all certification applications in the *Federal Register,* followed by a 45-day public review and comment period. After reviewing all pertinent data, EPA will publish a final decision in the *Federal Register.* Transit agencies may contact EPA at the Washington, D.C. office to receive direct mailings. APTA will also distribute information to its members or to all interested transit agencies.
- *Companies that have submitted equipment for EPA certification*--As of this printing, Engelhard is the only company to have formally applied for EPA certification. However, no equipment has been certified for use under EPA's program at this time. A list of expected certification applications is included in Appendix C.
- *Request for exemptions if retrofit/rebuild equipment does not become certified for specific engines*--EPA does not require agencies to install any equipment unless it becomes certified for use under the program. Therefore, exemptions are not required. Under Option 1, transit agencies are only required to install upgrade equipment if such equipment becomes certified.

Under Option 2, post-rebuild levels will be based on equipment certified under Option 1. EPA has, however, made one exception under Option 2 by allowing a PM emissions level of 0.30 for the installation of uncertified upgrade kits currently available from DDC for 1979 through 1987 MY 6V92TA engines. Although not certified at this time, the DDC upgrade kits for mechanically controlled 6V92TA engines are virtually identical to the certification level of an 1989 MY engine. Transit agencies are allowed to use the DDC upgrade kit until 6 months after certified kits become available.

- *Responsibility for making the LCC calculations needed to obtain equipment certification*--The certifier of the equipment is responsible for the LCC calculations as part of the overall certification process. In some cases, transit agencies may be required to provide fuel costing information to groups offering to sell them the rebuild equipment. In all cases, the public will be given a 45-day review and comment period in which to challenge the data included in the certification application.

Enforcement and Penalties

- *Record-keeping requirements*--Transit agencies must keep adequate records showing that they have been in full compliance with at least one of the two options available under the program. Records include purchase records, receipts, and a listing of all part numbers used when rebuilding the engine.

Transit agencies are also required to provide a brief history of each pre 1994 MY engine affected by the program, including retrofit/rebuild dates along with the equipment used. For the use of clean diesel fuels or fuel additives, fuel purchase records must be provided. All records must be kept for 5 years, or until engines are rebuilt again.

- *Conducting audits to ensure compliance*--To enforce its Retrofit/Rebuild Program, EPA is authorized to inspect and audit all transit agency records, facilities, buses, and related equipment. Agencies must grant EPA access to any facility where records and equipment are kept to determine compliance.

Transit agencies can voluntarily submit information to EPA at any time to verify compliance.

- *Methods used to monitor actual emissions levels*--EPA is authorized to conduct random in-use testing of rebuilt engines to ensure that all equipment certified under the program

meets emissions and durability requirements. If EPA determines that the engine does not meet emissions requirements, it may attempt to identify the cause of the failure. Such determinations will be handled on a case-by-case basis.

- *Penalties for noncompliance*--Under the enforcement provisions of the CAA, transit agencies are subject to a fine of up to $25,000 for each violation. Under Option 1, the penalty will apply to each engine that is rebuilt or replaced without the appropriate equipment. Under Option 2, penalties would apply if the agency's FLA average is not equal to or below the TLF. EPA will determine the minimum number of engines needed to be retrofitted or rebuilt to comply with the TLF, and impose the penalty based on that number of engines. Penalties also apply to each engine with improperly installed equipment.
- *Responsibility for the proper use of retrofit/rebuild equipment once it becomes installed on an engine*--Transit agencies must install, maintain, and service all certified equipment in accordance with written instructions provided by the supplier. The instructions will be used to determine who is at fault if the equipment is not operating properly. *Agencies that fail to maintain equipment as specified are subject to the enforcement penalties of the CAA.*
- *Engine rebuild contracts negotiated before January 1995*--Regardless of any contract negotiated with the party that performs the actual rebuilding of bus engines, it is the organization responsible for setting the maintenance policy that will be responsible for complying with EPA's program. Transit agencies that have contracted with an outside party for engine rebuilding may need to renegotiate the contract to ensure the rebuilds comply with the program requirements.

Option 1

- *Applying the $10,000 engine replacement credit*—For equipment that replaces an existing urban bus engine with a new, previously unused engine, certifiers may include a credit of $10,000 (1992 dollars) when calculating the overall LCC. EPA believes that $10,000 is a reasonable estimate of the savings realized from not having to rebuild the original engine.

In order for a replacement engine that achieves a 0.10 PM emissions level to become a trigger under Option 1, the LCC of that engine, including the incremental cost of installation, maintenance, and fuel, cannot exceed $17,940 (in 1992 dollars). The price of $17,940 represents the sum of $7,940 (maximum LCC allowed for a 0.10 PM emissions level) and $10,000 (the engine replacement credit). The $10,000 engine replacement credit can also be applied to the 25 percent PM emissions reduction fallback requirement under Option 1.

- *Determining if a complete rebuild (i.e., one that meets EPA's definition) was performed on engines under Option 1*--EPA is requiring transit agencies to keep a brief history of each pre 1994 engine, showing when it was rebuilt or replaced. The engine history, maintained manually in an agency log or through a computerized MIS, must show when each engine was rebuilt or replaced, along with all the equipment used to rebuild the engine (i.e., upgrade kit, retrofit kit, replacement engine).

Records must be detailed enough to show how the major cylinder components in the engine were treated. This documentation will be used to determine whether the maintenance activity performed on the engine meets the criteria of EPA's definition for engine rebuild. See Appendix D for a sample compliance sheet for Option 1, and Appendices E and F for sample spreadsheets for Option 2.

- *Option I requirements when rebuilding an engine*--Under Option 1, transit agencies must meet a 0.10 PM emissions level on all pre 1994 engines when they are rebuilt or replaced after January 1, 1995, assuming the equipment is available for less than the LCC limit of $7,940. If such equipment is not available at time of rebuild, agencies must comply with the appropriate fallback requirement. If no equipment becomes available under the program, operators are allowed to rebuild the engine to its original configuration and still be in compliance with Option 1. Default provisions come into force if no equipment has been certified by July 1996.
- *Inclusion of parts and labor in the LCC ceilings established under Option 1*--The LCC of equipment includes the incremental costs associated with the equipment. The LCC includes the purchase price of the equipment, as well as installation costs (parts and labor), potential fuel penalties or savings, fuel additive costs, maintenance costs (parts only), and other costs incremental to a standard rebuild. Because all costs are incremental, LCCs do not include the parts and labor normally required to rebuild an engine to its original configuration.
- *Penalties under Option 1 for upgrading equipment before the start of the program-EPA's* program does not penalize anyone for installing equipment that reduces PM emissions. Under Option 1, the upgrade level required for specific engines depends on the availability of certified equipment at time of rebuild. However, some manufacturers are already selling upgrade equipment for specific engines.

It is possible that upgrades performed to these engines before the program's start may be similar to equipment that actually becomes certified under Option 1. For example, DDC's current upgrade kits available for both mechanically controlled and electronically controlled 6V92 engines are expected to be very similar to kits that DDC plans to submit for certification.

Option 2

- *Determining fleet averages under Option* 2--For each year of the program, transit agencies complying with Option 2 essentially compare two averages: the average level of PM emissions that the fleet has actually attained (expressed as FLA), and a target level of expected PM emissions from the fleet (expressed as TLF). For each year of the program, the actual FLA average must be equal to or below the TLF. To simplify the calculations needed for Option 2, EPA offers floppy disks (Lotus 123 and Excel) containing a spreadsheet.
- *Buses included in the fleet averages under Option 2*--EPA defines an urban bus as a passenger-carrying vehicle powered by an HHDD engine with a load capacity of 15 or more passengers and intended primarily for within-city operation. Applicable vehicles include active and spare urban buses in an operator's fleet, but do not include emergency contingency vehicles. Electric buses are not included in the program, although electric conversions are allowed under the program.

Transit agencies should note that EPA's program applies to the HHDD engines used in the urban buses described above. When the model years of the engine and bus are different, it is

the model year of the engine that must comply with EPA's program requirements.

- *The effect of buses and engines purchased after 1993 on FLA averages under Option* 2--The largest benefit under Option 2 is gained by retiring pre 1994 MY engines from the fleet. If they are retired before reaching 15 years of age, a PM emissions level of zero is used when calculating FLA averages until the engine would have been 15 years old. This benefit applies if the engine is retired along with the bus, or if the bus is repowered with a 1994 or newer MY engine.

Many transit agencies are under the impression that new buses added to the fleet can be averaged with pre 1994 MY engines to help lower FLA averages. This is not the case. New buses purchased after the start of the program are not included in the FLA averaging process. However, new buses can contribute to lower FLA averages to the extent they cause pre 1994 MY engines to be retired.

- *Establishing post-rebuild levels for determining TLFs under Option* 2--When calculating TLFs for calendar years 1996 and 1997, transit agencies would use the post-rebuild PM emissions levels included in Table 3. TLFs for 1998 and later will be based on post-rebuild levels included in a revised table, which will be published by EPA in the *Federal Register* after July 1996.
- *Minimum 6-month lead time given for the procurement of equipment under Option* 2--Under Option 2, the TLF for a given calendar year is based on PM emissions expected in the previous year. TLF calculations made for calendar year 1998, for example, reflect PM emissions expected in 1997. Because TLF levels expected in 1997 will be based on equipment certified under Option 1 by July 1996, transit agencies are given a minimum 6-month period in which to plan their rebuilds and purchase certified equipment.

Option 1 also has a 6-month lead time requirement. Once equipment is approved by EPA for less than the LCC limits, transit agencies have 6 months before they are required to use the equipment under Option 1.

Miscellaneous

- *January 2, 1995, as a realistic date for starting the program*--No changes have been made to EPA's program. Transit agencies affected by the program must maintain records beginning on January 2, 1995, showing that they have been in compliance with at least one of the two options offered under the program. Because no equipment had been certified by July 1994, transit agencies choosing to comply with Option 2 can use existing rebuild equipment to remain in compliance for calendar years 1996 and 1997 (rebuilds performed in 1995 and 1996, respectively). The only exception is that EPA will expect transit agencies to use the DDC upgrade kit for 6V92TA engines.

Under Option 1, transit agencies have until 6 months after equipment becomes certified before they are required to install that equipment. For both options, transit agencies must keep a brief history of the rebuild activity, including the date of rebuild and the parts used. Failure to do so could make transit agencies liable for the penalty provisions of the CAA.

- *Advance preparations for EPA's Retrofit/Rebuild Program*--Transit agencies can start planning their strategies before the program begins to minimize the impact on their overall operation.
- *Availability of additional funding from the federal government to pay for the extra costs associated with EPA's program*--Except for the traditional funding provided by FTA, no funds have been specifically set aside for EPA's program. One transit agency indicated the possibility of obtaining limited federal funding through the Congestion Mitigation Air Quality (CMAQ) Improvement program (personal communication with Frank Venezia, Chicago Transit Authority, Illinois, July 1994).
- *Changes made to the program now that traps do not appear to be a viable alternative*--EPA's program is not dependent upon the certification of any one technology or type of equipment. Under Option 1, transit agencies are only required to install equipment that becomes certified and available for less than the LCC ceilings. Under Option 2, the level of PM emissions reduction is also based on equipment that becomes certified under the program. If trap equipment should become certified by EPA, it will be treated like all other equipment.
- *Credits for engine upgrades performed before January 1995*--Under Option 1, credits do not apply because transit agencies are only required to install certified equipment after the program begins. Under Option 2, EPA is allowing the continued use of certain equipment installed before 1995 without requiring actual certification of that equipment. Under these provisions, trap-equipped engines and alternatively fueled engines put into service before January 1, 1995, are assumed to be operating at a level of 0.10 g/bhp-hr when calculating FLA averages. Diesel engines upgraded to a later configuration before the program begins are assumed to be operating at the certification level of the later model year.
- *Credits for the use of low-sulfur fuel before it was mandated*--EPA's program does not allow transit agencies to claim additional PM emissions reductions resulting from the use of low-sulfur fuel (0.05 percent weight) before it was required by law beginning in October 1993. However, Option 2 does contain a provision that allows agencies to claim additional PM emissions reductions beginning January 2, 1995, for clean diesel fuels (lower than 0.05 percent weight sulfur) .

Before an agency can claim PM emissions reductions from the use of clean fuel, all pre 1994 engines in the fleet, including those retrofitted with upgrade equipment (i.e., traps, upgrade kits, etc.), must have supporting test data showing the amount of PM emissions reduction achieved from the use of the clean diesel fuel.

- *Cities with populations less than 750,000*--EPA's Retrofit/Rebuild Program only affects pre 1994 MY urban buses operating in CMSAs and MSAs with a 1980 population of 750,000 or more. A complete listing of the areas affected by EPA's program is included in Appendix A.

CHAPTER FOUR

CASE STUDIES

Three transit agencies were investigated in-depth as case studies in this synthesis report. These agencies have programs in place to reduce PM emissions from their fleets, and are well underway **in** planning their strategies for meeting the requirements of EPA's Retrofit/Rebuild Program. Of the three agencies selected, one has decided to comply with Option 1, while two are making initial preparations to comply with Option
2. Each agency has made **an** extensive evaluation of its program in relationship to its own mix of pre 1994 MY engines and future engine rebuilding plans. The preparations made by these agencies will assist others in developing their own approach for complying with the program. Profiles of the three case study agencies are shown in Table 6.

TABLE 6

PROFILES OF THE THREE CASE STUDY AGENCIES

Greater Bridgeport Transit District
Location: Bridgeport, Connecticut
Service Area: 90.3 mi^2 (235 km^2)
Number of Staff: 150
Annual Miles: 1,800,000 (2,880,000 km)
Annual Ridership: 5,100,000
Total No. Buses: 64
Pre 1994 HHDD Engines: 52
Case Study Option: Option 1
Orange County Transportation Authority
Location: Orange County, California
Service Area: 800 mi^2 (2040 km^2)
Number of Staff: 1,600
Annual Miles: 20,000,000 (32,000,000 km)
Annual Ridership: 44,000,000
Total No. Buses: 739
Pre 1994 HHDD Engines: 503
Case Study Option: Option 2
MTA Long Island Bus
Location: Long Island, New York
Service Area: 320 mi^2 (832 km^2)
Number of Staff: 855
Annual Miles: 10,400,000 (16,640,000 km)
Annual Ridership: 24,950,000
Total No. Buses: 318
Pre 1994 HHDD Engines: 308
Case Study Option: Option 2

GREATER BRIDGEPORT TRANSIT DISTRICT (GBTD)--OPTION 1

GBTD serves Bridgeport, Connecticut and environs. Although the area reflects a 1980 population of 444,000, it is part of the New York-Northern New Jersey-Long Island, NY/NJ/CT consolidated metropolitan statistical area (CMSA) with a 1980 population of over 17 million. While the population for the area in which it serves is under 750,000, GBTD must comply with EPA's program because it is part of a CMSA with a 1980 population well over 750,000.

GBTD operates a total of 52 pre 1994 MY buses equipped with HHDD engines affected by EPA's program. The pre 1994 MY engine mix for GBTD includes 14 1983 DDC 6V92TA engines and 38 1991 DDC 6L71TA DDEC engines.

Beginning in the late 1980s, GBTD has taken an active role in reducing emissions from its fleet. The maintenance manager at GBTD had paid particular attention to the legislative activities concerning the CAA, and began a comprehensive program to eliminate visible emissions from GBTD's entire bus fleet. The management at GBTD was concerned about the negative image generated by smoking buses and actively supported the maintenance-led initiative to reduce emissions.

One of the first actions taken by GBTD involved the purchase of low-sulfur diesel fuel. GBTD began specifying low-sulfur fuel in 1990, 3 years before it was required by law. Beginning in October 1993, the sulfur content of on-road diesel fuel must be below 0.05 weight percent. Since 1990, GBTD has purchased diesel fuel with a minimum sulfur content of 0.03 weight percent. Samples of the fuel are taken periodically and sent to a laboratory for testing to verify the sulfur content.

In addition to operating the fleet on low-sulfur fuel, GBTD began a program in 1991 to rebuild its fleet of 14 1983 MY DDC engines with an upgrade kit available from DDC. This kit, number DD 10A, brought GBTD's 1983 DDC 6V92TA mechanically controlled engines to a 1989 MY configuration, the last year DDC offered such an engine for transit. GBTD's upgrade program began in May 1991 and concluded in May 1994.

To reduce emissions even further, GBTD had three of its 1983 6V92TA engines modified with a thermal barrier coating process. The plasma-applied ceramic coating is said to improve combustion efficiency by insulating combustion components such as piston crowns, valves, and fire decks from thermal transmission and shock. Similar coatings have been used in marine and aerospace applications for years. The ceramic coating process was applied to three engines on a trial basis and GBTD claimed that the buses equipped with the ceramic process performed better than their standard fleet. To prove these objective evaluations, GBTD tested one of the ceramic-treated buses at an emissions facility operated by the New York Department of Transportation.

Pleased with the test results, GBTD began making plans to have the ceramic process applied to 38 buses equipped with 1991 DDC 6L71TA engines to be purchased. However, DDC could not apply a ceramic coating to a previously certified engine unless a waiver was obtained from EPA. Therefore, GBTD worked with EPA and DDC to obtain the waiver, which allowed them to have 34 of the engines modified with the ceramic process. Four engines remained in their original 1991 MY configuration for comparison purposes. The ceramic coating was applied to the valves, fire deck, and piston crowns

of the engines. The components were then returned to DDC and assembled into the engines.

After a careful review of EPA's Retrofit/Rebuild Program, GBTD decided that Option 1 was consistent with its existing program to reduce diesel exhaust emissions. Although Option 2 offered an alternative, GBTD was not interested in an averaging approach. Instead, GBTD is committed to having each bus in its pre 1994 fleet achieve the lowest level of PM emissions within the cost ceilings offered by Option 1. GBTD is willing to install any certified kit that may become available at time of rebuild, and has budgeted for the extra costs based on existing LCC limits.

With a fleet mix of only two pre 1994 MY engine models, GBTD believes it will be relatively easy to keep emissions at a low level, especially when 14 engines (27 percent of its pre 1994 fleet) already contain upgrade kits. In 1995, GBTD plans to retire its 1983 fleet and replace it with 1995/96 MY buses, leaving 38 1992 MY engines needing upgrade equipment in the future.

GBTD plans to tear down some of the 1992 MY engines when they reach 350,000 miles, and inspect them for internal wear and deterioration. Main and rod bearings will be inspected for wear, and other internal parts will be inspected for damage. If the major cylinder components do not require replacement, GBTD will replace the main and rod bearings only at the 350,000-mile interval. Replacing these bearings, along with two oil-regulating valves in the engine, ensures adequate oil pressure to the top end of the engine and extends the interval between major overhauls.

In preparation for EPA's Retrofit/Rebuild Program, GBTD has developed a checklist to account for all pre 1994 engines rebuilt after January 1, 1995. The form, included in Appendix D, contains most of the pertinent information needed to show compliance with Option 1.

Although its MIS will store this information in a computer file, GBTD will also maintain an agency log to ensure adequate record keeping. Individual work orders will be kept on file as backup records, detailing all maintenance activity performed on the engines. Additionally, invoices for upgrade kits and other components will be kept on file to substantiate the rebuild activity.

ORANGE COUNTY TRANSPORTATION AUTHORITY (OCTA)--OPTION 2

OCTA, based in Orange, California, provides service in the Los Angeles-Anaheim-Riverside, California CMSA with a 1980 population of more than 11 million. OCTA operates a total of 739 buses, of which 503 are affected by EPA's program. The mix of pre 1994 MY HHDD engines at OCTA is as follows:

- 27 1976 DDC 8V71,
- 105 1983 DDC 6V92,
- 15 1988 DDC 6V92TA DDEC II,
- 52 1988 Cummins L10,
- 61 1989 Cummins L10,
- 2 1989 CNG-powered Cummins L10,
- 2 1989 LPG-powered Cummins L10,
- 2 1993 LNG-powered Cummins L10,
- 2 1994 LPG-powered Caterpillar 3306G,
- 174 1990 DDC 6V92TA DDEC II,
- 53 1990 Cummins L10, and
- 8 1992 trap-equipped Cummins L-10.

Before EPA's Retrofit/Rebuild Program was an issue, OCTA was actively involved in a two-tier program to reduce harmful emissions from its bus fleet. One part of the program involved testing of a variety of alternative fuels in preparation for new bus purchases that would lower emissions. The second part involved searching for cost-effective solutions to reduce pollutants from existing engines, with the goal of completely eliminating visible smoke from the entire fleet. OCTA had replaced some of its older engines in the fleet with newer, lower-emissions engines. It had also tested a ceramic-coated engine.

To reduce emissions even further, OCTA investigated two forms of exhaust aftertreatment technology, including particulate trap retrofits and catalyzed filter retrofits. In addition, OCTA investigated the replacement of existing engines with 1994 MY engines using the latest clean diesel technology. OCTA began its testing program with particulate traps. Based on its initial experience, OCTA determined that the complexity of the system and concerns over reliability would produce a negative impact on overall operation. OCTA then turned to a catalyzed filter, which, unlike a particulate trap, is a passive system that does not require outside control to regenerate the accumulated particulate. Initial test results were encouraging because the catalyzed filters appeared to reduce maintenance costs when compared to particulate traps.

OCTA continued its evaluation by testing completely new engines installed in older model buses. The replacement engines were certified to 1994 standards with an extremely low PM emissions level of 0.07 g/bhp-hr. The so-called advanced technology diesel engines were considered an alternative to the costly and time-consuming process of rebuilding engines and then retrofitting them with exhaust aftertreatment devices. Testing of the newer engines turned out to be more cost effective than either of the two exhaust aftertreatment technologies evaluated by OCTA. Without considering the cost savings resulting from reduced maintenance, OCTA estimated that an engine replacement program would result in savings of approximately $3.3 million. Funding for 80 percent of the engine replacement program will come from an FTA grant, while the remaining 20 percent will come from funds already allocated for engine rebuilds.

While OCTA was conducting its evaluation of retrofit technology, EPA promulgated its final rules concerning the Urban Bus Retrofit/Rebuild Program. Following a close examination, OCTA determined that its engine replacement program exceeded EPA's requirements. As a result of extensive testing and evaluation, OCTA decided to begin an engine replacement program, which included the following benefits:

- Surpassing of EPA's Retrofit/Rebuild Program requirements,
- Usage of the latest advanced diesel engine technology that will result in no visible smoke,
- Reduction in maintenance costs because complete engines will have a warranty for 2 years,
- Reduction in operational cost because new engines potentially have better fuel economy compared to the engines they are replacing, and

- Reduction in rear axle weight because some of the newer engines are lighter.

To determine which option would be in its best interest, OCTA examined the requirements of EPA's Retrofit/Rebuild Program very closely. Option 1, which requires every pre 1994 MY engine to meet a specified PM emissions level, appeared at first to be consistent with OCTA's engine replacement program. However, despite OCTA's active program to reduce emissions, it did not want to spend money unwisely. OCTA has older engines that would not be cost-effective to rebuild with upgrade equipment under Option 1, and because OCTA is expecting to replace the older engines soon, installing upgrade kits would not be a cost-effective solution. Therefore, OCTA does not believe there is sufficient life remaining in the engines to warrant the emissions-reduction equipment.

OCTA then took a close look at Option 2. Although more difficult to understand, Option 2 allows transit agencies to average PM emissions from all pre 1994 MY engines. Under Option 2, pre 1994 MY engines less than 15 years of age replaced with a 1994 or newer engine are considered early retirements. There is a significant incentive for agencies to retire bus engines less than 15 years of age, because the agencies may assume a PM emissions level of zero when calculating their FLA averages. Agencies may continue to include the zero level in the FLA averaging until those engines would have been 15 years old, thereby reducing the FLA by a significant amount.

To determine if Option 2 would be appropriate, OCTA took an inventory of all pre 1994 MY engines affected by EPA's program. OCTA also contacted EPA and requested the Lotus version of the spreadsheet program available for calculating Option 2 averages. OCTA then scrutinized its own engine and bus replacement program for each year beginning in 1995 and ending in 2000, which is as follows:

- 1995: Retire 27 buses equipped with 1976 DDC 8V71 engines, retire 51 buses equipped with 1983 DDC 6V92 engines, replace 52 1988 Cummins L10 engines with 1994 MY engines, and replace 61 1989 Cummins L10 engines with 1994 MY engines.
- 1996: Retire the remaining 54 buses equipped with 1983 DDC 6V92 engines, retire 23 buses equipped with 1990 DDC 6V92TA DDEC II engines, and replace 53 1990 Cummins L10 engines with 1994 MY engines.
- 1997: Retire another 50 buses equipped with 1990 DDC 6V92TA DDEC II engines.
- 1998: Retire another 28 buses equipped with 1990 DDC 6V92TA DDEC II engines.
- 1999: Retire another 27 buses equipped with 1990 DDC 6V92TA DDEC II engines.
- 2000: Retire the remaining 46 buses equipped with 1990 DDC 6V92TA engines.

Once OCTA's bus and engine replacement plan was established, data were transferred to EPA's spreadsheet program. The program automatically calculates the TLF and FLA averages for each year of the program. For those choosing to calculate Option 2 averages manually, the averages must be calculated individually before a comparison can be made.

It took OCTA at least five attempts at entering the data in the appropriate columns before the correct averages were obtained. At first, retired buses were incorrectly entered in the "rebuild" column, and a PM emissions level of 0.07 was entered to reflect the replacement buses. However, 1994 and newer buses added to the fleet are not used in the calculations, and buses (or bus engines) retired from the fleet actually belonged in the "number retired" column. For engines that are retired at less than 15 years of age, EPA's program applies a PM emissions level of zero when calculating the FLA. By placing the number of buses retired in the "rebuild" column, OCTA was not receiving the zero level credit that it was entitled to under Option 2.

Another error made by OCTA in its original calculations involved omitting pre 1994 engines from the spreadsheet after they had been retired from the fleet. Because the spreadsheet did not "see" these engines, it did not extend the zero credit for each year until the engines would have been 15 years old.

The calculations revealed that OCTA's FLA for PM emissions was less than the expected TLF for each year of the program. The low FLA averages obtained by OCTA allow rebuilds to be performed on older engines without installation of more costly upgrade kits if they should become available. OCTA will recalculate TLF and FLA averages for each year of the program, making adjustments as required due to unscheduled engine rebuilds and any changes made to its original bus and engine replacement program. By making calculations throughout the year, OCTA can adjust its engine rebuild/replacement plans if FLA averages should rise above the TLF. OCTA will also update its spreadsheet program after July 1996, when making calculations for 1988 and later.

A sample of OCTA's spreadsheet calculations made for calendar year 1996 is included in Appendix E.

MTA LONG ISLAND BUS (MTA LI BUS)-- OPTION 2

MTA LI Bus, an agency of New York's Metropolitan Transportation Authority, is located in Garden City, New York. MTA LI Bus provides transit bus service in the New York-Northern New Jersey-Long Island NY/NJ/CT CMSA, which has a 1980 population of more than 17.5 million. MTA LI Bus operates a total of 318 buses, of which 312 are affected by EPA's program. The fleet mix of pre 1994 MY HHDD engines at MTA LI Bus includes:

- 7 1970 DDC 6V71,
- 11 1978 DDC 8V71,
- 111 1981 DDC 8V71,
- 34 1984 DDC 8V71,
- 61 1988 DDC 6V92TA DDEC II,
- 21 1990 DDC 6V92TA DDEC II,
- 57 1991 DDC 6V92TA DDEC II, and
- 10 1992 CNG-powered Cummins L10.

MTA LI Bus is committed to operating a low-emissions bus fleet and has chosen compressed natural gas (CNG) as its clean fuel of the future. In preparation for the change from diesel fuel to CNG, MTA LI Bus is installing a fast-fill CNG fueling station at its bus storage and maintenance facility. Beginning in 1991, all buses purchased by MTA LI Bus will

be powered by CNG engines and, by 2003, the entire bus fleet will operate on CNG.

To determine which of the two options offered by EPA's program would be appropriate for its operation and budget, MTA LI Bus evaluated its fleet replacement plan from 1994 to 2004. The bus replacement plan revealed that by 1996, 168 of all pre 1994 MY buses will be retired from the fleet, leaving 144 engines affected by EPA's Retrofit/Rebuild Program. Of the 144 engines affected by the program, 10 were powered by CNG before the program began and are assumed by EPA to operate at a PM emissions level of 0.10 g/bhp-hr. Of the 134 pre 1994 MY buses remaining in the fleet by 1996, all will be powered by DDC 6V92TA DDEC II engines, originally certified to a relatively low PM emissions level of 0.31 g/bhp-hr.

In addition to its active schedule to replace diesel-fueled buses with CNG-fueled buses, MTA LI Bus plans to repower 25 pre 1994 MY buses with MHDD engines. The agency believes that HHDD engines traditionally used in transit buses are underutilized for many urban routes. According to MTA LI Bus, the lighter, cleaner and more fuel-efficient medium-duty engines will be sufficient for certain routes.

While reviewing its overall bus replacement plan, MTA LI Bus also studied EPA's Retrofit/Rebuild Program to develop a compliance strategy. After careful evaluation, the agency decided that the fleet-averaging approach offered by Option 2 best suited its needs for the following reasons:

- The active bus replacement program will result in the early retirement of pre 1994 MY buses, providing MTA LI Bus with an FLA benefit until the replaced buses would have reached 15 years of age;
- The 10 CNG buses purchased before the start of the program allow MTA LI Bus to use a 0.10 PM emissions level for those buses when calculating FLA averages;
- The plan to repower 25 buses with MHDD engines will also give an emissions-averaging benefit; and
- The only pre 1994 MY engines remaining in the fleet after 1996 will be DDC 6V92TA DDEC II engines. If upgrade equipment was needed to maintain the appropriate FLA averages under Option 2, the single-model engine will allow the use of standardized upgrade equipment.

To simplify the calculations required for Option 2, MTA LI Bus requested the computer spreadsheet program from EPA and began to input data. Like many transit agencies working with EPA's spreadsheet program for the first time, MTA LI Bus encountered some difficulties. For those not fluent with spreadsheet macros, the agency felt that explicit directions should be provided with the program. Because the many columns included in the program are not identified, MTA LI Bus had a difficult time understanding how the spreadsheet functioned.

Once EPA's spreadsheet program was sorted out, MTA LI Bus began to input data to determine its actual FLA and TLF averages for Option 2. Unfamiliar with the program, however, the agency made several attempts at entering data before arriving at accurate results. For example, under the "buses added" column, the agency included new buses planned for 1994 and beyond. Because the program does not include any buses newer than 1993 MY, the data were entered incorrectly. The "buses added" column is used to account for any pre 1994 MY buses that may be added to the existing fleet.

In addition, MTA LI Bus did not claim proper credit for the pre 1994 MY buses replaced with new engines. Instead of entering 25 buses in the "buses retired" column, the replacement engines were treated as rebuilds, which were assigned a PM emissions level of 0.10 g/bhp-hr. As mentioned in the case study for OCTA, any pre 1994 MY bus repowered with a 1994 MY or newer engine is considered a retired bus. The computer program automatically assigns a PM emissions level of zero for the repowered buses and will continue to do so until the replaced engines would have been 15 years of age, giving transit agencies a substantial benefit.

Once the corrections were made, MTA LI Bus ran the spreadsheet program again. The new data revealed that the FLA average was below the TLF average for each year of the program. Because the agency does not have a formal engine overhaul program where a specified number of engines are rebuilt each year, it had to estimate the number of rebuilds that would be performed through 2003. The rebuild estimate was based on engine age, past experience, and the present condition of the engines involved.

MTA LI Bus was encouraged by the preliminary results obtained from the calculations made for Option 2. A sample of the spread sheet calculations is included in Appendix F.

MTA LI Bus understands that the calculations must be updated for each year of the program based on the actual number of rebuilds performed. Based on the preliminary findings, MTA LI Bus is confident that it can meet the target levels established under Option 2 until 2003, when all diesel-fueled buses will be retired from its fleet. The decision made by MTA LI Bus to adopt Option 2 as a strategy is based in part on the uncertainty of equipment that may become available for use under the program. By adopting the fleet-averaging approach offered by Option 2, the agency can meet EPA's program requirements without being tied to specific technology or equipment that may not be suitable for its operation. Under Option 1, MTA LI Bus would be obligated to install certified equipment for a specific engine once that engine is rebuilt or replaced.

Under Option 2, however, MTA LI Bus can choose not to install the certified equipment as long as its FLA averages remain equal to or below its TLFs. If certified equipment is compatible with its operation, the agency could install that equipment and comply with both options. The increased flexibility offered by Option 2 allows MTA LI Bus to evaluate the equipment that becomes available under the program and make decisions accordingly.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

CONCLUSIONS

EPA's Urban Bus Retrofit/Rebuild Program recognizes the financial concerns of public transit and attempts to balance the cost of the program with the emissions reduction goals of the CAA. The program achieves this balance by encouraging the application of new technology while setting cost limits on equipment before it is required for use. To make its program reasonable, EPA has established several provisions designed to safeguard transit agencies from excessive cost, and to provide sufficient time for agencies to plan their budgets.

To accommodate a variety of technologies and financial concerns, EPA's program contains several approaches to reduce PM emissions. The flexibility offered by the program, however, makes it somewhat complex and difficult to comprehend. Each alternative has its own set of conditions that first must be satisfied before an approach can be applied. EPA's program contains equations, fallback requirements, and default provisions, all of which must be carefully evaluated by the transit agencies to determine their full responsibilities.

Transit agencies responding to the survey have expressed mixed feelings toward EPA's program. Some view it as a complex, unfunded government program designed to increase operating cost and add more control to an industry already burdened by government regulation. Others view it as a means to reduce harmful emissions, standardize fleets, and provide bus service that enhances overall community image.

Regardless of the viewpoint, agencies responding to the survey expressed a sincere willingness to understand EPA's program as a way to help improve the environment. EPA's program offers the flexibility needed to meet that responsibility in a cost-effective manner. The level of cost effectiveness achieved in meeting the program's requirements depends on an agency's ability to tailor the provisions contained in the program to its own maintenance operation.

Any worthwhile program designed to improve the environment is bound to have costs and sacrifices associated with it. Likewise, any regulation that tries to accommodate so many interests will be complex and difficult to understand. Fortunately, EPA's program contains a variety of provisions that allow agencies the flexibility needed to reduce harmful emissions in a cost-effective manner. Unfortunately, unless an agency makes sufficient efforts, the provisions can be cumbersome and somewhat difficult to understand. Transit agencies who take the time to comprehend the program can minimize the impact to their maintenance operations while maximizing the amount of PM emissions reduction achieved from their fleets.

Of the two options offered by the program, Option 1 is easier to understand and implement. Option 2, although more complex, provides agencies with increased flexibility. Choosing the appropriate option depends upon the agency's mix of pre 1994 engines and equipment that actually becomes certified for use under the program. While Option 1 may be easier to understand, installing upgrade equipment on older engines scheduled to be retired shortly may not be cost effective. Additionally, Option 1 may restrict agencies to a particular technology that may not be favorable to their operation in the long term. Agencies that have focused on Option 1 solely as a way of meeting EPA's program requirements should also become familiar with Option 2.

Likewise, Option 2 may present unwanted results. For example, the calculations used to determine compliance for calendar years 1996 and 1997 are based on equipment certified under Option 1 by July 1994. Because no equipment had been certified by that date, meeting TLFs during the early stages of the program will be easy to achieve. Meeting the requirements in 1998 and later could become increasingly difficult because TLFs will be based on a much larger group of equipment certified by July 1996. Furthermore, once an agency fails to comply with a particular option, it is not allowed to return to that option again.

A transit agency may want to consider a strategy that complies with both options initially. Those that limit their understanding to one option may be forced into using equipment they may regret in the future. By developing a strategy that complies with both options initially, agencies will have greater flexibility and more time in which to sort out the program. The additional time also allows agencies to gain a complete understanding of the range of equipment that actually becomes available under the program.

RECOMMENDATIONS FOR FURTHER RESEARCH

The purpose of this synthesis is to provide a concise summary of EPA's Urban Bus Retrofit/Rebuild Program and to make it easier for transit agencies to understand. This synthesis clarifies many of the issues raised from the survey and summarizes the approaches taken by agencies as they prepare to implement the program.

Following implementation of EPA's program, further research could include:

- A study of the actual equipment that becomes certified for use under the program;
- Benefits realized from implementing EPA's program (i.e., standardization of rebuild equipment, requirement that all PM emissions-reduction equipment must be certified, etc.);
- How each technology achieves its stated reduction of PM emissions;
- The cost of such equipment and how LCCs were determined in the certification process;
- How transit agencies have modified their approach to the program based on certified equipment that becomes available;

- Case studies showing how transit agencies are actually complying with the program (e.g., in Option 1 include actual installation of kits, record keeping, etc.); and
- Any changes made to the program by EPA, including the implementation of default provisions as contained in the Final Rule.

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LIST OF ABBREVIATIONS AND ACRONYMS

APTA	American Public Transit Association
CAA	Clean Air Act
CAAA	Clean Air Act Amendments of 1990
CO	Carbon monoxide
CPI	Consumer Price Index
CNG	Compressed Natural Gas
DDC	Detroit Diesel Corporation
DDEC	Detroit Diesel Electronic Control
EPA	Environmental Protection Agency
FLA	Fleet level attained
g/bhp-hr	Grams per brake horsepower hour
GBTD	Greater Bridgeport Transit District
HC	Hydrocarbons
HDD	Heavy-duty diesel
HHDD	Heavy heavy-duty diesel
LCC	Life-cycle cost
LNG	Liquified natural gas
LPG	Liquified petroleum gas
MECA	Manufacturers of Emission Controls Association
MHDD	Medium heavy-duty diesel
MIS	Management information system
MY	Model year
NO_x	Oxides of nitrogen
NPRM	Notice of Proposed Rulemaking
OCTA	Orange County Transportation Authority
PM	Particulate matter
SAE	Society of Automotive Engineers
TLF	Target level for a fleet
TRB	Transportation Research Board

APPENDIX A

Areas Affected by the EPA's Urban Bus Retrofit/Rebuild Program
October 1994

The following list is accurate to the best of EPA's current knowledge. EPA expects that any operator of an urban bus located in or providing service to any of these areas is subject to this program.

APPENDIX A (Continued)

1 Albany-Schenectady-Troy NY

Albany County
Greene County
Montgomery County
Rensselaer County
Saratoga County
Schenectady County

2 Atlanta GA

Barrow County
Butts County
Cherokee County
Clayton County
Cobb County
Coweta County
De Kalb County
Douglas County
Fayette County
Forsyth County
Fulton County
Gwinnett County
Henry County
Newton County
Paulding County
Rockdale County
Spalding County
Walton County

3 Baltimore MD

Anne Arundel County
Baltimore County
Carroll County
Harford County
Howard County
Queen Anne's County
Baltimore city

4 Birmingham AL

Blount County
Jefferson County
St. Clair County
Shelby County
Walker County

5 Boston-Lawrence-Salem MA/NH

Bristol County, MA
Essex County, MA
Middlesex County, MA
Norfolk County, MA
Plymouth County, MA
Suffolk County, MA
Worcester County, MA

Hillsborough County, NH
Rockingham County, NH

6 Buffalo-Niagara Falls NY

Erie County
Niagara County

7 Charlotte-Gastonia-Rock Hill NC/SC

Cabarrus County, NC
Gaston County, NC
Lincoln County, NC
Mecklenburg County, NC
Rowan County, NC
Union County, NC

York County, SC

8 Chicago-Gary-Lake County IL/IN/WI

Cook County, IL
Du Page County, IL
Grundy County, IL
Kane County, IL
Kendall County, IL
Lake County, IL
McHenry County, IL
Will County, IL

Lake County, IN
Porter County, IN

Kenosha County, WI

APPENDIX A (Continued)

9 Cincinnati-Hamilton OH/KY/IN

Dearborn County, IN

Boone County, KY
Campbell County, KY
Kenton County, KY

Butler County, OH
Clermont County, OH
Hamilton County, OH
Warren County, OH

10 Cleveland-Akron-Lorain OH

Cuyahoga County
Geauga County
Lake County
Lorain County
Medina County
Portage County
Summit County

11 Columbus OH

Delaware County
Fairfield County
Franklin County
Licking County
Madison County
Pickaway County
Union County

12 Dallas-Fort Worth TX

Collin County
Dallas County
Denton County
Ellis County
Johnson County
Kaufman County
Parker County
Rockwall County
Tarrant County

13 Dayton-Springfield OH

Clark County
Greene County
Miami County
Montgomery County

14 Denver-Boulder CO

Boulder County
Adams County
Arapahoe County
Denver County
Douglas County
Jefferson County

15 Detroit-Ann Arbor MI

Lapeer County
Livingston County
Macomb County
Monroe County
Oakland County
St. Clair County
Washtenaw County
Wayne County

16 Greensboro-Winston-Salem-High Point NC

Davidson County
Davie County
Forsyth County
Guilford County
Randolph County
Stokes County
Yadkin County

17 Hartford-New Britain-Middletown CT

Hartford County
Litchfield County
Middlesex County
New London County
County Tolland County

APPENDIX A (Continued)

18 Honolulu HI

Honolulu County

19 Houston-Galveston-Brazoria TX

Brazoria County
Galveston County
Fort Bend County
Harris County
Liberty County
Montgomery County
Waller County

20 Indianapolis IN

Boone County
Hamilton County
Hancock County
Hendricks County
Johnson County
Marion County
Morgan County
Shelby County

21 Kansas City MO/KS

Johnson County, KS
Leavenworth County, KS
Miami County, KS
Wyandotte County, KS

Cass County, MO
Clay County, MO
Jackson County, MO
Lafayette County, MO
Platte County, MO
Ray County, MO

22 Los Angeles-Anaheim-Riverside CA

Los Angeles County
Orange County
Riverside County
Ventura (San Buenaventura) County
San Bernardino County

23 Louisville KY/IN

Clark County, IN
Floyd County, IN
Harrison County, IN

Bullitt County, KY
Jefferson County, KY
Oldham County, KY
Shelby County, KY

24 Memphis TN/AR/MS

Crittenden County, AR

De Soto County, MS

Shelby County, TN
Tipton County, TN

25 Miami-Ft.Lauderdale FL

Broward County
Dade County

26 Milwaukee-Racine WI

Milwaukee County
Ozaukee County
Racine County
Washington County
Waukesha County

APPENDIX A (Continued)

27 Minneapolis-St.Paul MN/WI

Anoka County, MN
Carver County, MN
Chisago County, MN
Dakota County, MN
Hennepin County, MN
Isanti County, MN
Ramsey County, MN
Scott County, MN
Washington County, MN
Wright County, MN

St.Croix County, WI

28 Nashville TN

Cheatham County
Davidson County
Dickson County
Robertson County
Rutherford County
Sumner County
Williamson County
Wilson County

29 New Orleans LA

Jefferson Parish
Orleans Parish
St.Bernard Parish
St.Charles Parish
St.John the Baptist Parish
St.Tammany Parish

30 New York-Northern New Jersey-Long Island NY/NJ/CT

Fairfield County, CT
Litchfield County, CT
New Haven County, CT

Bergen County, NJ
Essex County, NJ
Hudson County, NJ
Hunterdon County, NJ
Middlesex County, NJ
Monmouth County, NJ
Morris County, NJ
Ocean County, NJ
Passaic County, NJ
Somerset County, NJ
Sussex County, NJ
Union County, NJ

Bronx County, NY
Kings County, NY
Nassau County, NY
New York County, NY
Orange County, NY
Putnam County, NY
Queens County, NY
Richmond County, NY
Rockland County, NY
Suffolk County, NY
Westchester County, NY

31 Norfolk-Virginia Beach-Newport News VA

Chesapeake city
Hampton city
Newport News city
Norfolk city
Poquoson city
Portsmouth city
Suffolk city
Virginia Beach city
Gloucester County
James City County
York County
Williamsburg city

APPENDIX A (Continued)

32 Oklahoma City OK

Canadian County
Cleveland County
Logan County
McClain County
Oklahoma County
Pottawatomie County

33 Philadelphia-Wilmington-Trenton PA/NJ/DE/MD

New Castle County, DE

Cecil County, MD

Burlington County, NJ
Camden County, NJ
Cumberland County, NJ
Gloucester County, NJ
Mercer County, NJ
Salem County, NJ

Bucks County, PA
Chester County, PA
Delaware County, PA
Montgomery County, PA
Philadelphia County, PA

34 Phoenix AZ

Maricopa County

35 Pittsburgh-Beaver Valley PA

Allegheny County
Beaver County
Fayette County
Washington County
Westmoreland County

36 Portland-Vancouver OR/WA

Clackamas County, OR
Multnomah County, OR
Washington County, OR
Yamhill County, OR

Clark County, WA

37 Providence-Pawtucket-Fall River RI/MA

Bristol County, MA
Norfolk County, MA
Worcester County, MA

Bristol County, RI
Kent County, RI
Newport County, RI
Providence County, RI
Washington County, RI

38 Richmond-Petersburg VA

Colonial Heights city
Hopewell city
Petersburg city
Richmond city
Charles City County
Chesterfield County
Dinwiddie County
Goochland County
Hanover County
Henrico County
New Kent County
Powhatan County
Prince George County

39 Rochester NY

Livingston County
Monroe County
Ontario County
Orleans County
Wayne County

APPENDIX A (Continued)

40 Sacramento CA

El Dorado County
Placer County
Sacramento County
Yolo County

41 St.Louis-East St.Louis-Alton MO/IL

Clinton County, IL
Jersey County, IL
Madison County, IL
Monroe County, IL
St.Clair County, IL

Franklin County, MO
Jefferson County, MO
St.Charles County, MO
St.Louis city, MO
St.Louis County, MO

42 Salt Lake City-Ogden UT

Davis County
Salt Lake County
Weber County

43 San Antonio TX

Bexar County
Comal County
Guadalupe County

44 San Diego CA

San Diego County

45 San Francisco-Oakland-San Jose CA

Alameda County
Contra Costa County
Marin County Napa County
San Mateo County
San Francisco County
Santa Cruz County
Santa Clara County
Sonoma County
Solano County

46 San Juan-Caguas, Puerto Rico

Bayamon Municipo
Caguas Municipio
Canovanas Municipio
Carolina Municipio
Catano Municipio
Guaynabo Municipio
Gurabo Municipio
Loiza Municipio
San Juan Municipio
San Lorenzo Municipo
Toa Baja Municipio
Trujillo Alto Municipio

47 Seattle-Tacoma WA

King County
Snohomish County
Pierce County

48 Tampa-St.Petersburg-Clearwater FL

Hernando County
Hillsborough County
Pasco County
Pinellas County

APPENDIX A (Continued)

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49 Washington DC/MD/VA

District of Columbia

Calvert County, MD
Charles County, MD
Frederick County, MD
Montgomery County, MD
Prince George's County, MD

Alexandria city, VA
Arlington County, VA
Fairfax city, VA
Fairfax County, VA
Falls Church city, VA
Loudoun County, VA
Manassas city, VA
Manassas Park city, VA
Prince William County, VA
Stafford County, VA

APPENDIX B

Transit Agency Questionnaire and Respondents

TRANSIT COOPERATIVE RESEARCH PROGRAM (TCRP)
SYNTHESIS TOPIC SC-4
RETROFIT OF BUSES TO MEET THE CLEAN AIR REGULATIONS

1994 QUESTIONNAIRE

The 1990 Clean Air Act Amendments (CAAA) provide that by January 2, 1995, transit agencies with urban buses operating in metropolitan areas with 1980 populations of 750,000 or more are required to comply with an engine retrofit/rebuild program certified by the Environmental Protection Agency (EPA). EPA issued the Final Rule on this portion of the Act (40 CFR Parts 85 and 86) on April 21, 1993, Volume 58, Part 75, pages 21359 to 21403 (58 FR 21359, April 21, 1993).

The Transportation Research Board (TRB) is seeking assistance in identifying strategies and methodologies that are being implemented, or are being tested to comply with the EPA requirements. These will be summarized in a synthesis of practice. By looking at different operating conditions and fleet perspectives we hope to provide transit professionals with different ways of viewing this issue and with practical information which will assist them in developing better strategies of their own.

Therefore, it is critical that you provide accurate and detailed information to the best of your experience at this time. It will assist us in presenting information in a report that could help others solve their own challenging problems.

The questionnaire is detailed and additional space is provided for narrative comment if you require it. Tell us about those issues which are particularly troublesome in your development or continuing implementation of retrofit /rebuild programs.

John Schiavone may be calling you after you have returned the completed questionnaire for clarification or further information.

Please return the completed questionnaire by March 29, 1994, to:

John J. Schiavone
32 State Street
Guilford, CT 06437

Direct any inquires to (or fax) John J. Schiavone at 203-453-2728 or telephone Donna L. Vlasak or Sally D. Liff at 800-424-9818 or 202-334-3242.

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1. Is your agency prepared to implement the EPA retrofit/rebuild program by the January 2, 1995, starting date?

   YES____ NO____

2. With which option available under the EPA program is your agency most likely to comply?

   ____Option No. 1 - specifies that a rebuilt or replacement engine must meet a 0.10g/bhp-hr particulate matter (PM) standard with certain cost restraints.

   ____Option No. 2 - specifies that a bus operator's fleet average for particulate emissions must meet a specific target level for each year.

   ____undecided at this time

3. Has your agency started to make any preliminary calculations or preparations concerning either of the two options described above?

YES____ NO____

4. If the answer to question No. 4 is yes, for which of the two options has your agency started preparing?

____Option No. 1
____Option No. 2
____Both

5. In your current agency program to rebuild diesel engines that do not meet a 0.10 PM standard, are you upgrading those engines with equipment designed to reduce particulate emissions?

YES____ NO____

6. If the answer to question No. 6 is yes, indicate the number of upgrades being performed.

____upgrade kits for mechanical engines
____upgrade kits for electronic engines (i.e., DDEC II)
____methanol conversions
____CNG/LNG conversions
____ethanol conversions
____particulate trap conversions
____catalyst conversions
____other

7. Is your agency replacing (re-powering) original equipment engines with newer diesel engines or alternatively-fueled engines designed to reduce particulate emissions?

YES____ NO____

8. If the answer to question No. 8 is yes, list the type of engine(s) being replaced: Quantity:

_____ _____
_____ _____

List the type of engine(s) being used to replace the original equipment engines: Quantity:

_____ _____
_____ _____

9. Is your agency familiar with the requirements of EPA's Retrofit/Rebuild program that become effective on January 2, 1995? (Check one and add the agency time spent (in hours) preparing for implementation of this requirement.)

____very good understanding ____hours
____good understanding ____hours
____clarifications desirable ____hours
____detail required (be sure to answer question No. 10)

10. What aspects of EPA's retrofit/rebuild program are confusing and need more detailed clarification by example? (Please be specific.)

_____
_____
_____
_____
_____
_____
_____

Name:_____Title: _____
Transit Agency:_____
Telephone:_____

Please return by **March 29, 1994 to:**

John J. Schiavone
32 State Street
Guilford, CT 06437
(203) 453-2728 (FAX & Phone)

THANK YOU VERY MUCH FOR YOUR PARTICIPATION.

ATTACHMENT TO APPENDIX B

Survey Respondents

Alabama

Metro Area Express
Birmingham, AL

Arizona

Phoenix Transit System
Phoenix, AZ

California

AC Transit
Oakland, CA

Central Contra Costa Transit Authority
Concord, CA

Golden Gate Transit
San Rafael, CA

Los Angeles Country Metropolitan Transportation Authority
Los Angeles, CA

North San Diego County Transit District
Oceanside, CA

Orange County Transportation Authority
Orange, CA

San Mateo County Transit District
San Carlos, CA

Santa Cruz Metropolitan Transit District
Santa Cruz, CA

Santa Monica Municipal Bus Lines
Santa Monica, CA

Connecticut

Connecticut Transit
Hartford, CT

Greater Bridgeport Transit District
Bridgeport, CT

Delaware

Delaware Administration for Regional Transit
Wilmington, DE

Georgia

Metropolitan Atlanta Rapid Transit Authority
Atlanta, GA

Hawaii

Oahu Transit Service, Inc.
Honolulu, HI

Illinois

Chicago Transit Authority
Chicago, IL

Indiana

Indianapolis Public Transportation Corporation
Indianapolis, IN

Kentucky

Transit Authority of Northern Kentucky
Fort Wright, KY

Louisiana

Regional Transit Authority
New Orleans, LA

Massachusetts

Massachusetts Bay Transportation Authority
Boston, MA

Michigan

Ann Arbor Transportation Authority
Ann Arbor, MI

Minnesota

Metropolitan Transit Commission
Minneapolis, MN

Missouri

Kansas City Area Transportation Authority
Kansas City, MO

New Jersey

New Jersey Transit Corporation
Newark, NY

New York

Long Island Bus
Garden City, NY

Triboro Coach Corporation
Jackson Heights, NY

North Carolina

Winston-Salem Transit Authority
Winston-Salem, NC

Ohio

Central Ohio Transit Authority
Columbus, OH

METRO Regional Transit Authority
Akron, OH

LAKETRAN
Grand River, OH

Miami Valley Regional Transit Authority
Dayton, OH

Oklahoma

Central Oklahoma Transportation and Parking Authority
Oklahoma City, OK

Oregon

Tri-County Metropolitan Transportation District of Oregon
Portland, OR

Pennsylvania

Port Authority of Allegheny County
Pittsburgh, PA

Southeastern Pennsylvania Transportation Authority
Philadelphia, PA

Texas

Dallas Area Rapid Transit
Dallas, TX

Metropolitan Transit Authority of Harris County
Houston, TX

Utah

Utah Transit Authority
Salt Lake City, UT

Virginia

Greater Richmond Transit Company
Richmond, VA

Tidewater Regional Transit
Norfolk, VA

Washington

Pierce Transit Tacoma,
WA

Wisconsin

Waukesha Transit System Utility
Waukesha, WI

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* Two questions were returned without names.

APPENDIX C

Applications and Process for Certification

Certification Applications Expected

- **Applied Diesel Technology** - Two different kits, conversion to compressed natural gas (CNG) and catalytic converter installation.
- **Biofuels** - Alternative fuel. Blend of biological oils (e.g. soybean, 20% by volume) and diesel fuel.
- **Cummins** - Retrofit kit.
- **Detroit Diesel Corp. (DDC)** - Rebuild kit.
- **Engine Control Systems** - Particulate traps.
- **Engelhard** - Catalytic converter system.
- **Johnson Matthey** - Retrofit kit with oxidation catalytic converter and particulate trap.
- **Korody-Colyer** - Rebuild kit.
- **Lubrizol** - Exhaust after treatment (trap) system with fuel additive.
- **Pro-Staff Fuels** - Diesel engine conversion to CNG and liquefied natural gas (LNG).
- **Rhone-Poulenc** - Fuel additive and particulate trap system.
- **Vineyard Engine Systems** - Conversion to CNG or liquefied petroleum gas (LPG).

Equipment Certification

Equipment used for engine retrofit or rebuild must be certified for operators to receive credit for emissions reductions.

Certification Process

- Equipment manufacturer submits notification of intent to certify
- Published in Federal Register
- 45 day public comment period
- Available to public
- Mailing list

Certified Systems

- None
- Effective date of certification published in Federal Register

APPENDIX D

Option 1 Checklist, GBTD

OPTION 1 COMPLIANCE SHEET
BRIDGEPORT TRANSIT DISTRICT
ENGINE REBUILDS AFTER JAN 1, 1995

	DATE	WORK ORDER #	BUS#	ENGINE ID#	ENGINE MY	REBUILT MILEAGE	CERAMITIZED YES/NO	CERTIFIED KIT AVAILABLE YES/NO	CERTIFIED KIT # USED	CERTIFICATION LEVEL
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										

APPENDIX E

Option 2 Spreadsheet Example, OCTA

"URBAN BUS RETROFIT/REBUILD REPORT"

Orange County TA

MODEL	ADDED #	CERT	YEAR

MODEL		TOTAL	REBUILD #	CERT	YEAR	2nd REBUILD #	CERT	YEAR	RETIRED #	YEAR
1973	Diesel Fueled Engine	27	0	0	0	0	0	0	27	1995
1983	Diesel Fueled Engine	58	0	0	0	0	0	0	58	1995
1983	Diesel Fueled Engine	47	0	0	0	0	0	0	47	1996
1988	DDC 6V92TA DDEC II	15	0	0	0	0	0	0	15	2002
1988	Cummins L10	52	0	0	0	0	0	0	52	1995
1989	Cummins L10	61	0	0	0	0	0	0	61	1995
1989	Alternate Fueled Eng	8	0	0	0	0	0	0	0	0
1990	DDC 6V92TA DDEC II	23	0	0	0	0	0	0	23	1996
1990	DDC 6V92TA DDEC II	50	0	0	0	0	0	0	50	1997
1990	DDC 6V92TA DDEC II	28	0	0	0	0	0	0	28	1998
1990	DDC 6V92TA DDEC II	27	0	0	0	0	0	0	27	1999
1990	DDC 6V92TA DDEC II	46	0	0	0	0	0	0	46	2000
1990	Cummins L10	53	0	0	0	0	0	0	53	1996
1992	Diesel Fueled Engine	8	0	0	0	0	0	0	0	0
0	0	503	0	0	0	0	0	0	0	0

YEAR	TLF	FLA
1996	0.42	0.23
1997	0.42	0.11
1998	0.42	0.08
1999	0.32	0.08
2000	0.10	0.06
2001	0.10	0.02
2002	0.10	0.02
2003	0.10	0.00
2004	0.10	0.01
2005	0.10	0.00
2006	0.10	0.10
2007	0.10	0.10
2008	ERR	0.00

APPENDIX F

Option 2 Spreadsheet Example, MTA LI BUS

"URBAN BUS RETROFIT/REBUILD REPORT"

MTA Long Island Bus

MODEL	ADDED #	CERT	YEAR

				REBUILD			2nd REBUILD			RETIRED	
MODEL	TOTAL		TOTAL	#	CERT	YEAR	#	CERT	YEAR	#	YEAR
1981	DDC 8V71N		111	10	0.25	1995	0	0	0	111	1996
1984	DDC 8V71N		34	4	0.25	1995	0	0	0	34	1996
1988	DDC 6V92TA DDEC		25	25	0.1	1995	0	0	0	25	2000
1988	DDC 6V92TA DDEC		15	15	0.1	1996	0	0	0	15	2000
1988	DDC 6V92TA DDEC		21	21	0.1	1999	0	0	0	21	2000
1990	DDC 6V92TA DDEC		5	5	0.1	1996	0	0	0	5	2002
1990	DDC 6V92TA DDEC		5	5	0.1	1998	0	0	0	5	2002
1990	DDC 6V92TA DDEC		11	11	0.1	1999	0	0	0	11	2002
1991	DDC 6V92TA DDEC		25	0	0	0	0	0	0	25	1996
1991	DDC 6V92TA DDEC		32	15	0.1	1997	0	0	0	32	2003
1992	CUMMINS L10 CNG		10	10	0.05	1998	0	0	0	10	2004
0		0	294	0	0	0	0	0	0	0	0

YEAR	TLF	FLA
1996	0.40	0.37
1997	0.33	0.15
1998	0.27	0.13
1999	0.20	0.12
2000	0.10	0.10
2001	0.10	0.06
2002	0.10	0.06
2003	0.10	0.05
2004	0.10	0.01
2005	0.10	0.00
2006	0.10	0.00
2007	0.10	0.00
2008	ERR	0.00

THE TRANSPORTATION RESEARCH BOARD is a unit of the National Research Council, which serves the National Academy of Sciences and the National Academy of Engineering It evolved in 1974 from the Highway Research Board, which was established in 1920. The TRB incorporates all former HRB activities and also performs additional functions under a broader scope involving all modes of transportation and the interactions of transportation with society. The Board's purpose is to stimulate research concerning the nature and performance of transportation systems, to disseminate information that the research produces, and to encourage the application of appropriate research findings. The Board's program is carried out by more than 270 committees, task forces, and panels composed of more than 3,300 administrators, engineers, social scientists, attorneys, educators, and others concerned with transportation; they serve without compensation. The program is supported by state transportation and highway departments, the modal administrations of the U.S. Department of Transportation, the Association of American Railroads, the National Highway Traffic Safety Administration, and other organizations and individuals interested in the development of transportation.

The National Academy of Sciences is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr Bruce Alberts is president of the National Academy of Sciences.

The National Academy of Engineering was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. Robert M.White is president of the National Academy of Engineering.

The Institute of Medicine was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Kenneth
I. Shine is president of the Institute of Medicine.

The National Research Council was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Bruce Alberts and Dr. Robert M. White are chairman and vice chairman, respectively, of the National Research Council.