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Development of Heavy-Duty NOx OFF-CYCLE Emission Effects for MOBILE6

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U.S. Environmental Protection Agency

NOTICE

This technical report does not necessarily represent final EPA decisions or positions. It is intended to present technical analysis of issues using data that are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position, or regulatory action.

1.0 Background

For purposes of this modeling, the heavy-duty diesel vehicle (HDDV) off-cycle operation is a vehicle component or software which allows emissions in excess of the FTP certification standards to be produced during operating modes which are not explicitly covered by a certification test while still controlling emissions during the certification test. In the case of the heavy-duty vehicles, the excess NOX emissions that were produced during off-cycle operation mostly occurred during steady-state operating modes such as cruising down the freeway, and rarely occurred during transient operation.

In the late 1980's and early 1990's vehicles which produce off-cycle NOX emissions were being phased into the fleet. These vehicles were mostly confined to the heaviest of the heavy-duty diesels (8a and 8b vehicles). However, by the mid to late 1990's off-cycle NOX emission effects were widespread on virtually all of the heavy end engines. Even some of the medium heavy-duty diesels contain off-cycle emission effects. Originally, it was believed that off-cycle emission effects were scheduled to be reduced and eliminated by calendar year 2000. However, recent developments regarding the Heavy-duty Engine Manufacturer's Consent Decree indicate that limited quantities of engines will be produced in model years 2001 and 2002 that emit off-cycle NOX emissions. As a result, the effects for calendar year 2001 have now been included in MOBILE6.

This document describes the methodology used to estimate excess NOX emissions produced by heavy-duty diesel vehicles (HDDV) as the result of Off FTP Cycle operation. In previous MOBILE6 model development documents and in other related documents it was often referred to as "built-in defeat devices" or "alleged defeat devices". The term 'defeat device' has been dropped from the title and body of this report on the grounds that the resulting Heavy-duty Engine Manufacturers' Consent Decrees which arose from the investigation into the 'defeat devices' did not result in an admission or determination that the disputed devices were actually defeat devices. The term "Off Cycle Operation" meaning Off FTP Cycle operation, is being substituted because it better describes the effect which will be modeled without the presumption of a "defeat device." Also presented in the document are emission estimates based on two programs designed to mitigate the effect of the off-cycle operation on fleet NOX emission levels. These include the incorporation of more stringent HDDV standards earlier than originally required (pull ahead), and accelerated engine rebuild programs (rebuild) to get in-use engines into better compliance.

This document is NOT a legal document, or an official emission inventory document. Such official documents can be found in the official EPA Consent Decree documents and supporting material. This current document is merely an attempt to compile estimates of the impact of the heavy-duty vehicle NOX off-cycle emission effects, to account for the effect of the proposed solutions from official sources, and to account for these estimates in the framework of the MOBILE6 model. These results may differ from the other EPA emission estimates in tons per year or in other regards. A reader interested in the fleet impact of the off-cycle operation based on official sources should refer to the official consent decree document.

2.0 Introduction

The principal focus of this document is to describe the Heavy-Duty Diesel Vehicle Off Cycle Operation in the context of how it was developed for MOBILE6. It also presents the underlying parameters and assumptions, and presents some limited NOx emission results. The second focus is the heavy-duty off-cycle operation module that is built into the MOBILE6 emission factor model. It was developed and programmed into MOBILE6 using parameters from a spreadsheet model previously discussed in EPA Report M6.HDE.003.

This current document FINAL M6.HDE.003 differs from the DRAFT M6.HDE.003 in two ways. First, it no longer discusses issues and results which were inherent to the previous spreadsheet models such as by roadway ratios and comparisons between MOBILE5 based inputs and MOBILE6 based inputs. These were developed so that off-cycle effects could easily be incorporated into existing MOBILE type outputs through the use of multiplicative factors. Second, it includes changes made in early calendar year 2001 that reflect updates made to the basic 'Consent Decree' and assumptions made during the 2000 Heavy-duty emission standards rulemaking process.

In cases where this current document differs from the previous document, M6.HDE.003, the user should consider the previous document out of date. These differences are in the areas of Pull Ahead effects, Engine Rebuild effects, and calendar year extensions. The effect of all three of these changes is to increase the emissions of Heavy-duty vehicle Off-Cycle NOx emissions. The previous document is being kept active because it is the sole documentation for the heavy-duty off-cycle spreadsheet models based on Draft MOBILE6 and MOBILE5 which had limited release in calendar year 2000.

This document is structured into three principal parts. The first part describes the structure and parameters that were used to develop the HDDV NOx Off-cycle effects in MOBILE6. This part is composed of several sub-sections. These include a description of the model's overall structure, the data parameters of the model and the control parameter. The second part briefly describes the the results from the model and references the companion spreadsheets which contain the data and the results The third part is an Appendix which contains the FORTRAN code used to implement the algorithm in MOBILE6, and a list of comments from reviewers and EPA responses.

3.0 Heavy-Duty Diesel Vehicle OFF-CYCLE Operation

This section describes the overall structure, data parameters, and input / output structure of the HDDV off-cycle operation. The Excel spreadsheet entitled "DDM6_Data.xls" is available that contains a summary of the important data parameters.

3.1 Overview of the Basic Structure

The MOBILE6 model is basically a calculator that weights the individual model year and vehicle class emission factors with vehicle miles traveled (VMT) inputs and presents these results as average emission factors in grams per mile. The following data parameters are used in the MOBILE6 model, and are defined in the subsequent sections.

MOBILE6 Heavy-Duty Vehicle Conversion Factors
MOBILE6 Basic Emission Factors WITHOUT Off-Cycle Operation Effects
Basic Emission Factors WITH Off-Cycle Operation Effects
Off-Cycle Operation Parameter and Fleet Penetration Rates
Total HDDV Vehicle Miles Traveled (VMT)
MOBILE6 Distribution of VMT by Roadway Type, Vehicle Class and Model Year
MOBILE6 HDDV Speed Correction Factors

Several equations are used to weight together these parameters and sum the results. These equations are shown in the section labeled "Calculations".

3.2 MOBILE6 Heavy-Duty Vehicle Conversion Factors

The HDDV conversion factors (CF) used in this model are shown in Excel Spreadsheet DDM6_Data.xls in worksheet CF. These conversion factors were taken from MOBILE6 and are referenced in EPA report "Update Heavy-Duty Engine Emission Conversion Factors for MOBILE6: Analysis of BSFCs and Calculation of Heavy-Duty Engine Emission Conversion Factors" - EPA420-P-98-015. The conversion factors are used to convert the basic heavy-duty diesel emission factors from g/bhp-hr into g/mi units. This is necessary so that the four individual heavy-duty diesel vehicle class emission factors and the individual roadway factors can be properly weighted together by VMT. Emission factors in units of g/bhp-hr cannot be VMT weighted because the basis units are in bhp-hr rather than in miles.

The conversion factors are shown as a function of model year and vehicle class. The model years range from 1964 through 2030. Each column in the worksheet CF contains a conversion factor for one of the four heavy-duty vehicle classes: Light, Medium, Class 8a and Class8b. In all cases, the Light class conversion factors are composite values obtained by weighting the individual sub-classes (light-heavy duty standard classes of 2b, 3, 4 and 5) together with the Bus conversion factors based on VMT. This was done because neither the Light or Bus class contain off-cycle operation effects in any appreciable quantity.

3.3 MOBILE6 Basic Emission Factors WITHOUT Off-Cycle Operation Effects

The basic emission factors without off-cycle operation effects used in the spreadsheet model are shown in Excel Spreadsheet DDM6_Data.xls in worksheet BEFs. These are the base emission levels for a particular model year and vehicle class if the off-cycle operation is not present or not working. The first five columns show the Without off-cycle operation emission factors. These are shown as a function of vehicle class (Light, Medium, 8a and 8b), and as a function of model year. Basic emission factors are shown for model years 1964 through 2030, and are in units of grams per brake-horsepower-hr (g/bhp-hr or g/hp-hr). These values are the default emission levels for HDDVs in MOBILE6, and are very heavily based on certification test results. The analogous MOBILE5 values are also default emission levels and are based on certification test results. The reference for the MOBILE6 values is EPA report EPA420-R-99-010 - "Update of Heavy-Duty Emission Levels (Model Years 1988 - 2004+) for Use in MOBILE6." The MOBILE5 values were taken from the MOBILE5 model code.

3.4 MOBILE6 Basic Emission Factors WITH Off-Cycle Operation Effects

The last four columns in worksheet BEFs of the Excel Spreadsheet DDM6_Data.xls show the basic NOX emission factors in g/bhp-hr units when the off-cycle operation is active and operating. Like the WITHOUT off-cycle operation emission levels, the WITH off-cycle emission levels are shown as a function of vehicle class and model year. Except for the Pull Ahead effects, the "Light-Duty" class is unaffected by the off-cycle operation so it shows the same NOX emission factors for both "WITH" and "WITHOUT" off-cycle operations. NOX emission factors are shown for the model year range of 1964 through 2030. One exception is the WITH off-cycle operation NOX emission factors for model years 2002 and 2003. These are lower than the WITHOUT off-cycle operation emission levels as the result of "Pull Ahead" requirements for lower certification standards. For model years 2004 and later, and model years 1987 and earlier, the WITH and WITHOUT off-cycle operation emission levels are equivalent, since there would be no off-cycle operation effects on emissions for these model year engines.

The off-cycle operation emission effects were determined on an engine by engine basis using available data and engineering judgement by experts familiar with engine control software. These individual estimates were weighted together by engine family using diesel vehicle sales information to produce model year average emission levels (this document uses a summary of the individual manufacturer results). The individual engine family or manufacturer specific engine control logic, emission results and sales projections are proprietary in nature and were made available to the EPA on a confidential basis as part of the Heavy-Duty Diesel Off-cycle operation Consent Decree. Thus, they are not provided in this document nor are they publically available in any other source.

3.5 Off-Cycle Operation Operating Parameter and Fleet Penetration Rates

The off-cycle operation operating parameters and fleet penetration rates used in the MOBILE6 model are shown in worksheet "Fleet Fractions" of Excel Spreadsheet DDM6_Data.xls. These are shown as a function of vehicle class (light, medium, 8a and 8b), model year, and roadway type. The three roadway types are Urban, Arterial, and Interstate. There are four sub-types within

each of these three broad classes, and they are also listed in spreadsheet DD_Data.xls worksheet "Fleet Fractions." The Urban type represents city driving which includes considerable stop-and-go transient operation. The Arterial type represents driving on primary roads in which there is both transient operation and steady-state operation. The Interstate type represents the operation which includes mostly steady state type driving at higher speeds. A zero (0.00) means that the off-cycle operation does not operate during that mode, and a one (1.00) would mean that it operates all of the time in that mode. This information is on a fleet summary basis. It was calculated from individual engine family off-cycle operation response data that was determined from proprietary and confidential data submitted by the engine manufacturers, limited testing of affected engines, and engineering judgment by experts in engine control and emission control software. As a general rule, the Urban type contains relatively little off-cycle operation and the Interstate type contains a very high percentage of off-cycle operation as can be seen in the low fractions for Urban and the high fractions for Interstate. The off-cycle operation operating fractions are also a function of model year.

The columns entitled "Fleet Fraction" show the percent of a particular model year and vehicle class that is equipped with the off-cycle operation or affected by the legal settlement. A value of zero means for that particular combination of vehicle class and model there are no off-cycle emissions, and a value of unity (1.0) means that in that model year, all vehicles of that class were capable of producing off-cycle NOX emissions. In general, the data suggests that the off-cycle operation penetration began slowly in the 1988 model year on the heavier class diesels, and slowly progressed to encompass most of the fleet. Virtually full penetration seems to have occurred by the mid 1990's on the heavier engines. Penetration drops off abruptly around calendar year 2001, presumably due to the settlement. The only exception to this rule is for the case of the 2002 and 2003 model years. These model year groups contain a coded factor to calculate the impact of "Pull Ahead." No off-cycle operations will be produced in those model years.

3.6 Total VMT Estimates

The Total VMT Estimates are shown in worksheet Total_VMT of Spreadsheet DDM6_Data.xls. Separate values are shown for calendar years 1988 through 2010. The VMT values were obtained from the EPA Trends model, and are typical HDDV VMT levels used in Air Quality modeling. Linear equations are used to project future VMT levels. The Total VMT estimate is an important factor in determining the total tons of NOX produced by the off-cycle operations. However, it is not explicitly used in the MOBILE6 model inputs because MOBILE6 does not produce NOX emissions in units of tons (only in grams per mile).

3.7 Distribution of VMT by Roadway Type, Vehicle Class and Model Year

The distribution of VMT by roadway type and vehicle class is an important topic that affects the total quantity of off-cycle NOX emissions. However, all of the assumptions and data regarding VMT distributions are present in MOBILE6, and are not unique to the HDDV Off-Cycle NOX emission calculation. Currently, the default MOBILE6 model assumes that all vehicle classes have the same distribution of VMT by roadway type, and that this single distribution was obtained from analyzing overall vehicle VMT data trends. The same distribution was assumed for all vehicle

classes because the roadside survey data could not be disaggregated by vehicle class (These data are collected in roadway surveys when vehicles run over the rubber hoses on roadways, and the vehicle class cannot easily be discerned). The effect of this type of data collection is that a heavy-duty diesel truck is assumed to accumulate on a percentage of total VMT basis, the same amount of expressway VMT as a passenger car. This assumption is not likely accurate because it is common knowledge that heavy-duty trucks spend more of their time on expressways than passenger cars. Therefore, this assumption makes it likely that the MOBILE6 model understates the percentage of expressway driving where the off-cycle emissions are highest, and thereby understates the Off-Cycle NOX emissions by a significant margin.

The assumption of equal VMT distributions by roadway and vehicle class is the default MOBILE6 assumption. However, user specific inputs to the program can override this assumption and different values can be entered for each vehicle type. Thus, if the user has good data on VMT distribution by vehicle class for the area they which to model, they can utilize it, and potentially obtain a more accurate result. See the MOBILE6 User's Guide for more details on how to enter alternative VMT distribution and a sample alternate VMT distribution.

3.8 MOBILE6 HDDV Speed Correction Factors

In this analysis, speed correction factors are used only to model the effect of speed on the heavy-duty emissions which are associated with "without off-cycle operation." The "with off-cycle operation heavy-duty emission factors" implicitly contain speed correction factors, and need no additional speed correction. Thus, the component of the off-cycle emission factor is not corrected for speed. This implicit relationship is an assumption that the off-cycle operation emission effects inherently contain all of the remaining speed related NOX emission effects that occur as the result of vehicle operation outside of the certification test cycle, and the certification cycle's average speed of 20 MPH. The basis for this assumption is that the off-cycle operation effects are a strong function of speed and typically only occur during the steady-state higher speed activity of the trucks. Also, based on the limited test and engineering data, it is not feasible to separate off-cycle operation NOX emission effects from normal speed correction NOX emission effects.

The average speed for each roadway type is used to calculate the NOX speed correction factors. The speed correction factor equation used in this analysis is the standard MOBILE6 equation for heavy-duty diesels. It is not a function of roadway type. The speed correction factors are calculated for each of the roadway types by inserting the appropriate average speed into Equation 1 below:

NOX Speed CF = 0.676 - 0.0480*speed + 0.00071*speed**2 Eqn 1a

'**2' means squared.

3.9 Calculations

The calculation of the HDDV off-cycle effects in MOBILE6 are quite simple. They are shown in the Appendix in the section with the FORTRAN code. They are also shown for a given roadway and vehicle class type using equation 1b. The overall off-cycle effect is the product of the base off-cycle effect in grams per mile and the fleet fraction that produce off-cycle emissions and the percent of time a vehicle class spends in off-cycle mode for a given roadway.

Off-Cycle(g/bhp-hr) = BASE Off-Cycle Effect * Fleet Penetration Frac * Time spent in Mode(iroad) Eqn1b

Where

BASE Off-Cycle Effect are the average NOx off-cycle emission increases on a per vehicle (discussed in Section 3.4).

Fleet Penetration Frac are the fraction of the fleet by vehicle class that is capable of producing off-cycle NOX emissions. (Section 3.5)

Time Spent in Mode(iroad) is the time that a given vehicle spends in Off-cycle mode for a given roadway type (iroad). Section 3.5 discusses this concept.

3.10 Rebuild Program Inputs to the Excess NOX Emission Spreadsheet Model

Most heavy-duty diesel engines are rebuilt after their initial useful life has elapsed. Typically, this occurs between the 500,000 mile and 1,000,000 mile points, and often includes replacing engine parts that affect NOX emissions. The practice of rebuilding is considerably more cost-effective to the truck owner than scrapping the engine. Because the rebuild practice is so widespread, the engine manufacturing industry agreed as part of the Consent Decree to rebuild a portion of the fleet in such a way as to reduce the effect of the off-cycle operation on rebuilt engines. This NOX excess spreadsheet model will reflect the effects of the rebuild program.

The following parameters are defined and used in the MOBILE6 and MOBILE5 spreadsheet models to account for rebuilds.

Rebuild Fraction - This is the fraction of the eligible fleet that will be rebuilt. Currently this fraction is assumed to be 0.90.

Model Year Range - Two options were available in the consent decree. The one which is modeled in the spreadsheet model includes only the 1994 through 1998 model years. The other rebuild option (not modeled) includes the 1993 model year.

After Rebuild Emission Level - This is the NOX emission level that the rebuilt engines will emit in units of g/bhp-hr, and is set equal to 6.00 g/bhp-hr. These were conservative values because the consent decree set these standards as "not-to-exceed" levels.

Years of Use Before Rebuild - This is the number of years prior to the first rebuild.

12 years for a medium duty
5 years for a 8a truck
5 years for a 8b truck

Also, no rebuild credit is given before calendar year 2000. Thus, a 1994 model year 8b engine will not be lowered to the 6.00 g/bhp-hr standard upon its first rebuild in 1999.

The effects of rebuild are implemented in the model by replacing the With Off-cycle operation Emission levels with the rebuild emission level of 6.00 g/bhp-hr on the fraction of the fleet that is rebuilt. The default value for the fraction of the fleet that is rebuilt is 90% of the 1994 through 1998 model years.

4.0 Results from MOBILE6

The MOBILE6 model was run after adding the HDDV off-cycle emission factors and parameters. The results are presented in this section as a series of five graphs for HDD Class 8a and Class 8b vehicles. The complete results including the underlying data and figures can be found in the Excel Spreadsheet Offcycleresults.xls. All of the results are shown in terms of emission factors in units of grams per mile. Thus, they should not be confused with inventory type presentations which are often in units of 'tons' and reflect assumptions about total vehicle miles traveled.

Each of the five figures shows a different aspect of HDDV Off-Cycle NOX emissions as a function of Calendar Year. The Y-axis of the figures is in terms of average NOX emissions for a given calendar year for either the 8A or 8B truck class. Because it is an average calendar year result, it contains a weighted distribution of 25 individual vehicle model years. Thus, the 2020 calendar year result contains vehicle emission results from model years 1995 through 2020.

Figures 4.1 and 4.2 show the HDDV NOX emissions versus calendar year for class 8a and class 8b, respectively. These figures include the total NOX emissions from these vehicles, not just the off-cycle emission portion. The "No Offcycle" line shows what the average NOX emissions of a heavy-duty diesel vehicle would be if the HDDV Off-Cycle Nox emissions had never existed. The "Default M6" line shows the contribution of the Off-Cycle emissions and the effects of the Pull Ahead and Rebuild Programs at lowering the Off-cycle NOX emission impact. The remaining two lines "w/o Pull Ahead" and "w/o Pull or Rebuild" show what the total Nox emissions would be if Pull Ahead was not implemented, and if neither Pull Ahead or Rebuild were implemented.

Comparing the "No Offcycle" line with the line entitled "Default M6" shows a sizeable increase in NOX emissions during calendar years 1990 through 2002. After that time, the off-cycle emissions begin to be phased out, and the "No Offcycle" line and the "Default M6" line begin to converge together. The figures also show the moderately higher emission levels that result if Pull Ahead and Rebuild are not done. This is particularly true in the time frame of calendar year 2000 through 2006.

Figure 4.3 shows the HDDV NOX off-cycle emissions as a function of calendar year and vehicle class 8a or 8b. The figure shows that the bulk of the off-cycle emissions are produced from calendar year 1990 through 2005. It also shows a slightly higher emission factor for the 8b vehicle class versus the 8a vehicle class. Figures 4.4 and 4.5 show the HDDV NOx off-cycle emission reductions due to Pull Ahead and Rebuild, respectively. As can be seen from the figures, the Nox emission reductions for the two programs (Pull Ahead and Rebuild) are similar in magnitude, and during their peak years reduce the NOX HDDV emission factors by about 2.0 grams per mile versus a peak Off-cycle emission factor of about 9 grams per mile.

Figures were not generated for medium duty diesel vehicles although some off-cycle emissions are generated by these vehicles. This was done because the off-cycle NOx emission effects are generally small. The necessary data do exist in the attached spreadsheet Offcycleresults.xls to generate such figures. This is left to the reader.

Figure 4.1
MOBILE6 HDDV Class 8A NOx Emissions versus Calendar Year

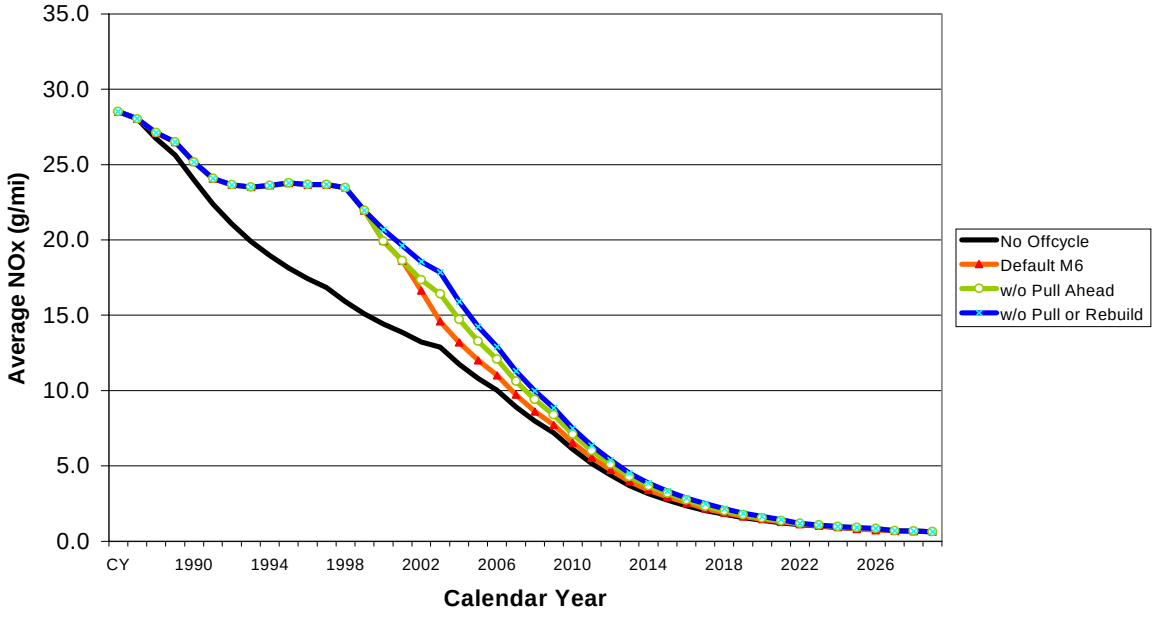


Figure 4.2
MOBILE6 HDDV Class 8B NOx Emissions versus Calendar Year

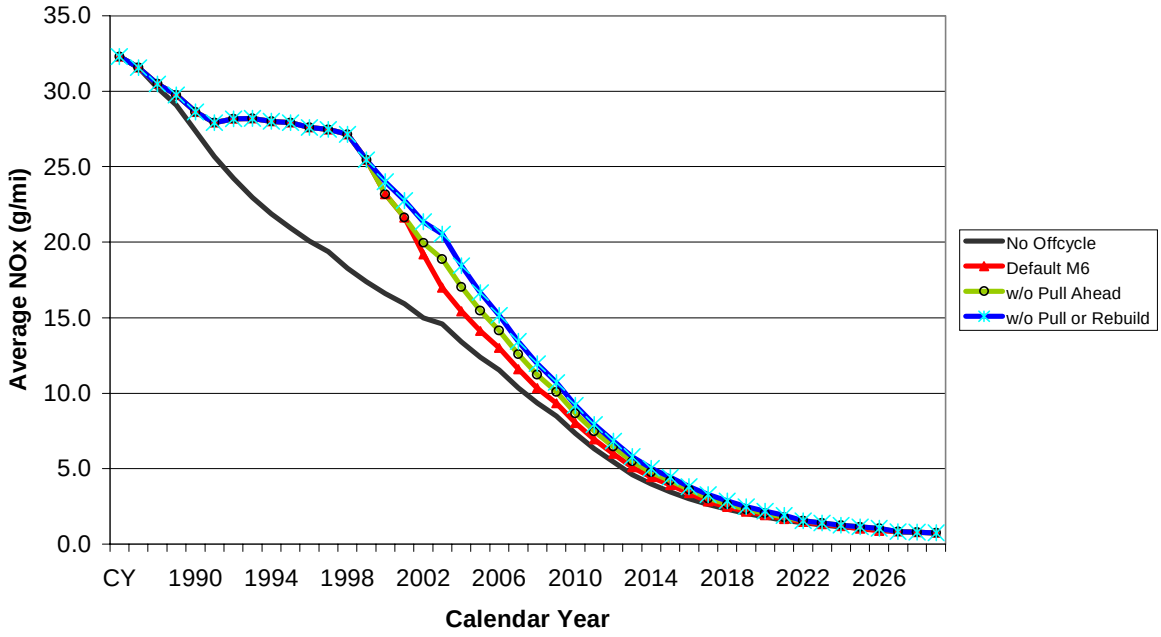


Figure 4.3
Total Off-Cycle NOx Emission Effect by Calendar Year
for Two Vehicle Classes

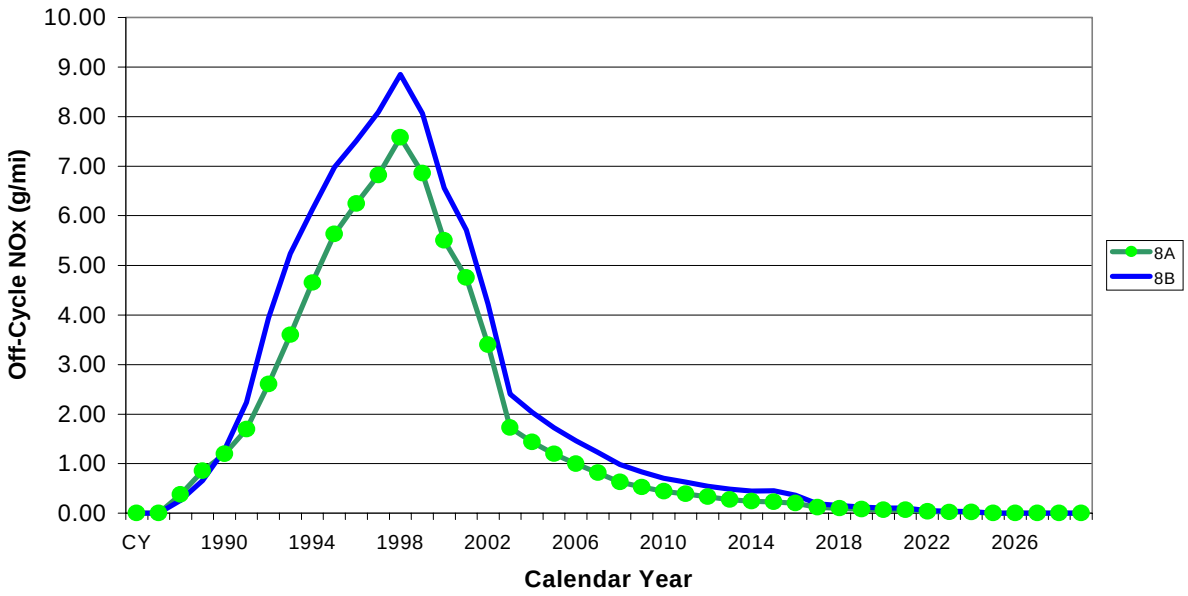


Figure 4.4
Effect of HDDV PULL-AHEAD on NOx Emissions by Calendar Year
for Two Vehicle Classes

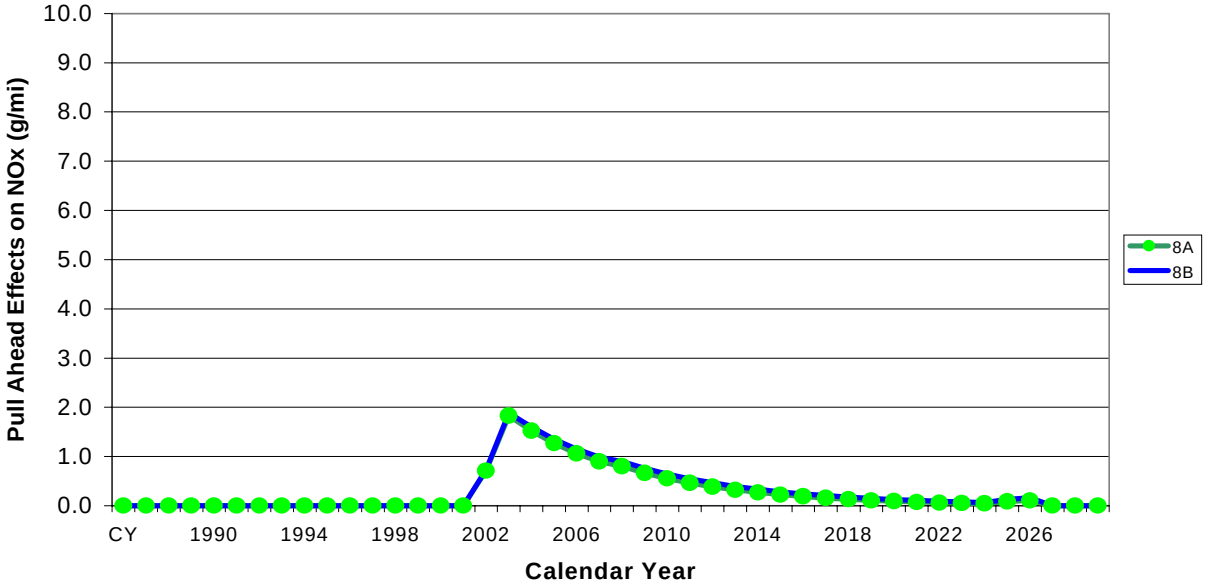
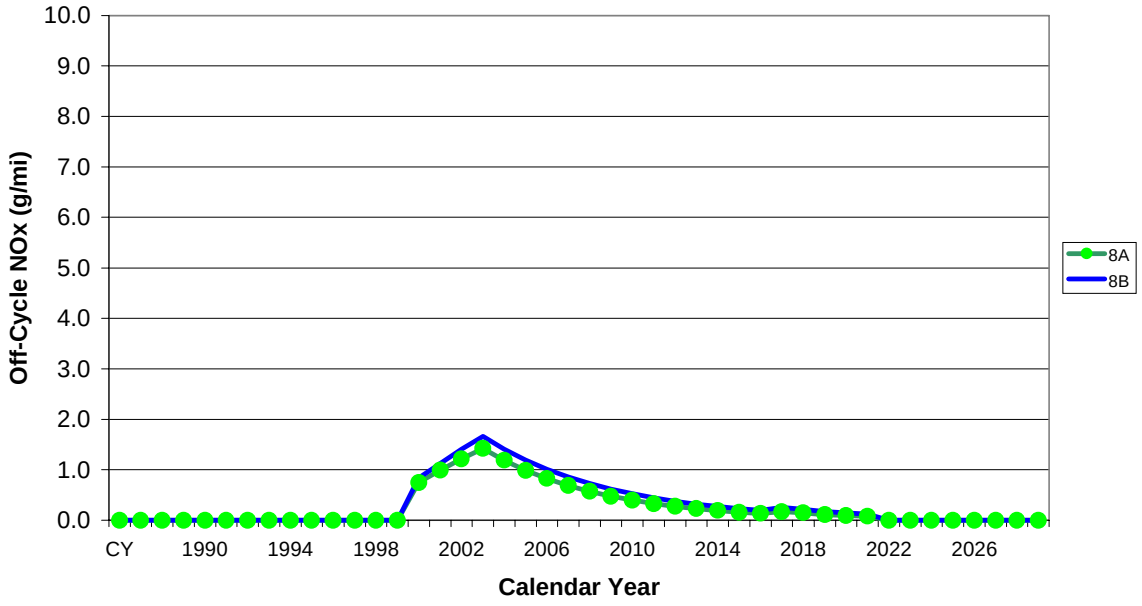


Figure 4.5
Effect of HDDV REBUILD on NOx Emissions by Calendar Year
for Two Vehicle Classes



Appendix A
Changes From Document M6.HDE.003

The EPA document DRAFT M6.HDE.003 discusses the methodology for modeling the heavy-duty diesel off-cycle emissions. The methodology and parameters mentioned in that document are very similar to those presented in this current document FINAL M6.HDE.003. Although the previous sections of M6.HDE.003 contain the new parameters and methodology, they are not explicitly presented. This Appendix re-presents these new parameters in a brief, but more explicit fashion.

A.1 The DRAFT M6.HDE.003 document and the associated Excel spreadsheets discussed spreadsheet models which could be used to model the effect of the heavy-duty diesel vehicle Off-Cycle NOx emissions. This current document FINAL M6.HDE.003 focuses on this task through the context of the MOBILE6 model, and thereby supercedes the previous spreadsheet models.

A.2 The previous spreadsheet model DRAFT M6.HDE.003 allowed alternative VMT distributions by vehicle class and roadway to be used. The current default MOBILE6 uses the same roadway VMT distribution for all classes. However, the user is allowed to enter alternate distributions.

A.3 The data parameters for Pull Ahead have been modified as a result of this new version. The vehicles are now assumed to be at a 6.00 g/bhp-hr standard for 2002 and 2003 model years.

A.4 Rebuild was previously assumed to reduce an engine from off-cycle emission levels down to 7.00 g/bhp-hr. This limit has now been lowered from 7.00 g/bhp-hr to 6.00 g/bhp-hr.

A.5 Off-cycle operation was assumed to end in the 2000 calendar year. It has now been extended to the 2001 calendar year.

A.6 8B engines were originally assumed to be rebuilt after 3 years of use. This has now been raised to 5 years of use.

Appendix B
Response of Stakeholder Comments

Only one set of significant stakeholder comments were received for this document. These comments were provided by David Piech of Navistar Corporation. In this section, the stakeholder comment will be paraphrased and a brief reply or explanation provided. For a complete record of the comment please see the MOBILE6 stakeholder comments archive.

1. The stakeholder claims that the draft version of this document incorrectly states that the excess emissions are from 'defeat devices'. Instead he recommends the phrase 'alleged defeat devices' to describe the source of the excess emissions.

   EPA agrees that our original nomenclature is in error. Consequently, the term 'defeat device' was replace with the term 'off-cycle operation' throughout the document. If time permits, it may also be eliminated from the MOBILE6 input command structure.

2. Navistar knows of no 'official' EPA heavy-duty defeat device inventory emission results prepared by OECA.

   EPA agrees and the word 'official' has been dropped.

3. The report fails to identify the source of the alleged defeat device activation estimates. Neither the report nor associated spreadsheets provide any background information as to the magnitude of the emissions associated with the disputed device nor the time or miles spent in such modes.

   EPA agrees that this information is the cornerstone of the NOX off-cycle emission factor preparation, and that this information is not available in the report. However, the information in question is proprietary to specific companies (contains potential trade secrets), and it cannot be published by EPA in this document.

4. The report inaccurately incorporates the defeat device prohibition, and provides an incorrect definition of a defeat device.

   EPA agrees that the definition as stated is not stated accurately. It has been removed from the text, and a new one has been substituted.

5. EPA incorrectly assumed that the disputed device had widespread utilization on most medium and light duty engines.

   This statement has been changed. A more accurate statement would read 'virtually no light heavy duty engines and few medium duty engines contained the disputed device.

6. EPA failed to incorporate reductions in correction factors (CF) since 1995.

   The correction factors which were used are the standard correction factors used in MOBILE6. These correction factors can be found in EPA report M6.HDE.004 'Update Heavy-Duty Engine Emission Conversion Factors for MOBILE6 Analysis of BSFCs and Calculation of Heavy-Duty Engine Emission Conversion Factors'

7. EPA's disputed device penetration for medium duty engines in 1998, 1999, and 2000 is wrong.

   The 100% value for disputed device penetration in these years in the spreadsheet is to activate the pull ahead requirements. EPA is aware that the fleet penetration of the disputed devices is not 100% and this has been corrected.

8. The report's use of VMT data is unclear

   The MOBILE6 model contains its own values for VMT distribution, and allows specific user input data. The built-in data have been updated for MOBILE6, and may not be exactly the same as those used in the report

9. The report fails to account for the speed relationship between the disputed devices and emissions.

   No good data were available on which to develop a speed relationship between the disputed devices Thus, it was assumed that the off-cycle emissions already contained the effects of speed.

12. The reports assumptions on the rebuild program are wrong.

    This is probably correct. An assumption that 90% of fleet will be rebuilt within a few years is probably not realistic. However, this number was provided by OECA. The MOBILE6 model also allows for a user supplied value that can range from 0 to 100%. The report also assumes that consent degree emission factor will be a NTE standard of 6.0 bhp-hr, and that the composite vehicle will emit on average at 6.0 bhp-hr. This is fairly pessimistic because if the NTE is 6.0 then the average may be lower.

```
       SUBROUTINE DEFEAT(MY,ICY,IV,IROAD,DDNOX)
C
C  Changes: (Last change first)
C
C 13 Feb 01 @EPA-elg    Added bus category to IVV determination.
C 08 Feb 01 @EPA-elg    Changed logic for IMY mapping for the NO PULL AHEAD
C                       case and removed RETURN. Added logic to include
C                       IRBLD, IRBSTRT and IRBEND to rebuild calculation.
C 01 May 00 @EPA- BG    Removed use of DATA statement initializations
C 22 Dec 99 @Dyntel-nh  1-004 removed diagnostic parameters and references.
C 07 Dec 99 @DynTel-NH  1-004  added subroutine DEFEAT_STAT
C 25 Oct 99 @DynTel-NH  1-004  New for the HDDV defeat task
C
C..Rebuild modeling options using variable IBUILD.
C    IBUILD = 0  -  Default option - Rebuild effects are included at a
C                                    90% penetration for MY 1994-98
C    IBUILD = 1  -  No Rebuild effects are included.
C    IBUILD = 2  -  Rebuild effects are included for MY 1994-98 at a
C                   user specified level (RBLEV).
C
C    IPULL = 0   -  Default option - Pull ahead effects are included for
C                   MY 2002 and 2003. Negative emission increases.
C    IPULL = 1   -  Pull ahead effects are not included for MY 2002 and
C                   2003.  Defeat device effects are equal to MY 2001 effects.
C
C
      USE DDDATA
C
      IMPLICIT NONE
C
      INTEGER, INTENT(IN) :: MY
      INTEGER, INTENT(IN) :: ICY
      INTEGER, INTENT(IN) :: IV
      INTEGER, INTENT(IN) :: IROAD

      INTEGER :: IMY, IVV                      ! Local variables
C
      REAL, INTENT(OUT) :: DDNOX
C
      REAL :: DDNOXX                           ! Local variables
C
C
      DDNOX=0.0
      IF(MY.LT.1988.OR.MY.GT.2003.OR.ICY.LT.1988.OR.
     *   IROAD.EQ.4) THEN
        DDNOX = 0.0                            ! Out of Range: No defeat device
effects
        RETURN
      ENDIF
C
      IF(MY.GE.2004) THEN
         IMY = 1
      ELSEIF(MY.LE.1987) THEN
         IMY = 18
      ELSE
         IMY = 2004 - MY + 1
      ENDIF
C
      IF((MY.EQ.2002.OR.MY.EQ.2003).AND.IPULL.EQ.1) THEN
        IMY = 2004 - 2001 + 1      ! Always takes 2001 value for no pull ahead.
      ENDIF
C
      IF(IV.GE.16.AND.IV.LE.19) THEN !was OR
         IVV = 1
```

```
      ELSEIF(IV.EQ.20.OR.IV.EQ.21) THEN
         IVV = 2
      ELSEIF(IV.EQ.22) THEN
         IVV = 3
      ELSEIF(IV.EQ.23) THEN
         IVV = 4
      ELSEIF(IV.EQ.26.OR.IV.EQ.27) THEN
         IVV = 5
      ENDIF
C
C     The base NOx excess does not contain rebuild effects.
C
      DDNOXX=NEFFCT(IMY,IVV)
C
C     Effect of rebuilds:
C     No rebuilds can occur before calendar year 2000 because
C     the defeat device litigation had not yet been concluded.
C
      IF(ICY.GT.2000) THEN
        IF(MY.GE.IRBSTRT.OR.MY.LE.IRBEND) THEN
          IF(ICY.GT.MY+IRBLD(IVV)) THEN
            IF(IBUILD.EQ.2) THEN
              DDNOXX = RBLEV *
     *               ((RBLD(IMY,IVV)-0.10*NEFFCT(IMY,IVV))/0.90)
     *              + (1-RBLEV)*NEFFCT(IMY,IVV)
            ELSEIF(IBUILD.EQ.1) THEN
              DDNOXX = NEFFCT(IMY,IVV)
            ELSE
              DDNOXX = RBLD(IMY,IVV)
            ENDIF
          ENDIF
        ENDIF
      ENDIF
C
C    Effects are adjusted for defeat device activation by roadway and percentage
C     of defeat device engines in the fleet.
C
      IF(IROAD.EQ.1) THEN
         DDNOX = DDNOXX * FLEET(IMY,IVV) * URBAN(IMY,IVV)
      ELSEIF(IROAD.EQ.2) THEN
         DDNOX = DDNOXX * FLEET(IMY,IVV) * ARTERL(IMY,IVV)
      ELSEIF(IROAD.EQ.3) THEN
         DDNOX = DDNOXX * FLEET(IMY,IVV) * EXPRES(IMY,IVV)
      ENDIF
C
C
      RETURN
      END

      SUBROUTINE RBEFFCTS(INPREC,INERR,RC)
C
C Changes last first
C
C 18 Oct 1999 @Duntel-nh. New subroutine added to set DDDATA module variable
IBUILD
C                        when "REBUILD EFFECTS" label or "NO REBUILD" label is
C                         found in input file.
C
C Called by DSPTCH
C
C Calls NXTTOK
C
C Argument List
C
```

```
C CHARACTER*(*) INPREC   record from input file
C INTEGER       INERR
C INTEGER       RC
C MODULE DDDATA variables
C
C INTEGER       IBUILD
C REAL          RBLEV
C
C Local variables
C
C CHARACTER*10  STR1  Return string from NXTTOK
C INTEGER       PTR1  Returned index from NXTTOK
C INTEGER       PTR2  INDEX for search in NXTTOK
C REAL          DELTA Used for REAL xero comparisons
C
      USE DDDATA
      IMPLICIT NONE
      CHARACTER*(*) INPREC
      INTEGER INERR
      INTEGER RC
      CHARACTER*10 STR1
      INTEGER PTR1,PTR2
      REAL, PARAMETER :: DELTA=0.000001
C
      IF(INDEX(INPREC,'REBUILD EFFECTS')>0) THEN
        IBUILD=2
        PTR2=21
        CALL NXTTOK(INPREC,STR1,PTR1,PTR2)
        READ(STR1,'(F4.0)')RBLEV
        IF ((ABS(RBLEV).LT.DELTA).OR.(RBLEV.GT.0.90)) THEN
           CALL QUITER(0.0,0,191,INERR)
        END IF
      ELSEIF(INDEX(INPREC,'NO REBUILD')>0)THEN
        IBUILD=1
      ELSEIF(INDEX(INPREC,'NO DEFEAT')>0)THEN
        DEFEAT_FLAG=.FALSE.
      ENDIF
      RC=0
      RETURN
      END SUBROUTINE

      SUBROUTINE NOXPUL(RC)
C
C CHANGES LAST FIRST
C
C 07 Jul 00 AIR Task 05: Removed unused INPREC and INERR from parameter list.
C 18 OCT 1999 @DYNTEL-NH. NEW SUBROUTINE ADDED TO SET DDDATA MODULE VARIABLE
IPULL
C                          WHEN "NO NOX PULL AHEAD" LABEL FOUND IN INPUT FILE
C CALLED BY DSPTCH
C
C ARGUMENT LIST
C
C INTEGER       RC
C
C MODULE DDDATA VARIABLES
C
C INTEGER       IPULL
C REAL          RBLEV
C
      USE DDDATA
      IMPLICIT NONE
      INTEGER RC
      IPULL=1
```

```
      RC=0
      RETURN
      END SUBROUTINE

      SUBROUTINE INIDEFEAT()
C
C CALLED BY REINIT TO RESET DEFAULT VALUES FOR EACH RUN.
C MODULE DDDATA VARIABLES
C
C INTEGER       IPULL
C INTEGER       IBUILD
C REAL          RBLEV
      USE DDDATA
      IMPLICIT NONE
      IPULL=0
      IBUILD=0
      RBLEV=0.90
      DEFEAT_FLAG=.TRUE.
      FIRST_DEFEAT=.TRUE.
      RETURN
      END SUBROUTINE

      LOGICAL FUNCTION DEFEAT_DEVICE()
      USE DDDATA
      IMPLICIT NONE
      DEFEAT_DEVICE=DEFEAT_FLAG
      END

      SUBROUTINE DEFEAT_STAT(IOUREP)
C
C
C CHANGES LAST FIRST
C
C 22 DEC 99 @DYNTEL-NH. INCREASED VERBOSITY OF MESSAGES TO REPORT FILE.
C 08-DEC-1999 @DYNTEL-NH. NEW SUBROUTINE ADDED TO REPORT DEFEAT OPTIONS.
C
C CALLED BY HRLOOP TO REPORT DEFEAT OPTIONS TO REPORT FILE
C
C MODULE DDDATA VARIABLES
C
C INTEGER       IPULL
C INTEGER       IBUILD
C REAL          RBLEV
C
C ARGUMENT LIST
C
C INTEGER IOUREP LOGICAL DEVICE NUMBER FOR REPORT FILE
C
C OUTPUTS
C
C STATUS TO REPORT FILE
C
      USE DDDATA
      IMPLICIT NONE
      INTEGER IOUREP
      IF (IPULL.EQ.1) THEN
         WRITE(IOUREP,
     C    '(" NO HDDV DEFEAT DEVICE PULL AHEAD EFFECTS ARE PRESENT.")')
      END IF
      SELECT CASE (IBUILD)
          CASE (1)
            WRITE(IOUREP,
     C       '( " NO HDDV DEFEAT DEVICE REBUILD PROGRAM IN EFFECT." )')
          CASE (2)
```

```
       WRITE(IOUREP,'( " HDDV DEFEAT DEVICE EFFECTS ARE PRESENT. ",
C             "THE REBUILD FRACTION IS ",F4.2,"." )')RBLEV
     CASE DEFAULT
 END SELECT
 IF (.NOT. DEFEAT_FLAG) THEN
    WRITE (IOUREP,
C    '(" NO HDDV DEFEAT DEVICE EFFECTS ARE PRESENT.")')
 END IF
 END SUBROUTINE
```

```
      MODULE DDDATA
C
C
C  Changes: (Last change first)
C
C 13 Feb 01 @EPA-elg    Added bus category to each array.
C 13 Feb 01 @EPA-elg    Changed Pull Ahead Emission Delta to reflect
C                       Changes in the underlying emission factors.
C 09 Feb 01 @EPA-djb    Updated IRBLD, NEFFCT, RBLD & FLEET values.
C                       Added IRBSTRT and IRBEND variables.
C 01 May 00 @EPA- BG    Removed use of DATA statement initializations
C 28 Apr 00 @EPA-elg    Corrected 8A Vehicle FLEET block data.
C 06 Dec 99 @DynTel-bg  1-004  defined logical variable FIRST_DEFEAT
C 19 Oct 99 @DynTel-NH  1-004  New for the HDDV defeat task
C
C  Dimension 18 reflects the MY's and 4 reflects the vehicle classes.
C  In RBLD - 7 reflects the MY's and 4 reflects the vehicle classes.
C
C  Values for NEFFCT are the increase in NOx emission levels
C  as the result of the heavy-duty NOx defeat device.
C
C  Light duty includes all diesel except classes 6,7,8a and 8b.
C
C..First entry is for model year 2004.  Last entry is
C  model year 1987 and earlier.  Negatives reflect Pull ahead effects.
C  Value of Zero is assigned if no Pull Ahead or effect.  There are no
C  effects for model years 2004+ or 1987 and earlier.
C
C..URBAN is the fraction of the time that the defeat device operates
C  when an equipped vehicle is operating in Urban type driving.
C
C..ARTERL is the fraction of the time that the defeat device operates
C  when an equipped vehicle is operating in Arterial type driving.
C
C..EXPRES is the fraction of the time that the defeat device operates
C  when an equipped vehicle is operating in Expressway type driving.
C
C..FLEET is the fraction of the fleet that is equipped with a defeat
C  device.
C
C..First year is 1999+ and last is 1993 and earlier.
C  Rebuilds only in 1994 through 1998 MYs for Plan A.
C..7.00 g/bhp-hr is the rebuild emission target for HDD8a and HDD8b.
C..6.00 g/bhp-hr is the rebuild emission target for MDDV.
C  Rebuild effect is the difference between the value and 7.00 or the
C  value and 6.00.
C
C..IRBLD is the age of a vehicle when the first rebuild is done.
C  parameters are available for the four vehicle classes.
C  These parameters are currently implicit in the results;  thus,
C  the array IRBLD is not currently used in Defeat.
C
C..IRBSTRT is the first model year where defeat device effects are
C  rebuilt. Rebuilds are affected by IRBLD parameters.
C
C..IRBEND is the last model year where defeat device effects are rebuilt.
C
C
      IMPLICIT NONE
      SAVE
C
      INTEGER, PARAMETER :: NCY = 18
      INTEGER, PARAMETER :: NVCLS = 5
C
```

```
      REAL                        :: RBLEV=0.90
      INTEGER                     :: IBUILD=0
      INTEGER                     :: IPULL=0
      LOGICAL                     :: DEFEAT_FLAG
      LOGICAL                     :: FIRST_DEFEAT
C
      INTEGER, DIMENSION(NVCLS)   :: IRBLD=(/ 99, 12, 5, 5, 99 /)
      INTEGER                     :: IRBSTRT=1994
      INTEGER                     :: IRBEND=1998
C
      REAL, DIMENSION(18,5) :: NEFFCT=RESHAPE((/
C  LIGHT DIESELS
     *0.0000, -1.1400, -0.2850, 0.0000, 0.000,
     *0.0000,  0.0000,  0.0000, 0.0000,
     *0.0000,  0.0000,  0.0000, 0.0000,
     *0.0000,  0.0000,  0.0000, 0.0000, 0.000,
C  MEDIUM DIESELS (CLS 6 & 7)
     * 0.0000, -1.5700,-0.3925, 0.0000, 0.0000,
     * 1.3533,  3.3623, 2.7163, 2.7408,
     * 2.9136,  2.4900, 2.5700, 0.0680,
     * 0.0680,  0.7890, 1.5000, 1.5000, 0.0000,
C  8A HEAVY-DUTIES
     * 0.0000, -1.5600,-0.3900, 2.3200, 2.3200,
     * 2.3200,  8.2377, 7.1143, 6.9407,
     * 7.1260,  6.9118, 7.4985, 7.9025,
     * 8.8713,  8.3125, 8.9200, 8.9200, 0.0000,
C  8B HEAVY-DUTIES
     * 0.0000, -1.5600,-0.3900, 2.3200, 2.3200,
     * 2.3200,  8.2617, 7.2067, 6.9501,
     * 7.1022,  6.8980, 7.3978, 7.7489,
     * 8.8179,  7.8961, 8.9200, 8.9200, 0.0000,
C  DIESEL BUSES
     *0.0000, -1.1400, -0.2850, 0.0000, 0.000,
     *0.0000,  0.0000,  0.0000, 0.0000,
     *0.0000,  0.0000,  0.0000, 0.0000,
     *0.0000,  0.0000,  0.0000, 0.0000, 0.000/),(/18,5/))
C
C
      REAL, DIMENSION(18,5) :: RBLD=RESHAPE((/
C  LIGHT DIESEL
     *0.0000, -1.6300, -0.4075, 0.0000, 0.000,
     *0.0000,  0.0000,  0.0000, 0.0000,
     *0.0000,  0.0000,  0.0000, 0.0000,
     *0.0000,  0.0000,  0.0000, 0.0000, 0.000,
C  MEDIUM DIESELS (CLS 6 & 7)
     * 0.0000, -1.8500,-0.4625, 0.0000, 0.0000,
     * 1.3533,  2.3152, 1.4226, 1.4251,
     * 1.4424,  1.4000, 2.5700, 0.0680,
     * 0.0680,  0.7890, 1.5000, 1.5000, 0.0000,
C  8A HEAVY-DUTIES
     * 0.0000,-1.8400, -0.4600, 2.3200, 2.3200,
     * 2.3200,  3.8118, 2.8624, 2.8451,
     * 2.8636,  2.8422, 7.4985, 7.9025,
     * 8.8713,  8.3125, 8.9200, 8.9200, 0.0000,
C  8B HEAVY-DUTIES
     * 0.0000, -1.8400,-0.4600, 2.3200, 2.3200,
     * 2.3200,  3.8142, 2.8717, 2.8460,
     * 2.8612,  2.8408, 7.3978, 7.7489,
     * 8.8179,  7.8961, 8.9200, 8.9200, 0.0000,
C  BUSES
     *0.0000, -1.6300, -0.4075, 0.0000, 0.000,
     *0.0000,  0.0000,  0.0000, 0.0000,
     *0.0000,  0.0000,  0.0000, 0.0000,
     *0.0000,  0.0000,  0.0000, 0.0000, 0.000/),(/18,5/))
```

```
C
C
      REAL, DIMENSION(18,5) :: URBAN=RESHAPE((/
C  LIGHT DIESEL
     *0.0000,  1.0000,  1.0000, 0.0000, 0.000,
     *0.0000,  0.0000,  0.0000, 0.0000,
     *0.0000,  0.0000,  0.0000, 0.0000,
     *0.0000,  0.0000,  0.0000, 0.0000, 0.000,
C  MEDIUM DIESELS (CLS 6 & 7)
     * 0.0000,  1.0000,  1.0000, 0.0009, 0.0009,
     * 0.0009,  0.0009, 0.0042, 0.0049,
     * 0.0692,  0.1200, 0.1200, 0.0000,
     * 0.0000,  0.0000, 0.0000, 0.0000,  0.0000,
C  8A HEAVY-DUTIES
     * 0.0000,  1.0000,  1.0000, 0.0210, 0.0210,
     * 0.0210,  0.0210, 0.0083, 0.0107,
     * 0.0468,  0.0341, 0.0271, 0.0188,
     * 0.0295,  0.0612, 0.0000, 0.0000,  0.0000,
C  8B HEAVY-DUTIES
     * 0.0000,  1.0000,  1.0000, 0.0267, 0.0267,
     * 0.0267,  0.0267, 0.0116, 0.0115,
     * 0.0487,  0.0362, 0.0299, 0.0216,
     * 0.0363,  0.0753, 0.0000, 0.0000,  0.0000,
C  DIESEL BUSES
     *0.0000,  1.0000,  1.0000, 0.0000, 0.000,
     *0.0000,  0.0000,  0.0000, 0.0000,
     *0.0000,  0.0000,  0.0000, 0.0000,
     *0.0000,  0.0000,  0.0000, 0.0000, 0.000/),(/18,5/))
C
C
      REAL, DIMENSION(18,5) :: ARTERL=RESHAPE((/
C  LIGHT DIESEL
     * 0.0000,  1.0000,  1.0000, 0.0000, 0.000,
     * 0.0000,  0.0000,  0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000, 0.000,
C  MEDIUM DIESELS (CLS 6 & 7)
     * 0.0000,  1.0000,  1.0000, 0.2000, 0.2000,
     * 0.2000,  0.2000, 0.0385, 0.0247,
     * 0.3516,  0.6100, 0.6100, 0.0000,
     * 0.0000,  0.0000, 0.0000, 0.0000,  0.0000,
C  8A HEAVY-DUTIES
     * 0.0000,  1.0000,  1.0000, 0.3651, 0.3651,
     * 0.3651,  0.3651, 0.3592, 0.3399,
     * 0.4022,  0.3704, 0.4080, 0.4392,
     * 0.5095,  0.5093, 0.6600, 0.6600,  0.0000,
C  8B HEAVY-DUTIES
     * 0.0000,  1.0000,  1.0000, 0.3949, 0.3949,
     * 0.3949,  0.3949, 0.3881, 0.3511,
     * 0.4130,  0.3825, 0.4103, 0.4384,
     * 0.5188,  0.4810, 0.6600, 0.6600,  0.0000,
C  DIESEL BUSES
     * 0.0000,  1.0000,  1.0000, 0.0000, 0.000,
     * 0.0000,  0.0000,  0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000, 0.000/),(/18,5/))
C
      REAL, DIMENSION(18,5) :: EXPRES=RESHAPE((/
C  LIGHT DIESEL
     * 0.0000,  1.0000,  1.0000, 0.0000, 0.000,
     * 0.0000,  0.0000,  0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000, 0.000,
C  MEDIUM DIESELS (CLS 6 & 7)
```

```
     * 0.0000,  1.0000,  1.0000, 0.8220, 0.8220,
     * 0.8220,  0.8220, 0.5026, 0.5396,
     * 0.9249,  0.9800, 0.9800, 0.0000,
     * 0.0000,  0.0000, 0.0000,  0.0000,
C  8A HEAVY-DUTIES
     * 0.0000,  1.0000,  1.0000, 0.9225, 0.9225,
     * 0.9225,  0.9225, 0.9154, 0.9153,
     * 0.9439,  0.9357, 0.9510, 0.9568,
     * 0.9023,  0.8925, 0.9800, 0.9800,  0.0000,
C  8B HEAVY-DUTIES
     * 0.0000,  1.0000,  1.0000, 0.9377, 0.9377,
     * 0.9377,  0.9377, 0.9373, 0.9285,
     * 0.9533,  0.9478, 0.9625, 0.9697,
     * 0.9064,  0.8756, 0.9800, 0.9800,  0.0000,
C  DIESEL BUSES
     * 0.0000,  1.0000,  1.0000, 0.0000, 0.000,
     * 0.0000,  0.0000,  0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000, 0.000/),(/18,5/))
C
C
      REAL, DIMENSION(18,5) :: FLEET=RESHAPE((/
C  LIGHT DIESELS
     * 0.0000,  0.0000,  0.0000, 0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000, 0.0000,
C  MEDIUM DIESELS (CLS 6 & 7)
     * 0.0000,  0.4000,  0.4000, 1.0000, 1.0000,
     * 1.0000,  1.0000,  0.4950, 0.2470,
     * 0.0592,  0.0120,  0.0060, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000, 0.0000,
C  8A HEAVY-DUTIES
     * 0.0000,  1.0000,  1.0000, 1.0000, 1.0000,
     * 1.0000,  1.0000,  1.0000, 1.0000,
     * 1.0000,  1.0000,  0.7590, 0.5780,
     * 0.2900,  0.2110,  0.1860, 0.1300, 0.0000,
C  8B HEAVY-DUTIES
     * 0.0000,  1.0000,  1.0000, 1.0000, 1.0000,
     * 1.0000,  1.0000,  1.0000, 1.0000,
     * 1.0000,  1.0000,  1.0000, 0.9940,
     * 0.4680,  0.3400,  0.1510, 0.0880, 0.0000,
C  DIESEL BUSES
     * 0.0000,  0.7500,  0.7500, 0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000,
     * 0.0000,  0.0000,  0.0000, 0.0000, 0.0000/),(/18,5/))
C
      END MODULE DDDATA
```