

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL VEHICLE AND FUEL EMISSIONS LABORATORY
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ANN ARBOR, MICHIGAN 48105-2498

Feb 25, 1999

MEMORANDUM

SUBJECT: Updating the PART5 Model

TO: Docket A-97-10

FROM: Edward Glover, Engineer
 Scientific Assessment Group

This memo and its attachments document the modifications to the Part5 particulate model for use in the Tier2 inventory modeling. Three principal modifications were performed. All three were relatively minor in their effects. The modifications were:

1. Updating the Heavy-duty conversion factors
2. Use of Alternative MOBILE6 Mileage Accumulation and Registration Distribution Rates
3. Change in the FORTRAN code to allow the Sulfate emissions to vary as a function of gasoline sulfur level.

1.0 Heavy-duty Conversion Factors

The heavy-duty conversion factors are used to convert the emission results from units of grams per brake horsepower-hour into units of grams per mile. These factors are based on testing heavy-duty vehicles on both engine dynamometers and chassis dynamometers. They are necessary because most of the heavy-duty testing is engine testing and produces emission results in grams per brake horsepower-hour whereas Part5 outputs emission results for subsequent modeling in units of grams per mile.

For this task, the existing heavy-duty conversion factors in the Part5 model were updated with new conversion factors based on some recent testing. These new numbers will also be used in the new EPA MOBILE6 emission factor model. For comparison, the existing Part5 numbers are based on the EPA MOBILE5 emission factor model.

Attachment A-1 and B-1 show in FORTRAN code format the heavy-duty conversion factors for Part5 and the modified Part5 (Part5b), respectively. Comparison of the two tables shows that not all of the conversion factors have been updated. The changes reflect new data where it was available. If no data were available for a particular model year, then the conversion factor was not changed.

2.0 Alternative Mileage Accumulation and Registration Distribution Rates

Alternative mileage accumulation and registration rates were used for the Tier2 particulate modeling. The new rates were not updated in the model but attached to the input file as user inputs. A sample input file containing the new rates is shown in Attachment B.

Like the conversion factors, the alternative mileage and registration distributions are based on the MOBILE6 model and reflect new data. The existing Part5 mileage accumulations and registration rates are based on MOBILE5.

3.0 FORTRAN Code Changes

The Part5 FORTRAN code was changed to allow the direct sulfate emission factor to be a function of gasoline sulfur content. In the current Part5 model direct sulfate emissions are insensitive to fuel sulfur levels.

Equation 1 was used to calculate the direct sulfate emission as a function of fuel sulfur content and fuel economy.

$$\text{DCSULF} = 13.6079 * (1+\text{Water}) * \text{FDNSTY} * \text{GSWGTR} * \text{DCNVRT} / \text{FECONM} \quad \text{Eqn 1}$$

Where:

DCSULF is the direct sulfate emission factor.

FDNSTY is the density of the gasoline fuel.

Water is the weight ratio of seven water molecules to sulfate.

GSWGTR is the gasoline sulfur ratio by weight.

DCNVRT is the percent of sulfur exhausted that is directly converted into sulfuric acid.

FECONM is the fuel economy.

It is applied in Part5b using a two step process. The first step is to calculate a base sulfate emission factor at a fuel sulfur level of 0.034% wt using Equation 1. This fuel sulfur level was chosen because it is the baseline level at which the basic vehicle/engine emission testing was done. The next step is to calculate the sulfate emission factor using Equation 1 at the fuel sulfur level of interest, and take the ratio of the two sulfate emission levels (see Equation 2). This ratio is then applied subsequent in the code after speed and vehicle class effects are applied to calculate the final sulfate emission levels. As a result of this process, the sulfate emissions are proportional to the gasoline sulfur level.

$$\text{Ratio} = \text{DCSULF}(\text{fuel Sulfur X\%}) / \text{DCSULF}(0.034\%) \quad \text{Eqn 2}$$

Attachment C shows the Part5 FORTRAN code which was modified. The subroutine which was modified is GASSLF. Shown in Bold type are the changes/additions to the code.

Attachment A-1
Default Part5 Conversion Factors

C

C Gpbhp to gpm units conversion factors

C

C For HDDV

C

DATA HDCD2B/

* 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
* 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
* 0.000, 0.942, 0.923, 0.923, 0.922, 0.921, 0.919, 0.919, 0.919,
* 0.919, 0.919, 0.919, 0.919, 0.919, 0.919, 0.919, 0.919, 0.919,
* 0.919, 0.919, 0.919/

C

DATA HDCDLH/

* 2.161, 2.161, 2.161, 2.161, 2.161, 2.161, 2.161, 2.161, 2.161,
* 2.161, 2.161, 2.161, 2.009, 1.879, 1.762, 0.000, 0.000, 0.000,
* 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
* 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
* 0.000, 0.000, 0.000/

C

DATA HDCDMH/

* 2.606, 2.603, 2.602, 2.604, 2.601, 2.636, 2.640, 2.670, 2.702,
* 2.744, 2.784, 2.820, 2.840, 2.923, 2.960, 2.746, 2.544, 2.469,
* 2.139, 2.394, 2.183, 2.744, 2.403, 2.301, 2.596, 2.019, 2.267,
* 2.264, 2.259, 2.256, 2.248, 2.253, 2.252, 2.251, 2.253, 2.250,
* 2.249, 2.249, 2.247/

C

DATA HDCDHH/

* 3.074, 3.074, 3.074, 3.074, 3.074, 3.138, 3.138, 3.205, 3.205,
* 3.275, 3.275, 3.275, 3.326, 3.299, 3.353, 3.402, 3.361, 3.307,
* 3.332, 3.255, 3.152, 3.150, 3.141, 3.138, 3.129, 3.129, 3.129,
* 3.129, 3.129, 3.129, 3.129, 3.129, 3.129, 3.129, 3.129, 3.129,
* 3.129, 3.129, 3.129/

C

DATA HDCBUS/

* 2.937, 2.937, 2.938, 2.938, 2.937, 2.939, 3.060, 3.119, 3.153,
* 3.088, 3.285, 3.082, 2.908, 3.020, 2.881, 2.930, 2.947, 2.932,
* 2.948, 3.008, 2.967, 3.012, 2.941, 2.791, 2.730, 2.728, 2.711,
* 2.692, 2.675, 2.667, 2.659, 2.653, 2.643, 2.641, 2.642, 2.634,
* 2.635, 2.636, 2.640/

C

C Oct-20-1993 @ ARC-bsg Subtask 325 expanded BUS conversion factors

C

DATA HBUST1 /39*3.3/

DATA HBUST2 /39*7.9/

DATA HBUST3 /39*18.1/

C

DATA LOWYR,MAXCIG/1962,39/

C

END

Attachment A-2
Modified Conversion Factors

C

C Gpbhp to gpm units conversion factors

C

C For HDDV

C

DATA HDCD2B/

* 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
* 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000, 0.000,
* 0.000, 0.942, 0.923, 0.923, 0.922, 0.921, 0.919, 1.105, 1.103,
* 1.101, 1.099, 1.097, 1.095, 1.094, 1.093, 1.091, 1.090, 1.090,
* 1.090, 1.090, 1.090/

C

DATA HDCDLH/

* 2.161, 2.161, 2.161, 2.161, 2.161, 2.161, 2.161, 2.161, 2.161,
* 2.161, 2.161, 2.161, 2.009, 1.879, 1.762, 1.762, 1.762, 1.762,
* 1.762, 1.762, 1.762, 1.762, 1.762, 1.762, 1.762, 1.377, 1.373,
* 1.369, 1.365, 1.361, 1.358, 1.355, 1.352, 1.349, 1.346, 1.346,
* 1.346, 1.346, 1.346/

C

DATA HDCDMH/

* 2.606, 2.603, 2.602, 2.604, 2.601, 2.636, 2.640, 2.670, 2.702,
* 2.744, 2.784, 2.820, 2.840, 2.923, 2.960, 2.746, 2.544, 2.469,
* 2.139, 2.394, 2.183, 2.744, 2.403, 2.301, 2.596, 2.019, 2.267,
* 2.264, 2.259, 2.256, 2.248, 2.253, 2.252, 2.251, 2.253, 2.250,
* 2.249, 2.249, 2.247/

C

DATA HDCDHH/

* 3.074, 3.074, 3.074, 3.074, 3.074, 3.138, 3.138, 3.205, 3.205,
* 3.275, 3.275, 3.275, 3.326, 3.299, 3.353, 3.402, 3.361, 3.307,
* 3.332, 3.255, 3.152, 3.150, 3.141, 3.138, 3.129, 3.198, 3.168,
* 3.138, 3.110, 3.082, 3.054, 3.028, 3.001, 2.976, 2.951, 2.951,
* 2.951, 2.951, 2.951/

C

DATA HDCBUS/

* 2.937, 2.937, 2.938, 2.938, 2.937, 2.939, 3.060, 3.119, 3.153,
* 3.088, 3.285, 3.082, 2.908, 3.020, 2.881, 2.930, 2.947, 2.932,
* 2.948, 3.008, 2.967, 3.012, 2.941, 2.791, 2.730, 2.728, 2.711,
* 2.692, 2.675, 2.667, 2.659, 2.653, 2.643, 2.641, 2.642, 2.634,
* 2.635, 2.636, 2.640/

C

C Oct-20-1993 @ ARC-bsg Subtask 325 expanded BUS conversion factors

C

DATA HBUST1 /39*3.3/

DATA HBUST2 /39*7.9/

DATA HBUST3 /39*18.1/

C

DATA LOWYR,MAXCIG/1962,39/

C

END

Attachment B Alternative Mileage Accumulations and Registration Distributions

| | |
|--|-------------|
| .14910 .14174 .13475 .12810 .12178 .11577 .11006 .10463 .09947 .09456 .08989 .08546 .08124 .07723 .07342 .06980 .06636 .06308 .05997 .05701 .05420 .05152 .04898 .04656 .04427 | LDGV miles |
| .19496 .18384 .17308 .16267 .15260 .14289 .13352 .12451 .11584 .10752 .09955 .09194 .08467 .07775 .07118 .06496 .05909 .05356 .04839 .04357 .03909 .03497 .03120 .02777 .02470 | LDGT1 miles |
| .21331 .19865 .18500 .17228 .16044 .14942 .13915 .12959 .12068 .11239 .10466 .09747 .09077 .08453 .07872 .07331 .06827 .06358 .05921 .05514 .05135 .04782 .04454 .04148 .03863 | LDGT2 miles |
| .20112 .18813 .17602 .16470 .15413 .14427 .13505 .12645 .11841 .11090 .10388 .09732 .09120 .08548 .08012 .07512 .07045 .06608 .06199 .05817 .05460 .05126 .04813 .04521 .04248 | HDGV miles |
| .04786 .04475 .04164 .03853 .03543 .03232 .02921 .02611 .02300 .01989 .01678 .01368 .00000 .00000 .00000 .00000 .00000 .00000 .00000 .00000 .00000 .00000 .00000 .00000 .00000 | MC miles |
| .14910 .14174 .13475 .12810 .12178 .11577 .11006 .10463 .09947 .09456 .08989 .08546 .08124 .07723 .07342 .06980 .06636 .06308 .05997 .05701 .05420 .05152 .04898 .04656 .04427 | LDDV miles |
| .26720 .24262 .22033 .20012 .18177 .16513 .15004 .13634 .12390 .11262 .10238 .09307 .08463 .07696 .07000 .06367 .05792 .05270 .04796 .04364 .03973 .03616 .03293 .02998 .02731 | LDDT miles |
| .27137 .24831 .22721 .20791 .19024 .17407 .15928 .14575 .13336 .12203 .11166 .10217 .09349 .08555 .07828 .07163 .06554 .05997 .05488 .05021 .04595 .04204 .03847 .0352 .03221 | HD2b miles |
| .31955 .28852 .2607 .23574 .21333 .19321 .17511 .15884 .14419 .13099 .11911 .10838 .0987 .08995 .08205 .0749 .06842 .06256 .05725 .05242 .04804 .04406 .04044 .03714 .03414 | LHDDV miles |
| .40681 .36872 .3342 .30291 .27455 .24885 .22555 .20443 .18529 .16795 .15222 .13797 .12505 .11335 .10273 .09312 .0844 .0765 .06933 .06284 .05696 .05163 .04679 .04241 .03844 | MHDDV |
| 1.132271.02229 .92305 .83348 .75264 .67967 .61382 .55436 .5007 .45224 .4085 .36901 .33335 .30115 .27207 .24581 .2221 .20068 .18134 .16387 .14808 .13383 .12095 .10931 .0988 | HHDDV |
| .16033 .15784 .15543 .15309 .15083 .14865 .14653 .14448 .14249 .14057 .13871 .13691 .13516 .13347 .13184 .13026 .12872 .12724 .12581 .12441 .12307 .12177 .12050 .11928 .1181 | Buses |
| .036 .072 .072 .072 .072 .071 .070 .069 .067 .064 .060 .055 .047 .037 .029 .023 .018 .015 .012 .009 .007 .006 .005 .004 .010 | LDGV reg. |
| .040 .079 .078 .077 .076 .074 .071 .067 .062 .057 .051 .044 .038 .031 .025 .020 .015 .011 .009 .008 .008 .008 .007 .007 .037 | LDGT1 reg. |
| .040 .075 .070 .065 .061 .057 .053 .049 .046 .043 .040 .037 .035 .032 .030 .028 .026 .024 .023 .021 .020 .018 .017 .016 .075 | LDGT2 reg. |
| .060 .081 .074 .068 .063 .058 .054 .049 .046 .042 .039 .036 .033 .031 .028 .026 .024 .022 .020 .019 .017 .016 .015 .014 .063 | HDGV reg. |
| .144 .168 .135 .109 .088 .070 .056 .045 .036 .029 .023 .097 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 .000 | MC reg. |
| .036 .072 .072 .072 .072 .071 .070 .069 .067 .064 .060 .055 .047 .037 .029 .023 .018 .015 .012 .009 .007 .006 .005 .004 .010 | LDDV reg. |
| .040 .079 .078 .077 .076 .074 .071 .067 .062 .057 .051 .044 .038 .031 .025 .020 .015 .011 .009 .008 .008 .008 .007 .007 .037 | LDDT reg. |
| .050 .092 .083 .076 .069 .063 .057 .052 .047 .043 .039 .036 .032 .029 .027 .024 .022 .020 .018 .017 .015 .014 .013 .011 .050 | 2B |
| .059 .084 .077 .070 .065 .059 .055 .050 .046 .042 .039 .036 .033 .030 .028 .025 .023 .022 .020 .018 .017 .015 .014 .013 .060 | LHDD |

.075 .070 .065 .061 .057 .053 .050 .047 .044 .041
.038 .036 .034 .031 .029 .027 .026 .024 .022 .021
.020 .018 .017 .016 .077
.075 .070 .065 .061 .057 .053 .050 .047 .044 .041
.038 .036 .034 .031 .029 .027 .026 .024 .022 .021
.020 .018 .017 .016 .077
.038 .071 .067 .064 .060 .057 .054 .051 .048 .046
.043 .041 .039 .037 .034 .030 .026 .023 .021 .019
.018 .016 .015 .014 .067

MHDD

HHDD

Buses

Attachment C
Modified Part5 Fortran Code
(Modifications are shown in Bold)

```

SUBROUTINE GASSLF( ICY,MY, IV,DSULF, ISULF,SO2)
C
C Called by: EFCALX
C
C Calls TAMPER, LEDPTR
C
C Input on call:
C   parameter list: ICY, MY, IV
C   common blocks:
C
C Output on return: DSULF,ISULF,SO2
C
C Local variable dictionary:
C
C   Name      Type      Description
C   -----
C CTLFRC     R          Catalyst fraction for a given IV and MY
C DCSULF     R          Direct calculation of sulfate emissions based upon the
C               fuel sulfur content and the fuel economy.
C DSULFC     R          Direct sulfate emission factor for catalyst vehicles
C DSLFCL     R          19.6 MPH or slower D-sulf for catalyst unleaded vehicles
C DSLFCH     R          34.8 MPH or faster D-sulf for catalyst unleaded vehicles
C DSULFN     R          Direct sulfate emission factor for noncatalyst vehicles
C DSULF      R          Direct sulfate emission factor for fleet average gasoline
C               vehicle
C DSUFNL     R          No cat no lead direct sulfur emissions term
C DUMMY      R          Used as a dummy parameter in call to TAMPER
C FCNVRC     R          Estimated percent of sulfur that is converted to sulfate
C               in a catalyst vehicle
C FCNVRN     R          Estimated percent of sulfur that is converted to sulfate
C               in a noncatalyst vehicle
C HDNLTM     R          Heavy Duty Gasoline Vehicle No-lead Not-catalyst equipped
C               term
C ISULFC     R          Estimated indirect sulfate from catalyst vehicles
C ISULFN     R          Estimated indirect sulfate from noncatalyst vehicles
C ISULF      R          Estimated indirect sulfate emission factor
C IFRAC      I          MY Pointer to catalyst fraction array
C IYPT       I          Discretionary fuel switching index variable
C SO2C       R          Gaseous sulfur emissions from catalyst vehicles
C SO2N       R          Gaseous sulfur emissions from noncatalyst vehicles
C SO2        R          Gaseous sulfur emission factor
C
C
C Notes:
C Oct-13-1993 @ ARC-bsg Subtask 325 change code to remove warning
C Jan-31-1994 @ CSC-bsg Request 390 New Sulfate equations added ICY
C parameter to GASSLF because RMIS is calculated from a call to
C NLCONS which requires ICY. RMIS is used in the new equations.
C Feb-7-1994 @ CSC-bsg Request 390 modified the calculation of catalyst
C fractions. They now come from the sum of four block data numbers.
C Eliminated the need for a call to GETPTR to get the catalyst fractions.
C Feb-10-1994 @ CSC-bsg Request 390 Modified calculation of CATFRC to
C include RMIS and remove RMIS from sulfate calculation
C Mar-9-1994 @ CSC-bsg Request 401 Add user input variables for
C sulfur weight percent for gasoline and diesel fuel or default values
C Mar-9-1994 @ CSC-bsg Request 402 Change Sulfate calculation to include
C DFS term
C Mar-22-1994 @ CSC-bsg Request 409 Changed SULFLG to RFGFLG
C Apr-7-1994 @ CSC-bsg Request 418 Removed Particle sizes from sulfur
C
C
C   INCLUDE 'PARAM.INC'
C   INCLUDE 'LEAD.INC'
C   INCLUDE 'FRACT.INC'
C   INCLUDE 'FLAGS.INC'

```



```

        INCLUDE 'PSIZE.INC'
        INCLUDE 'SCENE.INC'
        INCLUDE 'DFSBLK.INC'
C
        REAL ISULF,ISULFC,ISULFN
C
C The base sulfate emission factors come from
C EPA 460/3-85-005, "Size Specific Total Particulate Emission Factors
C for Mobile Sources"
C
C Oct-13-1993 @ ARC-bsg Subtask 325 change code to remove warning
C
        IF (IV.GT.5) THEN
            DSULF = 0.
            ISULF = 0.
            SO2   = 0.
            GOTO 99
        ENDIF
C
C Feb-7-1994 @ CSC-bsg Request 390 modified the calculation of catalyst
C fractions. They now come from the sum of four block data numbers.
C Get the model year pointer to the catalyst fraction array
C
        IF (MY.LT.1968) THEN
            IFRAC = 1
        ELSE IF (MY.GE.1968.AND.MY.LE.1971) THEN
            IFRAC = 2
        ELSE IF (MY.LE.1991) THEN
            IFRAC = 3 + (MY - 1972)
        ELSE
            IFRAC = 22
        ENDIF
C
C Jan-31-1994 @ CSC-bsg Request 390 New Sulfate equations Get the
C misfueling rates:
C
        CALL TAMPER(ICY, MY, IV, DUMMY, RMIS)
C
C Mar-9-1994 @ CSC-bsg Request 402 Change Sulfate calculation to include
C DFS term -- determine discretionary fuel switching index variable.
C
        CALL LEDPTR(IYPT,IV,MY)
C
C Feb-10-1994 @ CSC-bsg Request 390 Modified calculation of CATFRC to
C include RMIS and remove RMIS from sulfate calculation.
C Get the catalyst fraction of the gasoline vehicle population.
C
        CTLFRC = (FRACA(IFRAC,1,IV)+FRACA(IFRAC,2,IV)+
        2          FRACA(IFRAC,3,IV)+FRACA(IFRAC,4,IV))*(1.-RMIS)
C
C For each Vehicle Type get the corresponding fuel economy
C
        FECONM = FLECON(MY,IV)
C
C Mar-9-1994 @ CSC-bsg Request 401 Add user input variables for
C sulfur weight percent for gasoline and diesel fuel or default values
C
CC        SWGHT = GSWGHT
        FDNSTY = GDENS
C
C Compute the grams/mile emission factor of the direct sulfate material:
C
C 13.6079 = (453.592 * 3.)/100.
C where: 453.592 = number of grams in a pound
C         3       = weight ratio of SO4 to sulfur
C and the division by 100 is to correc for GSWGTR the gasoline weight
C ratio of sulfur content in fuel.
C
C WATER = weight ratio of seven water molecules to sulfate
C (see p. 6-25 of "Regulatory Impact Analysis,
C Control of Sulfur and Aromatics Contents of On-
C Highway Diesel Fuel")

```

```

C      FDNSTY = fuel density in lbs/gallon
C      FECONM = fuel economy
C      GSWGTR = gasoline weight ratio of sulfur content in fuel
C      DCONVRT = percent of sulfur exhausted that is directly converted
C              into sulfuric acid.
C
C
C      Equation 1: This is the equation that is used to calculate direct
C      sulfate as a function of the sulfur content and fuel economy:
C      (used for calculating the fraction of sulfur in the fuel that
C      gets converted to sulfate, DCONVRT.
C
C
C.. NEW CODE FOR SULFATE CALCULATION
C
C      D1SULF = 13.6079*(1.+ WATER)*FDNSTY*GSWGTR*DCONVRT/FECONM
C
C      D2SULF = 13.6079*(1.+ WATER)*FDNSTY * 0.0340 *
C      *
C              DCONVRT/FECONM
C
C      RATSUL = D1SULF / D2SULF
C
C
C      IF(IV.NE.4) THEN
C
C      Jan-31-1994 @ CSC-bsg Request 390 New Sulfate equations
C      Calculation for LDGV, LDGT1, LDGT2, MC
C      Calculate the direct sulfate for catalyst and noncatalyst vehicles:
C      Feb-10-1994 @ CSC-bsg Request 390 Modified calculation of CATFRC to
C      include RMIS and remove RMIS from sulfate calculation
C
C      IF (SPD.LE.19.6) THEN
C
C      Mar-9-1994 @ CSC-bsg Request 402 Change Sulfate calculation to include
C      DSUFNL term
C      Mar-22-1994 @ CSC-bsg Request 409 Changed SULFLG to RFGFLG removed
C      user input for sulfur weight
C
C      DSUFNL = .002
C      DSULFN = .002
C      DSULFC =
C      2      (FRACA(IFRAC,1,IV)+FRACA(IFRAC,3,IV))* .005
C      3      +(FRACA(IFRAC,2,IV)+FRACA(IFRAC,4,IV))* .016
C
C      ELSE IF (SPD.GE.34.8) THEN
C      DSULFN = .001
C      DSULFC =
C      2      (FRACA(IFRAC,1,IV)* .005
C      3      +FRACA(IFRAC,3,IV)* .001
C      4      +FRACA(IFRAC,2,IV)* .020
C      5      +FRACA(IFRAC,4,IV)* .025 )
C      ELSE
C
C      Interpolate for speeds between 19.6 and 34.8
C
C      DSULFN = ((.002-.001)*(SPD-19.6)/(19.6-34.8)+.002)
C      DSLFCL =
C      2      ((FRACA(IFRAC,1,IV)+FRACA(IFRAC,3,IV))* .005
C      3      +(FRACA(IFRAC,2,IV)+FRACA(IFRAC,4,IV))* .016)
C      DSLFCH =
C      2      (FRACA(IFRAC,1,IV)* .005
C      3      +FRACA(IFRAC,3,IV)* .001
C      4      +FRACA(IFRAC,2,IV)* .020
C      5      +FRACA(IFRAC,4,IV)* .025 )

```

```

        DSULFC = (DSLFCL-DSLFCH)*(SPD-19.6)/(19.6-34.8)+DSLFCL
C
C end of interpolation section
C
        ENDIF

        DSULF = ( CTLFRC*DSULFC + (1. - CTLFRC)*DSULFN ) * RATSUL
C
C
CC      IF(ICY.EQ.1995.AND.IV.EQ.1) WRITE(11,201) IV,ICY,MY,SPD(1),
CC      *CTLFRC,DSULFC,DSULFN,DSULF
CC201  FORMAT(' IV  ICY  MY SPEED  CTLFRC  DSULFC  DSULFN  DSULF'/
CC      *I3,I5,I5,F5.1,1X,4F9.6)
C
C end of non-HDGV section
C
        ELSE IF(IV.EQ.4) THEN
C
C HDGV code goes here
C
        DSULFN = .006*(5.0/FECONM)
        DSULFC = (.048)*(5.0/FECONM)
C
C Mar-9-1994 @ CSC-bsg Request 402 Change Sulfate calculation to include
C DSUFNL term
C
        IF(SPD.LE.19.6) THEN
            DSUFNL = 0.002
        ELSEIF(SPD.GE.34.8) THEN
            DSUFNL = 0.001
        ELSE
C
C Interpolate for speeds between 19.6 and 34.8
C
            DSUFNL = ((.002-.001)*(SPD-19.6)/(19.6-34.8)+.002)
        ENDIF
C
C end of HDGV section
C Sum the contributions from catalyst and noncatalyst vehicles:
C Jan-31-1994 @ CSC-bsg Request 390 New Sulfate equations
C Mar-9-1994 @ CSC-bsg Request 402 Change Sulfate calculation to include
C DFS term
C
        DSULF = ( CTLFRC*DSULFC + (1.-CTLFRC)*DSULFN*(1.-DFS(IYPT,IV))
2          + (1. - CTLFRC)*DSUFNL*DFS(IYPT,IV) ) * RATSUL
        ENDIF
C
C
C Calculate the fraction of sulfur in the fuel that was converted
C to sulfate (based on Equation 1 above) for catalyst and non-
C catalyst vehicles:
C
FCNVRC = DSULFC*RATSUL*FECONM/(13.6079*(1.+WATER)*FDNSTY*GSWGTR)
FCNVRN = DSULFN*RATSUL*FECONM/(13.6079*(1.+WATER)*FDNSTY*GSWGTR)
C
C Compute the exhausted SO2:
C
C 9.072 = (453.592 * 2.)/100.
C where: 453.592 = number of grams in a pound
C         2. = weight ratio of SO2 to sulfur
C and the division by 100 is to correct for GSWGTR the gasoline weight
C ratio of sulfur content in fuel
C

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SO2C = 9.072*FDNSTY*GSWGTR*(1.-FCNVRC)/FECONM
SO2N = 9.072*FDNSTY*GSWGTR*(1.-FCNVRN)/FECONM
SO2 = CTLFRC*SO2C + (1.-CTLFRC)*SO2N
C
C      3./2. = weight ratio of SO2 to SO4
C      AMNWGT = the estimated weight ratio of the combination of
C                ammonium bisulfate and ammonium sulfate in the
C                atmosphere to SO4 (see p 6-25).
C
C      Compute the estimated sulfate material that is formed in the
C      in the atmosphere due to the SO2 emissions:
C
C      ISULFC = ICNVRT * SO2C * (3./2.) * AMNWGT
C      ISULFN = ICNVRT * SO2N * (3./2.) * AMNWGT
C
C      Feb-10-1994 @ CSC-bsg Request 390
C      Changed to make consistent with direct sulfates
C
CC     ISULF = CTLFRC*ISULFC*PSNLCT + (1.-CTLFRC)*ISULFN*PSC
C      ISULF = CTLFRC*ISULFC + (1.-CTLFRC)*ISULFN
C
99     RETURN
      END

```