

Technical Report

Heavy-Duty Engine Testing Report

Correlation Testing of Cummins NTCC-400

By

Thomas M. Baines

October, 1986

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Standards Development and Support Branch  
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Office of Mobile Sources  
Office of Air and Radiation  
U. S. Environmental Protection Agency

## I. Background

EPA has performed several testing programs on Cummins engines for the purpose of providing correlation data to compare the EPA and Cummins laboratories. One such program was in June of 1985 and the engine was an NTCC-400. The engine was subsequently returned to Cummins where further testing was performed which enlarged the data base on this engine. This engine was then scheduled to be sent to Southwest Research Institute (SwRI) for inclusion in the Coordinating Research Council (CRC) VE-1 fuels study.

The SwRI/CRC study is being performed on four medium- and heavy-duty diesel engines (calibrated for 5.0 g/BHP-hr NOx) and six fuel compositions of varying aromaticity to investigate how these parameters influence gaseous and particulate exhaust emissions. This study is of special importance to EPA as it will be heavily relied upon for EPA's fuel sulfur effects information.

Work on this project was temporarily suspended by the CRC committee due to SwRI measuring HC 20 percent lower than Caterpillar on the first engine (a Caterpillar 3406 B). EPA then suggested that no further work be done until a broader set of correlation questions could be answered. EPA concerns relate to the most recent EPA/SwRI correlation work in which a Daimler-Benz HDD was tested at EPA and then shipped to SwRI. SwRI measured 20 percent lower HC and CO, 13 percent lower particulate, 16 percent higher NOx, 9 percent higher fuel consumption and 5 percent higher actual power.

Since the Cummins NTCC-400 was already planned to be part of the SwRI/CRC fuels study, and since the engine already had an extensive emissions test data base, it was decided that it should be the next engine to be tested at SwRI. However, before shipment to SwRI it was judged to be in the best interests of EPA and the CRC project to re-check the emissions levels of the engine at the EPA emissions testing facility. This was done and the purpose of this report is to discuss the results of this EPA testing.

## II. Engine, Fuels and Test Plan

The engine used for this testing was a Cummins NTCC-400. This 400 horsepower engine is designed for the California 5.0 g/BHP-hr NOx standard and incorporates a Mechanical Variable Timing (MVT) system. This system senses boost pressure and changes injection timing from advanced to retarded when load is applied to the engine (i.e., at a given boost pressure). This system is easily configured to operate normally or in continuously advanced or continuously retarded modes. Thus three levels of HC, NOx and particulate are easily obtainable from this engine.

All previous EPA testing (June, 1985) was performed on EPA's batch of Phillips "DOE Reference" fuel known as batch G-075. The engine was returned to Cummins and there it was tested on Cummins in-house fuel, Cummins "Cert." fuel and on some G-075 fuel that EPA shipped to them in barrels. By the time the engine was returned to EPA, EPA had run out of G-075 and replaced it with a new batch of Phillips "DOE Reference" fuel, known as batch G-463. The bulk of EPA testing was performed on the "current" fuel, i.e., G-463. Some additional testing was performed on the old EPA fuel (G-075) and the Cummins "Cert" fuel for additional correlation data to compare to Cummins data.

The two batches of Phillips fuel are very similar in their properties. The new batch is three percent lower in Cetane Number and slightly lower in weight percent sulfur. The remainder of the properties are practically identical. The property analysis results of both fuels are presented in Table 1.

The test plan called for a set of 3 cold/hot transient tests to establish the "certification" type emission levels. The remainder of the work was with hot starts and included normal, advanced and retarded timing, all with the current EPA fuel (G-463). Hot start transients were also run on the old EPA fuel (G-075) and the Cummins "cert." fuel. Steady state data were obtained using the current EPA and Cummins "Cert." fuel.

### III. Results

The results of this work are presented in Table 2 through 10. The reader is encouraged to review these tables, using the following narrative to assist in interpreting the data highlights contained therein.

Table 2 presents the torque lug map and resultant integrated reference horsepower. Comparing the current map to the previous EPA map it can be seen that the engine produced slightly less torque throughout the range, resulting in less integrated reference horsepower. The EPA torque map and the Cummins torque map are very similar in the region between peak torque speed (1300 RPM) and rated speed (2100 RPM). However, between 1000 and 1200 RPM there are some large differences between the maps. This is because this is a very steep part of the torque curve and minor differences in engine operation (pre-conditioning, etc.) can lead to large apparent differences in the torque map. Never the less, the integrated reference horsepowers are very close.

Table 3 presents the cold/hot combination "certification" type results from this engine. As can be seen from this data, the engine meets its design goals of less than 5 g/BHP-hr NO<sub>x</sub> at a particulate level less than 0.6 g/BHP-hr. It also has HC and CO levels below their respective standards. The coefficients of variability are very good for all measurements

Table 1

Table of Property Analysis  
 Results for Previous EPA  
 Diesel Test Fuel (G-075)  
 and Current EPA Diesel Test  
 Fuel (G-463)

| <u>Property</u>                      | <u>Phillips Analysis Results</u> |       |
|--------------------------------------|----------------------------------|-------|
|                                      | G-463                            | G-075 |
| Cetane Number                        | 44.8                             | 46.2  |
| Cetane Index                         | 46.7                             | N/A*  |
| Distillation Range                   |                                  |       |
| IBP, °F                              | 374                              | 375   |
| 10%, °F                              | 429                              | 431   |
| 50%, °F                              | 506                              | 505   |
| 90%, °F                              | 591                              | 598   |
| EP, °F                               | 634                              | 653   |
| Sulfur, wt. %                        | 0.31                             | 0.35  |
| Aromatics, minimum                   | 32.3                             | 32.1  |
| Flashpoint, °F minimum               | 155                              | 162   |
| Viscosity, centistokes @ 40° C       | 2.43                             | 2.52  |
| Gravity, °API, 60°F                  | 35.1                             | 35.2  |
| Copper Strip Corrosion, maximum      | No. 1                            | N/A   |
| Oxidation Stability, mg/100 ml, max. | 0.4                              | N/A   |
| Cloud Point, Maximum, °F             | 8                                | N/A   |
| Particulate matter, maximum, mg/l    | 1.7                              | N/A   |
| Carbon Density, grams carbon/gal.    | 2782                             | N/A   |
| Net Heat of Combustion, BTU/lb.      | 19435                            | N/A   |

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\* Not available.

Table 2

Table of Torque Map  
Values and Resultant  
Reference BHP-Hr  
for Cummins NTCC-400  
Correlation Engine

| <u>Speed</u>        | <u>Current EPA</u> | <u>Previous EPA</u> |                | <u>Cummins</u> |                |
|---------------------|--------------------|---------------------|----------------|----------------|----------------|
|                     | <u>Torque</u>      | <u>Torque</u>       | <u>% Diff.</u> | <u>Torque</u>  | <u>% Diff.</u> |
| 677                 | 514                | 517                 | 0.6            | 517            | 0.6            |
| 777                 | 510                | 550                 | 7.8            | 523            | 2.5            |
| 877                 | 529                | 594                 | 12.3           | 555            | 4.9            |
| 977                 | 583                | 691                 | 18.5           | 583            | 0.0            |
| 1077                | 828                | 1098                | 32.6           | 608            | -26.6          |
| 1177                | 1172               | 1189                | 1.5            | 1025           | -12.5          |
| 1277                | 1221               | 1238                | 1.4            | 1221           | 0.0            |
| 1377                | 1240               | 1256                | 1.3            | 1229           | -0.9           |
| 1477                | 1215               | 1236                | 1.7            | 1211           | -0.3           |
| 1577                | 1186               | 1202                | 1.3            | 1177           | -0.8           |
| 1677                | 1146               | 1160                | 1.2            | 1139           | -0.6           |
| 1777                | 1113               | 1128                | 1.3            | 1105           | -0.7           |
| 1877                | 1088               | 1095                | 0.6            | 1076           | -1.1           |
| 1977                | 1061               | 1070                | 0.8            | 1051           | -0.9           |
| 2077                | 1027               | 1040                | 1.3            | 1024           | -1.5           |
| 2177                | 817                | 830                 | 1.6            | 792            | -4.6           |
| 2277                | 246                | 336                 | 36.6           | 172            | -48.8          |
| 2377                | -191               | -178                |                | -356           |                |
| Reference<br>BHP-Hr | 26.736             | 27.356              | 2.3%           | 26.7           | -0.1%          |

Table 3

Table of Composite Transient  
 Test Results From  
 Cummins NTCC-400  
 Correlation Engine  
 Standard Timing, EPA Fuel (G-463)

| Test<br>No | Emissions, g/BHP-hr. |      |      |       | BSFC,<br>lb/BHP-hr. | Actual<br>Work,<br>BHP-hr. |
|------------|----------------------|------|------|-------|---------------------|----------------------------|
|            | HC                   | CO   | NOx  | Part. |                     |                            |
| 3171       | 0.56                 | 3.45 | 4.42 | 0.58  | 0.423               | 25.49                      |
| 3174       | 0.50                 | 2.98 | 4.52 | 0.55  | 0.411               | 25.66                      |
| 3177       | 0.54                 | 3.18 | 4.67 | 0.58  | 0.416               | 25.56                      |
| $\bar{X}$  | 0.53                 | 3.20 | 4.54 | 0.57  | 0.417               | 25.57                      |
| COV %      | 5.73                 | 7.36 | 2.77 | 3.04  | 1.44                | 0.33                       |

except CO, which is about two percentage points above the level usually found. This can not be explained at this time, but is of little concern considering the very low absolute level of CO emissions relative to the standard. Cummins produced only hot start data and therefore there are no corresponding cold/hot combination data with which to compare these results.

Table 4 presents the hot start transient results at standard timing and using the current EPA fuel. The variability of the eight tests is generally within the expected range. Relative to the previous tests at EPA (all of which used G-075 fuel), the long term repeatability was quite good, except for particulate. However, after the previous EPA work was completed, it was discovered that the calibration of the particulate sampling system had shifted, and thus the current particulate data are the most representative for this engine. In comparing the EPA data to that of Cummins (all fuels included in the data base), good correlation is seen.

Table 5 presents the hot start results at advanced timing. The variation in the four tests is quite low. Compared to previous EPA data, there is generally good repeatability, except for particulate and HC. The somewhat poor particulate repeatability is probably due to the previously mentioned calibration error. As to the HC difference, it will be discussed later. Comparing the EPA data to Cummins data, there is quite good correlation on particulate and NOx but Cummins measured HC 20 percent higher than EPA. Again, a possible reason for this will be discussed later.

Table 6 presents the hot start transient, retarded timing, EPA fuel results. Four such tests were run, with very good repeatability. Comparing current tests to previous tests, there was good repeatability, with the exception of particulate. The previous particulate data were probably low. Cummins results were quite close for NOx and particulate but were 21 percent low for HC.

Table 7 presents the data that came from EPA testing using the previous batch of fuel (G-075). In comparing the results from current testing of the old and new fuels, there are relatively small differences in all of the data with the exception of HC, where the "old fuel" HC results were 15 percent lower than the current fuel HC results. This is very surprising considering the similarity of the fuels and in fact could be due to a measurement error. This will be discussed later.

In comparing the current EPA tests with G-075 fuel to old EPA tests (which were with G-075 fuel), there is close similarity in all data except particulate and HC. The particulate discrepancy could be due to a previous calibration error and the HC discrepancy could be due to a HFID measurement

Table 4

Table of Hot Start  
 Transient Results From  
 Cummins NTCC-400  
 Correlation Engine  
 Standard Timing, EPA Fuel (G-463)

| Test No   | Emissions, g/BHP-hr |      |      |       | BSFC,<br>lb/BHP-hr. | Actual Work,<br>BHP-hr. |
|-----------|---------------------|------|------|-------|---------------------|-------------------------|
|           | HC                  | CO   | NOx  | Part. |                     |                         |
| 3171      | 0.55                | 3.45 | 4.47 | 0.57  | 0.420               | 25.52                   |
| 3172      | 0.59                | 3.46 | 4.51 | 0.54  | 0.418               | 25.58                   |
| 3174      | 0.47                | 2.97 | 4.56 | 0.54  | 0.408               | 25.71                   |
| 3175      | 0.49                | 3.04 | 4.76 | 0.53  | 0.413               | 25.65                   |
| 3177      | 0.52                | 3.16 | 4.71 | 0.56  | 0.414               | 25.59                   |
| 3178      | 0.53                | 3.18 | 4.73 | 0.57  | 0.409               | 25.54                   |
| $\bar{X}$ | 0.53                | 3.21 | 4.62 | 0.55  | 0.414               | 25.59                   |
| COV %     | 8.15                | 6.38 | 2.70 | 3.12  | 1.15                | 0.28                    |

Previous EPA Tests (G-075 fuel)

|  |       |       |        |       |       |
|--|-------|-------|--------|-------|-------|
| 0.49                                   | 3.00  | 4.51  | 0.45** | 0.405 | 26.65 |
| % difference relative to current tests |       |       |        |       |       |
| -7.55                                  | -6.54 | -2.38 | -18.18 | -2.17 | 4.14  |

Cummins data, all fuels

|                                    |      |      |       |      |      |
|------------------------------------|------|------|-------|------|------|
| 0.55                               | N/A* | 4.65 | 0.51  | N/A* | N/A* |
| % difference relative to EPA tests |      |      |       |      |      |
| 3.77                               | -    | 0.65 | -7.27 | -    | -    |

\* N/A = not available.

\*\* These data are thought to be low, due to an equipment calibration error.

Table 5

Table of Hot Start  
 Transient Test Results From  
 Cummins NTCC-400  
 Correlation Engine  
 Advanced Timing, EPA Fuel (G-463)

| Test<br>No. | Emission, g/BHP-hr. |      |      |         | BSFC,<br>lb/BHP-hr | Actual<br>Work,<br>lb/BHP-hr |
|-------------|---------------------|------|------|---------|--------------------|------------------------------|
|             | HC                  | CO   | NOx  | Part.   |                    |                              |
| 3180        | 0.45                | 2.84 | 7.69 | 0.39    | 0.396              | 25.50                        |
| 3181        | 0.37                | 2.72 | 7.55 | 0.40    | 0.389              | 25.59                        |
| 3182        | 0.39                | 2.81 | 7.64 | 0.41    | 0.392              | 25.53                        |
| 3183        | 0.38                | 2.80 | 7.62 | (0.70)* | 0.396              | 25.55                        |
| $\bar{X}$   | 0.40                | 2.79 | 7.62 | 0.40    | 0.393              | 25.54                        |
| COV %       | 9.04                | 1.83 | 0.76 | 2.50    | 0.86               | 0.15                         |

## Previous EPA Tests (G-075)

|  |       |      |        |       |       |
|--|-------|------|--------|-------|-------|
| 0.46                                   | 2.56  | 7.95 | 0.33** | 0.390 | 26.56 |
| % difference relative to current tests |       |      |        |       |       |
| 15.00                                  | -8.24 | 4.33 | -17.50 | -0.76 | 3.99  |

## Cummins tests, all fuels

|                                    |        |      |       |        |        |
|------------------------------------|--------|------|-------|--------|--------|
| 0.48                               | N/A*** | 8.29 | 0.38  | N/A*** | N/A*** |
| % difference relative to EPA tests |        |      |       |        |        |
| 20.00                              | -      | 8.79 | -5.00 | -      | -      |

\* This value is an obvious outlier and was thus not used in the calculations. The input data to this value were double checked and they appear to be correct. This high value could have been due to particulate slough off from the tunnel and/or particulate sampling system.

\*\* These data are thought to be low, due to on equipment calibration error.

\*\*\* N/A = not available.

Table 6

Table of Hot Start  
 Transient Test Results From  
 Cummins NTCC-400  
 Correlation Engine  
 Retard Timing, EPA Fuel (G-463)

| Test<br>No.                            | Emissions, g/BHP-hr. |       |       |        | BSFC,<br>lb/BHP-hr | Actual<br>Work<br>lb/BHP-hr |
|--|----------------------|-------|-------|--------|--------------------|-----------------------------|
|  | HC                   | CO    | NOx   | Part   |                    |                             |
| 3184                                   | 1.25                 | 4.11  | 3.89  | 0.71   | 0.419              | 25.88                       |
| 3185                                   | 1.17                 | 4.08  | 3.88  | 0.69   | 0.423              | 25.89                       |
| 3186                                   | 1.12                 | 4.00  | 4.03  | 0.69   | 0.427              | 25.81                       |
| 3187                                   | 1.17                 | 4.04  | 3.75  | 0.67   | 0.420              | 26.02                       |
| $\bar{X}$                              | 1.18                 | 4.06  | 3.89  | 0.69   | 0.422              | 25.90                       |
| COV %                                  | 4.56                 | 1.18  | 2.94  | 2.37   | 0.85               | 0.34                        |
| <br>Previous EPA tests (G-075 fuel)    |                      |       |       |        |                    |                             |
|  | 1.19                 | 4.18  | 3.55  | 0.60*  | 0.418              | 26.95                       |
| % difference relative to current tests |                      |       |       |        |                    |                             |
|  | 0.85                 | 2.96  | -8.74 | -13.04 | -0.95              | 4.05                        |
| <br>Cummins tests, all fuels           |                      |       |       |        |                    |                             |
|  | 0.93                 | N/A** | 3.68  | 0.67   | N/A**              | N/A**                       |
| % difference relative to EPA tests     |                      |       |       |        |                    |                             |
|  | -21.19               | -     | -5.40 | -2.90  | -                  | -                           |

\* These data are thought to be low, due to on equipment calibration error.

\*\* N/A = not available.

Table 7

Table of Hot Start  
 Transient Test Results From  
 Cummins NTCC-400  
 Correlation Engine  
 Standard Timing, Old EPA Fuel (G-075)

| Test No   | Emissions, g/BHP-hr. |      |      |       | BSFC,<br>lb/BHP-hr. | Actual Work<br>BHP-hr |
|---|----------------------|------|------|-------|---------------------|-----------------------|
|   | HC                   | CO   | NOx  | Part. |                     |                       |
| 3188  | 0.48                 | 3.12 | 4.25 | 0.54  | 0.412               | 25.76                 |
| 3189  | 0.45                 | 3.01 | 4.36 | 0.57  | 0.409               | 25.71                 |
| 3190  | 0.43                 | 2.89 | 4.45 | 0.51  | 0.408               | 25.90                 |
| $\bar{X}$   | 0.45                 | 3.01 | 4.35 | 0.54  | 0.410               | 25.79                 |
| COV %   | 5.55                 | 3.83 | 2.30 | 5.56  | 0.42                | 0.38                  |
| Current EPA Fuel (G-463) tested at EPA                        |                      |      |      |       |                     |                       |
|   | 0.53                 | 3.21 | 4.62 | 0.55  | 0.414               | 25.59                 |
| % Difference relative to current EPA fuel                     |                      |      |      |       |                     |                       |
|   | -15.1                | -6.2 | -5.8 | -1.8  | -1.0                | 0.8                   |
| Old EPA fuel (G-075) tested previously by EPA                 |                      |      |      |       |                     |                       |
|   | 0.49                 | 3.00 | 4.51 | 0.45  | 0.405               | 26.65                 |
| % Difference relative to current tests using the old EPA fuel |                      |      |      |       |                     |                       |
|   | 8.9                  | -0.3 | 3.7  | -16.7 | -1.2                | 3.3                   |
| Old EPA fuel (G-075) tested at Cummins                        |                      |      |      |       |                     |                       |
|   | 0.57                 | N/A* | 4.46 | 0.51  | N/A                 | N/A                   |
| % Difference relative to old EPA fuel (G-075) tested at EPA   |                      |      |      |       |                     |                       |
|   | 26.7                 | -    | 2.5  | -5.6  | -                   | -                     |

\* N/A = not available.

error (to be discussed below). In comparing the EPA G-075 fuel data to Cummins data on the same fuel, there is reasonably good correlation on particulate and NO<sub>x</sub> but poor correlation on HC, with EPA much lower than Cummins.

Table 8 presents data from EPA testing of the Cummins "Cert." fuel. In comparing the EPA tests of the Cummins fuel to EPA tests with G-463, we see lower values for all emissions, which is to be expected because of the higher quality of this Cummins fuel. However, the 13 percent difference in HC is greater than expected and could be due to an EPA measurement error.

Tables 9 and 10 present the steady state data taken. The main item of interest from those tables is that the variation in the data is quite low. The main reason for taking this data is to have it available for use by labs who will test the engine in the future.

In the above presentation of data and discussion of it, it is apparent that there is generally good correlation on all measurements except hydrocarbon. This may be due to an error in the EPA measurement system. In testing the engine immediately after the Cummins (a Ford 7.8 liter diesel), a leak in the filter housing located in the HFID oven was detected. In tests on the Ford before the problem was discovered, the average hot start transient HC was 0.63 g/BHP-hr. After repair of the problem, average hot start results were 0.86. Thus, the in-error data were 26.7 percent lower than the HC data judged to be correct.

How long previous to the detection of the leak it existed, and how it influenced the data becomes a major question. There are two ways to try to answer it. The first is to track all of the hot starts using EPA fuel (G-463) and standard timing versus time. This is shown in Graph 1. (Test numbers 3194 through 3211 were from the testing of this engine in a subsequent program.) Here it is seen that there is a distinct drop in HC results after test 3172, suggesting that the problem could have initiated with the tests of July 14.

Graph 2 displays the Cold-Hot FID Index results as a function of test number (and therefore time). The Cold-Hot FID Index is a measure being developed at the MVEL as an additional check on HFID values. It is the percent difference between a cold FID bag reading and the continuous HFID reading, relative to the latter. It is sensitive to hydrocarbon type and thus operating mode, engine type and other variables. Although the data base on this index is still being developed, some conclusions can be drawn. For example, based on previous engines, the composite (bags 1-4) Index for standard timing would be expected to be in the -40 to -50 range. In reviewing Graph 2, it can be seen that only the first two standard timing hot starts fall in this range. The remainder are about 16 percent lower.

Table 8

Table of Hot Start Transient  
Test Results From  
Cummins NTCC-400  
Standard Timing, Cummins "Cert" Fuel

| Test<br>No.   | Emissions, g/BHP-hr. |            |             |               | BSFC,<br>lb/BHP-hr. | Actual<br>Work<br>BHP-hr |
|---|----------------------|------------|-------------|---------------|---------------------|--------------------------|
|   | HC<br>3191           | CO<br>0.51 | NOx<br>3.10 | Part.<br>4.34 |                     |                          |
| 25.69   |                      |            |             |               | 0.52                | 0.410                    |
| 3192  | 0.46                 | 3.06       | 4.30        | 0.52          | 0.406               | 25.70                    |
| 3193  | 0.42                 | 3.00       | 4.27        | 0.53          | 0.409               | 25.66                    |
| $\bar{X}$   | 0.46                 | 3.05       | 4.30        | 0.52          | 0.408               | 25.68                    |
| COV %   | 9.73                 | 1.65       | 0.82        | 1.10          | 0.51                | 0.08                     |
| Current EPA fuel (G-463)                              |                      |            |             |               |                     |                          |
|   | 0.53                 | 3.21       | 4.62        | 0.55          | 0.414               | 25.59                    |
| % Difference relative to current EPA fuel (G-463)     |                      |            |             |               |                     |                          |
|   | -13.2                | -5.0       | -6.9        | -5.5          | -1.5                | 0.4                      |
| Cummins Fuel tested at Cummins                        |                      |            |             |               |                     |                          |
|   | 0.54                 | N/A*       | 4.61        | 0.57          | N/A                 | N/A                      |
| % Difference relative to EPA tests using Cummins fuel |                      |            |             |               |                     |                          |
|   | 17.4                 | -          | 7.2         | 9.6           | -                   | -                        |

\* N/A = not available.

Table 9

Table of Steady State  
Emissions Results from  
Cummins NTCC-400  
Correlation Engine  
Standard Timing - Various Fuels

| <u>Fuel</u><br><u>EPA</u> | <u>Speed,</u><br><u>RPM</u> | <u>Load</u><br><u>ft.lb.</u> | <u>Test</u><br><u>No</u> | <u>Emissions,</u> q/hr     |              |              |               |                       |
|---------------------------|-----------------------------|------------------------------|--------------------------|----------------------------|--------------|--------------|---------------|-----------------------|
|                           |                             |                              |                          | <u>HC</u>                  | <u>CO</u>    | <u>NOx</u>   | <u>Part.*</u> | <u>CO<sub>2</sub></u> |
|                           | 630                         | 24                           | 3173                     | 74.99                      | 52.29        | 35.34        | 8.91          | 5175.35               |
|                           |                             |                              | 3176                     | 74.26                      | 65.29        | 35.31        | 8.93          | 4782.30               |
|                           |                             |                              | <u>3179</u>              | <u>73.64</u>               | <u>56.52</u> | <u>35.58</u> | <u>10.03</u>  | <u>4818.29</u>        |
|                           |                             |                              | <u>X</u>                 | 74.30                      | 58.03        | 35.41        | 9.29          | 4925.31               |
|                           |                             |                              | COV %                    | 0.91                       | 11.43        | 0.42         | 6.90          | 4.41                  |
| <u>EPA</u>                | <u>1300</u>                 | <u>316</u>                   | <u>3173</u>              | <u>Emissions,</u> q/BHP-hr |              |              |               |                       |
|                           |                             |                              |                          | 0.37                       | 0.83         | 6.45         | 0.396         | 536.86                |
|                           |                             |                              | 3176                     | 0.36                       | 0.77         | 6.22         | 0.396         | 522.25                |
|                           |                             |                              | <u>3179</u>              | <u>0.41</u>                | <u>0.80</u>  | <u>6.34</u>  | <u>0.309</u>  | <u>529.80</u>         |
|                           |                             |                              | <u>X</u>                 | 0.38                       | 0.80         | 6.34         | 0.367         | 529.64                |
|                           |                             |                              | COV %                    | 6.96                       | 3.75         | 1.81         | 13.69         | 1.38                  |
| CEC                       | 1300                        | 316                          | 3212                     | 0.39                       | 0.77         | -            | -             | 528.90                |
|                           |                             |                              | <u>Δ%</u>                | <u>2.63</u>                | <u>-3.75</u> | <u>-</u>     | <u>-</u>      | <u>-0.14</u>          |
| <u>EPA</u>                | <u>1300</u>                 | <u>516</u>                   | <u>3173</u>              | 0.22                       | 0.91         | 7.47         | 0.304         | 496.92                |
|                           |                             |                              |                          | 3176                       | 0.23         | 0.89         | 7.49          | 0.344                 |
|                           |                             |                              | <u>3179</u>              | <u>0.23</u>                | <u>0.89</u>  | <u>7.16</u>  | <u>0.275</u>  | <u>492.71</u>         |
|                           |                             |                              | <u>X</u>                 | 0.23                       | 0.90         | 7.37         | 0.308         | 491.72                |
|                           |                             |                              | COV %                    | 1.30                       | 1.29         | 2.51         | 11.26         | 1.17                  |

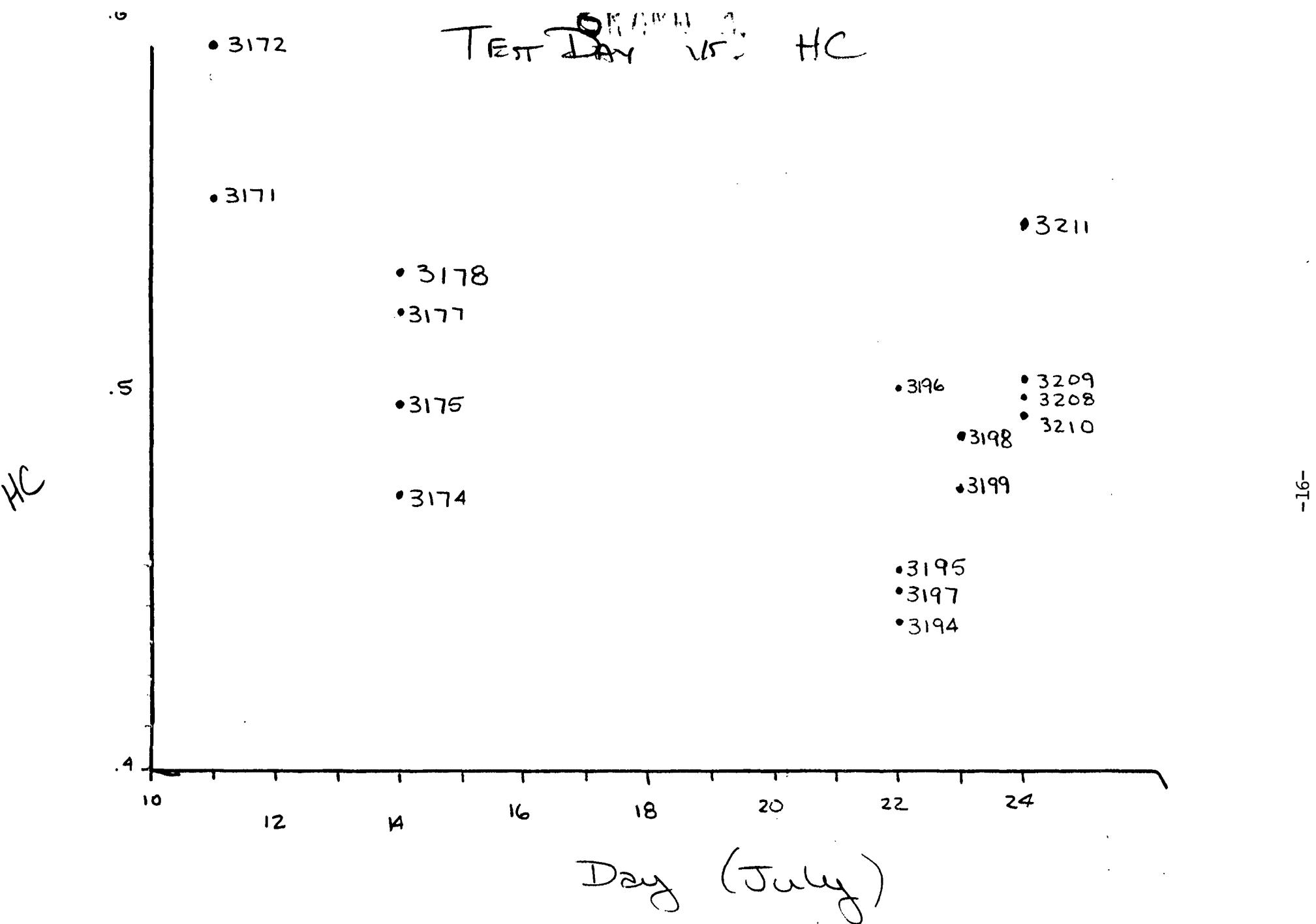
\* Primary plus Secondary filter weights used to compute these data.

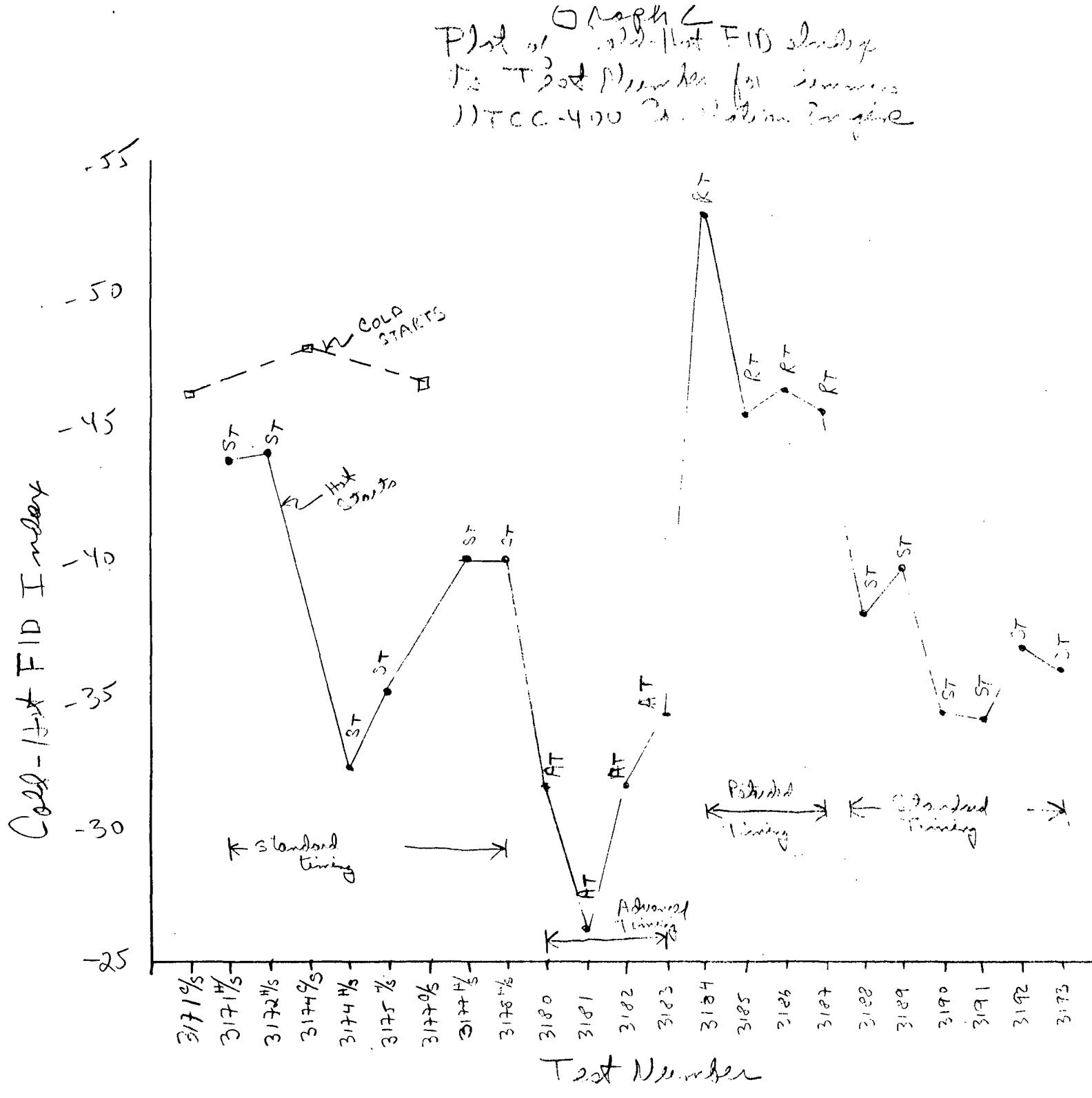
Table 10

Table of Steady State  
Emissions Results from  
Cummins NTCC-400  
Correlation Engine  
Standard Timing - Various Fuels

| Fuel<br>EPA | Speed, Load,       |       | Test<br>No         | Emissions,    |              |              | q/BHP-hr      | $\text{CO}_2$  |
|-------------|--------------------|-------|--------------------|---------------|--------------|--------------|---------------|----------------|
|             | RPM                | FT-lb |                    | HC            | CO           | NOX          |               |                |
| EPA         | 2100               | 250   | 3173               | 1.12          | 1.31         | 3.06         | 0.524         | 729.91         |
|             |                    |       | 3176               | 1.14          | 1.26         | 3.01         | 0.512         | 714.78         |
|             |                    |       | <u>3179</u>        | <u>1.09</u>   | <u>1.26</u>  | <u>3.08</u>  | <u>0.542</u>  | <u>718.36</u>  |
|             | $\bar{X}$<br>COV % |       |                    | 1.12          | 1.28         | 3.05         | 0.526         | 721.02         |
|             |                    |       |                    | 2.25          | 2.26         | 1.18         | 2.87          | 1.09           |
| CEC         | 2100               | 250   | 3212               | 1.07          | 1.27         | -            | -             | 728.77         |
|             |                    |       | $\Delta\%$         | -4.46         | -0.78        | -            | -             | 1.07           |
|             | 2100               | 750   | 3173               | 0.256         | 0.80         | 4.20         | 0.248         | 578.57         |
| EPA         | 2100               | 750   | 3176               | 0.265         | 0.80         | 4.17         | 0.255         | 560.75         |
|             |                    |       | <u>3179</u>        | <u>0.257</u>  | <u>0.76</u>  | <u>3.85</u>  | <u>0.248</u>  | <u>555.26</u>  |
|             |                    |       | $\bar{X}$<br>COV % | 0.259<br>1.90 | 0.79<br>2.94 | 4.07<br>4.76 | 0.250<br>1.61 | 564.86<br>2.16 |
|             | CEC                | 2100  | 3212               | 0.228         | .77          | -            | -             | 572.27         |
|             |                    |       | $\Delta, \%$       | -11.97        | -2.53        | -            | -             | 1.31           |

\* Primary plus Secondary filter weights used to compute these data.





Thus, there is strong evidence that the HC measurements taken were inaccurate. An adjustment was made to them and the results are presented in Table 11. The "description" column of this table identifies the table and the data that are involved in the analysis. The HC "initial" column is a repeat of the HC data found in Tables 4 through 8. The HC "revised" column contains the best estimate corrected HC data and is based on the Cold-Hot FID Index data where it is assumed that the cold FID data are correct. The percent difference "initial" column is a repeat of the percent difference figures found in Tables 4 through 8 and the percent difference "revised" is based on the revised HC figures. In reviewing this table it is seen that the revised HC data results in a reduction of the absolute value of the percent difference in 8 of the 11 cases.

Ultimately, it is not known how to best correct the HC data. However, from the data presented it is felt that the emissions from the engine have not shifted to any great degree. Thus, in the event one would rather not rely on the above described "revised" HC data, then the next best approach would be to rely on the HC data from the previous EPA testing.

#### IV. Summary

To briefly summarize, there were some measurement problems with HC (current tests) and particulate tests (previous EPA tests). However, when these problems are accounted for, generally good correlation is seen between present and past EPA tests and between EPA tests and those at Cummins. The notable exception is hydrocarbon during retarded mode, where Cummins measures substantially lower levels relative to EPA. This difference is currently unexplained.

**Table 11**  
**Table of Initial and Revised**  
**HC Values from EPA Testing**

| <u>Description</u>              | <u>HC, g/BHP-hr.</u> |                | <u>Percent Difference</u> |                |
|---------------------------------|----------------------|----------------|---------------------------|----------------|
|                                 | <u>Initial</u>       | <u>Revised</u> | <u>Initial</u>            | <u>Revised</u> |
| <b>Table 4</b>                  |                      |                |                           |                |
| Standard Timing G-463 fuel      |                      |                |                           |                |
| Hot Start Results               | 0.53                 | 0.57           |                           |                |
| Previous EPA tests (G-075 fuel) | 0.49                 | NC*            | -7.55                     | -13.3          |
| Cummins data, all fuels         | 0.55                 | NC             | 3.77                      | -3.51          |

|                                 |      |      |       |      |
|---------------------------------|------|------|-------|------|
| <u>Table 5</u>                  |      |      |       |      |
| Advanced Timing, G-463 fuel     |      |      |       |      |
|                                 |      |      |       |      |
| Hot Start Results               | 0.40 | 0.45 |       |      |
| Previous EPA tests (G-075 fuel) | 0.46 | NC   | 15.00 | 2.22 |
| Cummins data, all fuels         | 0.48 | NC   | 20.00 | 6.67 |

|                                 |      |      |        |        |
|---------------------------------|------|------|--------|--------|
| <u>Table 6</u>                  |      |      |        |        |
| Retarded Timing, G-463 fuel     |      |      |        |        |
|                                 |      |      |        |        |
| Hot Start Results               | 1.18 | 1.32 |        |        |
| Previous EPA tests (G-075 fuel) | 1.19 | NC   | 0.85   | -9.85  |
| Cummins data, all fuels         | 0.93 | NC   | -21.19 | -29.55 |

|                                 |      |      |       |       |
|---------------------------------|------|------|-------|-------|
| <u>Table 7</u>                  |      |      |       |       |
| Standard Timing, G-075 fuel     |      |      |       |       |
|                                 |      |      |       |       |
| Hot Start Results               | 0.45 | 0.50 |       |       |
| Current EPA fuel (G-463)        | 0.53 | 0.57 | -15.1 | -12.3 |
| G-075 fuel tested. prev. by EPA | 0.49 | NC   | 8.9   | -2.00 |
| G-075 fuel tested at Cummins    | 0.57 | NC   | 26.7  | 14.00 |

|                                |      |      |       |       |
|--------------------------------|------|------|-------|-------|
| <u>Table 8</u>                 |      |      |       |       |
| Standard Timing, Cummins fuel  |      |      |       |       |
|                                |      |      |       |       |
| Hot Start Results              | 0.46 | 0.52 |       |       |
| Current EPA fuel (G-463)       | 0.53 | 0.57 | -13.2 | -8.77 |
| Cummins fuel tested at Cummins | 0.54 | NC   | 17.4  | 3.85  |

\* No change.

## Appendix

### Table of Contents

EPA Torque Map - Graph  
EPA Torque Map - Table  
EPA Emission Summaries for each test  
Engine Information Sheet  
Cummins Torque Map - Table  
Cummins Torque Map - Graph

Graph of EPA Torque Map

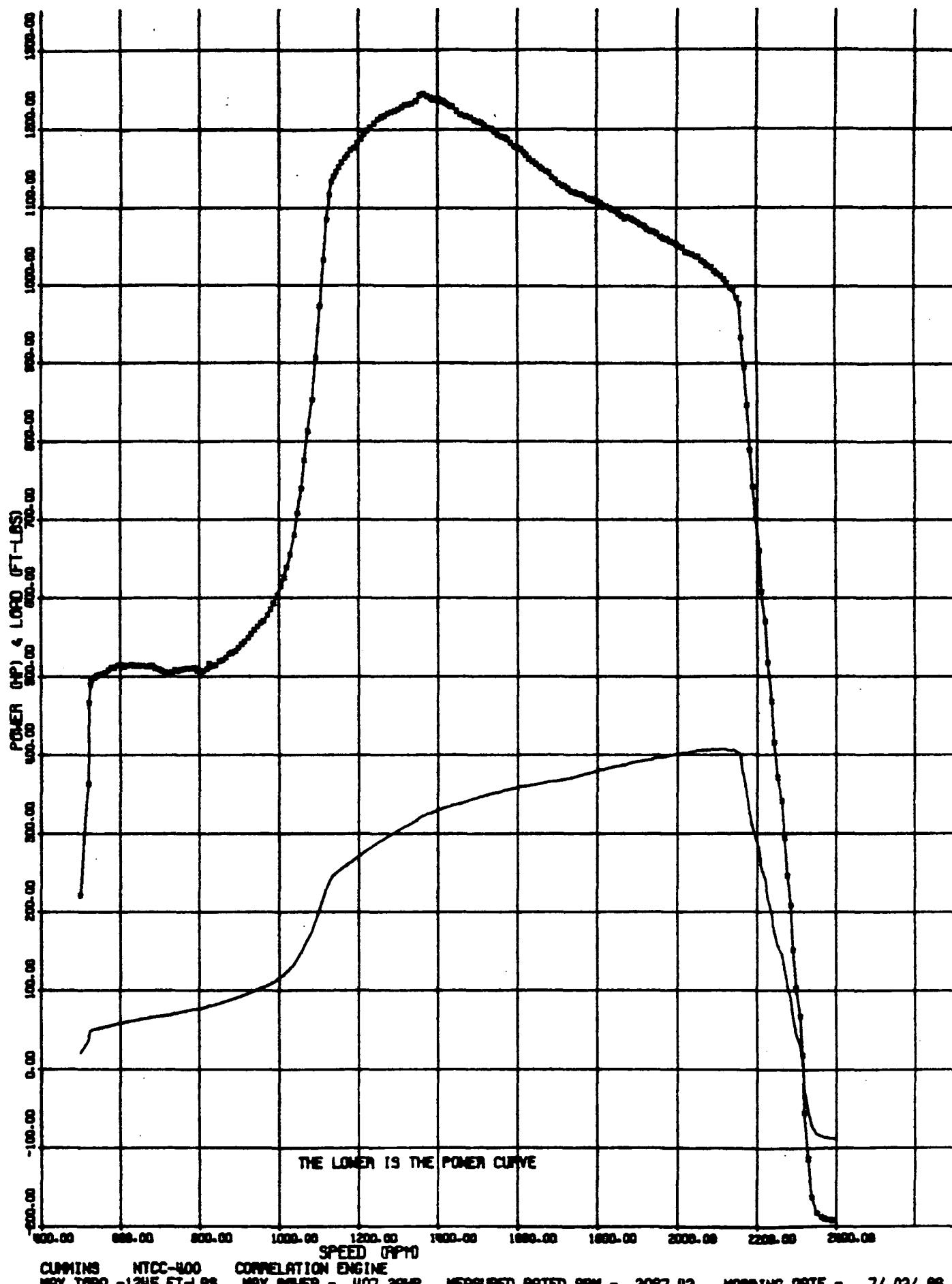


Table of EPA Torque Map Values

NTCC-400  
7/2/86

SMMW:  
7000D  
CD5162

THERE ARE ( 240 ) MAPPING DATA POINTS:

|      |       |       |        |             |             |             |             |
|------|-------|-------|--------|-------------|-------------|-------------|-------------|
| 499. | 220.9 | 811.  | 507.4  | 1138.1140.9 | 1437.1228.9 | 1776.1112.9 | 2095.1019.3 |
| 519. | 363.4 | 819.  | 509.7  | 1144.1146.9 | 1447.1223.3 | 1785.1111.7 | 2102.1016.5 |
| 521. | 466.1 | 825.  | 516.5  | 1150.1153.0 | 1458.1218.6 | 1791.1109.4 | 2111.1013.7 |
| 524. | 489.4 | 832.  | 513.3  | 1157.1158.9 | 1471.1216.1 | 1800.1108.6 | 2119.1009.3 |
| 527. | 495.3 | 841.  | 514.1  | 1166.1164.5 | 1482.1215.0 | 1809.1106.6 | 2125.1003.7 |
| 535. | 499.4 | 850.  | 519.3  | 1173.1168.6 | 1493.1211.3 | 1815.1103.3 | 2134. 998.1 |
| 541. | 502.1 | 858.  | 520.9  | 1180.1174.5 | 1503.1210.1 | 1825.1102.1 | 2141. 995.7 |
| 547. | 502.2 | 867.  | 524.1  | 1188.1177.0 | 1510.1208.5 | 1832.1100.5 | 2150. 985.0 |
| 554. | 503.4 | 874.  | 528.6  | 1197.1183.8 | 1517.1205.0 | 1840.1098.6 | 2157. 976.9 |
| 563. | 505.3 | 881.  | 529.8  | 1206.1188.2 | 1526.1202.2 | 1848.1096.5 | 2161. 933.0 |
| 570. | 508.1 | 890.  | 532.1  | 1213.1195.0 | 1536.1200.9 | 1855.1092.9 | 2167. 894.2 |
| 579. | 511.3 | 898.  | 536.9  | 1221.1198.5 | 1543.1197.7 | 1863.1090.5 | 2174. 845.7 |
| 586. | 511.3 | 906.  | 541.3  | 1229.1202.9 | 1550.1192.5 | 1870.1086.5 | 2180. 788.1 |
| 594. | 514.6 | 914.  | 544.6  | 1239.1208.1 | 1560.1191.0 | 1879.1088.5 | 2188. 741.4 |
| 603. | 514.1 | 923.  | 549.4  | 1249.1213.0 | 1569.1189.7 | 1887.1086.2 | 2196. 701.3 |
| 609. | 512.5 | 930.  | 554.5  | 1257.1216.1 | 1575.1187.3 | 1894.1084.2 | 2206. 660.6 |
| 618. | 513.8 | 939.  | 558.9  | 1266.1216.9 | 1583.1182.9 | 1902.1082.1 | 2211. 608.2 |
| 627. | 515.0 | 947.  | 563.4  | 1273.1220.1 | 1592.1178.5 | 1909.1078.6 | 2221. 570.1 |
| 635. | 513.7 | 955.  | 568.2  | 1283.1222.5 | 1599.1177.3 | 1920.1076.9 | 2227. 517.4 |
| 642. | 513.7 | 962.  | 570.9  | 1292.1223.4 | 1609.1175.3 | 1926.1073.0 | 2236. 467.7 |
| 649. | 513.8 | 972.  | 578.1  | 1300.1225.7 | 1616.1171.0 | 1935.1070.5 | 2242. 415.4 |
| 657. | 513.7 | 979.  | 585.0  | 1309.1228.1 | 1622.1168.1 | 1943.1070.1 | 2251. 370.9 |
| 668. | 512.5 | 987.  | 593.3  | 1317.1231.3 | 1631.1162.9 | 1951.1067.8 | 2263. 341.3 |
| 675. | 513.7 | 995.  | 603.3  | 1326.1231.7 | 1639.1159.3 | 1961.1063.7 | 2269. 293.7 |
| 681. | 513.3 | 1005. | 614.9  | 1334.1232.6 | 1648.1156.1 | 1968.1060.5 | 2277. 246.1 |
| 688. | 510.5 | 1012. | 626.1  | 1344.1236.1 | 1656.1152.5 | 1976.1060.6 | 2285. 208.5 |
| 698. | 509.0 | 1019. | 639.0  | 1354.1243.0 | 1663.1150.1 | 1985.1057.8 | 2290. 151.3 |
| 706. | 506.9 | 1028. | 655.3  | 1362.1244.9 | 1672.1147.7 | 1992.1055.7 | 2299. 103.3 |
| 713. | 505.3 | 1039. | 680.2  | 1372.1241.8 | 1680.1145.8 | 2001.1053.4 | 2308. 67.7  |
| 721. | 503.8 | 1046. | 707.8  | 1381.1239.7 | 1687.1139.7 | 2007.1050.1 | 2315. 18.2  |
| 730. | 505.4 | 1056. | 739.3  | 1387.1237.3 | 1696.1136.2 | 2015.1049.7 | 2318. -54.5 |
| 739. | 508.1 | 1063. | 775.7  | 1394.1238.5 | 1704.1131.8 | 2023.1044.1 | 2328.-113.3 |
| 745. | 507.3 | 1073. | 812.1  | 1398.1237.0 | 1713.1128.9 | 2031.1042.5 | 2338.-163.0 |
| 753. | 508.1 | 1083. | 852.1  | 1403.1238.2 | 1720.1127.8 | 2040.1041.0 | 2350.-182.5 |
| 760. | 509.7 | 1093. | 906.6  | 1405.1236.1 | 1727.1124.9 | 2050.1038.5 | 2361.-187.7 |
| 769. | 510.2 | 1102. | 972.9  | 1409.1236.1 | 1736.1121.3 | 2056.1038.2 | 2370.-190.1 |
| 778. | 510.1 | 1112. | 1032.5 | 1413.1235.4 | 1744.1120.9 | 2063.1033.3 | 2380.-191.3 |
| 786. | 510.9 | 1120. | 1085.3 | 1418.1233.7 | 1750.1118.5 | 2072.1030.5 | 2388.-192.1 |
| 793. | 507.4 | 1127. | 1117.3 | 1423.1231.7 | 1760.1117.7 | 2076.1026.9 | 2393.-192.1 |
| 802. | 501.8 | 1132. | 1134.1 | 1429.1229.8 | 1769.1116.1 | 2087.1024.6 | 2394.-191.7 |

<COMMENT> MAX POWER: 407.4 HP @ 2111. RPM.

<COMMENT> RATED SPEED: 2067. RPM.

WANT A CALCOMP PLOT OF THE MAPPING CURVE? (Y/N), (DEFLT = N):

DO YOU WANT THE RPM,TQ & HP DATA LIST? (Y/N): Y

HD-863171  
740 NTCC40085HCCOR02 2  
8B

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-11-86 TIME: 15:08:52 HD-863171

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863171  
TEST DATE/TIME: 7- 9-86 8:27  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 28.90 "HG  
DRY BULB TEMPERATURE: 75.40 F  
ABSOLUTE HUMIDITY: 54.10 GRAINS H2O / LB. DRY AIR

| EMISSION RESULTS      | CS       | HS       | WTD TEST | CYCLE STATISTICS            | CS      | HS      |
|-----------------------|----------|----------|----------|-----------------------------|---------|---------|
| HC (INTEGRATED)       |          |          |          | SPEED                       |         |         |
| BACKGROUND, PPM       | 5.73     | 5.95     |          | NUMBER                      | 1176    | 1176    |
| EXHAUST+BKG, GM       | 19.37    | 19.06    |          | SLOPE                       | 0.99623 | 0.99713 |
| NET, GM/BHP-HR        | 0.576    | 0.552    | 0.555    | (LIMIT: 0.97-1.03)          |         |         |
| CO (BAG)              |          |          |          | Y-INTERCEPT                 | 3.728   | 1.689   |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | (LIMIT: +-50 RPM)           |         |         |
| EXHAUST+BKG, GM       | 87.74    | 88.02    |          | STD ERROR                   | 25.496  | 25.298  |
| NET, GM/BHP-HR        | 3.47     | 3.45     | 3.45     | (LIMIT: 100 RPM)            |         |         |
| NOX (INTEGRATED)      |          |          |          | R-SQUARE                    | 0.99821 | 0.99824 |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | (LIMIT: 0.97)               |         |         |
| EXHAUST+BKG, GM       | 110.05   | 120.27   |          | TORQUE                      |         |         |
| NET, GM/BHP-HR        | 4.124    | 4.470    | 4.421    | NUMBER                      | 944     | 953     |
| CO2 (BAG)             |          |          |          | SLOPE                       | 1.00404 | 1.00420 |
| BACKGROUND, PPM       | 0.037    | 0.036    |          | (LIMIT: 0.77/0.83-1.03)     |         |         |
| EXHAUST+BKG, GM       | 16936.89 | 16273.41 |          | Y-INTERCEPT                 | -11.282 | -11.168 |
| NET, GM/BHP-HR        | 630.9    | 600.4    | 604.8    | (LIMIT: +-15 FT-LBS)        |         |         |
| PARTICULATE           |          |          |          | STD ERROR                   | 4.588%  | 4.376%  |
| SECONDARY TARE, GM    | 0.156600 | 0.157900 |          | (LIMIT: 13% MAX ENG TQ)     |         |         |
| SECONDARY PART, GM    | 0.156700 | 0.158000 |          | R-SQUARE                    | 0.96968 | 0.97301 |
| PRIMARY TARE, GM      | 0.156900 | 0.155500 |          | (LIMIT: 0.85/0.88)          |         |         |
| PRIMARY PART, GM      | 0.168400 | 0.165800 |          | POWER                       |         |         |
| TOTAL, GM/BHP-HR      | 0.65     | 0.57     | 0.58     | NUMBER                      | 943     | 953     |
| FUEL CONSUMPTION      |          |          |          | SLOPE                       | 0.99991 | 0.99995 |
| LBS                   | 11.17    | 10.73    | 10.79    | (LIMIT: 0.87/0.89-1.03)     |         |         |
| LBS/BHP-HR            | 0.442    | 0.420    | 0.423    | Y-INTERCEPT                 | -2.492  | -2.574  |
| BRAKE HORSEPOWER-HOUR | 25.308   | 25.516   | 25.486   | STD ERROR                   | 4.295%  | 4.030%  |
|                       |          |          |          | R-SQUARE                    | 0.97886 | 0.98165 |
|                       |          |          |          | (LIMIT: 0.91)               |         |         |
|                       |          |          |          | WORK                        |         |         |
|                       |          |          |          | ACTUAL                      | 25.308  | 25.516  |
|                       |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |         |         |
|                       |          |          |          | REFERENCE                   | 26.736  | 26.737  |
|                       |          |          |          | % DIFFERENCE                | -5.34%  | -4.57%  |

HD-863172  
740 NTCC40085HCC0R02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-11-86 TIME: 15:16:11 HD-863172

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863172  
TEST DATE/TIME: 7- 9-86 10: 2  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCC0R02 2

AMBIENT DATA

BAROMETER (DRY): 28.90 "HG  
DRY BULB TEMPERATURE: 76.00 F  
ABSOLUTE HUMIDITY: 51.75 GRAINS H<sub>2</sub>O / LB. DRY AIR

| EMISSION RESULTS      |          |          | CYCLE STATISTICS |                             |                 |
|-----------------------|----------|----------|------------------|-----------------------------|-----------------|
|                       | CS       | HS       | WTD TEST         |                             | CS HS           |
| HC (INTEGRATED)       |          |          |                  | SPEED                       |                 |
| BACKGROUND, PPM       | 0.00     | 6.25     |                  | NUMBER                      | 0 1176          |
| EXHAUST+BKG, GM       | 0.00     | 20.29    |                  | SLOPE                       | 0.00000 0.99576 |
| NET, GM/BHP-HR        | 0.000    | 0.589    | 0.589            | (LIMIT: 0.97-1.03)          |                 |
| CO (BAG)              |          |          |                  | Y-INTERCEPT                 | 0.000 4.326     |
| BACKGROUND, PPM       | 0.00     | 0.00     |                  | (LIMIT: +-50 RPM)           |                 |
| EXHAUST+BKG, GM       | 0.00     | 88.57    |                  | STD ERROR                   | 0.000 25.315    |
| NET, GM/BHP-HR        | 0.00     | 3.46     | 3.46             | (LIMIT: 100 RPM)            |                 |
| R-SQUARE              |          |          |                  | (R-SQUARE)                  | 0.00000 0.99824 |
| (LIMIT: 0.97)         |          |          |                  |                             |                 |
| NOX (INTEGRATED)      |          |          |                  | TORQUE                      |                 |
| BACKGROUND, PPM       | 0.00     | 0.00     |                  | NUMBER                      | 0 952           |
| EXHAUST+BKG, GM       | 0.00     | 122.30   |                  | SLOPE                       | 0.00000 1.00006 |
| NET, GM/BHP-HR        | 0.000    | 4.508    | 4.508            | (LIMIT: 0.77/0.83-1.03)     |                 |
| CO2 (BAG)             |          |          |                  | Y-INTERCEPT                 | 0.000 -7.966    |
| BACKGROUND, PPM       | 0.000    | 0.033    |                  | (LIMIT: +-15 FT-LBS)        |                 |
| EXHAUST+BKG, GM       | 0.00     | 16118.07 |                  | STD ERROR                   | 0.000% 4.448%   |
| NET, GM/BHP-HR        | 0.0      | 596.6    | 596.6            | (LIMIT: 13% MAX ENG TQ)     |                 |
| R-SQUARE              |          |          |                  | (R-SQUARE)                  | 0.00000 0.97181 |
| (LIMIT: 0.85/0.88)    |          |          |                  |                             |                 |
| PARTICULATE           |          |          |                  | POWER                       |                 |
| SECONDARY TARE, GM    | 0.000000 | 0.158300 |                  | NUMBER                      | 0 951           |
| SECONDARY PART, GM    | 0.000000 | 0.158400 |                  | SLOPE                       | 0.00000 0.99927 |
| PRIMARY TARE, GM      | 0.000000 | 0.153800 |                  | (LIMIT: 0.87/0.89-1.03)     |                 |
| PRIMARY PART, GM      | 0.000000 | 0.163600 |                  | Y-INTERCEPT                 | 0.000 -2.199    |
| TOTAL, GM/BHP-HR      | 0.00     | 0.54     | 0.54             | (LIMIT: +-5 BHP)            |                 |
| FUEL CONSUMPTION      |          |          |                  | STD ERROR                   | 0.000% 4.084%   |
| LBS                   | 0.00     | 10.69    | 10.69            | (LIMIT: 8%)                 |                 |
| LBS/BHP-HR            | 0.000    | 0.418    | 0.418            | R-SQUARE                    | 0.00000 0.98112 |
| (LIMIT: 0.91)         |          |          |                  |                             |                 |
| BRAKE HORSEPOWER-HOUR | 0.000    | 25.583   | 25.583           | WORK                        |                 |
|                       |          |          |                  | ACTUAL                      | 0.000 25.583    |
|                       |          |          |                  | (LIMIT: -15%-5% REF BHP-HR) |                 |
|                       |          |          |                  | REFERENCE                   | 0.000 26.736    |
|                       |          |          |                  | % DIFFERENCE                | 0.00% -4.31%    |

HD-863174  
740 NTCC40085HCCOR02 2  
8B

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-14-86 TIME: 10:28:42 HD-863174

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863174  
TEST DATE/TIME: 7-10-86 8:18  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 73.10 F  
ABSOLUTE HUMIDITY: 65.18 GRAINS H2O / LB. DRY AIR

| EMISSION RESULTS      | CS       | HS       | WTD TEST | CYCLE STATISTICS            | CS      | HS      |
|-----------------------|----------|----------|----------|-----------------------------|---------|---------|
| HC (INTEGRATED)       |          |          |          | SPEED                       |         |         |
| BACKGROUND, PPM       | 5.28     | 6.10     |          | NUMBER                      | 1176    | 1176    |
| EXHAUST+BKG, GM       | 21.08    | 17.28    |          | SLOPE                       | 0.99405 | 0.99392 |
| NET, GM/BHP-HR        | 0.655    | 0.472    | 0.498    | (LIMIT: 0.97-1.03)          |         |         |
| CO (BAG)              |          |          |          | Y-INTERCEPT                 | 6.348   | 4.858   |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | (LIMIT: +-50 RPM)           |         |         |
| EXHAUST+BKG, GM       | 77.78    | 76.33    |          | STD ERROR                   | 24.937  | 25.052  |
| NET, GM/BHP-HR        | 3.06     | 2.97     | 2.98     | (LIMIT: 100 RPM)            |         |         |
|                       |          |          |          | R-SQUARE                    | 0.99828 | 0.99827 |
| (LIMIT: 0.97)         |          |          |          | TORQUE                      |         |         |
| NOX (INTEGRATED)      |          |          |          | NUMBER                      | 949     | 959     |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | SLOPE                       | 0.99611 | 0.98940 |
| EXHAUST+BKG, GM       | 110.80   | 120.23   |          | (LIMIT: 0.77/0.83-1.03)     |         |         |
| NET, GM/BHP-HR        | 4.253    | 4.561    | 4.517    | Y-INTERCEPT                 | -5.455  | -0.289  |
| CO2 (BAG)             |          |          |          | STD ERROR                   | 4.605%  | 4.460%  |
| BACKGROUND, PPM       | 0.037    | 0.036    |          | (LIMIT: 13% MAX ENG TQ)     |         |         |
| EXHAUST+BKG, GM       | 16488.24 | 15952.20 |          | R-SQUARE                    | 0.96985 | 0.97208 |
| NET, GM/BHP-HR        | 610.6    | 583.4    | 587.2    | (LIMIT: 0.85/0.88)          |         |         |
| PARTICULATE           |          |          |          | POWER                       |         |         |
| SECONDARY TARE, GM    | 0.156100 | 0.158000 |          | NUMBER                      | 948     | 959     |
| SECONDARY PART, GM    | 0.156200 | 0.158100 |          | SLOPE                       | 0.99754 | 0.99476 |
| PRIMARY TARE, GM      | 0.154600 | 0.154600 |          | (LIMIT: 0.87/0.89-1.03)     |         |         |
| PRIMARY PART, GM      | 0.165650 | 0.164400 |          | Y-INTERCEPT                 | -1.846  | -1.330  |
| TOTAL, GM/BHP-HR      | 0.62     | 0.54     | 0.55     | STD ERROR                   | 4.252%  | 4.029%  |
| FUEL CONSUMPTION      |          |          |          | (LIMIT: 8%)                 |         |         |
| LBS                   | 10.85    | 10.49    | 10.54    | R-SQUARE                    | 0.97960 | 0.98192 |
| LBS/BHP-HR            | 0.427    | 0.408    | 0.411    | (LIMIT: 0.91)               |         |         |
| BRAKE HORSEPOWER-HOUR | 25.403   | 25.706   | 25.663   | WORK                        |         |         |
|                       |          |          |          | ACTUAL                      | 25.403  | 25.706  |
|                       |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |         |         |
|                       |          |          |          | REFERENCE                   | 26.736  | 26.737  |
|                       |          |          |          | % DIFFERENCE                | -4.99%  | -3.86%  |

-25-

HD-863175  
740 NTCC40085HCCOR02 2  
HS

HEAVY DUTY DIESEL TRANSIENT ENGINE TEST  
DIESEL SUMMARY REPORT

DATE: 07-14-86 TIME: 10:30:06 HD-863175

TEST NUMBER: HD-863175  
TEST DATE/TIME: 7-10-86 9:52  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.00 "HG  
DRY BULB TEMPERATURE: 74.70 F  
ABSOLUTE HUMIDITY: 78.32 GRAINS H2O / LB. DRY AIR

| EMISSION RESULTS      | CS       | HS       | WTD TEST | CYCLE STATISTICS            | CS      | HS      |
|-----------------------|----------|----------|----------|-----------------------------|---------|---------|
| HC (INTEGRATED)       |          |          |          | SPEED                       |         |         |
| BACKGROUND, PPM       | 0.00     | 6.77     |          | NUMBER                      | 0       | 1176    |
| EXHAUST+BKG, GM       | 0.00     | 18.34    |          | SLOPE                       | 0.00000 | 0.99270 |
| NET, GM/BHP-HR        | 0.000    | 0.493    | 0.493    | (LIMIT: 0.97-1.03)          |         |         |
| CO (BAG)              |          |          |          | Y-INTERCEPT                 | 0.000   | 6.304   |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | (LIMIT: +-50 RPM)           |         |         |
| EXHAUST+BKG, GM       | 0.00     | 77.99    |          | STD ERROR                   | 0.000   | 25.044  |
| NET, GM/BHP-HR        | 0.00     | 3.04     | 3.04     | (LIMIT: 100 RPM)            |         |         |
|                       |          |          |          | R-SQUARE                    | 0.00000 | 0.99826 |
| NOX (INTEGRATED)      |          |          |          | (LIMIT: 0.97)               |         |         |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | TORQUE                      |         |         |
| EXHAUST+BKG, GM       | 0.00     | 120.91   |          | NUMBER                      | 0       | 954     |
| NET, GM/BHP-HR        | 0.000    | 4.756    | 4.756    | SLOPE                       | 0.00000 | 0.99075 |
| CO2 (BAG)             |          |          |          | (LIMIT: 0.77/0.83-1.03)     |         |         |
| BACKGROUND, PPM       | 0.000    | 0.030    |          | Y-INTERCEPT                 | 0.000   | -1.481  |
| EXHAUST+BKG, GM       | 0.00     | 15919.00 |          | (LIMIT: +-15 FT-LBS)        |         |         |
| NET, GM/BHP-HR        | 0.0      | 590.1    | 590.1    | STD ERROR                   | 0.000%  | 4.489%  |
| PARTICULATE           |          |          |          | (LIMIT: 13% MAX ENG TQ)     |         |         |
| SECONDARY TARE, GM    | 0.000000 | 0.169000 |          | R-SQUARE                    | 0.00000 | 0.97113 |
| SECONDARY PART, GM    | 0.000000 | 0.169050 |          | (LIMIT: 0.85/0.88)          |         |         |
| PRIMARY TARE, GM      | 0.000000 | 0.165900 |          | POWER                       |         |         |
| PRIMARY PART, GM      | 0.000000 | 0.175400 |          | NUMBER                      | 0       | 953     |
| TOTAL, GM/BHP-HR      | 0.00     | 0.53     | 0.53     | SLOPE                       | 0.00000 | 0.99298 |
| FUEL CONSUMPTION      |          |          |          | (LIMIT: 0.87/0.89-1.03)     |         |         |
| LBS                   | 0.00     | 10.58    | 10.58    | Y-INTERCEPT                 | 0.000   | -1.382  |
| LBS/BHP-HR            | 0.000    | 0.413    | 0.413    | (LIMIT: +-5 BHP)            |         |         |
| BRAKE HORSEPOWER-HOUR | 0.000    | 25.646   | 25.646   | STD ERROR                   | 0.000%  | 4.056%  |
|                       |          |          |          | (LIMIT: 8%)                 |         |         |
|                       |          |          |          | R-SQUARE                    | 0.00000 | 0.98132 |
|                       |          |          |          | (LIMIT: 0.91)               |         |         |
|                       |          |          |          | WORK                        |         |         |
|                       |          |          |          | ACTUAL                      | 0.000   | 25.646  |
|                       |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |         |         |
|                       |          |          |          | REFERENCE                   | 0.000   | 26.736  |
|                       |          |          |          | % DIFFERENCE                | 0.00%   | -4.08%  |

HD-863177  
740 NTCC40085HCCOR02 2  
BB

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-14-86 TIME: 16:41:02 HD-863177

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863177  
TEST DATE/TIME: 7-14-86 8:36

MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 75.60 F  
ABSOLUTE HUMIDITY: 74.97 GRAINS H2O / LB. DRY AIR

| EMISSION RESULTS        | CS       | HS       | WTD TEST | CYCLE STATISTICS            | CS      | HS      |
|-------------------------|----------|----------|----------|-----------------------------|---------|---------|
| <b>HC (INTEGRATED)</b>  |          |          |          |                             |         |         |
| BACKGROUND, PPM         | 4.09     | 5.28     |          | SPEED                       |         |         |
| EXHAUST+BKG, GM         | 20.13    | 17.73    |          | NUMBER                      | 1176    | 1176    |
| NET, GM/BHP-HR          | 0.657    | 0.519    | 0.539    | SLOPE                       | 0.99579 | 0.99440 |
| <b>CO (BAG)</b>         |          |          |          |                             |         |         |
| BACKGROUND, PPM         | 0.00     | 0.00     |          | Y-INTERCEPT                 | 4.804   | 6.835   |
| EXHAUST+BKG, GM         | 83.69    | 80.95    |          | (LIMIT: 0.97-1.03)          |         |         |
| NET, GM/BHP-HR          | 3.29     | 3.16     | 3.18     | STD ERROR                   | 25.158  | 24.977  |
| <b>NOx (INTEGRATED)</b> |          |          |          |                             |         |         |
| BACKGROUND, PPM         | 0.00     | 0.00     |          | R-SQUARE                    | 0.99826 | 0.99828 |
| EXHAUST+BKG, GM         | 112.01   | 120.49   |          | (LIMIT: 0.97)               |         |         |
| NET, GM/BHP-HR          | 4.409    | 4.709    | 4.666    | TORQUE                      |         |         |
| <b>CO2 (BAG)</b>        |          |          |          | NUMBER                      | 949     | 956     |
| BACKGROUND, PPM         | 0.034    | 0.033    |          | SLOPE                       | 1.00029 | 0.99999 |
| EXHAUST+BKG, GM         | 16580.63 | 15993.81 |          | Y-INTERCEPT                 | -8.109  | -7.636  |
| NET, GM/BHP-HR          | 617.7    | 591.4    | 595.2    | (LIMIT: 0.77/0.83-1.03)     |         |         |
| <b>PARTICULATE</b>      |          |          |          | STD ERROR                   | 4.590%  | 4.386%  |
| SECONDARY TARE, GM      | 0.157600 | 0.168200 |          | R-SQUARE                    | 0.97035 | 0.97320 |
| SECONDARY PART, GM      | 0.157900 | 0.168400 |          | (LIMIT: 0.85/0.88)          |         |         |
| PRIMARY TARE, GM        | 0.146300 | 0.163500 |          | POWER                       |         |         |
| PRIMARY PART, GM        | 0.159600 | 0.173900 |          | NUMBER                      | 948     | 956     |
| TOTAL, GM/BHP-HR        | 0.73     | 0.56     | 0.58     | SLOPE                       | 0.99912 | 0.99913 |
| <b>FUEL CONSUMPTION</b> |          |          |          | Y-INTERCEPT                 | -2.102  | -2.139  |
| LBS                     | 10.98    | 10.59    | 10.64    | (LIMIT: 0.87/0.89-1.03)     |         |         |
| LBS/BHP-HR              | 0.432    | 0.414    | 0.416    | STD ERROR                   | 4.279%  | 4.014%  |
| BRAKE HORSEPOWER-HOUR   | 25.406   | 25.588   | 25.562   | R-SQUARE                    | 0.97948 | 0.98207 |
|                         |          |          |          | (LIMIT: 0.91)               |         |         |
| <b>WORK</b>             |          |          |          |                             |         |         |
|                         |          |          |          | ACTUAL                      | 25.406  | 25.588  |
|                         |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |         |         |
|                         |          |          |          | REFERENCE                   | 26.736  | 26.737  |
|                         |          |          |          | % DIFFERENCE                | -4.97%  | -4.30%  |

HD-863178  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-14-86 TIME: 16:41:17 HD-863178

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863178  
TEST DATE/TIME: 7-14-86 10: 5  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 77.50 F  
ABSOLUTE HUMIDITY: 78.33 GRAINS H2O / LB. DRY AIR

| EMISSION RESULTS      | CS       | HS       | WTD TEST | CYCLE STATISTICS            | CS      | HS      |
|-----------------------|----------|----------|----------|-----------------------------|---------|---------|
| HC (INTEGRATED)       |          |          |          | SPEED                       |         |         |
| BACKGROUND, PPM       | 0.00     | 6.03     |          | NUMBER                      | 0       | 1176    |
| EXHAUST+BKG, GM       | 0.00     | 18.69    |          | SLOPE                       | 0.00000 | 0.99484 |
| NET, GM/BHP-HR        | 0.000    | 0.533    | 0.533    | (LIMIT: 0.97-1.03)          |         |         |
| CO (BAG)              |          |          |          | Y-INTERCEPT                 | 0.000   | 5.058   |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | (LIMIT: +-50 RPM)           |         |         |
| EXHAUST+BKG, GM       | 0.00     | 81.08    |          | STD ERROR                   | 0.000   | 25.252  |
| NET, GM/BHP-HR        | 0.00     | 3.18     | 3.18     | (LIMIT: 100 RPM)            |         |         |
| R-SQUARE              |          |          |          | R-SQUARE                    | 0.00000 | 0.99824 |
| (LIMIT: 0.97)         |          |          |          | (LIMIT: 0.97)               |         |         |
| NOX (INTEGRATED)      |          |          |          | TORQUE                      |         |         |
| BACKGROUND, PPM       | 0.00     | 0.25     |          | NUMBER                      | 0       | 952     |
| EXHAUST+BKG, GM       | 0.00     | 120.40   |          | SLOPE                       | 0.00000 | 1.00243 |
| NET, GM/BHP-HR        | 0.000    | 4.728    | 4.728    | (LIMIT: 0.77/0.83-1.03)     |         |         |
| CO2 (BAG)             |          |          |          | Y-INTERCEPT                 | 0.000   | -9.418  |
| BACKGROUND, PPM       | 0.000    | 0.034    |          | STD ERROR                   | 0.000%  | 4.409%  |
| EXHAUST+BKG, GM       | 0.00     | 15845.11 |          | (LIMIT: 13% MAX ENG TQ)     |         |         |
| NET, GM/BHP-HR        | 0.0      | 584.8    | 584.8    | R-SQUARE                    | 0.00000 | 0.97241 |
| PARTICULATE           |          |          |          | (LIMIT: 0.85/0.88)          |         |         |
| SECONDARY TARE, GM    | 0.000000 | 0.160000 |          | POWER                       |         |         |
| SECONDARY PART, GM    | 0.000000 | 0.160200 |          | NUMBER                      | 0       | 951     |
| PRIMARY TARE, GM      | 0.000000 | 0.164000 |          | SLOPE                       | 0.00000 | 0.99935 |
| PRIMARY PART, GM      | 0.000000 | 0.173700 |          | (LIMIT: 0.87/0.89-1.03)     |         |         |
| TOTAL, GM/BHP-HR      | 0.00     | 0.57     | 0.57     | Y-INTERCEPT                 | 0.000   | -2.337  |
| FUEL CONSUMPTION      |          |          |          | STD ERROR                   | 0.000%  | 4.053%  |
| LBS                   | 0.00     | 10.45    | 10.45    | (LIMIT: 8%)                 |         |         |
| LBS/BHP-HR            | 0.000    | 0.409    | 0.409    | R-SQUARE                    | 0.00000 | 0.98140 |
| (LIMIT: 0.91)         |          |          |          | (LIMIT: 0.91)               |         |         |
| BRAKE HORSEPOWER-HOUR | 0.000    | 25.538   | 25.538   | WORK                        |         |         |
|                       |          |          |          | ACTUAL                      | 0.000   | 25.538  |
|                       |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |         |         |
|                       |          |          |          | REFERENCE                   | 0.000   | 26.736  |
|                       |          |          |          | % DIFFERENCE                | 0.00%   | -4.48%  |

HD-863180  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-17-86 TIME: 11:11:27 HD-863180

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863180  
TEST DATE/TIME: 7-15-86 14:22

MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 73.90 F  
ABSOLUTE HUMIDITY: 72.91 GRAINS H<sub>2</sub>O / LB. DRY AIR

| EMISSION RESULTS      | CS       | HS       | WTD TEST | CYCLE STATISTICS            | CS      | HS      |
|-----------------------|----------|----------|----------|-----------------------------|---------|---------|
| HC (INTEGRATED)       |          |          |          | SPEED                       |         |         |
| BACKGROUND, PPM       | 0.00     | 4.54     |          | NUMBER                      | 0       | 1176    |
| EXHAUST+BKG, GM       | 0.00     | 15.40    |          | SLOPE                       | 0.00000 | 0.99504 |
| NET, GM/BHP-HR        | 0.000    | 0.453    | 0.453    | (LIMIT: 0.97-1.03)          |         |         |
| (CO (BAG)             |          |          |          | Y-INTERCEPT                 | 0.000   | 3.519   |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | (LIMIT: +-50 RPM)           |         |         |
| EXHAUST+BKG, GM       | 0.00     | 72.40    |          | STD ERROR                   | 0.000   | 25.825  |
| NET, GM/BHP-HR        | 0.00     | 2.84     | 2.84     | (LIMIT: 100 RPM)            |         |         |
| R-SQUARE              |          |          |          | (LIMIT: 0.97)               | 0.00000 | 0.99816 |
| NOX (INTEGRATED)      |          |          |          | TORQUE                      |         |         |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | NUMBER                      | 0       | 957     |
| EXHAUST+BKG, GM       | 0.00     | 197.27   |          | SLOPE                       | 0.00000 | 1.00737 |
| NET, GM/BHP-HR        | 0.000    | 7.693    | 7.693    | (LIMIT: 0.77/0.83-1.03)     |         |         |
| CO <sub>2</sub> (BAG) |          |          |          | Y-INTERCEPT                 | 0.000   | -11.982 |
| BACKGROUND, PPM       | 0.000    | 0.031    |          | (LIMIT: +-15 FT-LBS)        |         |         |
| EXHAUST+BKG, GM       | 0.00     | 15282.59 |          | STD ERROR                   | 0.000%  | 4.348%  |
| NET, GM/BHP-HR        | 0.0      | 566.8    | 566.8    | (LIMIT: 13% MAX ENG TQ)     | 0.00000 | 0.97420 |
| R-SQUARE              |          |          |          | (LIMIT: 0.85/0.88)          |         |         |
| PARTICULATE           |          |          |          | POWER                       |         |         |
| SECONDARY TARE, GM    | 0.000000 | 0.149400 |          | NUMBER                      | 0       | 956     |
| SECONDARY PART, GM    | 0.000000 | 0.149400 |          | SLOPE                       | 0.00000 | 1.00203 |
| PRIMARY TARE, GM      | 0.000000 | 0.153900 |          | (LIMIT: 0.87/0.89-1.03)     |         |         |
| PRIMARY PART, GM      | 0.000000 | 0.161200 |          | Y-INTERCEPT                 | 0.000   | -2.741  |
| TOTAL, GM/BHP-HR      | 0.00     | 0.39     | 0.39     | (LIMIT: +-5 BHP)            |         |         |
| FUEL CONSUMPTION      |          |          |          | STD ERROR                   | 0.000%  | 4.005%  |
| LBS                   | 0.00     | 10.10    | 10.10    | (LIMIT: 8%)                 |         |         |
| LBS/BHP-HR            | 0.000    | 0.396    | 0.396    | R-SQUARE                    | 0.00000 | 0.98238 |
| (LIMIT: 0.91)         |          |          |          | (LIMIT: 0.91)               |         |         |
| BRAKE HORSEPOWER-HOUR | 0.000    | 25.502   | 25.502   | WORK                        |         |         |
|                       |          |          |          | ACTUAL                      | 0.000   | 25.502  |
|                       |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |         |         |
|                       |          |          |          | REFERENCE                   | 0.000   | 26.736  |
|                       |          |          |          | % DIFFERENCE                | 0.00%   | -4.62%  |

HD-863181  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-17-86 TIME: 16:10:01 HD-863181

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863181  
TEST DATE/TIME: 7-15-86 15: 2  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 72.90 F  
ABSOLUTE HUMIDITY: 69.76 GRAINS H2O / LB. DRY AIR

| EMISSION RESULTS      | CS       | HS       | WTD TEST | CYCLE STATISTICS            | CS      | HS      |
|-----------------------|----------|----------|----------|-----------------------------|---------|---------|
| HC (INTEGRATED)       |          |          |          | SPEED                       |         |         |
| BACKGROUND, PPM       | 0.00     | 5.66     |          | NUMBER                      | 0       | 1176    |
| EXHAUST+BKG, GM       | 0.00     | 14.15    |          | SLOPE                       | 0.00000 | 0.99429 |
| NET, GM/BHP-HR        | 0.000    | 0.365    | 0.365    | (LIMIT: 0.97-1.03)          |         |         |
| CO (BAG)              |          |          |          | Y-INTERCEPT                 | 0.000   | 4.032   |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | (LIMIT: +-50 RPM)           |         |         |
| EXHAUST+BKG, GM       | 0.00     | 69.51    |          | STD ERROR                   | 0.000   | 25.734  |
| NET, GM/BHP-HR        | 0.00     | 2.72     | 2.72     | (LIMIT: 100 RPM)            |         |         |
|                       |          |          |          | R-SQUARE                    | 0.00000 | 0.99817 |
|                       |          |          |          | (LIMIT: 0.97)               |         |         |
| THC (INTEGRATED)      |          |          |          | TORQUE                      |         |         |
| BACKGROUND, PPM       | 0.00     | 0.50     |          | NUMBER                      | 0       | 957     |
| EXHAUST+BKG, GM       | 0.00     | 197.35   |          | SLOPE                       | 0.00000 | 0.99659 |
| NET, GM/BHP-HR        | 0.000    | 7.553    | 7.553    | (LIMIT: 0.77/0.83-1.03)     |         |         |
| CO2 (BAG)             |          |          |          | Y-INTERCEPT                 | 0.000   | -4.589  |
| BACKGROUND, PPM       | 0.000    | 0.032    |          | (LIMIT: +-15 FT-LBS)        |         |         |
| EXHAUST+BKG, GM       | 0.00     | 15100.89 |          | STD ERROR                   | 0.000%  | 4.463%  |
| NET, GM/BHP-HR        | 0.0      | 556.9    | 556.9    | (LIMIT: 13% MAX. ENG TQ)    |         |         |
|                       |          |          |          | R-SQUARE                    | 0.00000 | 0.97227 |
|                       |          |          |          | (LIMIT: 0.85/0.88)          |         |         |
| PARTICULATE           |          |          |          | POWER                       |         |         |
| SECONDARY TARE, GM    | 0.000000 | 0.163900 |          | NUMBER                      | 0       | 956     |
| SECONDARY PART, GM    | 0.000000 | 0.163900 |          | SLOPE                       | 0.00000 | 0.99771 |
| PRIMARY TARE, GM      | 0.000000 | 0.160000 |          | (LIMIT: 0.87/0.89-1.03)     |         |         |
| PRIMARY PART, GM      | 0.000000 | 0.167600 |          | Y-INTERCEPT                 | 0.000   | -1.882  |
| TOTAL, GM/BHP-HR      | 0.00     | 0.40     | 0.40     | (LIMIT: +-5 BHP)            |         |         |
|                       |          |          |          | STD ERROR                   | 0.000%  | 4.052%  |
| FUEL CONSUMPTION      |          |          |          | (LIMIT: 8%)                 |         |         |
| LBS                   | 0.00     | 9.96     | 9.96     | R-SQUARE                    | 0.00000 | 0.98181 |
| LBS/BHP-HR            | 0.000    | 0.389    | 0.389    | (LIMIT: 0.91)               |         |         |
| BRAKE HORSEPOWER-HOUR | 0.000    | 25.594   | 25.594   | WORK                        |         |         |
|                       |          |          |          | ACTUAL                      | 0.000   | 25.594  |
|                       |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |         |         |
|                       |          |          |          | REFERENCE                   | 0.000   | 26.736  |
|                       |          |          |          | % DIFFERENCE                | 0.00%   | -4.27%  |

HD-863182  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-17-86 TIME: 11:12:30 HD-863182

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863182  
TEST DATE/TIME: 7-15-86 15:43 MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 72.30 F  
ABSOLUTE HUMIDITY: 72.21 GRAINS H2O / LB. DRY AIR

| <u>EMISSION RESULTS</u> | <u>CS</u> | <u>HS</u> | <u>WTD TEST</u> | <u>CYCLE STATISTICS</u>     | <u>CS</u> | <u>HS</u> |
|-------------------------|-----------|-----------|-----------------|-----------------------------|-----------|-----------|
| HC (INTEGRATED)         |           |           |                 | SPEED                       |           |           |
| BACKGROUND, PPM         | 0.00      | 5.36      |                 | NUMBER                      | 0         | 1176      |
| EXHAUST+BKG, GM         | 0.00      | 14.59     |                 | SLOPE                       | 0.00000   | 0.99585   |
| NET, GM/BHP-HR          | 0.000     | 0.394     | 0.394           | (LIMIT: 0.97-1.03)          |           |           |
| O <sub>2</sub> (BAG)    |           |           |                 | Y-INTERCEPT                 | 0.000     | 1.551     |
| BACKGROUND, PPM         | 0.00      | 0.00      |                 | (LIMIT: +-50 RPM)           |           |           |
| EXHAUST+BKG, GM         | 0.00      | 71.74     |                 | STD ERROR                   | 0.000     | 25.640    |
| NET, GM/BHP-HR          | 0.00      | 2.81      | 2.81            | (LIMIT: 100 RPM)            |           |           |
|                         |           |           |                 | R-SQUARE                    | 0.00000   | 0.99819   |
|                         |           |           |                 | (LIMIT: 0.97)               |           |           |
| NOX (INTEGRATED)        |           |           |                 | TORQUE                      |           |           |
| BACKGROUND, PPM         | 0.00      | 0.25      |                 | NUMBER                      | 0         | 958       |
| EXHAUST+BKG, GM         | 0.00      | 197.18    |                 | SLOPE                       | 0.00000   | 1.00176   |
| NET, GM/BHP-HR          | 0.000     | 7.642     | 7.642           | (LIMIT: 0.77/0.83-1.03)     |           |           |
| CO <sub>2</sub> (BAG)   |           |           |                 | Y-INTERCEPT                 | 0.000     | -8.290    |
| BACKGROUND, PPM         | 0.000     | 0.033     |                 | (LIMIT: +-15 FT-LBS)        |           |           |
| EXHAUST+BKG, GM         | 0.00      | 15180.09  |                 | STD ERROR                   | 0.000%    | 4.419%    |
| NET, GM/BHP-HR          | 0.0       | 560.6     | 560.6           | (LIMIT: 13% MAX ENG TQ)     |           |           |
|                         |           |           |                 | R-SQUARE                    | 0.00000   | 0.97320   |
|                         |           |           |                 | (LIMIT: 0.85/0.88)          |           |           |
| PARTICULATE             |           |           |                 | POWER                       |           |           |
| SECONDARY TARE, GM      | 0.000000  | 0.164300  |                 | NUMBER                      | 0         | 957       |
| SECONDARY PART, GM      | 0.000000  | 0.164300  |                 | SLOPE                       | 0.00000   | 0.99929   |
| PRIMARY TARE, GM        | 0.000000  | 0.164600  |                 | (LIMIT: 0.87/0.89-1.03)     |           |           |
| PRIMARY PART, GM        | 0.000000  | 0.172300  |                 | Y-INTERCEPT                 | 0.000     | -2.309    |
| TOTAL, GM/BHP-HR        | 0.00      | 0.41      | 0.41            | (LIMIT: +-5 BHP)            |           |           |
|                         |           |           |                 | STD ERROR                   | 0.000%    | 4.050%    |
| FUEL CONSUMPTION        |           |           |                 | (LIMIT: 8%)                 |           |           |
| LBS                     | 0.00      | 10.00     | 10.00           | R-SQUARE                    | 0.00000   | 0.98194   |
| LBS/BHP-HR              | 0.000     | 0.392     | 0.392           | (LIMIT: 0.91)               |           |           |
| BRAKE HORSEPOWER-HOUR   | 0.000     | 25.527    | 25.527          | WORK                        |           |           |
|                         |           |           |                 | ACTUAL                      | 0.000     | 25.527    |
|                         |           |           |                 | (LIMIT: -15%-5% REF BHP-HR) |           |           |
|                         |           |           |                 | REFERENCE                   | 0.000     | 26.736    |
|                         |           |           |                 | % DIFFERENCE                | 0.00%     | -4.52%    |

HD-863183  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-17-86 TIME: 11:13:13 HD-863183

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863183  
TEST DATE/TIME: 7-15-86 16:22  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 72.90 F  
ABSOLUTE HUMIDITY: 71.68 GRAINS H<sub>2</sub>O / LB. DRY AIR

| EMISSION RESULTS      | CS       | HS       | WTD TEST | CYCLE STATISTICS            | CS      | HS      |
|-----------------------|----------|----------|----------|-----------------------------|---------|---------|
| HC (INTEGRATED)       |          |          |          | SPEED                       |         |         |
| BACKGROUND, PPM       | 0.00     | 5.51     |          | NUMBER                      | 0       | 1176    |
| EXHAUST+BKG, GM       | 0.00     | 14.41    |          | SLOPE                       | 0.00000 | 0.99471 |
| NET, GM/BHP-HR        | 0.000    | 0.381    | 0.381    | (LIMIT: 0.97-1.03)          |         |         |
| CO (BAG)              |          |          |          | Y-INTERCEPT                 | 0.000   | 3.643   |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | (LIMIT: +-50 RPM)           |         |         |
| EXHAUST+BKG, GM       | 0.00     | 71.55    |          | STD ERROR                   | 0.000   | 25.928  |
| NET, GM/BHP-HR        | 0.00     | 2.80     | 2.80     | (LIMIT: 100 RPM)            |         |         |
| R-SQUARE              |          |          |          | (LIMIT: 0.97)               | 0.00000 | 0.99815 |
| NOX (INTEGRATED)      |          |          |          | TORQUE                      |         |         |
| BACKGROUND, PPM       | 0.00     | 0.25     |          | NUMBER                      | 0       | 958     |
| EXHAUST+BKG, GM       | 0.00     | 197.09   |          | SLOPE                       | 0.00000 | 0.99882 |
| NET, GM/BHP-HR        | 0.000    | 7.620    | 7.620    | (LIMIT: 0.77/0.83-1.03)     |         |         |
| CO <sub>2</sub> (BAG) |          |          |          | Y-INTERCEPT                 | 0.000   | -6.781  |
| BACKGROUND, PPM       | 0.000    | 0.030    |          | (LIMIT: +-15 FT-LBS)        |         |         |
| EXHAUST+BKG, GM       | 0.00     | 15265.94 |          | STD ERROR                   | 0.000%  | 4.418%  |
| NET, GM/BHP-HR        | 0.0      | 566.2    | 566.2    | (LIMIT: 13% MAX ENG TQ)     | 0.00000 | 0.97306 |
| R-SQUARE              |          |          |          | (LIMIT: 0.85/0.88)          |         |         |
| PARTICULATE           |          |          |          | POWER                       |         |         |
| SECONDARY TARE, GM    | 0.000000 | 0.164600 |          | NUMBER                      | 0       | 957     |
| SECONDARY PART, GM    | 0.000000 | 0.164600 |          | SLOPE                       | 0.00000 | 0.99869 |
| PRIMARY TARE, GM      | 0.000000 | 0.169800 |          | (LIMIT: 0.87/0.89-1.03)     |         |         |
| PRIMARY PART, GM      | 0.000000 | 0.182900 |          | Y-INTERCEPT                 | 0.000   | -2.172  |
| TOTAL, GM/BHP-HR      | 0.00     | 0.70     | 0.70     | (LIMIT: +-5 BHP)            |         |         |
| FUEL CONSUMPTION      |          |          |          | STD ERROR                   | 0.000%  | 4.032%  |
| LBS                   | 0.00     | 10.11    | 10.11    | (LIMIT: 8%)                 |         |         |
| LBS/BHP-HR            | 0.000    | 0.396    | 0.396    | R-SQUARE                    | 0.00000 | 0.98207 |
| BRAKE HORSEPOWER-HOUR | 0.000    | 25.551   | 25.551   | (LIMIT: 0.91)               |         |         |
| WORK                  |          |          |          | ACTUAL                      | 0.000   | 25.551  |
|                       |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |         |         |
|                       |          |          |          | REFERENCE                   | 0.000   | 26.736  |
|                       |          |          |          | % DIFFERENCE                | 0.00%   | -4.43%  |

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HD-863184  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-17-86 TIME: 17:06:44 HD-863184

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863184  
TEST DATE/TIME: 7-16-86 8:45  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 78.00 F  
ABSOLUTE HUMIDITY: 85.84 GRAINS H2O / LB. DRY AIR

| <u>EMISSION RESULTS</u> | <u>CS</u> | <u>HS</u> | <u>WTD TEST</u> | <u>CYCLE STATISTICS</u>     | <u>CS</u> | <u>HS</u> |
|-------------------------|-----------|-----------|-----------------|-----------------------------|-----------|-----------|
| HC (INTEGRATED)         |           |           |                 | SPEED                       |           |           |
| BACKGROUND, PPM         | 0.00      | 5.28      |                 | NUMBER                      | 0         | 1176      |
| EXHAUST+BKG, GM         | 0.00      | 36.89     |                 | SLOPE                       | 0.00000   | 0.99601   |
| NET, GM/BHP-HR          | 0.000     | 1.254     | 1.254           | (LIMIT: 0.97-1.03)          |           |           |
| CO (BAG)                |           |           |                 | Y-INTERCEPT                 | 0.000     | 5.237     |
| BACKGROUND, PPM         | 0.00      | 0.00      |                 | (LIMIT: +-50 RPM)           |           |           |
| EXHAUST+BKG, GM         | 0.00      | 106.40    |                 | STD ERROR                   | 0.000     | 25.643    |
| NET, GM/BHP-HR          | 0.00      | 4.11      | 4.11            | (LIMIT: 100 RPM)            |           |           |
| R-SQUARE                |           |           |                 | (LIMIT: 0.97)               | 0.00000   | 0.99819   |
| NOX (INTEGRATED)        |           |           |                 | TORQUE                      |           |           |
| BACKGROUND, PPM         | 0.00      | 0.00      |                 | NUMBER                      | 0         | 967       |
| EXHAUST+BKG, GM         | 0.00      | 97.86     |                 | SLOPE                       | 0.00000   | 0.99137   |
| NET, GM/BHP-HR          | 0.000     | 3.891     | 3.891           | (LIMIT: 0.77/0.83-1.03)     |           |           |
| CO2 (BAG)               |           |           |                 | Y-INTERCEPT                 | 0.000     | -2.371    |
| BACKGROUND, PPM         | 0.000     | 0.034     |                 | (LIMIT: +-15 FT-LBS)        |           |           |
| EXHAUST+BKG, GM         | 0.00      | 16329.03  |                 | STD ERROR                   | 0.000%    | 4.462%    |
| NET, GM/BHP-HR          | 0.0       | 595.7     | 595.7           | (LIMIT: 13% MAX ENG TQ)     | 0.00000   | 0.97305   |
| R-SQUARE                |           |           |                 | (LIMIT: 0.85/0.88)          |           |           |
| PARTICULATE             |           |           |                 | POWER                       |           |           |
| SECONDARY TARE, GM      | 0.000000  | 0.164600  |                 | NUMBER                      | 0         | 966       |
| SECONDARY PART, GM      | 0.000000  | 0.164600  |                 | SLOPE                       | 0.00000   | 0.99497   |
| PRIMARY TARE, GM        | 0.000000  | 0.169800  |                 | (LIMIT: 0.87/0.89-1.03)     |           |           |
| PRIMARY PART, GM        | 0.000000  | 0.182900  |                 | Y-INTERCEPT                 | 0.000     | -1.455    |
| TOTAL, GM/BHP-HR        | 0.00      | 0.71      | 0.71            | (LIMIT: +-5 BHP)            |           |           |
| FUEL CONSUMPTION        |           |           |                 | STD ERROR                   | 0.000%    | 4.042%    |
| LBS                     | 0.00      | 10.85     | 10.85           | (LIMIT: 8%)                 |           |           |
| LBS/BHP-HR              | 0.000     | 0.419     | 0.419           | R-SQUARE                    | 0.00000   | 0.98215   |
| BRAKE HORSEPOWER-HOUR   | 0.000     | 25.880    | 25.880          | (LIMIT: 0.91)               |           |           |
| WORK                    |           |           |                 | WORK                        |           |           |
| ACTUAL                  |           |           |                 | ACTUAL                      | 0.000     | 25.880    |
| REFERENCE               |           |           |                 | (LIMIT: -15%-5% REF BHP-HR) |           |           |
| % DIFFERENCE            |           |           |                 | REFERENCE                   | 0.000     | 26.736    |
|                         |           |           |                 | % DIFFERENCE                | 0.00%     | -3.20%    |

HD-863185  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-17-86 TIME: 17:07:18 HD-863185

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863185  
TEST DATE/TIME: 7-16-86 13:49  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG

DRY BULB TEMPERATURE: 78.40 F

ABSOLUTE HUMIDITY: 77.84 GRAINS H2O / LB. DRY AIR

| <u>EMISSION RESULTS</u> | <u>CS</u> | <u>HS</u> | <u>WTD TEST</u> | <u>CYCLE STATISTICS</u>     | <u>CS</u> | <u>HS</u> |
|-------------------------|-----------|-----------|-----------------|-----------------------------|-----------|-----------|
| HC (INTEGRATED)         |           |           |                 | SPEED                       |           |           |
| BACKGROUND, PPM         | 0.00      | 5.43      |                 | NUMBER                      | 0         | 1176      |
| EXHAUST+BKG, GM         | 0.00      | 34.71     |                 | SLOPE                       | 0.00000   | 0.99735   |
| NET, GM/BHP-HR          | 0.000     | 1.165     | 1.165           | (LIMIT: 0.97-1.03)          |           |           |
| CO (BAG)                |           |           |                 | Y-INTERCEPT                 | 0.000     | 3.771     |
| BACKGROUND, PPM         | 0.00      | 0.00      |                 | (LIMIT: +-50 RPM)           |           |           |
| EXHAUST+BKG, GM         | 0.00      | 105.54    |                 | STD ERROR                   | 0.000     | 25.533    |
| NET, GM/BHP-HR          | 0.00      | 4.08      | 4.08            | (LIMIT: 100 RPM)            |           |           |
| R-SQUARE                |           |           |                 | (LIMIT: 0.97)               | 0.00000   | 0.99821   |
| NOX (INTEGRATED)        |           |           |                 | TORQUE                      |           |           |
| BACKGROUND, PPM         | 0.00      | 0.00      |                 | NUMBER                      | 0         | 967       |
| EXHAUST+BKG, GM         | 0.00      | 99.58     |                 | SLOPE                       | 0.00000   | 0.99198   |
| NET, GM/BHP-HR          | 0.000     | 3.875     | 3.875           | (LIMIT: 0.77/0.83-1.03)     |           |           |
| CO2 (BAG)               |           |           |                 | Y-INTERCEPT                 | 0.000     | -2.817    |
| BACKGROUND, PPM         | 0.000     | 0.032     |                 | (LIMIT: +-15 FT-LBS)        |           |           |
| EXHAUST+BKG, GM         | 0.00      | 16416.35  |                 | STD ERROR                   | 0.000%    | 4.766%    |
| NET, GM/BHP-HR          | 0.0       | 601.8     | 601.8           | (LIMIT: 13% MAX ENG TQ)     | 0.00000   | 0.96940   |
| R-SQUARE                |           |           |                 | (LIMIT: 0.85/0.88)          |           |           |
| PARTICULATE             |           |           |                 | POWER                       |           |           |
| SECONDARY TARE, GM      | 0.000000  | 0.162300  |                 | NUMBER                      | 0         | 966       |
| SECONDARY PART, GM      | 0.000000  | 0.162500  |                 | SLOPE                       | 0.00000   | 0.99634   |
| PRIMARY TARE, GM        | 0.000000  | 0.154800  |                 | (LIMIT: 0.87/0.89-1.03)     |           |           |
| PRIMARY PART, GM        | 0.000000  | 0.167400  |                 | Y-INTERCEPT                 | 0.000     | -1.548    |
| TOTAL, GM/BHP-HR        | 0.00      | 0.69      | 0.69            | (LIMIT: +-5 BHP)            |           |           |
| FUEL CONSUMPTION        |           |           |                 | STD ERROR                   | 0.000%    | 4.122%    |
| LBS                     | 0.00      | 10.96     | 10.96           | (LIMIT: 8%)                 |           |           |
| LBS/BHP-HR              | 0.000     | 0.423     | 0.423           | R-SQUARE                    | 0.00000   | 0.98150   |
| BRAKE HORSEPOWER-HOUR   | 0.000     | 25.890    | 25.890          | (LIMIT: 0.91)               |           |           |
| WORK                    |           |           |                 | ACTUAL                      | 0.000     | 25.890    |
|                         |           |           |                 | (LIMIT: -15%-5% REF BHP-HR) |           |           |
|                         |           |           |                 | REFERENCE                   | 0.000     | 26.736    |
|                         |           |           |                 | % DIFFERENCE                | 0.00%     | -3.16%    |

HD-863186  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-17-86 TIME: 17:07:32 HD-863186

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863186  
TEST DATE/TIME: 7-16-86 14:24  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 75.90 F  
ABSOLUTE HUMIDITY: 94.25 GRAINS H2O / LB. DRY AIR

| <u>EMISSION RESULTS</u> | <u>CS</u> | <u>HS</u> | <u>WTD TEST</u> | <u>CYCLE STATISTICS</u>     | <u>CS</u> | <u>HS</u> |
|-------------------------|-----------|-----------|-----------------|-----------------------------|-----------|-----------|
| HC (INTEGRATED)         |           |           |                 | SPEED                       |           |           |
| BACKGROUND, PPM         | 0.00      | 6.79      |                 | NUMBER                      | 0         | 1176      |
| EXHAUST+BKG, GM         | 0.00      | 34.51     |                 | SLOPE                       | 0.00000   | 0.99881   |
| NET, GM/BHP-HR          | 0.000     | 1.117     | 1.117           | (LIMIT: 0.97-1.03)          |           |           |
| CO (BAG)                |           |           |                 | Y-INTERCEPT                 | 0.000     | 0.909     |
| BACKGROUND, PPM         | 0.00      | 0.00      |                 | (LIMIT: +-50 RPM)           |           |           |
| EXHAUST+BKG, GM         | 0.00      | 103.28    |                 | STD ERROR                   | 0.000     | 26.113    |
| NET, GM/BHP-HR          | 0.00      | 4.00      | 4.00            | (LIMIT: 100 RPM)            |           |           |
|                         |           |           |                 | R-SQUARE                    | 0.00000   | 0.99814   |
|                         |           |           |                 | (LIMIT: 0.97)               |           |           |
| H2A (INTEGRATED)        |           |           |                 | TORQUE                      |           |           |
| BACKGROUND, PPM         | 0.00      | 0.00      |                 | NUMBER                      | 0         | 959       |
| EXHAUST+BKG, GM         | 0.00      | 98.81     |                 | SLOPE                       | 0.00000   | 0.99572   |
| NET, GM/BHP-HR          | 0.000     | 4.030     | 4.030           | (LIMIT: 0.77/0.83-1.03)     |           |           |
| CO2 (BAG)               |           |           |                 | Y-INTERCEPT                 | 0.000     | -5.877    |
| BACKGROUND, PPM         | 0.000     | 0.030     |                 | (LIMIT: +-15 FT-LBS)        |           |           |
| EXHAUST+BKG, GM         | 0.00      | 16481.23  |                 | STD ERROR                   | 0.000%    | 4.749%    |
| NET, GM/BHP-HR          | 0.0       | 607.9     | 607.9           | (LIMIT: 13% MAX ENG TQ)     |           |           |
|                         |           |           |                 | R-SQUARE                    | 0.00000   | 0.96861   |
|                         |           |           |                 | (LIMIT: 0.85/0.88)          |           |           |
| PARTICULATE             |           |           |                 | POWER                       |           |           |
| SECONDARY TARE, GM      | 0.000000  | 0.161100  |                 | NUMBER                      | 0         | 958       |
| SECONDARY PART, GM      | 0.000000  | 0.161100  |                 | SLOPE                       | 0.00000   | 0.99655   |
| PRIMARY TARE, GM        | 0.000000  | 0.167000  |                 | (LIMIT: 0.87/0.89-1.03)     |           |           |
| PRIMARY PART, GM        | 0.000000  | 0.179550  |                 | Y-INTERCEPT                 | 0.000     | -1.878    |
| TOTAL, GM/BHP-HR        | 0.00      | 0.69      | 0.69            | (LIMIT: +-5 BHP)            |           |           |
|                         |           |           |                 | STD ERROR                   | 0.000%    | 4.140%    |
| FUEL CONSUMPTION        |           |           |                 | (LIMIT: 8%)                 |           |           |
| LBS                     | 0.00      | 11.03     | 11.03           | R-SQUARE                    | 0.00000   | 0.98080   |
| LBS/BHP-HR              | 0.000     | 0.427     | 0.427           | (LIMIT: 0.91)               |           |           |
| BRAKE HORSEPOWER-HOUR   | 0.000     | 25.814    | 25.814          | WORK                        |           |           |
|                         |           |           |                 | ACTUAL                      | 0.000     | 25.814    |
|                         |           |           |                 | (LIMIT: -15%-5% REF BHP-HR) |           |           |
|                         |           |           |                 | REFERENCE                   | 0.000     | 26.736    |
|                         |           |           |                 | % DIFFERENCE                | 0.00%     | -3.45%    |

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HD-863187  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-17-86 TIME: 17:07:44 HD-863187

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863187  
TEST DATE/TIME: 7-17-86 8:50  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.20 "HG  
DRY BULB TEMPERATURE: 74.50 F  
ABSOLUTE HUMIDITY: 81.03 GRAINS H<sub>2</sub>O / LB. DRY AIR

| EMISSION RESULTS      | CS       | HS       | WTD TEST | CYCLE STATISTICS            | CS      | HS      |
|-----------------------|----------|----------|----------|-----------------------------|---------|---------|
| HC (INTEGRATED)       |          |          |          | SPEED                       |         |         |
| BACKGROUND, PPM       | 0.00     | 6.34     |          | NUMBER                      | 0       | 1176    |
| EXHAUST+BKG, GM       | 0.00     | 35.84    |          | SLOPE                       | 0.00000 | 0.99619 |
| NET, GM/BHP-HR        | 0.000    | 1.173    | 1.173    | (LIMIT: 0.97-1.03)          |         |         |
| CO (BAG)              |          |          |          | Y-INTERCEPT                 | 0.000   | 4.330   |
| BACKGROUND, PPM       | 0.00     | 0.48     |          | (LIMIT: +-50 RPM)           |         |         |
| EXHAUST+BKG, GM       | 0.00     | 105.89   |          | STD ERROR                   | 0.000   | 25.645  |
| NET, GM/BHP-HR        | 0.00     | 4.04     | 4.04     | (LIMIT: 100 RPM)            |         |         |
| R-SQUARE              |          |          |          | (LIMIT: 0.97)               | 0.00000 | 0.99819 |
| NOX (INTEGRATED)      |          |          |          | TORQUE                      |         |         |
| BACKGROUND, PPM       | 0.00     | 0.25     |          | NUMBER                      | 0       | 967     |
| EXHAUST+BKG, GM       | 0.00     | 96.62    |          | SLOPE                       | 0.00000 | 0.98299 |
| NET, GM/BHP-HR        | 0.000    | 3.746    | 3.746    | (LIMIT: 0.77/0.83-1.03)     |         |         |
| CO <sub>2</sub> (BAG) |          |          |          | Y-INTERCEPT                 | 0.000   | 3.923   |
| BACKGROUND, PPM       | 0.000    | 0.039    |          | (LIMIT: +-15 FT-LBS)        |         |         |
| EXHAUST+BKG, GM       | 0.00     | 16569.04 |          | STD ERROR                   | 0.000%  | 4.823%  |
| NET, GM/BHP-HR        | 0.0      | 597.5    | 597.5    | (LIMIT: 13% MAX ENG TQ)     | 0.00000 | 0.96814 |
| R-SQUARE              |          |          |          | (LIMIT: 0.85/0.88)          |         |         |
| PARTICULATE           |          |          |          | POWER                       |         |         |
| SECONDARY TARE, GM    | 0.000000 | 0.168650 |          | NUMBER                      | 0       | 966     |
| SECONDARY PART, GM    | 0.000000 | 0.168800 |          | SLOPE                       | 0.00000 | 0.99282 |
| PRIMARY TARE, GM      | 0.000000 | 0.160650 |          | (LIMIT: 0.87/0.89-1.03)     |         |         |
| PRIMARY PART, GM      | 0.000000 | 0.173100 |          | Y-INTERCEPT                 | 0.000   | -0.748  |
| TOTAL, GM/BHP-HR      | 0.00     | 0.67     | 0.67     | (LIMIT: +-5 BHP)            |         |         |
| FUEL CONSUMPTION      |          |          |          | STD ERROR                   | 0.000%  | 4.118%  |
| LBS                   | 0.00     | 10.94    | 10.94    | (LIMIT: 8%)                 |         |         |
| LBS/BHP-HR            | 0.000    | 0.420    | 0.420    | R-SQUARE                    | 0.00000 | 0.98141 |
| BRAKE HORSEPOWER-HOUR | 0.000    | 26.016   | 26.016   | (LIMIT: 0.91)               |         |         |
| WORK                  |          |          |          | ACTUAL                      | 0.000   | 26.016  |
|                       |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |         |         |
|                       |          |          |          | REFERENCE                   | 0.000   | 26.736  |
|                       |          |          |          | % DIFFERENCE                | 0.00%   | -2.69%  |

HD-863188  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 08-06-86 TIME: 09:55:26 HD-863188

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863188  
TEST DATE/TIME: 7-18-86 8:45  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 74.50 F  
ABSOLUTE HUMIDITY: 49.91 GRAINS H2O / LB. DRY AIR

| EMISSION RESULTS      | CS       | HS       | WTD TEST | CYCLE STATISTICS            | CS      | HS      |
|-----------------------|----------|----------|----------|-----------------------------|---------|---------|
| HC (INTEGRATED)       |          |          |          | SPEED                       |         |         |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | NUMBER                      | 0       | 1176    |
| EXHAUST+BKG, GM       | 0.00     | 16.95    |          | SLOPE                       | 0.00000 | 0.99740 |
| NET, GM/BHP-HR        | 0.000    | 0.483    | 0.483    | (LIMIT: 0.97-1.03)          |         |         |
| CO (BAG)              |          |          |          | Y-INTERCEPT                 | 0.000   | 4.466   |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | (LIMIT: +-50 RPM)           |         |         |
| EXHAUST+BKG, GM       | 0.00     | 80.37    |          | STD ERROR                   | 0.000   | 25.395  |
| NET, GM/BHP-HR        | 0.00     | 3.12     | 3.12     | (LIMIT: 100 RPM)            |         |         |
|                       |          |          |          | R-SQUARE                    | 0.00000 | 0.99823 |
|                       |          |          |          | (LIMIT: 0.97)               |         |         |
| NOX (INTEGRATED)      |          |          |          | TORQUE                      |         |         |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | NUMBER                      | 0       | 955     |
| EXHAUST+BKG, GM       | 0.00     | 117.36   |          | SLOPE                       | 0.00000 | 1.00233 |
| NET, GM/BHP-HR        | 0.000    | 4.252    | 4.252    | (LIMIT: 0.77/0.83-1.03)     |         |         |
| CO2 (BAG)             |          |          |          | Y-INTERCEPT                 | 0.000   | -6.893  |
| BACKGROUND, PPM       | 0.000    | 0.000    |          | (LIMIT: +-15 FT-LBS)        |         |         |
| EXHAUST+BKG, GM       | 0.00     | 16039.31 |          | STD ERROR                   | 0.000%  | 4.718%  |
| NET, GM/BHP-HR        | 0.0      | 586.4    | 586.4    | (LIMIT: 13% MAX ENG TQ)     |         |         |
|                       |          |          |          | R-SQUARE                    | 0.00000 | 0.96901 |
|                       |          |          |          | (LIMIT: 0.85/0.88)          |         |         |
| PARTICULATE           |          |          |          | POWER                       |         |         |
| SECONDARY TARE, GM    | 0.000000 | 0.151900 |          | NUMBER                      | 0       | 954     |
| SECONDARY PART, GM    | 0.000000 | 0.151900 |          | SLOPE                       | 0.00000 | 1.00359 |
| PRIMARY TARE, GM      | 0.000000 | 0.156000 |          | (LIMIT: 0.87/0.89-1.03)     |         |         |
| PRIMARY PART, GM      | 0.000000 | 0.166000 |          | Y-INTERCEPT                 | 0.000   | -1.960  |
| TOTAL, GM/BHP-HR      | 0.00     | 0.54     | 0.54     | (LIMIT: +-5 BHP)            |         |         |
|                       |          |          |          | STD ERROR                   | 0.000%  | 4.113%  |
| FUEL CONSUMPTION      |          |          |          | (LIMIT: 8%)                 |         |         |
| LBS                   | 0.00     | 10.57    | 10.57    | R-SQUARE                    | 0.00000 | 0.98123 |
| LBS/BHP-HR            | 0.000    | 0.410    | 0.410    | (LIMIT: 0.91)               |         |         |
| BRAKE HORSEPOWER-HOUR | 0.000    | 25.761   |          | WORK                        |         |         |
|                       |          |          |          | ACTUAL                      | 0.000   | 25.761  |
|                       |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |         |         |
|                       |          |          |          | REFERENCE                   | 0.000   | 26.736  |
|                       |          |          |          | % DIFFERENCE                | 0.00%   | -3.65%  |

HD-863189  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-21-86 TIME: 09:55:59 HD-863189

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863189  
TEST DATE/TIME: 7-18-86 9:20  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 75.60 F  
ABSOLUTE HUMIDITY: 56.12 GRAINS H2O / LB. DRY AIR

| EMISSION RESULTS      | CS       | HS       | WTD TEST | CYCLE STATISTICS            | CS      | HS      |
|-----------------------|----------|----------|----------|-----------------------------|---------|---------|
| HC (INTEGRATED)       |          |          |          | SPEED                       |         |         |
| BACKGROUND, PPM       | 0.00     | 5.36     |          | NUMBER                      | 0       | 1176    |
| EXHAUST+BKG, GM       | 0.00     | 15.99    |          | SLOPE                       | 0.00000 | 0.99617 |
| NET, GM/BHP-HR        | 0.000    | 0.447    | 0.447    | (LIMIT: 0.97-1.03)          |         |         |
| CO (BAG)              |          |          |          | Y-INTERCEPT                 | 0.000   | 5.163   |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | (LIMIT: +-50 RPM)           |         |         |
| EXHAUST+BKG, GM       | 0.00     | 77.32    |          | STD ERROR                   | 0.000   | 25.361  |
| NET, GM/BHP-HR        | 0.00     | 3.01     | 3.01     | (LIMIT: 100 RPM)            |         |         |
|                       |          |          |          | R-SQUARE                    | 0.00000 | 0.99823 |
| NOX (INTEGRATED)      |          |          |          | (LIMIT: 0.97)               |         |         |
| BACKGROUND, PPM       | 0.00     | 0.50     |          | TORQUE                      |         |         |
| EXHAUST+BKG, GM       | 0.00     | 119.08   |          | NUMBER                      | 0       | 953     |
| NET, GM/BHP-HR        | 0.000    | 4.364    | 4.364    | SLOPE                       | 0.00000 | 0.99333 |
| CO2 (BAG)             |          |          |          | (LIMIT: 0.77/0.83-1.03)     |         |         |
| BACKGROUND, PPM       | 0.000    | 0.034    |          | Y-INTERCEPT                 | 0.000   | -3.141  |
| EXHAUST+BKG, GM       | 0.00     | 15961.33 |          | STD ERROR                   | 0.000%  | 4.771%  |
| NET, GM/BHP-HR        | 0.0      | 585.7    | 585.7    | (LIMIT: +-15 FT-LBS)        |         |         |
|                       |          |          |          | R-SQUARE                    | 0.00000 | 0.96748 |
| PARTICULATE           |          |          |          | (LIMIT: 0.85/0.88)          |         |         |
| SECONDARY TARE, GM    | 0.000000 | 0.158100 |          | POWER                       |         |         |
| SECONDARY PART, GM    | 0.000000 | 0.158150 |          | NUMBER                      | 0       | 952     |
| PRIMARY TARE, GM      | 0.000000 | 0.158350 |          | SLOPE                       | 0.00000 | 0.99780 |
| PRIMARY PART, GM      | 0.000000 | 0.168700 |          | (LIMIT: 0.87/0.89-1.03)     |         |         |
| TOTAL, GM/BHP-HR      | 0.00     | 0.57     | 0.57     | Y-INTERCEPT                 | 0.000   | -1.603  |
| FUEL CONSUMPTION      |          |          |          | STD ERROR                   | 0.000%  | 4.126%  |
| LBS                   | 0.00     | 10.52    | 10.52    | (LIMIT: 8%)                 |         |         |
| LBS/BHP-HR            | 0.000    | 0.409    | 0.409    | R-SQUARE                    | 0.00000 | 0.98077 |
| BRAKE HORSEPOWER-HOUR | 0.000    | 25.705   | 25.705   | (LIMIT: 0.91)               |         |         |
|                       |          |          |          | WORK                        |         |         |
|                       |          |          |          | ACTUAL                      | 0.000   | 25.705  |
|                       |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |         |         |
|                       |          |          |          | REFERENCE                   | 0.000   | 26.736  |
|                       |          |          |          | % DIFFERENCE                | 0.00%   | -3.86%  |

HD-863190  
740 NTCC40085HCCOR02 2  
HS

HEAVY DUTY DIESEL TRANSIENT ENGINE TEST  
DIESEL SUMMARY REPORT

DATE: 07-21-86 TIME: 09:56:07 HD-863190

TEST NUMBER: HD-863190  
TEST DATE/TIME: 7-18-86 10:50  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 74.10 F  
ABSOLUTE HUMIDITY: 58.27 GRAINS H2O / LB. DRY AIR

| EMISSION RESULTS            | CS       | HS       | WTD TEST | CYCLE STATISTICS        | CS      | HS      |
|-----------------------------|----------|----------|----------|-------------------------|---------|---------|
| HC (INTEGRATED)             |          |          |          | SPEED                   |         |         |
| BACKGROUND, PPM             | 0.00     | 5.28     |          | NUMBER                  | 0       | 1176    |
| EXHAUST+BKG, GM             | 0.00     | 15.46    |          | SLOPE                   | 0.00000 | 0.99515 |
| NET, GM/BHP-HR              | 0.000    | 0.426    | 0.426    | (LIMIT: 0.97-1.03)      |         |         |
| CO (BAG)                    |          |          |          | Y-INTERCEPT             | 0.000   | 6.706   |
| BACKGROUND, PPM             | 0.00     | 0.00     |          | (LIMIT: +-50 RPM)       |         |         |
| EXHAUST+BKG, GM             | 0.00     | 74.76    |          | STD ERROR               | 0.000   | 25.688  |
| NET, GM/BHP-HR              | 0.00     | 2.89     | 2.89     | (LIMIT: 100 RPM)        |         |         |
| R-SQUARE                    |          |          |          | (LIMIT: 0.97)           | 0.00000 | 0.99818 |
| NOX (INTEGRATED)            |          |          |          | TORQUE                  |         |         |
| BACKGROUND, PPM             | 0.00     | 0.00     |          | NUMBER                  | 0       | 958     |
| EXHAUST+BKG, GM             | 0.00     | 120.31   |          | SLOPE                   | 0.00000 | 0.99065 |
| NET, GM/BHP-HR              | 0.000    | 4.452    | 4.452    | (LIMIT: 0.77/0.83-1.03) |         |         |
| CO2 (BAG)                   |          |          |          | Y-INTERCEPT             | 0.000   | 1.452   |
| BACKGROUND, PPM             | 0.000    | 0.034    |          | (LIMIT: +-15 FT-LBS)    |         |         |
| EXHAUST+BKG, GM             | 0.00     | 16016.72 |          | STD ERROR               | 0.000%  | 4.809%  |
| NET, GM/BHP-HR              | 0.0      | 584.5    | 584.5    | (LIMIT: 13% MAX ENG TQ) | 0.00000 | 0.96759 |
| PARTICULATE                 |          |          |          | R-SQUARE                |         |         |
| SECONDARY TARE, GM          | 0.000000 | 0.163600 |          | (LIMIT: 0.85/0.88)      |         |         |
| SECONDARY PART, GM          | 0.000000 | 0.163700 |          | POWER                   |         |         |
| PRIMARY TARE, GM            | 0.000000 | 0.167700 |          | NUMBER                  | 0       | 957     |
| PRIMARY PART, GM            | 0.000000 | 0.177150 |          | SLOPE                   | 0.00000 | 0.99924 |
| TOTAL, GM/BHP-HR            | 0.00     | 0.51     | 0.51     | (LIMIT: 0.87/0.89-1.03) |         |         |
| FUEL CONSUMPTION            |          |          |          | Y-INTERCEPT             | 0.000   | -1.035  |
| LBS                         | 0.00     | 10.58    | 10.58    | (LIMIT: +-5 BHP)        |         |         |
| LBS/BHP-HR                  | 0.000    | 0.408    | 0.408    | STD ERROR               | 0.000%  | 4.140%  |
| BRAKE HORSEPOWER-HOUR       | 0.000    | 25.897   | 25.897   | R-SQUARE                | 0.00000 | 0.98102 |
|                             |          |          |          | (LIMIT: 0.91)           |         |         |
| WORK                        |          |          |          | WORK                    |         |         |
| ACTUAL                      |          |          |          | ACTUAL                  | 0.000   | 25.897  |
| (LIMIT: -15%-5% REF BHP-HR) |          |          |          | REFERENCE               | 0.000   | 26.736  |
| REFERENCE                   |          |          |          | % DIFFERENCE            | 0.00%   | -3.14%  |
|                             |          |          |          |                         |         |         |

HD-863191  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-21-86 TIME: 14:56:52 HD-863191

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863191  
TEST DATE/TIME: 7-18-86 13:24

MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 72.90 F  
ABSOLUTE HUMIDITY: 54.87 GRAINS H2O / LB. DRY AIR

| <u>EMISSION RESULTS</u>         |  | <u>CS</u> | <u>HS</u> | <u>WTD TEST</u> | <u>CYCLE STATISTICS</u>     |  | <u>CS</u> | <u>HS</u> |
|---------------------------------|--|-----------|-----------|-----------------|-----------------------------|--|-----------|-----------|
| HC (INTEGRATED)                 |  |           |           |                 | SPEED                       |  |           |           |
| BACKGROUND, PPM                 |  | 0.00      | 4.69      |                 | NUMBER                      |  | 0         | 1176      |
| EXHAUST+BKG, GM                 |  | 0.00      | 17.16     |                 | SLOPE                       |  | 0.00000   | 0.99540   |
| NET, GM/BHP-HR                  |  | 0.000     | 0.515     | 0.515           | (LIMIT: 0.97-1.03)          |  |           |           |
| CO (BAG)                        |  |           |           |                 | Y-INTERCEPT                 |  | 0.000     | 4.919     |
| BACKGROUND, PPM                 |  | 0.00      | 0.00      |                 | (LIMIT: +-50 RPM)           |  |           |           |
| EXHAUST+BKG, GM                 |  | 0.00      | 79.58     |                 | STD ERROR                   |  | 0.000     | 25.676    |
| NET, GM/BHP-HR                  |  | 0.00      | 3.10      | 3.10            | R-SQUARE                    |  | 0.00000   | 0.99819   |
| (LIMIT: 0.97)                   |  |           |           |                 | (LIMIT: 0.97)               |  |           |           |
| NOX (INTEGRATED)                |  |           |           |                 | TORQUE                      |  |           |           |
| BACKGROUND, PPM                 |  | 0.00      | 0.00      |                 | NUMBER                      |  | 0         | 952       |
| EXHAUST+BKG, GM                 |  | 0.00      | 117.43    |                 | SLOPE                       |  | 0.00000   | 1.00020   |
| NET, GM/BHP-HR                  |  | 0.000     | 4.344     | 4.344           | (LIMIT: 0.77/0.83-1.03)     |  |           |           |
| CO2 (BAG)                       |  |           |           |                 | Y-INTERCEPT                 |  | 0.000     | -6.372    |
| BACKGROUND, PPM                 |  | 0.000     | 0.032     |                 | (LIMIT: +-15 FT-LBS)        |  |           |           |
| EXHAUST+BKG, GM                 |  | 0.00      | 15885.99  |                 | STD ERROR                   |  | 0.000%    | 4.755%    |
| NET, GM/BHP-HR                  |  | 0.0       | 586.0     | 586.0           | R-SQUARE                    |  | 0.00000   | 0.96792   |
| PARTICULATE                     |  |           |           |                 | (LIMIT: 0.85/0.86)          |  |           |           |
| SECONDARY TARE, GM              |  | 0.000000  | 0.165000  |                 | POWER                       |  |           |           |
| SECONDARY PART, GM              |  | 0.000000  | 0.165100  |                 | NUMBER                      |  | 0         | 951       |
| PRIMARY TARE, GM                |  | 0.000000  | 0.163800  |                 | SLOPE                       |  | 0.00000   | 0.99990   |
| PRIMARY PART, GM                |  | 0.000000  | 0.173350  |                 | (LIMIT: 0.87/0.89-1.03)     |  |           |           |
| TOTAL, GM/BHP-HR                |  | 0.00      | 0.52      | 0.52            | Y-INTERCEPT                 |  | 0.000     | -1.911    |
| FUEL CONSUMPTION                |  |           |           |                 | STD ERROR                   |  | 0.000%    | 4.131%    |
| LBS                             |  | 0.00      | 10.53     | 10.53           | (LIMIT: 8%)                 |  |           |           |
| LBS/BHP-HR                      |  | 0.000     | 0.410     | 0.410           | R-SQUARE                    |  | 0.00000   | 0.98071   |
| BRAKE HORSEPOWER-HOUR           |  | 0.000     | 25.687    | 25.687          | (LIMIT: 0.91)               |  |           |           |
| WORK                            |  |           |           |                 | WORK                        |  |           |           |
| ACTUAL                          |  |           |           |                 | ACTUAL                      |  | 0.000     | 25.687    |
| (REFERENCE: -15%-5% REF BHP-HR) |  |           |           |                 | (LIMIT: -15%-5% REF BHP-HR) |  |           |           |
| REFERENCE                       |  |           |           |                 | REFERENCE                   |  | 0.000     | 26.736    |
| % DIFFERENCE                    |  |           |           |                 | % DIFFERENCE                |  | 0.00%     | -3.92%    |

HD-863192  
740 NTCC40085HCCOR02 2  
HS

## HEAVY DUTY DIESEL TRANSIENT ENGINE TEST

DATE: 07-21-86 TIME: 10:42:08 HD-863192

## DIESEL SUMMARY REPORT

TEST NUMBER: HD-863192  
TEST DATE/TIME: 7-18-86 14: 1  
MANUFACTURER: CUMMINS  
ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 72.50 F  
ABSOLUTE HUMIDITY: 53.84 GRAINS H2O / LB. DRY AIR

| EMISSION RESULTS      | CS       | HS       | WTD TEST | CYCLE STATISTICS            | CS      | HS      |
|-----------------------|----------|----------|----------|-----------------------------|---------|---------|
| HC (INTEGRATED)       |          |          |          | SPEED                       |         |         |
| BACKGROUND, PPM       | 0.00     | 5.95     |          | NUMBER                      | 0       | 1176    |
| EXHAUST+BKG, GM       | 0.00     | 16.78    |          | SLOPE                       | 0.00000 | 0.99604 |
| NET, GM/BHP-HR        | 0.000    | 0.458    | 0.458    | (LIMIT: 0.97-1.03)          |         |         |
| CO (BAG)              |          |          |          | Y-INTERCEPT                 | 0.000   | 3.847   |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | (LIMIT: +-50 RPM)           |         |         |
| EXHAUST+BKG, GM       | 0.00     | 78.54    |          | STD ERROR                   | 0.000   | 25.980  |
| NET, GM/BHP-HR        | 0.00     | 3.06     | 3.06     | (LIMIT: 100 RPM)            |         |         |
|                       |          |          |          | R-SQUARE                    | 0.00000 | 0.99814 |
| (LIMIT: 0.97)         |          |          |          |                             |         |         |
| NOX (INTEGRATED)      |          |          |          | TORQUE                      |         |         |
| BACKGROUND, PPM       | 0.00     | 0.25     |          | NUMBER                      | 0       | 954     |
| EXHAUST+BKG, GM       | 0.00     | 117.42   |          | SLOPE                       | 0.00000 | 0.99461 |
| NET, GM/BHP-HR        | 0.000    | 4.305    | 4.305    | (LIMIT: 0.77/0.83-1.03)     |         |         |
| CO2 (BAG)             |          |          |          | Y-INTERCEPT                 | 0.000   | -3.546  |
| BACKGROUND, PPM       | 0.000    | 0.034    |          | (LIMIT: +-15 FT-LBS)        |         |         |
| EXHAUST+BKG, GM       | 0.00     | 15814.15 |          | STD ERROR                   | 0.000%  | 4.778%  |
| NET, GM/BHP-HR        | 0.0      | 580.9    | 580.9    | (LIMIT: 13% MAX ENG TQ)     |         |         |
|                       |          |          |          | R-SQUARE                    | 0.00000 | 0.96750 |
| (LIMIT: 0.85/0.88)    |          |          |          |                             |         |         |
| PARTICULATE           |          |          |          | POWER                       |         |         |
| SECONDARY TARE, GM    | 0.000000 | 0.163100 |          | NUMBER                      | 0       | 953     |
| SECONDARY PART, GM    | 0.000000 | 0.163200 |          | SLOPE                       | 0.00000 | 0.99764 |
| PRIMARY TARE, GM      | 0.000000 | 0.152750 |          | (LIMIT: 0.87/0.89-1.03)     |         |         |
| PRIMARY PART, GM      | 0.000000 | 0.162400 |          | Y-INTERCEPT                 | 0.000   | -1.655  |
| TOTAL, GM/BHP-HR      | 0.00     | 0.52     | 0.52     | (LIMIT: +-5 BHP)            |         |         |
|                       |          |          |          | STD ERROR                   | 0.000%  | 4.143%  |
| FUEL CONSUMPTION      |          |          |          | (LIMIT: 8%)                 |         |         |
| LBS                   | 0.00     | 10.44    | 10.44    | R-SQUARE                    | 0.00000 | 0.98057 |
| LBS/BHP-HR            | 0.000    | 0.406    | 0.406    | (LIMIT: 0.91)               |         |         |
| BRAKE HORSEPOWER-HOUR | 0.000    | 25.702   | 25.702   |                             |         |         |
|                       |          |          |          | WORK                        |         |         |
|                       |          |          |          | ACTUAL                      | 0.000   | 25.702  |
|                       |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |         |         |
|                       |          |          |          | REFERENCE                   | 0.000   | 26.736  |
|                       |          |          |          | % DIFFERENCE                | 0.00%   | -3.87%  |

HD-863193  
740 NTCC40085HCCOR02 2  
HS

HEAVY DUTY DIESEL TRANSIENT ENGINE TEST DATE: 07-21-86 TIME: 10:42:23 HD-863193  
DIESEL SUMMARY REPORT

TEST NUMBER: HD-863193 MANUFACTURER: CUMMINS  
TEST DATE/TIME: 7-18-86 14:42 ENGINE ID: 740 NTCC40085HCCOR02 2

AMBIENT DATA

BAROMETER (DRY): 29.10 "HG  
DRY BULB TEMPERATURE: 73.30 F  
ABSOLUTE HUMIDITY: 50.10 GRAINS H2O / LB. DRY AIR

| EMISSION RESULTS      |          |          |          | CYCLE STATISTICS            |                 |
|-----------------------|----------|----------|----------|-----------------------------|-----------------|
|                       | CS       | HS       | WTD TEST | CS                          | HS              |
| HC (INTEGRATED)       |          |          |          | SPEED                       |                 |
| BACKGROUND, PPM       | 0.00     | 6.18     |          | NUMBER                      | 0 1176          |
| EXHAUST+BKG, GM       | 0.00     | 16.00    |          | SLOPE                       | 0.00000 0.99635 |
| NET, GM/BHP-HR        | 0.000    | 0.421    | 0.421    | (LIMIT: 0.97-1.03)          |                 |
| CO (BAG)              |          |          |          | Y-INTERCEPT                 | 0.000 3.698     |
| BACKGROUND, PPM       | 0.00     | 0.00     |          | (LIMIT: +-50 RPM)           |                 |
| EXHAUST+BKG, GM       | 0.00     | 76.94    |          | STD ERROR                   | 0.000 26.153    |
| NET, GM/BHP-HR        | 0.00     | 3.00     | 3.00     | (LIMIT: 100 RPM)            |                 |
| R-SQUARE              |          |          |          |                             | 0.00000 0.99812 |
| NOX (INTEGRATED)      |          |          |          | TORQUE                      |                 |
| BACKGROUND, PPM       | 0.00     | 0.25     |          | NUMBER                      | 0 955           |
| EXHAUST+BKG, GM       | 0.00     | 117.26   |          | SLOPE                       | 0.00000 0.99528 |
| NET, GM/BHP-HR        | 0.000    | 4.266    | 4.266    | (LIMIT: 0.77/0.83-1.03)     |                 |
| CO2 (BAG)             |          |          |          | Y-INTERCEPT                 | 0.000 -4.590    |
| BACKGROUND, PPM       | 0.000    | 0.033    |          | (LIMIT: +-15 FT-LBS)        |                 |
| EXHAUST+BKG, GM       | 0.00     | 15873.81 |          | STD ERROR                   | 0.000% 4.758%   |
| NET, GM/BHP-HR        | 0.0      | 584.8    | 584.8    | (LIMIT: 13% MAX ENG TQ)     |                 |
| R-SQUARE              |          |          |          |                             | 0.00000 0.96799 |
| PARTICULATE           |          |          |          | POWER                       |                 |
| SECONDARY TARE, GM    | 0.000000 | 0.158400 |          | NUMBER                      | 0 954           |
| SECONDARY PART, GM    | 0.000000 | 0.158450 |          | SLOPE                       | 0.00000 0.99782 |
| PRIMARY TARE, GM      | 0.000000 | 0.165200 |          | (LIMIT: 0.87/0.89-1.03)     |                 |
| PRIMARY PART, GM      | 0.000000 | 0.175000 |          | Y-INTERCEPT                 | 0.000 -1.796    |
| TOTAL, GM/BHP-HR      | 0.00     | 0.53     | 0.53     | (LIMIT: +-5 BHP)            |                 |
| FUEL CONSUMPTION      |          |          |          | STD ERROR                   | 0.000% 4.117%   |
| LBS                   | 0.00     | 10.49    | 10.49    | (LIMIT: 8%)                 |                 |
| LBS/BHP-HR            | 0.000    | 0.409    | 0.409    | R-SQUARE                    | 0.00000 0.98091 |
| BRAKE HORSEPOWER-HOUR | 0.000    | 25.664   | 25.664   | (LIMIT: 0.91)               |                 |
| WORK                  |          |          |          | ACTUAL                      | 0.000 25.664    |
|                       |          |          |          | (LIMIT: -15%-5% REF BHP-HR) |                 |
|                       |          |          |          | REFERENCE                   | 0.000 26.736    |
|                       |          |          |          | % DIFFERENCE                | 0.00% -4.01%    |

-42-

TEST NO.: HD-863173

ENGINE: 740 NTCC40085HCC0R02 2

TEST D/T: 7- 9-86 13:30

REPORT D/T: 07-11-86 13:38

P040684

WEIGHTED SUMMARY REPORTAMBIENT DATA

AVERAGE BAROMETER (DRY) : 28.59 (" HG)  
 AVERAGE DRY BULB TEMPERATURE : 78.3 (DEG F)  
 AVERAGE ABSOLUTE HUMIDITY :: 56.68 (GRAINS H<sub>2</sub>O/LB AIR)

MODE-TO-MODE RESULTS

| MODE            | SPEED<br>(RPM) | TORQUE<br>(FT-LB) | *UN*                | MEASURED<br>FUEL<br>(LB/HR) | HC<br>(GM/HR) | CO<br>(GM/HR) | NOX<br>(GM/HR) | CO <sub>2</sub><br>(GM/HR) |
|-----------------|----------------|-------------------|---------------------|-----------------------------|---------------|---------------|----------------|----------------------------|
|                 |                |                   | CORR<br>BHP<br>(HP) |                             |               |               |                |                            |
| 1               | 1300           | 319.0             | 78.96               | 28.67                       | 29.29         | 65.77         | 509.40         | 42389.92                   |
| 2               | 1300           | 520.5             | 128.83              | 44.34                       | 28.87         | 117.80        | 962.96         | 64019.51                   |
| 3               | 2100           | 252.5             | 100.96              | 51.59                       | 112.56        | 132.17        | 309.10         | 73691.09                   |
| 4               | 2100           | 747.5             | 298.88              | 115.14                      | 76.38         | 238.56        | 1256.41        | 172922.46                  |
| 5               | 627            | 23.5              | 2.81                | 3.52                        | 74.99         | 52.29         | 35.38          | 5175.35                    |
| WEIGHTED TOTALS |                |                   | 47.78               | 19.08                       | 25.38         | 47.65         | 239.07         | 28090.66                   |

EPA Final Test (2-46)

TEST NO.: HD-863176

ENGINE: 740 NICC40085HCCOR02 2

TEST D/T: 7-10-86 13:30

REPORT D/T: 07-24-86 14:44

P040684

WEIGHTED SUMMARY REPORTAMBIENT DATA

AVERAGE BAROMETER (DRY) : 28.51 (" HG)  
 AVERAGE DRY BULB TEMPERATURE : 79.1 (DEG F)  
 AVERAGE ABSOLUTE HUMIDITY : 81.80 (GRAINS H<sub>2</sub>O/LB AIR)

MODE-TO-MODE RESULTS

| MODE            | SPEED<br>(RPM) | TORQUE<br>(FT-LB) | *UN*                |                 | MEASURED      |               |                |                            |
|-----------------|----------------|-------------------|---------------------|-----------------|---------------|---------------|----------------|----------------------------|
|                 |                |                   | CORR<br>BHP<br>(HP) | FUEL<br>(LB/HR) | HC<br>(GM/HR) | CO<br>(GM/HR) | NOX<br>(GM/HR) | CO <sub>2</sub><br>(GM/HR) |
| 1               | 1300           | 317.5             | 78.59               | 28.77           | 28.36         | 60.83         | 489.07         | 41042.51                   |
| 2               | 1300           | 516.0             | 127.72              | 44.12           | 29.41         | 113.23        | 956.37         | 62011.30                   |
| 3               | 2100           | 251.5             | 100.56              | 49.72           | 114.50        | 126.55        | 302.15         | 71878.09                   |
| 4               | 2100           | 747.0             | 298.68              | 111.39          | 79.12         | 239.57        | 1246.10        | 167485.40                  |
| 5               | 630            | 21.5              | 2.58                | 3.49            | 74.26         | 65.29         | 35.31          | 4782.30                    |
| WEIGHTED TOTALS |                |                   | 47.60               | 18.62           | 25.67         | 47.63         | 235.80         | 27228.73                   |

EPA [unclear] [S-45]

TEST NO.: HD-863179

ENGINE: 740 NTCC40085IICCOR02 2

TEST D/T: 7-15-86 8: 0

REPORT D/T: 07-15-86 16:10

P040684

WEIGHTED SUMMARY REPORTAMBIENT DATA

AVERAGE BAROMETER (DRY) : 28.70 (" HG)  
 AVERAGE DRY BULB TEMPERATURE : 80.6 (DEG F)  
 AVERAGE ABSOLUTE HUMIDITY : 77.77 (GRAINS H<sub>2</sub>O/LB AIR)

MODE-TO-MODE RESULTS

| MODE            | SPEED<br>(RPM) | TORQUE<br>(FT-LB) | *UN*                | MEASURED<br>FUEL<br>(LB/HR) | HC<br>(GM/HR) | CO<br>(GM/HR) | NOX<br>(GM/HR) | CO <sub>2</sub><br>(GM/HR) |
|-----------------|----------------|-------------------|---------------------|-----------------------------|---------------|---------------|----------------|----------------------------|
|                 |                |                   | CORR<br>BHP<br>(HP) |                             |               |               |                |                            |
| 1               | 1300           | 316.5             | 78.34               | 30.54                       | 32.27         | 62.52         | 496.73         | 41504.48                   |
| 2               | 1300           | 517.5             | 128.09              | 42.77                       | 29.22         | 113.88        | 916.98         | 63112.50                   |
| 3               | 2100           | 253.0             | 101.16              | 50.63                       | 110.60        | 127.04        | 311.80         | 72669.09                   |
| 4               | 2100           | 751.5             | 300.48              | 106.84                      | 77.15         | 227.81        | 1155.50        | 166842.91                  |
| 5               | 632            | 26.5              | 3.19                | 3.00                        | 73.64         | 56.52         | 35.58          | 4818.29                    |
| WEIGHTED TOTALS |                |                   | 47.86               | 18.30                       | 25.40         | 46.19         | 226.70         | 27362.38                   |

14  
 EPA 14 mode fuel (S-463)

TEST NO.: HD-863212

ENGINE: 740 NTCC40085HCCOR02 2

TEST D/T: 7-23-86 16:15

REPORT D/T: 07-24-86 13:58

P040684

WEIGHTED SUMMARY REPORTAMBIENT DATA

AVERAGE BAROMETER (DRY) : 28.81 (" HG)  
 AVERAGE DRY BULB TEMPERATURE : 79.4 (DEG F)  
 AVERAGE ABSOLUTE HUMIDITY : 75.42 (GRAINS H2O/LB AIR)

MODE-TO-MODE RESULTS

| MODE            | SPEED<br>(RPM) | TORQUE<br>(FT-LB) | CORR<br>BHP<br>(HP) | MEASURED        |               |               |                |
|-----------------|----------------|-------------------|---------------------|-----------------|---------------|---------------|----------------|
|                 |                |                   |                     | FUEL<br>(LB/HR) | HC<br>(GM/HR) | CO<br>(GM/HR) | NOX<br>(GM/HR) |
| 1               | 2100           | 750.0             | 299.88              | 116.45          | 68.30         | 231.45        | 0.0 171611.72  |
| 2               | 2100           | 250.0             | 99.96               | 50.36           | 106.91        | 127.24        | 0.0 72848.08   |
| 3               | 1300           | 316.0             | 78.22               | 28.68           | 30.53         | 60.28         | 0.0 41368.83   |
| WEIGHTED TOTALS |                |                   | 34.25               | 14.09           | 15.55         | 30.43         | 0.0 20578.13   |

Comments "not" fuel

DIESEL INFORMATION SHEET

Manufacturer Cummins (740) Contact \_\_\_\_\_ Phone \_\_\_\_\_

ENGINE INFORMATION

1. Engine family and model NTCC 400
2. Serial number 10780756
3. Engine model year
4. Displacement 855
5. Fuel type (diesel #1 or #2) #1
6. Required fuel pressure \_\_\_\_\_ (if not specified, 5 psig will be used)
7. Rated HP 400 @ 2100 rpm (Fuel rate \_\_\_\_ mm<sup>3</sup>/stroke \_\_\_\_ lbs/hr)
8. Max. TQ 1231 @ 1300 rpm (Fuel rate \_\_\_\_ mm<sup>3</sup>/stroke \_\_\_\_ lbs/hr)
9. Accumulated hours or mileage 2107 7387
10. Certified injection timing 966 TQ
11. Engine oil type 15W 40 0 gal 148.5 fl. oz.
12. (Nominal thermostat temperature \_\_\_\_ °F) 45.6 in its limit
13. Vehicle application/type of service corr 1500  
117.1 lb/in limit  
142 lb/in limit  
22 lb/in limit

SET-UP INFORMATION

1. Max. full load gov. speed 2100 rpm
2. Curb idle speed 675 rpm (max. safe N.L. speed 2350 rpm)
3. Inlet depression:  
13-mode "H<sub>2</sub>O  
Transient 20 "H<sub>2</sub>O
4. Exhaust backpressure:  
13-mode "H<sub>2</sub>O  
Transient \*2 "H<sub>2</sub>O \* as per T. Barnes  
7/1/86
5. Fuel shut-off system (man., 24v, 12v) 12v MAN
6. Output shaft rotation (CW, CCW) CW from back  
CW from front
7. (Supply fuel pressure \_\_\_\_ psi)

SPECIAL INSTRUCTIONS

Starting instructions, request for presence of company representative, intention to do restorative maintenance at EPA, engine disposition, etc.

80PSI AIR

740 ATC MANUFACTURERS VO2

Graph of Cummins Torque Map

SN 10730756  
N7CC400 Blockin

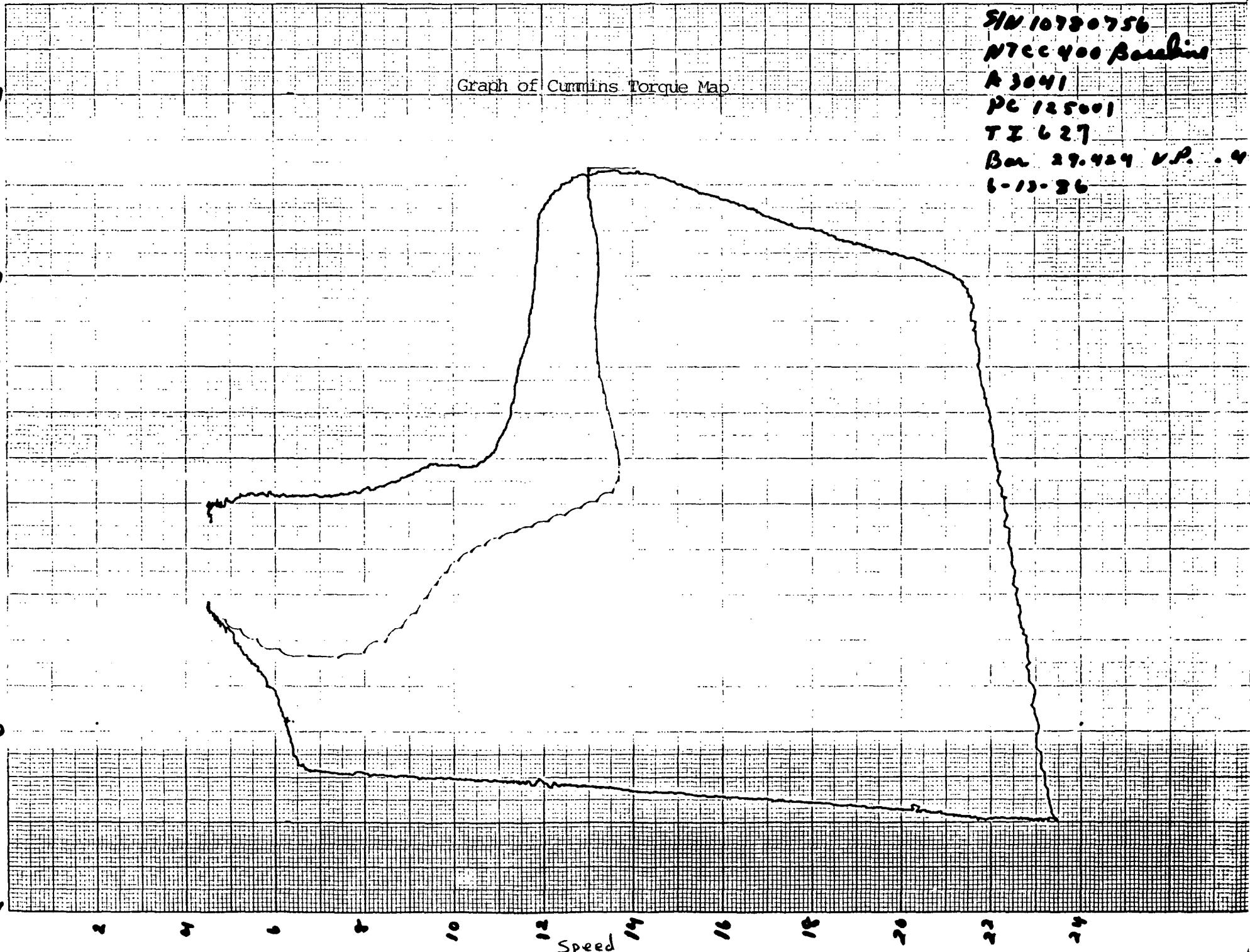
A3041

PC 125001

T1 627

Bor 29.424 V.P. .4

6-13-86



To: Mr. TOM BAINES , EPA  
ANN ARBOR

RANSIENT EMISSION CYCLE

ENGINE SERIAL NUMBER 10780756

|                          |   |                |
|--------------------------|---|----------------|
| IDLE SPEED               | = | 627.0          |
| RATED SPEED              | = | 2100.0         |
| EPA RATED SPEED          | = | 2100.0         |
| DYNO TYPE CODE           | = | 0              |
| PUMP TYPE CODE           | = | 0              |
| DYNO INERTIA             | = | 200.0          |
| DYNO ZERO                | = | 0.0            |
| DYNO SPAN                | = | -1250.0        |
| DYNO PREDICTION GAIN     | = | 1.00           |
| THROTTLE PREDICTION GAIN | = | 0.80           |
| MAXIMUM TORQUE           | = | <u>1229.29</u> |
| RATED HORSEPOWER         | = | <u>402.78</u>  |
| MAXIMUM HORSEPOWER       | = | <u>405.17</u>  |
| AT SPEED                 | = | <u>2066.0</u>  |
| WITH CALCULATED TORQUE   | = | 1030.0         |

A 3041  
PC 125001  
TC 304  
6-13-86

07/01/86

08:43

TECH. CENTER 5TH

NO. 001

001

Cummins  
Torque  
Map

The  
Torque  
Map

ENGINE TORQUE CURVE

| SPEED  | NIDE OPEN | CLOSED |
|--------|-----------|--------|
| 677.0  | 516.7     | -67.9  |
| 777.0  | 523.4     | -92.2  |
| 877.0  | 555.0     | -97.3  |
| 977.0  | 583.0     | -102.0 |
| 1077.0 | 607.7     | -108.0 |
| 1177.0 | 1025.0    | -109.4 |
| 1277.0 | 1221.0    | -119.7 |
| 1377.0 | 1229.3    | -128.0 |
| 1477.0 | 1211.4    | -132.4 |
| 1577.0 | 1177.2    | -140.5 |
| 1677.0 | 1138.7    | -147.7 |
| 1777.0 | 1104.8    | -152.3 |
| 1877.0 | 1075.7    | -161.3 |
| 1977.0 | 1050.5    | -168.9 |
| 2077.0 | 1023.9    | -177.9 |
| 2177.0 | 791.6     | -184.7 |
| 2277.0 | 172.0     | -192.3 |
| 2377.0 | -355.6    | -195.2 |

FROM: SHIRISH SHIMPI  
CUMMINS