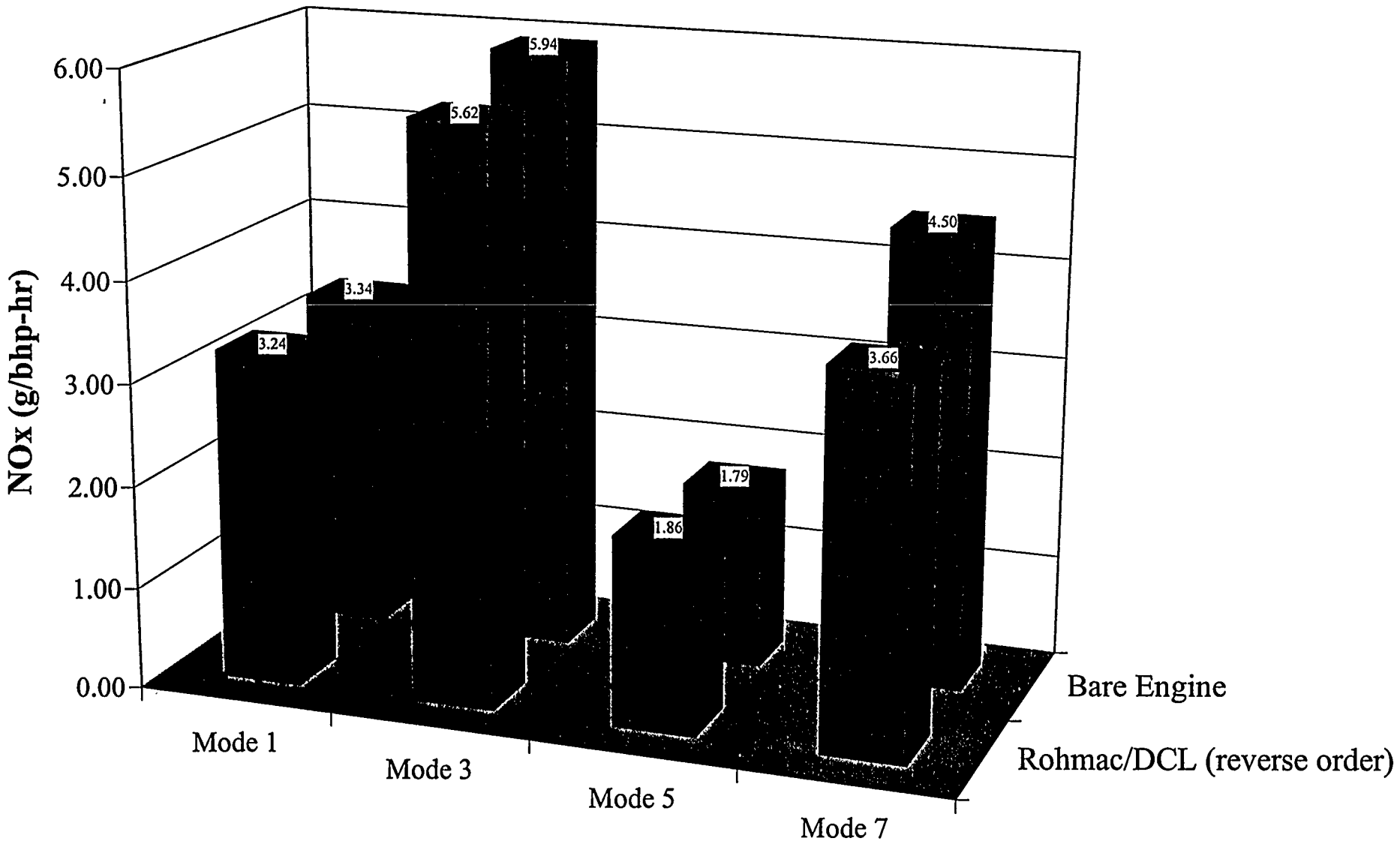


**Figure 43. Comparison of Oxides of Nitrogen Mass Emission Rates from Isuzu C240: Bare Engine and Rohmac/DCL System (Reverse Order) Equipped Engine**

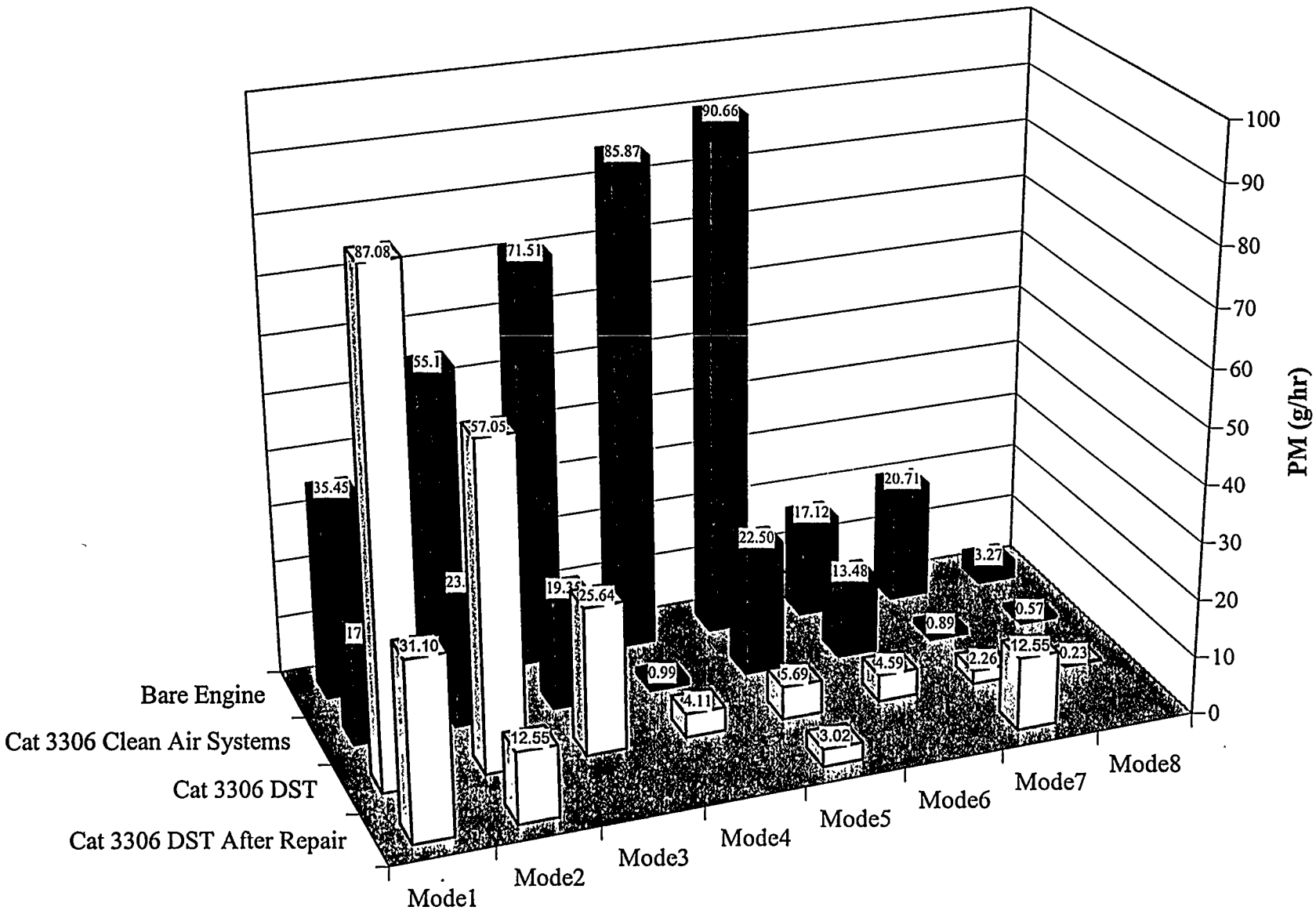


**Figure 44. Comparison of Particulate Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)*, and Clean Air Systems Catalyzed Trap**

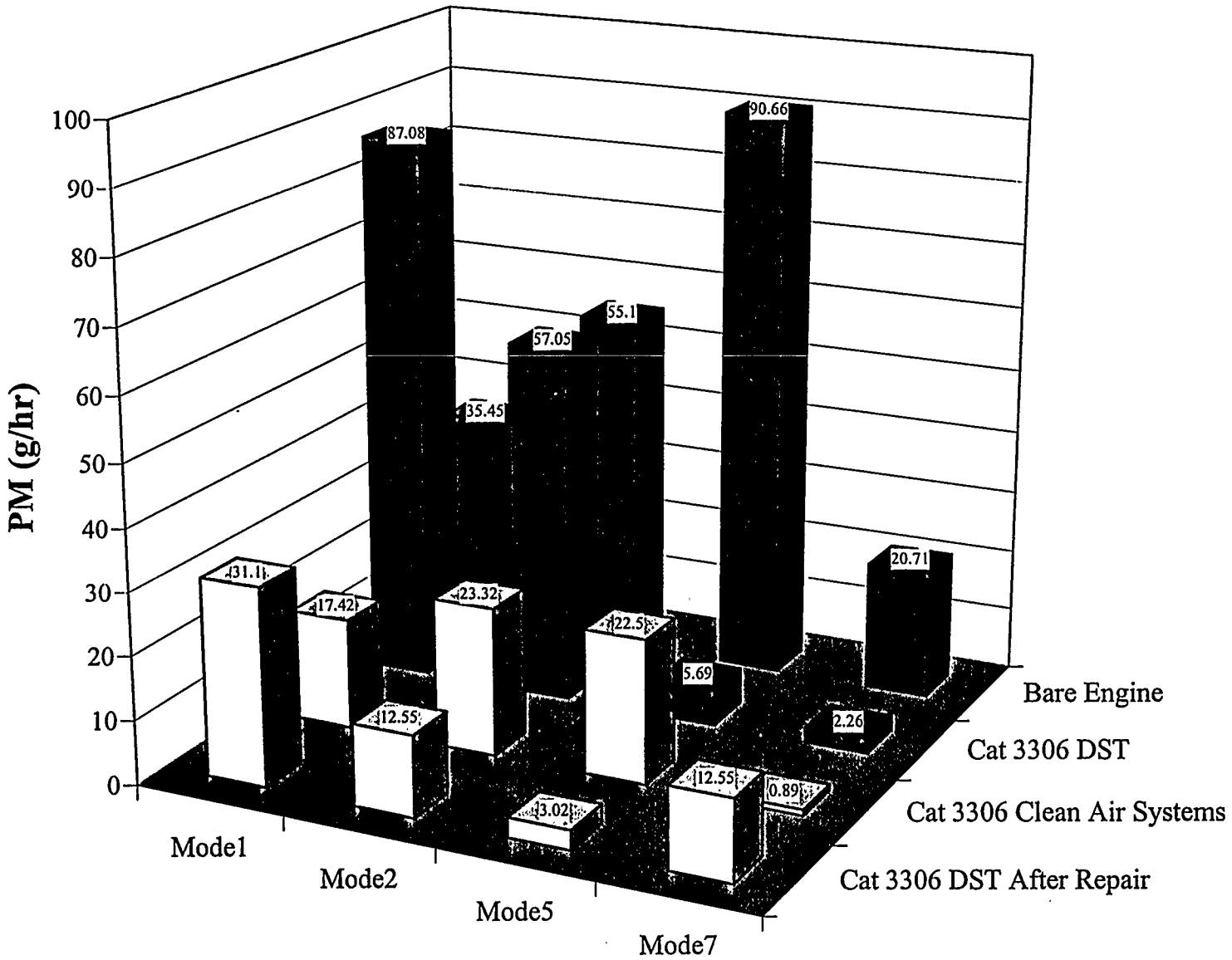


**Figure 45. Comparison of Particulate Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)*, and Clean Air Systems Catalyzed Trap**

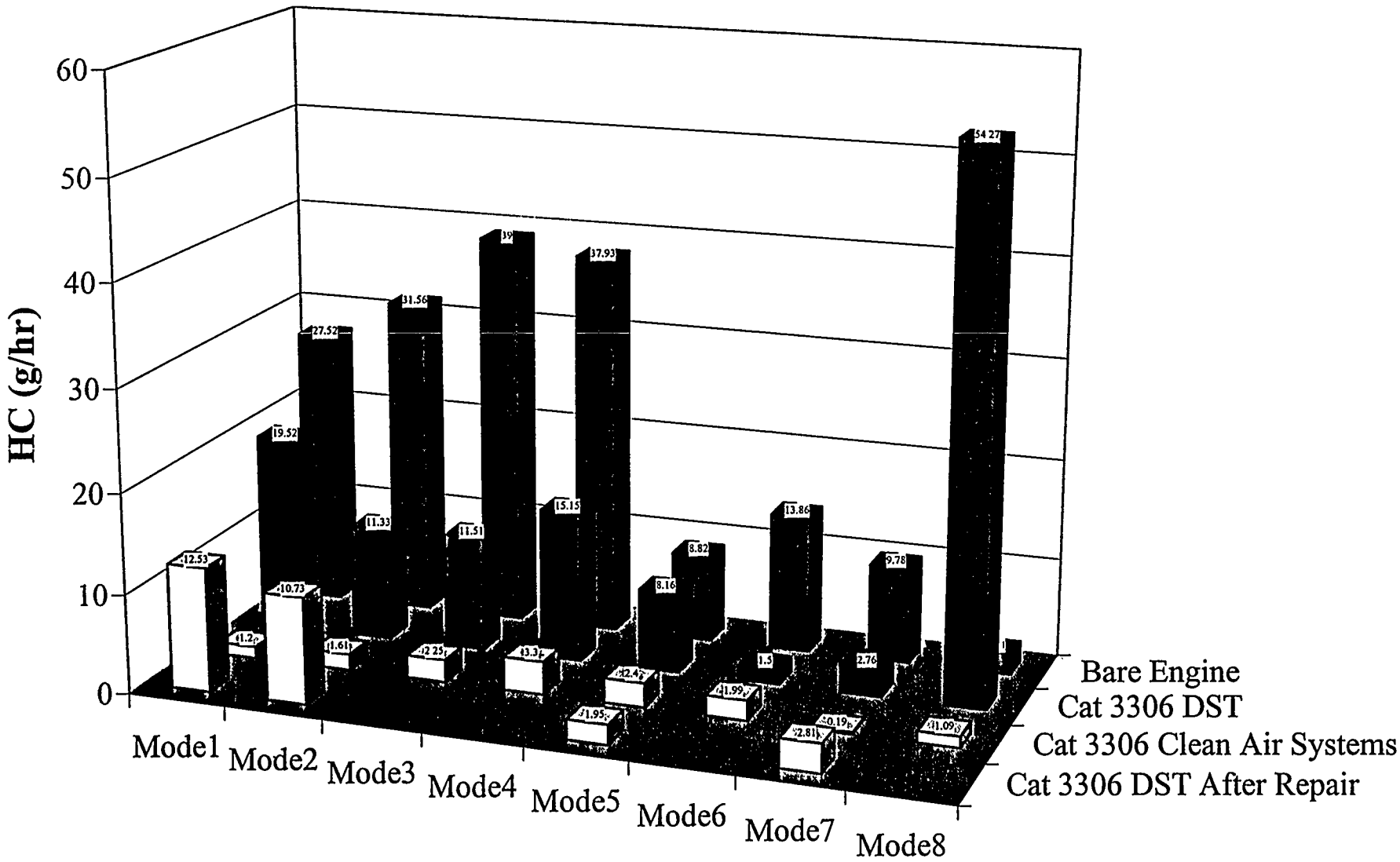


**Figure 46. Comparison of Hydrocarbon Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

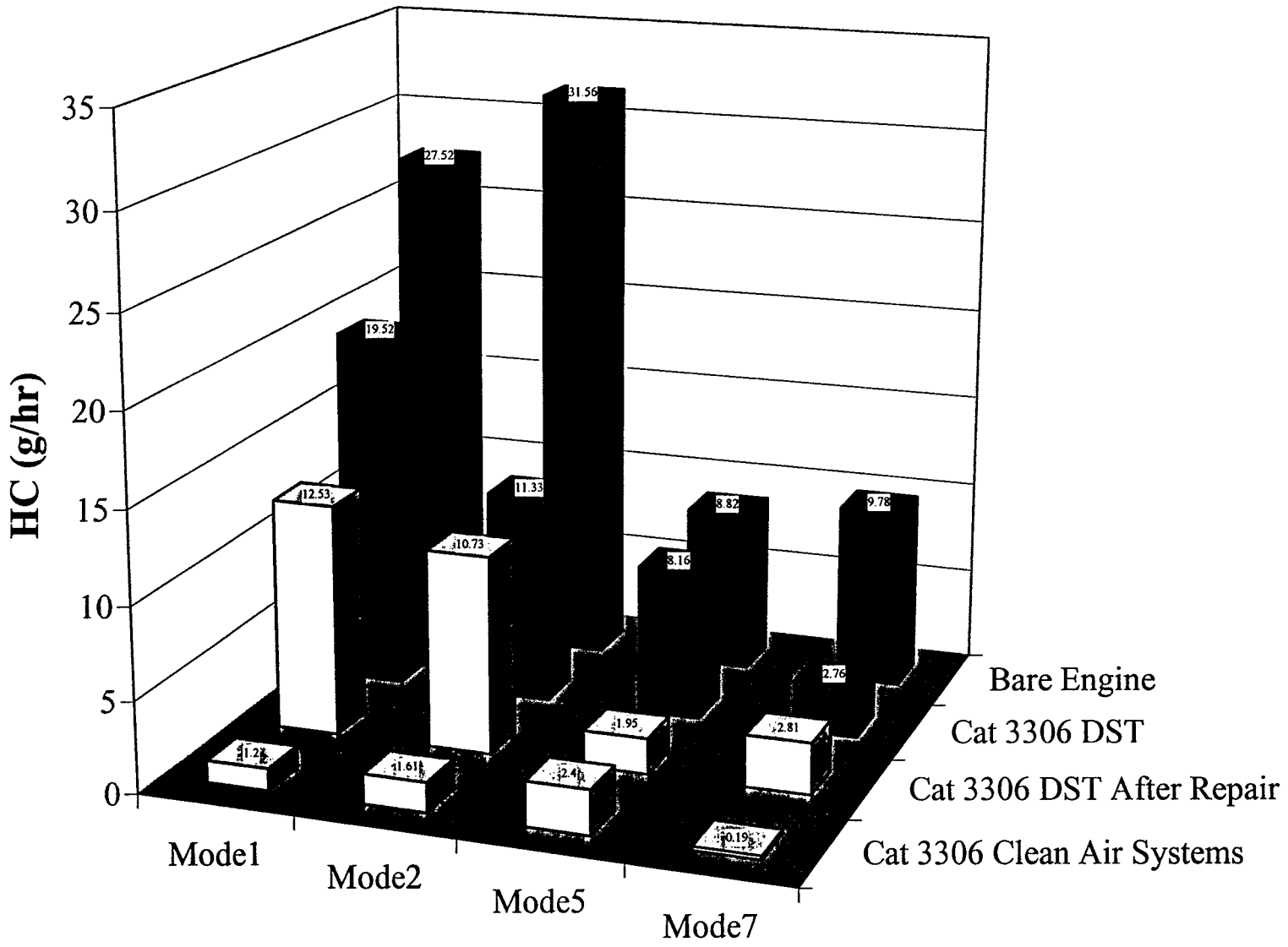


**Figure 47. Comparison of Hydrocarbon Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

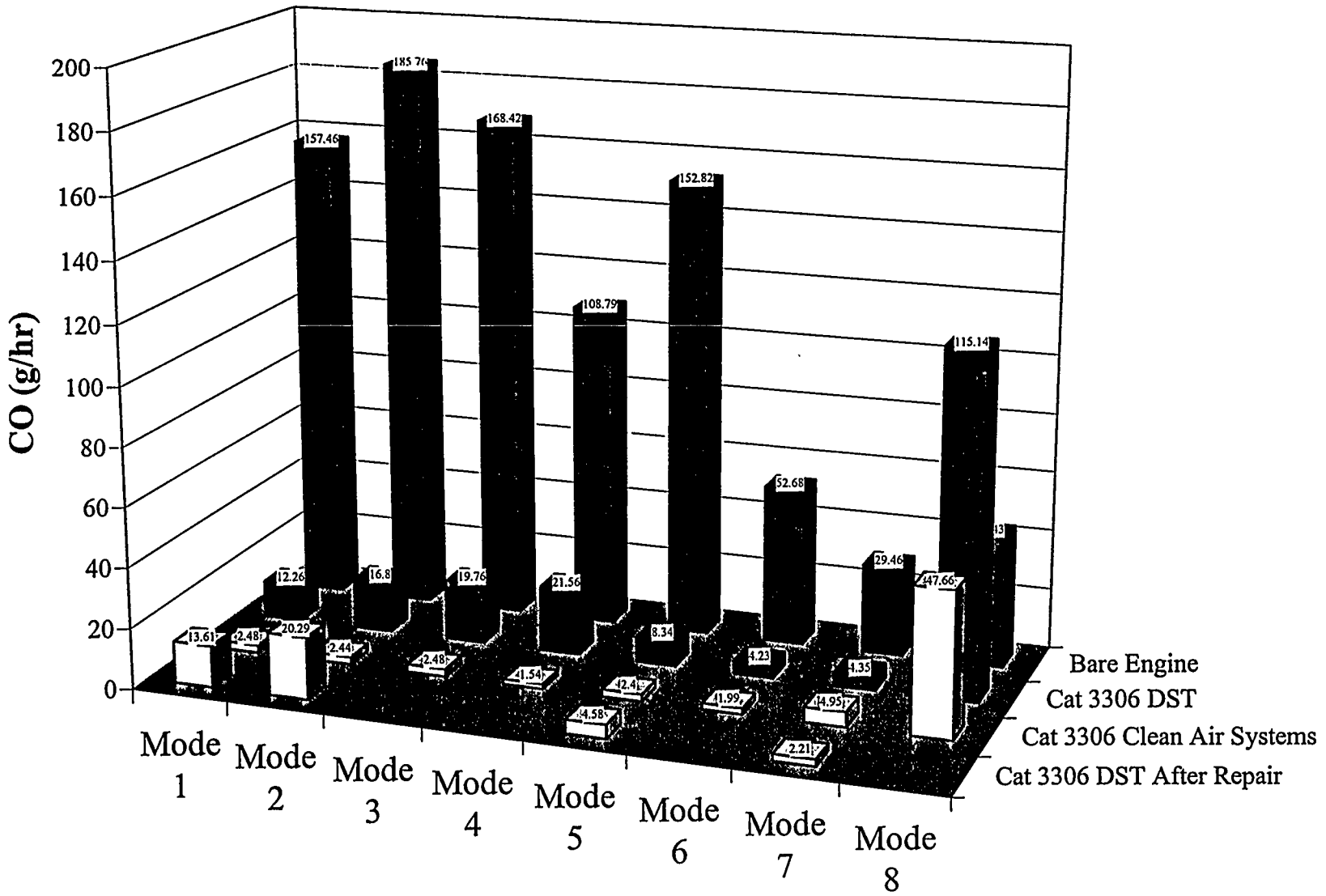


**Figure 48. Comparison of Carbon-Monoxide Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

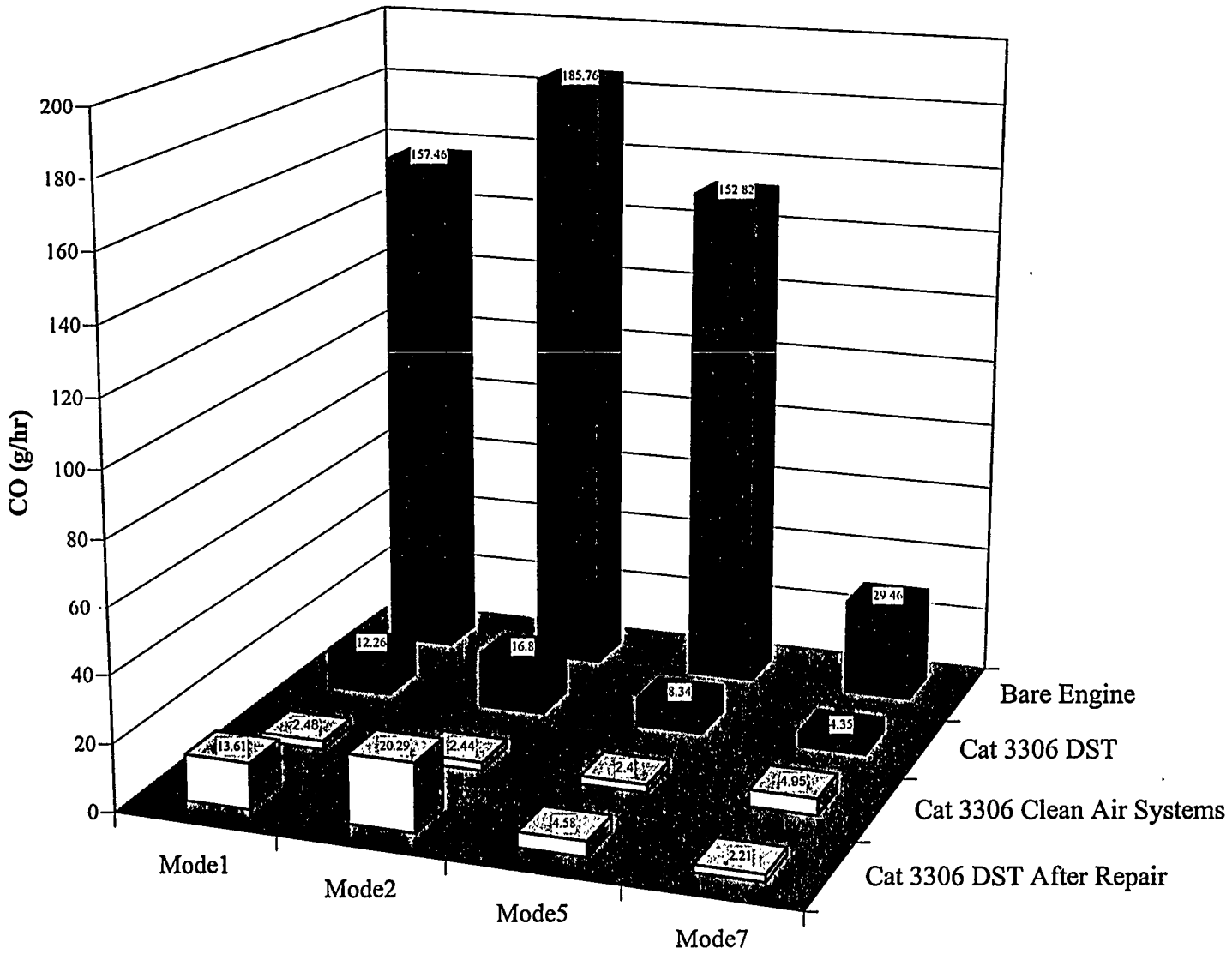


**Figure 49. Comparison of Carbon-Monoxide Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

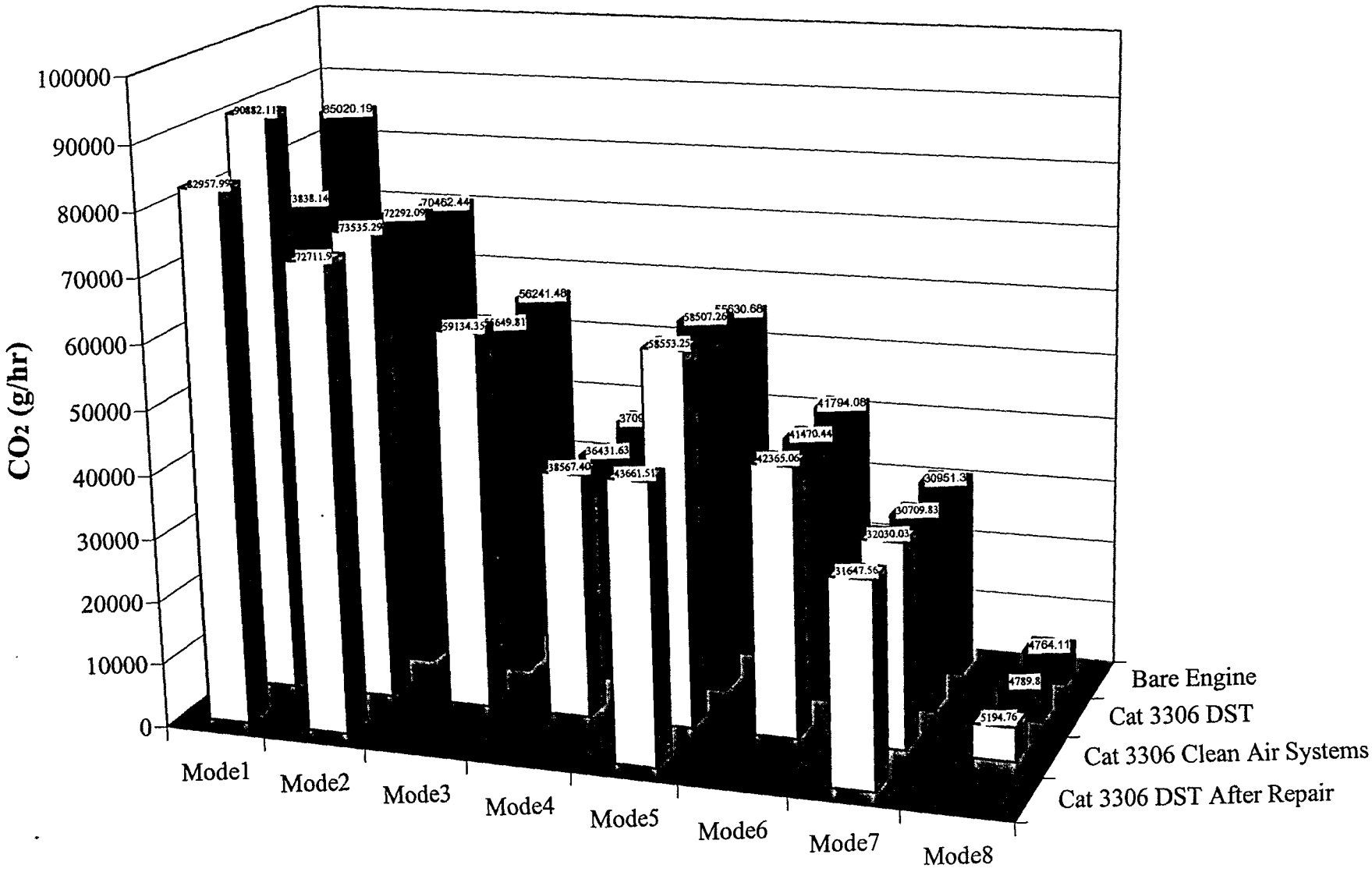


**Figure 50. Comparison of Carbon Dioxide Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

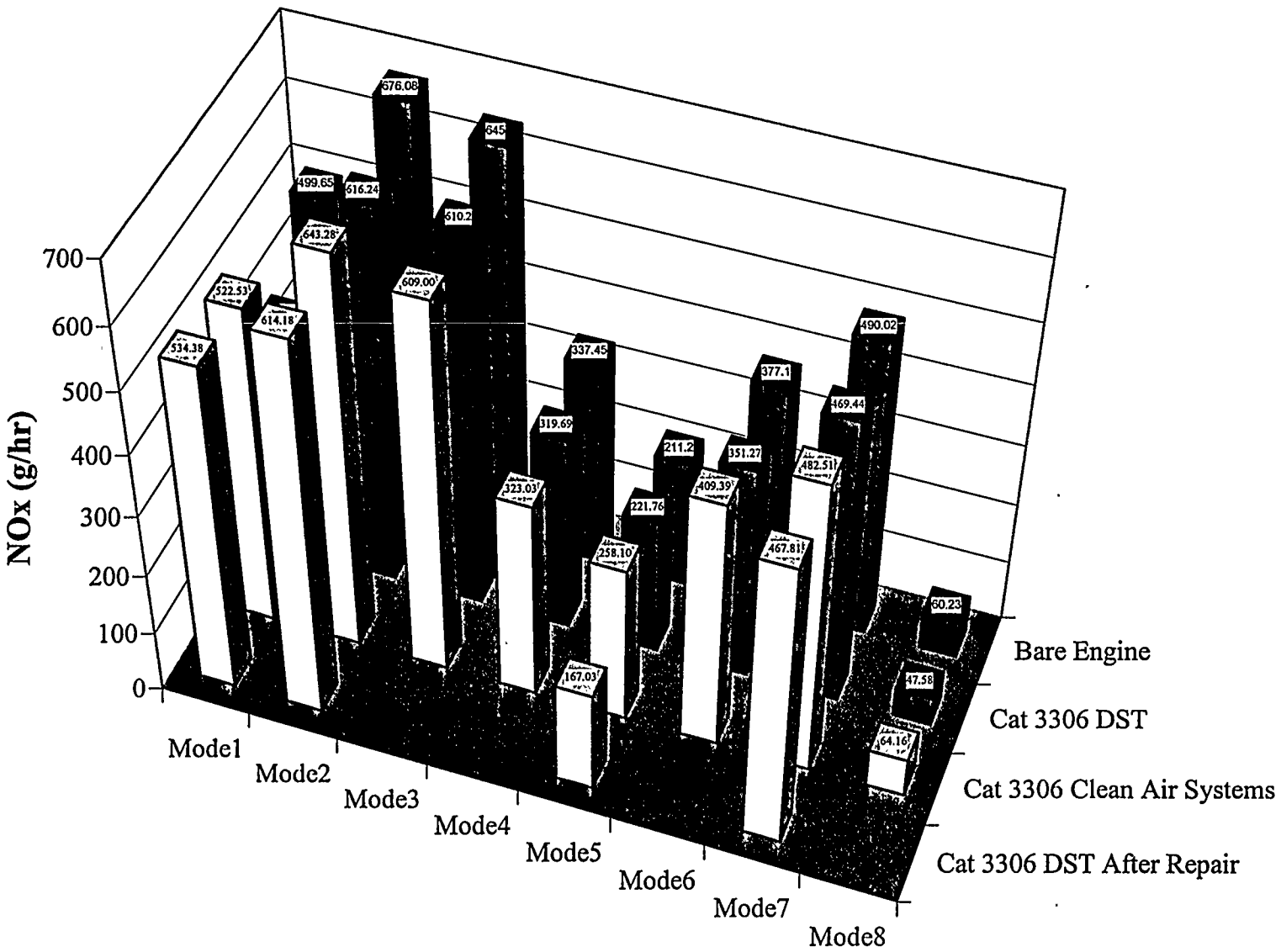


**Figure 51. Comparison of Oxides of Nitrogen Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

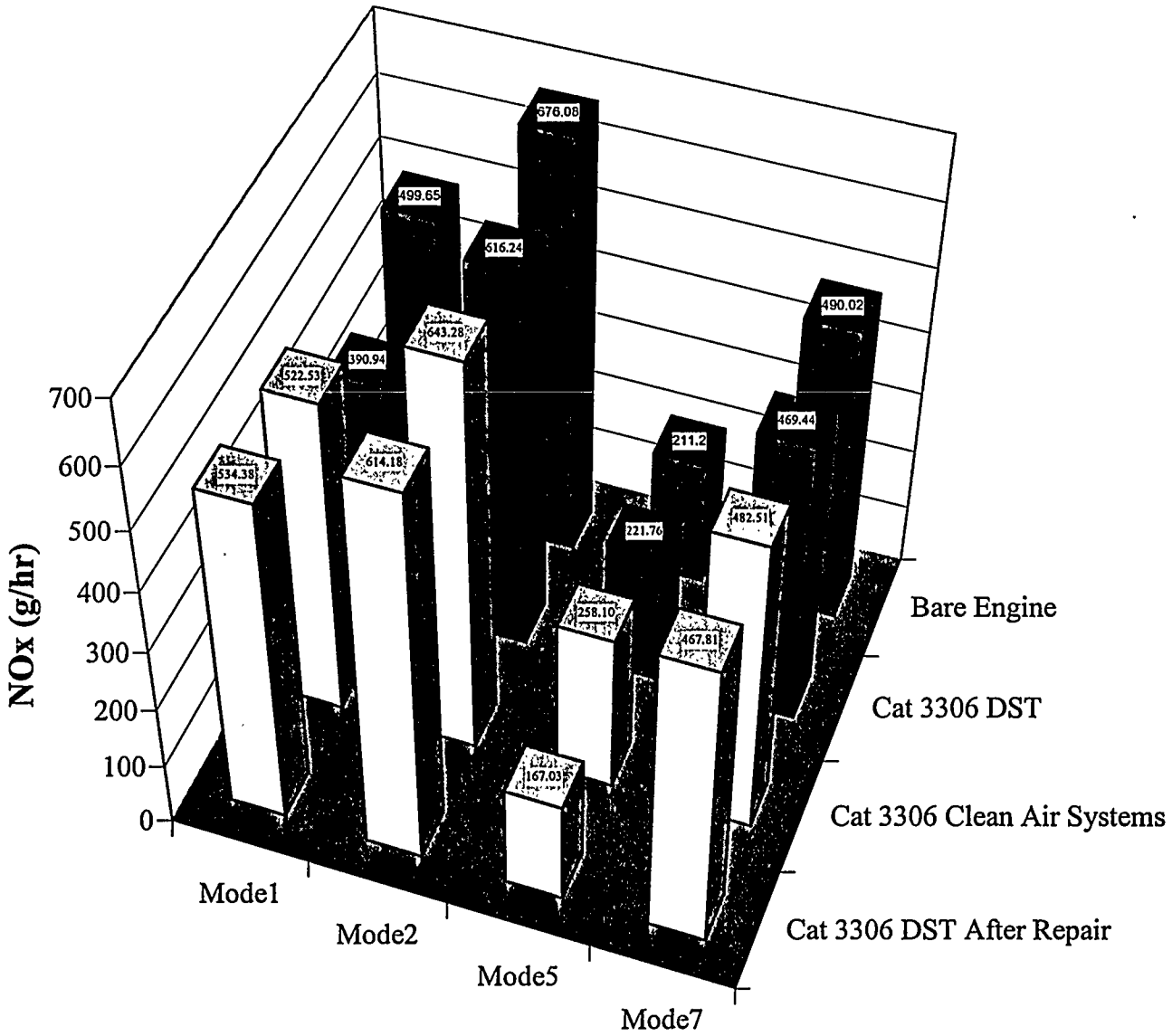


**Figure 52. Comparison of Oxides of Nitrogen Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

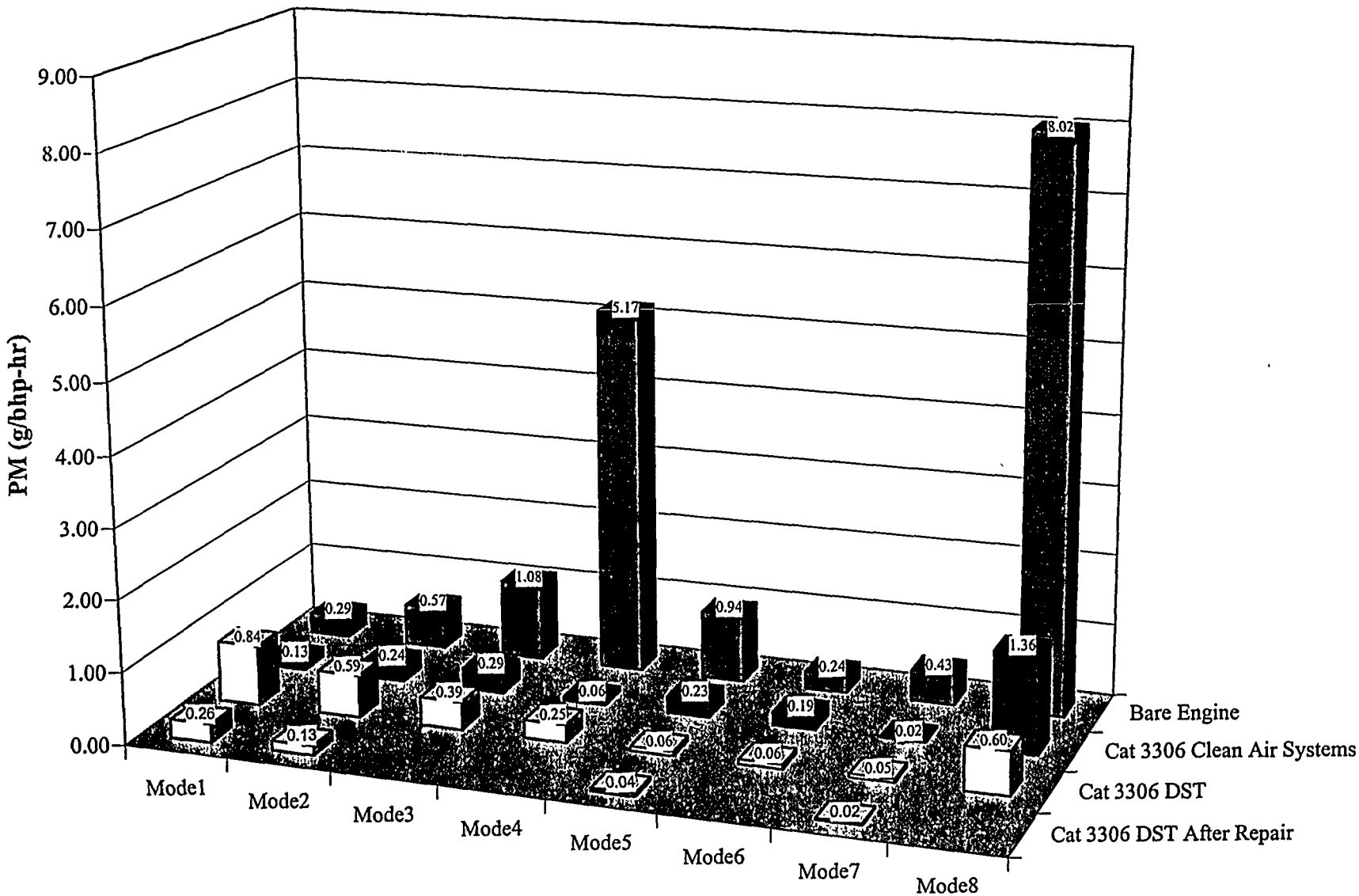


**Figure 53. Comparison of Particulate Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)*, and Clean Air Systems Catalyzed Trap**

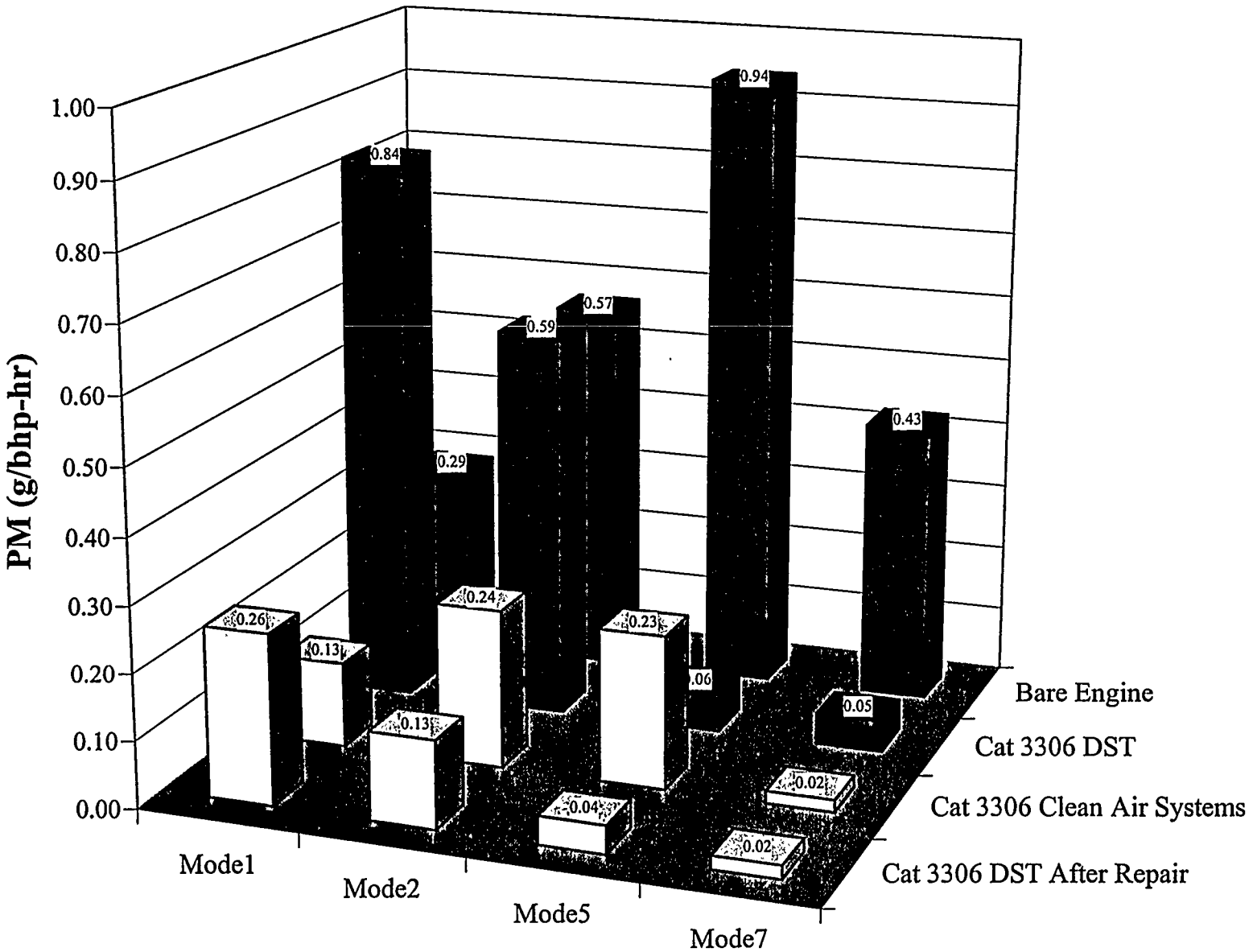


**Figure 54. Comparison of Particulate Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)*, and Clean Air Systems Catalyzed Trap**

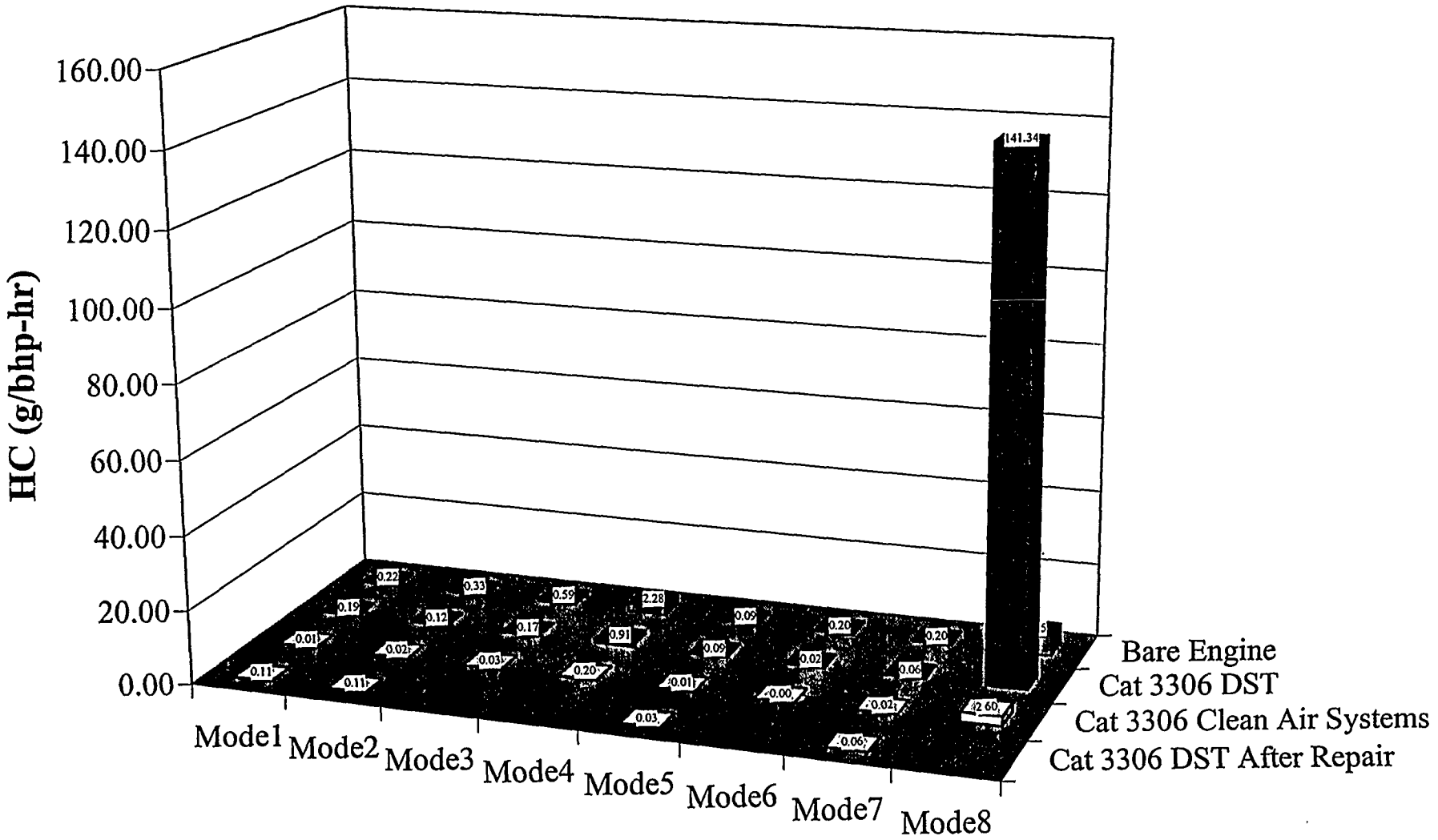


**Figure 55. Comparison of Hydrocarbon Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

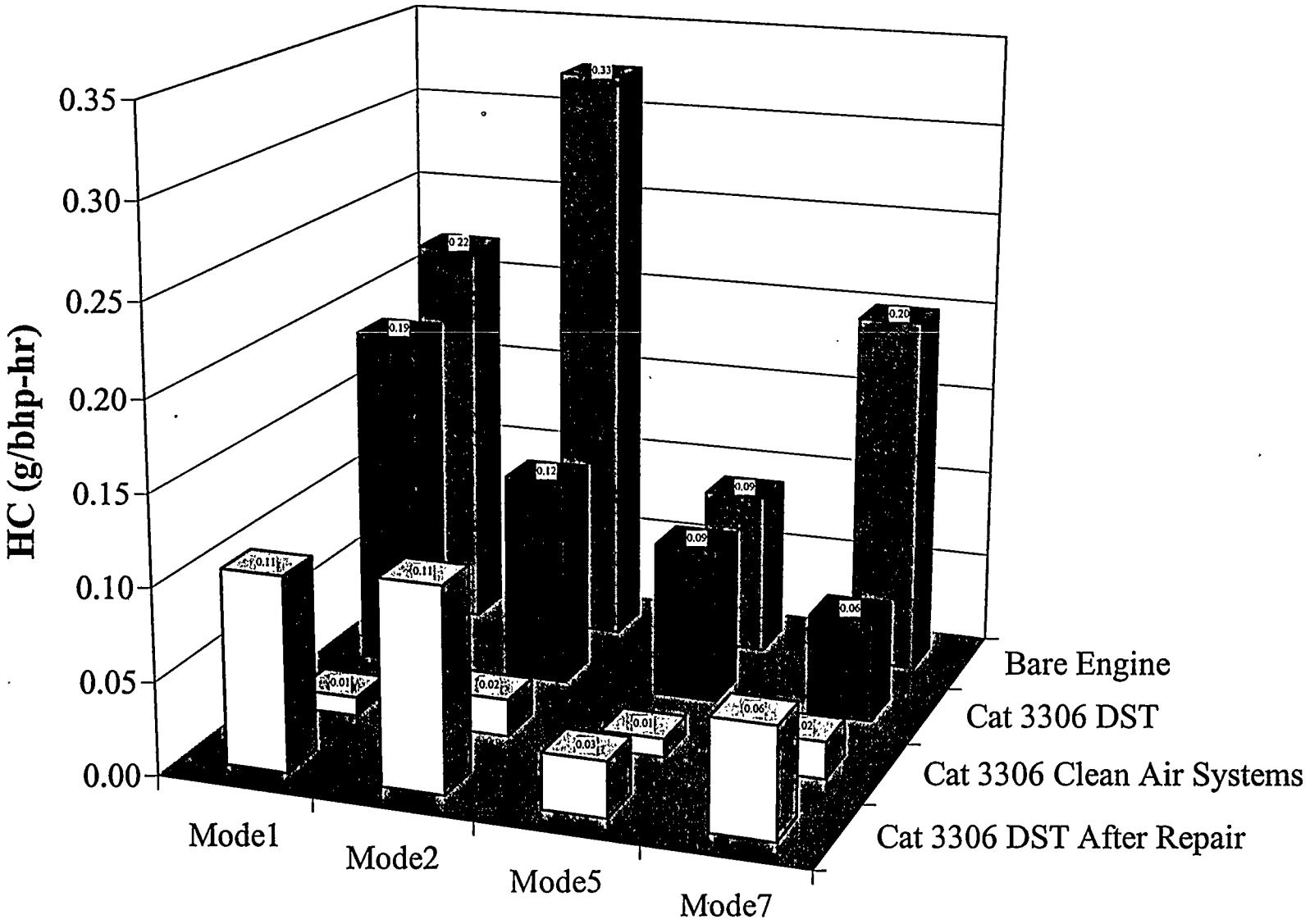


**Figure 56. Comparison of Hydrocarbon Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

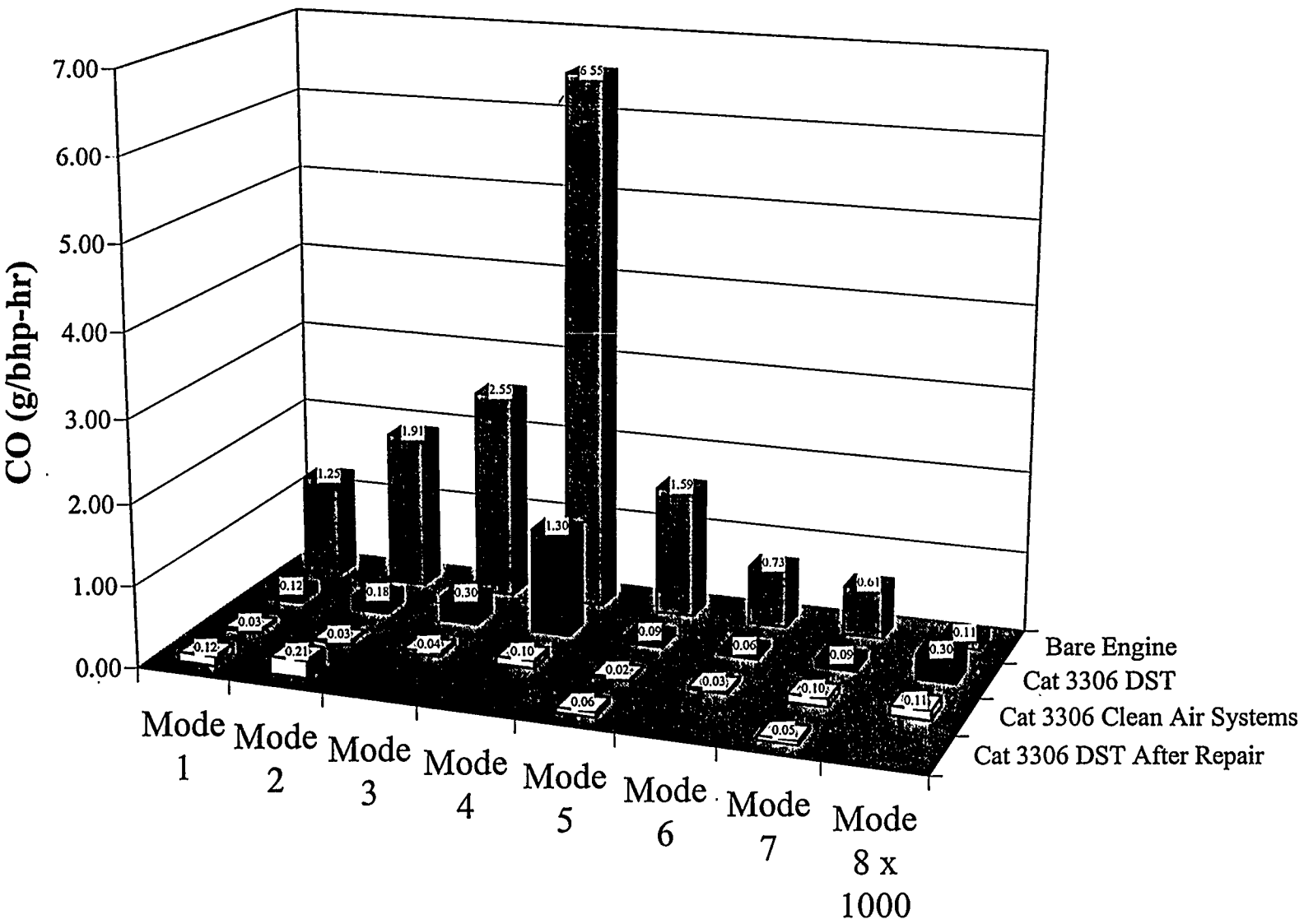


**Figure 57. Comparison of Carbon-Monoxide Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

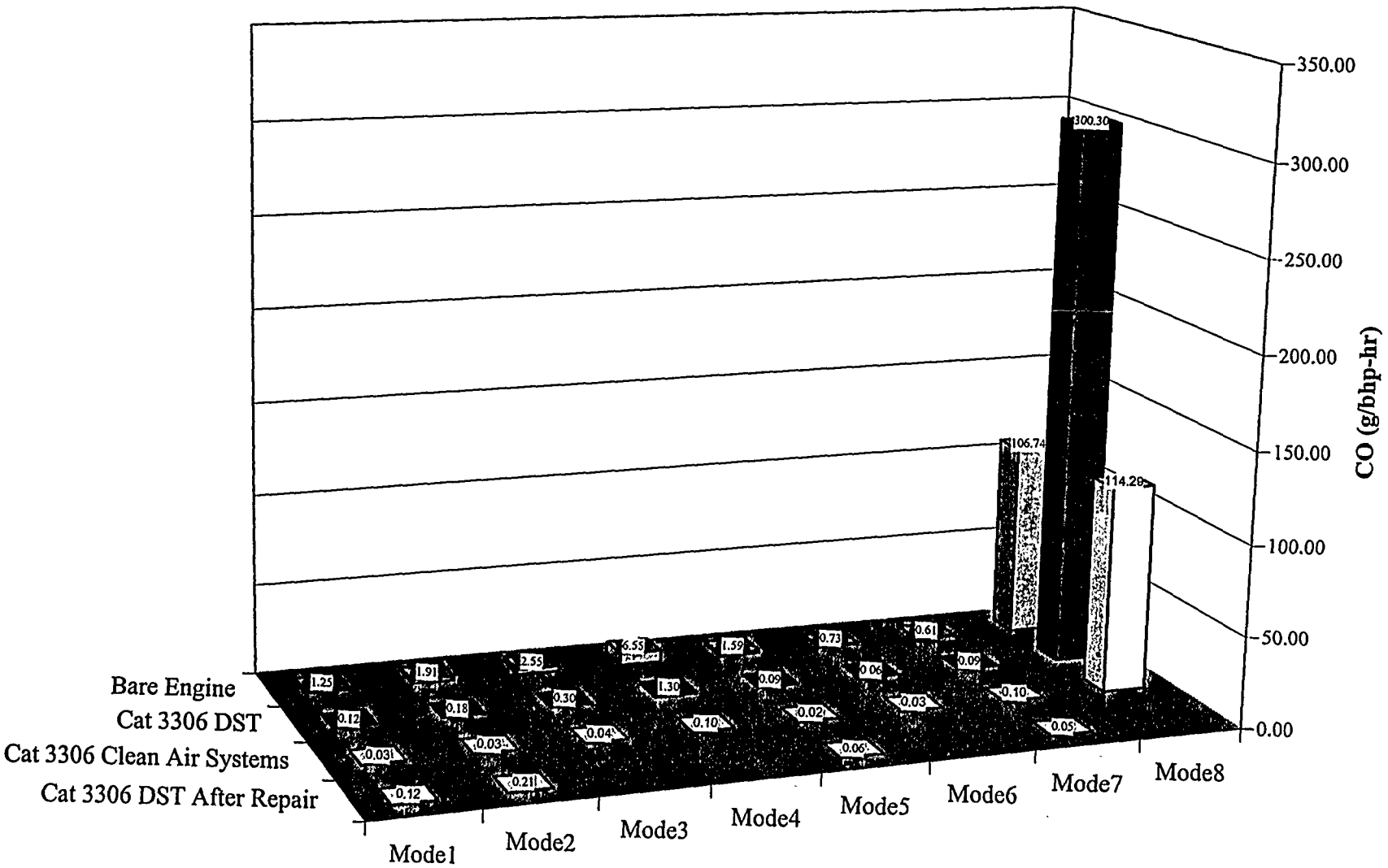


**Figure 58. Comparison of Carbon-Monoxide Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

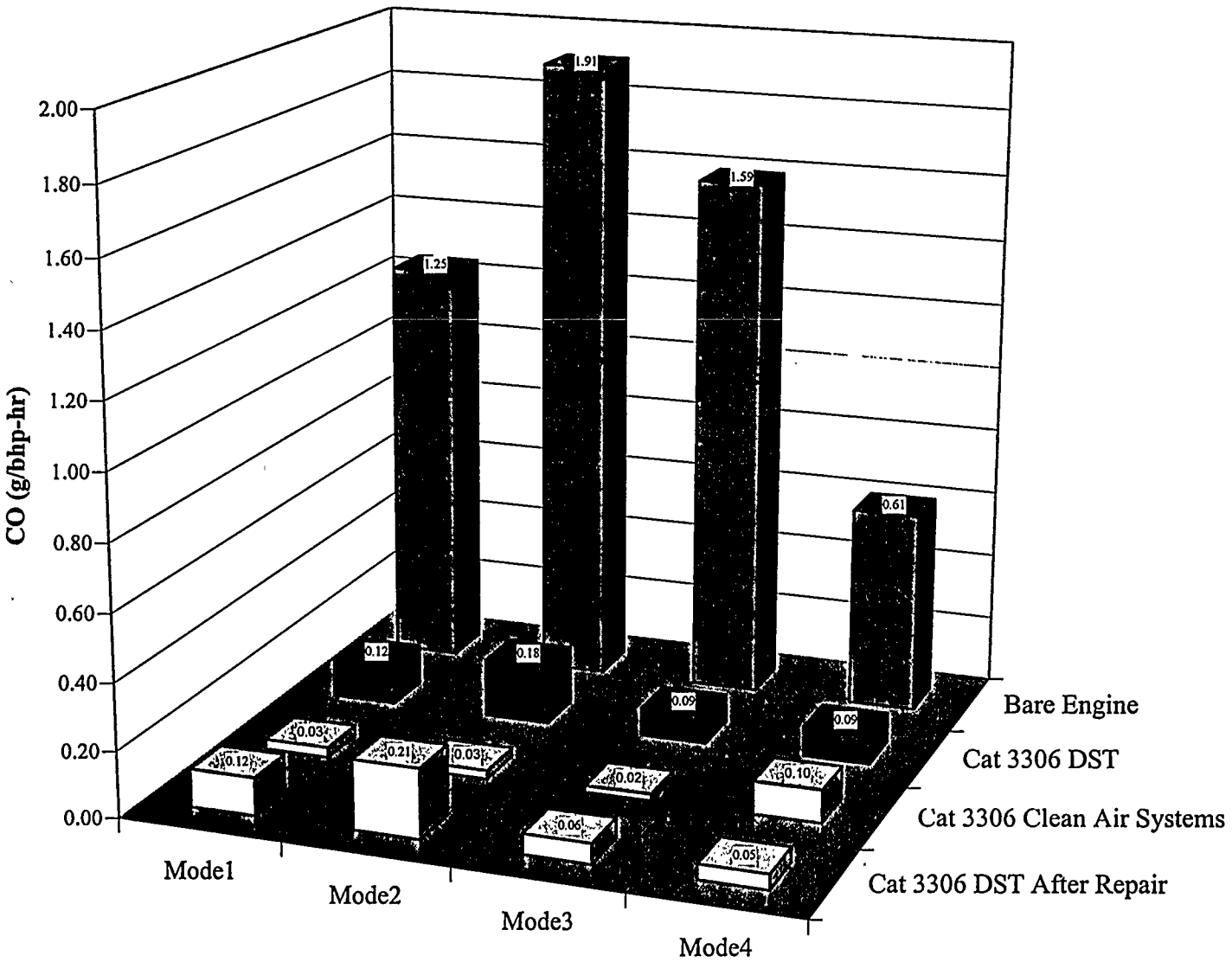


**Figure 59. Comparison of Carbon-Monoxide Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

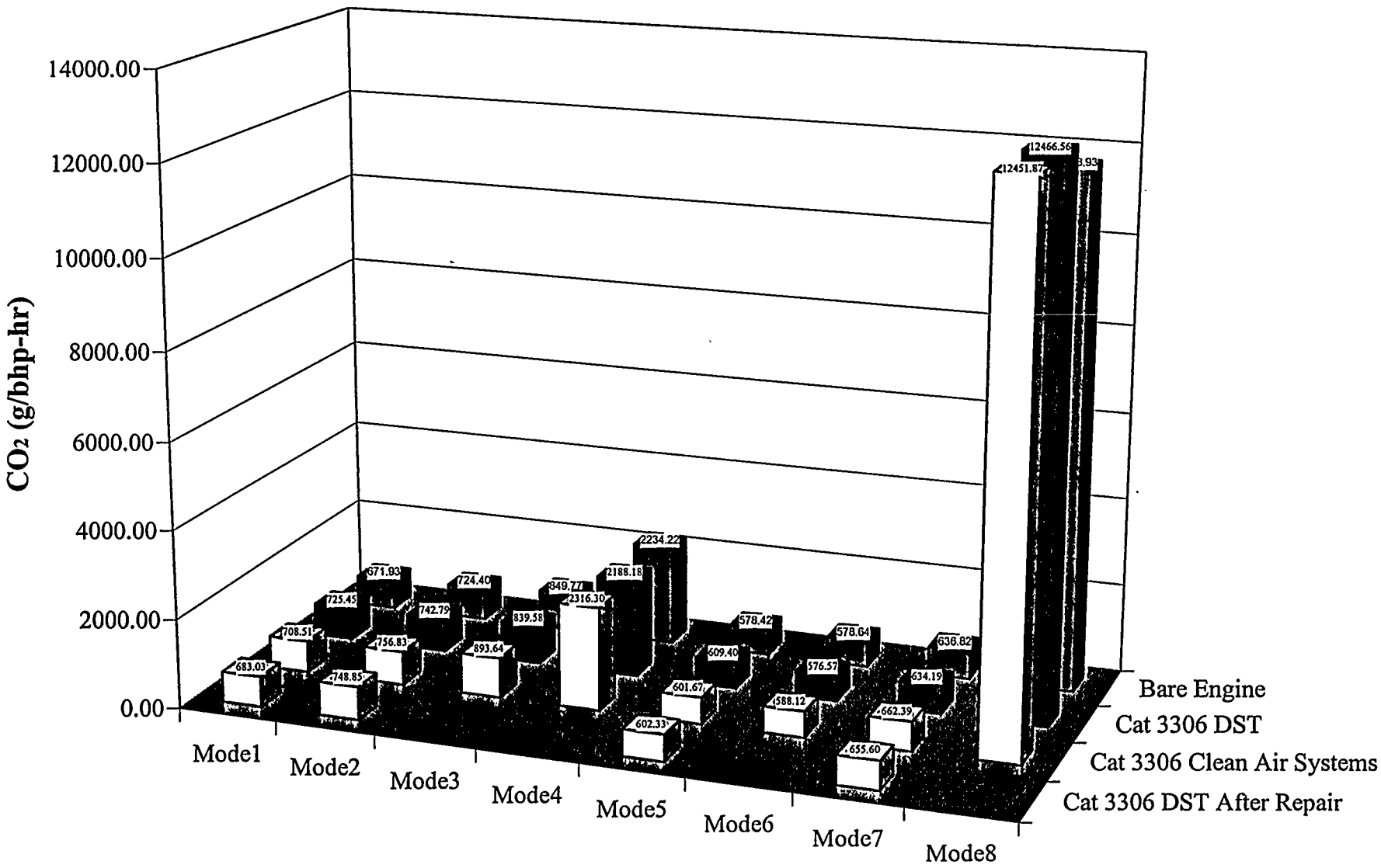


**Figure 60. Comparison of Carbon Dioxide Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

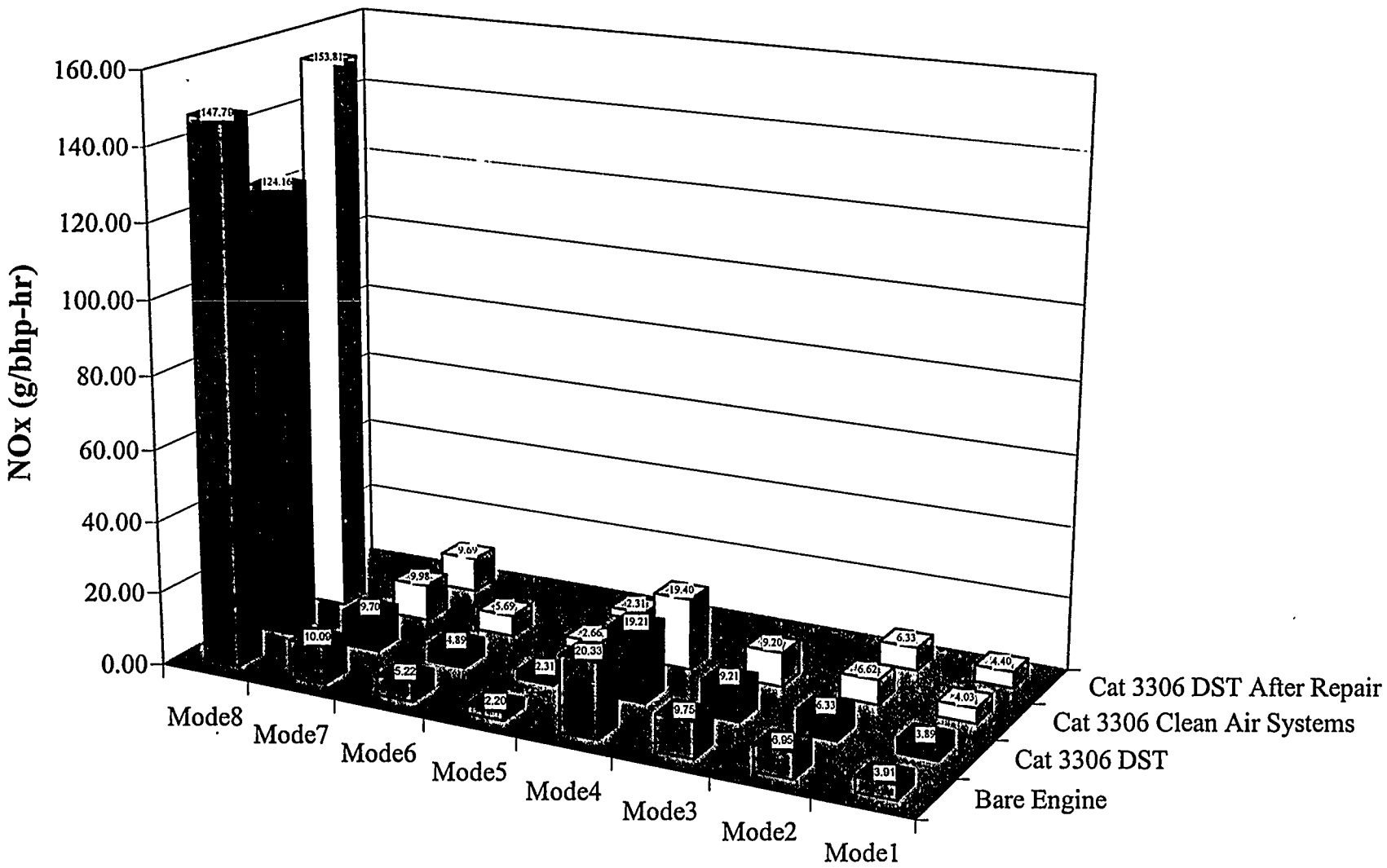


**Figure 61. Comparison of Oxides of Nitrogen Mass Emission Rates from Caterpillar 3306: Bare Engine, DST System(s)* and Clean Air Systems Catalyzed Trap**

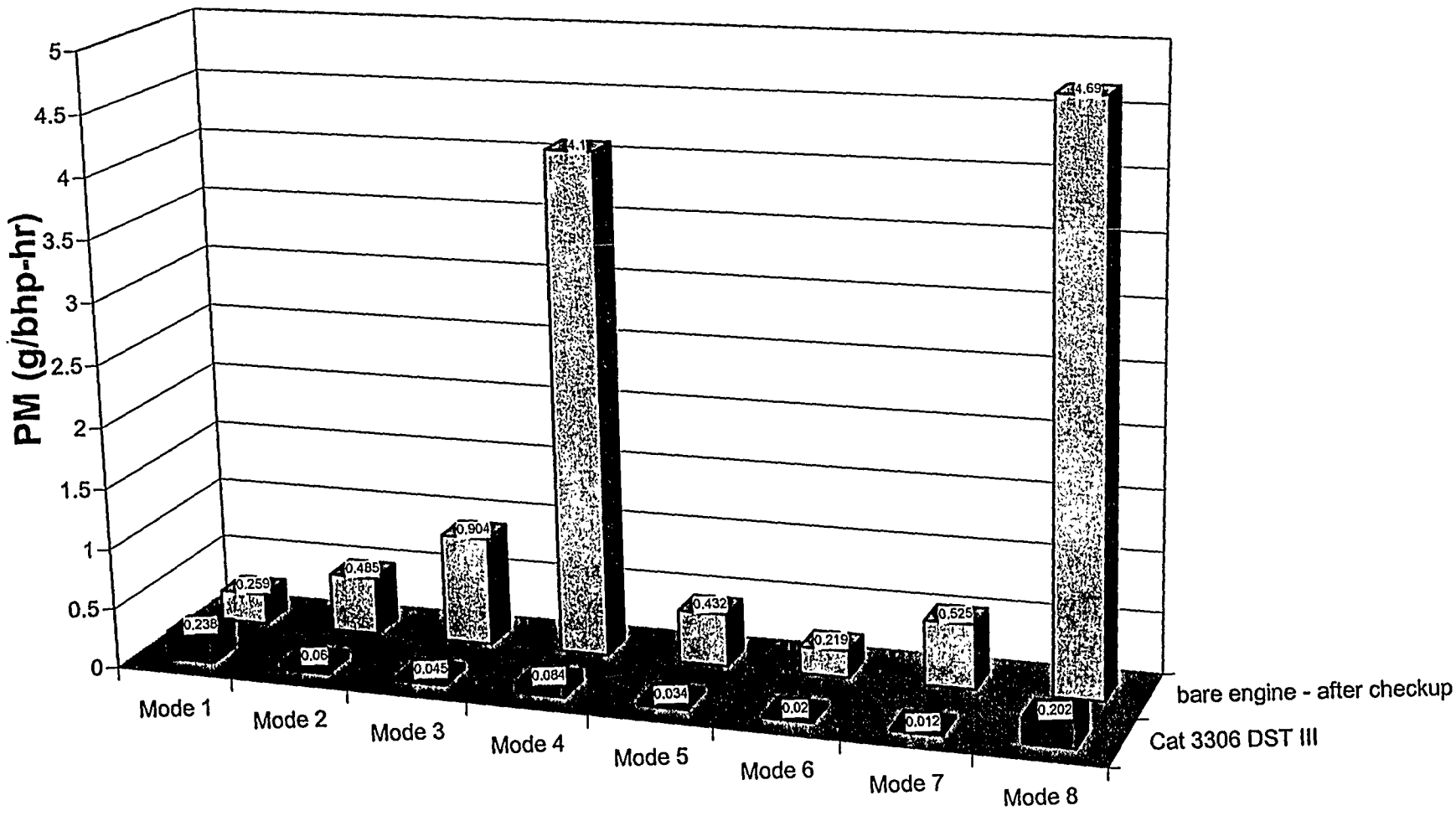


**Figure 62. Comparison of Particulate Mass Emission Rates from Caterpillar 3306: DSTIII System**

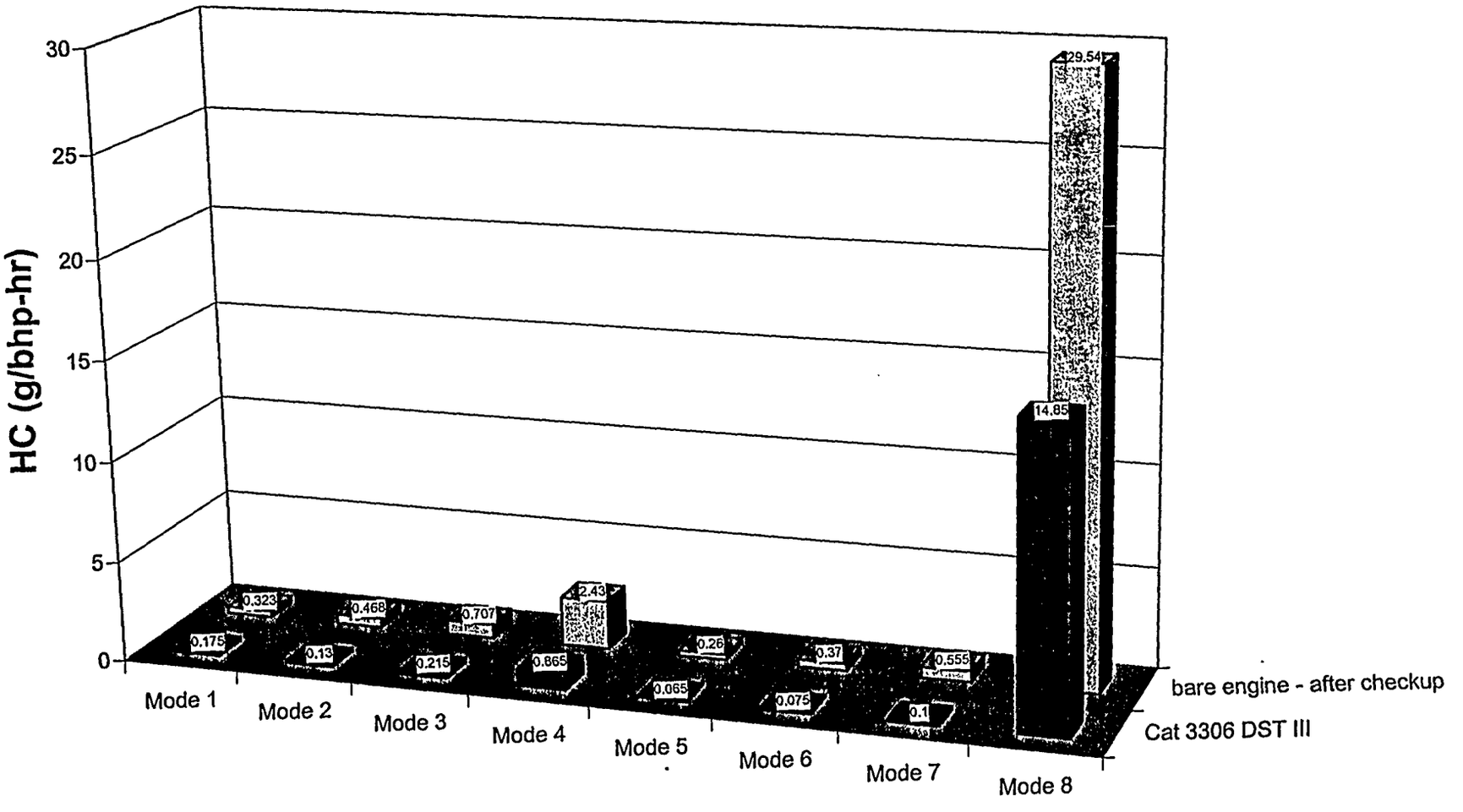


**Figure 63. Comparison of Hydrocarbon Mass Emission Rate from Caterpillar 3306: DSTIII System**

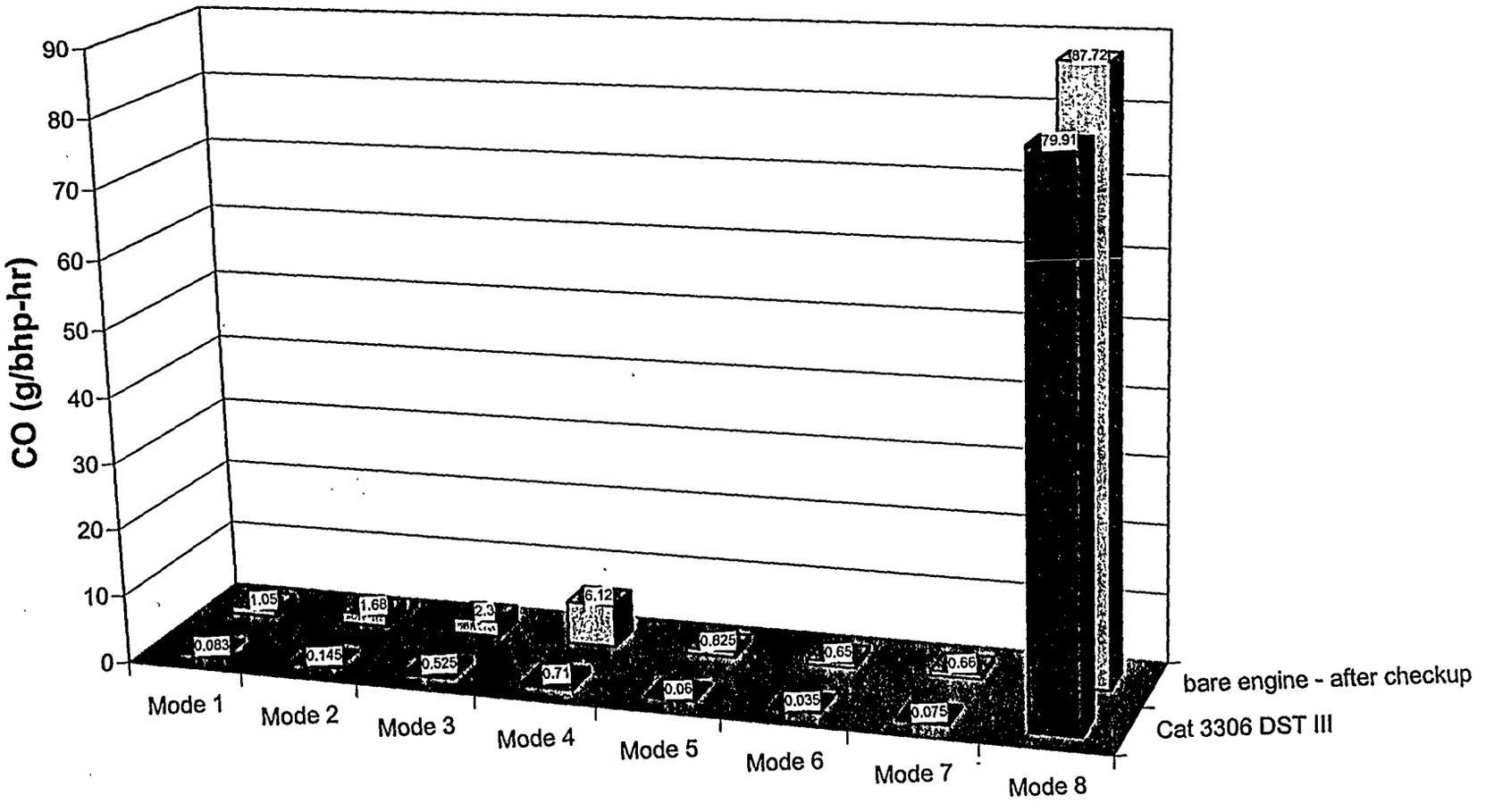


**Figure 64. Comparison of Carbon-Monoxide Mass Emission Rate from Caterpillar 3306: DSTIII System**

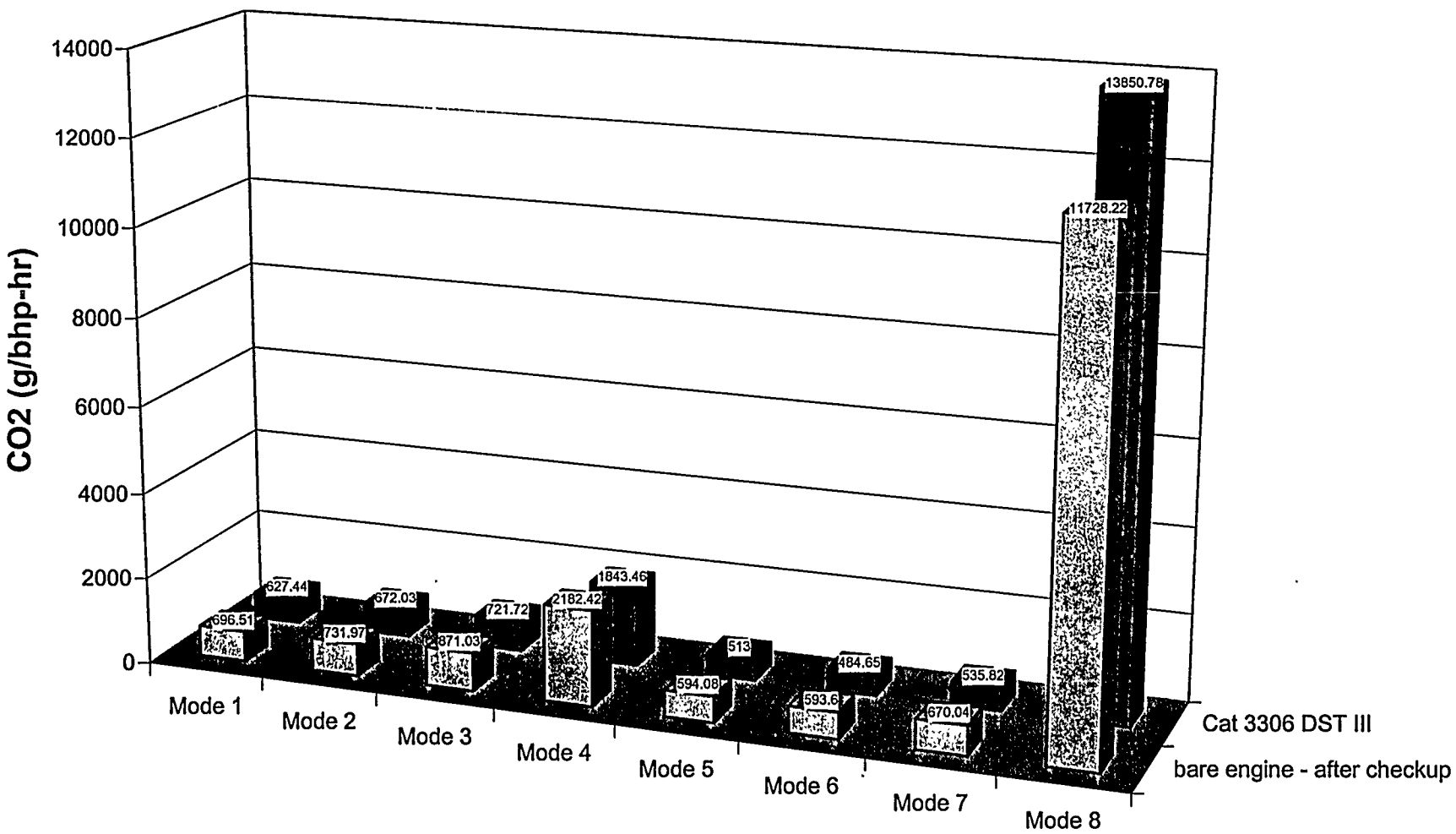


**Figure 65. Comparison of Carbon Dioxide Emission Rates from Caterpillar 3306: DSTIII System**

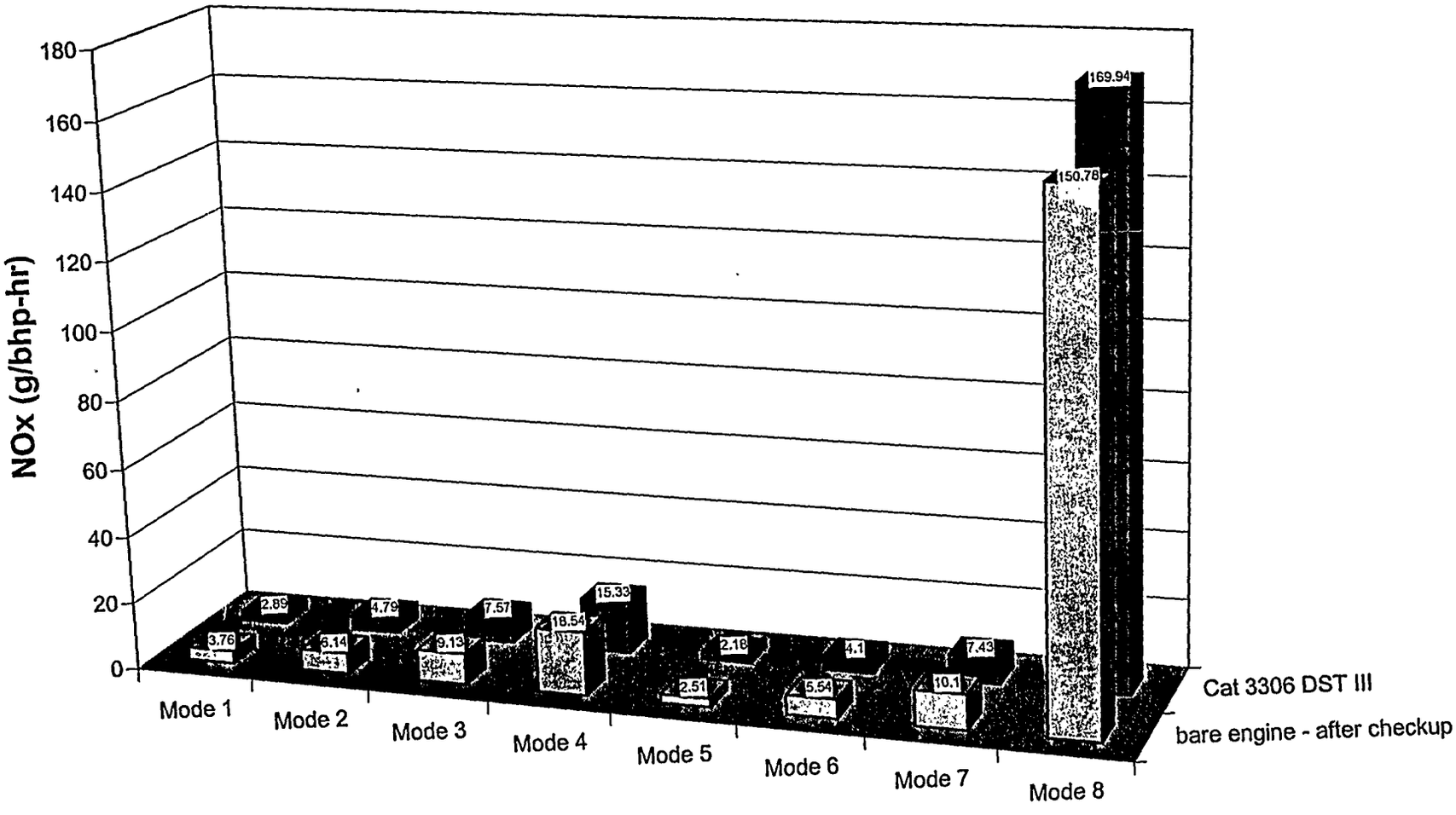


**Figure 66. Comparison of Nitrogen Oxides Mass Emission Rates from Caterpillar 3306: Bare Engine and DST III System**

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# Appendix A

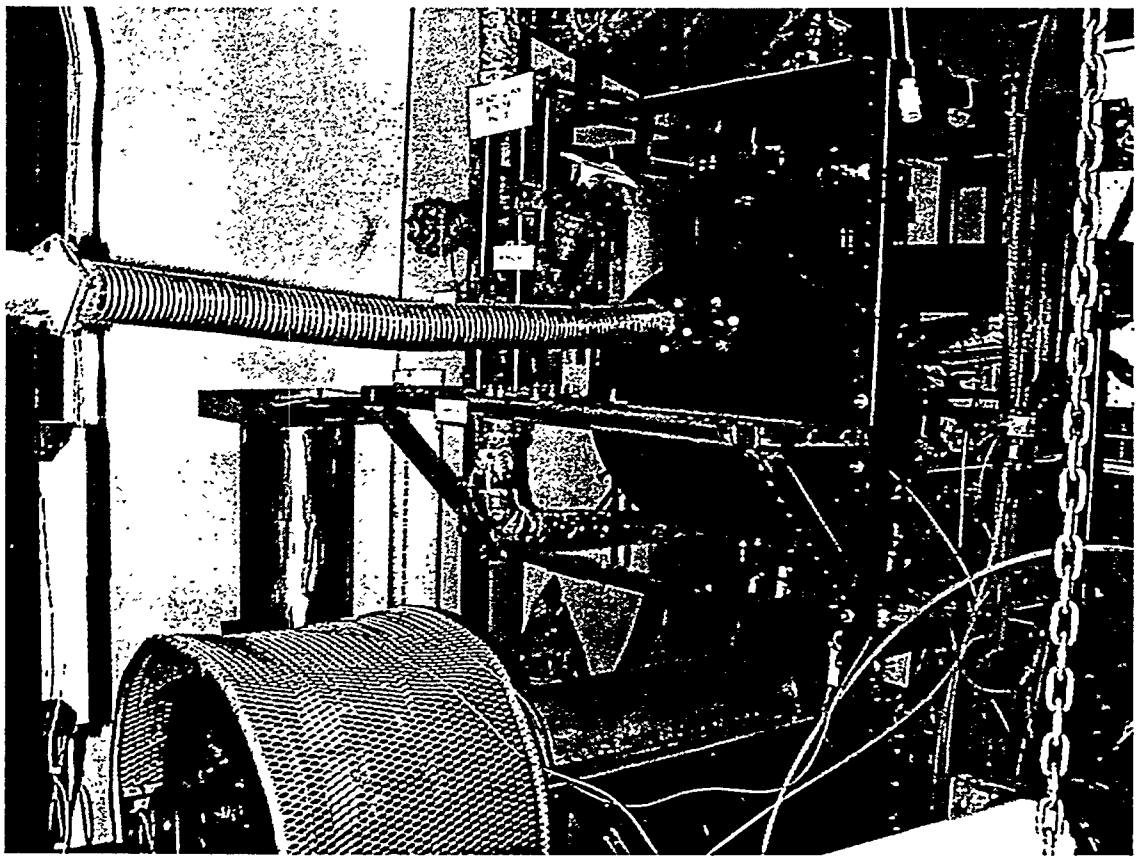


**Figure A.1-1.** MWM D916-6 on an Eddy Current Dynamometer Test Bed

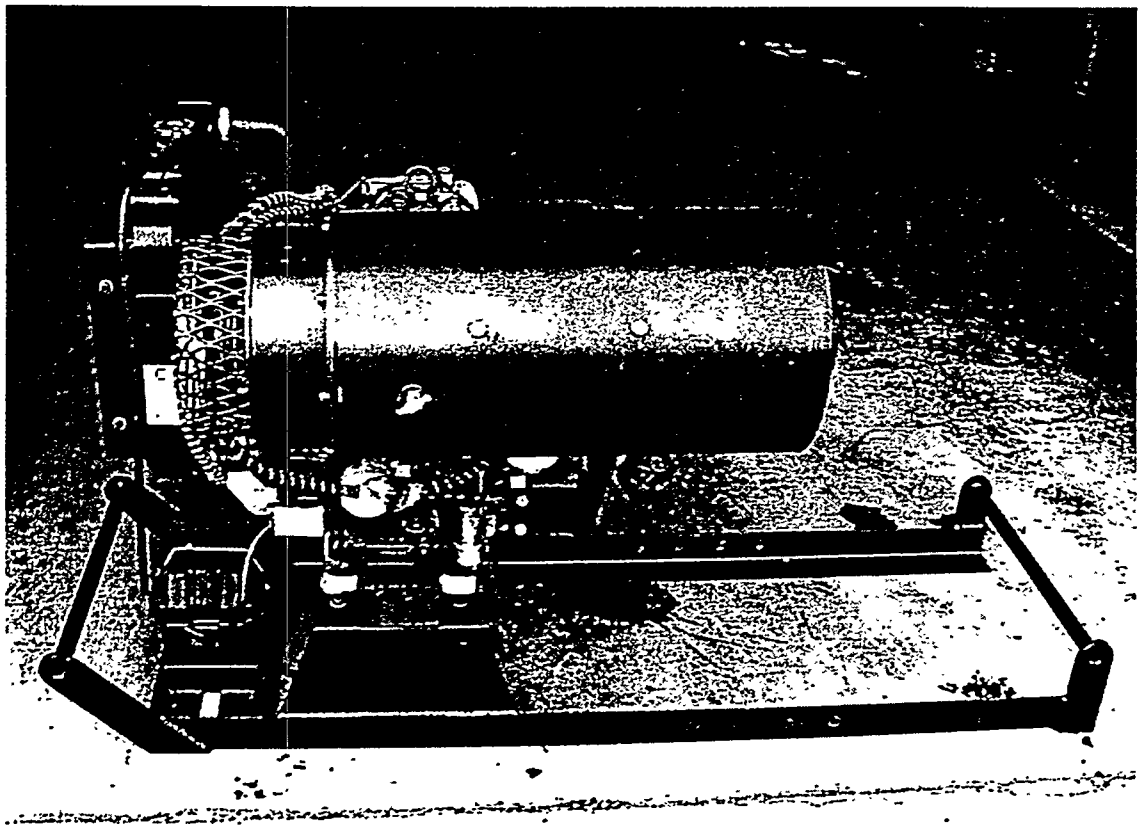


**Figure A.2-1** LPU-2 Engine with Rohmac/DCL Control System (Side View)

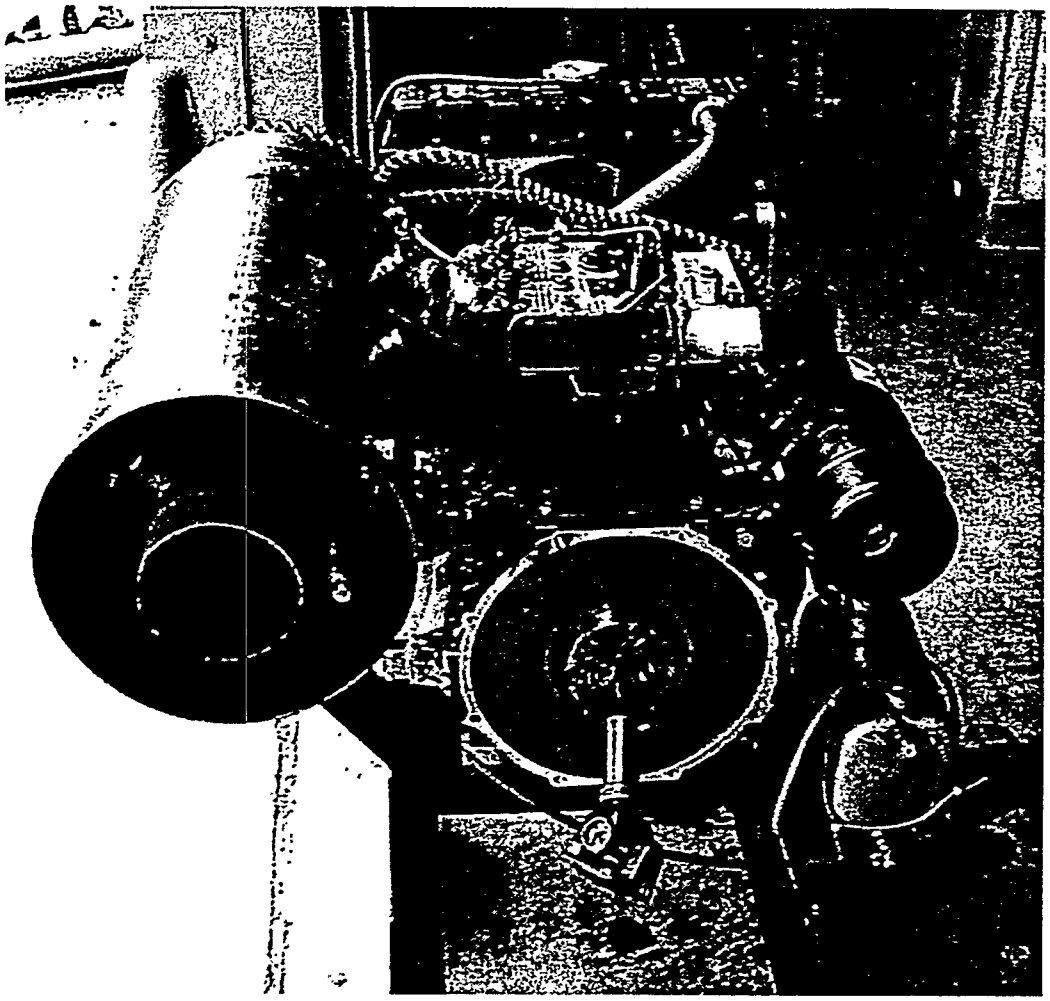


**Figure A.2-2.** LPU-2 Engine with Rohmac/DCL Control System (End View)

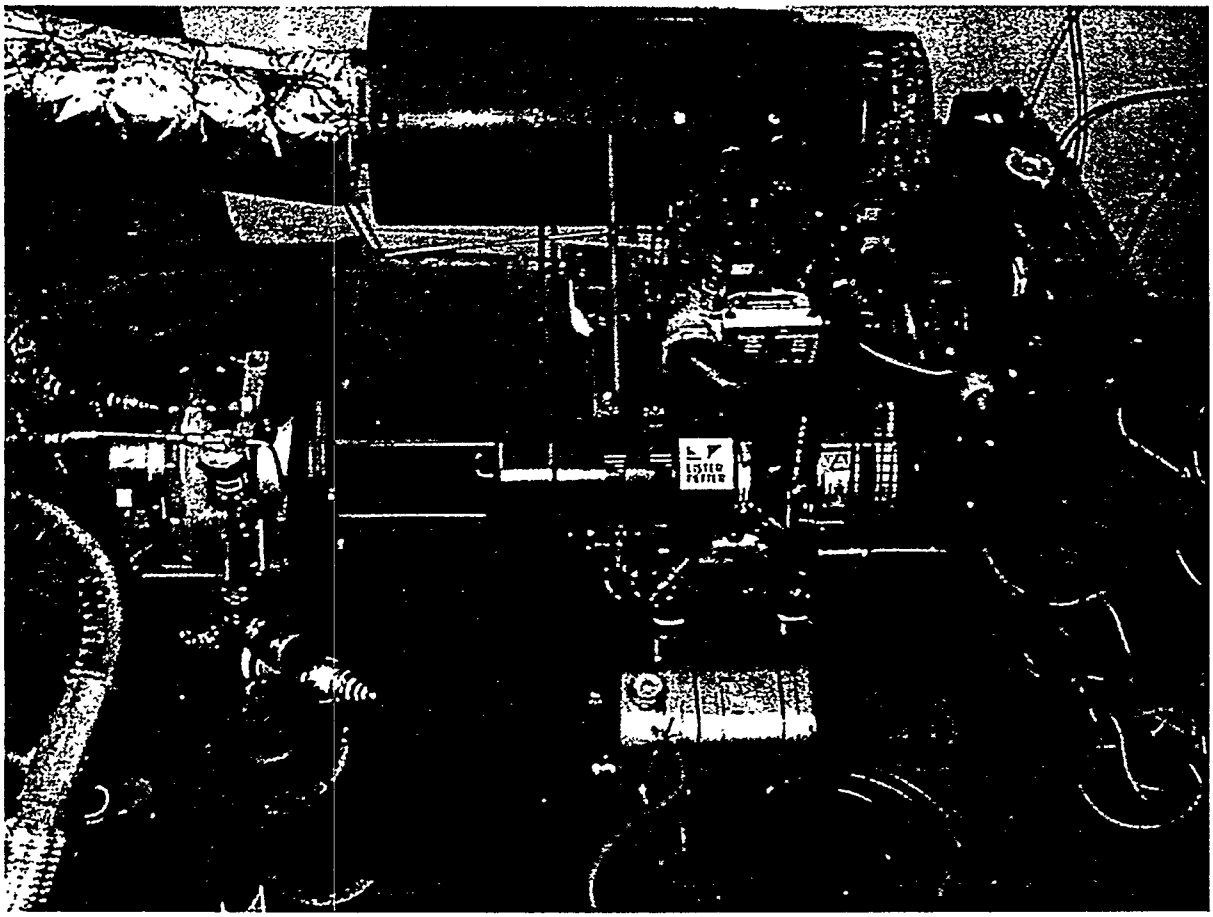


**Figure A.2-3** Lister Petter LPU-2 Engine with Rohmac/DCL DPM Control System on a Water Brake Dynamometer Test Bed

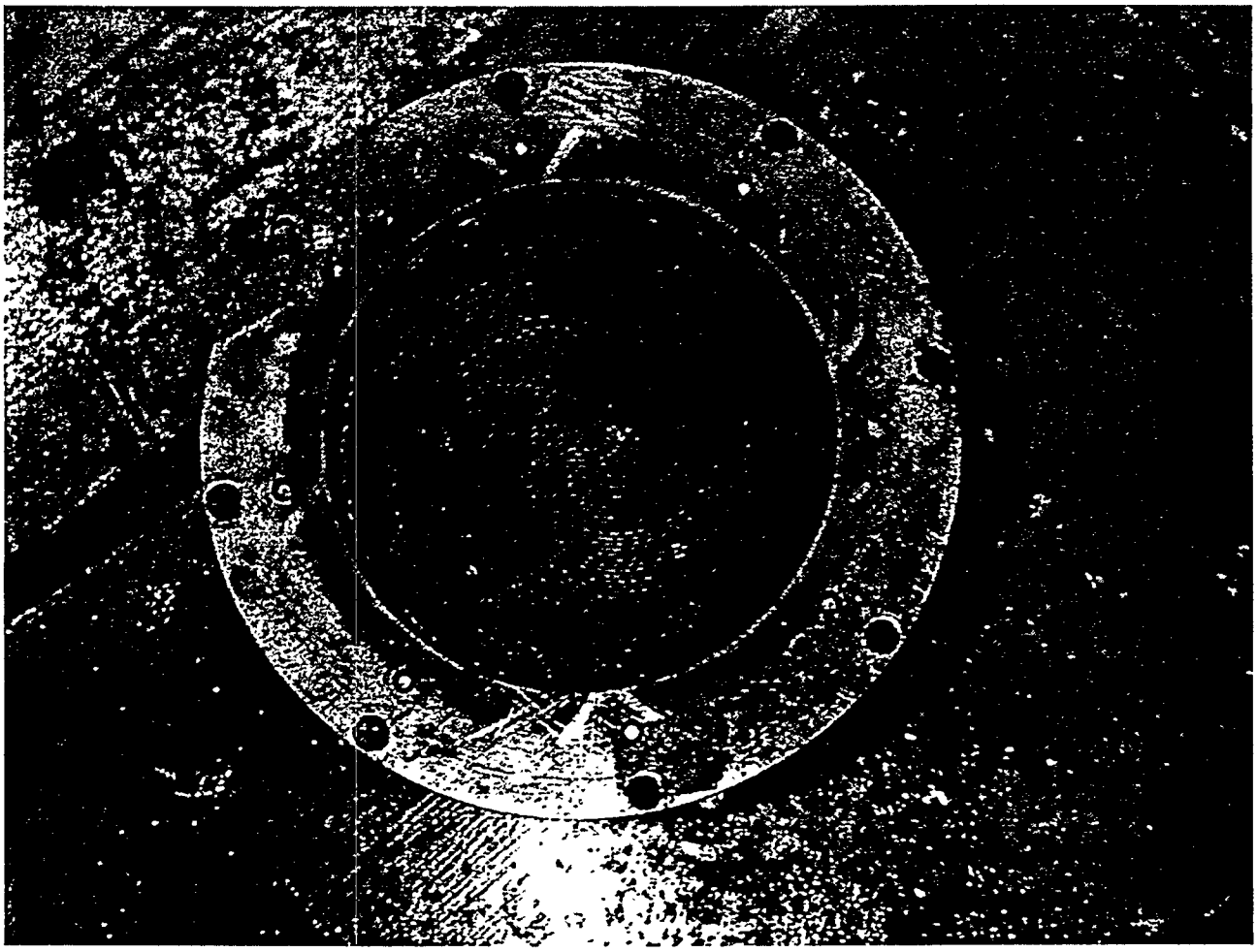


**Figure A.2-4** Downstream Face of the Rohmac/DCL Catalyst Prior to Regeneration.

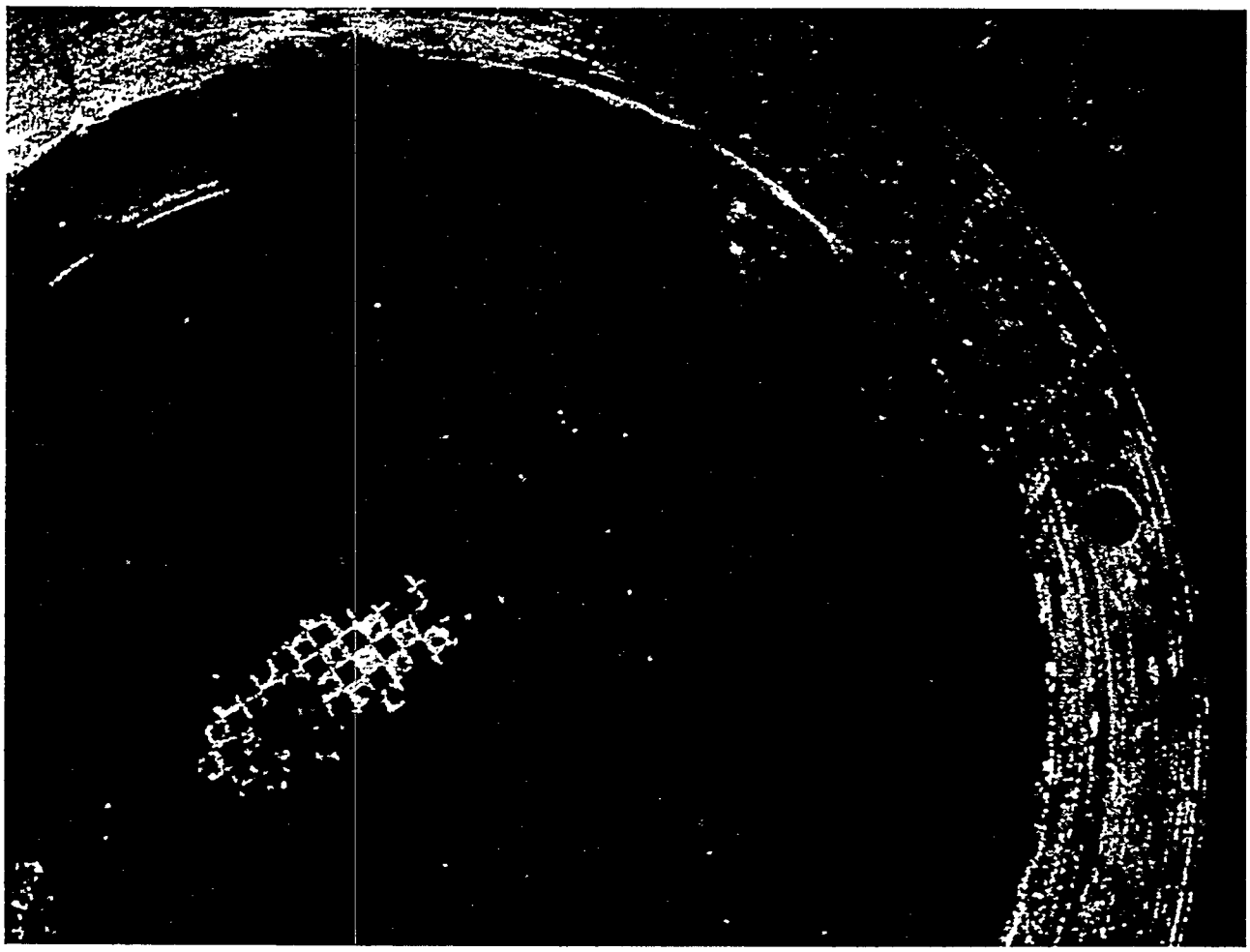


**Figure A.2-5** Upstream Face of the Rohmac/DCL Trap Prior to Regeneration

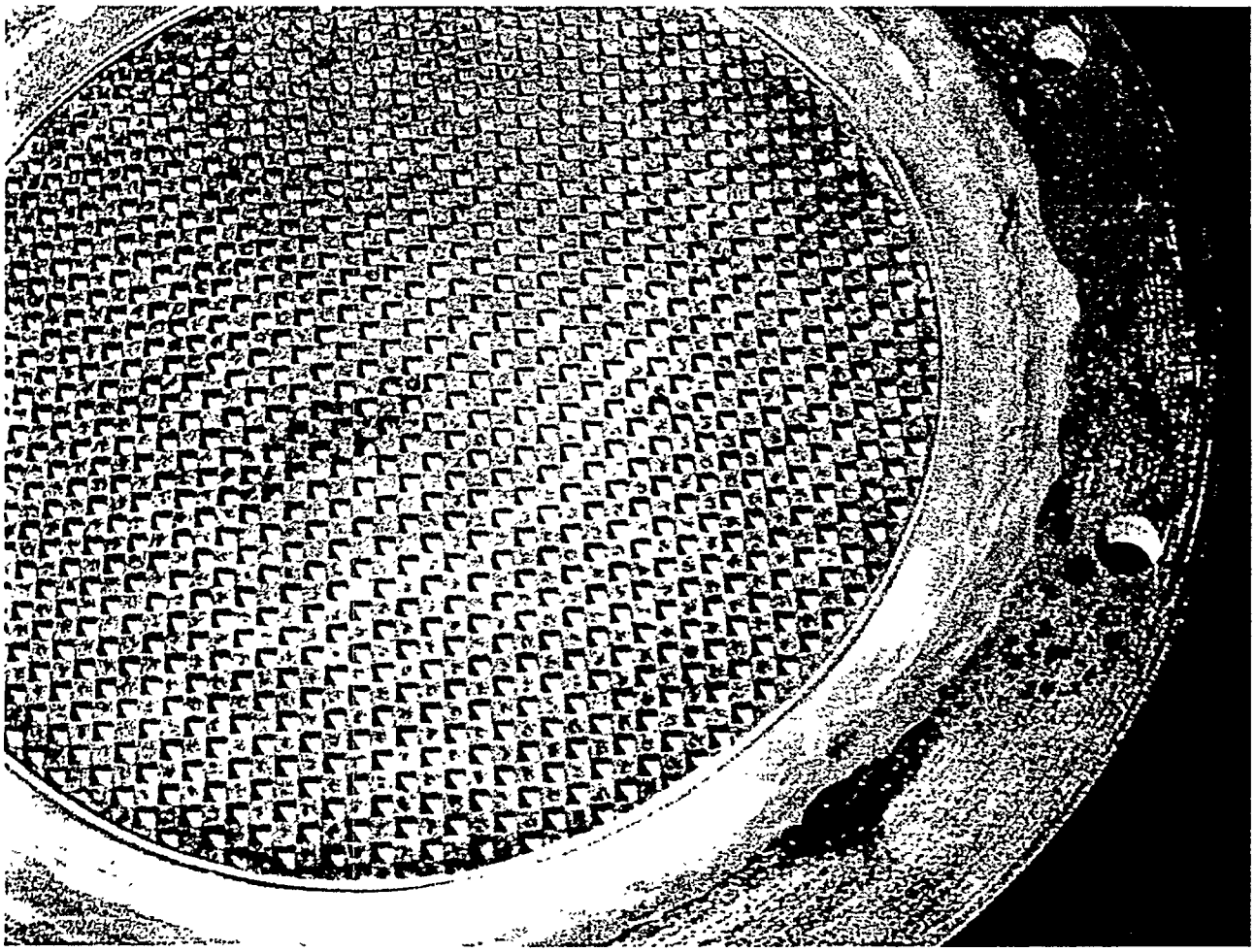


**Figure A.2-6** Downstream Face of the Rohmac/DCL Trap Prior to Regeneration

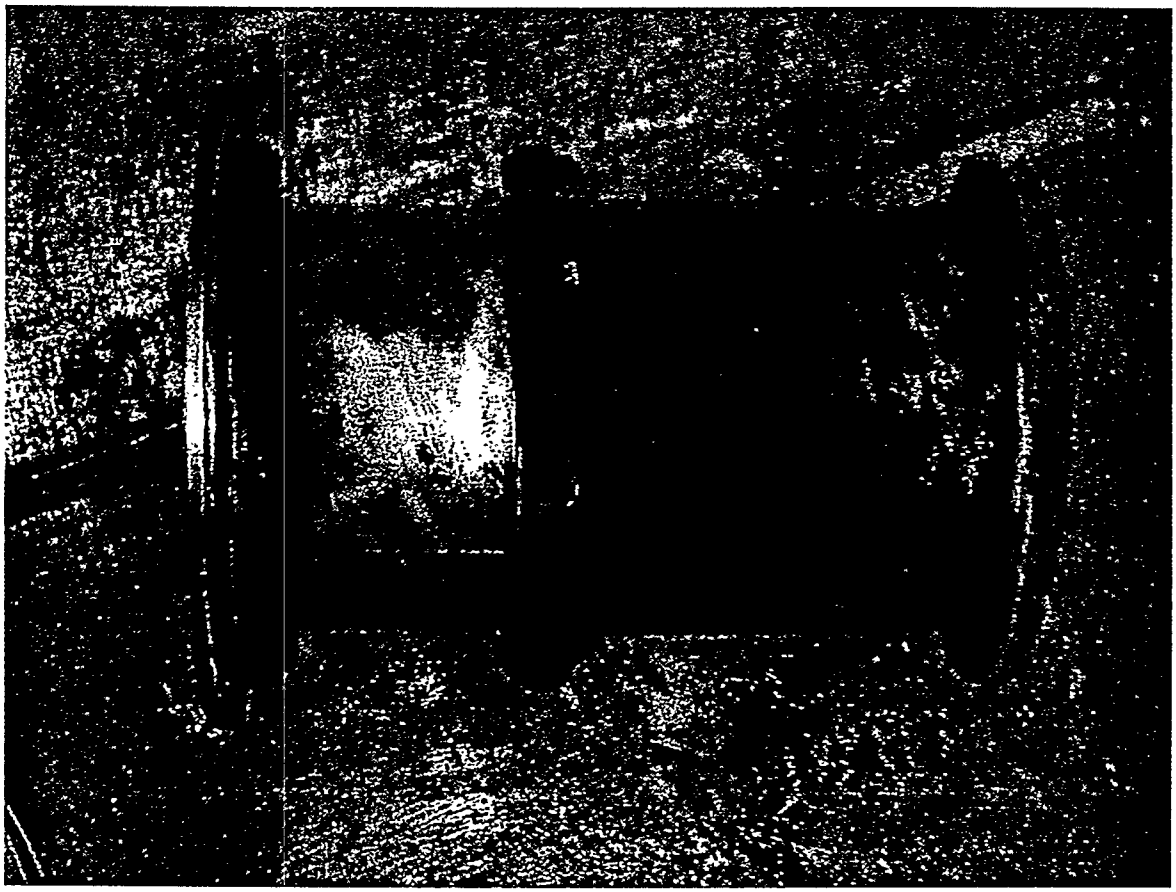


**Figure A.2-7** Rohmac/DCL Trap-Catalyst Assembly for the LPU-2 System Prior to Regeneration

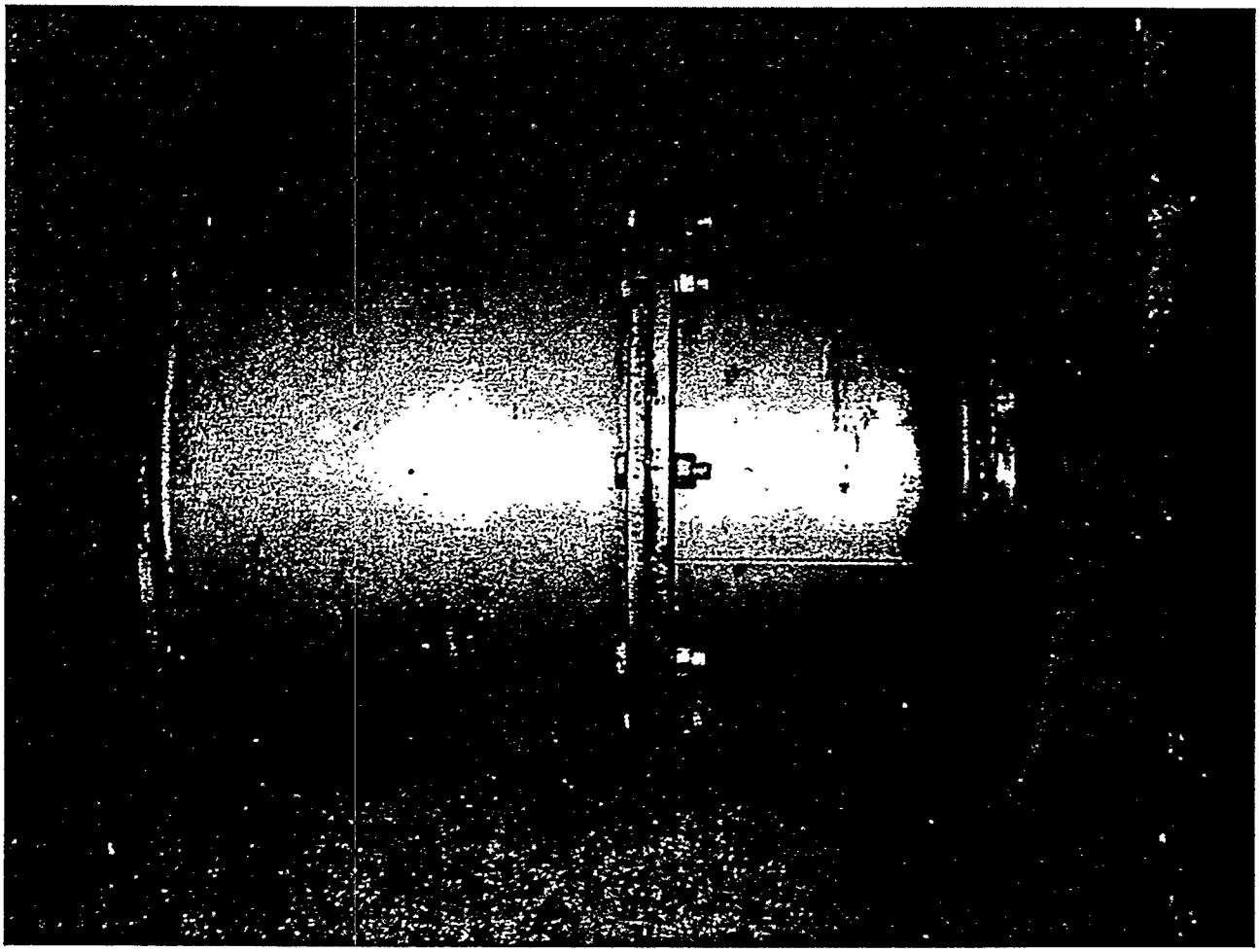


**Figure A.2-8** Rohmac/DCL Trap-Catalyst Assembly for the LPU-2 System Following Regeneration

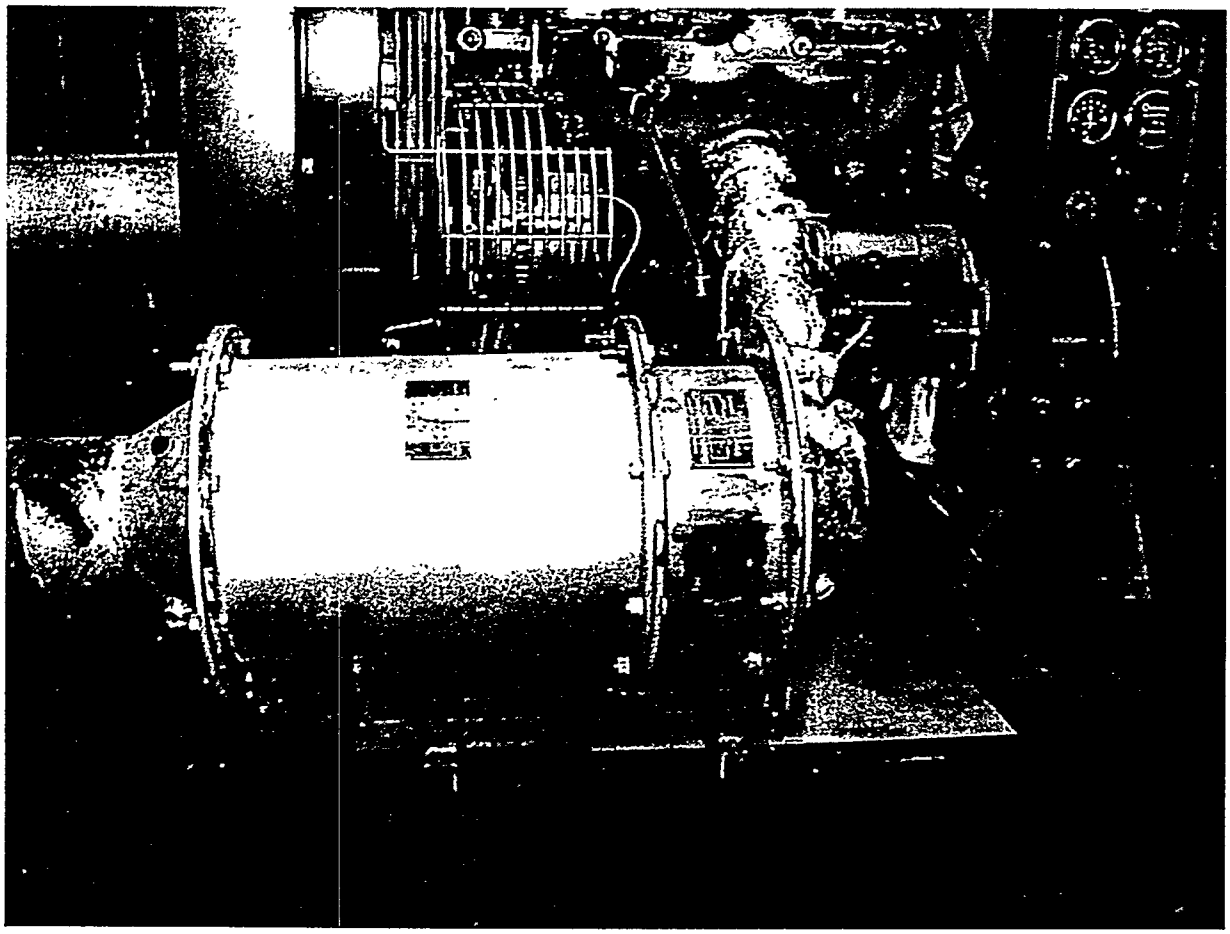


**Figure A.3-1** Isuzu C240 with Rohmac/DCL Catalyst-Trap System (Reverse Order Configuration)

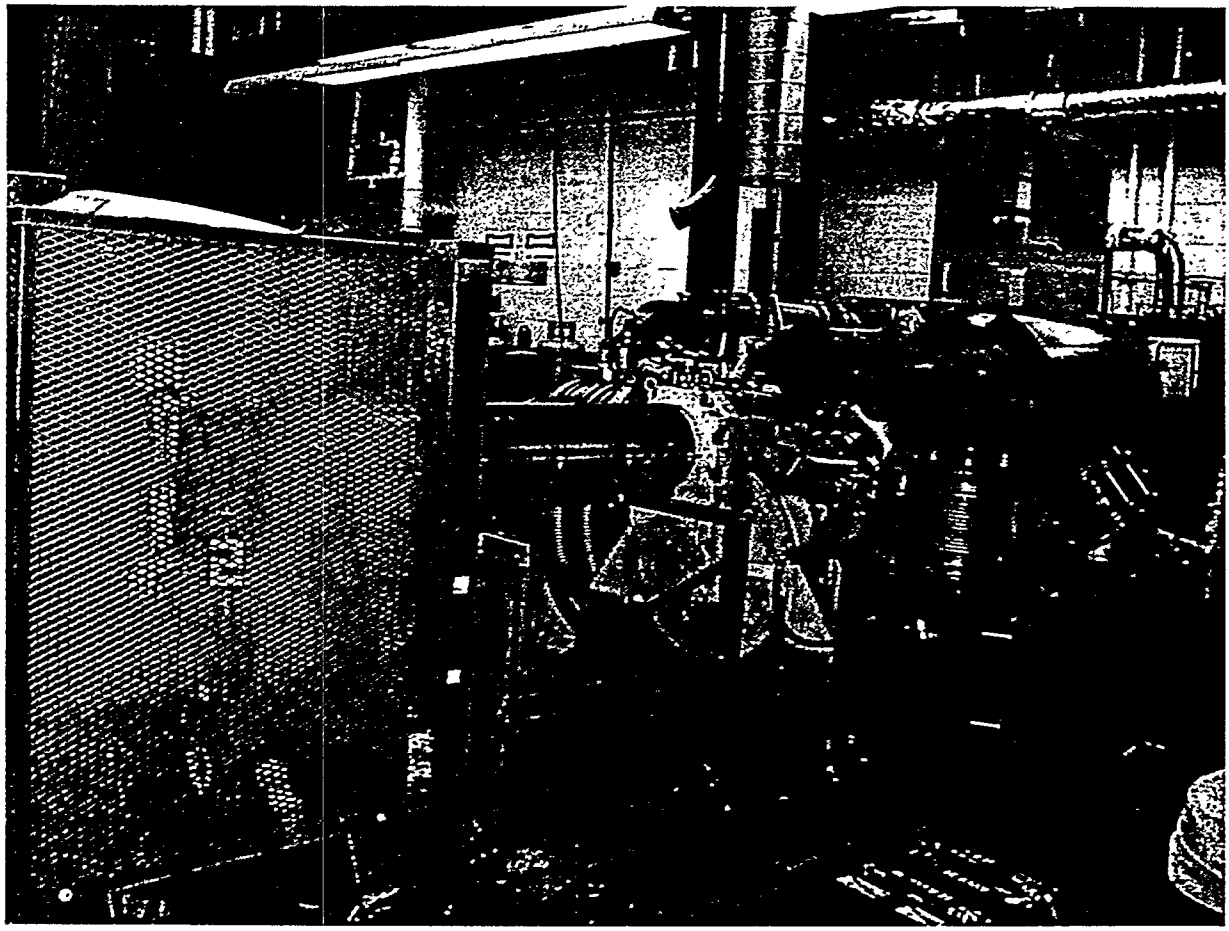


**Figure A.4-1** Caterpillar 3306 with DST on an Eddy-Current Dynamometer Test Bed

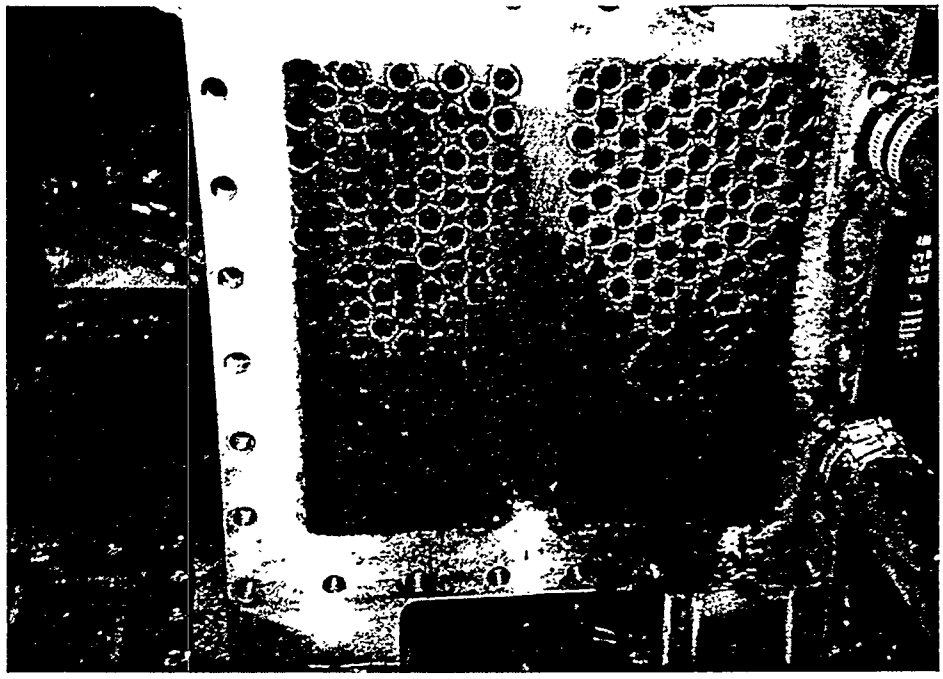


**Figure A.4-2** End View of the DST Heat Exchanger
(Taken During the Repairs of the Coolant Leak)

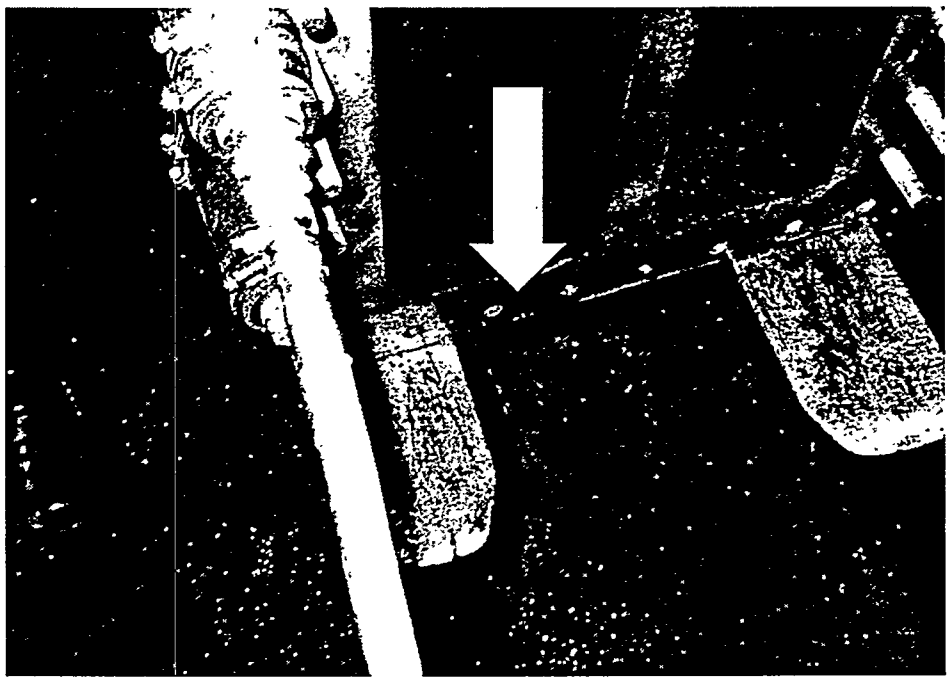


**Figure A.4-3.** Manifold Section of the DST Heat Exchanger During the Repair Process (Note Coolant Leaking From Cracks Between Mounting Holes)

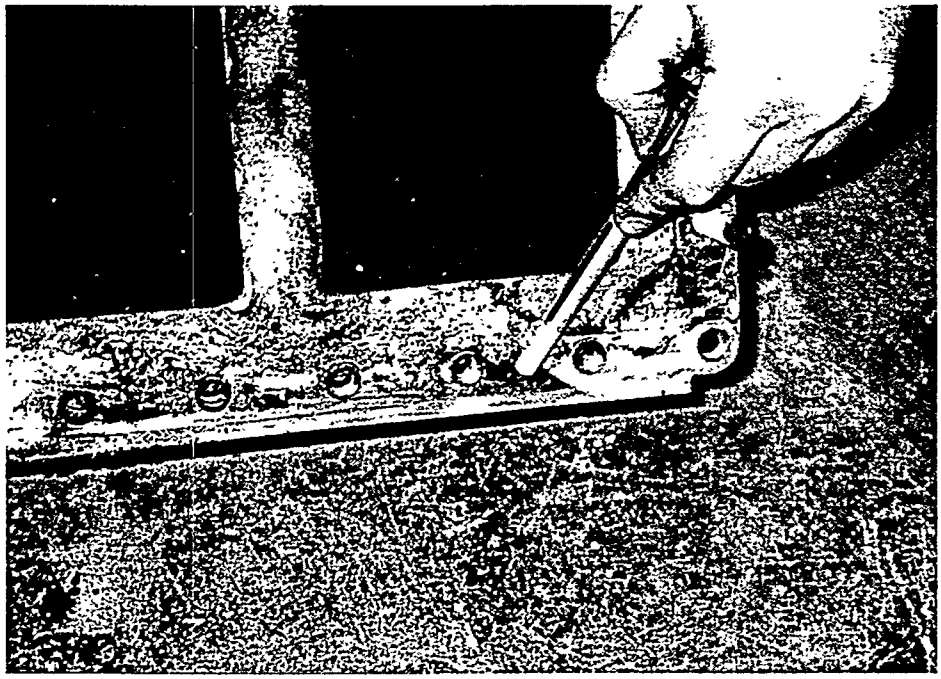


**Figure A.4-4** Manifold Section of the DST Heat Exchanger During the Repair Process (Note the Crack Between the Mounting Holes)

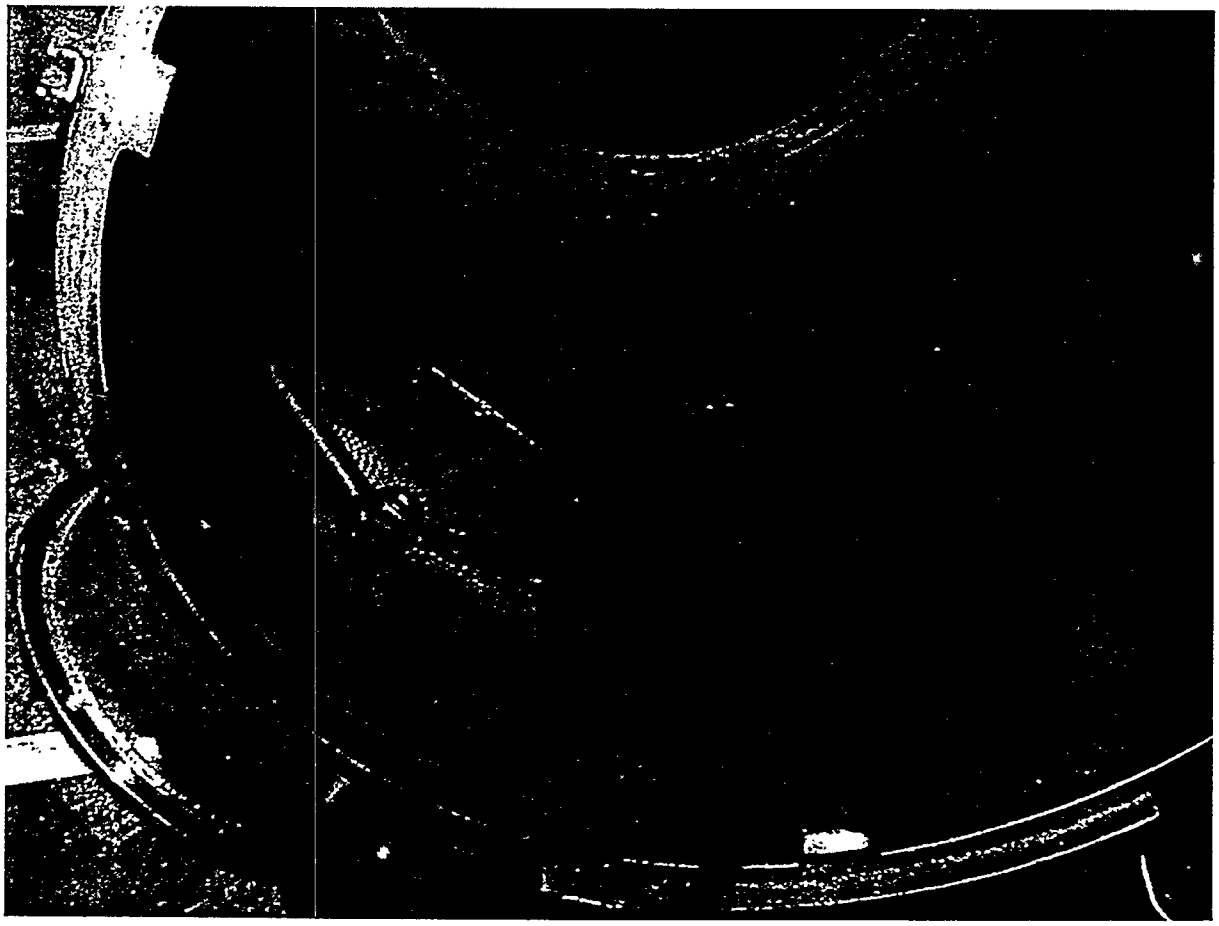


**Figure A.4-5** Internal End View of the DST Filter Canister
(Taken Following the Detection of Coolant Leak)

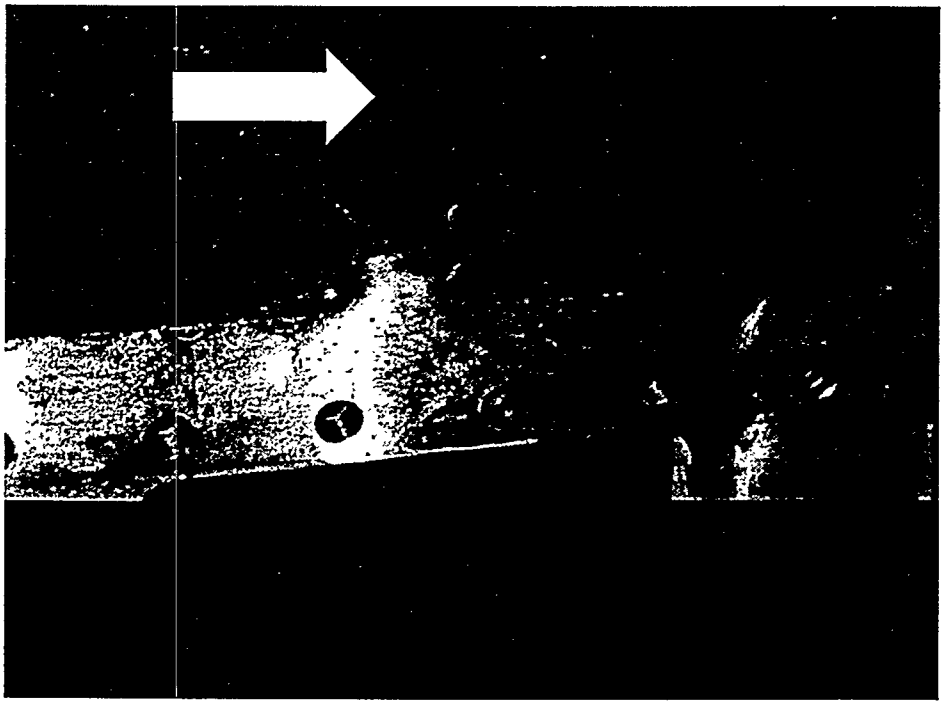


**Figure A.4-6** DST Heat Exchanger During the Repair Process (Note Evidence of Exhaust Leak Between High and Low Temperature Streams)

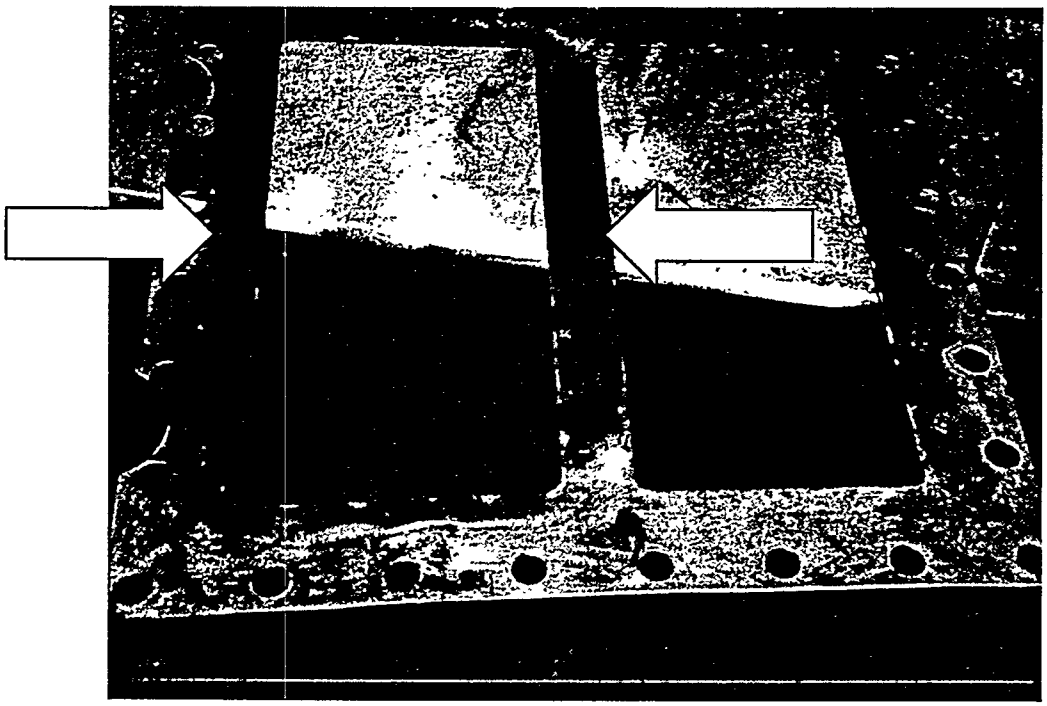


**Figure A.4-7** Manifold-Body Gasket From the DST Heat Exchanger During the Repair Process (Note Evidence of Exhaust Leak Between High and Low Temperature Streams)

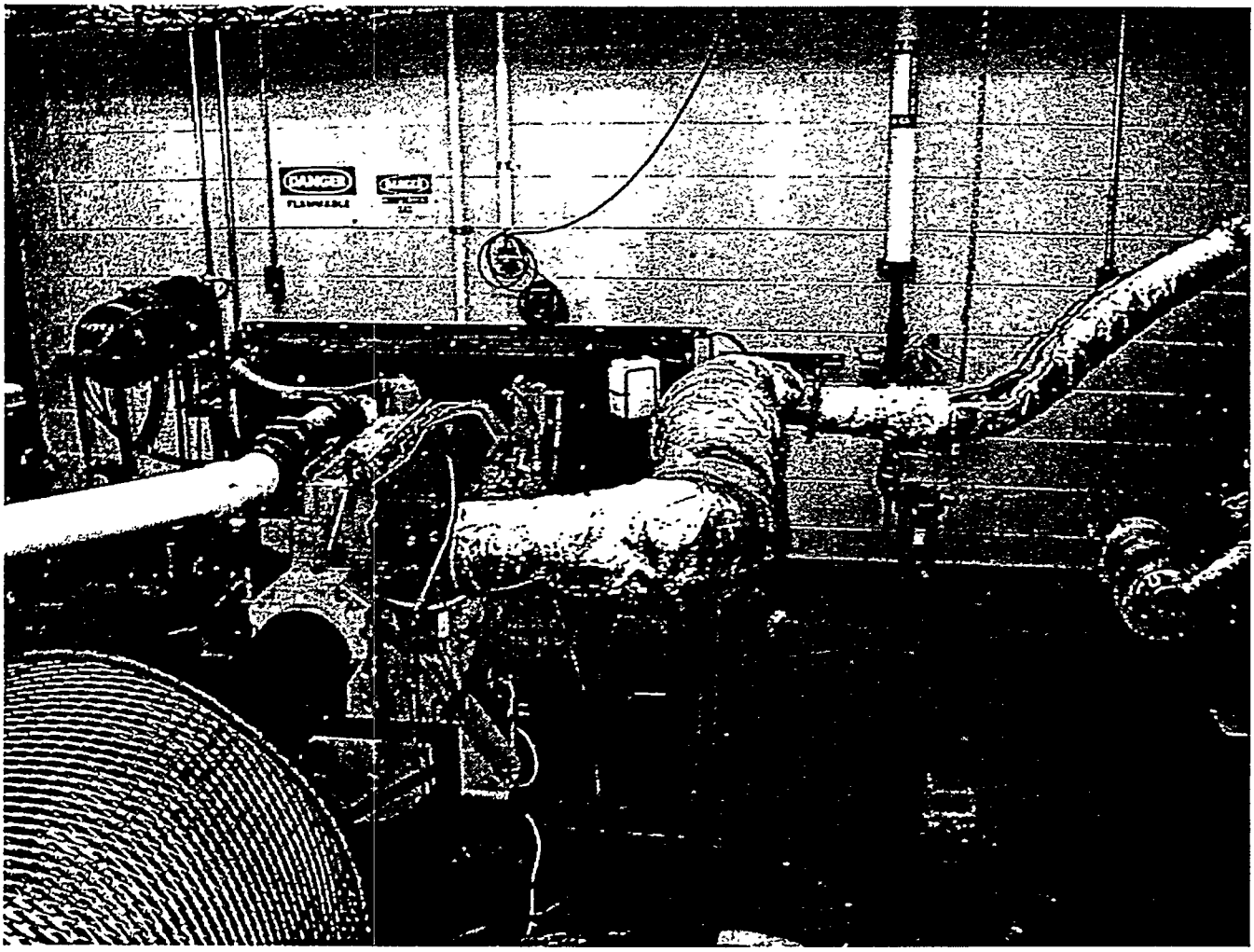



**Figure A.4-8** Caterpillar 3306 with Clean Air Systems Trap (End View)

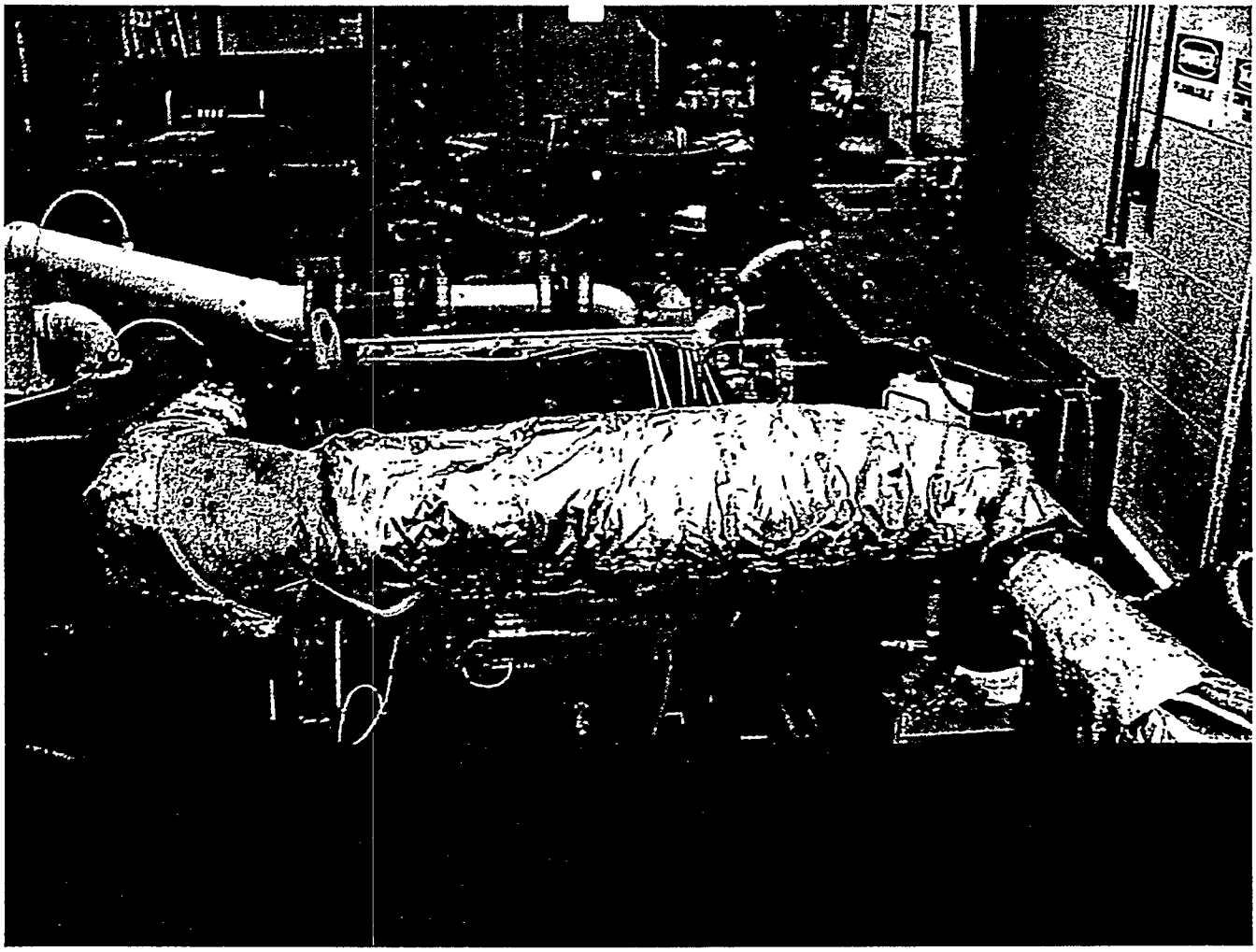


**Figure A.4-9** Caterpillar 3306 with Clean Air Systems Trap (Side View)

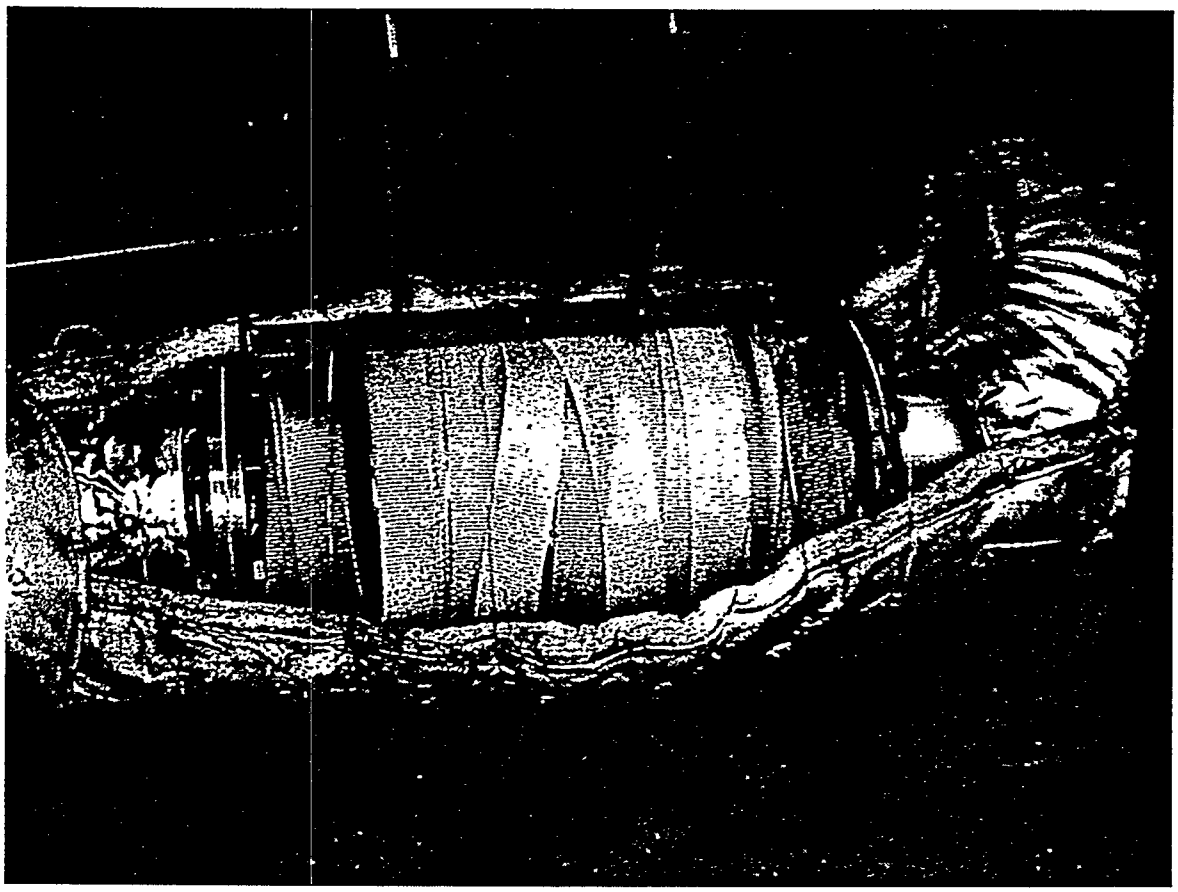


**Figure A.4-10** Insulated Clean Air Systems Catalyzed Trap

# Appendix B

Emissions Data for MWM D916-6 with Low-sulfur (0.05%) Fuel (in g/hr)

Mode 1

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 24.756 | 23.28 | 23.304 | 23.780 |
| HC | 3.72 | 4.08 | 3.24 | 3.680 |
| CO | 52.56 | 51.12 | 50.52 | 51.400 |
| CO2 | 40092.6 | 37594.68 | 39143.88 | 38943.72 |
| Nox | 247.56 | 251.04 | 248.4 | 249.000 |

Mode 2

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 20.424 | 20.592 | 20.472 | 20.496 |
| HC | 5.76 | 4.92 | 4.68 | 5.120 |
| CO | 44.04 | 46.2 | 45.24 | 45.160 |
| CO2 | 34315.44 | 34670.4 | 34489.8 | 34491.88 |
| Nox | 249.72 | 251.28 | 252.96 | 251.320 |

Mode 3

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 19.716 | 18.576 | 17.628 | 18.640 |
| HC | 4.8 | 4.56 | 4.44 | 4.600 |
| CO | 32.28 | 30.72 | 33.84 | 32.280 |
| CO2 | 26066.16 | 25849.56 | 25610.4 | 25842.04 |
| Nox | 231.48 | 229.32 | 228.72 | 229.840 |

Mode 4

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 10.632 | 10.596 | 11.232 | 10.820 |
| HC | 2.16 | 2.16 | 2.52 | 2.280 |
| CO | 29.76 | 30.24 | 31.2 | 30.400 |
| CO2 | 14191.08 | 14169.48 | 14315.4 | 14225.32 |
| Nox | 121.2 | 117.24 | 118.68 | 119.040 |

Mode 5

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 24.048 | 22.884 | 22.2 | 23.044 |
| HC | 2.16 | 2.28 | 1.8 | 2.080 |
| CO | 37.32 | 35.4 | 35.52 | 36.080 |
| CO2 | 29745.24 | 29440.8 | 29190.84 | 29458.96 |
| Nox | 195.84 | 146.64 | 198.48 | 180.320 |

Mode 6

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 16.488 | 16.848 | 16.872 | 16.736 |
| HC | 2.4 | 2.52 | 2.4 | 2.440 |
| CO | 31.2 | 30.36 | 29.88 | 30.480 |
| CO2 | 24414 | 24605.88 | 24289.92 | 24436.60 |
| Nox | 200.52 | 4.8 | 137.88 | 114.400 |

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 13.704 | 14.832 | 14.868 | 14.468 |
| HC | 2.28 | 3 | 3.12 | 2.800 |
| CO | 26.76 | 29.76 | 30.48 | 29.000 |
| CO2 | 18239.28 | 18194.88 | 18224.4 | 18219.52 |
| Nox | 186.96 | 185.4 | 184.44 | 185.600 |

Mode 8

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 1.368 | 1.902 | 3.366 | 2.212 |
| HC | | | 0.42 | 0.420 |
| CO | 8.58 | 8.82 | 9 | 8.800 |
| CO2 | 2649.72 | 2595.96 | 2541.9 | 2595.860 |
| Nox | 32.88 | 31.5 | 30.12 | 31.500 |

Emissions Data for MWM D916-6 with High-sulfur (0.25%) Fuel (in g/hr)

Mode 1

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 33.528 | 33.84 | 29.628 | 32.332 |
| HC | 3.48 | 3.48 | 3.24 | 3.400 |
| CO | 51.12 | 52.44 | 51.96 | 51.840 |
| CO2 | 44178.6 | 42818.64 | 43093.2 | 43363.48 |
| Nox | 255.6 | 255.12 | 256.68 | 255.800 |

Mode 2

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 25.26 | 25.128 | 25.752 | 25.380 |
| HC | 5.28 | 5.16 | 4.92 | 5.120 |
| CO | 44.4 | 41.52 | 44.16 | 43.360 |
| CO2 | 35865 | 35823 | 36107.16 | 35931.72 |
| Nox | 234.24 | 232.92 | 232.44 | 233.200 |

Mode 3

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 21.588 | 20.964 | 20.712 | 21.088 |
| HC | 5.28 | 4.68 | 5.4 | 5.120 |
| CO | 28.92 | 29.52 | 30.48 | 29.640 |
| CO2 | 26761.8 | 27064.68 | 26566.2 | 26797.56 |
| Nox | 218.16 | 219.48 | 218.04 | 218.560 |

Mode 4

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 13.596 | 14.22 | 14.364 | 14.060 |
| HC | 2.28 | 2.88 | 3.00 | 2.720 |
| CO | 30.72 | 33.36 | 34.08 | 32.720 |
| CO2 | 14856.12 | 14707.08 | 14779.92 | 14781.04 |
| Nox | 118.92 | 116.76 | 117.24 | 117.640 |

Mode 5

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 31.56 | 29.568 | 27.96 | 29.696 |
| HC | 1.56 | 1.68 | 2.16 | 1.800 |
| CO | 33.84 | 31.56 | 31.08 | 32.160 |
| CO2 | 31528.08 | 31080 | 30822.36 | 31143.48 |
| Nox | 185.4 | 179.88 | 184.2 | 183.160 |

Mode 6

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 20.208 | 23.268 | 22.092 | 21.856 |
| HC | 2.88 | 3.12 | 3.00 | 3.000 |
| CO | 26.64 | 27.6 | 26.88 | 27.040 |
| CO2 | 25705.08 | 25681.08 | 25618.44 | 25668.20 |
| Nox | 189.96 | 188.04 | 187.8 | 188.600 |

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 16.536 | 17.352 | 17.46 | 17.116 |
| HC | 3.36 | 3.72 | 3.48 | 3.520 |
| CO | 23.4 | 27.6 | 25.92 | 25.640 |
| CO2 | 18835.92 | 18976.08 | 18957.48 | 18923.16 |
| Nox | 176.64 | 177.6 | 175.68 | 176.640 |

Mode 8

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 4.578 | 5.814 | 5.526 | 5.306 |
| HC | 0.3 | 0.54 | 0.72 | 0.520 |
| CO | 8.22 | 12.3 | 15.06 | 11.860 |
| CO2 | 2850.96 | 2784.6 | 2791.86 | 2809.140 |
| Nox | 24.18 | 22.56 | 22.98 | 23.240 |

**Emissions Data for Lister Petter LPU-2 bare engine (in g/hr)**

Mode 1

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 109.464 | 102.612 | 100.128 | 104.068 |
| HC | 4.92 | 2.16 | 1.56 | 2.880 |
| CO | 799.44 | 653.88 | 613.68 | 689.000 |
| CO2 | 16479.96 | 16582.32 | 16366.68 | 16476.32 |
| Nox | 31.44 | 32.04 | 32.04 | 31.840 |
| Exh Temp | 1457 | 1775 | 1792 | 1674.667 |

Mode 2

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 4.1925 | 3.744 | 3.432 | 3.790 |
| HC | 6.975 | 7.2 | 6.36 | 6.845 |
| CO | 18.75 | 18 | 17.28 | 18.010 |
| CO2 | 11016.6 | 10783.8 | 10859.16 | 10886.52 |
| Nox | 51.225 | 51.36 | 51.96 | 51.515 |
| Exh Temp | 915 | 903 | 898 | 905.333 |

Mode 3

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 3.168 | 3.36 | 3.096 | 3.208 |
| HC | 12.72 | 14.28 | 12.36 | 13.120 |
| CO | 15.72 | 18.24 | 15.36 | 16.440 |
| CO2 | 9048 | 9102.48 | 9168.12 | 9106.200 |
| Nox | 50.88 | 51.24 | 51.72 | 51.280 |
| Exh Temp | 748 | 747 | 748 | 747.667 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 4.548 | 3.66 | 4.104 |
| HC | 6.96 | 4.92 | 5.940 |
| CO | 17.52 | 13.68 | 15.600 |
| CO2 | 7016.28 | 7017.6 | 7016.940 |
| Nox | 40.44 | 40.56 | 40.500 |
| Exh Temp | 583 | 578 | 580.500 |

Mode 5

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 109.044 | 108.876 | 109.392 | 109.104 |
| HC | 17.52 | 16.8 | 17.04 | 17.120 |
| CO | 472.92 | 452.64 | 456.6 | 460.720 |
| CO2 | 11580.48 | 11390.04 | 11270.16 | 11413.56 |
| Nox | 23.28 | 22.44 | 21.72 | 22.480 |
| Exh Temp | 1138 | 1162 | 1233 | 1177.667 |

Mode 6

| | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | AVG |
|---|---|---|---|---|---|---|
| PM | 5.388 | 6.78 | 5.532 | 6 | 5.508 | 5.842 |
| HC | 10.68 | 10.56 | 8.52 | 4.56 | 4.2 | 7.704 |
| CO | 36.24 | 36.12 | 35.04 | 27.72 | 27.72 | 32.568 |
| CO2 | 8105.28 | 8010.12 | 7881.6 | 7467.72 | 7509.72 | 7794.888 |
| Nox | 58.32 | 50.16 | 48.12 | 40.68 | 40.92 | 47.640 |
| Exh Temp | 1349 | 1483 | 1810 | 1526 | 1560 | 1545.600 |

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 2.508 | 2.976 | 3.1575 | 2.881 |
| HC | 24.84 | 23.4 | 24 | 24.080 |
| CO | 46.44 | 44.64 | 46.2 | 45.760 |
| CO2 | 6033.96 | 5989.8 | 5952.675 | 5992.145 |
| Nox | 56.52 | 53.88 | 54.525 | 54.975 |
| Exh Temp | 567 | 567 | 569 | 567.667 |

Mode 8

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.168 | 0.15 | 0.138 | 0.152 |
| HC | 0.24 | 0.12 | 0.12 | 0.160 |
| CO | 1.44 | 1.5 | 1.08 | 1.340 |
| CO2 | 1297.26 | 1267.44 | 1252.08 | 1272.260 |
| Nox | 31.56 | 32.46 | 33.24 | 32.420 |
| Exh Temp | 269 | 231 | 227 | 242.333 |

**Emissions Data for Lister Petter LPU-2 with failed trap (in g/hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 38.712 | 34.836 | 36.774 |
| HC | 0.12 | 0.06 | 0.090 |
| CO | 2.34 | 2.94 | 2.640 |
| CO2 | 8614.26 | 8643.54 | 8628.900 |
| Nox | 16.32 | 16.56 | 16.440 |
| Exh Temp | 1452 | 1459 | 1455.500 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 2.094 | 4.35 | 3.222 |
| HC | 0.06 | 0.15 | 0.105 |
| CO | 0.3 | 1.5 | 0.900 |
| CO2 | 5985.72 | 11776.28 | 8880.998 |
| Nox | 24.6 | 48 | 36.300 |
| Exh Temp | 940 | 937 | 938.500 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 2.19 | 2.505 | 2.348 |
| HC | 0.3 | 0.3 | 0.300 |
| CO | 1.5 | 1.35 | 1.425 |
| CO2 | 9931.5 | 9856.125 | 9893.813 |
| Nox | 48.825 | 48.975 | 48.900 |
| Exh Temp | 931 | 763 | 847.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.816 | 0.978 | 0.897 |
| HC | 0.24 | | 0.240 |
| CO | 2.04 | 0.6 | 1.320 |
| CO2 | 7688.4 | 7647.84 | 7668.120 |
| Nox | 37.74 | 37.68 | 37.710 |
| Exh Temp | 596 | 593 | 594.500 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 34.962 | 37.698 | 36.330 |
| HC | 0.06 | 0.12 | 0.090 |
| CO | 0.6 | 0.72 | 0.660 |
| CO2 | 5920.8 | 5902.2 | 5911.500 |
| Nox | 12.48 | 12.24 | 12.360 |
| Exh Temp | 1208 | 1217 | 1212.500 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 1.674 | 1.65 | 1.662 |
| HC | 0.48 | 0.3 | 0.390 |
| CO | 0.24 | 0.96 | 0.600 |
| CO2 | 4311.3 | 4270.86 | 4291.080 |
| Nox | 19.68 | 20.28 | 19.980 |
| Exh Temp | 827 | 824 | 825.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.39 | 0.342 | 0.366 |
| HC | 1.02 | 0.96 | 0.990 |
| CO | 0.66 | 0.42 | 0.540 |
| CO2 | 3224.1 | 3213.96 | 3219.030 |
| Nox | 25.74 | 25.92 | 25.830 |
| Exh Temp | 602 | 592 | 597.000 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.054 | 0.084 | 0.069 |
| HC | 0 | 0 | 0.000 |
| CO | | 0.72 | 0.720 |
| CO2 | 1290.84 | 1353.18 | 1322.010 |
| Nox | 27.48 | 28.5 | 27.990 |
| Exh Temp | 281 | 248 | 264.500 |

Emissions Data for Lister Petter LPU-2 Bare Engine (in g/hr)

Mode 6

| | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | AVG |
|---|---|---|---|---|---|---|
| PM | 5.388 | 6.78 | 5.532 | 6 | 5.508 | 5.842 |
| HC | 10.68 | 10.56 | 8.52 | 4.56 | 4.2 | 7.704 |
| CO | 36.24 | 36.12 | 35.04 | 27.72 | 27.72 | 32.568 |
| CO2 | 8105.28 | 8010.12 | 7881.6 | 7467.72 | 7509.72 | 7794.888 |
| Nox | 58.32 | 50.16 | 48.12 | 40.68 | 40.92 | 47.640 |
| Ex. Temp | 1349 | 1483 | 1810 | 1526 | 1560 | 1545.600 |

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 2.508 | 2.976 | 3.1575 | 2.881 |
| HC | 24.84 | 23.4 | 24 | 24.080 |
| CO | 46.44 | 44.64 | 46.2 | 45.760 |
| CO2 | 6033.96 | 5989.8 | 5952.675 | 5992.145 |
| Nox | 56.52 | 53.88 | 54.525 | 54.975 |
| Ex. Temp | 567 | 567 | 569 | 567.667 |

Emissions Data for Lister Petter LPU-2 Rohmac/DCL system with new trap (in g/hr)

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.978 | 1.182 | 1.080 |
| HC | 0 | 0 | 0.000 |
| CO | 0.78 | 0.54 | 0.660 |
| CO2 | 8205.18 | 8042.34 | 8123.760 |
| Nox | 36.66 | 37.38 | 37.020 |
| Ex. Temp | 806 | 807 | 806.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 1.05 | 0.24 | 0.645 |
| HC | 0.06 | 0 | 0.030 |
| CO | 0.84 | 0.9 | 0.870 |
| CO2 | 6597.84 | 6546.24 | 6572.040 |
| Nox | 44.34 | 45 | 44.670 |
| Ex. Temp | 593 | 597 | 595.000 |

Emissions Data for Lister Petter LPU-2 Bare Engine (in g/hr)

Mode 1

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 109.464 | 102.612 | 100.128 | 104.068 |
| HC | 4.92 | 2.16 | 1.56 | 2.880 |
| CO | 799.44 | 653.88 | 613.68 | 689.000 |
| CO2 | 16479.96 | 16582.32 | 16366.68 | 16476.32 |
| Nox | 31.44 | 32.04 | 32.04 | 31.840 |
| Ex. Temp | 1457 | 1775 | 1792 | 1674.667 |

Mode 5

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 109.044 | 108.876 | 109.392 | 109.104 |
| HC | 17.52 | 16.8 | 17.04 | 17.120 |
| CO | 472.92 | 452.64 | 456.6 | 460.720 |
| CO2 | 11580.48 | 11390.04 | 11270.16 | 11413.56 |
| Nox | 23.28 | 22.44 | 21.72 | 22.480 |
| Ex. Temp | 1138 | 1162 | 1233 | 1177.667 |

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 2.508 | 2.976 | 3.1575 | 2.881 |
| HC | 24.84 | 23.4 | 24 | 24.080 |
| CO | 46.44 | 44.64 | 46.2 | 45.760 |
| CO2 | 6033.96 | 5989.8 | 5952.675 | 5992.145 |
| Nox | 56.52 | 53.88 | 54.525 | 54.975 |
| Ex. Temp | 567 | 567 | 569 | 567.667 |

Emissions Data for Lister Petter LPU-2 Rohmac/DCL system with oxidation catalyst only (in g/hr)

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 60.06 | 67.146 | 63.603 |
| HC | 1.44 | 1.2 | 1.320 |
| CO | 262.74 | 260.64 | 261.690 |
| CO2 | 7997.88 | 7956.42 | 7977.150 |
| Nox | 7.08 | 5.82 | 6.450 |
| Ex. Temp | 1351 | 1389 | 1370.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 54.828 | 55.662 | 55.245 |
| HC | 0.24 | 0.3 | 0.270 |
| CO | 0.96 | 1.08 | 1.020 |
| CO2 | 5648.52 | 5607.42 | 5627.970 |
| Nox | 12.84 | 12.3 | 12.570 |
| Ex. Temp | 1203 | 1205 | 1204.000 |

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 2.874 | 1.128 | 1.056 | 1.686 |
| HC | 1.32 | 1.32 | 1.38 | 1.340 |
| CO | 0.42 | 0.36 | 0.12 | 0.300 |
| CO2 | 3136.32 | 3115.14 | 3102.42 | 3117.960 |
| Nox | 24.66 | 25.02 | 25.32 | 25.000 |
| Ex. Temp | 622 | 601 | 597 | 606.667 |

Emissions Data for Lister Petter LPU-2 Bare Engine (in g/hr)

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 2.508 | 2.976 | 3.1575 | 2.881 |
| HC | 24.84 | 23.4 | 24 | 24.080 |
| CO | 46.44 | 44.64 | 46.2 | 45.760 |
| CO2 | 6033.96 | 5989.8 | 5952.675 | 5992.145 |
| Nox | 56.52 | 53.88 | 54.525 | 54.975 |
| Ex. Temp | 567 | 567 | 569 | 567.667 |

Emissions Data for Lister Petter LPU-2 Rohmac/DCL system with new trap and Pallflex paper filter (in g/hr)

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.222 | 0.042 | 0.132 |
| HC | 2.1 | 2.16 | 2.130 |
| CO | 0.6 | 0.84 | 0.720 |
| CO2 | 5528.76 | 5396.64 | 5462.700 |
| Nox | 38.64 | 39.78 | 39.210 |
| Ex. Temp | 616 | 609 | 612.500 |

Emissions Data for Isuzu C240 bare engine (in g/hr)

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 11.7 | 11.124 | 11.412 |
| HC | 4.56 | 6.12 | 5.340 |
| CO | 41.64 | 51.48 | 46.560 |
| CO2 | 36463.8 | 36823.68 | 36643.74 |
| Nox | 194.76 | 189.6 | 192.180 |
| Ex. Temp | 1065 | 1077 | 1071.000 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 10.344 | 10.188 | 10.266 |
| HC | 6 | 5.52 | 5.760 |
| CO | 46.8 | 45.48 | 46.140 |
| CO2 | 29094.48 | 29156.88 | 29125.68 |
| Nox | 216.36 | 219 | 217.680 |
| Ex. Temp | 828 | 825 | 826.500 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 9.833 | 10.704 | 10.269 |
| HC | 49.05 | 55.68 | 52.365 |
| CO | 32.175 | 37.08 | 34.628 |
| CO2 | 21905.48 | 21872.4 | 21888.94 |
| Nox | 200.4 | 209.4 | 204.900 |
| Ex. Temp | 646 | 646 | 646.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 11.27 | 11.85 | 11.560 |
| HC | 5.4 | 5.85 | 5.625 |
| CO | 23.5 | 23.175 | 23.338 |
| CO2 | 13960.9 | 13992.98 | 13976.94 |
| Nox | 118 | 121.875 | 119.938 |
| Ex. Temp | 444 | 444 | 444.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 34.392 | 35.076 | 34.734 |
| HC | 0.48 | 0.24 | 0.360 |
| CO | 111.6 | 110.4 | 111.000 |
| CO2 | 24669.48 | 24595.2 | 24632.34 |
| Nox | 73.08 | 68.88 | 70.980 |
| Ex. Temp | 1092 | 1093 | 1092.500 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 3.864 | 3.792 | 3.828 |
| HC | 1.44 | 0.72 | 1.080 |
| CO | 14.16 | 5.76 | 9.960 |
| CO2 | 17282.76 | 6799.68 | 12041.22 |
| Nox | 91.08 | 35.76 | 63.420 |
| Ex. Temp | 758 | 750 | 754.000 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 3.348 | 3.128 | 3.238 |
| HC | 3.24 | 3.6 | 3.420 |
| CO | 15 | 15.825 | 15.413 |
| CO2 | 12440.28 | 12569.33 | 12504.8 |
| Nox | 97.68 | 93.3 | 95.490 |
| Ex. Temp | 542 | 546 | 544.000 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.222 | 0.264 | 0.243 |
| HC | 0.66 | 0.72 | 0.690 |
| CO | 14.58 | 13.44 | 14.010 |
| CO2 | 1691.22 | 1668.12 | 1679.670 |
| Nox | 12.78 | 12.06 | 12.420 |
| Ex. Temp | 198 | 189 | 193.500 |

Emissions Data for Isuzu C240 with Trap and Oxidation Catalyst (in g/hr)

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 9.822 | 9.338 | 9.580 |
| HC | 0.674298 | 0.525 | 0.600 |
| CO | | 0.9 | 0.900 |
| CO2 | 37554.63 | 37134.6 | 37344.62 |
| Nox | 193.6733 | 195.825 | 194.749 |
| Ex. Temp | 1199 | 1195 | 1197.000 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 1.695 | 6.03 | 3.863 |
| HC | 0.675 | 0.675 | 0.675 |
| CO | 0 | | 0.000 |
| CO2 | 29320.8 | 29292.6 | 29306.7 |
| Nox | 231.3 | 230.1 | 230.700 |
| Ex. Temp | 917 | 921 | 919.000 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.96 | 2.7 | 1.830 |
| HC | 0.45 | 0.45 | 0.450 |
| CO | 0.825 | 0.675 | 0.750 |
| CO2 | 22842.68 | 22885.43 | 22864.05 |
| Nox | 206.4 | 200.625 | 203.513 |
| Ex. Temp | 697 | 699 | 698.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.06 | 0.1125 | 0.086 |
| HC | 0.3 | 0.375 | 0.338 |
| CO | 1.575 | 1.575 | 1.575 |
| CO2 | 14365.2 | 14401.2 | 14383.2 |
| Nox | 103.2 | 95.7 | 99.450 |
| Ex. Temp | 482 | 485 | 483.500 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 11.828 | 7.335 | 9.582 |
| HC | 0.225 | 0.3 | 0.263 |
| CO | 1.35 | 1.8 | 1.575 |
| CO2 | 25221 | 25035.98 | 25128.49 |
| Nox | 68.625 | 65.925 | 67.275 |
| Ex. Temp | 1261 | 1275 | 1268.000 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.1575 | 0.12 | 0.139 |
| HC | 0.225 | 0.3 | 0.263 |
| CO | 0.225 | 0.15 | 0.188 |
| CO2 | 18020.4 | 18053.55 | 18036.98 |
| Nox | 86.775 | 88.8 | 87.788 |
| Ex. Temp | 867 | 860 | 863.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.0675 | 0.09 | 0.079 |
| HC | 0.375 | 0.45 | 0.413 |
| CO | 1.125 | 0.375 | 0.750 |
| CO2 | 13147.28 | 13172.93 | 13160.1 |
| Nox | 83.775 | 85.65 | 84.713 |
| Ex. Temp | 622 | 618 | 620.000 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.03 | 0.0225 | 0.026 |
| HC | 0.075 | 0.225 | 0.150 |
| CO | 0.15 | 4.8 | 2.475 |
| CO2 | 1821.525 | 1794 | 1807.763 |
| Nox | 17.475 | 15.6 | 16.538 |
| Ex. Temp | 233 | 223 | 228.000 |

Appendix B-4. Isuzu C240 Emissions Data

**Emissions Data for Isuzu C240 bare engine (in g/hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 11.7 | 11.124 | 11.412 |
| HC | 4.56 | 6.12 | 5.340 |
| CO | 41.64 | 51.48 | 46.560 |
| CO2 | 36463.8 | 36823.68 | 36643.74 |
| Nox | 194.76 | 189.6 | 192.180 |
| Ex. Temp | 1065 | 1077 | 1071.000 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 9.833 | 10.704 | 10.269 |
| HC | 49.05 | 55.68 | 52.365 |
| CO | 32.175 | 37.08 | 34.628 |
| CO2 | 21905.48 | 21872.4 | 21888.94 |
| Nox | 200.4 | 209.4 | 204.900 |
| Ex. Temp | 646 | 646 | 646.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 34.392 | 35.076 | 34.734 |
| HC | 0.48 | 0.24 | 0.360 |
| CO | 111.6 | 110.4 | 111.000 |
| CO2 | 24669.48 | 24595.2 | 24632.34 |
| Nox | 73.08 | 68.88 | 70.980 |
| Ex. Temp | 1092 | 1093 | 1092.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 3.348 | 3.128 | 3.238 |
| HC | 3.24 | 3.6 | 3.420 |
| CO | 15 | 15.825 | 15.413 |
| CO2 | 12440.28 | 12569.33 | 12504.8 |
| Nox | 97.68 | 93.3 | 95.490 |
| Ex. Temp | 542 | 546 | 544.000 |

**Emissions Data for Isuzu C240 with Oxidation Catalyst and Trap (in g/hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 6.9075 | 6.7425 | 6.825 |
| HC | 0.45 | 0.375 | 0.413 |
| CO | 3.3 | 0.825 | 2.063 |
| CO2 | 39984.68 | 40076.93 | 40030.8 |
| Nox | 195.75 | 183.45 | 189.600 |
| Ex. Temp | 1193 | 1206 | 1199.500 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.705 | 0.84 | 0.773 |
| HC | 0.225 | 0.075 | 0.150 |
| CO | 2.7 | 1.65 | 2.175 |
| CO2 | 22345.28 | 22137.15 | 22241.21 |
| Nox | 200.025 | 187.65 | 193.838 |
| Ex. Temp | 706 | 708 | 707.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 7.395 | 6.84 | 7.118 |
| HC | 0.075 | | 0.075 |
| CO | 1.575 | 1.05 | 1.313 |
| CO2 | 23712.6 | 23642.63 | 23677.61 |
| Nox | 71.475 | 69.075 | 70.275 |
| Ex. Temp | 1184 | 1181 | 1182.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.0375 | 0.045 | 0.041 |
| HC | 0.075 | 0.075 | 0.075 |
| CO | 1.65 | | 1.650 |
| CO2 | 12872.25 | 12657.38 | 12764.81 |
| Nox | 77.025 | 78.975 | 78.000 |
| Ex. Temp | 613 | 605 | 609.000 |

**Emissions Data for Isuzu C240 bare engine (in g/hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 11.7 | 11.124 | 11.412 |
| HC | 4.56 | 6.12 | 5.340 |
| CO | 41.64 | 51.48 | 46.560 |
| CO2 | 36463.8 | 36823.68 | 36643.74 |
| Nox | 194.76 | 189.6 | 192.180 |
| Ex. Temp | 1065 | 1077 | 1071.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 34.392 | 35.076 | 34.734 |
| HC | 0.48 | 0.24 | 0.360 |
| CO | 111.6 | 110.4 | 111.000 |
| CO2 | 24669.48 | 24595.2 | 24632.34 |
| Nox | 73.08 | 68.88 | 70.980 |
| Ex. Temp | 1092 | 1093 | 1092.500 |

**Emissions Data for Isuzu C240 with Oxidation Catalyst only (in g/hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 19.788 | 19.512 | 19.650 |
| HC | 0.36 | 1.08 | 0.720 |
| CO | 4.08 | 3.96 | 4.020 |
| CO2 | 36590.88 | 36981.6 | 36786.24 |
| Nox | 186.72 | 186.6 | 186.660 |
| Ex. Temp | 1065 | 1183 | 1124.000 |

Mode 5

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 53.676 | 53.172 | 58.524 | 55.124 |
| HC | 0.24 | 0.12 | 0.12 | 0.160 |
| CO | 5.04 | 4.44 | 6.6 | 5.360 |
| CO2 | 25327.68 | 25662.96 | 25625.28 | 25538.64 |
| Nox | 69.36 | 69 | 72 | 70.120 |
| Ex. Temp | 1236 | 1237 | 1231 | 1234.667 |

**Emissions Data for bare Caterpillar 3306 (in g/hr)**

**Mode 1**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 34.15 | 36.756 | 35.453 |
| HC | 31.64706 | 23.4 | 27.524 |
| CO | 147.6471 | 167.28 | 157.464 |
| CO2 | 86429.41 | 83610.96 | 85020.19 |
| Nox | 499.6471 | | 499.647 |
| Exh Temp | 1094 | 1130 | 1112.000 |

**Mode 2**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 55.416 | 54.78 | 55.098 |
| HC | 32.16 | 30.96 | 31.560 |
| CO | 188.64 | 182.88 | 185.760 |
| CO2 | 70344.72 | 70580.16 | 70462.44 |
| Nox | 676.68 | 675.48 | 676.080 |
| Exh Temp | 861 | 875 | 868.000 |

**Mode 3**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 71.856 | 71.172 | 71.514 |
| HC | 39.96 | 38.04 | 39.000 |
| CO | 169.8 | 167.04 | 168.420 |
| CO2 | 56281.8 | 56201.16 | 56241.48 |
| Nox | 645.6 | 644.4 | 645.000 |
| Exh Temp | 1094 | 1130 | 1112.000 |

**Mode 4**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 84.47 | 87.28 | 85.875 |
| HC | 37.4583 | 38.4 | 37.929 |
| CO | 107.3709 | 110.2 | 108.785 |
| CO2 | 37166.93 | 37021.4 | 37094.16 |
| Nox | 337.6966 | 337.2 | 337.448 |
| Exh Temp | 483 | 483 | 483.000 |

**Mode 5**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 91.608 | 89.712 | 90.660 |
| HC | 9.00 | 8.64 | 8.820 |
| CO | 158.28 | 147.36 | 152.820 |
| CO2 | 56241.24 | 55020.12 | 55630.68 |
| Nox | 211.2 | | 211.200 |
| Exh Temp | 1098 | 1094 | 1096.000 |

**Mode 6**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 17.364 | 16.884 | 17.124 |
| HC | 14.16 | 13.56 | 13.860 |
| CO | 52.92 | 52.44 | 52.680 |
| CO2 | 41964.24 | 41623.92 | 41794.08 |
| Nox | 334.32 | 419.88 | 377.100 |
| Exh Temp | 703 | 700 | 701.500 |

**Mode 7**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 20.346 | 21.048 | 20.697 |
| HC | 9.72 | 9.84 | 9.780 |
| CO | 31.32 | 27.6 | 29.460 |
| CO2 | 30531.24 | 31371.36 | 30951.3 |
| Nox | 490.2 | 489.84 | 490.020 |
| Exh Temp | 537 | | 537.000 |

**Mode 8**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 3.2925 | 3.24 | 3.266 |
| HC | 2.025 | 2.25 | 2.138 |
| CO | 45.00 | 41.85 | 43.425 |
| CO2 | 4806.3 | 4721.925 | 4764.113 |
| Nox | 59.625 | 60.825 | 60.225 |
| Exh Temp | 194 | 187 | 190.500 |

**Emissions Data for Caterpillar 3306 with DST I (in g/hr)**

**Mode 1**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 117.73 | 56.4375 | 87.084 |
| HC | 25.125 | 14.175 | 19.650 |
| CO | 15.6 | 8.925 | 12.263 |
| CO2 | 93152.1 | 54524.18 | 73838.14 |
| Nox | 473.55 | 308.325 | 390.938 |
| Exh Temp | 1178 | 1147 | 1162.500 |

**Mode 2**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 57.945 | 56.16 | 57.053 |
| HC | 10.95 | 11.7 | 11.325 |
| CO | 15.375 | 18.225 | 16.800 |
| CO2 | 72499.88 | 72084.3 | 72292.09 |
| Nox | 619.275 | 613.2 | 616.238 |
| Exh Temp | 920 | 925 | 922.500 |

**Mode 3**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 22.75 | 28.52 | 25.635 |
| HC | 11.55 | 11.475 | 11.513 |
| CO | 19.05 | 20.475 | 19.763 |
| CO2 | 55716.75 | 55582.88 | 55649.81 |
| Nox | 641.325 | 579.075 | 610.200 |
| Exh Temp | 739 | 737 | 738.000 |

**Mode 4**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 4.043 | 4.178 | 4.111 |
| HC | 15.825 | 14.475 | 15.150 |
| CO | 21.00 | 22.125 | 21.563 |
| CO2 | 36258.75 | 36604.5 | 36431.63 |
| Nox | 320.625 | 318.75 | 319.688 |
| Exh Temp | 505 | 507 | 506.000 |

**Mode 5**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 5.196 | 6.18 | 5.688 |
| HC | 9.6 | 6.72 | 8.160 |
| CO | 7.68 | 9.00 | 8.340 |
| CO2 | 58748.4 | 58266.12 | 58507.26 |
| Nox | 222.36 | 221.16 | 221.760 |
| Exh Temp | 983 | 1000 | 991.500 |

**Mode 6**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 4.698 | 4.482 | 4.590 |
| HC | 1.62 | 1.38 | 1.500 |
| CO | 3.42 | 5.04 | 4.230 |
| CO2 | 41920.8 | 41020.08 | 41470.44 |
| Nox | 348.42 | 354.12 | 351.270 |
| Exh Temp | 766 | 751 | 758.500 |

**Mode 7**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 2.154 | 2.358 | 2.256 |
| HC | 2.94 | 2.58 | 2.760 |
| CO | 5.34 | 3.36 | 4.350 |
| CO2 | 30754.44 | 30665.22 | 30709.83 |
| Nox | 466.8 | 472.08 | 469.440 |
| Exh Temp | 556 | 555 | 555.500 |

**Mode 8**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.288 | 0.162 | 0.225 |
| HC | 52.56 | 55.98 | 54.270 |
| CO | 113.88 | 116.4 | 115.140 |
| CO2 | 4613.64 | 4965.96 | 4789.800 |
| Nox | 47.16 | 48.00 | 47.580 |
| Exh Temp | 219 | 194 | 206.500 |

Appendix B-6. Caterpillar 3306 Emissions Data

**Emissions Data for Caterpillar 3306 bare engine (in g/hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 34.15 | 36.756 | 35.453 |
| HC | 31.64706 | 23.4 | 27.524 |
| CO | 147.6471 | 167.28 | 157.464 |
| CO2 | 86429.41 | 83610.96 | 85020.19 |
| Nox | 499.6471 | | 499.647 |
| Exh Temp | 1094 | 1130 | 1112.000 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 55.416 | 54.78 | 55.098 |
| HC | 32.16 | 30.96 | 31.560 |
| CO | 188.64 | 182.88 | 185.760 |
| CO2 | 70344.72 | 70580.16 | 70462.44 |
| Nox | 676.68 | 675.48 | 676.080 |
| Exh Temp | 861 | 875 | 868.000 |

**Emissions Data for Caterpillar 3306 with DST I with no oxidation catalyst (in g/hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 108.56 | 88.87 | 98.715 |
| HC | 10.3 | 46.3 | 28.300 |
| CO | 138.7 | 133.4 | 136.050 |
| CO2 | 87388.1 | 85469.3 | 86428.7 |
| Nox | 58.7 | 534.8 | 296.750 |
| Exh Temp | 1122 | 1172 | 1147.000 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 32.89 | 32.16 | 32.525 |
| HC | 40.9 | 39.3 | 40.100 |
| CO | 181.4 | 187 | 184.200 |
| CO2 | 71168.2 | 71012.5 | 71090.35 |
| Nox | 646 | 647.9 | 646.950 |
| Exh Temp | 915 | 907 | 911.000 |

**Emissions Data for Caterpillar 3306 bare engine (in g/hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 34.15 | 36.756 | 35.453 |
| HC | 31.64706 | 23.4 | 27.524 |
| CO | 147.6471 | 167.28 | 157.464 |
| CO2 | 86429.41 | 83610.96 | 85020.19 |
| Nox | 499.6471 | | 499.647 |
| Exh Temp | 1094 | 1130 | 1112.000 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 55.416 | 54.78 | 55.098 |
| HC | 32.16 | 30.96 | 31.560 |
| CO | 188.64 | 182.88 | 185.760 |
| CO2 | 70344.72 | 70580.16 | 70462.44 |
| Nox | 676.68 | 675.48 | 676.080 |
| Exh Temp | 861 | 875 | 868.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 91.608 | 89.712 | 90.660 |
| HC | 9.00 | 8.64 | 8.820 |
| CO | 158.28 | 147.36 | 152.820 |
| CO2 | 56241.24 | 55020.12 | 55630.68 |
| Nox | 211.2 | | 211.200 |
| Exh Temp | 1098 | 1094 | 1096.000 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 20.346 | 21.048 | 20.697 |
| HC | 9.72 | 9.84 | 9.780 |
| CO | 31.32 | 27.6 | 29.460 |
| CO2 | 30531.24 | 31371.36 | 30951.3 |
| Nox | 490.2 | 489.84 | 490.020 |
| Exh Temp | 537 | | 537.000 |

**Emissions Data for Caterpillar 3306 with DST II (in g/hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 34.3875 | 27.81 | 31.099 |
| HC | 12.075 | 12.975 | 12.525 |
| CO | 13.275 | 13.95 | 13.613 |
| CO2 | 84532.58 | 81383.4 | 82957.99 |
| Nox | 561.225 | 507.525 | 534.375 |
| Exh Temp | 1155 | 1118 | 1136.500 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 11.7975 | 13.2975 | 12.548 |
| HC | 10.5 | 10.95 | 10.725 |
| CO | 18.375 | 22.2 | 20.288 |
| CO2 | 72514.95 | 72908.85 | 72711.9 |
| Nox | 616.125 | 612.225 | 614.175 |
| Exh Temp | 914 | 912 | 913.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 3.12 | 2.925 | 3.023 |
| HC | 2.1 | 1.8 | 1.950 |
| CO | 4.575 | | 4.575 |
| CO2 | 43344.23 | 43978.8 | 43661.52 |
| Nox | 167.4 | 166.65 | 167.025 |
| Exh Temp | 1028 | 1034 | 1031.000 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.99 | 0.945 | 0.968 |
| HC | 2.7 | 2.925 | 2.813 |
| CO | 1.125 | 3.3 | 2.213 |
| CO2 | 31581.82 | 31713.3 | 31647.56 |
| Nox | 461.93 | 473.7 | 467.815 |
| Exh Temp | 543 | 536 | 539.500 |

** The results were from the repeated testing on DST after it was "fixed"

**Emissions Data for Caterpillar 3306 bare engine-after checkup (in g/hr)**

Mode 1

| | Test 1 | Test 2 | Test 3 | Test 4 | AVG |
|---|---|---|---|---|---|
| PM | 34.56 | 32.184 | | | 32.184 |
| HC | 47.64 | 45.96 | 36.24 | 36.24 | 39.480 |
| CO | 142.2 | 137.76 | 124.32 | 136.56 | 132.880 |
| CO2 | 89224.8 | 87880.92 | 91530.12 | 91827.36 | 90412.80 |
| Nox | 481.68 | 462.72 | 494.28 | 506.64 | 487.880 |
| Exh Temp | 1101 | 1109 | 1094 | 1098 | 1100.333 |

Mode 2

| | Test 1 | Test 2 | Test 3 | Test 4 | AVG |
|---|---|---|---|---|---|
| PM | 47.076 | 48.216 | | 43.176 | 45.696 |
| HC | 50.16 | 50.16 | 41.00662 | 42 | 44.389 |
| CO | 162 | 162.84 | 168.0795 | 166.8 | 165.906 |
| CO2 | 69888.84 | 71885.76 | 72709.27 | 72922.08 | 72505.70 |
| Nox | 544.44 | 624.96 | 619.8675 | 622.32 | 622.383 |
| Exh Temp | 878 | 876.2 | 887 | 873 | 878.733 |

Mode 3

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 60.336 | 60.204 | 60.588 | 60.376 |
| HC | 47.64 | 46.08 | 48 | 47.240 |
| CO | 157.2 | 152.76 | 151.08 | 153.680 |
| CO2 | 57959.4 | 58596.36 | 57997.56 | 58184.44 |
| Nox | 613.08 | 603.36 | 612.12 | 609.520 |
| Exh Temp | 696 | 694 | 692 | 694.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 68.1 | 68.79826 | 68.449 |
| HC | 39.6 | 41.38829 | 40.494 |
| CO | 98.6 | 105.7354 | 102.168 |
| CO2 | 36144 | 36756.08 | 36450.04 |
| Nox | 311.2 | 308.1475 | 309.674 |
| Exh Temp | 478 | 479 | 478.500 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 39.36 | 39.492 | 39.426 |
| HC | 23.88 | 24.00 | 23.940 |
| CO | 79.2 | 70.8 | 75.000 |
| CO2 | 54458.64 | 53988.72 | 54223.68 |
| Nox | 229.08 | 229.2 | 229.140 |
| Exh Temp | 975 | 987 | 981.000 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 14.784 | 15.264 | 15.024 |
| HC | 25.32 | 25.2 | 25.260 |
| CO | 43.92 | 45.48 | 44.700 |
| CO2 | 40808.52 | 40994.88 | 40901.70 |
| Nox | 385.08 | 377.4 | 381.240 |
| Exh Temp | 704 | 694 | 699.000 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 25.236 | 23.292 | 24.264 |
| HC | 25.68 | 25.56 | 25.620 |
| CO | 30.96 | 30.00 | 30.480 |
| CO2 | 30972.6 | 30974.64 | 30973.62 |
| Nox | 469.68 | 463.8 | 466.740 |
| Exh Temp | 504 | 505 | 504.500 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 3.107071 | 3.383008 | 3.245 |
| HC | 20.62891 | 20.07083 | 20.350 |
| CO | 60.10399 | 61.09611 | 60.600 |
| CO2 | 7807.28 | 8420.155 | 8113.717 |
| Nox | 106.7101 | 101.364 | 104.037 |
| Exh Temp | 208 | 196 | 202.000 |

**Emissions Data for Caterpillar 3306 with DST III (in g/hr)**

Mode 1

| | Test 1 | Test 2 | Test 3* | AVG |
|---|---|---|---|---|
| PM | 34.932 | 26.46 | 29.268 | 30.220 |
| HC | | 17.64 | 26.64 | 22.140 |
| CO | 14.28 | 8.28 | 8.64 | 10.400 |
| CO2 | 80699.04 | 80383.8 | 65516.28 | 75533.04 |
| Nox | 385.68 | 372.96 | 346.08 | 368.240 |
| Exh Temp | 1198 | 1196 | 1174 | 1189.333 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 5.796 | 5.94 | 5.868 |
| HC | 14.28 | 12.12 | 13.200 |
| CO | 14.28 | 15.12 | 14.700 |
| CO2 | 66092.16 | 66595.68 | 66343.92 |
| Nox | 476.64 | 468.12 | 472.380 |
| Exh Temp | 929 | 927 | 928.000 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 2.837143 | 3.214286 | 3.026 |
| HC | 14.14286 | 14.74286 | 14.443 |
| CO | 52.8 | 17.57143 | 35.186 |
| CO2 | 48648.6 | 48369.86 | 48509.23 |
| Nox | 504.7714 | 503.5714 | 504.171 |
| Exh Temp | 738 | 740 | 739.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 1.242857 | 1.56 | 1.401 |
| HC | 13.88571 | 15.17143 | 14.529 |
| CO | 5.142857 | 18.51429 | 11.829 |
| CO2 | 31057.29 | 30807.94 | 30932.61 |
| Nox | 255.2571 | 259.2 | 257.229 |
| Exh Temp | 520 | 529 | 524.500 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 2.808 | 3.348 | 3.078 |
| HC | 5.16 | 6.36 | 5.760 |
| CO | | 5.04 | 5.040 |
| CO2 | 46472.4 | 45889.08 | 46180.74 |
| Nox | 196.8 | 196.08 | 196.440 |
| Exh Temp | 987 | 973 | 980.000 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 1.448571 | 1.277143 | 1.363 |
| HC | 5.657143 | 4.628571 | 5.143 |
| CO | 4.371429 | 0.514286 | 2.443 |
| CO2 | 33461.66 | 33303.34 | 33382.50 |
| Nox | 282.5143 | 282.4286 | 282.471 |
| Exh Temp | 732 | 723 | 727.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.555 | 0.5475 | 0.551 |
| HC | 5.175 | 4.275 | 4.725 |
| CO | 2.475 | 4.5 | 3.488 |
| CO2 | 24698.18 | 24925.43 | 24811.80 |
| Nox | 341.325 | 346.575 | 343.950 |
| Exh Temp | | 534 | 534.000 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.084 | 0.042 | 0.063 |
| HC | 5.4 | 4.14 | 4.770 |
| CO | 25.74 | 26.1 | 25.920 |
| CO2 | 4333.86 | 4683.06 | 4508.460 |
| Nox | 55.44 | 54.78 | 55.110 |
| Exh Temp | 230 | 202 | 216.000 |

Emissions Data for bare Caterpillar 3306 (in g/hr)

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 34.15 | 36.756 | 35.453 |
| HC | 31.64706 | 23.4 | 27.524 |
| CO | 147.6471 | 167.28 | 157.464 |
| CO2 | 86429.41 | 83610.96 | 85020.19 |
| Nox | 499.6471 | | 499.647 |
| Exh Temp | 1094 | 1130 | 1112.000 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 55.416 | 54.78 | 55.098 |
| HC | 32.16 | 30.96 | 31.560 |
| CO | 188.64 | 182.88 | 185.760 |
| CO2 | 70344.72 | 70580.16 | 70462.44 |
| Nox | 676.68 | 675.48 | 676.080 |
| Exh Temp | 861 | 875 | 868.000 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 71.856 | 71.172 | 71.514 |
| HC | 39.96 | 38.04 | 39.000 |
| CO | 169.8 | 167.04 | 168.420 |
| CO2 | 56281.8 | 56201.16 | 56241.48 |
| Nox | 645.6 | 644.4 | 645.000 |
| Exh Temp | 1094 | 1130 | 1112.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 84.47 | 87.28 | 85.875 |
| HC | 37.4583 | 38.4 | 37.929 |
| CO | 107.3709 | 110.2 | 108.785 |
| CO2 | 37166.93 | 37021.4 | 37094.16 |
| Nox | 337.6966 | 337.2 | 337.448 |
| Exh Temp | 483 | 483 | 483.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 91.608 | 89.712 | 90.660 |
| HC | 9.00 | 8.64 | 8.820 |
| CO | 158.28 | 147.36 | 152.820 |
| CO2 | 56241.24 | 55020.12 | 55630.68 |
| Nox | 211.2 | | 211.200 |
| Exh Temp | 1098 | 1094 | 1096.000 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 17.364 | 16.884 | 17.124 |
| HC | 14.16 | 13.56 | 13.860 |
| CO | 52.92 | 52.44 | 52.680 |
| CO2 | 41964.24 | 41623.92 | 41794.08 |
| Nox | 334.32 | 419.88 | 377.100 |
| Exh Temp | 703 | 700 | 701.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 20.346 | 21.048 | 20.697 |
| HC | 9.72 | 9.84 | 9.780 |
| CO | 31.32 | 27.6 | 29.460 |
| CO2 | 30531.24 | 31371.36 | 30951.3 |
| Nox | 490.2 | 489.84 | 490.020 |
| Exh Temp | 537 | | 537.000 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 3.2925 | 3.24 | 3.266 |
| HC | 2.025 | 2.25 | 2.138 |
| CO | 45.00 | 41.85 | 43.425 |
| CO2 | 4806.3 | 4721.925 | 4764.113 |
| Nox | 59.625 | 60.825 | 60.225 |
| Exh Temp | 194 | 187 | 190.500 |

Emissions Data for Caterpillar 3306 with CleanAir (in g/hr)

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 18.473 | 16.365 | 17.419 |
| HC | 0.975 | 1.425 | 1.200 |
| CO | 3.975 | 0.975 | 2.475 |
| CO2 | 90115.35 | 91648.88 | 90882.11 |
| Nox | 523.2 | 521.85 | 522.525 |
| Exh Temp | 1112 | 1151 | 1131.500 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 22.2 | 24.435 | 23.318 |
| HC | 1.575 | 1.65 | 1.613 |
| CO | 2.325 | 2.55 | 2.438 |
| CO2 | 73586.25 | 73484.33 | 73535.29 |
| Nox | 648.075 | 638.475 | 643.275 |
| Exh Temp | 902 | 901 | 901.500 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 19.35 | | 19.350 |
| HC | 2.25 | | 2.250 |
| CO | 2.475 | | 2.475 |
| CO2 | 59134.35 | | 59134.35 |
| Nox | 609 | | 609.000 |
| Exh Temp | 712 | | 712.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.9075 | 1.08 | 0.994 |
| HC | 3.3 | 3.3 | 3.300 |
| CO | 0.6 | 2.475 | 1.538 |
| CO2 | 38571.6 | 38563.2 | 38567.4 |
| Nox | 323.925 | 322.125 | 323.025 |
| Exh Temp | 500 | 511 | 505.500 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 20.84 | 24.16 | 22.500 |
| HC | 0.6 | 0.4 | 0.500 |
| CO | | 2.4 | 2.400 |
| CO2 | 58387.8 | 58718.7 | 58553.25 |
| Nox | 254.7 | 261.5 | 258.100 |
| Exh Temp | 1005 | 982 | 993.500 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 13.66 | 13.298 | 13.479 |
| HC | 1.5 | 1.275 | 1.388 |
| CO | 2.175 | 1.8 | 1.988 |
| CO2 | 42365.4 | 42364.73 | 42365.06 |
| Nox | 410.025 | 408.75 | 409.388 |
| Exh Temp | 718 | 698 | 708.000 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.848 | 0.923 | 0.886 |
| HC | 0.3 | 0.075 | 0.188 |
| CO | 4.575 | 5.325 | 4.950 |
| CO2 | 31881.45 | 32178.6 | 32030.03 |
| Nox | 480.00 | 485.025 | 482.513 |
| Exh Temp | 519 | 516 | 517.500 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.615 | 0.525 | 0.570 |
| HC | 1.65 | 0.525 | 1.088 |
| CO | 47.775 | 47.55 | 47.663 |
| CO2 | 5257.65 | 5131.875 | 5194.763 |
| Nox | 65.175 | 63.15 | 64.163 |
| Exh Temp | 193 | 191 | 192.000 |

Appendix B-9. Caterpillar 3306 Emissions Data

# Appendix C

Emissions Data for MWM D916-6 with Low-sulfur (0.05%) Fuel (in g/bhp-hr)

Mode 1

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.346 | 0.328 | 0.331 | 0.335 |
| HC | 0.05 | 0.06 | 0.05 | 0.053 |
| CO | 0.74 | 0.72 | 0.72 | 0.727 |
| CO2 | 560.95 | 557.7 | 556.28 | 558.310 |
| Nox | 3.46 | 3.53 | 3.53 | 3.507 |

Mode 2

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.334 | 0.336 | 0.334 | 0.335 |
| HC | 0.09 | 0.08 | 0.08 | 0.083 |
| CO | 0.72 | 0.75 | 0.74 | 0.737 |
| CO2 | 561.78 | 565.16 | 562.27 | 563.070 |
| Nox | 4.09 | 4.1 | 4.12 | 4.103 |

Mode 3

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.463 | 0.436 | 0.419 | 0.439 |
| HC | 0.11 | 0.11 | 0.11 | 0.110 |
| CO | 0.76 | 0.72 | 0.8 | 0.760 |
| CO2 | 611.65 | 606.32 | 608.18 | 608.717 |
| Nox | 5.43 | 5.38 | 5.43 | 5.413 |

Mode 4

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.913 | 0.931 | 0.946 | 0.930 |
| HC | 0.19 | 0.18 | 0.21 | 0.193 |
| CO | 2.55 | 2.66 | 2.63 | 2.613 |
| CO2 | 1218.6 | 1244.92 | 1206.29 | 1223.270 |
| Nox | 10.41 | 10.3 | 10 | 10.237 |

Mode 5

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.429 | 0.409 | 0.399 | 0.412 |
| HC | 0.04 | 0.04 | 0.03 | 0.037 |
| CO | 0.67 | 0.63 | 0.64 | 0.647 |
| CO2 | 530.57 | 526.24 | 525.03 | 527.280 |
| Nox | 3.49 | 2.62 | 3.57 | 3.227 |

Mode 6

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.353 | 0.362 | 0.364 | 0.360 |
| HC | 0.05 | 0.05 | 0.05 | 0.050 |
| CO | 0.67 | 0.65 | 0.65 | 0.657 |
| CO2 | 522.95 | 528.86 | 524.22 | 525.343 |
| Nox | 4.29 | | 2.98 | 3.635 |

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.429 | 0.463 | 0.471 | 0.454 |
| HC | 0.07 | 0.09 | 0.1 | 0.087 |
| CO | 0.84 | 0.93 | 0.97 | 0.913 |
| CO2 | 570.79 | 568.38 | 577.18 | 572.117 |
| Nox | 5.85 | 5.79 | 5.84 | 5.827 |

Mode 8

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 3.067 | 3.718 | 6.002 | 4.262 |
| HC | | | 0.71 | 0.710 |
| CO | 19.19 | 17.24 | 16.06 | 17.497 |
| CO2 | 5945.7 | 5078.77 | 5434.11 | 5486.193 |
| Nox | 73.77 | 61.66 | 53.74 | 63.057 |

Emissions Data for MWM D916-6 with High-sulfur (0.25%) Fuel (in g/bhp-hr)

Mode 1

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.44 | 0.453 | 0.394 | 0.429 |
| HC | 0.05 | 0.05 | 0.04 | 0.047 |
| CO | 0.67 | 0.7 | 0.69 | 0.687 |
| CO2 | 580.01 | 572.84 | 573.25 | 575.367 |
| Nox | 3.36 | 3.41 | 3.41 | 3.393 |

Mode 2

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.414 | 0.411 | 0.421 | 0.415 |
| HC | 0.09 | 0.08 | 0.08 | 0.083 |
| CO | 0.73 | 0.68 | 0.72 | 0.710 |
| CO2 | 587.82 | 585.74 | 589.89 | 587.817 |
| Nox | 3.84 | 3.81 | 3.8 | 3.817 |

Mode 3

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.512 | 0.488 | 0.491 | 0.497 |
| HC | 0.13 | 0.11 | 0.13 | 0.123 |
| CO | 0.69 | 0.69 | 0.72 | 0.700 |
| CO2 | 634.4 | 629.88 | 629.24 | 631.173 |
| Nox | 5.17 | 5.11 | 5.16 | 5.147 |

Mode 4

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 1.158 | 1.213 | 1.198 | 1.190 |
| HC | 0.2 | 0.24 | 0.25 | 0.230 |
| CO | 2.62 | 2.85 | 2.84 | 2.770 |
| CO2 | 1265.63 | 1254.47 | 1232.75 | 1250.950 |
| Nox | 10.13 | 9.96 | 9.78 | 9.957 |

Mode 5

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.553 | 0.523 | 0.499 | 0.525 |
| HC | 0.03 | 0.03 | 0.04 | 0.033 |
| CO | 0.59 | 0.56 | 0.55 | 0.567 |
| CO2 | 552.43 | 550.26 | 549.92 | 550.870 |
| Nox | 3.25 | 3.18 | 3.29 | 3.240 |

Mode 6

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.432 | 0.499 | 0.47 | 0.467 |
| HC | 0.06 | 0.07 | 0.07 | 0.067 |
| CO | 0.57 | 0.59 | 0.57 | 0.577 |
| CO2 | 549.69 | 550.41 | 545.09 | 548.397 |
| Nox | 4.06 | 4.03 | 3.99 | 4.027 |

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.517 | 0.54 | 0.548 | 0.535 |
| HC | 0.1 | 0.11 | 0.11 | 0.107 |
| CO | 0.73 | 0.86 | 0.81 | 0.800 |
| CO2 | 589.04 | 590.97 | 594.75 | 591.587 |
| Nox | 5.52 | 5.53 | 5.51 | 5.520 |

Mode 8

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 8.151 | 10.322 | 9.798 | 9.424 |
| HC | 0.5 | 0.93 | 1.31 | 0.913 |
| CO | 14.62 | 21.85 | 26.73 | 21.067 |
| CO2 | 5076.56 | 4944.06 | 4949.94 | 4990.187 |
| Nox | 43.01 | 40.07 | 40.72 | 41.267 |

Emissions Data for Lister Petter LPU-2 bare engine (in g/bhp-hr)

Mode 1

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 6.122 | 5.778 | 5.676 | 5.859 |
| HC | 0.27 | 0.12 | 0.09 | 0.160 |
| CO | 44.71 | 36.82 | 34.79 | 38.773 |
| CO2 | 921.7 | 933.69 | 927.82 | 927.737 |
| Nox | 1.76 | 1.8 | 1.81 | 1.790 |
| Exh Temp | 1457 | 1775 | 1792 | 1674.667 |

Mode 2

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.319 | 0.286 | 0.264 | 0.290 |
| HC | 0.53 | 0.55 | 0.49 | 0.523 |
| CO | 1.43 | 1.37 | 1.33 | 1.377 |
| CO2 | 839.36 | 824.45 | 837.9 | 833.903 |
| Nox | 3.9 | 3.93 | 4.01 | 3.947 |
| Exh Temp | 915 | 903 | 898 | 905.333 |

Mode 3

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.326 | 0.342 | 0.319 | 0.329 |
| HC | 1.31 | 1.45 | 1.27 | 1.343 |
| CO | 1.62 | 1.85 | 1.58 | 1.683 |
| CO2 | 930.87 | 925.05 | 943.22 | 933.047 |
| Nox | 5.24 | 5.2 | 5.32 | 5.253 |
| Exh Temp | 748 | 747 | 748 | 747.667 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.881 | 0.727 | 0.804 |
| HC | 1.34 | 0.97 | 1.155 |
| CO | 3.39 | 2.71 | 3.050 |
| CO2 | 1359.75 | 1392.39 | 1376.070 |
| Nox | 7.84 | 8.05 | 7.945 |
| Exh Temp | 583 | 580 | 581.500 |

Mode 5

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 7.833 | 7.889 | 7.996 | 7.906 |
| HC | 1.26 | 1.22 | 1.25 | 1.243 |
| CO | 33.98 | 32.8 | 33.38 | 33.387 |
| CO2 | 831.94 | 825.37 | 823.84 | 827.050 |
| Nox | 1.67 | 1.63 | 1.59 | 1.630 |
| Exh Temp | 1138 | 1162 | 1233 | 1177.667 |

Mode 6

| | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | AVG |
|---|---|---|---|---|---|---|
| PM | 0.505 | 0.635 | 0.518 | 0.568 | 0.516 | 0.548 |
| HC | 1 | 0.99 | 0.8 | 0.43 | 0.4 | 0.724 |
| CO | 3.4 | 3.38 | 3.28 | 2.62 | 2.59 | 3.054 |
| CO2 | 758.93 | 750.02 | 737.97 | 707.17 | 703.16 | 731.450 |
| Nox | 5.49 | 4.7 | 4.5 | 3.85 | 3.83 | 4.474 |
| Exh Temp | | | | 763 | 780 | 771.500 |

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.367 | 0.435 | 0.458 | 0.420 |
| HC | 3.64 | 3.43 | 3.48 | 3.517 |
| CO | 6.78 | 6.52 | 6.69 | 6.663 |
| CO2 | 882.15 | 875.7 | 862.71 | 873.520 |
| Nox | 8.26 | 7.87 | 7.9 | 8.010 |
| Exh Temp | 567 | 567 | 569 | 567.667 |

Mode 8

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.283 | 0.276 | 0.255 | 0.271 |
| HC | 0 | 0 | 0 | 0.000 |
| CO | 2.39 | 2.74 | 2.04 | 2.390 |
| CO2 | 2162.11 | 2347.07 | 2318.72 | 2275.967 |
| Nox | 52.64 | 60.15 | 61.57 | 58.120 |
| Exh Temp | 269 | 231 | 227 | 242.333 |

Emissions Data for Lister Petter LPU-2 with failed trap (in g/bhp-hr)

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 4.481 | 3.923 | 4.202 |
| HC | 0.02 | 0.01 | 0.015 |
| CO | 0.27 | 0.33 | 0.300 |
| CO2 | 997.02 | 973.37 | 985.195 |
| Nox | 1.89 | 1.87 | 1.880 |
| Exh Temp | 1452 | 1459 | 1455.500 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.332 | 0.345 | 0.339 |
| HC | 0.01 | 0.01 | 0.010 |
| CO | 0.05 | 0.12 | 0.085 |
| CO2 | 950.12 | 934.63 | 942.375 |
| Nox | 3.9 | 3.95 | 3.925 |
| Exh Temp | 940 | 937 | 938.500 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.223 | 0.259 | 0.241 |
| HC | 0 | 0 | 0.000 |
| CO | 0.15 | 0.14 | 0.145 |
| CO2 | 1010.78 | 1018.72 | 1014.750 |
| Nox | 4.97 | 5.06 | 5.015 |
| Exh Temp | 931 | 763 | 847.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.164 | 0.196 | 0.180 |
| HC | 0.05 | 0 | 0.025 |
| CO | 0.41 | 0.12 | 0.265 |
| CO2 | 1543.86 | 1535.71 | 1539.785 |
| Nox | 7.57 | 7.57 | 7.570 |
| Exh Temp | 596 | 593 | 594.500 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 5.067 | 5.512 | 5.290 |
| HC | 0.01 | 0.01 | 0.010 |
| CO | 0.09 | 0.11 | 0.100 |
| CO2 | 858.09 | 862.9 | 860.495 |
| Nox | 1.81 | 1.79 | 1.800 |
| Exh Temp | 1208 | 1217 | 1212.500 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.317 | 0.308 | 0.313 |
| HC | 0.09 | 0.05 | 0.070 |
| CO | 0.04 | 0.17 | 0.105 |
| CO2 | 816.53 | 799.79 | 808.160 |
| Nox | 3.73 | 3.8 | 3.765 |
| Exh Temp | 827 | 824 | 825.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.116 | 0.102 | 0.109 |
| HC | 0.3 | 0.29 | 0.295 |
| CO | 0.2 | 0 | 0.100 |
| CO2 | 959.55 | 956.54 | 958.045 |
| Nox | 7.66 | 7.72 | 7.690 |
| Exh Temp | 602 | 592 | 597.000 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.146 | 0.202 | 0.174 |
| HC | 0 | 0 | 0.000 |
| CO | 0 | 1.71 | 0.855 |
| CO2 | 3585.66 | 3221.89 | 3403.775 |
| Nox | 76.42 | 67.81 | 72.115 |
| Exh Temp | 281 | 248 | 264.500 |

Emissions Data for Lister Petter LPU-2 Bare Engine (in g/bhp-hr)

Mode 6

| | Test 1 | Test 2 | Test 3 | Test 4 | Test 5 | AVG |
|---|---|---|---|---|---|---|
| PM | 0.505 | 0.635 | 0.515 | 0.568 | 0.516 | 0.548 |
| HC | 1 | 0.99 | 0.5 | 0.43 | 0.4 | 0.724 |
| CO | 3.4 | 3.38 | 3.25 | 2.62 | 2.59 | 3.054 |
| CO2 | 758.93 | 750.02 | 737.9 | 707.17 | 703.16 | 731.450 |
| Nox | 5.46 | 4.7 | 4.5 | 3.85 | 3.83 | 4.468 |
| Ex. Temp | 1349 | 1483 | 1810 | 1526 | 1560 | 1545.600 |

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.367 | 0.435 | 0.458 | 0.420 |
| HC | 3.64 | 3.43 | 3.48 | 3.517 |
| CO | 6.78 | 6.52 | 6.69 | 6.663 |
| CO2 | 882.15 | 875.7 | 862.71 | 873.520 |
| Nox | 8.26 | 7.87 | 7.9 | 8.010 |
| Ex. Temp | 567 | 567 | 569 | 567.667 |

Emissions Data for Lister Petter LPU-2 Rohmac/DCL system with new trap (in g/bhp-hr)

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.091 | 0.111 | 0.101 |
| HC | 0 | 0 | 0.000 |
| CO | 0.07 | 0.05 | 0.060 |
| CO2 | 763.98 | 753.03 | 758.505 |
| Nox | 3.41 | 3.5 | 3.455 |
| Ex. Temp | 806 | 807 | 806.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | | 0.033 | 0.033 |
| HC | 0 | 0 | 0.000 |
| CO | 0.12 | 0.13 | 0.125 |
| CO2 | 924.07 | 916.84 | 920.455 |
| Nox | 6.21 | 6.31 | 6.260 |
| Ex. Temp | 593 | 597 | 595.000 |

Emissions Data for Lister Petter LPU-2 Bare Engine (in g/bhp-hr)

Mode 1

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 6.122 | 5.778 | 5.676 | 5.859 |
| HC | 0.27 | 0.12 | 0.09 | 0.160 |
| CO | 44.71 | 36.82 | 34.79 | 38.773 |
| CO2 | 921.7 | 933.69 | 927.82 | 927.737 |
| Nox | 1.76 | 1.8 | 1.81 | 1.790 |
| Ex. Temp | 1457 | 1775 | 1792 | 1674.667 |

Mode 5

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 7.833 | 7.889 | 7.996 | 7.906 |
| HC | 1.26 | 1.22 | 1.25 | 1.243 |
| CO | 33.98 | 32.8 | 33.38 | 33.387 |
| CO2 | 831.94 | 825.37 | 823.84 | 827.050 |
| Nox | 1.67 | 1.63 | 1.59 | 1.630 |
| Ex. Temp | 1138 | 1162 | 1235 | 1177.667 |

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.367 | 0.435 | 0.458 | 0.420 |
| HC | 3.64 | 3.43 | 3.48 | 3.517 |
| CO | 6.78 | 6.52 | 6.69 | 6.663 |
| CO2 | 882.15 | 875.7 | 862.71 | 873.520 |
| Nox | 8.26 | 7.87 | 7.9 | 8.010 |
| Ex. Temp | 567 | 567 | 569 | 567.667 |

Emissions Data for Lister Petter LPU-2 Rohmac/DCL system with oxidation catalyst only (in g/bhp-hr)

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 7.05 | 7.881 | 7.466 |
| HC | 0.17 | 0.14 | 0.155 |
| CO | 30.84 | 30.59 | 30.715 |
| CO2 | 938.72 | 933.85 | 936.285 |
| Nox | 0.83 | 0.68 | 0.755 |
| Ex. Temp | 1351 | 1389 | 1370.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 8.087 | 8.21 | 8.149 |
| HC | 0.04 | 0.04 | 0.040 |
| CO | 0.14 | 0.16 | 0.150 |
| CO2 | 833.12 | 827.05 | 830.085 |
| Nox | 1.9 | 1.81 | 1.855 |
| Ex. Temp | 1203 | 1205 | 1204.000 |

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | | 0.325 | 0.303 | 0.314 |
| HC | 0.38 | 0.38 | 0.39 | 0.383 |
| CO | 0.13 | 0.1 | 0.03 | 0.087 |
| CO2 | 901.24 | 895.15 | 891.5 | 895.963 |
| Nox | 7.09 | 7.2 | 7.27 | 7.187 |
| Ex. Temp | 622 | 601 | 597 | 606.667 |

Emissions Data for Lister Petter LPU-2 Bare Engine (in g/bhp-hr)

Mode 7

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.367 | 0.435 | 0.458 | 0.420 |
| HC | 3.64 | 3.43 | 3.48 | 3.517 |
| CO | 6.78 | 6.52 | 6.69 | 6.663 |
| CO2 | 882.15 | 875.7 | 862.71 | 873.520 |
| Nox | 8.26 | 7.87 | 7.9 | 8.010 |
| Ex. Temp | 567 | 567 | 569 | 567.667 |

Emissions Data for Lister Petter LPU-2 Rohmac/DCL system with new trap and Pallflex paper filter (in g/bhp-hr)

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.033 | 0.006 | 0.020 |
| HC | 0.3 | 0.32 | 0.310 |
| CO | 0.09 | 0.12 | 0.105 |
| CO2 | 808.3 | 795.97 | 802.135 |
| Nox | 5.65 | 5.87 | 5.760 |
| Ex. Temp | 616 | 609 | 612.500 |

**Emissions Data for Isuzu C240 bare engine (in g/bhp-hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.204 | 0.192 | 0.198 |
| HC | 0.08 | 0.11 | 0.095 |
| CO | 0.73 | 0.89 | 0.810 |
| CO2 | 637.19 | 634.82 | 636.005 |
| Nox | 3.4 | 3.27 | 3.335 |
| Exh Temp | 1065 | 1077 | 1071.000 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.223 | 0.219 | 0.221 |
| HC | 0.13 | 0.12 | 0.125 |
| CO | 1.01 | 0.98 | 0.995 |
| CO2 | 627.29 | 627.61 | 627.450 |
| Nox | 4.66 | 4.72 | 4.690 |
| Exh Temp | 828 | 825 | 826.500 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.285 | 0.31 | 0.298 |
| HC | 1.42 | 1.61 | 1.515 |
| CO | 0.93 | 1.07 | 1.000 |
| CO2 | 635.11 | 632.4 | 633.755 |
| Nox | 5.81 | 6.06 | 5.935 |
| Exh Temp | 646 | 646 | 646.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.752 | 0.767 | 0.760 |
| HC | 0.36 | 0.38 | 0.370 |
| CO | 1.57 | 1.5 | 1.535 |
| CO2 | 931.57 | 906.15 | 918.860 |
| Nox | 7.87 | 7.89 | 7.880 |
| Exh Temp | 444 | 444 | 444.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.865 | 0.879 | 0.872 |
| HC | 0.01 | 0.01 | 0.010 |
| CO | 2.81 | 2.77 | 2.790 |
| CO2 | 620.54 | 616.43 | 618.485 |
| Nox | 1.84 | 1.73 | 1.785 |
| Exh Temp | 1092 | 1093 | 1092.500 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.127 | 0.125 | 0.126 |
| HC | 0.05 | 0.06 | 0.055 |
| CO | 0.46 | 0.48 | 0.470 |
| CO2 | 568.7 | 566.64 | 567.670 |
| Nox | 3 | 2.98 | 2.990 |
| Exh Temp | 758 | 750 | 754.000 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.158 | 0.147 | 0.153 |
| HC | 0.15 | 0.17 | 0.160 |
| CO | 0.7 | 0.74 | 0.720 |
| CO2 | 585.34 | 590.88 | 588.110 |
| Nox | 4.6 | 4.39 | 4.495 |
| Exh Temp | 542 | 546 | 544.000 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.249 | 0.295 | 0.272 |
| HC | 0.75 | 0.77 | 0.760 |
| CO | 16.24 | 14.9 | 15.570 |
| CO2 | 1881.92 | 1847.15 | 1864.535 |
| Nox | 14.25 | 13.38 | 13.815 |
| Exh Temp | 198 | 189 | 193.500 |

**Emissions Data for Isuzu C240 with Trap and Oxidation Catalyst (in g/bhp-hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.167 | 0.159 | 0.163 |
| HC | 0 | 0 | 0.000 |
| CO | 0 | 0.02 | 0.010 |
| CO2 | 637.33 | 631.1 | 634.215 |
| Nox | 3.29 | 3.33 | 3.310 |
| Exh Temp | 1199 | 1195 | 1197.000 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.035 | 0.126 | 0.081 |
| HC | 0 | 0 | 0.000 |
| CO | 0 | 0 | 0.000 |
| CO2 | 613.81 | 614.08 | 613.945 |
| Nox | 4.84 | 4.82 | 4.830 |
| Exh Temp | 917.29 | 921 | 919.145 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.027 | 0.077 | 0.052 |
| HC | 0.01 | 0.01 | 0.010 |
| CO | 0.02 | 0 | 0.010 |
| CO2 | 646.14 | 651.24 | 648.690 |
| Nox | 5.84 | 5.71 | 5.775 |
| Exh Temp | 697 | 699 | 698.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.004 | 0.007 | 0.006 |
| HC | 0 | 0 | - |
| CO | 0.1 | 0.1 | 0.100 |
| CO2 | 925.35 | 924.75 | 925.050 |
| Nox | 6.65 | 6.15 | 6.400 |
| Exh Temp | 482 | 485 | 483.500 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.303 | 0.187 | 0.245 |
| HC | 0 | 0 | 0.000 |
| CO | 0.03 | 0.05 | 0.040 |
| CO2 | 646.13 | 639 | 642.565 |
| Nox | 1.76 | 1.68 | 1.720 |
| Exh Temp | 1261 | 1275 | 1268.000 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.005 | 0.004 | 0.005 |
| HC | 0 | 0 | 0.000 |
| CO | 0.01 | 0.01 | 0.010 |
| CO2 | 581.31 | 583.36 | 582.335 |
| Nox | 2.8 | 2.87 | 2.835 |
| Exh Temp | 867 | 860 | 863.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.003 | 0.004 | 0.004 |
| HC | 0 | 0 | 0.000 |
| CO | 0.05 | 0.02 | 0.035 |
| CO2 | 604.7 | 604.26 | 604.480 |
| Nox | 3.85 | 3.93 | 3.890 |
| Exh Temp | 622 | 618 | 620.000 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.055 | 0.044 | 0.050 |
| HC | 0.12 | 0.23 | 0.175 |
| CO | 0.18 | 5.3 | 2.740 |
| CO2 | 2013.87 | 1971.5 | 1992.685 |
| Nox | 19.32 | 17.13 | 18.225 |
| Exh Temp | 233 | 223 | 228.000 |

Emissions Data for Isuzu C240 bare engine (in g/bhp-hr)

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.204 | 0.192 | 0.198 |
| HC | 0.08 | 0.11 | 0.095 |
| CO | 0.73 | 0.89 | 0.810 |
| CO2 | 637.19 | 634.82 | 636.005 |
| Nox | 3.4 | 3.27 | 3.335 |
| Exh Temp | 1065 | 1077 | 1071.000 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.285 | 0.31 | 0.298 |
| HC | 1.42 | 1.61 | 1.515 |
| CO | 0.93 | 1.07 | 1.000 |
| CO2 | 635.11 | 632.4 | 633.755 |
| Nox | 5.81 | 6.06 | 5.935 |
| Exh Temp | 646 | 646 | 646.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.865 | 0.879 | 0.872 |
| HC | 0.01 | 0.01 | 0.010 |
| CO | 2.81 | 2.77 | 2.790 |
| CO2 | 620.54 | 616.43 | 618.485 |
| Nox | 1.84 | 1.73 | 1.785 |
| Exh Temp | 1092 | 1093 | 1092.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.158 | 0.147 | 0.153 |
| HC | 0.15 | 0.17 | 0.160 |
| CO | 0.7 | 0.74 | 0.720 |
| CO2 | 585.34 | 590.88 | 588.110 |
| Nox | 4.6 | 4.39 | 4.495 |
| Exh Temp | 542 | 546 | 544.000 |

Emissions Data for Isuzu C240 with Oxidation Catalyst and Trap (in g/bhp-hr)

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.118 | 0.115 | 0.117 |
| HC | 0 | 0 | 0.000 |
| CO | 0.06 | 0.01 | 0.035 |
| CO2 | 682.19 | 685.31 | 683.750 |
| Nox | 3.34 | 3.14 | 3.240 |
| Exh Temp | 1193 | 1206 | 1199.500 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.02 | 0.024 | 0.022 |
| HC | 0.01 | 0 | 0.005 |
| CO | 0.08 | 0.05 | 0.065 |
| CO2 | 646.09 | 642.86 | 644.475 |
| Nox | 5.78 | 5.45 | 5.615 |
| Exh Temp | 705 | 708 | 706.500 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.195 | 0.181 | 0.188 |
| HC | 0 | 0 | 0.000 |
| CO | 0.04 | 0.03 | 0.137 |
| CO2 | 625.35 | 626.35 | 649.200 |
| Nox | 1.89 | 1.83 | 1.783 |
| Exh Temp | 1184 | 1181 | 1182.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.002 | 0.002 | 0.002 |
| HC | 0 | 0 | 0.000 |
| CO | 0.08 | 0 | 0.040 |
| CO2 | 603.55 | 592.47 | 598.010 |
| Nox | 3.61 | 3.7 | 3.655 |
| Exh Temp | 613 | 605 | 609.000 |

Emissions Data for Isuzu C240 bare engine (in g/bhp-hr)

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.204 | 0.192 | 0.198 |
| HC | 0.08 | 0.11 | 0.095 |
| CO | 0.73 | 0.89 | 0.810 |
| CO2 | 637.19 | 634.82 | 636.005 |
| Nox | 3.4 | 3.27 | 3.335 |
| Exh Temp | 1065 | 1077 | 1071.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.865 | 0.879 | 0.872 |
| HC | 0.01 | 0.01 | 0.010 |
| CO | 2.81 | 2.77 | 2.790 |
| CO2 | 620.54 | 616.43 | 618.485 |
| Nox | 1.84 | 1.73 | 1.785 |
| Exh Temp | 1092 | 1093 | 1092.500 |

Emissions Data for Isuzu C240 with Oxidation Catalyst only (in g/bhp-hr)

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.338 | 0.338 | 0.338 |
| HC | 0.01 | 0 | 0.005 |
| CO | 0.07 | 0.07 | 0.070 |
| CO2 | 624.68 | 640.69 | 632.685 |
| Nox | 3.19 | 3.23 | 3.210 |
| Exh Temp | 1185 | 1183 | 1184.000 |

Mode 5

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 1.366 | 1.356 | 1.481 | 1.401 |
| HC | 0 | 0 | 0 | 0.000 |
| CO | 0.13 | 0.11 | 0.17 | 0.137 |
| CO2 | 644.68 | 654.45 | 648.47 | 649.200 |
| Nox | 1.77 | 1.76 | 1.82 | 1.783 |
| Exh Temp | 1236 | 1237 | 1231 | 1234.667 |

**Emissions Data for bare Caterpillar 3306 (in g/bhp-hr)**

**Mode 1**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.275 | 0.298 | **0.287** |
| HC | 0.25 | 0.19 | **0.220** |
| CO | 1.16 | 1.33 | **1.245** |
| CO2 | 677.1 | 666.75 | **671.925** |
| Nox | 3.91 | | **3.910** |
| Exh Temp | 1094 | 1130 | **1112.000** |

**Mode 2**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.571 | 0.562 | **0.567** |
| HC | 0.33 | 0.32 | **0.325** |
| CO | 1.94 | 1.88 | **1.910** |
| CO2 | 724.21 | 724.58 | **724.395** |
| Nox | 6.97 | 6.93 | **6.950** |
| Exh Temp | 861 | 875 | **868.000** |

**Mode 3**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 1.086 | 1.075 | **1.081** |
| HC | 0.6 | 0.57 | **0.585** |
| CO | 2.57 | 2.52 | **2.545** |
| CO2 | 850.5 | 849.04 | **849.770** |
| Nox | 9.76 | 9.73 | **9.745** |
| Exh Temp | 694 | 698 | **696.000** |

**Mode 4**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 5.083 | 5.261 | **5.172** |
| HC | 2.25 | 2.31 | **2.280** |
| CO | 6.46 | 6.64 | **6.550** |
| CO2 | 2236.71 | 2231.72 | **2234.215** |
| Nox | 20.32 | 20.33 | **20.325** |
| Exh Temp | 483 | 483 | **483.000** |

**Mode 5**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.953 | 0.932 | **0.943** |
| HC | 0.09 | 0.09 | **0.090** |
| CO | 1.65 | 1.53 | **1.590** |
| CO2 | 585.07 | 571.77 | **578.420** |
| Nox | 2.2 | | **2.200** |
| Exh Temp | 1098 | 1094 | **1096.000** |

**Mode 6**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.241 | 0.234 | **0.238** |
| HC | 0.2 | 0.19 | **0.195** |
| CO | 0.73 | 0.72 | **0.725** |
| CO2 | 581.35 | 575.93 | **578.640** |
| Nox | 4.63 | 5.81 | **5.220** |
| Exh Temp | 703 | 700 | **701.500** |

**Mode 7**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.419 | 0.433 | **0.426** |
| HC | 0.2 | 0.2 | **0.200** |
| CO | 0.64 | 0.57 | **0.605** |
| CO2 | 628.3 | 645.33 | **636.815** |
| Nox | 10.09 | 10.08 | **10.085** |
| Exh Temp | 537 | | **537.000** |

**Mode 8**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 8.531 | 7.507 | **8.019** |
| HC | 5.2 | 5.29 | **5.245** |
| CO | 116.49 | 96.99 | **106.74** |
| CO2 | 12451.7 | 10946.15 | **11698.93** |
| Nox | 154.54 | 141.04 | **147.790** |
| Exh Temp | 193 | 186 | **189.500** |

**Emissions Data for Caterpillar 3306 with DST I (in g/bhp-hr)**

**Mode 1**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.934 | 0.736 | **0.835** |
| HC | 0.2 | 0.18 | **0.190** |
| CO | 0.12 | 0.12 | **0.120** |
| CO2 | 739.4 | 711.49 | **725.445** |
| Nox | 3.76 | 4.02 | **3.890** |
| Exh Temp | 1178 | 1147 | **1162.500** |

**Mode 2**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.595 | 0.577 | **0.586** |
| HC | 0.11 | 0.12 | **0.115** |
| CO | 0.16 | 0.19 | **0.175** |
| CO2 | 744.78 | 740.79 | **742.785** |
| Nox | 6.36 | 6.3 | **6.330** |
| Exh Temp | 920 | 925 | **922.500** |

**Mode 3**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.343 | 0.43 | **0.387** |
| HC | 0.17 | 0.17 | **0.170** |
| CO | 0.29 | 0.31 | **0.300** |
| CO2 | 840.47 | 838.69 | **839.580** |
| Nox | 9.67 | 8.74 | **9.205** |
| Exh Temp | 739 | 737 | **738.000** |

**Mode 4**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.243 | 0.251 | **0.247** |
| HC | 0.95 | 0.87 | **0.910** |
| CO | 1.26 | 1.33 | **1.295** |
| CO2 | 2179.95 | 2196.41 | **2188.180** |
| Nox | 19.28 | 19.13 | **19.205** |
| Exh Temp | 505 | 507 | **506.000** |

**Mode 5**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.054 | 0.065 | **0.060** |
| HC | 0.1 | 0.07 | **0.085** |
| CO | 0.08 | 0.09 | **0.085** |
| CO2 | 610.68 | 608.11 | **609.395** |
| Nox | 2.31 | 2.31 | **2.310** |
| Exh Temp | 983 | 1000 | **991.500** |

**Mode 6**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.065 | 0.062 | **0.064** |
| HC | 0.02 | 0.02 | **0.020** |
| CO | 0.05 | 0.07 | **0.060** |
| CO2 | 583.06 | 570.07 | **576.565** |
| Nox | 4.85 | 4.92 | **4.885** |
| Exh Temp | 765 | 751 | **758.000** |

**Mode 7**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.044 | 0.049 | **0.047** |
| HC | 0.06 | 0.05 | **0.055** |
| CO | 0.11 | 0.07 | **0.090** |
| CO2 | 635.02 | 633.36 | **634.190** |
| Nox | 9.64 | 9.75 | **9.695** |
| Exh Temp | 556 | 555 | **555.500** |

**Mode 8**

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.814 | 0.391 | **0.603** |
| HC | 148.23 | 134.45 | **141.340** |
| CO | 321.28 | 279.31 | **300.295** |
| CO2 | 13017.7 | 11915.42 | **12466.56** |
| Nox | 133.14 | 115.17 | **124.155** |
| Exh Temp | 219 | 194 | **206.500** |

**Emissions Data for Caterpillar 3306 bare engine (in g/bhp-hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.275 | 0.298 | 0.287 |
| HC | 0.25 | 0.19 | 0.220 |
| CO | 1.16 | 1.33 | 1.245 |
| CO2 | 677.1 | 666.75 | 671.925 |
| Nox | 3.91 | | 3.910 |
| Exh Temp | 1094 | 1130 | 1112.000 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.571 | 0.562 | 0.567 |
| HC | 0.33 | 0.32 | 0.325 |
| CO | 1.94 | 1.88 | 1.910 |
| CO2 | 724.21 | 724.58 | 724.395 |
| Nox | 6.97 | 6.93 | 6.950 |
| Exh Temp | 861 | 875 | 868.000 |

**Emissions Data for Caterpillar 3306 with DST I no catalyst (in g/bhp-hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.877 | 0.73 | 0.804 |
| HC | 0.08 | 0.38 | 0.230 |
| CO | 1.12 | 1.1 | 1.110 |
| CO2 | 705.79 | 701.82 | 703.805 |
| Nox | 0.47 | 4.39 | 2.430 |
| Exh Temp | 1122 | 1172 | 1147.000 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.338 | 0.331 | 0.335 |
| HC | 0.42 | 0.4 | 0.410 |
| CO | 1.87 | 1.92 | 1.895 |
| CO2 | 731.64 | 730.44 | 731.040 |
| Nox | 6.64 | 6.66 | 6.650 |
| Exh Temp | 915 | 907 | 911.000 |

**Emissions Data for Caterpillar 3306 bare engine (in g/bhp-hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.275 | 0.298 | 0.287 |
| HC | 0.25 | 0.19 | 0.220 |
| CO | 1.16 | 1.33 | 1.245 |
| CO2 | 677.1 | 666.75 | 671.925 |
| Nox | 3.91 | | 3.910 |
| Exh Temp | 1094 | 1130 | 1112.000 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.571 | 0.562 | 0.567 |
| HC | 0.33 | 0.32 | 0.325 |
| CO | 1.94 | 1.88 | 1.910 |
| CO2 | 724.21 | 724.58 | 724.395 |
| Nox | 6.97 | 6.93 | 6.950 |
| Exh Temp | 861 | 875 | 868.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.953 | 0.932 | 0.943 |
| HC | 0.09 | 0.09 | 0.090 |
| CO | 1.65 | 1.53 | 1.590 |
| CO2 | 585.07 | 571.77 | 578.420 |
| Nox | 2.2 | | 2.200 |
| Exh Temp | 1098 | 1094 | 1096.000 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.419 | 0.433 | 0.426 |
| HC | 0.2 | 0.2 | 0.200 |
| CO | 0.64 | 0.57 | 0.605 |
| CO2 | 628.3 | 645.33 | 636.815 |
| Nox | 10.09 | 10.08 | 10.085 |
| Exh Temp | 537 | | 537.000 |

**Emissions Data for Caterpillar 3306 with DST II (in g/bhp-hr)**

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.282 | 0.23 | 0.256 |
| HC | 0.1 | 0.11 | 0.105 |
| CO | 0.11 | 0.12 | 0.115 |
| CO2 | 693.24 | 672.82 | 683.030 |
| Nox | 4.6 | 4.2 | 4.400 |
| Exh Temp | 1155 | 1118 | 1136.500 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.122 | 0.137 | 0.130 |
| HC | 0.11 | 0.11 | 0.110 |
| CO | 0.19 | 0.23 | 0.210 |
| CO2 | 747.32 | 750.38 | 748.850 |
| Nox | 6.35 | 6.3 | 6.325 |
| Exh Temp | 914 | 912 | 913.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.043 | 0.04 | 0.042 |
| HC | 0.03 | 0.03 | 0.030 |
| CO | 0.06 | | 0.060 |
| CO2 | 598.28 | 606.38 | 602.330 |
| Nox | 2.31 | 2.3 | 2.305 |
| Exh Temp | 1028 | 1034 | 1031.000 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.02 | 0.02 | 0.020 |
| HC | 0.06 | 0.06 | 0.060 |
| CO | 0.02 | 0.07 | 0.045 |
| CO2 | 653.55 | 657.64 | 655.595 |
| Nox | 9.56 | 9.82 | 9.690 |
| Exh Temp | 543 | 536 | 539.500 |

** The results were from the repeated testing on DST after it was "fixed"

**Emissions Data for Caterpillar 3306 bare engine - after checkup (in g/bhp-hr)**

Mode 1

| | Test 1 | Test 2 | Test 3 | Test 4 | AVG |
|---|---|---|---|---|---|
| PM | 0.268 | 0.249 | | | 0.259 |
| HC | 0.37 | 0.36 | 0.28 | 0.28 | 0.323 |
| CO | 1.1 | 1.07 | 0.96 | 1.05 | 1.045 |
| CO2 | 690.92 | 680.7 | 707.03 | 707.38 | 696.508 |
| Nox | 3.73 | 3.58 | 3.82 | 3.9 | 3.758 |
| Exh Temp | 1101 | 1109 | 1094 | 1098 | 1100.500 |

Mode 2

| | Test 1 | Test 2 | Test 3 | Test 4 | AVG |
|---|---|---|---|---|---|
| PM | 0.479 | 0.491 | | | 0.485 |
| HC | 0.51 | 0.51 | 0.42 | 0.43 | 0.468 |
| CO | 1.65 | 1.66 | 1.72 | 1.7 | 1.683 |
| CO2 | 711.73 | 731.61 | 742.33 | 742.19 | 731.965 |
| Nox | 5.54 | 6.36 | 6.33 | 6.33 | 6.140 |
| Exh Temp | 878 | 876.2 | 887 | 873 | 878.550 |

Mode 3

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.903 | 0.901 | 0.908 | 0.904 |
| HC | 0.71 | 0.69 | 0.72 | 0.707 |
| CO | 2.35 | 2.29 | 2.26 | 2.300 |
| CO2 | 866.91 | 876.53 | 869.64 | 871.027 |
| Nox | 9.17 | 9.03 | 9.18 | 9.127 |
| Exh Temp | 696 | 694 | 692 | 694.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 4.086 | 4.112 | 4.099 |
| HC | 2.37 | 2.48 | 2.425 |
| CO | 5.92 | 6.32 | 6.120 |
| CO2 | 2168.39 | 2196.44 | 2182.415 |
| Nox | 18.67 | 18.41 | 18.540 |
| Exh Temp | 478 | 479 | 478.500 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.431 | 0.432 | 0.432 |
| HC | 0.26 | 0.26 | 0.260 |
| CO | 0.87 | 0.78 | 0.825 |
| CO2 | 596.87 | 591.29 | 594.080 |
| Nox | 2.51 | 2.51 | 2.510 |
| Exh Temp | 975 | 987 | 981.000 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.215 | 0.222 | 0.219 |
| HC | 0.37 | 0.37 | 0.370 |
| CO | 0.64 | 0.66 | 0.650 |
| CO2 | 592.04 | 595.15 | 593.595 |
| Nox | 5.59 | 5.48 | 5.535 |
| Exh Temp | 704 | 694 | 699.000 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.546 | 0.504 | 0.525 |
| HC | 0.56 | 0.55 | 0.555 |
| CO | 0.67 | 0.65 | 0.660 |
| CO2 | 669.73 | 670.34 | 670.035 |
| Nox | 10.16 | 10.04 | 10.100 |
| Exh Temp | 504 | 505 | 504.500 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 4.724 | 4.647 | 4.686 |
| HC | 31.43 | 27.65 | 29.540 |
| CO | 91.29 | 84.14 | 87.715 |
| CO2 | 11870.44 | 11586 | 11728.22 |
| Nox | 162.15 | 139.41 | 150.780 |
| Exh Temp | 208 | 196 | 202.000 |

**Emissions Data for Caterpillar 3306 with DST III (in g/bhp-hr)**

Mode 1

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.274 | 0.209 | 0.23 | 0.238 |
| HC | | 0.14 | 0.21 | 0.175 |
| CO | 0.11 | 0.07 | 0.07 | 0.083 |
| CO2 | 633.92 | 634.51 | 613.89 | 627.440 |
| Nox | 3.03 | 2.94 | 2.71 | 2.893 |
| Exh Temp | 1198 | 1196 | 1174 | 1189.333 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.059 | 0.06 | 0.060 |
| HC | 0.14 | 0.12 | 0.130 |
| CO | 0.14 | 0.15 | 0.145 |
| CO2 | 669.18 | 674.87 | 672.025 |
| Nox | 4.83 | 4.74 | 4.785 |
| Exh Temp | 929 | 927 | 928.000 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.042 | 0.048 | 0.045 |
| HC | 0.21 | 0.22 | 0.215 |
| CO | 0.79 | 0.26 | 0.525 |
| CO2 | 723.42 | 720.01 | 721.715 |
| Nox | 7.63 | 7.5 | 7.565 |
| Exh Temp | 738 | 740 | 739.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.074 | 0.094 | 0.084 |
| HC | 0.82 | 0.91 | 0.865 |
| CO | 0.31 | 1.11 | 0.710 |
| CO2 | 1841.32 | 1845.6 | 1843.460 |
| Nox | 15.13 | 15.53 | 15.330 |
| Exh Temp | 520 | 529 | 524.500 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.031 | 0.037 | 0.034 |
| HC | 0.06 | 0.07 | 0.065 |
| CO | | 0.06 | 0.060 |
| CO2 | 515.29 | 510.71 | 513.000 |
| Nox | 2.18 | 2.18 | 2.180 |
| Exh Temp | 987 | 973 | 980.000 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.021 | 0.019 | 0.020 |
| HC | 0.08 | 0.07 | 0.075 |
| CO | 0.06 | 0.01 | 0.035 |
| CO2 | 485.58 | 483.72 | 484.650 |
| Nox | 4.1 | 4.1 | 4.100 |
| Exh Temp | 732 | 723 | 727.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.012 | 0.012 | 0.012 |
| HC | 0.11 | 0.09 | 0.100 |
| CO | 0.05 | 0.1 | 0.075 |
| CO2 | 533.76 | 537.87 | 535.815 |
| Nox | 7.38 | 7.48 | 7.430 |
| Exh Temp | | 534 | 534.000 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.283 | 0.121 | 0.202 |
| HC | 18.06 | 11.64 | 14.850 |
| CO | 85.98 | 73.83 | 79.905 |
| CO2 | 14469.02 | 13232.53 | 13850.78 |
| Nox | 185.02 | 154.86 | 169.940 |
| Exh Temp | 230 | 202 | 216.000 |

Emissions Data for bare Caterpillar 3306 (in g/bhp-hr)

Mode 1

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.275 | 0.298 | 0.287 |
| HC | 0.25 | 0.19 | 0.220 |
| CO | 1.16 | 1.33 | 1.245 |
| CO2 | 677.1 | 666.75 | 671.925 |
| Nox | 3.91 | | 3.910 |
| Exh Temp | 1094 | 1130 | 1112.000 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.571 | 0.562 | 0.567 |
| HC | 0.33 | 0.32 | 0.325 |
| CO | 1.94 | 1.88 | 1.910 |
| CO2 | 724.21 | 724.58 | 724.395 |
| Nox | 6.97 | 6.93 | 6.950 |
| Exh Temp | 861 | 875 | 868.000 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 1.086 | 1.075 | 1.081 |
| HC | 0.6 | 0.57 | 0.585 |
| CO | 2.57 | 2.52 | 2.545 |
| CO2 | 850.5 | 849.04 | 849.770 |
| Nox | 9.76 | 9.73 | 9.745 |
| Exh Temp | 694 | 698 | 696.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 5.083 | 5.261 | 5.172 |
| HC | 2.25 | 2.31 | 2.280 |
| CO | 6.46 | 6.64 | 6.550 |
| CO2 | 2236.71 | 2231.72 | 2234.215 |
| Nox | 20.32 | 20.33 | 20.325 |
| Exh Temp | 483 | 483 | 483.000 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.953 | 0.932 | 0.943 |
| HC | 0.09 | 0.09 | 0.090 |
| CO | 1.65 | 1.53 | 1.590 |
| CO2 | 585.07 | 571.77 | 578.420 |
| Nox | 2.2 | | 2.200 |
| Exh Temp | 1098 | 1094 | 1096.000 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.241 | 0.234 | 0.238 |
| HC | 0.2 | 0.19 | 0.195 |
| CO | 0.73 | 0.72 | 0.725 |
| CO2 | 581.35 | 575.93 | 578.640 |
| Nox | 4.63 | 5.81 | 5.220 |
| Exh Temp | 703 | 700 | 701.500 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.419 | 0.433 | 0.426 |
| HC | 0.2 | 0.2 | 0.200 |
| CO | 0.64 | 0.57 | 0.605 |
| CO2 | 628.3 | 645.33 | 636.815 |
| Nox | 10.09 | 10.08 | 10.085 |
| Exh Temp | 537 | | 537.000 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 8.531 | 7.507 | 8.019 |
| HC | 5.2 | 5.29 | 5.245 |
| CO | 116.49 | 96.99 | 106.74 |
| CO2 | 12451.7 | 10946.15 | 11698.93 |
| Nox | 154.54 | 141.04 | 147.790 |
| Exh Temp | 193 | 186 | 189.500 |

Emissions Data for Caterpillar 3306 with Clean Air System (in g/bhp-hr)

Mode 1

| | Test 1 | Test 2 | Test 3 | AVG |
|---|---|---|---|---|
| PM | 0.115 | 0.146 | 0.127 | 0.129 |
| HC | 0.01 | 0.01 | 0.01 | 0.010 |
| CO | 0.05 | 0.03 | 0.01 | 0.030 |
| CO2 | 703.07 | 713.25 | 709.22 | 708.513 |
| Nox | 3.92 | 4.14 | 4.04 | 4.033 |
| Exh Temp | 1128 | 1112 | 1151 | 1130.333 |

Mode 2

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.229 | 0.251 | 0.240 |
| HC | 0.02 | 0.02 | 0.020 |
| CO | 0.02 | 0.03 | 0.025 |
| CO2 | 757.53 | 756.13 | 756.830 |
| Nox | 6.67 | 6.57 | 6.620 |
| Exh Temp | 902 | 901 | 901.500 |

Mode 3

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.292 | | 0.292 |
| HC | 0.03 | | 0.030 |
| CO | 0.04 | | 0.040 |
| CO2 | 893.64 | | 893.640 |
| Nox | 9.2 | | 9.200 |
| Exh Temp | 712 | | 712.000 |

Mode 4

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.054 | 0.065 | 0.060 |
| HC | 0.2 | 0.2 | 0.200 |
| CO | 0.04 | 0.15 | 0.095 |
| CO2 | 2315.89 | 2316.7 | 2316.295 |
| Nox | 19.45 | 19.35 | 19.400 |
| Exh Temp | 500 | 511 | 505.500 |

Mode 5

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.216 | 0.246 | 0.231 |
| HC | 0.01 | 0 | 0.005 |
| CO | | 0.02 | 0.020 |
| CO2 | 604.37 | 598.97 | 601.670 |
| Nox | 2.64 | 2.67 | 2.655 |
| Exh Temp | 1005 | 981 | 993.000 |

Mode 6

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.19 | 0.185 | 0.188 |
| HC | 0 | 0 | 0.000 |
| CO | 0.03 | 0.03 | 0.030 |
| CO2 | 588.43 | 587.81 | 588.120 |
| Nox | 5.7 | 5.67 | 5.685 |
| Exh Temp | 718 | 698 | 708.000 |

Mode 7

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 0.017 | 0.019 | 0.018 |
| HC | 0.01 | 0.03 | 0.020 |
| CO | 0.09 | 0.11 | 0.100 |
| CO2 | 658.39 | 666.39 | 662.390 |
| Nox | 9.91 | 10.04 | 9.975 |
| Exh Temp | 519 | 516 | 517.500 |

Mode 8

| | Test 1 | Test 2 | AVG |
|---|---|---|---|
| PM | 1.423 | 1.304 | 1.364 |
| HC | 3.9 | 1.29 | 2.595 |
| CO | 110.86 | 117.71 | 114.285 |
| CO2 | 12191.36 | 12712.37 | 12451.87 |
| Nox | 151.2 | 156.41 | 153.805 |
| Exh Temp | 193 | 191 | 192.000 |

Appendix C-9. Caterpillar 3306 Emissions Data

# Appendix D

## HC Concentration Trace for First Regenerative Cycle on Lister-Petter with Failed* Rohmac/DCL System

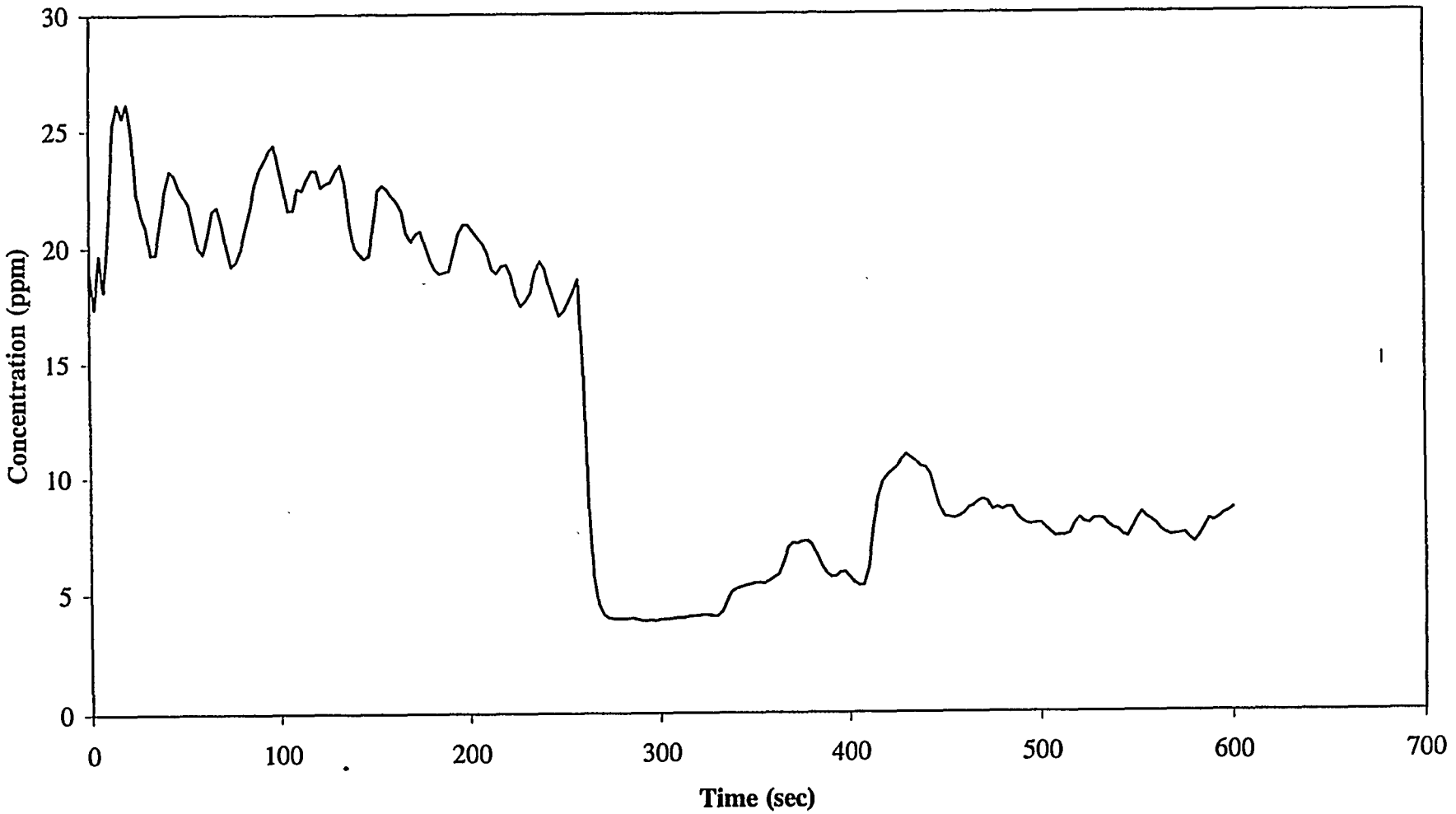



**Figure D.1-1**

*Failure was due to undersized catalyst/trap and overfueled engine (see text).

## CO Concentration Trace for First Regenerative Cycle on Lister-Petter with Failed* Rohmac/DCL System

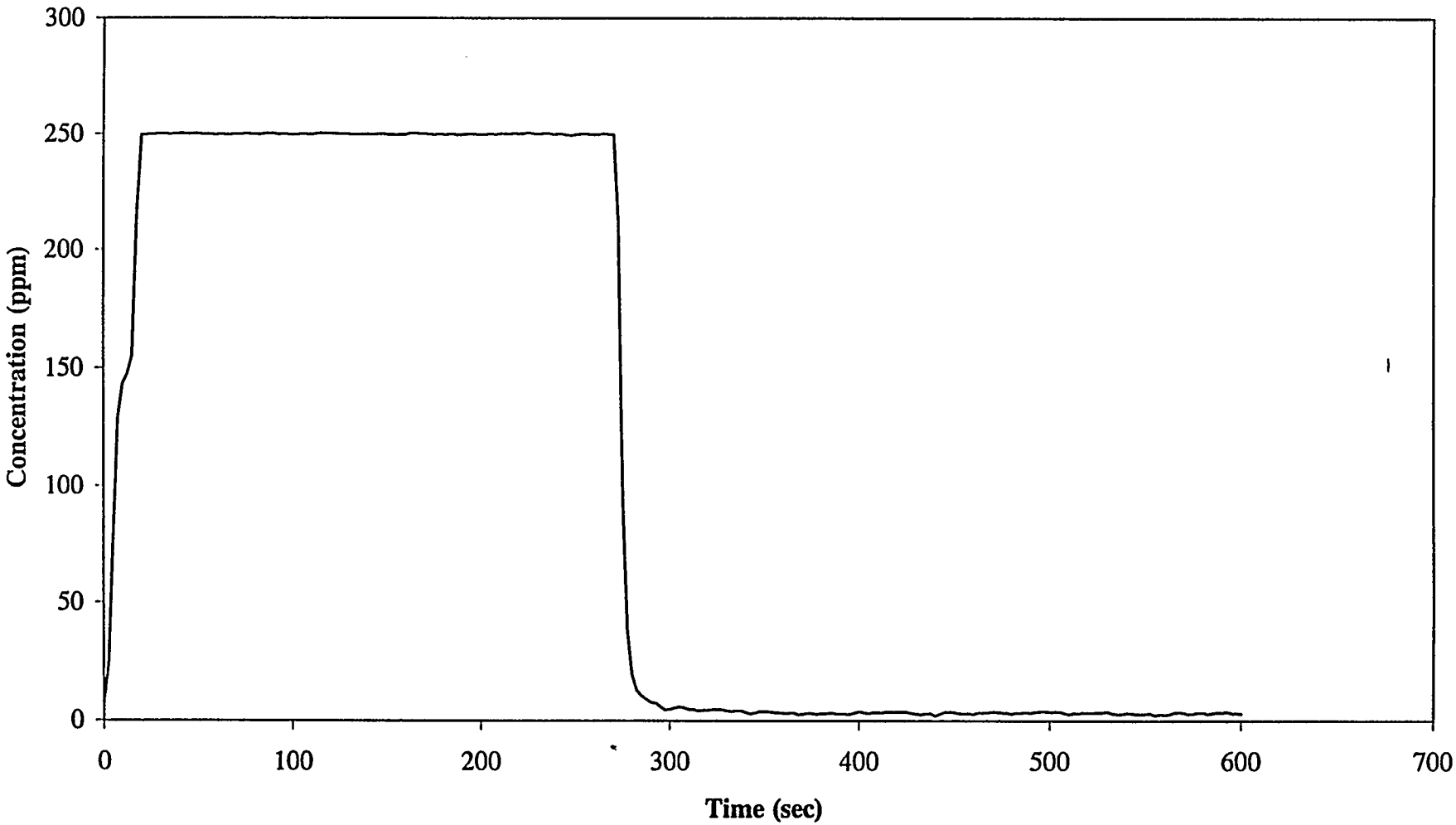



**Figure D.1-2**

*Failure was due to undersized catalyst/trap and overfueled engine (see text).

## CO2 Concentration Trace for First Regenerative Cycle on Lister-Petter with Failed* Rohmac/DCL System

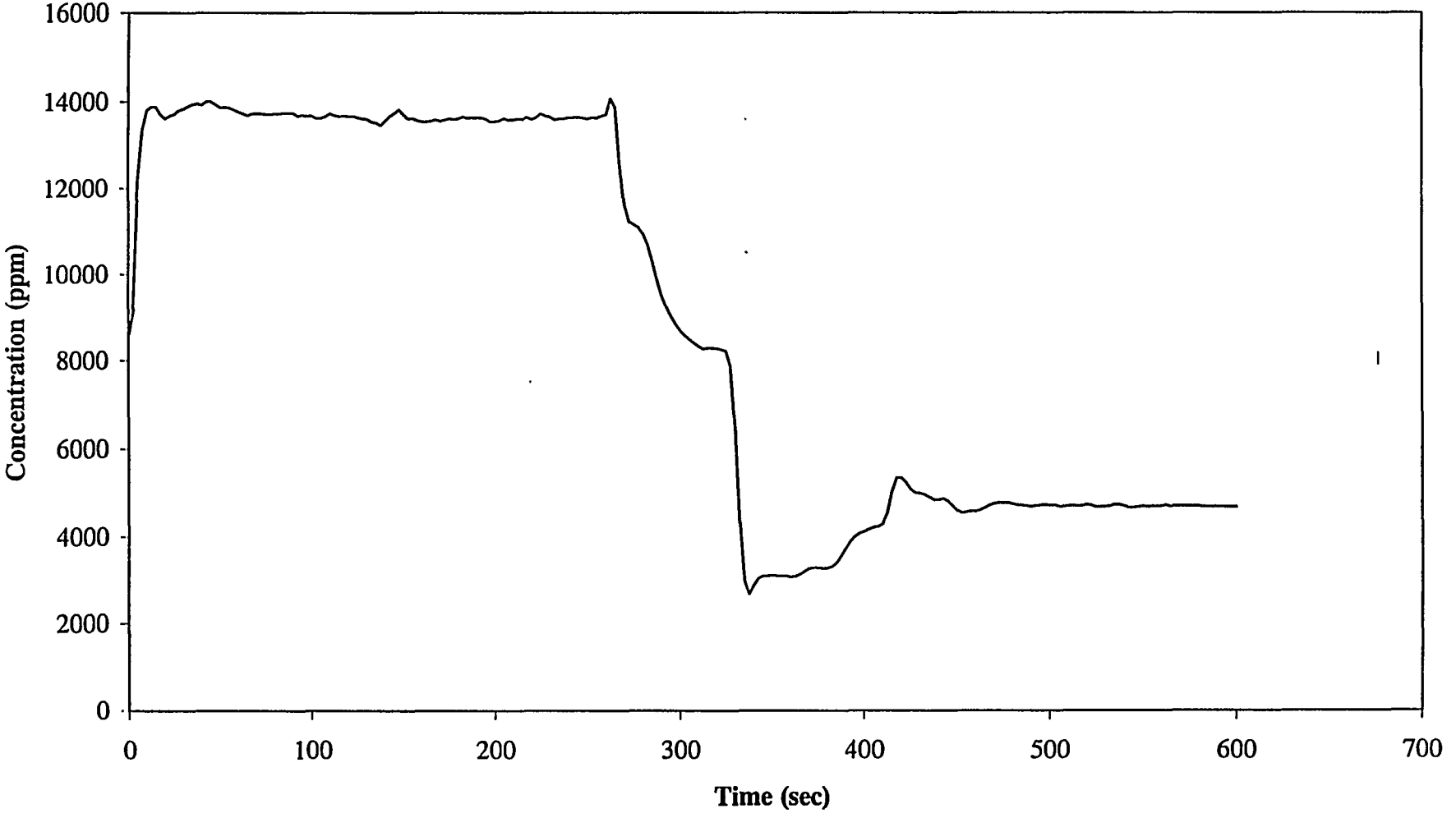



**Figure D.1-3**

*Failure was due to undersized catalyst/trap and overfueled engine (see text).

## NOx Concentration Trace for First Regenerative Cycle on Lister-Petter with Failed* Rohmac/DCL System

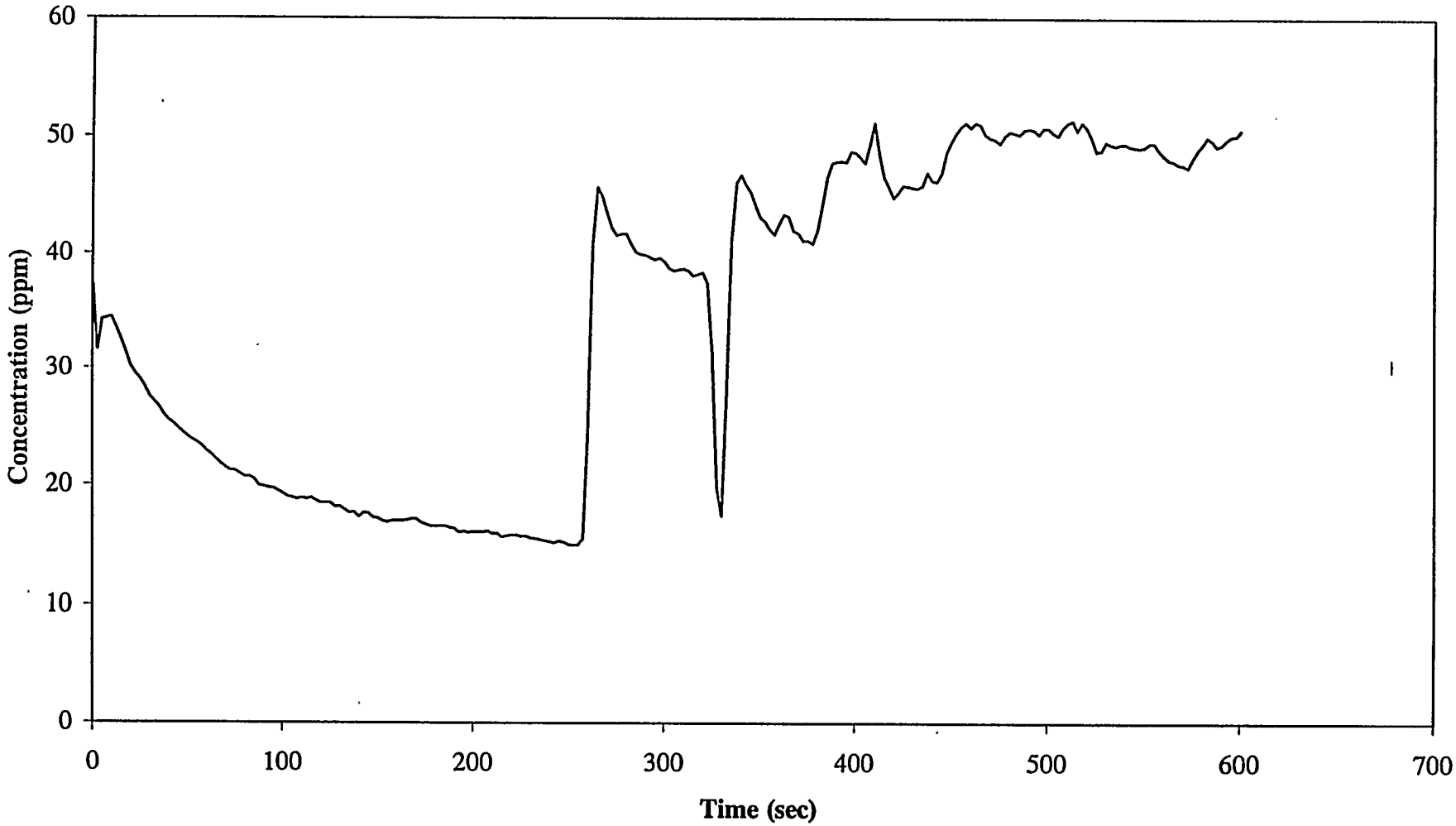



**Figure D.1-4**

*Failure was due to undersized catalyst/trap and overfueled engine (see text).

## Exhaust Manifold Backpressure Trace for First Regenerative Cycle on Lister-Petter with Failed* Rhomac/DCL System

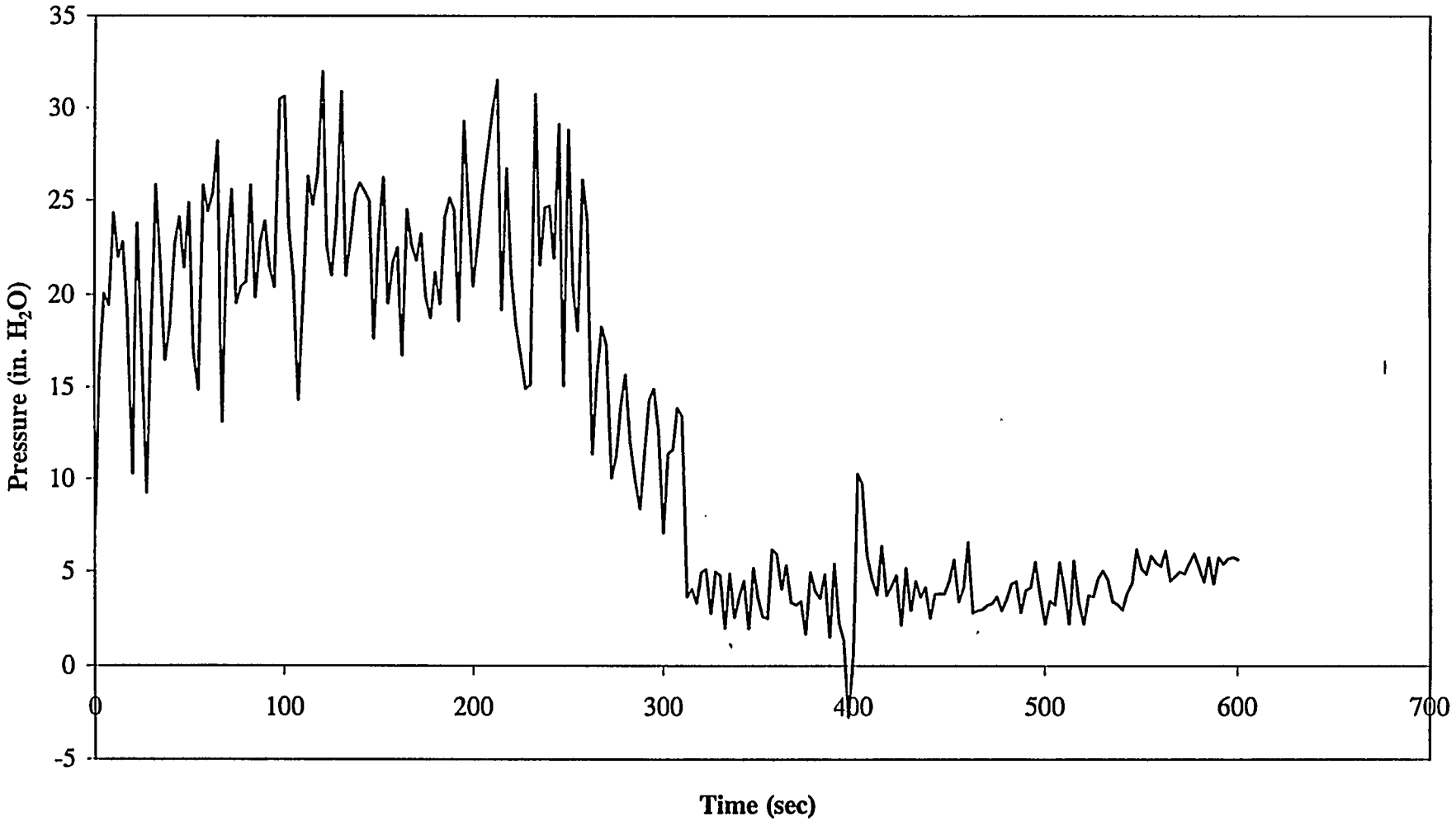



**Figure D.1-5**

*Failure was due to undersized catalyst/trap and overfueled engine (see text).

## Exhaust Gas Temperature Trace for First Regenerative Cycle on Lister-Petter with Failed* Rohmac/DCL System

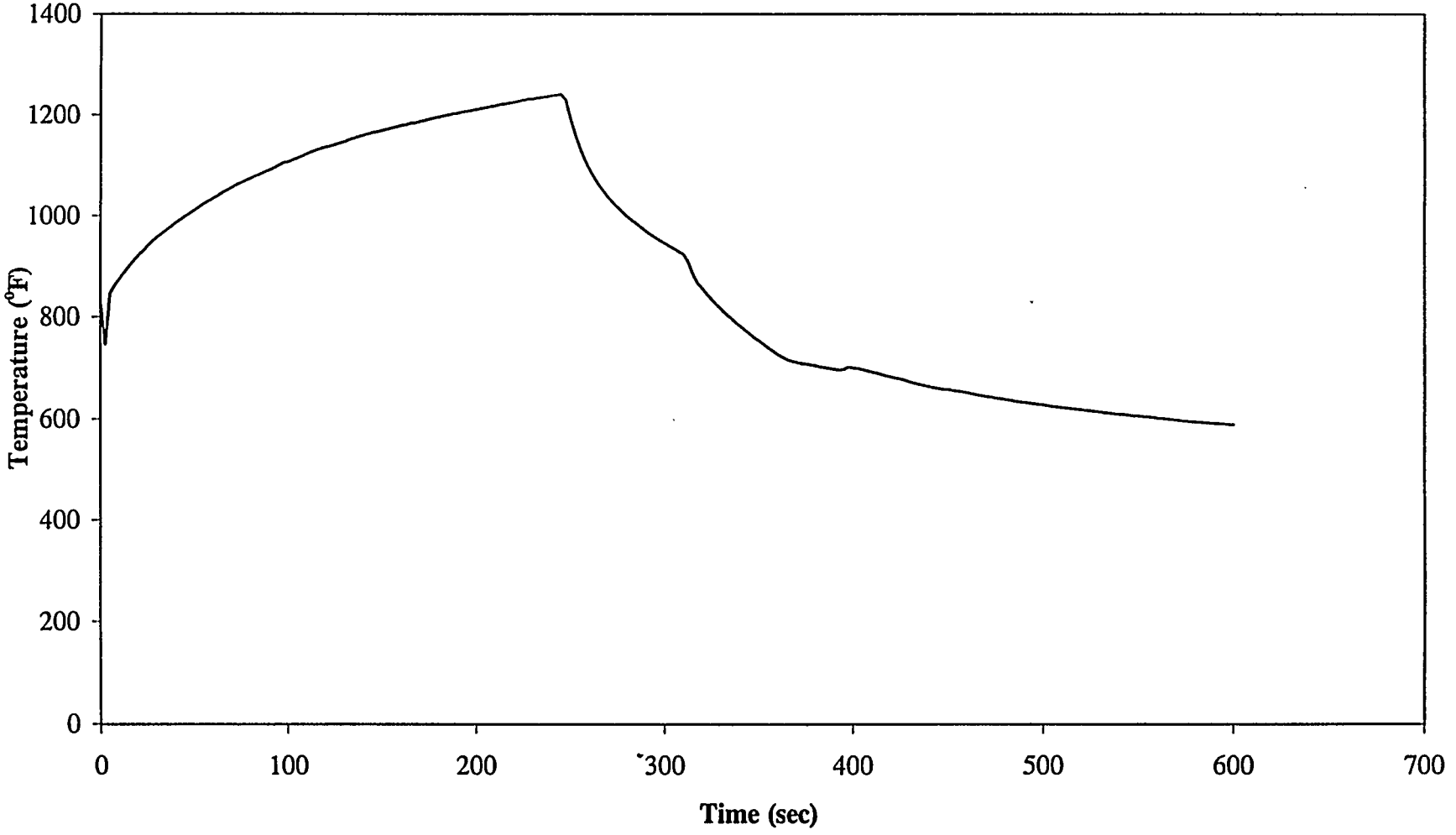



**Figure D.1-6**

*Failure was due to undersized catalyst/trap and overfueled engine (see text).

## HC Concentration Trace for Second Regenerative Cycle on Lister-Petter with Failed* Rohmac/DCL System

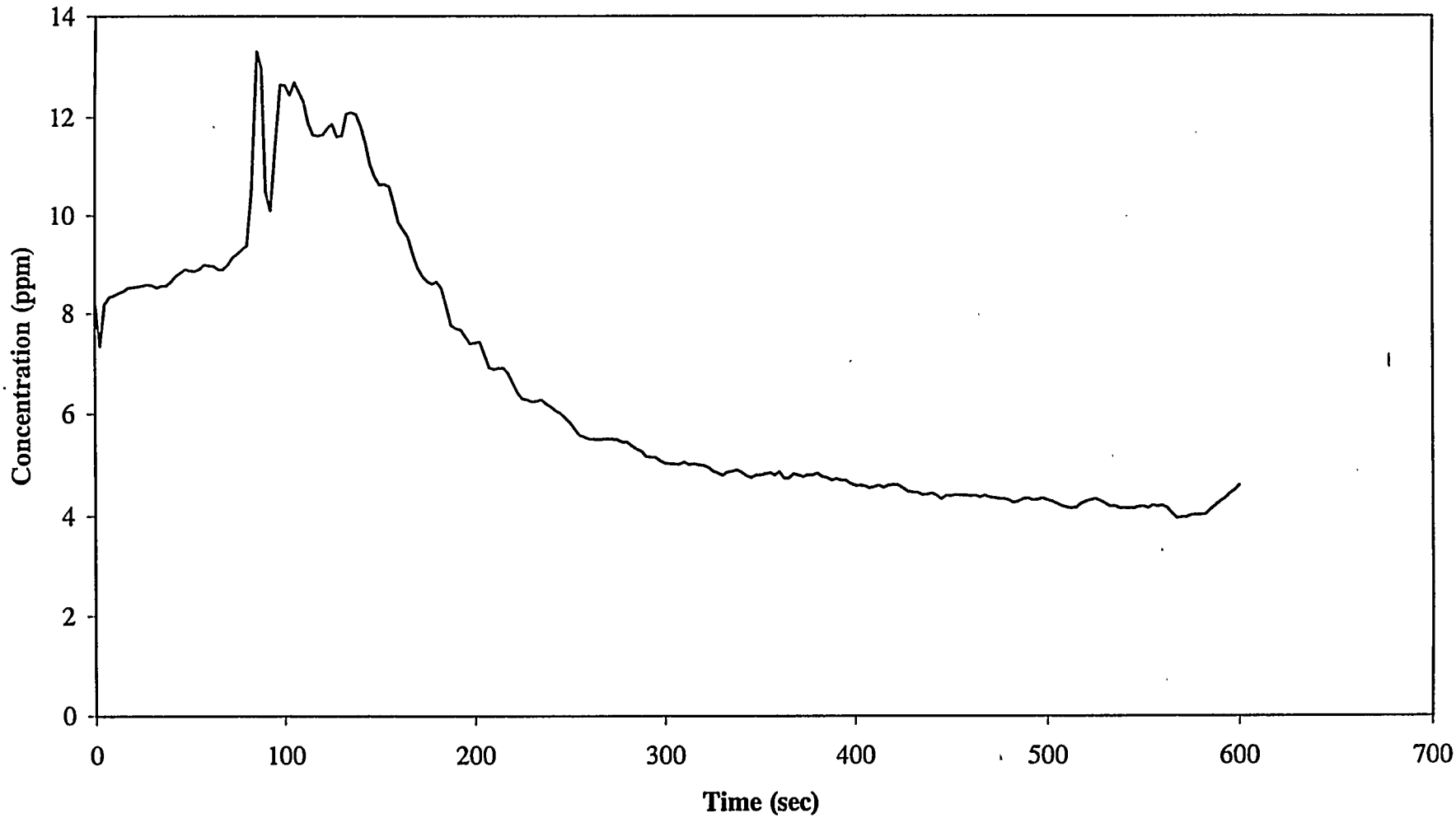



**Figure D.2-1**

*Failure was due to undersized catalyst/trap and overfueled engine (see text).

## CO Concentration Trace for Second Regenerative Cycle on Lister-Petter with Failed* Rohmac/DCL System

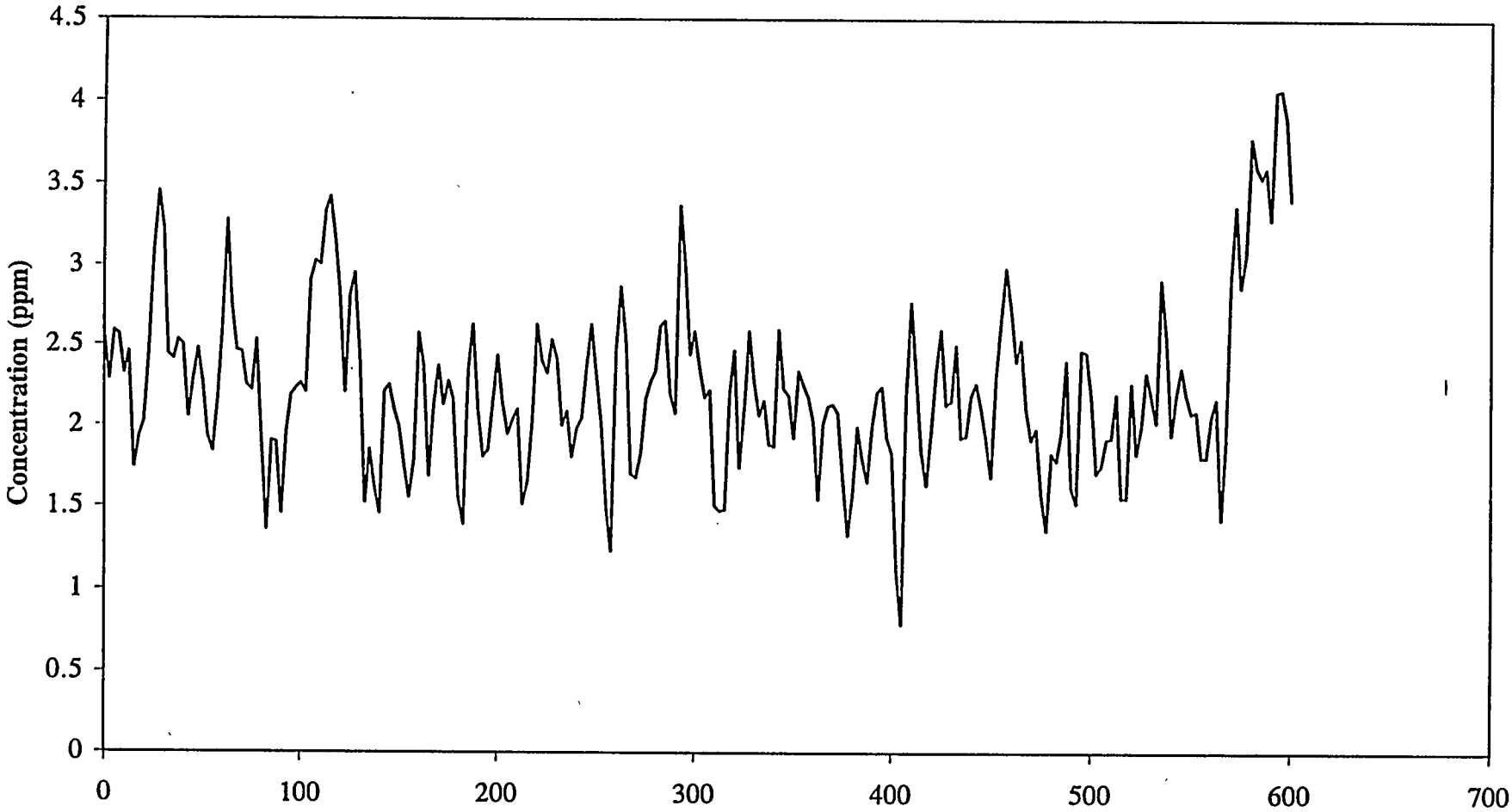



**Figure D.2-2**

*Failure was due to undersized catalyst/trap and overfueled engine (see text).

## CO2 Concentration Trace for Second Regenerative Cycle on Lister-Petter with Failed* Rohmac/DCL System

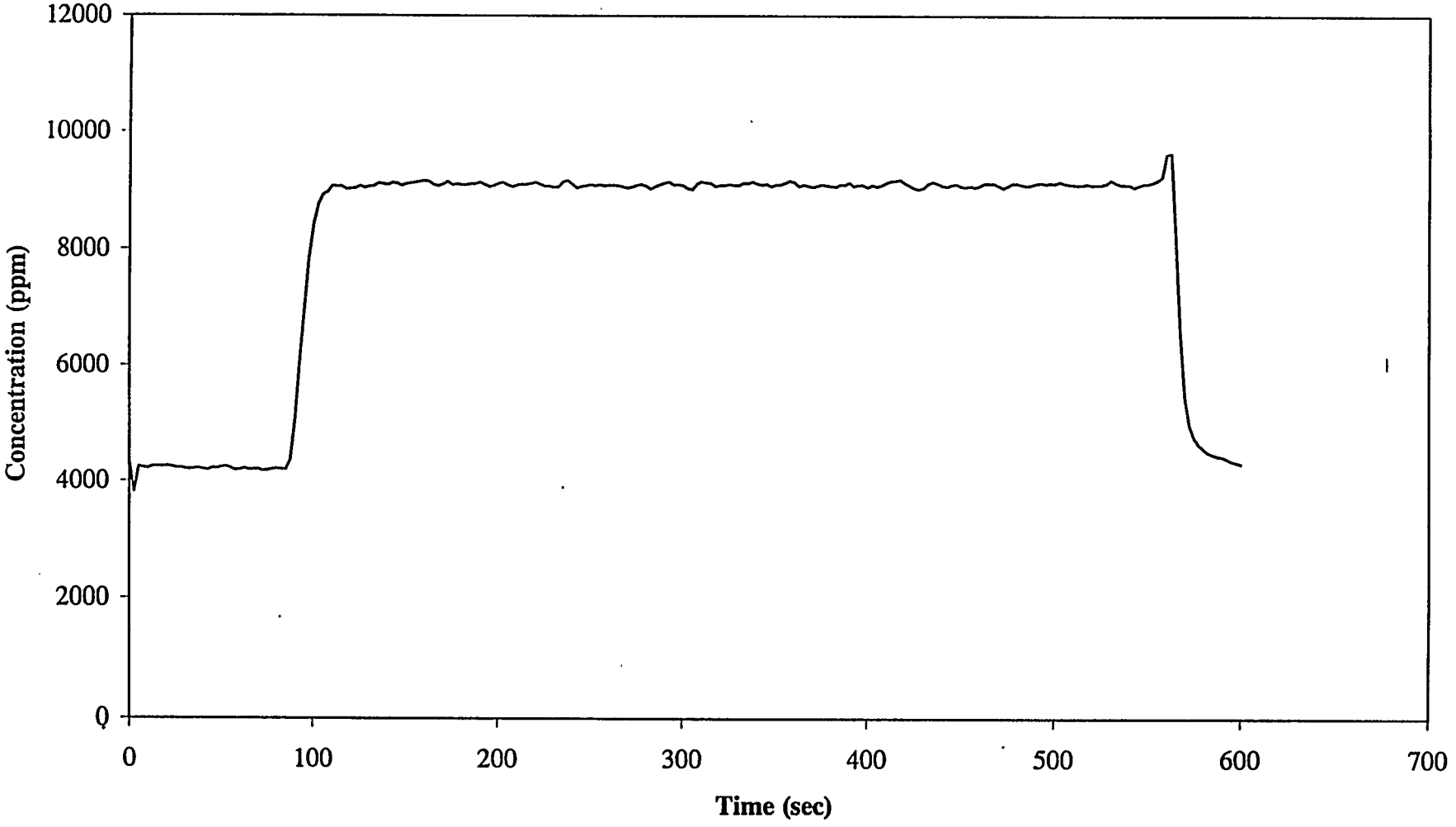



**Figure D.2-3**

*Failure was due to undersized catalyst/trap and overfueled engine (see text).

## NOx Concentration Trace for Second Regenerative Cycle on Lister-Petter with Failed* Rohmac/DCL System

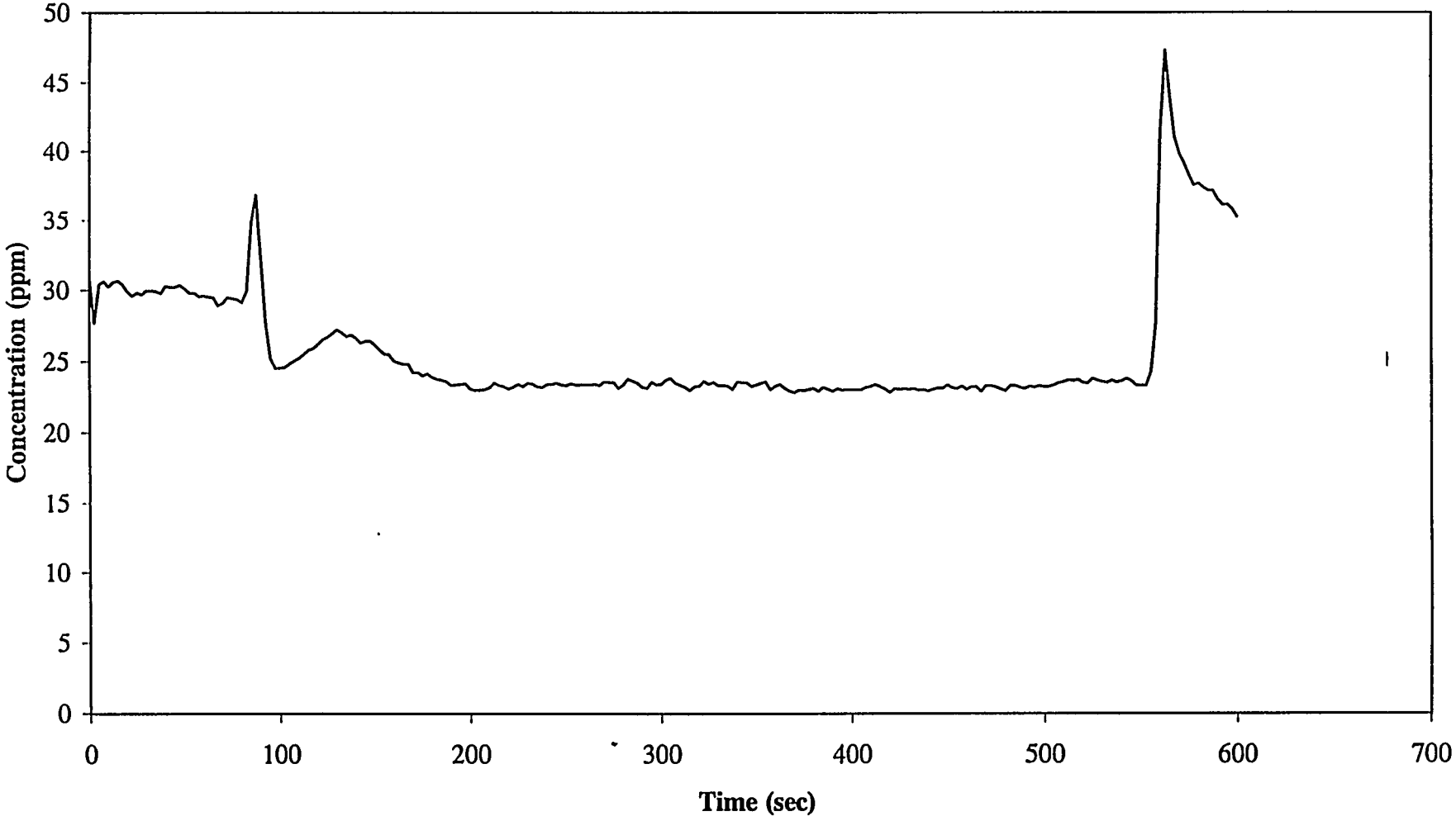



**Figure D.2-4**

*Failure was due to undersized catalyst/trap and overfueled engine (see text).

## Exhaust Manifold Backpressure Trace for Second Regenerative Cycle on Lister-Petter with Failed* Rohmac/DCL System

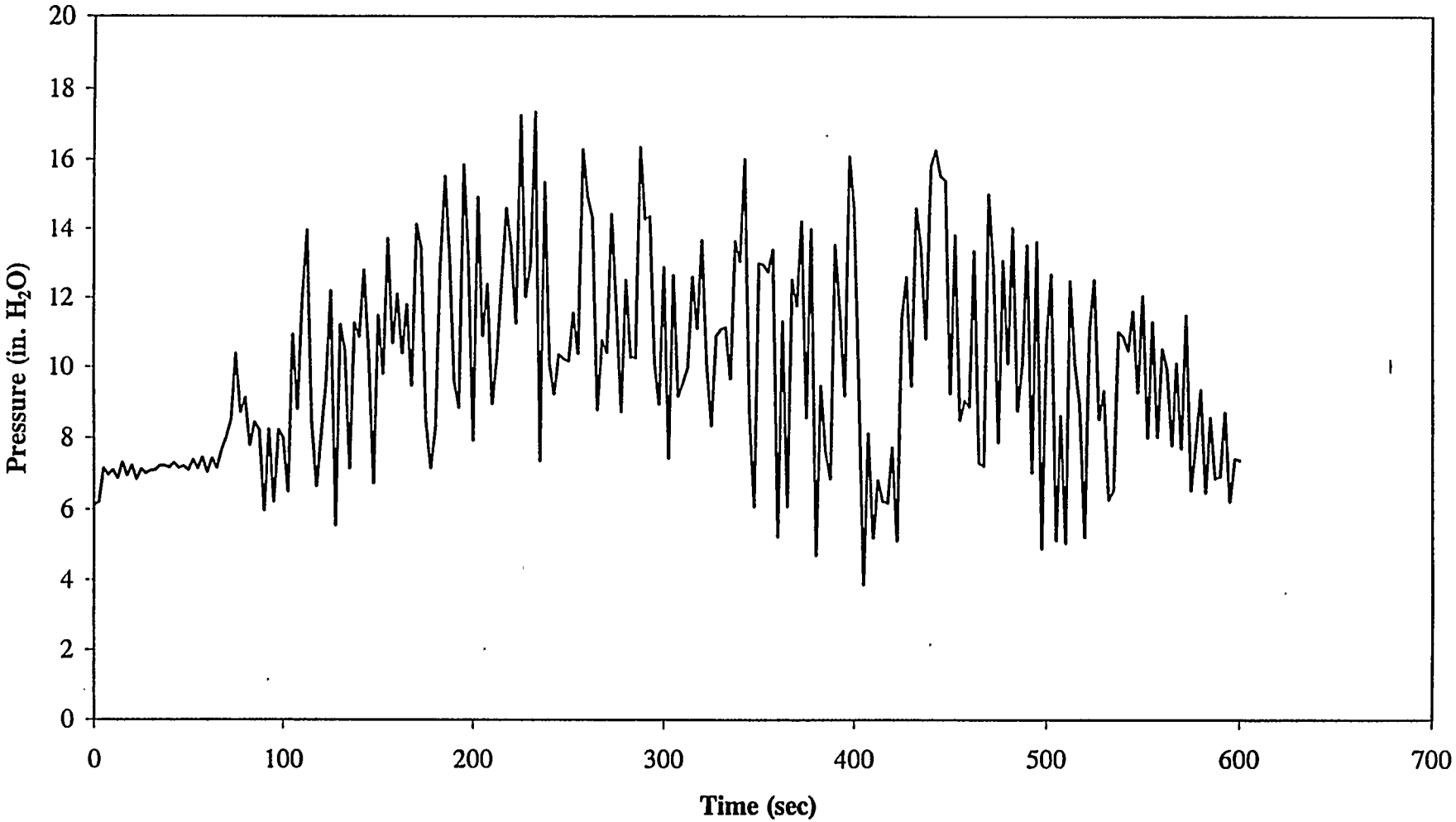



**Figure D.2-5**

*Failure was due to undersized catalyst/trap and overfueled engine (see text).

## Exhaust Gas Temperature Trace for Second Regenerative Cycle on Lister-Petter with Failed* Rohmac/DCL System

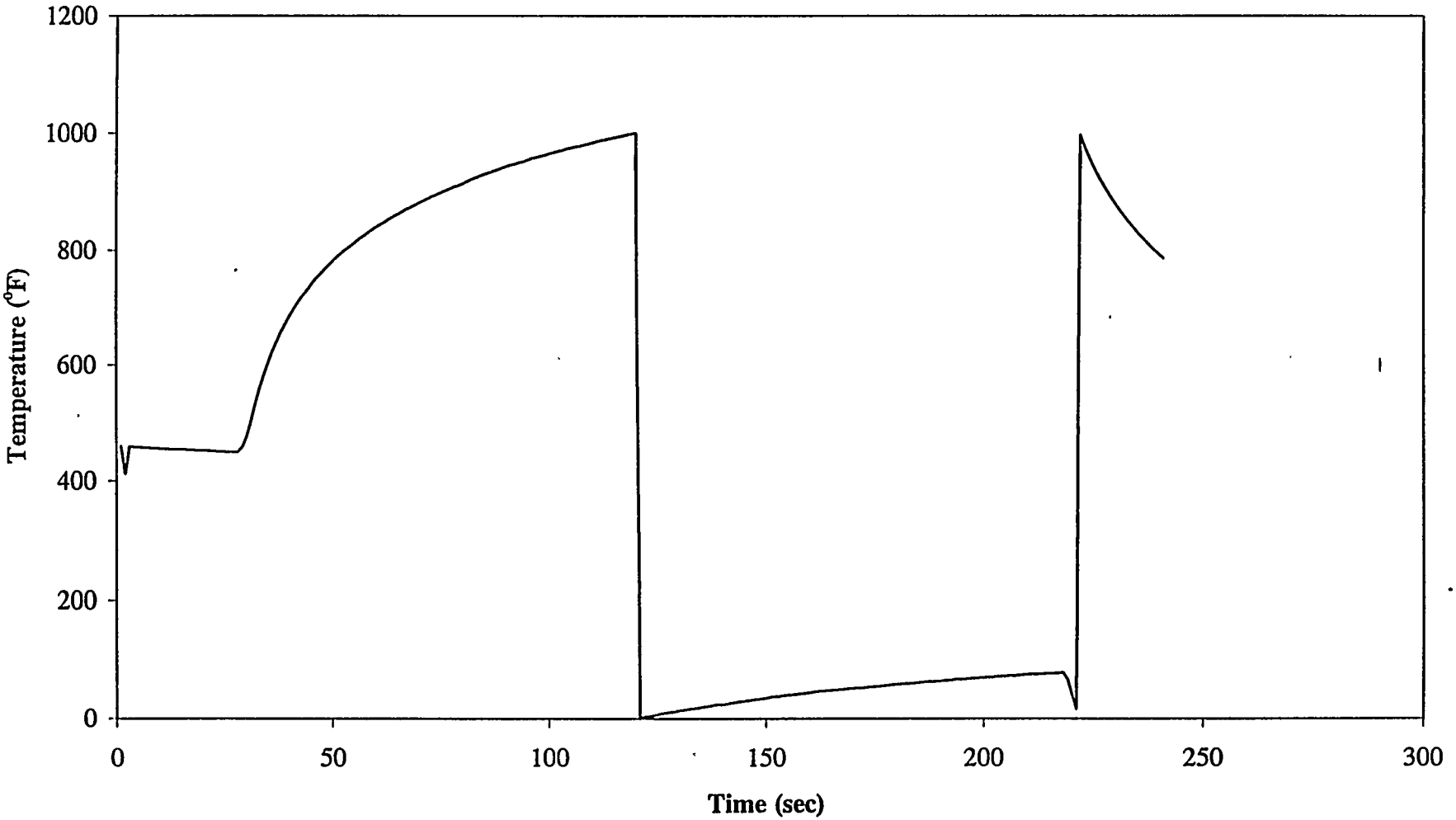



**Figure D.2-6**

*Failure was due to undersized catalyst/trap and overfueled engine (see text).

## HC Concentration Trace for a Regenerative Cycle on Lister-Petter with Rohmac/DCL System

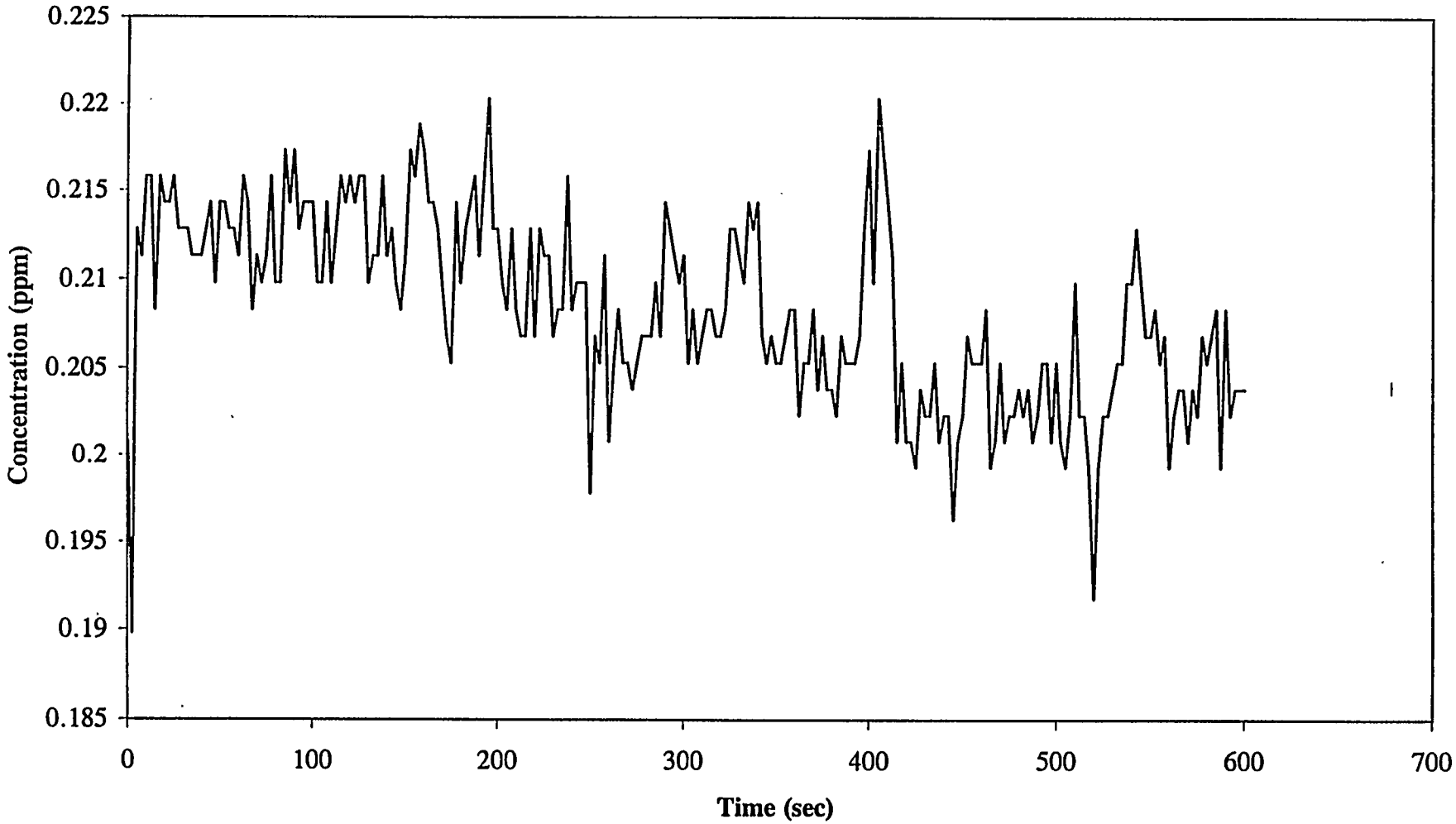



**Figure D.3-1**

## CO Concentration Trace for a Regenerative Cycle on Lister-Petter with Rohmac/DCL System

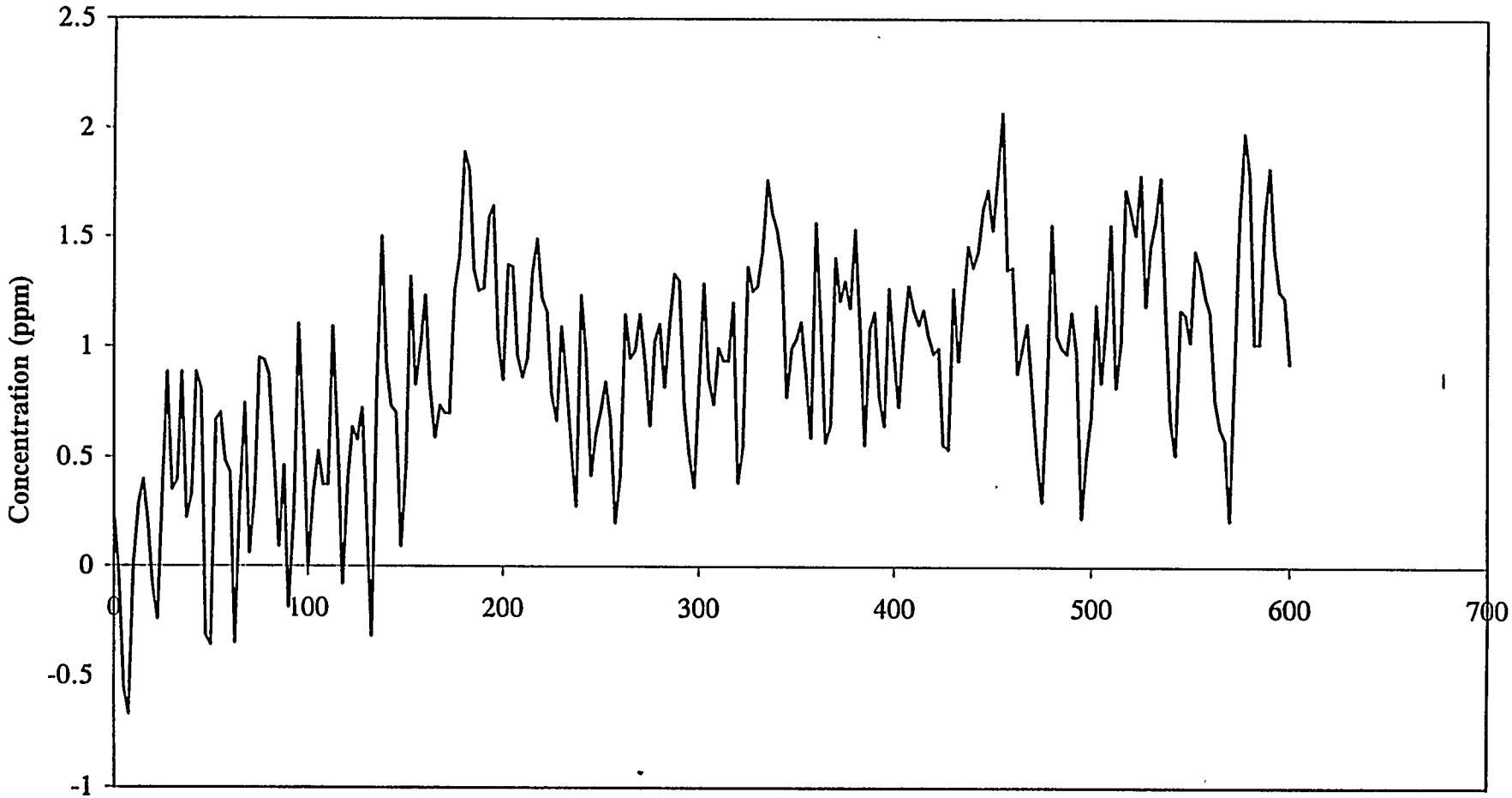



**Figure D.3-2**

## $CO_2$ Concentration Trace for a Regenerative Cycle on Lister-Petter with Rhomac/DCL System

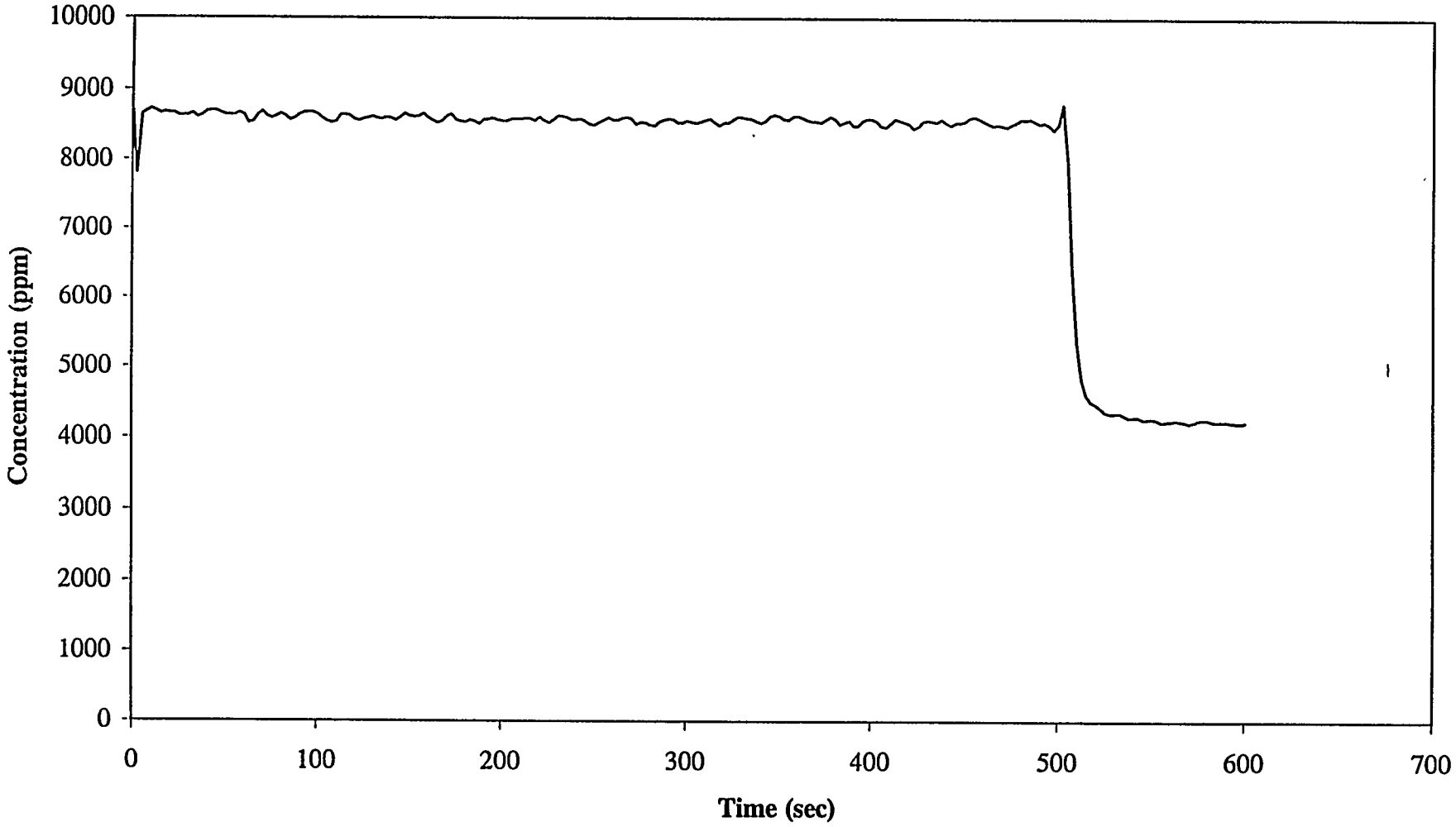



Figure D.3-3

## NOx Concentration Trace for a Regenerative Cycle on Lister-Petter with Rohmac/DCL System

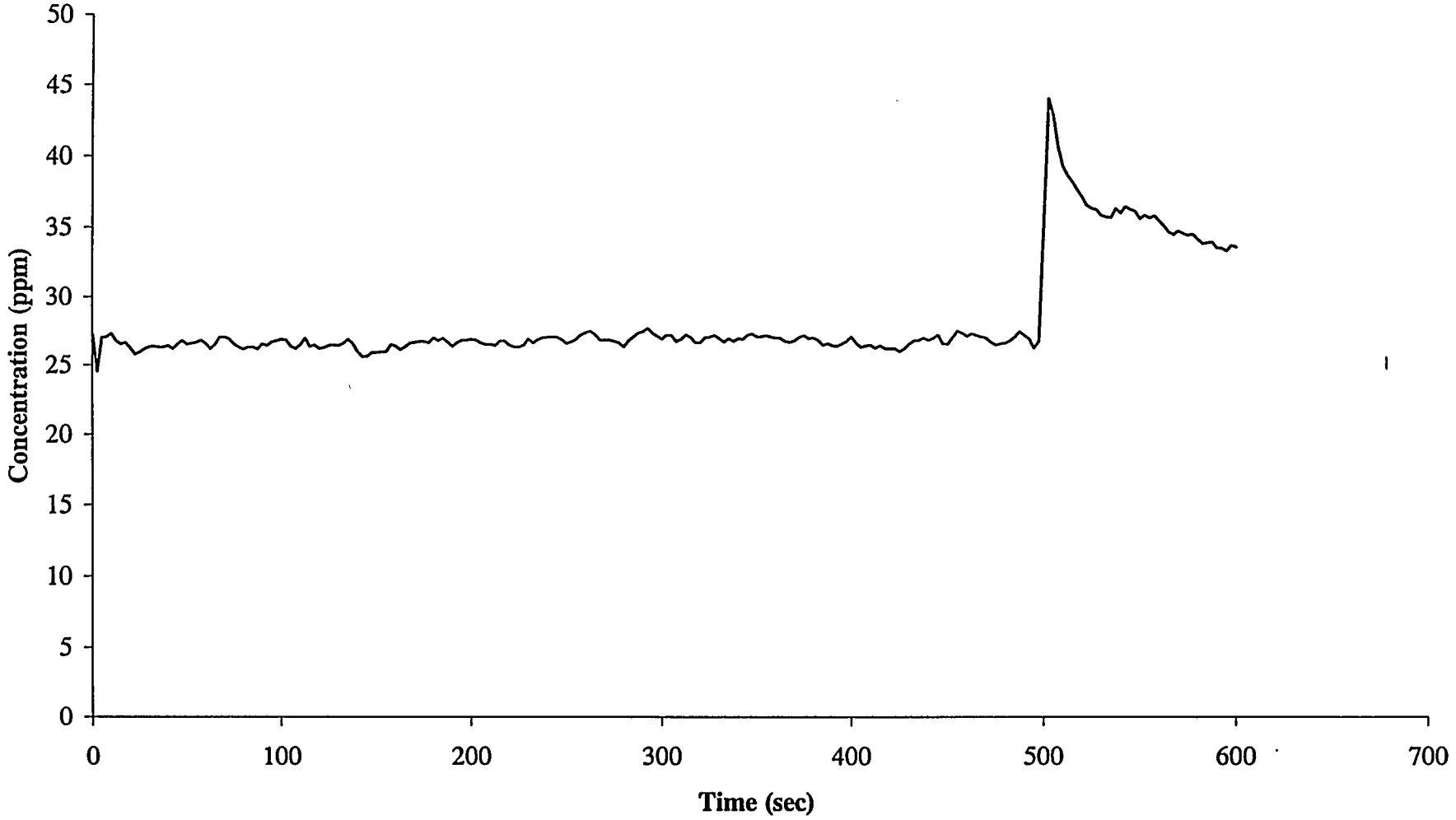



**Figure D.3-4**

## Exhaust Manifold Backpressure Trace for a Regenerative Cycle on Lister-Petter with Rhomac/DCL System

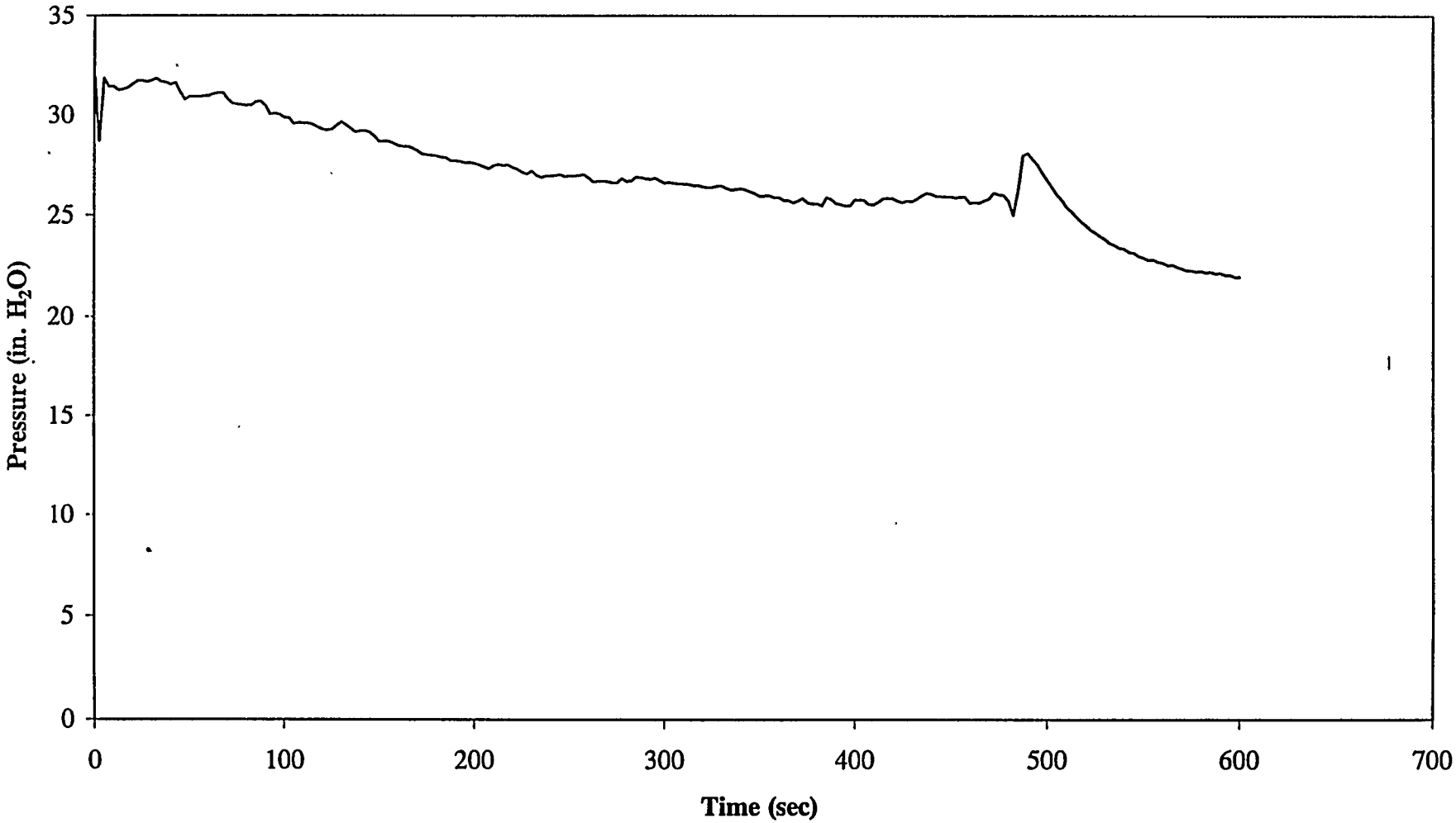



**Figure D.3-5**

## Exhaust Gas Temperature Trace for a Regenerative Cycle on Lister-Petter with Rhomac/DCL System

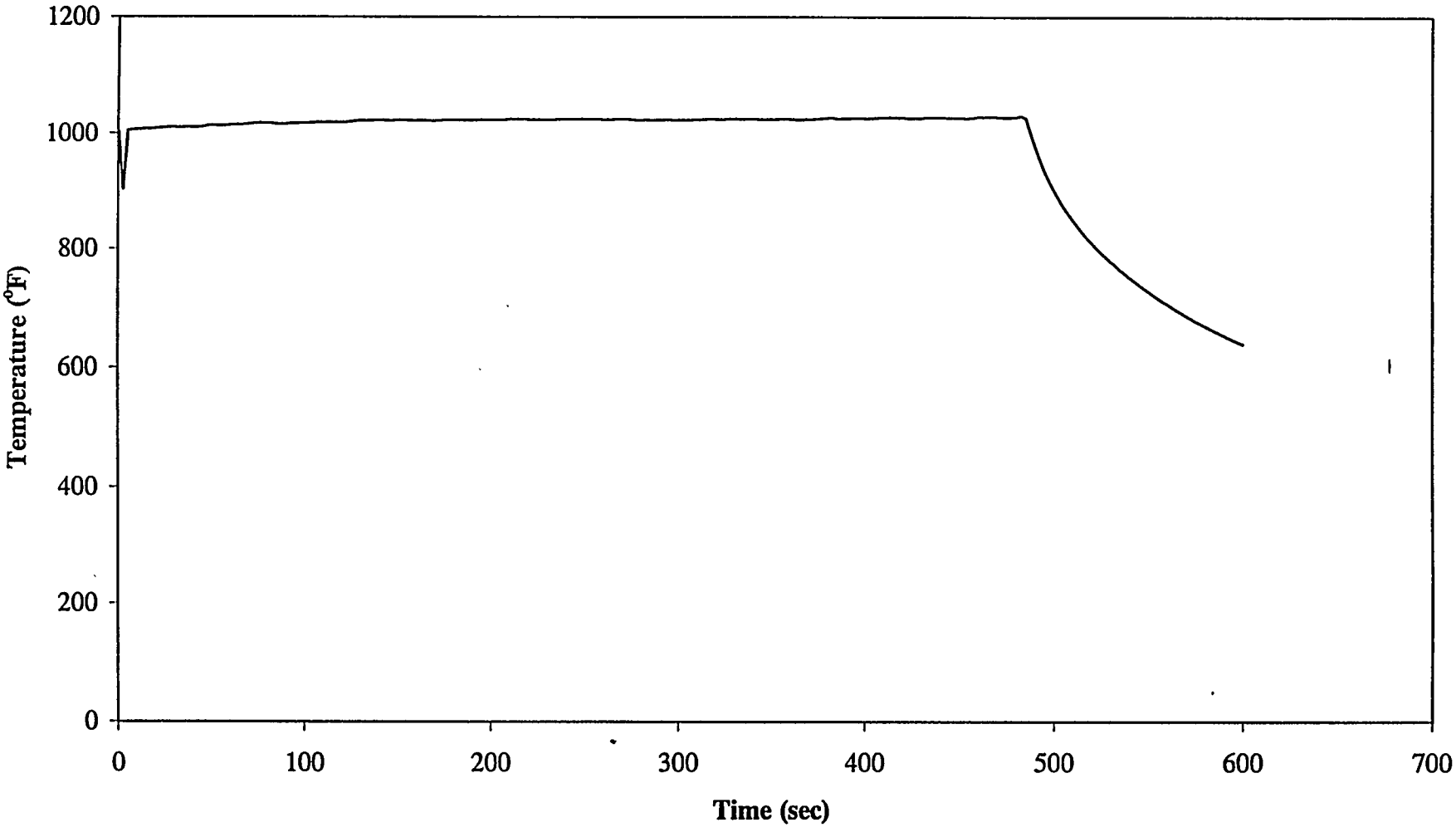



**Figure D.3-6**

# Appendix E

**goodman**
GOODMAN EQUIPMENT CORP

TONY BILITSKI
REGIONAL MANAGER

March 19, 1998

Ron Eberhart
Sr. Vice President
Goodman Equipment Corp.
5430 W. 70th Place
Bedford Park, Ill. 60638

Dear Ron,

Ron the following is synopsis of what happened on March 3rd and March 4th this week at WVU. Mr. Roger Fredrick from Beckwith performed all checks on the Cat 3306 engine serial # 23C2672 that had 41 hours recorded on the meter. Assisting with the testing was Mr. Dan Carder from WVU.

| Specifications to check | Findings/Reset Specifications |
|---|---|
| 1. Fuel rack setting discrepancy | Rack settings found: 3.35 mm full load<br>3.45 mm full torque<br><br>Reset rack settings to: 3.17 mm full load<br>3.25 mm full torque |
| 2. Check fuel injection timing | Timing found to be OK (perfect) by pin timing to engine. |
| 3. Check for engine blow-by. | Ran engine to operating temperature (1065 degrees F). We loaded engine and checked blow-by to be at 2" water. (4" water is the maximum spec.) |
| 4. Check for valve lash and valve timing | Found 2 intake valves 0.004 too tight. Adjusted to factory specification 0.015. Found all exhaust valves 0.004 too loose. Adjusted to factory specification 0.025. |
| 5. Check valve seals for leaks. | Taking into consideration the results of the previous tests (example: 1065 degree operating temp) and other specifications found, it could be determined with reasonable certainty that there are no leaking valve seals in this engine. |
| 6. Check spray patterns of injectors. | This check needed to be done at a test bench so the injectors had to be removed and then checked. All injectors tested to spec. |

| | |
|---|---|
| 7. Check opening pressure of injectors. | This check needed to be done at a test bench so the injectors had to be removed and then checked. Pressure tested at 700 to 750 psi. |

With items 6 & 7 completed, the injectors were then reinstalled. The engine was then run again to check for any fuel leaks. No leaks were found and the testing was considered complete.

I will be sending the original service reports from Caterpillar to your attention in Chicago.

Regards,
Tony

**CONSOL Inc.**
**RESEARCH & DEVELOPMENT**
**Rt. 19 S at Indian Creek**
**Morgantown, WV 26505**

# FACSIMILE TRANSMISSION

Date: June 11, 1998

No. of Pages (including cover): 2

| TO |
|---|
| Name: DR. GAUTAM |
| Company: MECH. & AEROSPACE ENGINEERING |
| Location: WVU |
| FAX No.: 293-6689 |
| Verification Phone No: 293-3111 |

| FROM |
|---|
| Name: PRAMOD THAKUR |
| R & D Phone No.: 304 983-3207 |
| Department: |
| FAX No.: (304) 983-3209 |
| Verification Phone No.: (304) 983-3201 |

Comments:

**goodman**

GOODMAN EQUIPMENT CORPORATION

RONALD D. EBERHART
Senior Vice President

Pl. Fax to
Dr. M. Gautam,
WVU.
6/11/98.

June 10, 1998

Mr. Pramod C. Thakur, Ph.D
Consol, Inc.
Research & Development
Route 1, Box 119
Morgantown, WV 26505-9799

Dear Pramod:

With reference to your inquiry on the condition of the CAT3306 engine and DST™ exhaust treatment package being tested at West Virginia University, we wish to inform you of the following findings.

1. The CAT3306 engine was inspected and adjusted by the local CAT dealer, Beckwith Machinery, and is to the best of our knowledge in proper running condition.

2. The DST™ exhaust treatment package was flushed by our local representative, Tony Bilitski, and necessary adjustments made to the filter housing lid, and is to the best of our knowledge in proper running condition.

If you should have any questions or require some additional information, please let us know and we will be pleased to help.

Yours very truly,

Ronald D. Eberhart
Senior Vice President
Mining

Enclosures

RDE:cd:Coast/Thakur

# Telefax Transmission


LISTER PETTER®

The right diesel for the job.™

IVECO aifo

December 17, 1997

To: Dan Carder

Company: University of West Virginia

Telefax No.: 304-293-6689

Pages: 2

Subject: Rohmac - LPU Emissions

From: Jack Echalier – Product Service Manager

Copied to: TJP RHS BAH

---

This is in response to Buck Lovern's request for base line emission data for the LPU2 engine that you are testing for Rohmac.

Please find attached some figures recently taken from an LPU3 engine. This 3-cylinder engine is identical in bore, stroke and fuel injection equipment to the 2-cylinder engine you are testing.

We should stress that these were obtained from a single engine test, and we cannot vouch for the accuracy or repeatability of these figures. We are providing them simply for you to compare with your own readings, and would ask you to keep them confidential.

If you need any further information please feel free to contact either Trevor Purnell, who is responsible for the Rohmac account, or Richard Soper, who is the engineer responsible for emissions, and who took the attached readings.

Regards,

Jack

Lister-Petter Inc.•815 E. 56 Highway•Olathe, Kansas 66061-4914 USA•Telephone: 913/764-3512•Telefax 913/764-5433

# EXHAUST EMISSIONS
## LISTER-PETTER MINE PUP
## MODEL LPU-3

Date: 15 December 1997
S/N: 4700028LPU3A801
Barometer: 29.23" Hg

Dry Bulb: 75°F
Wet Bulb: 58°F
Rel. Hum.: 35%

| Speed | Load Factor | BHP Advertised | BHP Observed | Torque Observed | Speed Observed | O2 % | CO2 % | CO ppm | NO ppm | NO2 ppm | SO2 ppm | CxHy % | Exc. Air |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3200 RPM | 100% | 28.8 | 29.5 | 18.2 lbf | 3240 rpm | 13.8 | 5.5 | 490 | 429 | 15 | 22 | 0.02 | 2.73 |
| | 75% | 21.6 | 22.9 | 13.8 lbf | 3316 rpm | 16.4 | 3.3 | 303 | 351 | 42 | 0 | 0 | 4.67 |
| | 50% | 14.4 | 15.4 | 9.2 lbf | 3355 rpm | 20 | 0.7 | 298 | 207 | 57 | 0 | 0 | 26.25 |
| | 0% | 0 | 0 | 0 | 3375 rpm | 21 | N/R | 505 | 65 | 55 | 0 | 0 | N/R |
| 2200 RPM | 100% | 23.3 | 24.1 | 21.3 lbf | 2263 rpm | 10.9 | 7.5 | 704 | 398 | 6 | 34 | 0.03 | 2.04 |
| | 75% | 17.5 | 18.2 | 16.3 lbf | 2350 rpm | 15.5 | 4.1 | 999 | 495 | 59 | 0 | 0.03 | 3.82 |
| | 50% | 11.7 | 12.9 | 10.7 lbf | 2418 rpm | 20.6 | 0.3 | 302 | 422 | 66 | 0 | 0.01 | N/R |
| | 0% | 0 | 0 | 0 | 2498 rpm | 21 | N/R | 295 | 102 | 64 | 0 | 0 | N/R |
| 2000 RPM | 100% | 21.3 | 22.1 | 21.6 lbf | 2045 rpm | 9.8 | 8.3 | 792 | 374 | 4 | 15 | 0.01 | 1.86 |
| | 75% | 16 | 17.8 | 16.3 lbf | 2179 rpm | 15.4 | 4.2 | 816 | 493 | 56 | 0 | 0.02 | 3.82 |
| | 50% | 10.7 | 12.2 | 10.8 lbf | 2250 rpm | 20.5 | 0.4 | 629 | 470 | 76 | 21 | 0.03 | 52.5 |
| | 0% | 0 | 0 | 0 | 2333 rpm | 21 | N/R | 254 | 119 | 50 | 0 | 0 | N/R |
| 970 RPM | 0% | 0 | 0 | 0 | 970 rpm | 21 | N/R | 56 | 507 | 65 | 0 | 0 | N/R |

CALIBRATION CHECK

| | | | | |
|---|---|---|---|---|
| Pre-Test: Span Gas | 897.5 | 1006 | 95.2 |
| Instrument Reading | 920 | 1015 | 109 |
| Post-Test: Span Gas | 997.5 | 1006 | 95.2 |
| Instrument Reading | 993 | 1009 | 98 |

Emissions Analyzer is an ECOM-AC, utilizing electro-chemical sensor cells. Probe was fitted 3 inches from exhaust manifold outlet, perpendicular to flow, in 1.5"NPT pipe. Dynamometer is a Carl Schenck water-brake; BHP = lbf torque x RPM / 2000.



FAX BY:OLATHE, KANSAS ;12-17-97 ; 2:45PM ; LISTER-PETTER INC.→ 913042936689;# 2/ 2

MSHA ID & CERT. 24/D

# TECHNICAL DATA

## QD-60-301 MC
## MSHA PART 32 (SCHEDULE 24) CERTIFIED

| | | | |
|---|---|---|---|
| **General** | | | |
| Output (SAE-J 816b) | | | |
| MSHA Part 32 Certified | | | |
| Intermittent ratings | Gross BHP/min$^{-1}$ | | 57/3000, 48/2500 |
| | Net BHP/min$^{-1}$ | | 53/3000, 47/2500 |
| Mine ventillation Rqd. | CFM | | 5500/3000, 5000/2500 |
| Number of cylinder | | | 4 |
| Displacement | cm$^3$ | | 2.369 |
| Moment of inertia GD$^2$ | kgm$^2$ | | 1 772 |
| Speed droop | | | |
| Permanent for genset | % | | 4 5 |
| Idle rpm | min$^{-1}$ | | 700 |
| No load max rpm | min$^{-1}$ | | 3260 |
| **Cooling system** | | | |
| Water discharge volume of water pump at 80°C coolant temperature | lit/min | | 51/1500. 61 1800. 100 3000 |
| Thermostat | | | |
| Opening temperature | °C (F°) | | 76.5 (170) |
| Fully opened temperature | °C (F°) | | 90 (194) |
| Top tank temperature | | | |
| Normal | °C (F°) | | 80 — 85 (176 — 185) |
| Max allowable | °C (F°) | | 95 (203) |
| Min. allowable radiator cap pressure | kg/cm$^2$ (psi) | | 0 5(7) |
| Heat rejection | MJ/min | | 1.46/1500, 1.71/1800, 2.14/2500, 2.37/3000 |
| | BTU/min | | 1384/1500, 1620/1800, 2025/2500, 2250/3000 |
| Cooling water capacity (engine only) | lit.(Qts) | | 5.2 (5.5) |
| **Air intake system** | | | |
| Inlet restriction | | | |
| Air cleaner | | Medium Duty | Heavy Duty |
| Dry type with precleaner | mmH2O | 250 | — |
| Dry type with precleaner and safety element | mmH2O | 300 | 250 |
| Max. allowable inlet restriction with dirty air filter element | mmH2O | 635 | 635 |
| Air flow | m$^3$/min | 1 51/1500. 1 81/1800. 3 02/3000 | |
| **Exhaust system** | | | |
| Exh. back pressure | mmHg | 75 | |
| Exh. pipe | | | |
| Min allowable internal diameter | mm | 45 | |
| Exh. temperature | °C | 480/1500. 510/1800. 660/3000 | |
| Exh. gas flow | m$^3$/min | 3 8/1500. 4 8/1800. 9 4/3000 | |
| **Lubrication system** | | | |
| Standard oil pan capacity | lit | 5 5 | |
| Oil pressure | kg/cm$^2$ | 1 5 — 2/idle. 4 0/1500. 4 1 1800. 4 3/3000 | |
| Angularity limits of std oil pan | deg | Front up 35. Front down 35. Side to side 35 | |
| **Fuel system** | | | |
| Feed pump suction head | m | 1 | |
| Fuel pipe min allowable internal diameter | mm | 8 | |
| **Electrical system** | | | |
| Max allowable resistance of starting circuit | mΩ | 1 | |
| Recommended battery capacity | AH | 12 — 100 | |
| **Power take off** | | | |
| Front P T O | kgfm | 7 5 | |

# ISUZU DIESEL

## OF NORTH AMERICA INC

DIESEL ENGINES

NOVI, MICHIGAN

## ENGINE PERFORMANCE

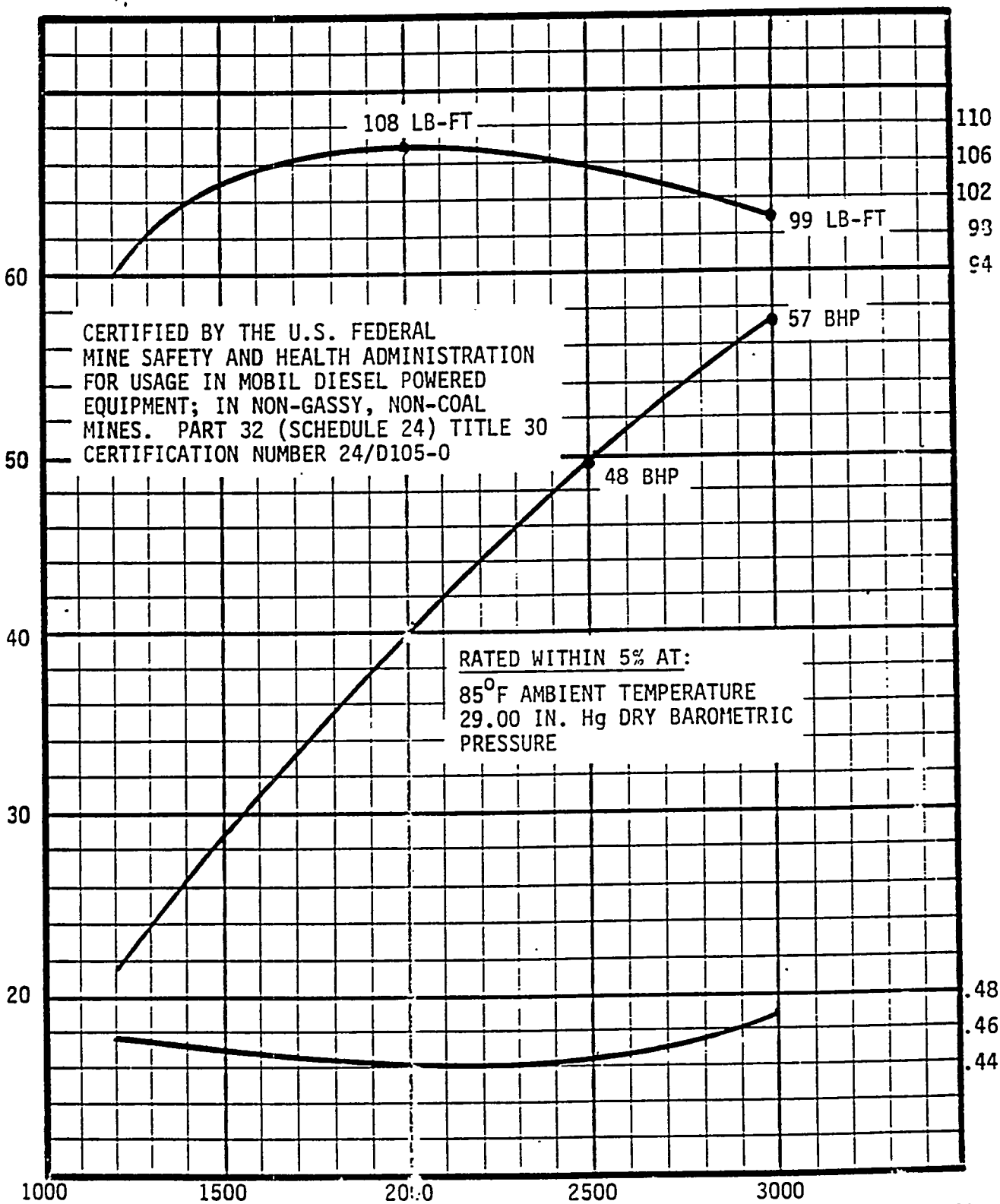
MODEL: QD-60

2.4L-4 CYL PRECOMBUSTION

APPLICATION: UNDERGROUND MINES

MSHA-PART 32-CERTIFIED

CONDITIONS: SAE-J816b-GROSS BHP




CURVE NO: 2.4-301-SG-161

SEPTEMBER 1. 1982

# C240 SPECIFICATIONS

| | | | | | |
|---|---|---|---|---|---|
| Type | 4 cylinder, four cycle, water-cooled, overhead valve, vertical in-line, indirect injected. | | | | |
| Piston displacement | 2369 cm³ (145 CID) | | | | |
| Performance (*Rating, SAE J816b) | | PART 32 (Schedule 24) | | PART 36 (Schedule 31) | |
| | RPM | BHP* | VENT (CFM) | BHP* | VENT. (CFM) |
| | 3000<br>2500 | 57<br>48 | 5500<br>5000 | 52<br>43 | 5500<br>4500 |
| Engine rotational direction | Counter clockwise as viewed from flywheel. | | | | |
| Engine starting method | Electric starter motor; gear reduction type. | | | | |
| Engine stop method | Fuel cut-off lever located on governor. | | | | |
| Compression ratio | 20:1 | | | | |
| Dimensions (LxWxH) | 800mm (31.5 in) x 535mm (21.1 in) x 694mm (27.3 in) | | | | |
| Air intake system | Naturally aspirated | | | | |
| Engine mounting system | Four point support-Front; engine feet mounted to RH & LH side of block. Rear: RH & LH side FW HSG mt. pads. | | | | |
| Firing order | 1-3-4-2 | | | | |
| Fuel used | Diesel fuel | | | | |
| Polarity & voltage of electric sys. | Negative grounding 12V. | | | | |
| Lubrication oil capacity | Max 4.3 lit (4.5 qts) Min 3.5 lit (3.7 qts) | | | | |
| Coolant capacity | 5.2 lit (5.5 qts) engine only. | | | | |
| Dry weight | 223 kg (492 lbs) | | | | |

| | |
|---|---|
| Type | Cast iron; monoblock type. Five main bearing support. Aluminum alloy crankcase; removable type. Integrated water delivery pipe and lube oil gallery. |
| Cylinder liner | Chromard press-in liner, 1mm (.0394 in) thick. Chromium plated dry liner. |

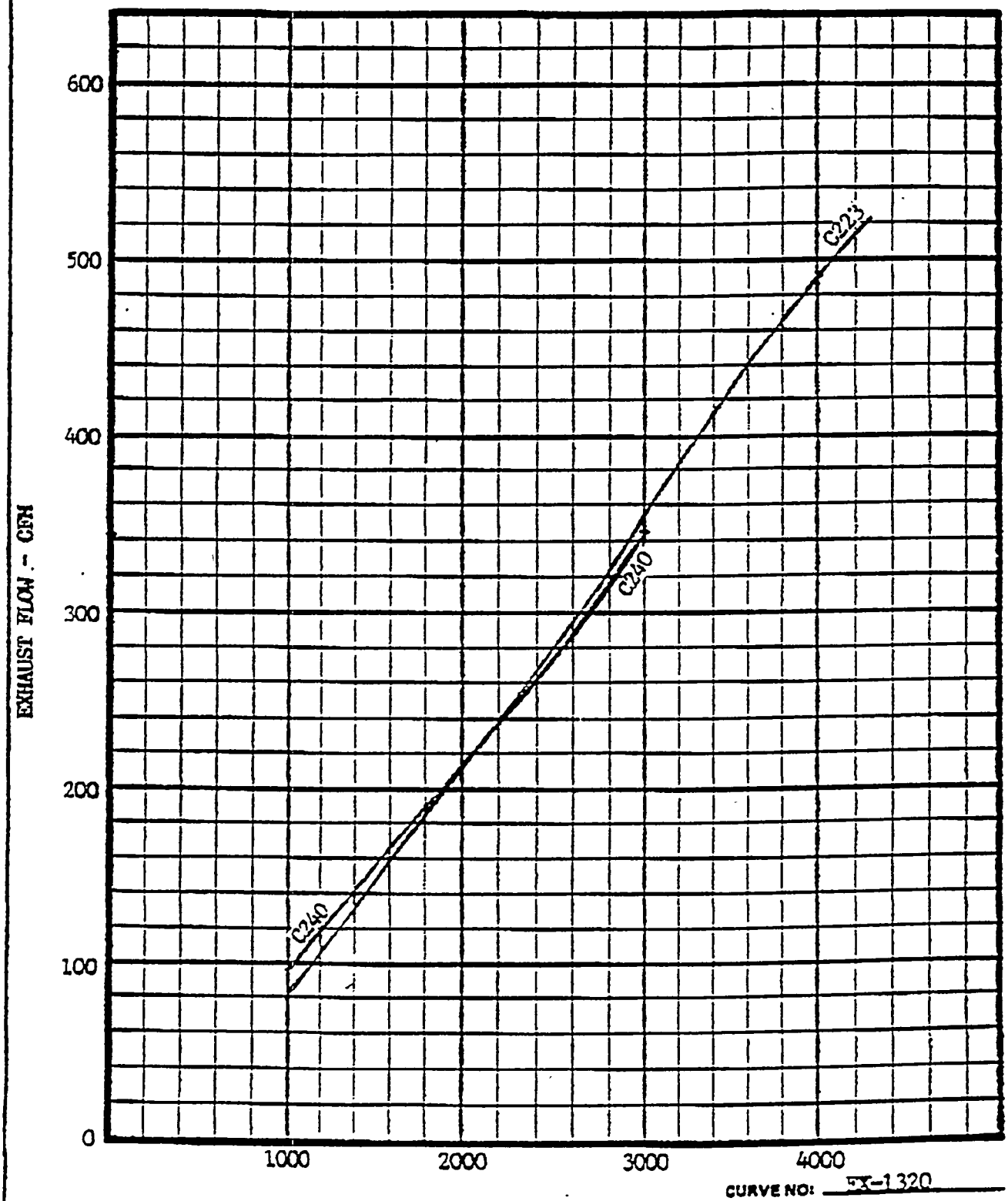
| | |
|---|---|
| Type | Cast iron; monoblock type. Overhead valve, two valves per cylinder, (one intake, one exhaust). Containing swirl combustion chambers, glow plugs & injections nozzle within the head assembly. |
| Cylinder head cover | Die cast aluminum alloy. Bolt mounted |
| Inlet Manifold | Cast aluminum alloy. Flange; two stud, ctr upwd. LH side engine. |
| Exhaust Manifold | Cast iron alloy. Flange; three stud, Frt upward LH side engine. |
| Thermostat housing | Die cast aluminum alloy, mounted on front of cyl head. |

# ISUZU DIESEL
## OF NORTH AMERICA INC
NOVI, MICHIGAN

EXHAUST FLOW AT FULL LOAD

C SERIES ENGINES

C223
C240 (QD-60)




CURVE NO: EX-1320

DATE: FEB. 20, 1987

# ISUZU DIESEL

## OF NORTH AMERICA INC

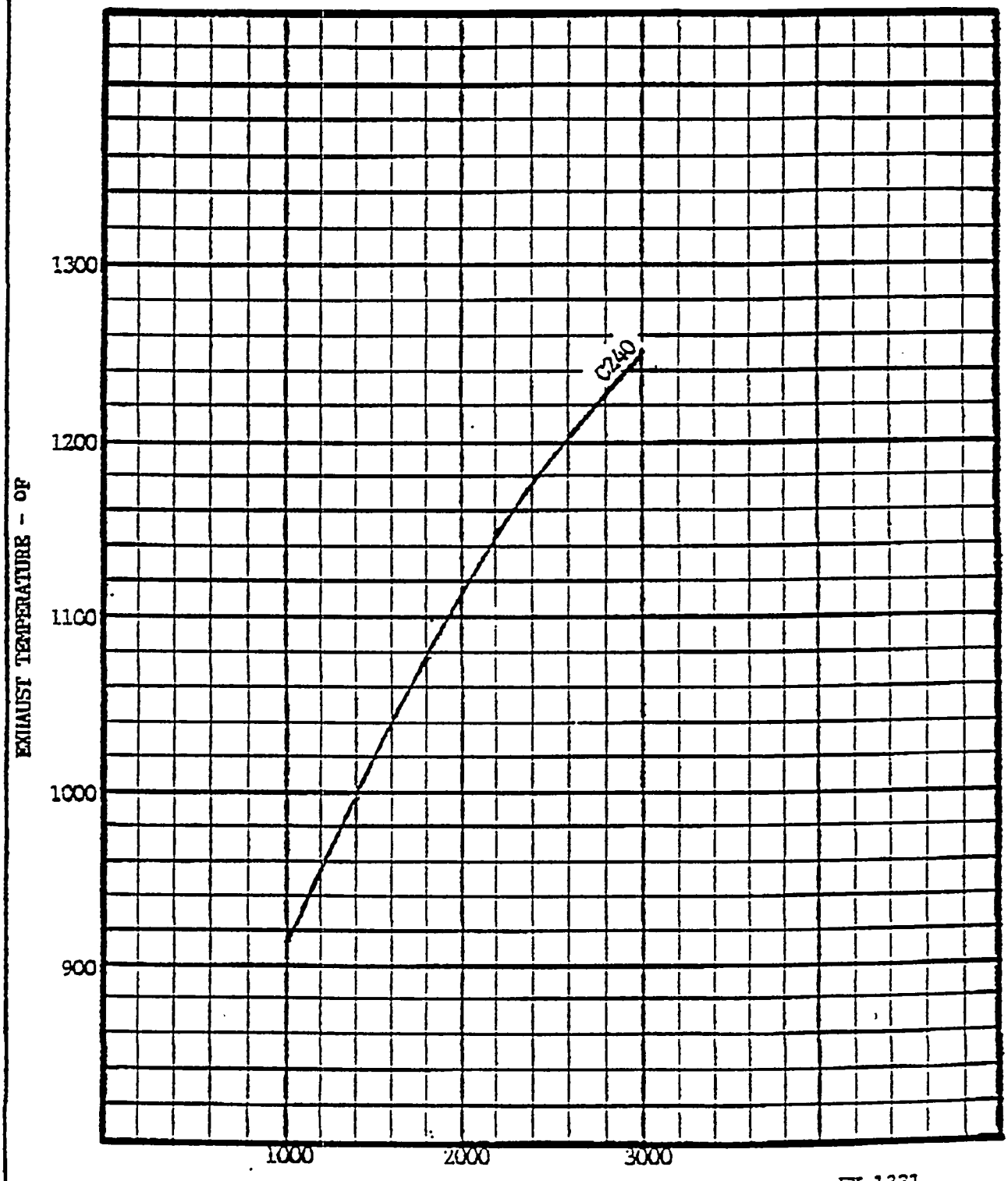
NOVI, MICHIGAN

DIESEL ENGINES

## EXHAUST TEMPERATURE AT FULL LOAD

C SERIES ENGINES

C240 (QD-60)




CURVE NO: EX-1331

DATE: FEB. 20, 1987

# ISUZU DIESEL

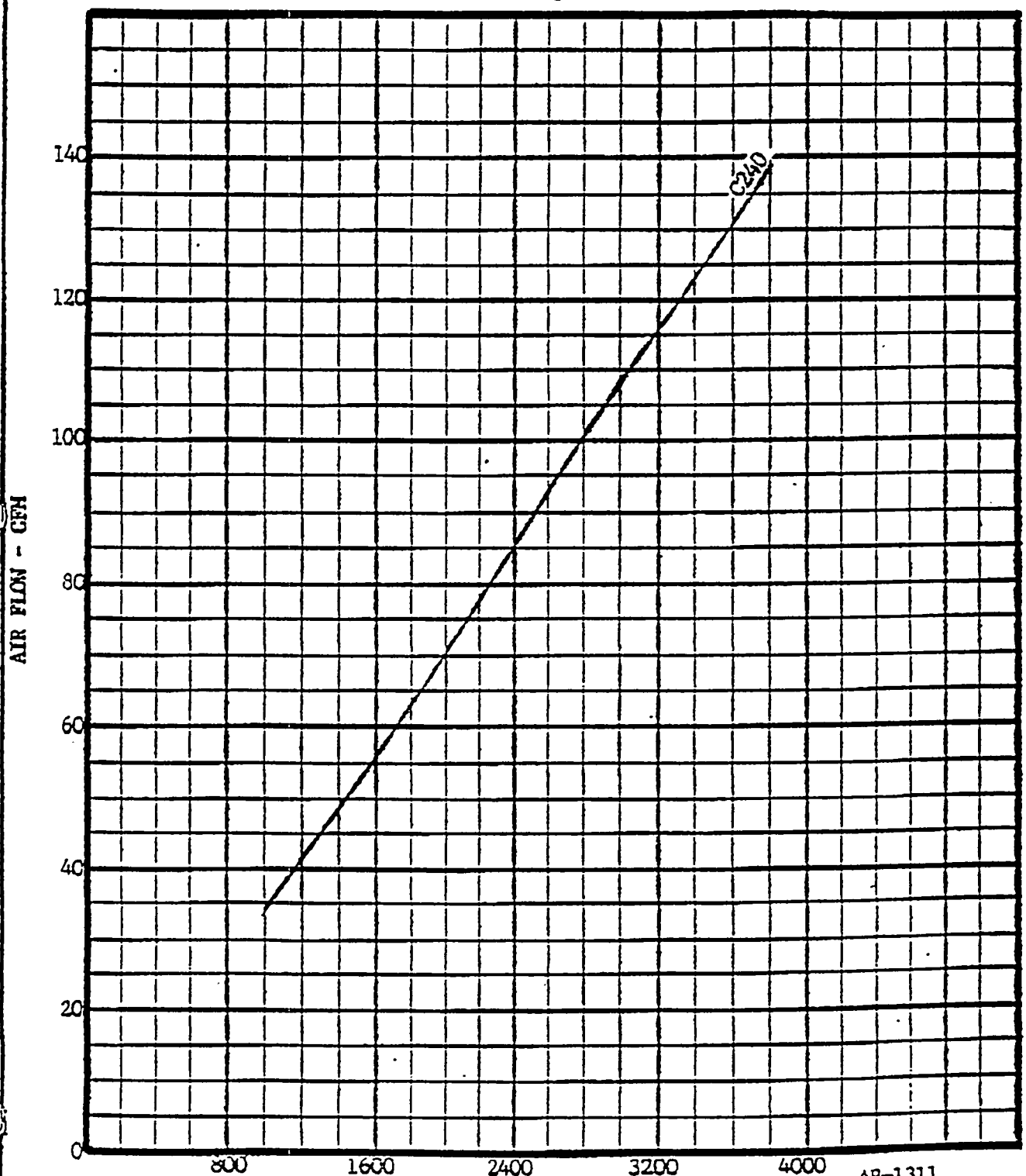
## OF NORTH AMERICA INC

NOVI, MICHIGAN

INTAKE AIR FLOW FOR COMBUSTION

C SERIES ENGINES

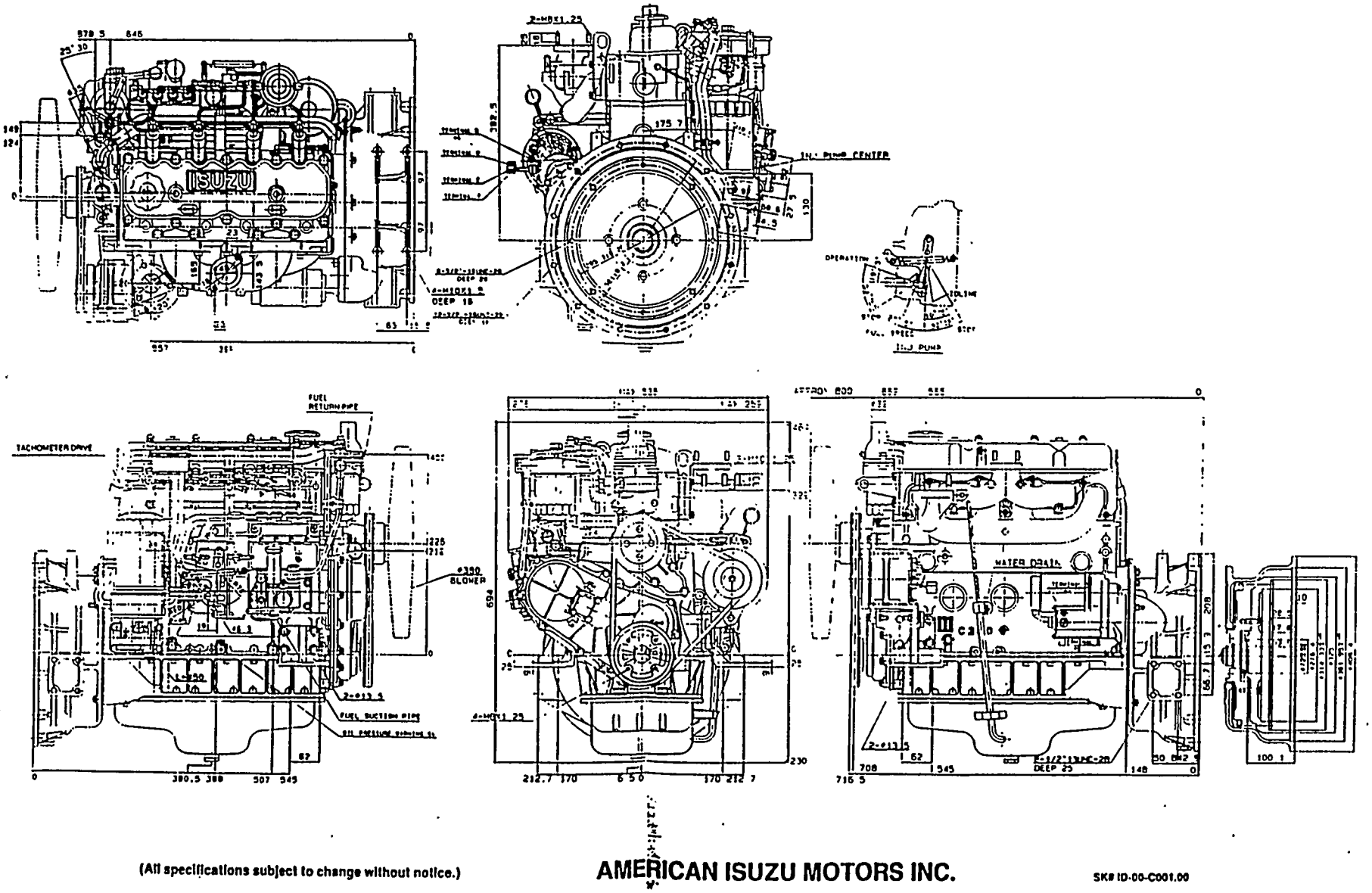
C240 (QD-60)




CURVE NO: AR-1311

DATE: FEB. 20, 1987

# ISUZU DIESEL ENGINE MODEL C240PW




(All specifications subject to change without notice.)

AMERICAN ISUZU MOTORS INC.

SK# ID-00-C001.00

# goodman

GOODMAN EQUIPMENT CORPORATION

TO: WVU

FAX NO: (304) 293-6689

ATIN: Dan Carder

FROM: Brian Wiltjer

DATE: 11/11/97 REF: CAT 3306

TOTAL PAGES (Including Cover Page): 3

IF NOT PROPERLY RECEIVED, PLEASE CONTACT THE ABOVE.

Dan,

Following are the data sheets for the engine.

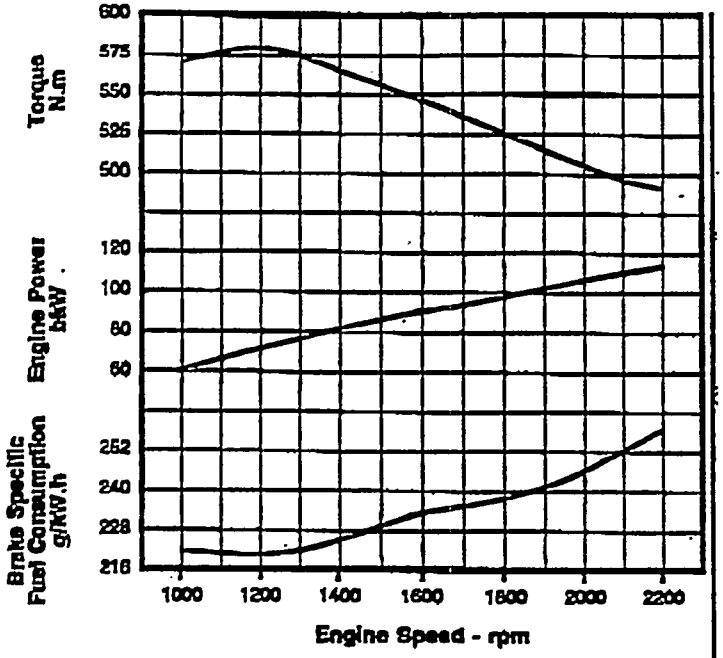
Brian

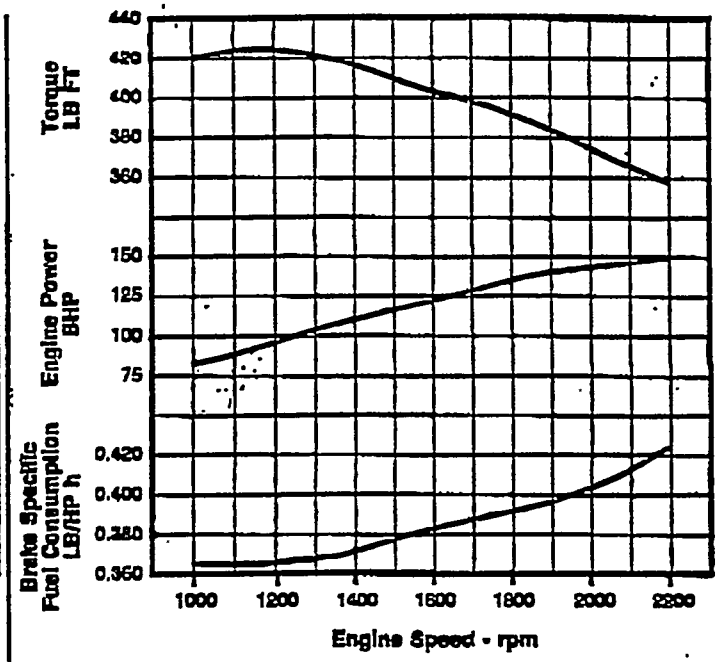
5430 WEST 70TH PLACE • BEDFORD PARK, ILLINOIS 60638 • 708-496-1188 • FAX 708-496-3939 • TELEX 6871228

# 3306 PCNA | INDUSTRIAL ENGINE GENERAL INFORMATION SHEET

| | | SI METRIC | ENGLISH |
|---|---|---|---|
| **General Engine Data** | No. of Cylinders & Arrangement | IN-LINE SIX | |
| | Bore & Stroke | 121 x 152 mm x mm | 4.75 x 6.00 in x in |
| | Displacement | 10.5 L | 638 cu in |
| | Compression Ratio | 21 to 1 | |
| | Cycle | 6 | |
| | Rotation-Facing Flywheel End | CCW | |
| | Firing Order | 1-5-3-6-2-4 | |
| **Air Intake System** | System Restriction Limits: | | |
| | Max. Allowable w/Clean Dry Element | 3.7 kPa | 15 in $H_2O$ |
| | Max. Allowable w/Dirty Element | 6.2 kPa | 25 in $H_2O$ |
| | Cleaner Type | Dry 1 Stage | |
| **Control System** | Governor Type | Hydra-Mechanical | |
| | Shutoff Type | Manual | |
| **Cooling System (Engine Only)** | Engine Coolant Capacity | 15.9 L | 16.8 qt |
| | Coolant Outlet Temperature (Max. Allowable) | 99°C | 210°F |
| | Coolant Inlet Temperature (Min. Allowable) | 71°C | 160°F |
| | Coolant Static Head (Max Allowable) | 17.4 m | 57 ft |
| | System Pressure (Min. Recommended) | 48 kPa | 7 psi |
| | Coolant System Regulator: | | |
| | Start to Open Temperature | 77-81°C | 170-177°F |
| | Fully Open Temperature | 90-94°C | 196-201°F |
| **Exhaust System** | Exhaust Manifold Type | Dry | |
| | Static Weight on Exhaust Connection (Max. Allowable) | 23 kg | 51 lb |
| | System Back Pressure (Max. Allowable) | 6.5 kPa | 34 in $H_2O$ |
| **Fuel System** | Fuel System Type | Sleeve Meter | |
| | Filter Type | Canister | |
| | Priming Pump Type | Manual | |
| | Fuel Supply Line Restriction (Max. Allowable) | 20 kPa | 6 in Hg |
| | Fuel Return Line Restriction (Max. Allowable) | 20 kPa | 6 in Hg |
| | Normal Fuel Pressure | 240 kPa | 35 psi |
| | Fuel Flow to Transfer Pump (Max.) | 113.5 L/h | 30.0 gph |
| **Lube Oil System** | Refill Volume with Filter Change | 27 L | 29 qt |
| | Sump Capacity: | | |
| | Low Mark Level | 19 L | 20 qt |
| | High Mark Level | 25 L | 28 qt |
| | Oil Pressure SAE 10w30 Oil @ 99°C (210°F): | | |
| | Normal Range | 324-372 kPa | 47-54 psi |
| | Min. @ Low Idle | 69 kPa | 10 psi |
| | Filter Type | Canister | |
| | Oil Type Recommended | API CD | |
| | Crankcase Ventilation Type | To Atmosphere | |
| | Oil Cooler Type | Tube | |
| **Mounting System (Engine Only)** | Length Overall | 1270.0 mm | 50.00 in |
| | Height Overall | 1009.2 mm | 37.93 in |
| | Width Overall | 759.3 mm | 29.87 in |
| | Unit Dry Weight | 929.9 kg | 2050 lb |
| | Flywheel Housing Size | SAE 1 | |
| | Static Bending Moment @ Rear Face Flywheel Housing (Max. Allowable) | 1356 N·m | 12002 lb-in |
| | Dimensional Drawing Number | 4W6360 | |
| **Starting System (Engine with SAE 10w30 Oil)** | Recommended Battery Capacity (Min.) for 90 sec. Cranking @ 0°C (32°F) and Above Ambient Temperture: | | |
| | 12 Volt Motor | 1140 CCA | |
| | 24 Volt Motor | 570 CCA | |

# INDUSTRIAL ENGINE PERFORMANCE CURVE | MODEL 3306 PCNA | TM8737-00




**112 kW @ 2200** — **SI METRIC**

| Engine Speed rpm | Engine Power kW | Engine Torque N.m | Engine BMEP kPa | Fuel Rate L/h | BSFC g/kW.h |
|---|---|---|---|---|---|
| 2200 | 112 | 485 | 586 | 34.1 | 257.3 |
| 2000 | 106 | 506 | 607 | 30.7 | 245.7 |
| 1800 | 99 | 526 | 634 | 27.3 | 233.0 |
| 1600 | 91 | 542 | 655 | 25.4 | 234.8 |
| 1500 | 87 | 556 | 669 | 23.5 | 228.1 |
| 1400 | 83 | 564 | 676 | 22.0 | 225.1 |
| 1200 | 73 | 582 | 696 | 18.9 | 219.6 |
| 1000 | 60 | 569 | 683 | 15.5 | 220.8 |

| Engine Speed rpm | Intake Manif Press kPa (gauge) | Intake Manif Temp °C | Exhaust Manif Temp °C | Exhaust Stack Temp °C | Air Flow m³/min | Exhaust Flow m³/min |
|---|---|---|---|---|---|---|
| 2200 | -0.6 | 29.4 | 638 | 616 | 8.6 | 28.7 |
| 2000 | -0.6 | 29.4 | 604 | 582 | 8.9 | 25.6 |
| 1800 | -0.6 | 29.4 | 593 | 571 | 8.2 | 23.2 |
| 1600 | -0.6 | 29.4 | 549 | 527 | 7.4 | 19.7 |
| 1500 | -0.6 | 29.4 | 546 | 524 | 6.9 | 18.4 |
| 1400 | -0.6 | 29.4 | 543 | 521 | 6.4 | 17.0 |
| 1200 | -0.6 | 29.4 | 521 | 499 | 5.4 | 13.8 |
| 1000 | -0.6 | 29.4 | 510 | 488 | 4.4 | 11.1 |

## HEAT REJECTION DATA

| Engine Speed rpm | Engine Power kW | Rejection to Coolant (Total) kW | Rejection to Exhaust (Total) kW | Rejection to Oil Cooler Coolant kW | Radiation to Atmosphere kW | Rejection to Aftercooler kW |
|---|---|---|---|---|---|---|
| 2200 | 112 | 109 | | | | |

**150 HP @ 2200** — **ENGLISH**

| Engine Speed rpm | Engine Power HP | Engine Torque LB FT | Engine BMEP PSI | Fuel Rate GAL/h | BSFC LB/HP h |
|---|---|---|---|---|---|
| 2200 | 150 | 358 | 85 | 9.0 | 0.423 |
| 2000 | 142 | 373 | 88 | 8.1 | 0.404 |
| 1800 | 133 | 388 | 92 | 7.2 | 0.383 |
| 1600 | 122 | 400 | 95 | 6.7 | 0.388 |
| 1500 | 117 | 410 | 97 | 6.2 | 0.376 |
| 1400 | 111 | 416 | 98 | 5.8 | 0.370 |
| 1200 | 98 | 429 | 101 | 5.0 | 0.361 |
| 1000 | 80 | 420 | 99 | 4.1 | 0.363 |

| Engine Speed rpm | Intake Manif Press IN.Hg (gauge) | Intake Manif Temp °F | Exhaust Manif Temp °F | Exhaust Stack Temp °F | Air Flow ft³/min | Exhaust Flow ft³/min |
|---|---|---|---|---|---|---|
| 2200 | -1.1 | 85 | 1180 | 1140 | 340 | 1012 |
| 2000 | -1.0 | 85 | 1120 | 1080 | 314 | 899 |
| 1800 | -1.0 | 85 | 1100 | 1060 | 291 | 819 |
| 1600 | -1.0 | 85 | 1020 | 980 | 260 | 696 |
| 1500 | -1.0 | 85 | 1015 | 975 | 243 | 649 |
| 1400 | -0.9 | 85 | 1010 | 970 | 227 | 602 |
| 1200 | -0.8 | 85 | 970 | 930 | 189 | 489 |
| 1000 | -0.7 | 85 | 950 | 910 | 154 | 392 |

## HEAT REJECTION DATA

| Engine Speed rpm | Engine Power HP | Rejection to Coolant (Total) Btu/min | Rejection to Exhaust (Total) Btu/min | Rejection to Oil Cooler Coolant Btu/min | Radiation to Atmosphere Btu/min | Rejection to Aftercooler Btu/min |
|---|---|---|---|---|---|---|
| 2200 | 150 | 6200 | | | | |