State of California
AIR RESOURCES BOARD

EXECUTIVE ORDER D-420
Relating to Exemptions Under Section 27156
of the Vehicle Code

ENGINE CONTROL SYSTEMS LTD.
"PURIMUFFLER"

WHEREAS, Vehicle Code Sections 27156 and 38391, and Title 13, California Code of Regulations (hereafter "CCR") Section 2222, authorize the California Air Resources Board (ARB) and its Executive Officer to exempt add-on and modified aftermarket devices from the prohibitions of Vehicle Code Section 27156.

WHEREAS, Engine Control Systems Ltd. of 165 Pony Drive, Newmarket, Ontario, Canada L3Y7V1, has applied to the ARB for exemption from the prohibitions in Vehicle Code Sections 27156 and 38391 for their "Purimuffler" system for installation on 1990 and older model-year Detroit Diesel Corporation (DDC) heavy-duty two-stroke diesel engines for urban bus applications.

WHEREAS, pursuant to the authority vested in the Executive Officer by Health and Safety Code Section 39515 and in the Chief, Mobile Source Operations Division by Health and Safety Code Section 39516 and Executive Order G-45-9, the ARB finds that the above "Purimuffler" complies with the California Vehicle Code Section 27156 and Section 2222 of Title 13, California Code of Regulations. Exemption of the "Purimuffler", is based on testing conducted by the Southwest Research Institute, San Antonio, Texas, and Mobile Source Emissions Division of Environment Canada.

IT IS HEREBY RESOLVED that the "Purimuffler" is exempt from the prohibitions in Vehicle Code Section 27156 for installation on 1990 and earlier model-year DDC heavy-duty two-stroke diesel engines for urban bus applications subject to the following conditions:

1. No changes are permitted to the "Purimuffler" as described in the original application for exemption. Any changes to the "Purimuffler", the installation instructions, or any of its components, and other factors addressed in this order must be evaluated and approved by the ARB prior to marketing in California.

2. Marketing of the "Purimuffler" using identification other than those shown in this Executive Order or the original submittal, or marketing of the "Purimuffler" for application other than the one listed in this Executive Order shall be prohibited unless prior approval is obtained from the ARB. Exemption of this product shall not be construed as an exemption to sell, offer for sale, or advertise any components of the "Purimuffler" as individual devices.

3. Any oral or written references to this Executive Order or its content by Engine Control Systems Ltd., its principals, agents, employees, distributors, dealers, or other representatives must include the disclaimer that the Executive Order or the exemption it provides is not an endorsement or approval of any emissions reduction claims for the "Purimuffler" and is only a finding that the "Purimuffler" is exempt from the prohibitions of Vehicle Code Section 27156.

4. Upon installation, the Purimuffler carries a warranty for 100,000 miles provided that it is installed in accordance with the installation instructions provided by Engine Control Systems Ltd.

THIS EXECUTIVE ORDER DOES NOT CONSTITUTE A CERTIFICATION, ACCREDITATION, APPROVAL, OR ANY OTHER TYPE OR ENDORSEMENT BY THE AIR RESOURCES BOARD OF ANY CLAIMS OF THE APPLICANT CONCERNING ANTI-POLLUTION BENEFITS OR ANY ALLEGED BENEFITS OF THE "PURIMUFFLER".

Violation of any of the above conditions shall be grounds for revocation of this order. The order may be revoked only after ten day written notice of intention to revoke it, during which period the holder of the order may request in writing a hearing to contest the proposed revocation. If a hearing is requested, it shall be held within ten days of receipt of the request, and the order may not be revoked until a determination is made, after the hearing, that grounds for revocation exist.

Executed at El Monte, California, this 18th day of February 1997.

R.B. Summerfield, Chief
Mobile Source Operations Division

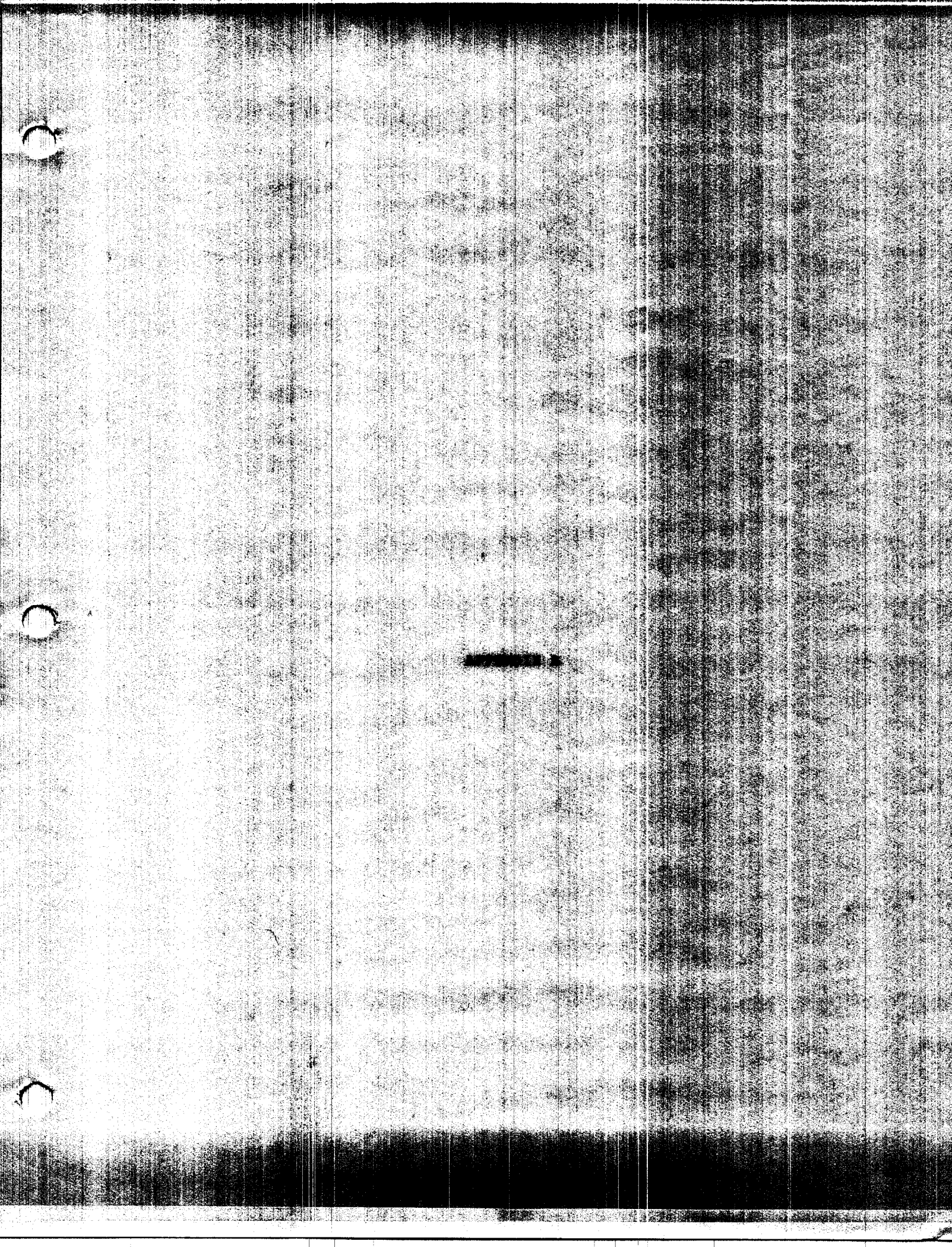

TABLE 5. HDTC Data for 1987 Cummins LT-A 10B; 179 kW @ 2100 rpm
Converter Muffler 1.83m from turbocharger outlet

| Emissions (g/kW-hr) | HC | CO | NOx | CO2 | PM | VOF | Non VOF | SO4 mg/ kW-hr |
|---|---|---|---|---|---|---|---|---|
| Engine-Out | | | | | | | | |
| Cold Start | 0.829 | 4.913 | 7.428 | 779 | 0.637 | 0.118 | 0.519 | 2.8 |
| Hot Start | 0.453 | 4.457 | 7.983 | 764 | 0.525 | 0.144 | 0.381 | 2.9 |
| Composite | 0.507 | 4.523 | 7.903 | 767 | 0.542 | 0.142 | 0.400 | 2.9 |
| With Converter Muffler | | | | | | | | |
| Cold Start | 0.023 | 3.206 | 7.111 | 806 | 0.532 | 0.059 | 0.473 | 4.0 |
| Hot Start | 0.012 | 3.204 | 7.759 | 769 | 0.422 | 0.049 | 0.373 | 7.2 |
| Composite | 0.013 | 3.205 | 7.666 | 775 | 0.438 | 0.050 | 0.388 | 6.8 |
| **Composite Percent Reductions** | **97.3%** | **29.1%** | **3.0%** | **-1.0%** | **19.2%** | **64.8%** | **3.0%** | **-234%** |

TABLE 6. HDTC Data for 1991 DDC 6V92TA DDEC II; 207 kW @ 2100 rpm
Converter Muffler 1.83m from turbocharger outlet

| Emissions (g/kW-hr) | HC | CO | NOx | CO2 | PM | VOF | Non VOF | SO4 mg/ kW-hr |
|---|---|---|---|---|---|---|---|---|
| Engine-Out | | | | | | | | |
| Cold Start | 0.495 | 1.791 | 6.550 | 964 | 0.244 | 0.081 | 0.163 | na |
| Hot Start | 0.578 | 1.568 | 6.644 | 922 | 0.227 | 0.079 | 0.148 | |
| Composite | 0.567 | 1.600 | 6.631 | 928 | 0.229 | 0.079 | 0.150 | |
| With Converter Muffler | | | | | | | | |
| Cold Start | 0.150 | 0.808 | 6.453 | 972 | 0.192 | 0.038 | 0.154 | na |
| Hot Start | 0.192 | 0.472 | 6.546 | 921 | 0.168 | 0.035 | 0.133 | |
| Composite | 0.186 | 0.520 | 6.532 | 929 | 0.170 | 0.036 | 0.134 | |
| **Composite Percent Reductions** | **67.1%** | **67.5%** | **1.5%** | **-0.1%** | **25.7%** | **54.4%** | **10.7%** | **na** |

na = not available

**TABLE 7.** NY Composite Chassis Dynamometer Data for 1989 MCI Classic urban bus with 6V92TA DDEC II; 189 kW @ 2100 rpm;Vehicle #8930

| Emissions (g/km) | HC | CO | NOx | CO2 | PM | SOF | Insol. | Fuel Use (km/L) |
|---|---|---|---|---|---|---|---|---|
| 18500 km after installation | | | | | | | | |
| Baseline | 1.91 | 3.47 | 11.46 | 1795 | 1.41 | na | na | 1.49 |
| With Catalyst | 1.31 | 2.30 | 12.04 | 1755 | 1.00 | | | 1.49 |
| % Reductions | 31.4% | 33.7% | -5.1% | 2.2% | 29.1% | | | 0.0% |

**TABLE 8.** NY Composite Chassis Dynamometer Data for 1984 GMC Classic urban bus with 1987 6V71N; 135 kW @ 2000 rpm;Vehicle #8423

| Emissions (g/km) | HC | CO | NOx | CO2 | PM | SOF | Insol. | Fuel Use (km/L) |
|---|---|---|---|---|---|---|---|---|
| 3500 km after installation | | | | | | | | |
| Baseline | 3.00 | 22.72 | 16.54 | 1734 | 1.53 | na | na | 1.51 |
| With Catalyst | 0.91 | 4.23 | 15.87 | 1666 | 0.96 | | | 1.61 |
| % Reductions | 69.6% | 81.4% | 4.1% | 3.9% | 37.3% | | | 6.6% |

**TABLE 9.** CBD Chassis Dynamometer Average Data for 1992 International School Buses with Navistar DT466; Vehicles # 1000 and #1001

| Emissions (g/km) | HC | CO | NOx | CO2 | PM | SOF | Insol. | Fuel Use (km/L) |
|---|---|---|---|---|---|---|---|---|
| Oct./Dec. 1994 | | | | | | | | |
| Fresh Catalyst | | | | | | | | |
| Baseline | 1.45 | 2.00 | 7.85 | 1126 | 0.347 | 0.120 | 0.227 | 2.33 |
| With Converter | 0.07 | 0.06 | 8.28 | 1116 | 0.257 | 0.094 | 0.163 | 2.35 |
| % Reductions | 95.2% | 97.0% | -5.4% | -0.9% | 25.9% | 21.6% | 28.2% | 0.9% |
| March, 1995 | | | | | | | | |
| After ca. 8000 km | | | | | | | | |
| Baseline | 1.62 | 2.18 | 7.85 | 1594 | 0.403 | 0.219 | 0.184 | 2.35 |
| With Catalyst | 0.15 | 0.09 | 8.23 | 1591 | 0.249 | 0.080 | 0.169 | 2.32 |
| % Reductions | 90.7% | 95.9% | -4.8% | 0.2% | 38.2% | 63.4% | 10.9% | -1.2% |
| August, 1995 | | | | | | | | |
| After ca. 17500 km | | | | | | | | |
| Baseline | 1.16 | 2.19 | 8.25 | 1120 | 0.550 | 0.203 | 0.347 | 2.39 |
| With Catalyst | 0.18* | 0.16 | 9.43 | 1152 | 0.348 | 0.043 | 0.305 | 2.34 |
| % Reductions | 84.5% | 92.7% | -14.3% | -2.8% | 36.7% | 78.8% | 12.1% | -2.1% |

**TABLE 10.** New York Bus Cycle Chassis Dynamometer Average Data for 1992 International School Buses with Navistar DT466; Vehicles #1000 and #1001

| Emissions (g/km) | HC | CO | NOx | CO2 | PM | SOF | Insol. | Fuel Use (km/L) |
|---|---|---|---|---|---|---|---|---|
| Oct./Dec., 1994 | | | | | | | | |
| Fresh Catalyst | | | | | | | | |
| Baseline | 1.50 | 3.98 | 18.84 | 2011 | 0.732 | 0.285 | 0.447 | 1.31 |
| With Converter | 0.22 | 1.02 | 17.60 | 2012 | 0.581 | 0.194 | 0.387 | 1.32 |
| % Reductions | 85.3% | 74.4% | 6.6% | 0.0% | 20.6% | 31.9% | 13.4% | 0.8% |
| March, 1995 | | | | | | | | |
| After ca. 8000 km | | | | | | | | |
| Baseline | 3.02 | 4.76 | 18.31 | 2039 | 0.962 | 0.538 | 0.424 | 1.28 |
| With Catalyst | 0.85 | 1.65 | 18.35 | 2032 | 0.553 | 0.130 | 0.423 | 1.30 |
| % Reductions | 71.9% | 65.3% | -0.2% | 0.3% | 42.5% | 75.8% | 0.2% | 1.6% |
| August, 1995 | | | | | | | | |
| After ca. 17500 km | | | | | | | | |
| Baseline | 2.74 | 4.81 | 19.10 | 2022 | 1.203 | 0.328 | 0.875 | 1.32 |
| With Catalyst | 0.84 | 2.39 | 20.46 | 2053 | 0.985 | 0.256 | 0.729 | 1.31 |
| % Reductions | 69.3% | 50.3% | -7.1% | -1.5% | 18.1% | 22.0% | 16.7% | -0.8% |

**TABLE 11.** New York Composite Cycle Chassis Dynamometer Average Data for 1992 International School Buses with Navistar DT466; Vehicles #1000 and #1001

| Emissions (g/km) | HC | CO | NOx | CO2 | PM | SOF | Insol. | Fuel Use (km/L) |
|---|---|---|---|---|---|---|---|---|
| Oct./Dec., 1994 Fresh Catalyst | | | | | | | | |
| Baseline | 0.97 | 1.88 | 8.35 | 1053 | 0.369 | 0.121 | 0.248 | 2.50 |
| With Converter | 0.19 | 0.44 | 8.66 | 1053 | 0.317 | 0.078 | 0.239 | 2.51 |
| % Reductions | 80.4% | 76.6% | -3.7% | 0.0% | 14.1% | 35.5% | 0.5% | 0.4% |
| March, 1995 After ca. 8000 km | | | | | | | | |
| Baseline | 1.69 | 2.20 | 8.30 | 1052 | 0.506 | 0.215 | 0.291 | 2.49 |
| With Catalyst | 0.24 | 0.63 | 8.73 | 1045 | 0.322 | 0.068 | 0.254 | 2.53 |
| % Reductions | 85.8% | 71.4% | -5.2% | 0.7% | 36.4% | 68.4% | 12.7% | 1.6% |
| August, 1995 After ca. 17500 km | | | | | | | | |
| Baseline | 1.33 | 2.27 | 9.00 | 1050 | 0.709 | 0.285 | 0.424 | 2.54 |
| With Catalyst | 0.27 | 0.75 | 10.01 | 1044 | 0.463 | 0.069 | 0.394 | 2.57 |
| % Reductions | 79.7% | 67.0% | -11.2% | 0.6% | 34.7% | 75.8% | 7.1% | 1.2% |

**TABLE 12.** New York Composite Cycle Chassis Dynamometer Average Data for Various Heavy Duty Trucks

| Emissions (g/km) | HC | CO | NOx | CO2 | PM | SOF | Insol. | Fuel Use (km/L) |
|---|---|---|---|---|---|---|---|---|
| 1992 Mack MS250P Vehicles # 46121 and #26005 | | | | | | | | |
| May 1995: Fresh Catalyst | | | | | | | | |
| Baseline | 0.53 | 2.43 | 11.15 | 921 | 0.391 | 0.284 | 0.107 | 2.53 |
| With Converter Muffler | 0.16 | 0.92 | 11.60 | 910 | 0.228 | 0.111 | 0.117 | 2.59 |
| % Reductions | 69.8% | 62.1% | -4.0% | 1.2% | 41.7% | 60.9% | -9.3% | 2.4% |
| August 1995: after ca. 12000 km | | | | | | | | |
| Baseline | 0.39 | 2.46 | 11.43 | 878 | 0.435 | 0.158 | 0.277 | 3.05 |
| With Converter Muffler | 0.11 | 1.22 | 12.21 | 895 | 0.235 | 0.059 | 0.176 | 3.00 |
| % Reductions | 71.8% | 50.4% | -6.8% | -1.9% | 46.0% | 62.6% | 36.5% | -1.6% |
| 1994 International Series 4900 | | | | | | | | |
| Nov.1995: After 100hr thermal aging | | | | | | | | |
| Baseline | 0.45 | 2.91 | 8.62 | 792 | 0.39 | na | na | na |
| With Converter Muffler | 0.39 | 1.19 | 8.70 | 755 | 0.24 | | | |
| %Reductions | 13.3% | 59.1% | -0.9% | 4.6% | 38.5% | | | |

na = not available at time of printing

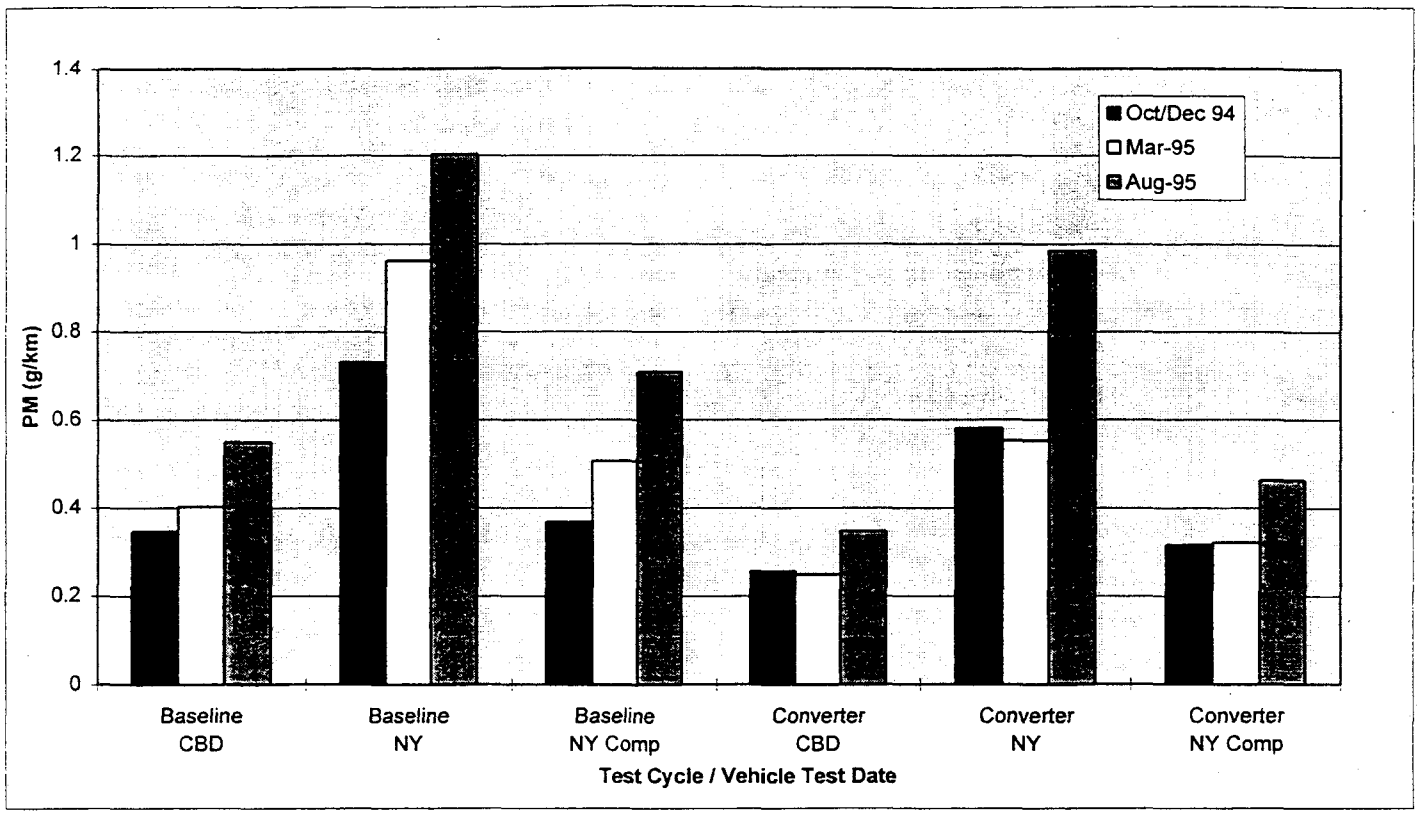


**Figure 1 :** Average PM Emissions over Various Chassis Test Cycles

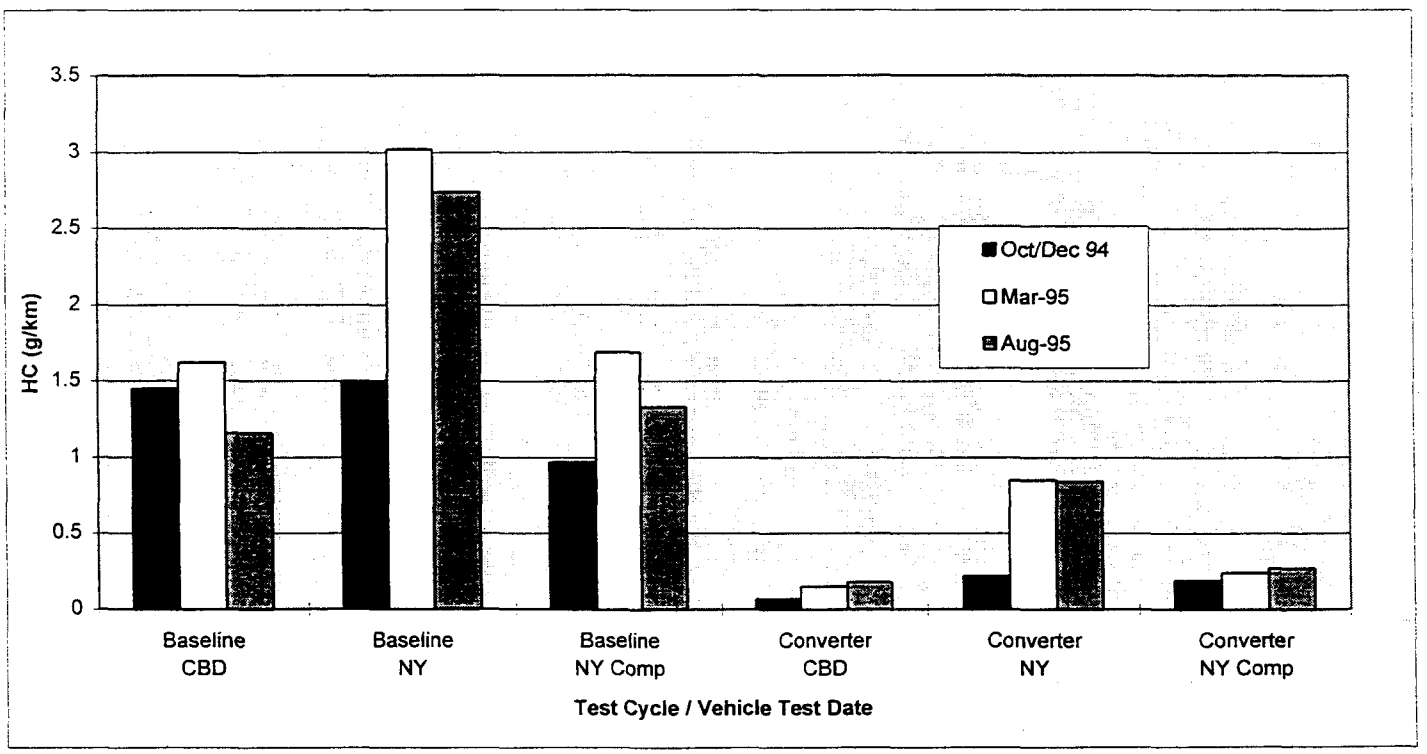


**Figure 2:** Average HC Emissions over Various Chassis Test Cycles

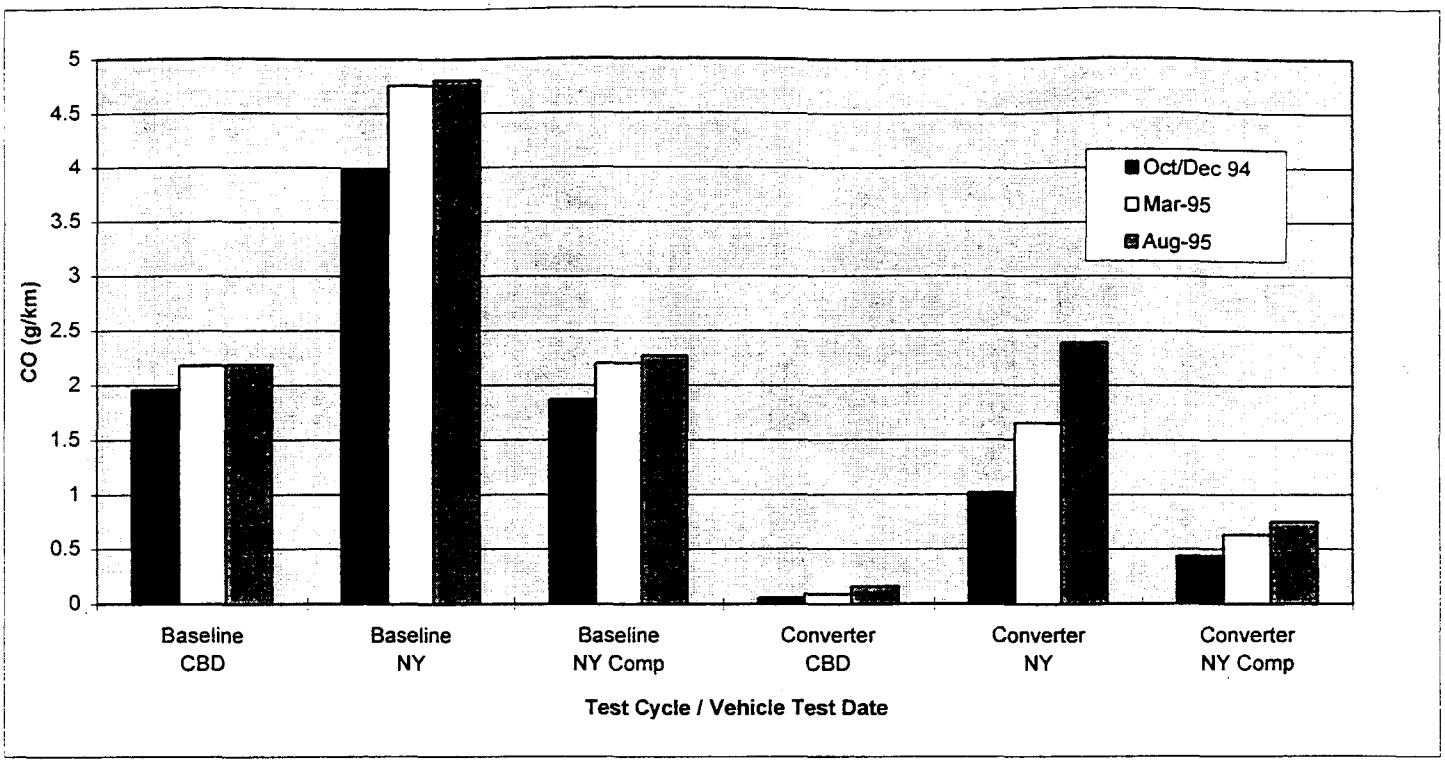


**Figure 3:** Average CO Emissions over Various Chassis Test Cycles

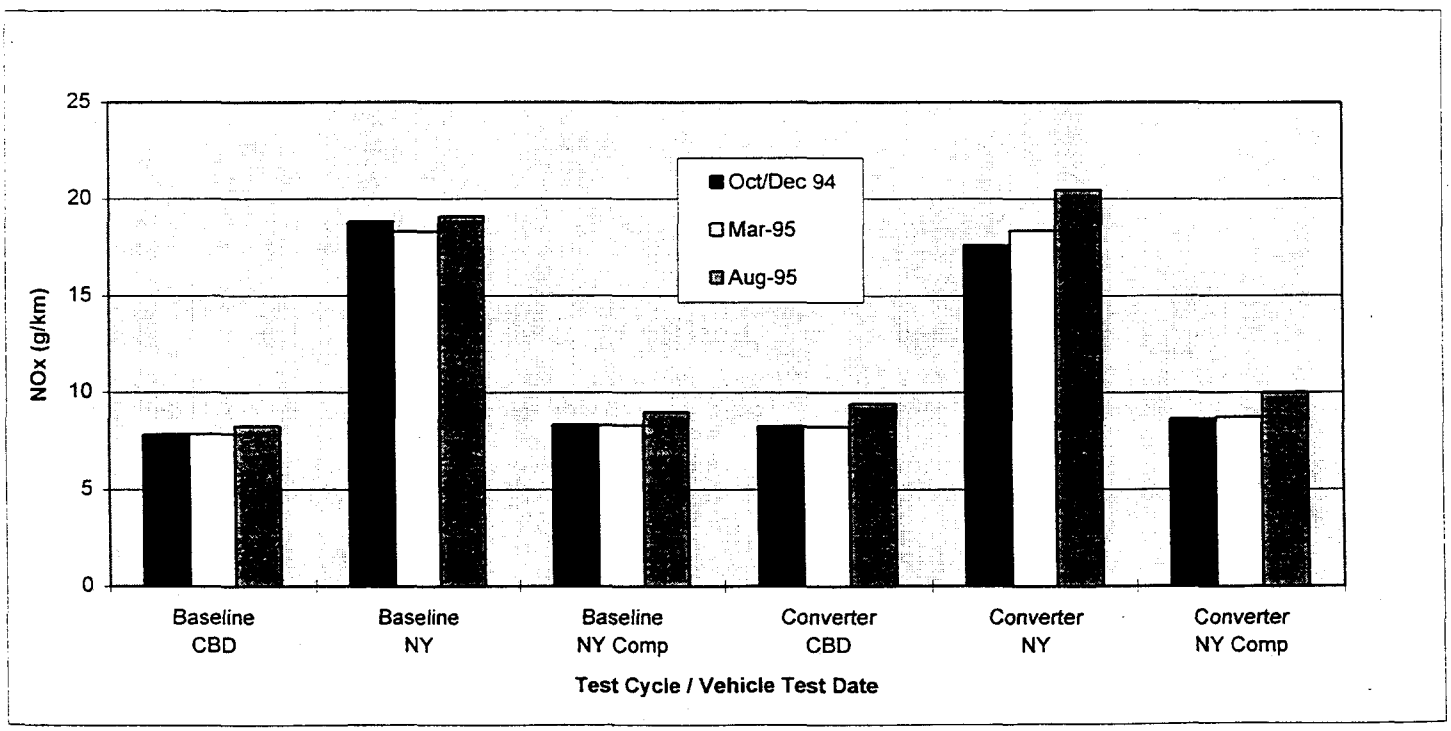


**Figure 4:** Average NOx Emissions over Various Chassis Test Cycles

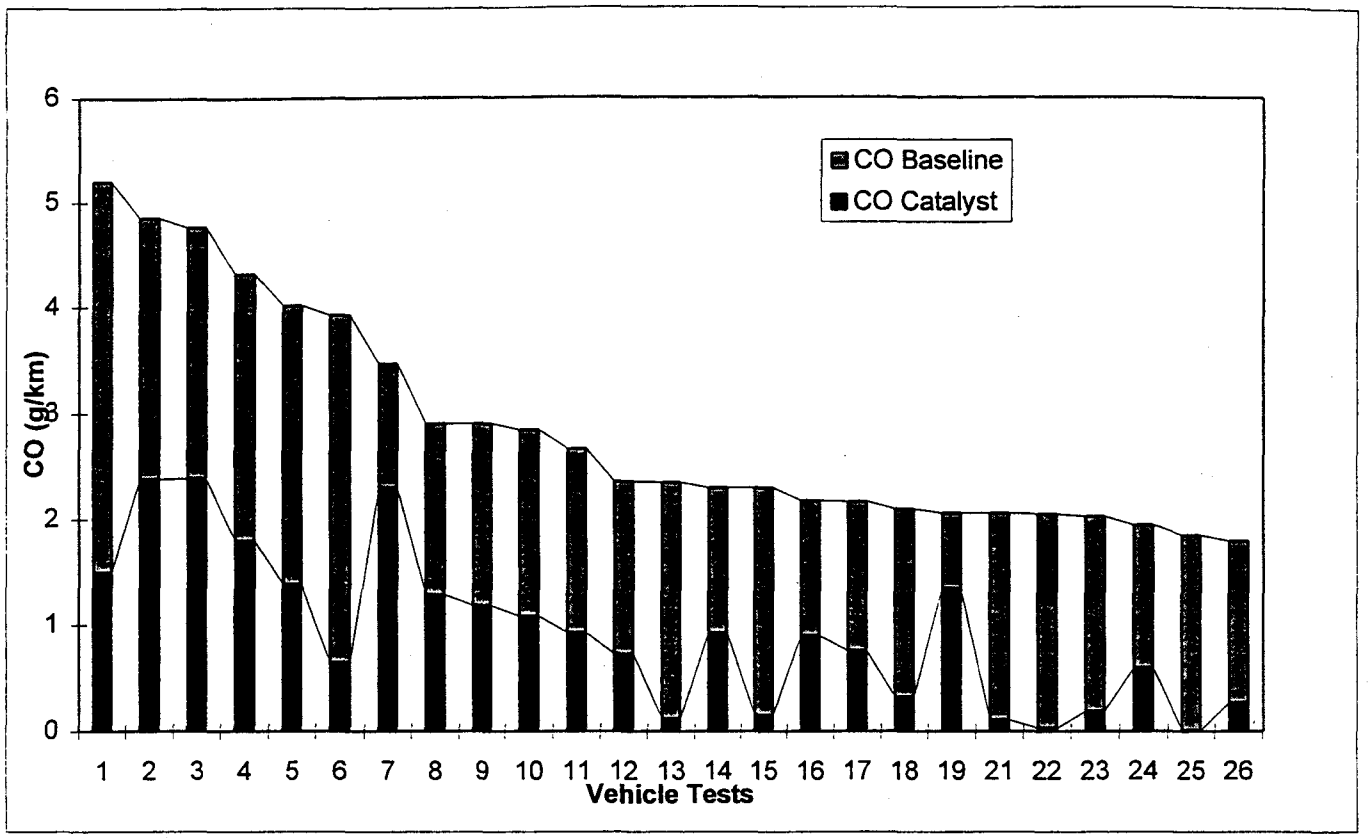


**Figure 7:** CO Emissions over all Chassis Test Cycles

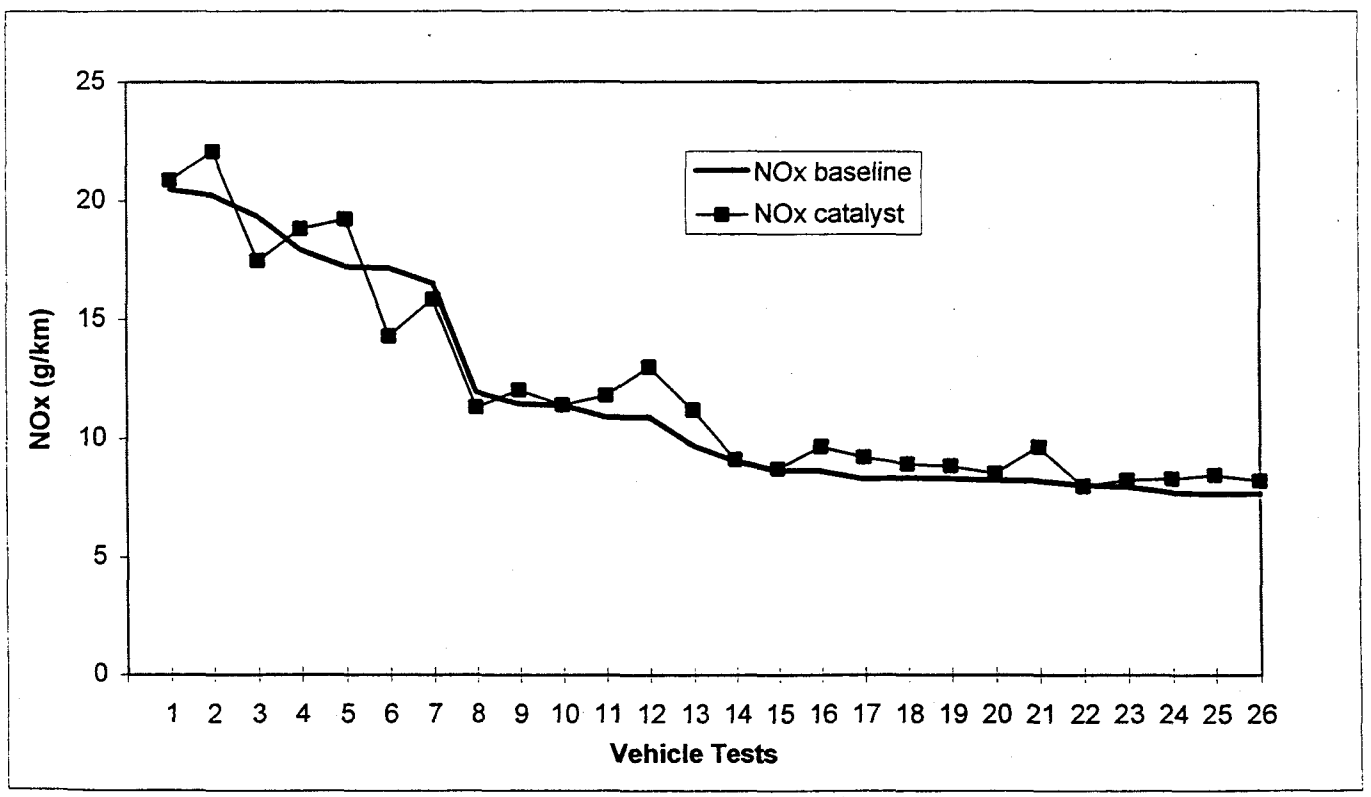


**Figure 8:** NOx Emissions over all Chassis Test Cycles

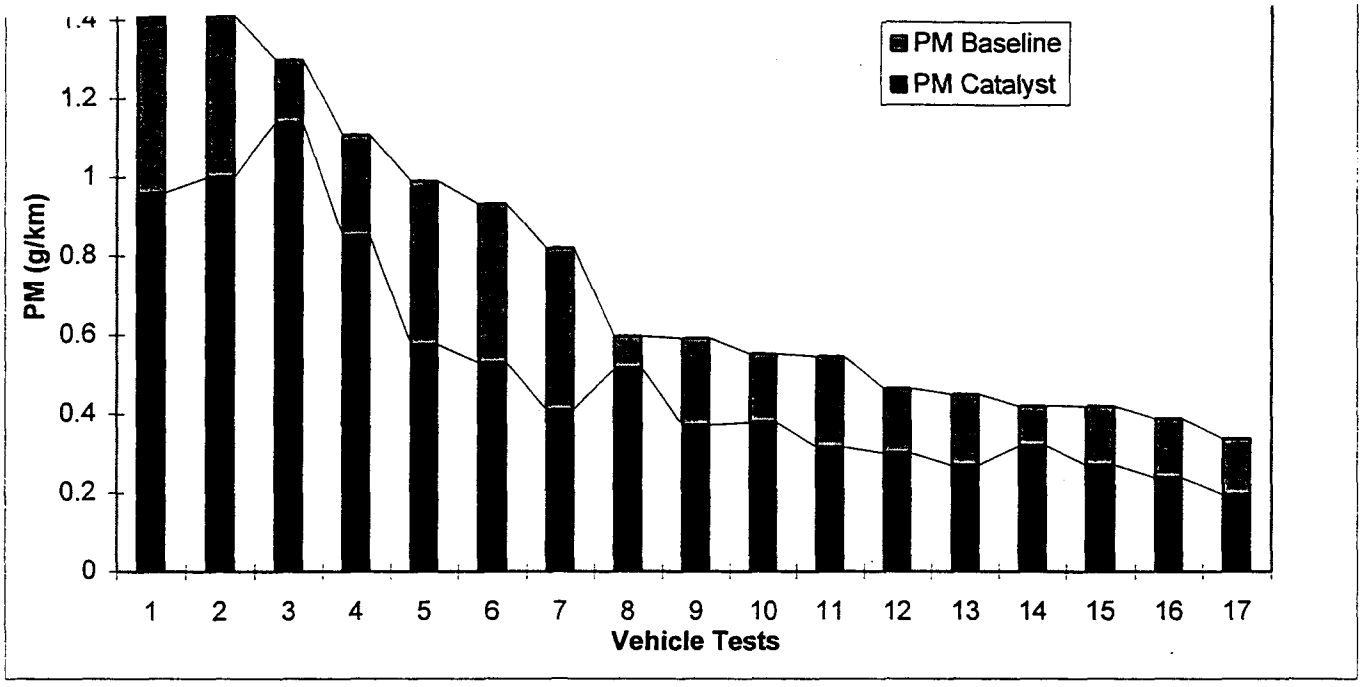


**Figure 5:** PM Emissions over all Chassis Test Cycles

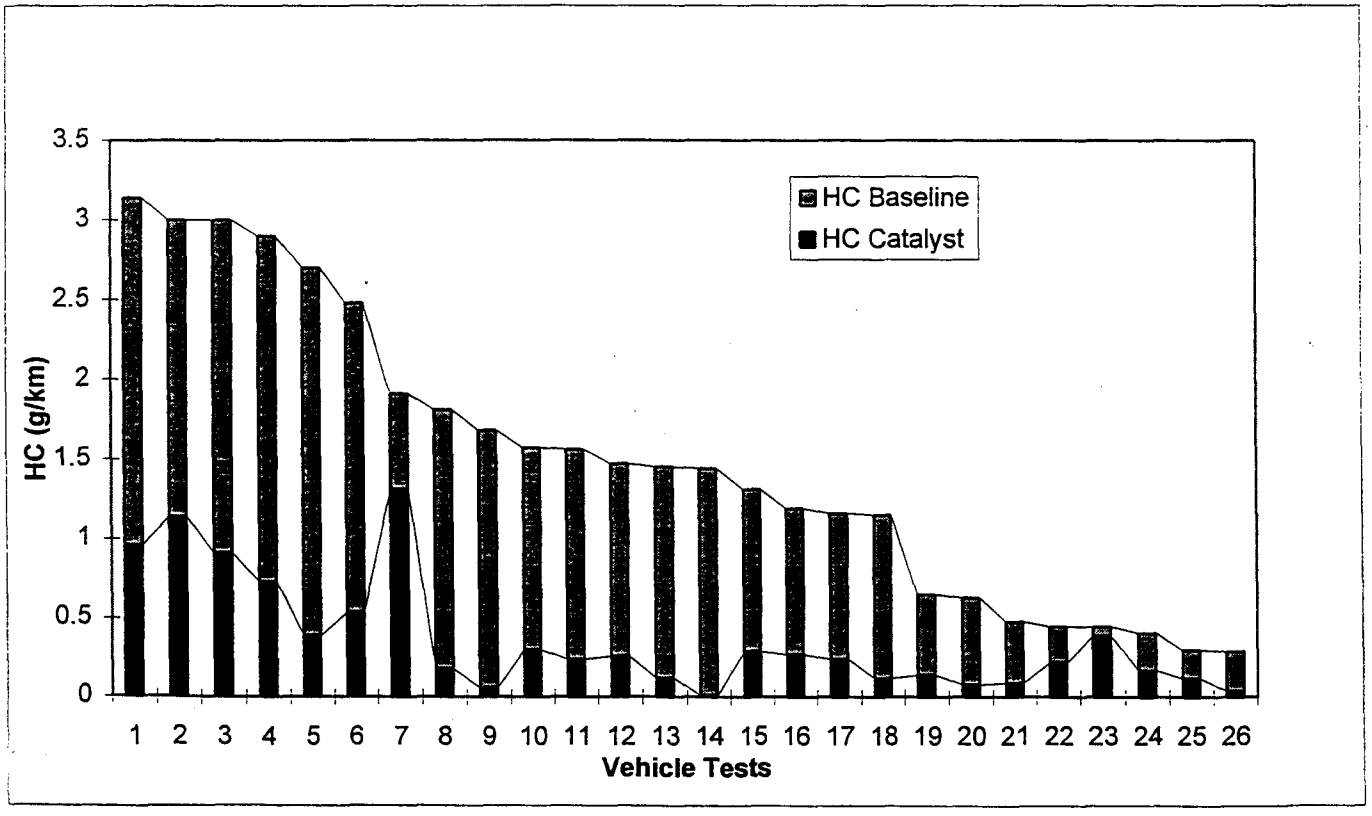


**Figure 6:** HC Emissions over all Chassis Test Cycles