United States
Environmental Protection
Agency

Atmospheric Sciences Research
Laboratory
Research Triangle Park NC 27711

Research and Development

EPA-600/S3-84-104 Dec. 1984

Project Summary

Characterization of Heavy-Duty Motor Vehicle Emissions Under Transient Driving Conditions

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The objective of this program was to characterize heavy-duty diesel truck and bus emissions produced during transient driving cycles. In the initial phase of the program an improved road-load simulation method was developed for use in operating large trucks on a chassis dynamometer. This method was used in testing vehicles on the chassis dynamometer in the latter parts of the program. The second phase of testing involved operation of six vehicles on the chassis dynamometer (over the chassis version of the heavy-duty transient cycle), removal of the engine and testing of the engines (over the heavy-duty engine transient cycle). Chassis emisisons were then compared to engine emissions. Additionally, chassis tests were conducted over a range of dynamometer inertia settings for two of the six vehicles for the purpose of comparison with engine emissions. Baseline emissions were also measured on six buses, five single-axle tractors, and 17 dual-axle tractors over the chassis version of the transient cycle. Regulated emissions and several unregulated emissions were measured on baseline tests. Unregulated emissions included particulate, aldehydes and ketones, phenols, DOAS odor, various elements, nitropyrenes, and Ames mutagenic response.

This Project Summary was developed by EPA's Atmospheric Sciences Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This project was divided into three tasks. The objective of the first task of testing was to determine the appropriate amount of power to be absorbed by a chassis dynamometer to simulate on-road driving conditions. The work performed in the first task involved three vehicles, a city bus, a single-axle truck tractor, and a tandem-axle truck tractor. Coastdowns were conducted on the road for each vehicle under essentially ideal weather conditions (primarily no wind) and with zero road grade. Coastdowns were also conducted on the chassis dynamometer with the single-axle tractor and the bus. Results of these determinations, along with data reported in the literature, were used to determine the power to be absorbed by a chassis dynamometer.

The objectives of the second task were to determine repeatability of HC, CO, CO_2, NO_x, and particulate emissions in chassis cycle and engine cycle tests and whether there is correlation between engine cycle and chassis cycle emissions. This task involved five sets of tests with four vehicles over a chassis version of the transient cycle for heavy-duty vehicles and with their respective engines over the 1984 transient test for heavy-duty engines.

The test vehicles included a city bus powered by a 1982 Detroit Diesel 6V-71, two dual-axle tractors, one with a 1980 Cummins Formula 350 and one with a 1980 Detroit Diesel 8V-92TA, and a single-axle tractor equipped with a 1979 IHC DT-466. Two additional vehicles underwent two sets of chassis and engine tests. These vehicles were also tested at several different inertia settings over the chassis transient cycle to determine the effect of inertia on emissions. Regulated emissions (HC, CO, CO_2, and NO_x) and particulate were measured for all chassis and engine transient tests. The city bus was tested using a DF-1 Emissions Test Fuel (EM-400-F) and the three tractors were tested with a DF-2 Certification Fuel (EM-528-F).

The objective of the third task was to measure HC, CO, CO_2, NO_x, particulate and several unregulated emissions during chassis testing of four single-axle tractors, fifteen dual-axle tractors, and five buses. Each vehicle was operated over a minimum of two duplicate transient cycles. The buses were tested with a DF-1 Emissions Test Fuel (EM-455-F), and the tractors were tested with a DF-2 Certification Fuel (EM-528-F). The unregulated emissions that were measured included aldehydes and ketones, DOAS odor, various elements, and organic solubles. In addition, Ames bioassay and nitropyrene analyses were performed on the organic soluble samples.

Procedures

Dynamometers and CVS Systems

Transient engine testing was performed in accord with the 1984 Transient test for Heavy-Duty Diesel Engines. The procedure specifies transient engine operation over variable speed and load, the magnitude of the load depending on the power output capability of the test engine. The cycle requires relatively rapid dynamometer control, that is, the capability to load the engine one moment and motor it the next. The system used in this program consisted of a GE 200 hp motoring/250 hp absorbing dynamometer coupled to a Midwest 500 hp eddy current (absorbing) dynamometer, with a suitable control system fabricated in-house.

Engine transient testing of Engine 2-1 was conducted using a double-dilution constant volume sampler (CVS) with the main dilution tunnel flow set at 1100 CFM. Engines 2-2, 2-3, and 2-4 were operated with a main dilution flow of 1900 CFM. This provided a dilution ratio of roughly 4:1 in the primary tunnel and 12:1 in the secondary tunnel. Secondary tunnel sample flowrates were about 1 CFM for all engine transient tests.

Chassis transient operation was conducted in general accord with the EPA Recommended Practice for determining exhaust emissions via the chassis version of the Transient Cycle. Vehicle testing was performed on a tandem drive dynamometer equipped with two air-gap 350 hp eddy current power absorbers and with inertia wheels directly connected to each set of rolls. A speed vs load curve, simulating road-load horsepower, was programmed into the system using a load control circuit.

A single dilution CVS with maximum capacity of 12,000 cfm was used with vehicles tested on the chassis dynamometer. The CVS was set at flow rates ranging from 4000 to 9000 cfm, depending on engine horsepower and ambient temperature.

Driving Cycles

Vehicle testing involved vehicle operation over three different driving cycles: the 1984 Transient FTP for Heavy-Duty Diesel Engines, the "Recommended Practice for Determining Exhaust Emissions from Heavy-Duty Vehicles Under Transient Conditions," and the New York Bus Cycle.

The 1984 engine transient cycle is described in the Federal Register by percent of maximum torque and percent of rated speed for each one-second interval, for a test cycle of 1199 seconds duration. This 20-minute transient cycle is composed of four five-minute segments. The four segments are described as follows:

Engine Transient Cycle Segment	Time, sec
New York Non-Freeway (NYNF)	297
Los Angeles Non-Freeway (LANF)	300
Los Angeles Freeway (LAF)	305
New York Non-Freeway (NYNF)	297

The chassis transient test is composed of a cold-start cycle followed by a 20-minute soak period and then a hot-start cycle. On the day preceding testing the vehicle is prepped by driving through the chassis transient test. The vehicle is then allowed to stand overnight prior to the cold-start. The transient cycle is composed of four segments which are described as follows:

Chassis Transient Cycle Segment	Time, sec
New York Non-Freeway (NYNF)	254
Los Angeles Non-Freeway (LANF)	267
Los Angeles Freeway (LAF)	285
New York Non-Freeway (NYNF)	254

One chassis transient cycle is a total of 1060 seconds, or approximately 18 minutes. Although engine and chassis transient cycles are quite similar in most respects, differences in cycle lengths exist because of inherent differences in the chassis and engine test procedures.

Another driving cycle used in testing of buses in Task 3 was the New York Bus Cycle. This experimental driving cycle was developed from a CAPE-21 study of several buses during in-service operation. Of the 1191 seconds duration of the cycle, 394 seconds are idle. The distance covered by the test is 2.90 miles and the maximum speed called for by the cycle is 36 mph.

Unregulated Emissions

Phenols

Phenols were sampled by bubbling dilute exhaust at 0.8 ft^3/min through glass impingers containing a chilled aqueous solution of 1 N potassium hydroxide. The samples were acidified, extracted with ether, and concentrated. Samples were analyzed on a gas chromatograph equipped with a flame ionization detector. This procedure analyzes for phenol, salicylaldehyde, m-cresol/p-cresol, p-ethylphenol/2-isopropylphenol/2,3-xylenol/3,5-xylenol/2,4,6-trimethylphenol, 2,3,5-trimethylphenol, and 2,3,5,6-tetramethylphenol.

Aldehydes and Ketones

Two variations of the 2,4-dinitrophenylhydrazine (DNPH) method were used in the analysis of aldehydes and ketones. The first method involved sampling dilute exhaust at 4 lit/min through an aqueous 2N HCl scrubber solution of DNPH. The samples were filtered, extracted with pentane, and analyzed on an HPLC. The compounds measured were formaldehyde, acetaldehyde, acrolein, propionaldehyde, acetone, crotonaldehyde, isobutyraldehyde, methylethylketone, benzaldehyde, and hexanaldehyde. This procedure was used for Vehicles 3-1 through 3-7.

An improved version of the 2,4-DNPH method was used to analyze samples from Vehicles 3-8 to 3-24. Dilute exhaust was bubbled through a solution of DNPH in acetonitrile spiked with 1N perchloric acid. A portion of the sample was analyzed by direct injection into an HPLC. The same aldehydes and ketones were measured with this method as with the original procedure, however, isobutyraldehyde and methylethylketone elute at the same retention time.

DOAS Odor

Dilute exhaust was sampled at approximately 2.8 lit/min for odorants using stainless steel traps packed with Chromosorb 102. Two traps were positioned in series for each sample taken. Samples were eluted from the traps with cyclohexane and a portion of each sample was analyzed on the Diesel Odor Analysis System (DOAS), a liquid chromatograph.

Elements

Particulate samples were collected on 47 mm Pallflex filters. The particulate from these filters was analyzed for several elements at EPA-RTP using a Siemens Model MRS-3 high resolution x-ray fluorescence multispectrometer.

Solvent Extraction of Particulate Filters

Particulate was also sampled on 20x20 inch Pallflex filters. These filters were Soxhlet extracted with methylene chloride for 8 hours at 4 cycles/hour and the resulting extractables were analyzed for nitropyrenes and for mutagenic activity (Ames Bioassay).

Nitropyrenes

Nitropyrenes were measured using a method developed by the EPA in which the samples were analyzed on a liquid chromatograph coupled to a fluorescence detector. Each organic extractable sample was dissolved in a 50:50 mixture of methylene chloride/methanol prior to analysis. The liquid chromatograph is equipped with four columns, two containing reduction catalyst, and two packed with Zorbax ODS. The catalyst columns remove oxidative compounds from the solvent and convert nitropyrenes to the highly fluorescent aminopyrenes. The Zorbax ODS columns separate the compounds in the sample. This procedure analyzes for 1-nitropyrene and three dinitropyrenes: 1,3-, 1,6-, and 1,8-dinitropyrene.

Ames Bioassay

Organic extractables were analyzed for mutagenic activity by the *S. typhimurium* mutagenicity test (Ames test), in tester strains TA1538, TA98, and TA100. The samples were analyzed in triplicate for mutagenic activity in the presence and absence of the S9 external metabolic activation system, Aroclor-induced rat liver homogenate.

Results

The first task of vehicle testing involved operation of six vehicles over the chassis transient cycle, removal of the respective engines, and subsequent engine operation over the engine transient cycle. The emissions results from these tests are summarized in Tables 1 and 2 in g/km and g/kg fuel. Engine emissions in g/km were calculated based on an engine cycle equivalent distance of 10.3 km. This value was determined by the EPA in 1978. Hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x), and particulate were measured and are reported as composite values weighted 1/7 cold-start and 6/7 hot-start. Vehicle 3-23 was inadvertently tested at 80 percent of standard horsepower. All other vehicles were tested at standard horsepower. HC chassis emissions, in g/km, generally exceeded engine emissions by 10 to 30 percent with the exception of Vehicle 2-1, in which chassis HC was lower than engine HC by 16 percent. Vehicle 3-23 emitted the highest level of chassis and engine HC while Vehicle 2-4 produced the lowest levels. Vehicle 2-1 had relatively high chassis CO emissions, 21 g/km compared to the other vehicles, 2 to 6 g/km. NO_x emissions from Vehicles 2-2, 2-3, 2-4, and 3-24 chassis and engine tests agreed within 11 percent. However, NO_x produced by Vehicle 2-1 during chassis tests exceeded engine NO_x by 65 percent while NO_x from vehicle 3-23 chassis tests were 38 percent lower than engine NO_x. Vehicle 3-24 produced the highest NO_x levels of the six vehicles. Particulate emissions from chassis tests were generally higher than particulate produced during engine testing (by 18 to 28 percent). Vehicle 2-3 produced nearly equivalent amounts of particulate in chassis and engine tests. Particulate emissions from chassis tests of Vehicle 2-1 were double the amount of particulate emissions from engine tests.

Engine and chassis emissions are also reported on a fuel specific basis, in g/kg fuel. The general trends observed between engine and chassis emissions in g/km are similar. However, in about half the measurements, the agreement between engine and chassis emissions improved when using fuel specific units for reporting emissions.

Two of the six vehicles that were tested over chassis and engine cycles were also tested at several inertia weights over the chassis transient cycle. Chassis transient

Table 1. *Comparison of Emissions from Chassis and Engine Tests from Several Vehicles*

		Composite Emission Rate, g/km							
		HC		*CO*		*NO_x*		*Part.*	
Vehicle Number	*Vehicle Description*	*Chassis*	*Engine*[a]	*Chassis*	*Engine*[a]	*Chassis*	*Engine*[a]	*Chassis*	*Engine*[a]
2-1	*Bus DD6V-71*	*1.74*	*2.08*	*21.4*	*5.92*	*10 8*	*6.56*	*1.28*	*0.63*
2-2	*Dual-Axle Cummins Form. 350*	*2.06*	*1.88*	*5.56*	*4.39*	*14.3*	*13.7*	*0.97*	*0.82*
2-3	*Dual-Axle DD8V-92TA*	*1.72*	*1.34*	*2.24*	*4.33*	*13.4*	*15.1*	*0.87*	*0.89*
2-4	*Single-Axle IHC DT-466*	*1.15*	*1.00*	*2.82*	*2.62*	*8 91*	*8.31*	*0.78*	*0.64*
3-23	*Single-Axle Cummins NTC-300*	*3.16*	*2.80*	*3.70*	*5.55*	*8.99*	*14.6*	*1 19*	*0 93*
3-24	*Dual-Axle DD8V-92TA*	*1.62*	*1.36*	*4.67*	*6.66*	*17.6*	*18 7*	*1.35*	*1.14*

[a] Engine transient emission rate based on an engine equivalent distance of 10.3 km.

Table 2. *Comparison of Fuel Specific Emissions from Chassis and Engine Transient Tests from Several Vehicles (g/kg fuel)*

Vehicle Number	Composite Emission Rate, g/kg fuel: HC Chassis	HC Engine	CO Chassis	CO Engine	NO_x Chassis	NO_x Engine	Particulate Chassis	Particulate Engine
2-1	4.23	7.25	51.9	20.5	26.4	22.8	3.10	2.21
2-2	4.69	4.83	12.7	11.3	32.7	34.6	2.21	2.12
2-3	3.81	2.97	4.97	9.50	29.8	33.2	1.93	1.94
2-4	3.69	3.63	8.89	9.47	28.1	30.1	2.50	2.30
3-23	9.60	7.26	11.2	14.4	27.2	37.9	3.59	2.42
3-24	3.18	2.71	9.17	13.3	34.4	37.2	2.64	2.28

testing is usually conducted at 70 percent of GVW. Vehicle 3-23, a single-axle tractor, was tested at 61%, 70%, 80%, and 93% of GVW. Vehicle 3-24, a dual-axle tractor, was operated at 55%, 70%, 86%, and 97% of GVW. Emissions results from these tests and from engine tests are reported in Tables 3 and 4 in g/km and in g/kg fuel, respectively. Vehicle 3-23 CO_2 and NO_x increased with increasing inertia when measured in g/km. On a fuel specific basis, however, CO_2 was constant while NO_x increased with inertia. HC and particulate were not affected by variations in inertia. For the dual-axle tractor, Vehicle 3-24, CO, CO_2, and NO_x emissions (in g/km) increased as inertia weight was added. On a fuel specific basis, CO_2 remained constant and CO and NO_x increased. Similar to Vehicle 3-23, HC and particulate did not vary with inertia weight with the exception of fuel specific HC, which decreased with increased inertia.

There was no single inertia setting at which chassis emissions were equivalent to engine emissions. For some emissions, chassis and engine emissions were never equivalent. This occurred with Vehicle 3-23. Chassis particulate emissions were higher and CO, CO_2, and NO_x emissions were lower than engine emissions. For Vehicle 3-24, chassis HC was greater than engine HC and chassis CO and NO_x (in g/kg fuel) were lower than engine emissions at all inertia settings.

Baseline emissions were measured on six buses, five single-axle tractors, and 17 dual-axle tractors over a minimum of two chassis transient cycles. Five of the six buses were also tested over two cycles of the New York Bus Cycle. Average baseline emissions (in g/km and g/kg fuel) are given in Table 5 for each vehicle type and for buses tested over the Bus Cycle. As a group, single-axle tractors produced relatively high HC levels and relatively low NO_x and particulate. Dual-axle tractors emitted relatively high CO_2 and NO_x and low HC and CO. Buses tested over the

Table 3. *Comparison of Engine and Chassis Emissions from Vehicles 3-23 and 3-24 Measured at Several Inertia Settings (g/km)*

Vehicle Number	Vehicle Description	Engine Emissions, g/km[a]: HC	CO	CO_2	NO_x[b]	Part.	Percent of GVW	Chassis Emissions, g/km: HC	CO	CO_2	NO_x[b]	Part.
3-23[c]	Single-axle 1981 Cummins NTC-300	2.80	5.55	1211	14.6	0.93	61%	3.33	3.79	1006	8.37	1.22
							70%	3.16	3.70	1036	8.99	1.19
							80%	3.54	4.15	1110	10.4	1.31
							93%	3.14	4.20	1152	10.8	1.26
3-24	Dual-axle 1980 DD8V-92TA	1.36	6.66	1583	18.7	1.14	55%	1.71	3.36	1416	14.4	1.14
							70%	1.62	4.67	1609	17.6	1.35
							86%	1.65	5.81	1775	19.8	1.26
							97%	1.66	7.62	1847	21.5	1.41

[a] *Engine emission rates are based on a 10.3 km engine test cycle.*
[b] *NO_x from bag measurement.*
[c] *Vehicle 3-23 chassis emissions were measured at 80 percent of standard horsepower.*

Table 4. *Comparison of Composite Fuel Specific Engine and Chassis Emissions from Vehicles 3-23 and 3-24 Measured at Several Inertia Settings (g/kg fuel)*

Vehicle Number	Vehicle Description	Engine Emissions, g/kg fuel: HC	CO	CO_2	NO_x[a]	Part.	Percent of GVW	Chassis Emissions, g/kg fuel: HC	CO	CO_2	NO_x[a]	Part.
3-23[b]	Single-axle 1981 Cummins NTC-300	7.26	14.4	3136	37.9	2.42	61%	10.4	11.8	3128	26.1	3.80
							70%	9.60	11.2	3130	27.2	3.59
							80%	10.0	11.7	3128	30.0	3.68
							93%	8.55	11.4	3134	29.6	3.44
3-24	Dual-axle 1980 DD8V-92TA	2.71	13.3	3153	37.2	2.28	55%	3.83	7.50	3156	32.1	2.53
							70%	3.18	9.17	3155	34.4	2.64
							86%	2.93	10.4	3154	35.2	2.24
							97%	2.82	13.0	3150	36.7	2.41

[a] *NO_x from bag measurement.*
[b] *Vehicle 3-23 chassis emissions were measured at 80 percent of standard horsepower.*

chassis transient cycle produced relatively high CO and particulate and low HC compared to single- and dual-axle tractors. Bus CO emissions were 4 to 6 times higher than tractor CO emissions and bus particulate was double that of tractor particulate emissions.

Bus emissions from the New York Bus Cycle generally exceeded chassis transient cycle emissions with the exception of fuel specific CO_2 and NO_x. The greatest difference between driving cycles was for CO and particulate emissions.

Table 5. *Summary of Baseline Emissions from Single-Axle Tractors, Dual-Axle Tractors, and Buses Over the Chassis Version of the Transient Cycle and of Buses Over the New York Bus Cycle*

	Emission Rate, g/km					Emission Rate, g/kg fuel				
	HC	CO	CO_2	NO_x	Part.	HC	CO	CO_2	NO_x	Part.
					Single-Axle Tractors					
Average	1.94	3.75	1056	9.37	1.07	5.75	11.1	3144	28.1	3.19
Std. Dev.	0.86	1.26	70	0.81	0.28	2.50	3.5	12	3.6	0.73
Coef. of Var. (%)	44	34	7	9	26	44	32	<0.5	13	23
					Dual-Axle Tractors					
Average	1.74	7.19	1464	17.0	1.47	3.74	15.3	3142	35.5	3.15
Std. Dev.	0.48	4.58	106	2.9	0.55	1.04	9.2	16	5.4	1.10
Coef. of Var. (%)	28	64	7	17	37	28	60	1	15	35
					Buses					
Average	1.71	27.4	1233	12.4	2.46	4.23	67.4	3045	30.7	6.04
Std. Dev.	0.10	16.6	37	3.0	1.45	0.30	40.7	64	7.4	3.56
Coef. of Var. (%)	6	61	3	24	59	7	60	2	24	59
					Buses Over New York Bus Cycle					
Average	2.23	48.0	1488	15.2	3.89	4.51	95.9	3000	30.7	7.74
Std. Dev.	0.32	28.6	32	3.1	2.30	0.76	55.5	86	7.0	4.40
Coef. of Var. (%)	14	60	2	20	69	17	58	3	23	57

Table 6. *Summary of Unregulated Emissions from Single-Axle Tractors, Dual-Axle Tractors, and Buses Over the Chassis Transient Cycle*

Emission	Single-Axle Tractors	Dual-Axle Tractors	Buses
Total Aldehydes and Ketones, mg/km[a]	451	238	381
Phenols, mg/km[b]	ND[c]	ND	ND
DOAS odor			
LCA, mg/km	253	340	895
LCO, mg/km	130	204	101
Phosphorus, mg/km[d]	1	2	3
Sulfur, mg/km[d]	19	28	9
1-nitropyrene, µg/km[e]	5	8	ND
Ames bioassay, revertants/km			
TA1538 +S9	440	277	127
-S9	208	262	47
TA98 +S9	438	304	128
-S9	359	345	63
TA100 +S9	414	343	285
-S9	560	434	196

[a] Average included only those vehicles analyzed with improved DNPH method.

[b] Negligible phenol levels measured.

[c] ND = Not Detected.

[d] Most common elements detected were phosphorus and sulfur.

[e] No dinitropyrenes detected above 1 µg/km.

Unregulated emissions were measured for 24 of the baseline test vehicles. Aldehydes and ketones, phenols, and odor were sampled over one cold-start and three hot-starts. Elemental composition and soluble organic fractions (for nitropyrene and Ames bioassay) were determined on filters sampled during one cold-start and filters sampled over one hot-start. Unregulated emissions results are summarized in Table 6. The emissions represent composite values weighted 1/7 cold-start and 6/7 hot-start.

As a group, single-axle tractors produced higher than average total aldehydes and ketones and relatively high Ames response. They also emitted lower than average LCA odor and phosphorus relative to all vehicle types. Dual-axle tractors produced relatively high LCO odor, sulfur, and 1-nitropyrene levels and low levels of aldehydes and ketones. Buses tended to produce higher than average LCA odor and phosphorus and relatively low amounts of 1-nitropyrene and low Ames response.

Recommendations

Results reported in this study have provided an important step forward in understanding the relationship between engine and chassis testing, as well as providing a significant data base for the characterization of heavy-duty trucks and buses for gaseous, particulate and unregulated emissions. Upon completion of this program, it was apparent many areas of investigation remain, before the knowledge of heavy-duty truck and bus emissions approach that of the automobile. Several of the areas suggested for additional research are briefly described by various vehicle categories.

City Buses

Engine versus chassis comparisons of a city bus showed virtually no agreement of gaseous or particulate emissions. Additional work is recommended to include engine versus chassis comparisons on a different bus with the same engine model. This study should include the engine bus transient cycle (a cycle not available at the time of this study) as well as several inertia weights during chassis testing.

Additional buses should be included that would expand the data base to include the DD 6V-92TA and Cummins V-903 engines, and other engines representing significant fractions of the bus population. These evaluations should include both chassis and engine testing for these engines. Consideration should be also given to developing a different bus cycle, if it is felt that the current cycle is not representative of real life bus operation.

Dual-Axle Diesel Truck Tractors

This program generated a substantial amount of emissions characterization from a variety of dual-axle tractors. These vehicles basically represent engine production from 1979-1981. Although most of the major engine models were included in this study, there will undoubtedly be new models introduced each year. In order to keep current on in-use emissions characterization of heavy-duty vehicles, it is suggested that EPA continue a limited amount of characterization to include new technology engines that will be built to meet the particulate standards.

Several factors influence the gaseous and particulate emissions from a given engine in a dual-axle truck. The influence of inertia weight on emissions was investigated in this study, but this was only a first step in understanding the relationship between chassis and engine emission results. For example, how much does the transmission and gear·train affect emissions, do the tires influence emissions results, do assumptions in frontal area significantly affect emissions from dual-axle tractor. Many of the questions could be answered by obtaining two vehicles with identical engines, but different drive trains, tires, etc.; testing the vehicles over the chassis cycle; then removing the engine and testing them over the engine transient cycle. Upon completion, the engines would be switched from their original chassis and the chassis testing repeated. This would provide information to determine if assumptions made during chassis testing significantly affect emissions as well as expand the data base for engine chassis comparisons. In addition, hot-start evaluations would be conducted at several horsepower settings and inertia weights to further assess the effects of these parameters.

Single-Axle Diesel Truck Tractors

Results of two engine-chassis comparisons were obtained in this study. In one case (IHC DT-466B), good agreement was observed, but in the other case (Cummins NTC-300), virtually no agreement between chassis and engine emissions was observed. In the case where good agreement was observed, the engine power to vehicle weight appeared to be more "normally" matched for a single-axle truck tractor. In the case of the second engine with virtually no agreement in emission results, the Cummins NTC-300 engine had a relatively high power to vehicle weight ratio. Several of the single-axle tractors had engines with relatively high power to vehicle weight ratios. The Cummins NTC-300 engine in a dual-axle tractor would probably provide a better agreement of chassis and engine emission results. If it is felt that a significant fraction of the single-axle, truck tractor population is in this category, then additional work would be warranted. This work could be similar to that described earlier, with a given engine model (e.g., Cummins NTC-300) being used in both single- and dual-axle tractors for chassis testing. This engine would also be tested over the engine transient cycle. The chassis tests should include various horsepower settings to simulate different frontal areas and different inertia weights to simulate different loadings.

Additional emissions characterization is also in order for single-axle tractors to include engines that were not available for this study and possibly include Class VI diesel vehicles. As the technology for developing low particulate heavy-duty diesel engines becomes available, it is suggested that EPA continue the characterization study at a low-level of effort.

Heavy-Duty Gasoline Vehicles

In-house studies in progress at EPA in Research Triangle Park are addressing heavy-duty gasoline vehicles requiring inertia up to about 19,000 lbs. A significant portion of the heavy-duty gasoline vehicles are above 19,000 lbs and will not be included in that study. Only a limited amount of chassis testing on heavy-duty gasoline vehicles has been conducted using the transient cycle; and even less data exists on engine versus chassis comparisons. In general, heavy-duty gasoline chassis tests have not included unregulated emissions characterization. The virtual lack of emissions data in the heavy-duty gasoline vehicle category suggest that additional work in this area may be justified. Some vehicle categories that would be good candidates would include school buses, large box vans and soft drink and beer delivery trucks.

☆U. S. GOVERNMENT PRINTING OFFICE: 1985/559-111/10751

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The complete report, entitled "Characterization of Heavy-Duty Motor Vehicle Emissions Under Transient Driving Conditions," (Order No. PB 85-124 154; Cost: $16.00, subject to change) will be available only from:

National Technical Information Service
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