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Comparison of the Vehicle Operational Characteristics of the EPA Highway Dynamometer Driving Schedule with the Rural Driving Data Collected by the GM CHASE Car Survey

by

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According to statistics provided by the Federal Highway Administration (FHWA), rural travel accounts for approximately 45% of the total vehicle miles accumulated by motor vehicle operation in the United States (1). Because the EPA Urban Dynamometer Driving Schedule (EPA UDDS) represents only the type of driving encountered in an urban environment, the EPA Highway Dynamometer Driving Schedule (EPA HDDS), developed in 1974, is a desirable supplement to the procedure for measuring fuel economy. The EPA HDDS is constructed from actual speed versus time traces that were generated by driving an instrumented test car over a variety of non-urban roads and highways (2). This schedule reflects the correct proportion of operation on each of the four major types of rural roads (as categorized by the FHWA) and preserves the non-steady-state characteristics of real-world driving (2).

Outside urban areas, the FHWA has delineated the following distinct road types as the basis for their functional classification scheme of rural roads and highways.

A. Principal arterial system
B. Minor arterial system
C. Collector system
D. Local system

The categorization of roads in a rural system begin at the top of the hierarchy and works down. First, the principal and minor arterial systems are designated on a statewide basis. Then, the collector and local road classifications are developed from a more localized (county) perspective.

In Table 1, the percentages of total highway vehicle miles travelled in the United States on each of these four types of roadway are expressed (2). Significantly, these percentages formed the basis for the construction of a composite highway driving schedule to simulate all modes of highway operation (2).

Table 2 presents a compilation of both the individual road type and composite highway trip operational characteristics that were established as goals to be achieved when designing the highway schedule (2).

During the formulation of the highway schedule, the decision was made to combine segments of actual on-road traces to representing travel on each of the different road types to compose the schedule (2). Additionally, the most realistic sequence of segments was found to be DCAB. The schedule starts from an idle, contains four major speed deviations (one each in B and D, two in C), and ends with a deceleration to a stop and idle. Two-second idle periods are included at both the beginning and the ending of the schedule (2).

Table 3 provides a compilation of the operational characteristics for both the individual road type segments and the composite EPA HDDS (3). In compliance with the original objective,) the results are quite similar to the figures furnished in Table 2.

During 1974, General Motors (GM) collected, as part of their CHASE Car survey, approximately 1700 miles of non-urban vehicle operational data. By using the chase car technique, GM attempted to gather light-duty vehicle operational data representative of urban and rural driving throughout the United States. Simply, the chase car method, entails following randomly selected vehicles with an instrumented vehicle and duplicating the operational behavior of each as precisely as possible. To facilitate statistical analysis, GM filtered the rural driving date by road type and these results will be referred to in this report as GM Rural RT (GM rural driving data filtered by road type). Table 4 supplies the operational characteristics for each of these individual road types, as well as the entire GM Rural RT data set.

Significantly, 98% (Table 4) of the mileage accumulated in non-urban locations was driven on roads classified by GM as either Rural Highway or Expressway. In contrast, the FHWA determined that only 62% (Table 1) of rural driving mileage in the U.S. is amassed on principal and minor arterial roads. Even though the GM road types cannot be correlated with FHWA road classifications on a one-to-one basis, these figures indicate that the GM chase cars did not travel enough on collector and local roads. As a result, an unusually high overall average speed is the expected tendency in the composite GM rural data, because principal and minor arterial systems have higher average speeds than do collectors and locals (see Table 2). In this respect, the GM Rural RT data may be biased. Conversely, though GM's chase cars seem to have driven few miles on roads that are categorized as collectors and locals (i.e. Unpaved-Rural, Unpaved-Suburban, and Suburban-No Curb), the average speeds they found on these road types are much lower than the speeds predicted by the FHWA data. Comparing the average speed and stops/mile data of Tables 2 and 4, Rural Highway statistics resemble those of FHWA collectors while Expressway statistics seem to be an average combining those or principal and minor arterial roads.

The purpose of this report is to compare vehicle operational characteristics of the EPA highway cycle with those of the GM Rural RT data. The computer program developed by GM to evaluate the rural GM CHASE Car data was also employed to analyze the highway schedule. Therefore, driving characteristics for both the GM Rural RT data and EPA HDDS were tabulated according to common criteria. Initially, the more easily calculable parameters such as average trip length, average trip duration, and average trip speed shall be contrasted for the EPA HDDS and GM Rural RT data. As seen in Table 5, the values are quite similar.

Stops/mile is the next parameter to be compared (Table 6). This is important in that average trip speed will decrease as stops/mile is increased. GM established three different categories of stops-rolling (similar to a vehicle rolling through a stop sign), noisy (vehicle stops in heavy traffic and moves ahead several times before clearing an intersection), and full (vehicle stops at a stop sign and then proceeds when the intersection clears) (5). Significantly, the EPA HDDS has more noisy and full stops per mile than the GM Rural RT data.

The percentages of miles and time spent in various speed bands indicate that the EPA HDDS has most of its driving around 45, 50 or 55 mph, while vehicle speeds are more evenly distributed in the GM Rural RT data. GM's chase cars also monitored a substantial amount of vehicle operation above 60 mph. The same trends can be seen by contrasting the percentages of miles and time spent in the different speed bands when cruising. GM defined cruising as an acceleration/ deceleration of less than $\pm$ 0.05 G's. These data are contained in Tables 7-10.

A comparison of the percentages of miles and time spent in various acceleration and deceleration bands reveals that the GM Rural RT data and EPA HDDS have very similar acceleration/deceleration patterns. The basis difference found is that the highway cycle confines acceleration to only two bands and deceleration to three bands (i.e. a small span) while a small portion of the acceleration and deceleration in the GM Rural RT data is again spread over a wide range of values. Otherwise, the acceleration and deceleration percentages seem to be quite similar. These data are contained in Tables 11-14.

Contrast of the operational mode summaries (Table 15) indicates that the EPA HDDS has slightly greater percentages of miles and time in both the idle and cruise modes, while GM Rural RT data show larger percentages of miles and time in the acceleration and deceleration modes.

In conclusion, comparison between the EPA HDDS and GM Rural RT data seems to suggest that both have very similar operational characteristics, most notably average trip speed. The primary discrepancies found are that the highway cycle has more stops/mile and the GM Rural RT data includes substantial driving at speeds above 60 mph. Because types of roadway are defined differently by General Motors and the FHWA, it is difficult to determine whether the percentage of miles driven on each road classification by the chase cars are comparable to those found in the EPA highway schedule. However, assuming that GM's definitions of Rural Highway and Expressway are synonymous with the concept of an arterial, it seems that GM's chase cars drove too much on principal and minor arterials and not enough on collectors and locals.

References

1. T.C. Austin and K.H. Hellman, "Passenger Car Fuel Economy as In fluenced by Trip Length", Paper 750004, presented at SAE Automotive Engineering Congress and Exposition, Detroit, Michigan, February, 1975.

2. R.E. Kruse and C.D. Paulsell, "Development of a Highway Driving Cycle for Fuel Economy Measurements", Environmental Protection Agency, March, 1974.

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4. T.C. Austin, K.H. Hellman, and C.D. Paulsell, "Passenger Car Fuel Economy During Non-Urban Driving", Paper 740592, presented at SAE West Coast Meeting, Anaheim, California, August, 1974.

5. T.M. Johnson, D.L. Formenti, R.F. Gray, and W.C. Peterson, "Measure ment of Motor Vehicle Operation Pertinent to Fuel Economy", Paper 750003, presented at SAE Automotive Engineering Congress and Ex position, Detroit, Michigan, February, 1975.

Appendix

Table 1

Type of Highway	Percent of Highway Vehicle Miles Travelled
A. Principal arterials	39.5
B. Minor arterials	22.4
C. Collectors	23.9
D. Locals	14.2
	100

Table 2

Average Highway Characteristics

Road Type	Average Speed (mph)	Stops/mile	Segment Length (miles)	Percent of Total Miles
A	57.16	0.0100	3.91	39.46
B	49.42	0.0575	2.22	22.40
C	45.80	0.1260	2.37	23.92
D	39.78	0.2360	1.41	14.23
Composite Trip	49.43	0.08	9.91	100.0

Table 3

Road Type Segment	Average Speed (mph)	Stops/mile	Segment Length (miles)	Percent of Total Miles	Segment Duration (seconds)
Idle	0.00		0.00	0.00	2
D	40.74	One stop	1.63	15.91	144
C	43.84	for the	2.11	20.57	173
A	56.11	entire cycle	3.97	38.80	255
B	48.23		2.53	24.72	189
Idle	0.00		0.00	0.00	2
EPA HDDS	48.20	0.098	10.24	100.0	765

Table 4

Characterization of Composite GM Rural RT Data Set

Road Type	Average Speed (mph)	Stops/Mile	Miles Travelled	Percent of Total Miles
Rural Highway	44.70	0.100	488	28.63
Expressway	53.12	0.034	1184	69.44
Unpaved-Rural	24.50	0.546	5	0.29
Unpaved-Suburban	17.71	0.739	3	0.18
Suburban-No Curb	21.45	0.964	25	1.47
GM Rural RT	49.08	0.069	1705	100.00

Table 5

	EPA HDDS	GM Rural RT
Average Trip Length (miles)	10.24	8.66
Average Trip Duration (minutes)	12.75	10.58
Average Trip Speed (mph)	48.20	49.08

Table 6

	EPA HDDS	GM Rural RT
Rolling Stops/Mile	0	0.093
Noisy Stops/Mile	0.191	0.060
Full Stops/Mile	0.191	0.069
Noisy & Full Stops/Mile	0.382	0.129
Total Stops/Mile	0.382	0.222

Table 7

Percentage of Miles Spent in Speed Bands

mph ± 2.5 mph	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
EPA HDDS	.05	.08	.10	.22	.24	.68	1.47	3.54	8.11	26.41	17.72	38.02	3.37	0	0	0
GM Rural RT	.01	.10	.21	.39	.85	1.26	2.22	3.34	5.71	8.59	16.08	24.68	20.08	9.14	5.37	1.24

Speed Range (mph)	EPA HDDS	GM Rural RT
0-42.5	14.49	14.09
42.5-57.5	82.15	49.35
57.5-77.5	3.37	35.83

Table 8

Percentage of Time Spent in Speed Bands

mph ± 2.5 mph	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
EPA HDDS	4.07	.51	.38	.64	.51	1.14	2.16	4.57	9.02	26.43	16.26	31.64	2.67	0	0	0
GM Rural RT	1.25	.96	1.01	1.27	2.07	2.46	3.62	4.65	6.97	9.33	15.68	22.06	17.13	6.92	3.79	.83

Table 9

Percentage of Miles Spent in Speed Bands While Cruising

mph ± 2.5 mph	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
EPA HDDS	0	0	0	0	0	.33	1.08	3.07	7.42	26.89	18.05	39.64	3.51	0	0	0
GM Rural RT	0	.05	.09	.15	.48	.82	1.68	2.78	5.20	8.18	16.34	25.80	21.85	9.59	5.66	1.31

Speed Range (mph)	EPA HDDS	GM Rural RT
0-42.5	11.90	11.25
42.5-57.5	84.58	50.32
57.5-77.5	3.51	38.41

Table 10

Percentage of Time Spent in Speed Bands While Cruising

mph ± 2.5 mph	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75
EPA HDDS	0	0	0	0	0	.57	1.70	4.25	8.78	28.75	17.71	35.27	2.97	0	0	0
GM Rural RT	0	.48	.44	.52	1.23	1.67	2.87	4.07	6.68	9.34	16.76	24.25	18.93	7.64	4.20	.92

Table 11

Percentage of Miles Spent in Acceleration Bands

G's	.05-.10	.10-.15	.15-.20	.20-.25	.25-.30	.30-.35	.35-.40	.40-.45	.45-.50	.50-.55	.55-.60	.60-.65
EPA HDDS	83.68	16.32										
GM Rural RT	82.51	11.81	4.84	.57	.09	.12	.02	0	.04	0	0	0

Table 12

Percentage of Time Spent in Acceleration Bands

G's	.05-.10	.10-.15	.15-.20	.20-.25	.25-.30	.30-.35	.35-.40	.40-.45	.45-.50	.50-.55	.55-.60	.60-.65
EPA HDDS	75.00	25.00										
GM Rural RT	76.87	14.77	6.98	1.02	.14	.16	.02	0	.04	0	0	0

Table 13

Percentage of Miles Spent in Deceleration Bands

G's	-.05 - -.10	-.10 - -.15	-.15 - -.20	-.20 - -.25	-.25 - -.30	-.30 - -.35	-.35 - -.40	-.40 - -.45	-.45 - -.50	-.50 - -.55	-.55 - -.60	-.60 - -.65
EPA HDDS	76.71	16.89	6.40									
GM Rural RT	77.94	13.68	6.47	1.42	.34	.09	0	0	.03	0	.03	0

Table 14

Percentage of Time Spent in Deceleration Bands

G's	-.05 - -.10	-.10 - -.15	-.15 - -.20	-.20 - -.25	-.25 - -.30	-.30 - -.35	-.35 - -.40	-.40 - -.45	-.45 - -.50	-.50 - -.55	-.55 - -.60	-.60 - -.65
EPA HDDS	73.53	20.59	5.88									
GM Rural RT	70.33	17.55	9.45	2.03	.49	.13	0	0	.01	0	.01	0

Table 15

Operational Mode Summary

	EPA HDDS		GM Rural RT	
Operating Mode	Percent Miles in Mode	Percent Time in Mode	Percent Miles in Mode	Percent Time in Mode
Idle	0	3.43	0	1.10
Cruise	95.90	89.71	93.45	88.84
Acceleration	1.32	2.54	3.02	4.47
Deceleration	2.78	4.32	3.55	5.60