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Technical Report

Vehicle Fuel Economy
Track vs. Dynamometer

by

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I. Introduction

In a recently completed program a 1979 Chevrolet Nova was operated over EPA driving cycles on a test track at the Transportation Research Center in Ohio and on a chassis dynamometer at EPA MVEL in Ann Arbor. The data obtained in this program provide an opportunity to compare road and dynamometer fuel economy.

This report discusses the results obtained from this program and discusses a dynamometer modification which would make the dynamometer fuel economy a more accurate predictor of fuel economy obtained by the vehicle on the road.

II. Discussion

Both the track and dynamometer portions of the tests consisted of driving the vehicle over the EPA driving cycles while fuel consumption was measured with a flowmeter. The EPA urban and highway driving cycles used in both the road and dynamometer tests simulate urban and highway driving respectively.

The EPA urban cycle (FTP) is intended to simulate a suburban to urban commute during rush hour and thus consists of low speed stop and go driving. The FTP is divided into three segments that are run consecutively. The segments are commonly referred to as "bags" because during emission testing exhaust gases from each of these segments are analyzed separately and therefore are stored in separate sample bags. The highway cycle simulates highway driving and thus consists of higher speed driving with no stops.

Fuel consumption during both dynamometer and road tests was measured with a Fluidyne flowmeter. Since fuel density varies with temperature, fuel consumption was corrected to the fuel density that occurs at 60° F.

Tests on both the road and dynamometer were conducted with four different sets of tires. For each set of tires, the dynamometer power absorber was set so that the vehicle 55-45 mph coastdown time on the dynamometer matched the coastdown time on the road. This method of determining the dynamometer power absorption values is commonly used in the EPA exhaust emission and fuel economy programs.1/ The data in Table 1 show the road and dynamometer fuel economy by bag for each of the four sets of tires. Also shown in Table 1 is the fuel economy for the composite of Bags 1-3. This is the total distance traveled divided by the total fuel consumed in Bags 1-3. The composite fuel economy numbers for the dynamometer tests compare well with the 16 mpg result from similar tests on Novas published in the 1979 Gas Mileage Guide.

The difference between road and dynamometer fuel economy in the Bag 1 tests is noticeably different than in the other tests. This can be explained by the fact that in dynamometer testing Bag 1 tests involve a cold start, but in track tests the vehicle was started and driven a short distance to the track before testing began. Although the distance from the vehicle storage area to the track was small, even this short drive allowed the vehicle to partially warm up before the test began. This means that the road fuel economy numbers for Bag 1 tests are probably somewhat higher than those that would be obtained by strictly following the EPA FTP test procedure. If Bag 1 tests are not considered, then the dynamometer fuel economy is an average of 10.1 percent higher than the road fuel economy. This is somewhat higher than the 5 percent difference reported previously.2/

Some of the difference between road and dynamometer fuel economy might have been due to differences in the ambient temperature. However, when the data was examined to develop a temperature correction, no statistically significant relationship could be found between ambient temperature and fuel economy. This is not surprising since the literature indicates that the temperature correction for the relatively small temperature range encountered in these tests would be small. The literature also indicates that the temperature effect is most important during vehicle warm-up. Since these data were taken after the vehicle was already partially warmed, the effect of ambient temperature would be expected to be very small.

The fact that the vehicle consumes less fuel on the dynamometer than it does when driven over the same cycle on the road implies that either the vehicle operates more efficiently on the dynamometer than on the road or that less energy is extracted from the vehicle on the dynamometer.

Previous EPA studies have shown that in normal dynamometer operation, the rear roll of the twin roll dynamometer will turn faster than the front roll because of tire deformation. This study concluded that, at least during steady speed operation, the front roll of the dynamometer simulated a lower vehicle speed while the rear roller simulated a higher vehicle speed than was measured on a track under similar conditions. This study further concluded that coupling the dynamometer rolls significantly reduced the velocity simulation error.3/

When the dynamometer is operated with the rolls coupled more energy is extracted from the vehicle than if the rolls are uncoupled because the power absorber is forced to turn at the higher, more appropriate, simulated speed. Consequently, one would expect a vehicle to consume more fuel and hence have lower fuel economy if it were operated on the dynamometer with rolls coupled. Tests conducted at EPA MVEL several years ago indicate that this is the case.4/

In order to investigate this further, the same test vehicle was driven over the same EPA test cycles on the dynamometer with the rolls coupled. The results of this test are compared to the results of the uncoupled test and the road test in Table 2. During these tests the dynamometer power absorber was readjusted so that the 55 mph to 45 mph vehicle-dynamometer coastdown times with the rolls coupled again matched the track coastdown times.

Table 2 shows that, as expected, vehicle fuel economy on the dynamometer is closer to the road fuel economy if the dynamometer rolls are coupled than if they are uncoupled. It is important to note, however, that only about 2/3 of the difference between road and dynamometer fuel economy is accounted for by coupling the rolls. Even with the rolls coupled there is still nearly a 4 percent difference between dynamometer and road fuel economy.

It is interesting to examine the effect of tire rolling resistance on the ratio of road to dynamometer fuel economy. In Table 1 the tires are listed in order of increasing rolling resistance. It is true in general that a vehicle operated on a dynamometer will get improved fuel economy with lower rolling resistance tires. However, as can be seen in Table 1 the ratio of road to dynamometer fuel economy decreases as tire rolling resistance increases. This indicates that in dynamometer testing either vehicles with high rolling resistance tires are not penalized sufficiently in fuel economy or low rolling resistance tires are not credited enough in comparison with the road effects.

III. Conclusion

Recently completed tests conducted with a 1979 Chevrolet Nova on both the road and dynamometer show that, after some vehicle warm up, the dynamometer tests overestimate road fuel economy by about 10 percent. Coupling the rolls of the dynamometer significantly reduces this difference; however, the difference in fuel economy between the road and the dynamometer with coupled rolls is still about 4 percent.

IV. Recommendation

It is recommended that further tests with other vehicles be conducted to verify that a dynamometer with coupled rolls more closely simulates the road experience of the vehicle than the presently used dynamometer configuration. However, since coupling the dynamometer rolls only appears to account for about two-thirds of the difference between road and dynamometer fuel economy, it is recommended that these test vehicles be instrumented to record torque and speed data in order to compute actual energy expended. Also since it is possible that some of the fuel economy difference is due to different vehicle efficiencies on the road and dynamometer, it is recommended that temperatures of various vehicle components be monitored during the test.

An attempt should be made to identify the causes and account for the entire difference in track and dynamometer fuel economy. If both energy and temperature are recorded, this should be possible.

Table 1

Bag 1	Road MPG	Dyno MPG	Road Dyno	Δ	%Δ
Uniroyal	15.92	14.69	1.08	-1.23	-7.73
Goodyear	15.75	14.85	1.06	-0.90	-5.71
BFG	15.45	14.60	1.06	-0.85	-5.50
Bridgestone	14.84	14.16	1.05	-0.68	-4.58
Bag 2					
Uniroyal	14.96	16.12	.93	1.16	7.75
Goodyear	14.90	16.10	.93	1.20	8.05
BFG	14.61	15.82	.92	1.21	8.28
Bridgestone	14.19	15.82	.90	1.63	11.49
Bag 3					
Uniroyal	16.52	17.76	.93	1.24	7.51
Goodyear	16.32	17.58	.93	1.26	7.72
BFG	16.03	17.42	.92	1.39	8.67
Bridgestone	15.60	17.02	.92	1.42	9.10
Composite FTP					
Uniroyal	15.78	16.26	.97	.48	3.04
Goodyear	15.64	16.26	.97	.56	3.58
BFG	15.34	15.94	.96	.60	3.91
Bridgestone	14.86	15.73	.94	.87	5.85
HFET					
Uniroyal	21.65	24.08	.90	2.43	11.22
Goodyear	21.39	24.26	.88	2.87	13.42
BFG	20.87	24.00	.87	3.13	15.00
Bridgestone	20.13	22.94	.88	2.81	13.96

Table 2

Bridgestone Tires

	Road MPG	Dyno Uncoupled MPG	% Diff from Road	Dyno Coupled MPG	% Diff from Road
Bag 1	14.84	14.16	-4.58	14.0	-5.9
Bag 2	14.19	15.82	11.49	14.6	2.9
Bag 3	15.60	17.02	9.10	16.2	3.8
Composite FTP	14.86	15.73	5.85	14.9	0.3
HFET	20.13	22.94	13.96	21.1	4.8

References

1/ EPA Advisory Circular 55/B "Determination and Use of Alternate Dynamometer Power Absorption Values," December 1978.

2/ T. Austin, "Passenger Car Fuel Economy - Dynamometer vs. Track vs. Road," EPA Technical Report, August 1975.

3/ J. Yurko, "A Track to Twin Roll Dynamometer Comparison of Several Different Methods of Vehicle Velocity Simulation," EPA Technical Report, June 1979.

4/ Conversation with Don Paulsell of the EPA, Ann Arbor Laboratory, March 1980.