SDSB 79-27

Technical Report

Tire Related Effects on Vehicle Fuel Economy

by

John Yurko

July 1979

NOTICE

Technical Reports do not necessarily represent final EPA decisions or positions. They are intended to present technical analysis of issues using data which are currently available. The purpose in the release of such reports is to facilitate the exchange of technical information and to inform the public of technical developments which may form the basis for a final EPA decision, position or regulatory action.

Standards Development and Support Branch
Emission Control Technology Division
Office of Mobile Source Air Pollution Control
Office of Air, Noise and Radiation
U.S. Environmental Protection Agency

Abstract

This paper analyzes the fuel economy results from steady-state and EPA Urban cycle tests that were conducted on the track at the Transportation Research Center of Ohio, during Fall 1978, and steady-state tests that were conducted on a twin roll dynamometer at the EPA, MVEL during Spring 1979. Results were obtained for four different sets of radial tires and four different sets of bias belted tires, and at different tire pressures.

The results showed that radial tires gave better fuel economy than bias belted tires on the track. However, bias belted tires gave better fuel economy on the dynamometer when the vehicle was tested at the same dynamometer power absorption.

Larger diameter tires gave better vehicle fuel economies than did smaller diameter tires on both the track and the dynamometer.

The tires tested varied in their effect on fuel economy by as much as 6%. The two extremes, high cost and low cost tires, produced better vehicle fuel economy results than the average quality tires.

The vehicle fuel economy rankings all tires were the same for both steady state results and for results from the LA4 transient cycle.

All radial tires ranked the same between dynamometer and track tests. Similarly, bias belted tires ranked the same between track and dynamometer tests. However, in the aggregate case, bias belted tires improved in their dynamometer ranking with respect to the radials, as compared to their ranking on the track.

Increasing tire pressure improved fuel economy.

Foreword

During the Fall 1978, a vehicle was tested on a track at the Transportation Research Center of Ohio (TRC), over steady-state and transient cycle tests, with several different sets of tires. Subsequently, the same vehicle and tires were tested at the EPA/MVEL, on a twin roll dynamometer at steady-state conditions. Although, the major concern of the test program was to determine the optimum speed sensor location on the dynamometer (1), enough fuel economy information was obtained to make various road and dynamometer tire comparisons.

Among the information obtained from this test program were fuel economy comparisons by; tire type, tire size, tire quality (cost), tire manufacturer and tire pressure. In addition, the vehicle fuel economy ranking order of the tires at steady-state conditions is compared to their ranking order over transient cycles on the track, and these are compared to the ranking order at steady-state on the dynamometer. This report presents the results of these fuel economy comparisons.

Summary

On the track tests, the radial tires showed about a 2 to 4% improvement in vehicle fuel economy over the bias belted tires. However, on the dynamometer, bias belted tires had the better vehicle fuel economy results, about 0.5% higher than that obtained with the radial tires.

The larger 15" diameter tires showed about a 1 to 2% vehicle fuel economy improvement over the smaller 14" diameter tires. It should be noted that the rolling resistance effects and the N/V (engine rpm to vehicle velocity ratio) effects were not distinguished, and that the net fuel economy result is reported.

Considering higher cost to indicate higher tire quality, the least expensive 15" radial tire (Multimile Supreme) showed a 2% vehicle fuel economy improvement over the moderately priced 15" radial tire (Firestone 721) on the track over the LA4 cycle, but only 0.3% over the most expensive 15" radial tire (Michelin-X). On the dynamometer, the least expensive radial also showed vehicle fuel economy improvements, over the most expensive radial, and the moderately priced radial tire, of about 2% and 3% respectively.

In contrast, for the bias belted tires, the most expensive 15" tire (Goodyear Custom Power) showed the best vehicle fuel economy results with improvements over, the least expensive 15" bias belted tire (Multimile Multiglass II), of about 2% during the LA4 cycles and 0.4% during steady-state tests on the track. As in the case of the radial tires, the moderately priced bias belted tire (Uniroyal Fastrak) showed the lowest vehicle fuel economy results, with about 3% lower vehicle fuel economy than obtained with the most expensive bias belted tires, during LA4 cycles. Only the moderately priced bias belted tires were tested on the dynamometer. Therefore, no comparison, by cost, among bias tires was possible for the dynamometer results.

The fuel economy ranking order, for the radial tires, was the same for steady-state track tests, LA4 track tests, and steady-state dynamometer tests. The ranking order of the bias belted tires was also unchanged in each case. However, the overall ranking order, including both radials and bias belted tires, was different between the track and dynamometer tests, due to the improvement in the relative performance of the bias belted tires on the dynamometer.

Based on LA4 tests, on one set of bias belted tires and one set of radial tires; higher tire pressures gave higher vehicle fuel economy for all tests. At 24 PSI, the radial tire showed about a 0.6% fuel economy improvement and the bias belted tire showed about a 1.4% improvement, over the 20 PSI tests. At 45 PSI, the radial tire showed about a 4% fuel economy improvement and the bias belted tire showed about a 10% improvement, over the 20 PSI tests.

Overall, the tests showed, with statistical significance, that the radial tires gave better vehicle fuel economy than the bias belted tires. Increasing tire size or tire pressures improved vehicle fuel economy. The least and most expensive tires gave better vehicle fuel economy than the moderately priced tires. However, specific correlation between tire cost and vehicle fuel economy cannot be obtained from these tests. The fuel economy ranking remained the same, within tire types, for all cases. However, combining radials and bias belted tires, the bias belted tires ranked higher with respect to the radials on the dynamometer as compared to their relative ranking on the road.

Introduction

The rolling resistance of the tires can account for about 20 to 30% of the resistive forces experienced by a vehicle in motion, under normal operation. In addition, the tires can affect the efficiency of the vehicle by changing the N/V ratio (engine rpm to vehicle velocity ratio). A decrease in N/V, in general, moves the engine operation to a state of greater efficiency and reduced internal losses. Such a change is usually also accompanied by a sacrifice in acceleration potential.

It has been known that radial tires, in general, give better vehicle fuel economy than bias belted tires, mainly because of their lower rolling resistance (1), and possibly a lower N/V effect. Tires of larger diameter give better vehicle fuel economy than smaller diameter tires, due to a decrease in both N/V and rolling resistance (1). Increasing tire pressure improves vehicle fuel economy, due mainly to a decrease in rolling resistance and to a lesser extent to N/V (2).

Vehicle fuel economy may differ signficantly between tires produced by different manufacturers (1). This may be the result of tire quality (tread thickness, tread material, etc.) or tire design (e.g., tread pattern) affecting differences in the rolling resistance. Also different tires within a nominal size class may slightly differ in actual size, which could cause rolling resistance and N/V differences between tires of different manufacturers. However, tires of the same nominal size are not expected to differ enough in actual size to cause a significant vehicle fuel economy difference.

One way to classify tires of the same type and size, but different manufacturer, is by the cost of the tire. The basis is that "cheaper" tires may have less tread thickness and thus lower rolling resistance. On the other hand, a more expensive tire may have a better quality rubber which could affect the rolling resistance, or perhaps thicker tread affecting rolling resistance and N/V. At any rate, it has been suggested that tire cost may be a useful predicter of fuel economy in tires, although there is little known in this area, at this time.

Discussion

The data of this report were obtained from track fuel economy tests of a 1976 Mercury Montego. The vehicle was fully warmed up for all tests. The tires were not warmed up prior to the LA4 tests, but were warmed up for 20 minutes at 50 mph prior to the steady-state tests. Fuel consumption per distance was determined by measuring fuel flow with a fluidyne flowmeter and distance from a fifth wheel. Ambient conditions were monitored and recorded during each test and were used to determine the validity of the tests.

Subsequently, the vehicle was tested on a twin roll dynamometer at the EPA laboratory in Ann Arbor, with six of the eight tires (excluding the high and low cost bias belted tires) that were tested on the track.

Only steady-state tests were conducted on the dynamometer. Fuel consumption was determined in the same manner as the road tests, except that the rear roll revolutions of the dynamometer, were used to determine the distance traveled.

The entire test program provided several fuel economy comparisons with different tire parameters which are outlined below and are discussed in the following sections:

1. Fuel Economy Comparison between Bias Belted and Radial Tires.

   1.1 On a test track over the LA4 cycle.
   1.2 On a test track over 50 mph steady-state tests.
   1.3 On a dynamometer at steady-state.

2. Fuel Economy Comparison between Different Tire Sizes

   2.1 On a test track over the LA4 cycle.
   2.2 On a test track over 50 mph steady-state tests.
   2.3 On a dynamometer at steady-state

3. Fuel Economy Comparison between Tires of Different Manufacturers

   3.1 On a test track over the LA4 cycle.
   3.2 On a test track over 50 mph steady-state tests.
   3.3 On a dynamometer at steady-state.

4. A Comparison of the Fuel Economy Ranking Order between LA4 Tests and Steady-state Tests on the Track.

5. A Comparison of the Fuel Economy Ranking Order between Dynamometer Tests and Track Tests

6. The Effect of Tire Pressures on Fuel Economy

Although the following sections are titled "Fuel Economy Comparisons", all the analyses are described in terms of fuel consumption, which is the inverse of the fuel economy. Since tests under several different conditions are being compared, a basis for every condition has been defined as the ratio of the fuel consumption of any tire "t" to the fuel consumption of tire no. 1 under nearly the same conditions. This ratio has been given the symbol, RT/1. A listing of each tire and its assigned number is given in Appendix A.

1. Fuel Economy Comparison between Bias Belted and Radial Tires

   1.1 On a test track over the LA4 cycle.

Referring to Table 1a, the results of the LA4 tests on the track showed that the radial tires gave an average of 2.5% lower vehicle fuel

Table 1

Ranking Order of Tires from Lowest to Highest Fuel Consumption

1a. Over LA4 cycles on the track

Tire No.	Type	Size	Cost	Fuel Consumed (cc/km)	RT/1	Std. Dev.	No. of Tests	Mean Ambient Temp.
4	R	15"	Low	269.4	0.997	0.024	3	58°
1	R	15"	High	270.3	1.000	0.000	3	65°
5	BB	15"	High	273.6	1.011	-	1	68°
2	R	15"	Mod	274.3	1.014	0.014	6	59°
3	R	14"	Mod	279.0	1.028	0.016	5	52°
8	BB	15"	Low	276.5	1.032	0.018	3	59°
6	BB	15"	Mod	282.1	1.042	0.016	4	57°
7	BB	14"	Mod	285.8	1.058	0.022	7	61°

1b. Over steady-state tests on the track

Tire No.	Type	Size	Cost	Fuel Consumed (cc/km)	RT/1	Std. Dev.	No. of Tests	Mean Ambient Temp.
4	R	15"	Low	165.1	0.960	-	1	67°
1	R	15"	High	172.0	1.000	-	1	63°
5	BB	15"	High	175.2	1.019	-	1	42°
8	BB	15"	Low	175.9	1.023	-	1	62°
3	R	14"	Mod	172.0	1.030	-	1	52°
7	BB	14"	Mod	165.1	1.044	-	1	56°

consumption than did the bias belted tires. Within a particular tire size, the difference between the "best" radial tire and the "worst" bias belted tire was more than 4%. Statistical T-tests showed over a 99% confidence that these differences between radial and bias belted tires were significant.

1.2 On a test track at 50 mph steady-state.

Referring to Table 1b, the steady-state track tests showed that the radial tires gave about 2 to 4% lower vehicle fuel consumption than did the bias belted tires. Although each tire was only tested once at steady-state on the track, the results are consistent with the LA4 tests on these same tires.

1.3 On a dynamometer at steady-state.

Since the test program was designed primarily for a road to dynamometer correlation to determine the optimum speed sensor location (3), the vehicle fuel economy data obtained on the dynamometer was spread over three different steady-state speeds; 40, 50, and 55 mph and 3 different dynamometer power settings; 10.4, 11.4, and 12.4 HP. A maximum of 18 tests were conducted on six of the eight tire sets. The results are listed in Table 2. In order to combine all the data for a given tire the RT/1 value was computed at each dynamometer condition and the average value over all the tests was reported.

In contrast to the track results, on the dynamometer, the bias belted tires exhibited about a 0.4% lower vehicle fuel consumption than did radial tires, as shown in Table 2. This difference is even higher, about 2%, when only comparing the two "worst" case radial tires and the two "worst case bias belted tires. This 2% lower fuel consumption of the bias belted tires over the radial tires is probably a more representative number, since the two bias belted tires, which were "best" on the track were not tested on the dynamometer. These differences were shown to be statistically significant with over 99% confidence.

2. Fuel Economy Comparison between Different Size Tires

2.1 On a test track over the LA4 cycle.

Referring again to Table 1a, the 15" tires showed an average of about 2% lower vehicle fuel consumption than did the 14" tires, over the LA4 cycle. Comparing identical tires, which differ only in size, the 15" Firestone 721 radial tire (tire 2) gave 1.4% lower vehicle fuel consumption than did the 14" Firestone 721 (tire 3), and the 15" Uniroyal Fastrak bias belted tire (tire 6) gave 1.6% lower vehicle fuel consumption than did the 14" Uniroyal (tire 7). Statistical confidence in these differences were greater than 98%.

2.2 On a test track at 50 mph steady-state.

Referring again to table 1b, the 15" diameter tires exhibited about a 4% lower vehicle fuel consumption than did the 14" diameter tires.

Table 2

Ranking Order of Tires by Fuel Consumption
at Steady-State on the Dynamometer
(lowest to highest fuel consumption)

Using the RT/1 Values

Tire No.	Cost	Type	Size	RT/1	Std. Dev.	No. of Tests
4	Low	R	15"	0.979	0.023	18
6	Mod	BB	15"	0.992	0.018	17
1	High	R	15"	1.000	-	18
2	Mod	R	15"	1.007	0.019	17
7	Mod	BB	14"	1.008	0.017	17
3	Mod	R	14"	1.032	0.012	17

This is consistent with the results from the LA4 tests. However, 4% may be slightly high, since the "worst" case 15" tires, which were the identical models as the 14" tires, were not tested under steady-state conditions on the track.

2.3 On the dynamometer at steady-state.

Comparing only the identical tire models, on the dynamometer the 15" tires exhibited 2% lower vehicle fuel consumption than did the 14" tires, as shown in Table 2. Overall the 15" tires exhibited about 3% lower vehicle fuel consumption. These results area consistant with tests on the track and have shown statistical significance with greater than 99% confidence.

3. Fuel Economy Comparison between Tires of Different Manufacturer (Tire quality or cost)

3.1 On the track over the LA4 cycle.

Referring to Table 3, the low cost 15" radial tire (Miltimile Supreme) showed about a 0.3% lower vehicle fuel consumption than did the high cost 15" radial tire (Michelin-X) and a 1.7% lower vehicle fuel consumption than the medium cost 15" radial tire (Firestone 721). However, the difference between the low and high cost radial tires was not statistically significant. In the case of the bias belted tires over LA4 cycle on the track, the high cost 15" tire (Goodyear Custom Power) gave the lowest vehicle fuel consumption; 2% lower than the low cost 15" bias belted tire (Multimile Multiglas II), and 3% lower than the medium cost 15" bias belted tire (Uniroyal Fastrak), as shown in Table 4a. These differences were statistically significant with over 95% confidence.

3.2 On a test track at 50 mph steady-state.

As was the case over the LA4 cycle, at steady-state the low cost radial tire exhibited lower vehicle fuel consumption than did the high cost radial tire, this time by about 4%, as shown in table 3b. The medium cost 15" tires were not tested, in either the bias belted or radial tires, at this condition.

Also consistent with the LA4 tests, for bias belted tires, but in contrast to the steady-state radial tire results, the high cost bias belted tire showed a 0.4% lower vehicle fuel consumption than did the low cost bias belted tire, as shown in Table 4b.

3.3 On a dynamometer at steady-state.

Referring to Table 3c the dynamometer tests were consistent with the track tests for radial tires, in that, the low cost radial tire exhibited a 2% lower vehicle fuel consumption than did the high cost radial and 3% lower fuel consumption than the medium cost radial tire. The high and low cost bias belted tires were not tested at steady-state on the dynamometer.

Table 3

Fuel Economy Ranking Order of Radial Tires
by Manufacturer (Best to Worst)

3a. At steady-state on the track

Tire No.	Tire Manufacturer	Cost	Size	Consumed Fuel (cc/km)	RT/1	Std. Dev.	Samples
4	Multimile Supreme	Cheap	15"	165.1	0.960	-	1
1	Michelin-X	Exp	15"	172.0	1.000	-	1
2	Firestone 721	Mod	15"	not tested		-	-
3	Firestone 721	Mod	14"	177.2	1.030	-	1

3b. Over LA4 cycles on the track

4	Multimile Supreme	Cheap	15"	269.6	0.997	0.026	3
1	Michelin-X	Exp	15"	270.5	1.000	-	3
2	Firestone 721	Mod	15"	274.2	1.014	0.014	6
3	Firestone 721	Mod	14"	278.2	1.028	0.016	5

3c. At steady-state on the dynamometer

4	Multimile Supreme	Cheap	15"	-	0.979	0.023	18
1	Michelin-X	Exp	15"	-	1.000	-	18
2	Firestone 721	Mod	15"	-	1.007	0.019	17
3	Firestone 721	Mod	14"	-	1.032	0.012	17

4. Comparison of the Relative Fuel Economy Ranking between Tires Tested Over the LA4 Cycle and 50 mph Steady-state

Looking back at Tables 3a and 3b, it is seen that the radial tires, that were tested, ranked equivalently for both steady-states and LA4 tests on the road. The same is true for the bias belted tires tested, as shown in Tables 4a and 4b. Note, however, that tire 2 and tire 6 were not tested at steady-state, yet their ranking showed statistical significance over the LA4 tests, with respect to the other tires of the same type. Tables 1a and 1b show the combined ranking order of bias belted and radial tires. Of all the tires tested, only adjacently ranked tires 8 and 3 reversed positions between the LA4 and steady-state tests. However, these tires differed in fuel consumption by less than 1% and this small difference is not statistically distinguishable. A general rule for comparing individual tires on these tests is; if the difference is greater than 1% it most likely has statistical significance.

5. Comparison of the Relative Fuel Economy Ranking between Tires Tested on the Dynamometer and on the Track

Looking again at Tables 3 and 4, no changes in the ranking order, between track and dynamometer tests, were observed within tire types, for both radial and bias belted tires. Note, in Table 4c, that bias belted tires 5 and 8 were not tested on the dynamometer.

Comparing Tables 1a and 2, it is evident that the bias belted tires moved up in the ranking from the track tests to the dynamometer tests. In fact, as was mentioned in section 1, the average results showed that bias belted tires had lower vehicle fuel consumption on the dynamometer than did the radial tires.

Comparing individual tires, the bias belted tire 6, which had higher fuel consumption than radial tires 1, 2, and 8 on the track by about 1% or greater, had lower consumption than these same tires on the dynamometer by at least 1%. By the same token, bias belted tire 7 had about a 3% higher vehicle fuel consumption than did radial tire 3 on the track, yet a 2% lower consumption than tire 3 on the dynamometer. These differences were statistically significant with over 99% confidence.

6. The Effect of Tire Pressures on Fuel Economy

6.1 Over LA4 cycles on the track.

Only two tires, 2 and 6, were tested at pressures other than 24 PSI. These tires were also tested at 20 psi and 45 psi over LA4 cycles on the track.

The tires were allowed a minimum of 4 hours to cool before capped air inflation pressures were set. The mean results of these tests are given in Table 5. As tire pressure increased vehicle fuel consumption decreased in all cases. For the radial tire number 2, the mean vehicle fuel consumption at 20 psi was about 0.6% higher than at 24 psi and the

Table 4

Fuel Economy Ranking Order of Bias Belted Tires
by Manufacturer (Best to Worst)

4a. At steady-state on the track

Tire No.	Tire Manufacturer	Cost	Size	Fuel Consumed (cc/km)	RT/1	Std. Dev.	Samples
5	Goodyear Custom Power	Exp	15"	175.2	1.019	-	1
8	Multimile Multiglas II	Cheap	15"	175.9	1.023	-	1
6	Uniroyal Fastrak	Mod	15"	not tested		-	1
7	Uniroyal Fastrak	Mod	14"	180.5	1.049	-	1

4b. Over LA4 cycles on the track

Tire No.	Tire Manufacturer	Cost	Size	Fuel Consumed (cc/km)	RT/1	Std. Dev.	Samples
5	Goodyear Custom Power	Exp	15"	273.6	1.011	-	1
8	Multimile Multiglas II	Cheap	15"	279.1	1.032	0.018	3
6	Uniroyal Fastrak	Mod	15"	281.9	1.042	0.016	4
7	Uniroyal Fastrak	Mod	14"	286.1	1.058	0.022	7

4c. At steady-state on the dynamometer

Tire No.	Tire Manufacturer	Cost	Size	Fuel Consumed (cc/km)	RT/1	Std. Dev.	Samples
5	not tested						
8	not tested						
6	Uniroyal Fastrack	Mod	15"	-	0.992	0.018	17
7	Uniroyal Fastrak	Mod	14"	-	1.008	0.017	17

Table 5

Mean Fuel Consumption at Different Tire Pressures for Tire 2 and Tire 6 over LA4 Cycles on the Track

	Pressure (psi)	Mean Fuel Consumed (cc/km)	Std. Dev.	No. of Tests	Mean Ambient Temp. (°F)
Tire 2	45	264.4	1.8	3	55°
	24	274.2	3.8	6	59°
	20	275.8	0.0	2	66°
Tire 6	45	253.0	4.4	4	57°
	24	281.9	4.0	3	57°
	20	285.9	-	1	70°

mean vehicle fuel consumption at 45 psi was about 3.6% lower than at 24 psi. For the bias belted tire number 6, the mean vehicle fuel consumption at 20 psi was 1.4% higher than at 24 psi, and 11% lower at 45 psi compared to 24 psi. There was over 99% confidence in the differences between 45 psi and 24 psi, and less than 70% confidence in the differences between 24 psi to 20 psi. These effects may be somewhat amplified by ambient temperature effects, since the mean ambient temperature during the 45 psi test was about 68°, while the mean temperature was about 58°F during the 24 psi tests, and about 56°F during the 20 psi tests. In order to determine how much of an effect the ambient temperature may have had on the fuel consumption, the vehicle fuel economy for the individual track tests of each tire, at 24 psi only, has been plotted versus ambient temperature, as shown in Figure 1. Although the plot is scattered, there is an apparent decrease in fuel consumption, with increasing ambient temperature, between 45°F and 75°F. The linear regression of the data showed about a 0.1% decrease in fuel consumption for a 1°F rise in ambient temperature. However, one low outlying data point may be causing an apparent decrease in the actual effect. At any rate, it does appear that the decrease in fuel consumption that was observed was due to a combined effect of increased pressure and increased temperature.

Conclusions

Radial tires produce lower vehicle fuel consumption than did bias belted tires on the road. However, the same bias-belted tires may produce lower vehicle fuel consumption than the radials on a twin-roll dynamometer.

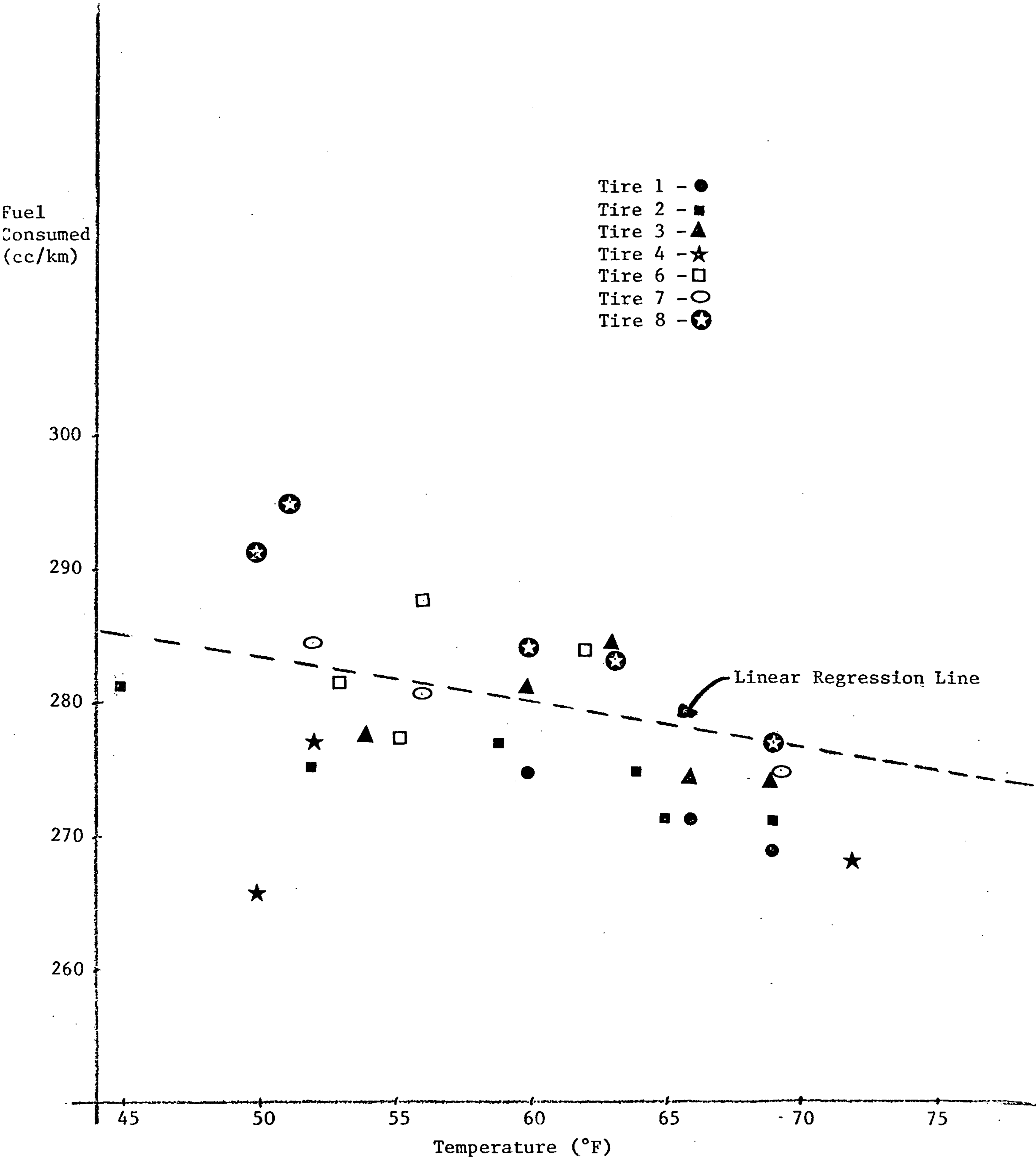
Larger diameter tires produce lower vehicle fuel consumption than the smaller diameter tires. However, these results were obtained by metered fuel flow and either fifth wheel or dynamometer roll speed. In practice, putting larger tires on a vehicle would cause the odometer to show a lower velocity than the true velocity. If the driver consequently drove faster this might negate any fuel economy benefits of the larger tire.

Within tire types, radial tires rank the same with respect to vehicle fuel consumption over steady-state or LA4 tests on the road, as well as on the dynamometer. This is also true within bias belted tires but not in the aggregate case. In the aggregate case, bias belted tires moved up in their ranking with respect to radial tires on the dynamometer, as compared to their ranking on the road. It should be pointed out, however, that this effect is somewhat compensated for by the certification road load equation and is taken in account by the alternate road load procedure.

Increasing tire pressure decreases vehicle fuel consumption. However, the magnitude of the effect from this test program could not be distinguished between the effect caused by an increase in ambient temperature, since an increase in ambient temperature also causes a decrease in fuel consumption.

Figure 1

Fuel Consumption vs. Ambient Temperature



Apparently tire quality (indicated by tire cost) can have an effect on fuel consumption, with tires at the low and high ends of the cost spectrum showing the lowest vehicle fuel consumption. However, cost alone is probably not the only factor involved when comparing tires of different manufacturers.

Recommendation

The results presented in this report are somewhat confounded by uncontrolled effects of temperature and by the effects of changes in the vehicle N/V ratio induced by changes in tire size. In order to improve the confidence in the statements of causality of the observed tire parameter fuel consumption effects it is recommended that future programs be carefully designed to avoid, or to identify and correct for the effects of changes in ambient conditions and the effects of changes in the vehicle N/V ratio.

References

1. Glenn D. Thompson, Myriam Torres, "Variations in Tire Rolling Resistance", EPA Technical Support Report for Regulatory Action, LDTP 77-5, October 1977.

2. Richard N. Burgeson, "Tire-Dynamometer Roll Effects", EPA Technical Report, LDTP 77-4, March 1978.

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

Appendix A

Tires

1 = Michelin-X GR78x15 (most expensive)
2 = Firestone 721 GR78x15 (moderately expensive)
3 = Firestone 721 GR78x14 (moderately expensive)
4 = Multimile Supreme GR78x15 (least expensive)
5 = Goodyear Custom Power Cushion G78x15 (most expensive)
6 = Uniroyal Fastrak G78x15 (moderately expensive)
7 = Uniroyal Fastrak G78x14 (moderately expensive)
8 = Multimile Multiglas II G78x15 (least expensive)