Interpreting the Road Test

BY ROGER HUNTINGTON

NEVER UNDERESTIMATE the power of a letter to the editor!

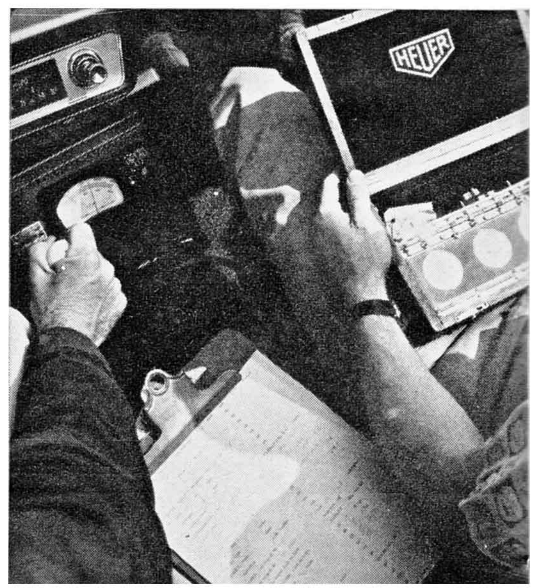
This article is a direct response to a recent letter from our good reader, Paul Tanenbaum, of Forest Hills, N.Y. He brought up a very interesting point. He complimented us on our comprehensive road tests; but he pointed out that these were necessarily limited to only one combination of body, engine, transmission and axle ratio in a given line. What about the dozens of other option combinations in that same line that would be based on the same basic engine—but with heavier or lighter bodies, other gear ratios, other engine equipment combinations that give more or less horsepower, etc.? Would there be any reasonably simple way that the published acceleration figures for a specific combination could be "corrected" to allow for these other variables? This would give the test reports a broader application.

At first we didn't know whether the problem had any "reasonably simple" solution—or whether there was a solution available at all. However, as we dug into the problem it began to look as though there might be possibilities. The question then was whether there would be too much arithmetic involved to make the correction method of any use to the average non-slide-rule-wielding reader. We've streamlined the procedure as much as we can (and still keep it applicable to a wide range of car types). You'll have to decide whether it's any good for you.

In the first place, we can't use the classic acceleration formulas found in physics books to describe the performance of an automobile. The rising and falling engine torque curve, the gear changes and the rising drag curve (wind resistance, tire rolling drag and chassis friction) make this impossible. About all we can do is to plot actual acceleration times, measured on a stop watch, against various combinations of car factors or parameters—like weight, bhp, gear ratio, engine displacement, torque. Then we try to fit these resulting graphical curves to some purely arbitrary or empirical mathematical formula. If we can do this, it's then a fairly simple matter to calculate how the acceleration times will vary with changes in the basic parameters.

Unfortunately, all the popular acceleration measurements, when plotted against a given set of parameters, won't follow the same mathematical curve. For instance, the 0–30 mph time depends more on traction than on weight and power—especially with our modern high-power passenger cars with heavy noses. The 0–60 mph times and elapsed times for the standing-start ¼-mile are close functions of the weight/bhp ratio; but their plots follow entirely different curves. This is partly because of the increasing effect of car drag on the acceleration rate in the higher speed ranges. Same with the terminal speed at the end of the quarter. Similarly, gear ratio has a much bigger effect on the 0–60 time than on the elapsed time.

For these reasons it's going to be impractical to give correction factors for all the popular acceleration intervals. We'll just concentrate on the popular 0–60 mph times and the standing ¼-mile elapsed time and terminal speed. The other timed figures will kind of follow along in proportion, giving a pretty complete picture.



The next question: On which car factors, or variables, should we concentrate? Weight and horsepower are obvious ones. Torque is useful, but since full-throttle acceleration through the gears is in an rpm range that brackets the peak of the power curve —not the torque curve—we feel it is not necessary to spend time on the torque parameter.

Axle gear ratio is known to have a

substantial effect on acceleration times, also the type of transmission: manual 3-speed, 4-speed, or automatic. But here we don't have enough reliable side-by-side comparative tests to intelligently evaluate the effect. Also, every type of automatic has a different performance pattern. So, we'll have to omit the transmission from our analysis—and leave it up to the reader's experience to correct for that. And we don't need to worry about the effect of optional tire sizes on the effective gear ratio. There's not a broad enough range of sizes available on any one line to have a great effect on acceleration times.

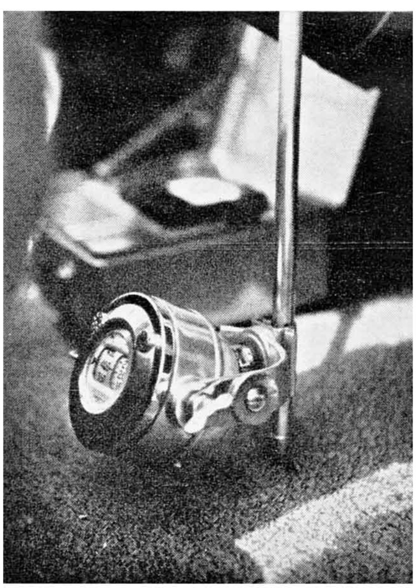
So this leaves us with weight, horsepower and axle ratio as our three major performance variables. Weight is easy enough to work with. For comparative figures we suggest the official factory shipping weights on the various models, published in the AMA specification sheets or in the NADA manual. But remember: Since this correction method uses percentage differences between parameters, it is necessary to use the same type of weight figure for the test car and the corrected model. We use actual curb weight in our test reports. The reader would need this figure on his car—or else would need to look up the shipping weights of both in specification tables (May *Car Life*). (Shipping weight doesn't include fuel or water, so is usually at least 150 lb. less than curb weight.)

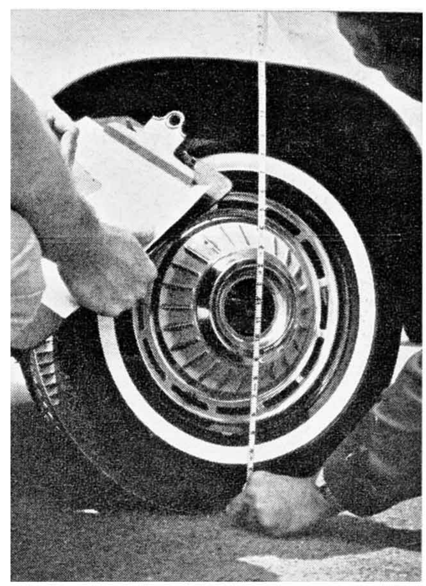
About all we can do with horsepower is to use factory-advertised figures. It would be better if we had accurate "as installed" figures on the various engines, but of course we don't —and there's no adequate way to get them. Another complicating factor is that some engines develop more as-installed horsepower in relation to their advertised power than others. For this reason I would advise going easy on applying this correction method to different basic engines. For instance, take our road test on a '63 Ford Galaxie (June CL) with the small 289-cu. in. V-8 of 195 bhp. Say we want to figure what that same body and axle ratio would do with the big 390-cu. in. 300-bhp engine. We wouldn't have as much confidence in this correction as if, say, we corrected up from the 352-cu. in. 220-bhp engine to the 300-bhp. These latter are the same basic engine. Of course, this isn't a hard and fast rule. But just keep in mind that performance comparisons are a bit less certain when we skip from one basic engine design to another.

Then there was the problem of deriving the empirical acceleration curves. Fortunately, we have a tremendous backlog of performance data in our files, gathered over a period of years. Much of it was plotted on curves against various parameters, which eased the job, making it pretty much a matter of deriving the mathematical relationships. For instance, the 0–60 mph time appears to be nearly directly proportional to the weight/bhp ratio, at least in the range between about 5 and 20 sec. This is very convenient, needless to say; a 20% increase in weight would raise the 0–60 mph time about 20%. A 20% increase in bhp would drop it 17%. (In this case 0.83 is the reciprocal of 1.20.) On the other hand, the effect of axle gear ratio on 0–60 mph times is much less pronounced. The figures indicate that this figure is roughly inversely proportional to the cube root of the axle ratio. In other words, a 20% raise in gear ratio would drop the 0–60 time only 6%.

The curve of ¼-mile elapsed time vs. weight/bhp ratio has an entirely different shape. The elapsed time appears to be proportional to the cube root of the weight/bhp ratio. The terminal speed appears to have equal correlation with the inverse cube root of this ratio. It also follows, of course, that the ¼-mile times would be related to the 0–60 time through a cube root function. And since the axle ratio is related to the 0–60 time through a cube root function, it follows that the axle ratio will be related to the ¼-mile time and speed through a 3 × 3 = ninth root function of the weight/bhp ratio. The elapsed time would be inversely proportional to the ninth root of the axle ratio. Theoretically, the terminal speed would be directly proportional to this ninth root . . . but in practice it doesn't seem to make much difference.

We have worked out the accompanying table giving acceleration factors for various percentage increases or decreases in car weight, horsepower and axle ratio. You merely multiply the acceleration time from our road test by the factors in the table to get the "corrected" figure. To get the percentage increase or decrease in a given parameter, of course, divide the corrected parameter by our test parameter. The resulting figure can be readily converted to percentage. (For instance, 1.19 would be 19% increase. A figure of 0.84 would be 16% decrease.) We have calculated factors for intervals of 5 percentage points in the tables. If your figure is between these, just estimate the factor between the two quoted.





Road Test

Clear as mud? Let's try a few examples. . . .

In the January *Car Life* is a test of a '63 Chevrolet Biscayne 2-door with the 283-cu. in. 195-bhp V-8 engine. The quoted 0–60 mph is 10.7 sec. with the quarter in 17.9 e.t. at 76 mph. (This is with 3-speed manual transmission and 3.08 rear end gears.) First, what could we expect out of this car with optional 3.70 axle gears? In this case we raise the ratio 3.70/3.08 = 1.20, or 20%. From the table we see that the 0-60 mph factor for a 20% raise in gear ratio is 0.94, and the quarter-mile e.t. factor is 0.98. Thus we would expect the 0–60 with 3.70 gears to be 10.7 × 0.94 = 10.0. The e.t. should be 17.9 × 0.98 = 17.5. the effect of the 3.70 gears we would multiply 0.65 × 0.94—giving an overall 0–60 factor of 0.61. and our calculated 0–60 time would thus be 10.7 × 0.61 = 6.5 sec. For the ¼-mile our chart shows an e.t. factor (for 54% power increase) of about 0.87. Thus the combined effect of power and gear ratio change would give an overall factor of 0.87 × 0.98 = 0.85, and the calculated elapsed time would be 17.9 × 0.85 = just under 15.3 sec. The terminal speed factor from the chart is 1.15 (with no effect from gear ratio) —so this figures to 76 × 1.15 = 87 mph.

Admittedly some of these corrected times seem rather quick. But remember, this is a manual shift with the wide-ratio small-engine gears (quick jump off the line), brutal 3.70 rear end gears and the curb weight in the *Car Life* test was only 3460 lb. It's easy to see that such a combination could do these things with the 300- for the convertible, and 2345 for the 4-door sedan. Thus our weight is reduced 2345/2645 = 0.89, or 11%. The power is reduced 85/101 = 16%. Our chart gives 0–60 factors (interpolated) of about 0.89 for the weight and 1.20 for the horsepower. Thus the overall factor is 0.89 × 1.20 = 1.07. And the corrected 0–60 mph time would be 21.6 × 1.07 = 23.1. (Obviously the reduction in weight almost compensates for the reduced bhp.) Our corresponding weight and bhp factors for the ¼-mile e.t. would be 0.97 and 1.06, for an overall factor of 1.03 (0.97 × 1.06)—and the e.t. would be 22.2 × 1.03 = 22.8. The terminal speed would be 0.97 × 61 = 59 mph.

In the February issue of *Car Life* is a test report on a '63 Plymouth Sport Fury with the 383-cu. in. 330-bhp engine, 3.23 rear end gears and Torque-Flite automatic. The 0–60 mph time was 8.0 sec., with ¼-mile in 15.5 e.t.

ACCELERATION CORRECTION FACTORS

(Multiply original acceleration figure by correction factor to get corrected figure)

		0–60 mph			¼-mile e.t.			¼-mile speed	
		WEIGHT	BHP	GEAR	WEIGHT	BHP	GEAR	WEIGHT	BHP
% INCREASE	80		0.56						1.22
	70		0.59						1.19
	60		0.63						1.17
	50	1.50	0.67	0.87	1.15	0.87	0.95	0.87	1.15
	45	1.45	0.69	0.88	1.13	0.88		0.88	1.13
	40	1.40	0.71	0.89	1.12	0.89	0.96	0.89	1.12
	35	1.35	0.74	0.91	1.10	0.91		0.91	1.10
	30	1.30	0.77	0.92	1.09	0.92	0.97	0.92	1.09
	25	1.25	0.80	0.93	1.08	0.93		0.93	1.08
	20	1.20	0.83	0.94	1.06	0.94	0.98	0.94	1.06
	15	1.15	0.87	0.96	1.05	0.96		0.96	1.05
	10	1.10	0.91	0.97	1.03	0.97	0.99	0.97	1.03
	5	1.05	0.95	0.99	1.02	0.99		0.99	1.02
% DECREASE	5	0.95	1.05	1.02	0.99	1.02		1.02	0.99
	10	0.90	1.11	1.03	0.97	1.03	1.01	1.03	0.97
	15	0.85	1.18	1.06	0.94	1.06		1.06	0.94
	20	0.80	1.25	1.08	0.93	1.08	1.03	1.08	0.93
	25	0.75	1.33	1.10	0.91	1.10		1.10	0.91
	30	0.70	1.43	1.13	0.89	1.13	1.04	1.13	0.89
	35	0.65	1.54	1.16	0.86	1.16		1.16	0.86
	40	0.60	1.67	1.19	0.84	1.19	1.06	1.19	0.84
	45	0.55	1.82	1.22	0.82	1.22		1.22	0.82
	50	0.50	2.00	1.26	0.79	1.26	1.08	1.26	0.79
	60		2.50			1.36			0.74
	70		3.33			1.49			0.67
	80		5.00			1.71			0.59

Now, let's get a little more complicated and figure the effect of powering this car with the optional 327-cu. in. V-8 with the 300-bhp power pack and include the effect of the switch to 3.70 gears. This is the same basic engine as the 283, so the figures should scale up pretty closely.

This bigger engine would raise the bhp by 300/195 = 1.54, or 54%. Interpolating in the 0–60 mph chart we get a factor of about 0.65. To include bhp power pack 4-barrel engine.

Now, let's try some figuring with a low-performance compact. The October 1962 CL carried a test of the '63 Falcon Futura convertible with the 101-bhp optional engine and Fordomatic. The 0–60 time was 21.6 sec., with the quarter in 22.2 sec. e.t. at 61 mph. So what could we expect from a standard 4-door sedan with the standard 85-bhp engine? Published factory shipping weights are 2645 lb. at 87 mph. Suppose we want to see what this car would do with the smaller 361-cu. in. 265-bhp engine (same basic engine), but with optional 3.91 gears in the rear end. Here we reduce bhp 265/330 = 20%, and raise gear ratio 3.91/3.23 = 21%. Our chart gives the 0–6C factors as 1.25 and 0.94 respectively—for an overall factor of 1.25 × 0.94 = 1.17—so the 0–60 mph time should be 8.0 × 1.17 = 9.4 sec. Our corresponding factors

Interpreting the Road Test: a Glossary of Terms

JUDGING FROM some letters we get, a few *Car Life* readers do not fully realize the time and effort which our staff devotes to road tests. These tests, usually 3 or 4 each month, take more staff time than any other single activity. Each car is driven by two, sometimes three staff members, for a total of 1000 miles if at all possible.

The performance tests require special techniques and instrumentation, though the actual recording of acceleration data takes only an hour or two. Acceleration times in particular are always quoted as the result of our own tests—not the manufacturers'. Likewise, we actually weigh the cars ourselves on our own scales because experience has shown that there is sometimes a very large discrepancy between the shipping weight and what a fully equipped sedan really weighs.

HORSEPOWER: This figure comes from the manufacturer and is usually a gross or advertised figure, sometimes erroneously called SAE horsepower. While the manufacturer's rating is taken with a stripped engine, the true net horsepower at the flywheel, with all accessories operating, exhaust system in place, etc., is usually between 80 and 85% of the advertised rating. The SAE (Society of Automotive Engineers) is currently advocating a return to the more realistic ratings of pre-war days and points out that SAE horsepower is and always was obtained by formula, for tax purposes (SAE tax horsepower is: bore in inches squared times number of cylinders divided by 2.5).

TORQUE is the true measure of mid-range performance and is given in lb./ft. by the manufacturer. The torque curve is flatter over a wider speed range than horsepower, where the peak is usually sharp, with a rapid fall-off if the engine is overspeeded. Like horsepower, the true net flywheel torque can usually be taken as closer to 85% of the advertised rating.

CORRECTED MPH: Nearly all cars have optimistic speedometers: about 5% fast in the majority of cars, but sometimes more than 10% fast. Odometer checks indicate that most cars have considerably less error in this department than is found in the speed indicator. All *Car Life* tests and reported data are made to corrected mph readings.

ACCELERATION TIMES: These are recorded at least 3 times to each speed and the results are averaged. Automatic transmission cars are started with the brakes on, and at full throttle. Stick-shift test cars are started at the best throttle setting for minimum clutch slip and wheelspin. All test cars are equipped with a portable electric tachometer and shift points are varied to determine the optimum rpm for best times. The shifts are effected forcefully, but speed shifts (no clutch) are not used.

TOP SPEED: The modern automobile is so fast that no attempt at timed top speed runs is made. We have developed a series of charts based on horsepower and frontal area. These are used to estimate the top speed and we believe the accuracy of this method is about plus or minus 2%. The maximum speed in each gear is given in the data panel and represents the corrected mph capability at an engine speed just below valve float or hydraulic lifter pump-up.

In cases where an automatic transmission can be controlled manually we experiment with forced shift techniques to see if acceleration times can be reduced. Usually they can't, but if forced shifts do give better performance the results appear in the data panel and the acceleration curve is plotted with an extra dotted line showing the exact improvement.

MPG RANGE: This shows the results of our driving on normal streets and highways; it does not include the performance testing. The low figure is mpg around town in moderate traffic, the high is for cruising at 60–70 mph with occasional passing of slower cars. Conservative drivers can usually expect better mileage than we report.

PULLING POWER is measured by an English-made accelerometer which reads "pull" under wide open acceleration in lb./long ton. These readings can be easily converted to maximum gradient capability at each speed—in our case we record pull at 30, 50 and 70 mph, and convert this to equivalent gradient capability where % grade is the tangent function of the angle, not the angle in degrees. Cars capable of spinning the rear wheels on dry pavement get readings of over 600 lb./ton, equivalent to a maximum gradient of 31.3%. The meter reads no higher, hence the data panel says "off-scale."

CALCULATED DATA: Here we take the actual test weight, advertised bhp, cu. in., etc., and come up with various significant performance indicators—on a theoretical basis.

The lb./hp is simple enough but the cu. ft. per ton mile is something else. This latter is the engineer's tool for evaluating potential performance, particularly in high gear, and for hill-climbing ability. Mph per 1000 revs of the engine and revs/mile tell the same thing in a different way.

Piston travel in ft. per mile is a good wear index but we multiply this by the engine revolutions per mile and divide by 100,000. The result is *Car Life's* wear index. Though only an arbitrary approximation, a car having a wear index below 50 can certainly give better service life than a car having an index approaching 100. ■

for the ¼-mile e.t. are 1.08 and 0.98, for an overall of 1.06. This gives the calculated e.t. of 1.06 × 15.5 = 16.4. The terminal speed would be scaled down by a factor of 0.93—or that would be 87 × 0.93 = 81 mph. The gear ratio would have little effect here.

Incidentally, the accompanying factor chart can also be used to estimate the effect of changes in car setup on known electric-eye drag strip times. Let's say a car turns an e.t. around 17.2 with the standard 3.23:1 rear end gears. What can we expect by going up to 4.56:1? In this case we are raising the ratio by 4.56/3.23 = 41%. The chart gives an e.t. factor of about 0.96 for a 41% raise in gear ratio. Thus we could expect an immediate improvement to 17.2 × 0.96 = 16.5 in e.t. The effect on trap speed would be very small.

Or, let's say a certain stock car has a racing weight (without driver) of 3740 lb. And let's say we manage to whack 220 lb. off that by removing all accessories, body insulation, etc. We have now reduced the weight by 3520/3740 = 6%. The chart gives ¼-mile e.t. and terminal speed factors of 0.99 and 1.02 respectively for a 6% reduction in weight. Thus if the car would turn, say, 16.3 sec. at 84 mph originally—we could expect 16.1 e.t. at 86 mph when we remove 220 lb. of weight. Simple . . . well, fairly. ■