Rolling Forward Under Idle: Speed, Acceleration, and Time

Rast et al.[1] measured the acceleration and maximum velocity achieved in a number of vehicles which had been brought to normal operating temperature for this study. This was a level-ground experiment conducted on a typical roadway surface. Speed was measured using a Laser Technology LT1 20/20 device and acceleration was measured using a Valentine Research G-Analyst.

The mean, median, SD, minimum, and maximum values were reported across all vehicles, which included small subcompacts and full sized SUVs. Their behavior was highly consistent and relatively unaffected by size. The results were:

Statistical Analysis of Test Results[1]

	Forward (fps^2)[2]		Reverse (fps^2)		Max Velocity (fps)[3]	
	Mean	Peak	Mean	Peak	Forward	Reverse
Mean	0.97	1.61	0.64	0.97	5.15	4.78
Median	0.97	1.61	0.64	0.97	4.41	4.41
SD	0.32	0.64	0.32	0.32	0.76	1.27
Minimum	0.32	0.64	0.32	0.64	4.41	2.94
Maximum	1.29		0.97		5.88	7.35

1. **Authors' reported values were rounded to the second decimal place.**
2. **Authors' reported acceleration (g) values were converted to fps^2.**
3. **Author's reported velocity values (mph) were converted to fps.**

The authors reported that there was very little variability between vehicles in terms of maximum velocity and acceleration, even considering variations in vehicle weight and engine displacement. The results of this series of tests would imply that, regardless of engine displacement or vehicle size (without extrapolating beyond the reach of this study, i.e., considering only passenger vehicles), the velocity under idle on a paved, flat surface will not typically exceed 6 mph.

Velocity Estimation Based on Acceleration and Distance

So, to evaluate the attainable velocity of a passenger vehicle given an estimated distance, we would use the following example. The defendant claimed to have been 5-8 ft behind the plaintiff vehicle while stopped. Then his foot slipped off the brake pedal momentarily and his car rolled forward under only the engine's idle, and bumped the rear of the plaintiff vehicle.

Using the mean value of 0.97 fps^2 ± 1 SD and the lower and upper ranges of the estimated separation distance, we can develop a reasonable uncertainty range using equation 0.1:

$$V_e = \sqrt{V_i^2 + 2ad} \tag{0.1}$$

Thus, the lower range considers a 5 ft gap and the mean acceleration minus 1 SD (0.97-0.32):

$$V_e = \sqrt{0^2 + 2(0.65)5} = 2.5\,fps \text{ or } 1.7\,mph \tag{0.2}$$

And the upper range considers an 8 ft gap and mean acceleration plus 1 SD (0.97 + 0.32):

$$V_e = \sqrt{0^2 + 2(1.29)8} = 4.5\,fps \text{ or } 3.1\,mph \tag{0.3}$$

Reaction Time Estimation Based on Velocity and Acceleration

Two important questions to consider in the above scenario would be (a) how often does it happen that a driver’s foot slips off the brake while stopped in traffic, and (b) what would be the actual risk of colliding with the vehicle in front if this did occur?

While the first question does not have an easy answer, we can approximate the second answer by considering the time it would take to cover the distance between the two vehicles knowing this range of acceleration and the velocity range estimated using equations 0.1 through 0.3. To do that we would use the simple equation:

$$t = \frac{V_e - V_i}{a} \tag{0.4}$$

Again, considering the probable extremes of range, and without considering any specific probability density function (PDF), i.e., considering a flat PDF encompassing the 90% confidence interval, we would have:

$$t = \frac{2.5\,fps}{0.65\,fps^2} = 3.8s \tag{0.5}$$

and,

$$t = \frac{4.5\,fps}{1.29\,fps^2} = 3.5s \tag{0.6}$$

Thus, we can be 90% confident that the true time interval between the point that the foot slips off the brake and the point of bumper-to-bumper contact in any modern passenger vehicle would be between 3.5 and 3.8 seconds, given an initial gap of 5-8 ft.

A well published and widely used general *reaction time* in the field of accident reconstruction is 1.5 seconds. This interval considers both the cognitive *perception* of the problem and the *action* taken to correct it. It is more probable than not that for an uncomplicated situation as occurs in a fully stopped vehicle under normal driving conditions, the mean human reaction time would be less than 1.5 seconds. Therefore, conservatively, the time interval of 3.5 to 3.8 seconds is much greater than twice the time that should be needed to reapply the brake, making it highly improbable that a sober, normal driver would not have more than sufficient time to stop his vehicle and avoid a collision.

[Beyond this, it would be important to consider the probability that the property damage is concordant with these approximated figures for velocity.]

Reference

1. Rast P, Stearns R, Allison M, Gloekler T, Beals D: Acceleration factors and maximum speeds under conditions of idle acceleration. *Accident Investigation Quarterly*, Summer: 16-17, 2000.