Acceleration Effects on the Damper

You run your damper at one speed, 10 in/sec. The dampers on the car operate at various speeds based on the input from the track including the sprung to unsprung interaction, braking, throttle, roll, pitch, dive, etc.. Does the damper react the same way at 10 in/sec as it does at 1 in/sec?? No, it does not. For any given speed, and stroke, the important factor is acceleration. On the shock dyno, the damper is traveling the same distance (the same stroke) but running at 2 very different speeds. If you only have to get to a peak speed of 1 in/sec then acceleration is low. To get to 10 over the same distance you must accelerate faster. On a 2-inch stroke, running at 1 or 10 in/sec is a massive change in the acceleration involved in the damper. And the damper can be very different when the acceleration is different. We will discuss this in this paper.

Early on, crank dynos were single speed and for the Roehrig dynos that was typically 10 in/sec. With the advancement of the motor controller and the software, people were able to run multiple speeds and test the damper across a range of speeds. Data acquisition indicated that on the track, the damper encountered multiple different speeds from a variety of inputs. The dyno had to test at these various speeds to truly characterize what the damper was doing. The question is.... If the car experiences events at 1 in/sec and 10 in/sec can you characterize the damper by only running one speed? Does the damper curve on a 10 in/sec run show what is really happening at 1 in/sec? To discuss speeds, we should define them.

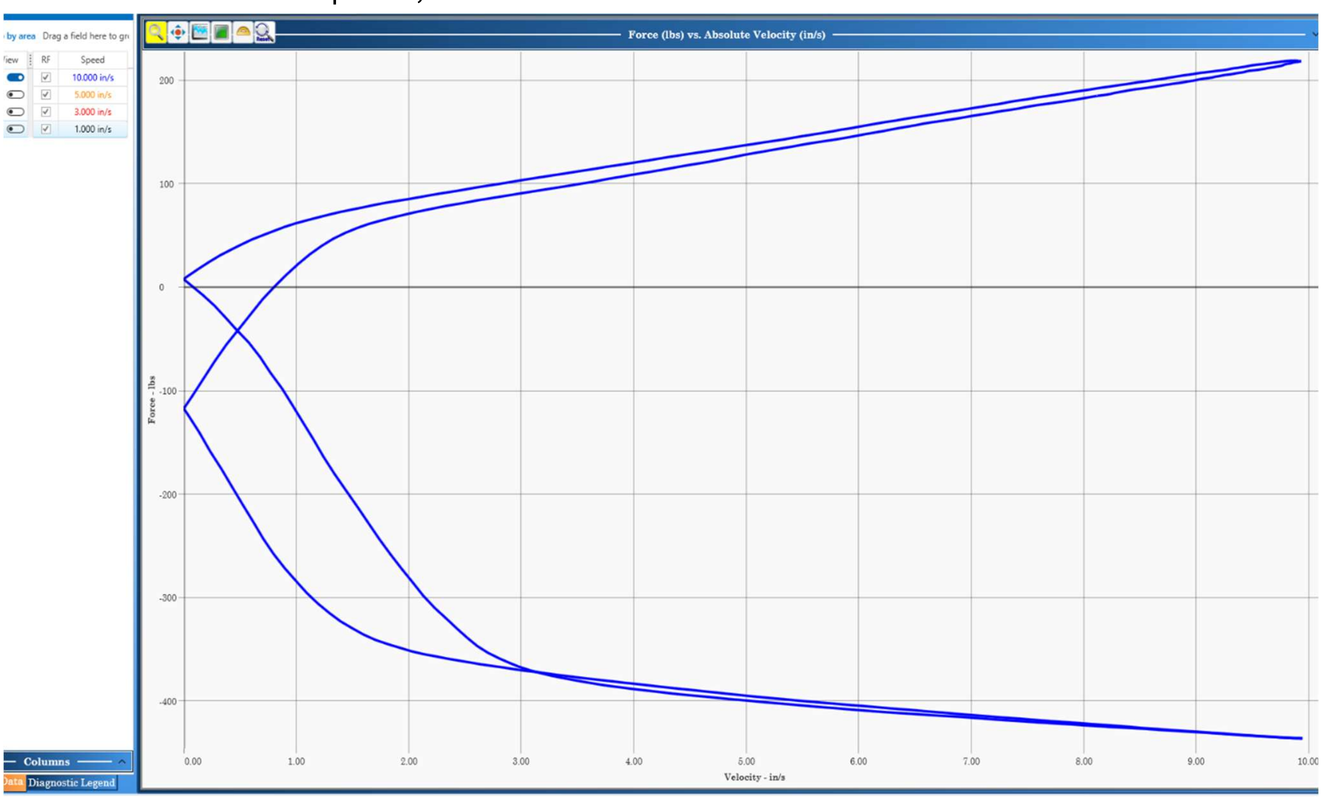

Figure 1: Force vs Absolute Velocity at 10 in/sec

Slow speed – let's think about this as the velocity where the bleed is the major factor of the forces generated. The shaft is displacing fluid, but the speed is slow and the bleed paths control the flow. The bleed can be in the piston, the shaft needle, piston band, piston to body seal, anything that allows fluid to move easily.

High speed – events like bumps, curb strikes, drop impacts, events with large amounts of energy and high flow rates. At these speeds, the bleed paths are filled and overwhelmed so the displaced fluid must go to the next available flow orifice. This is typically the piston valve stack.

Bleed and valve stack interaction – the transition area. The shaft is displacing the fluid so fast that the bleed paths get full and the piston comes into play. This is often where you see the slope change, the force slope changes as it goes from bleed to valve stack.

Valve stack – shaft speeds that are primarily working on the piston stacks and then any secondary stacks or damper components that will add a later stage.

If you have ever had two shocks that look the same at 10 in/sec, but your driver absolutely swears that one is better than the other, you are not testing the dampers in the range of velocity where they are different. They look the same at 10, but what do they look like at 1 in/sec? Chances are that is where they might differ in forces and feel to the driver.

If you have changed the bleed adjuster and the force at 10 in/sec only changes by a small amount, this is another time when you are not running at the velocity that captures what is changing. If you are making a bleed adjustment, chances are you need to run at a slow speed to see it. Same thing for a high-speed adjustment; looking at the 3 in/sec data when adjusting the high speed is likely not the best method.

If you are trying to affect the roll or pitch rate of the car and you are adjusting the high-speed shim stack you might make zero difference and end up wasting time on the track. If you are trying to help the car handle a curb strike better, then adjusting the bleed might not be the best way. This is how we start to break up vehicle dynamics with track events and then run the damper at a variety of speeds to best be able to see the true forces at the applicable speed of the event.

Does the damper react at 1 in/sec the same way it does at 10 in/sec? No. For a given stroke, a damper accelerates slowly at 1 in/sec compared to a very high acceleration at 10 in/sec. A bump in the track, a berm, a rock is a high-speed event. Chassis roll is a low-speed event. Because tuning at the track means understanding what you are trying to help, you might need to tune a low-speed event or a high-speed event and because of this you must test the dampers at different speeds. So, let's look at the data.

Here is a damper run on a 2-inch stroke at 1 and 10 in/sec. It is easy to see that the damper reacts very differently to the movement of the shaft (fluid displacement) based on the speed. This difference is because the ACCELERATION is different.

This damper uses a linear digressive piston with a set shaft bleed using a needle and seat type adjuster. At 1 in/sec the force curve shows almost no hysteresis, it has a nice little knee in the compression and the force in rebound grows quickly but creates the same forces in rebound open as rebound close. Conversely, at 10 in/sec we begin to see a separation in compression and that increases in rebound. The rebound is digressive with the slope changing around 2.5 in/sec. Clearly, these two speeds show very different force curves and the only thing we changed was the peak velocity which means that the damper had to accelerate faster.

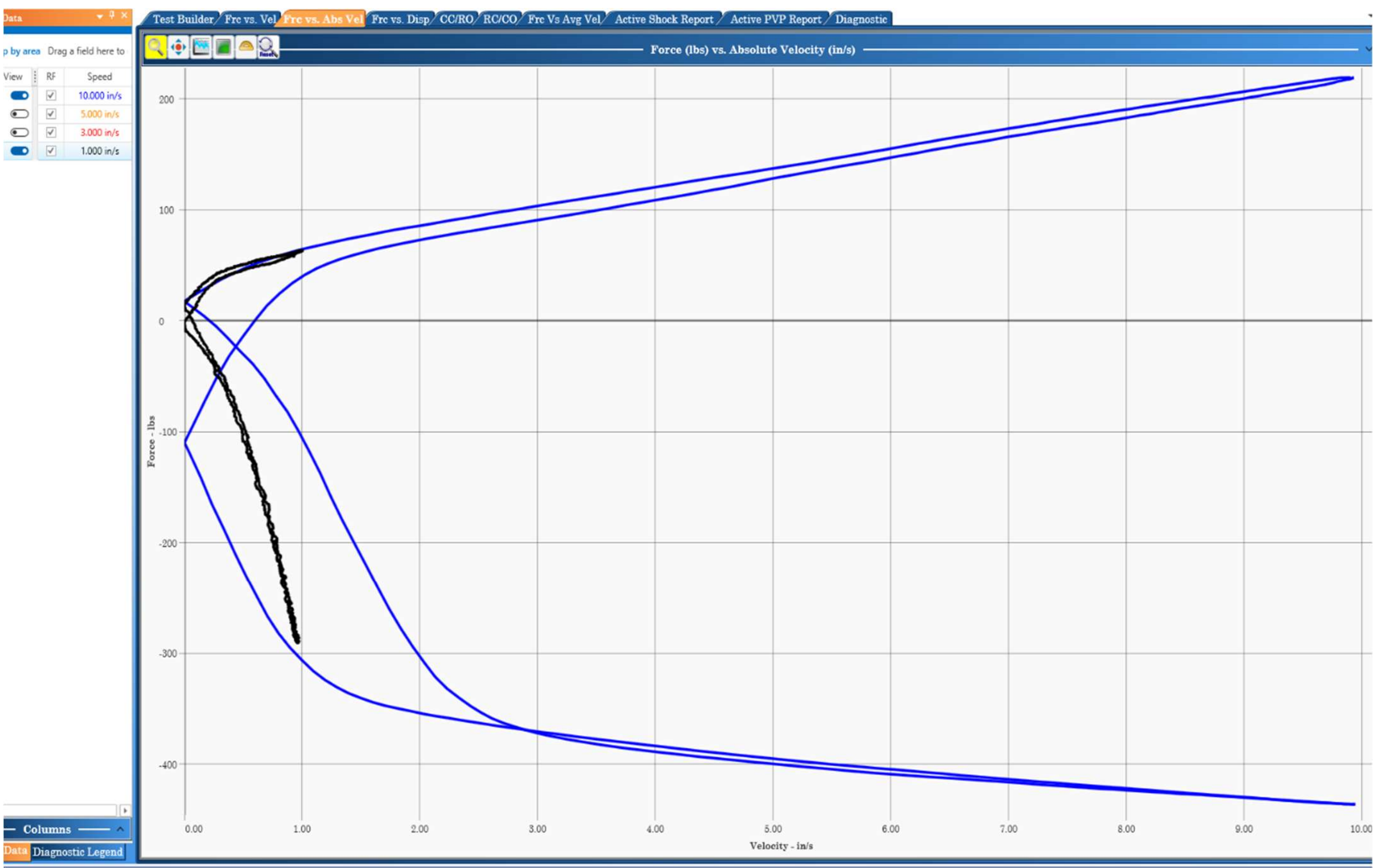

Figure 2: Same damper, same stroke run at two speeds

Clearly, if you wanted to tune the roll or pitch of the chassis, you would want to work on the bleed and run at 1 or 2 in/sec. But to emphasize the acceleration difference, let's look at the data in a different way. If we do a diagnostic of each speed and view the force for each speed, we see a very dramatic difference in how much the time difference is, the acceleration! Figure 3 shows the Force trace in time to compare the 1 and the 10 in/sec runs.

At 1 in/sec 1 full cycle takes 6.28 seconds. At 10 in/sec 1 full cycle takes 0.628 seconds. Think about the internals of the damper and how they react for each of the given time frames. One speed has time to work in the bleed paths and mechanical leaks and the other is moving so fast that bleeds get filled and quickly we move into the piston valving.

Math check: *A dyno makes one full rotation (or cycle) and that is a circle. This distance is the circumference of a circle: Pi x stroke. 3.14 x 2.00 = 6.28 inches.*

Looking at the Force traces, is there any way to use the faster speed to estimate the slower speed? No, the damper reacts differently at each speed. Figure 3 is an interesting way to view the Force signal in time. Based on time, it is easy to see the difference happening in the damper. The orange trace shows the long duration, slow movement of the force signal. This represents slow chassis motions. The green force signal shows the fast, high acceleration that your damper would see from hitting a bump, curb or rut.

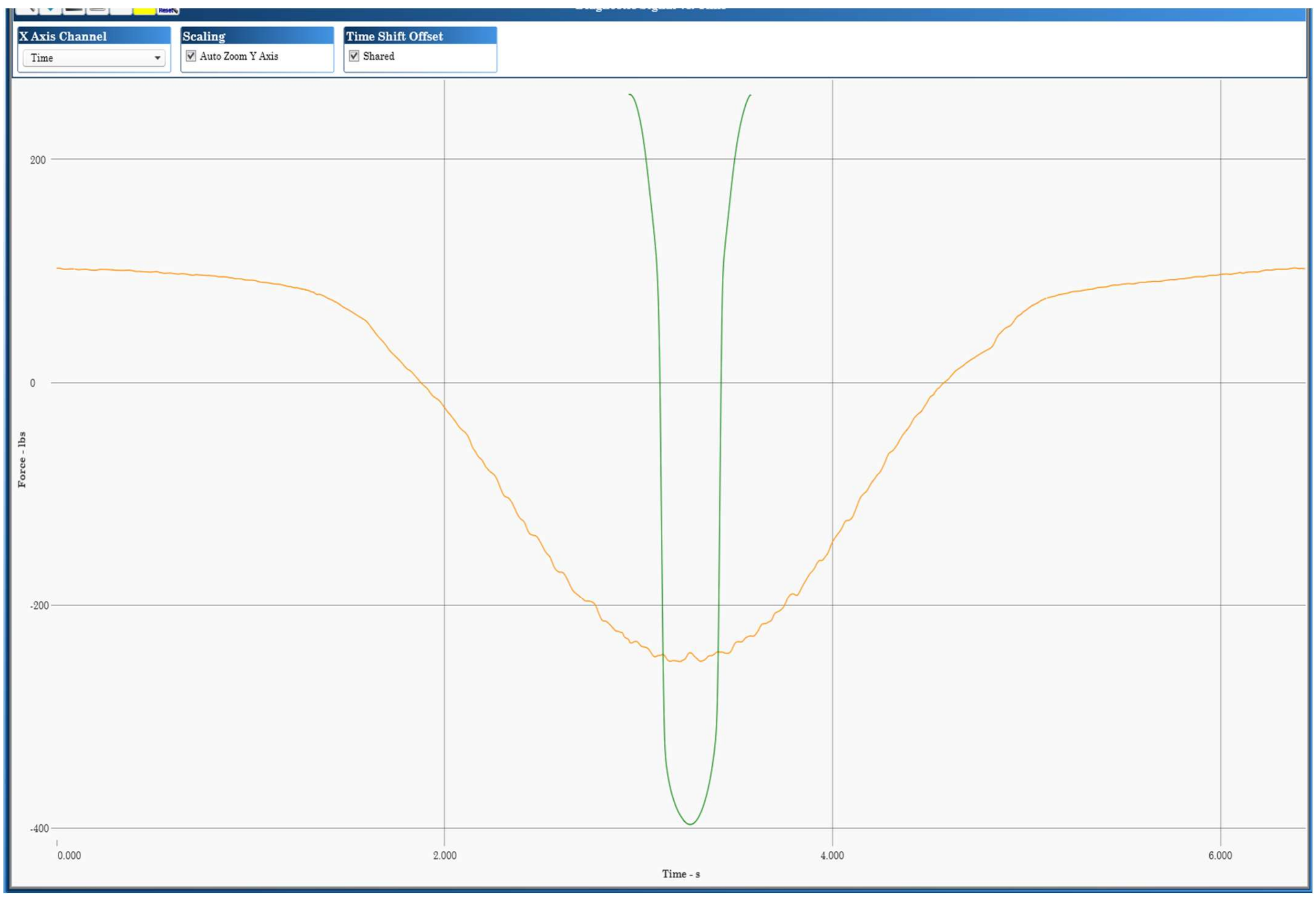

Figure 3: Force vs Time of each speed.

Now, let's look at the 1 and the 3 in/sec runs to break down what is shown by the graphs. Somewhere between the 1 and the 3 in/sec speeds we move from bleed dominant to the piston dominant areas. There is a large slope change in the transition area. Now, this transition is not always this dramatic, but it is best to start with extremes and then move towards less dramatic changes. A good way to understand your damper changing from one stage to another is by focusing on the slope changes on the force curve. This is also a great argument as to why looking at multiple views increases your chance of seeing the damper better. The Force vs Velocity shows things differently than the Force vs Displacement, and as you see the Force in Time, again you might notice different things.

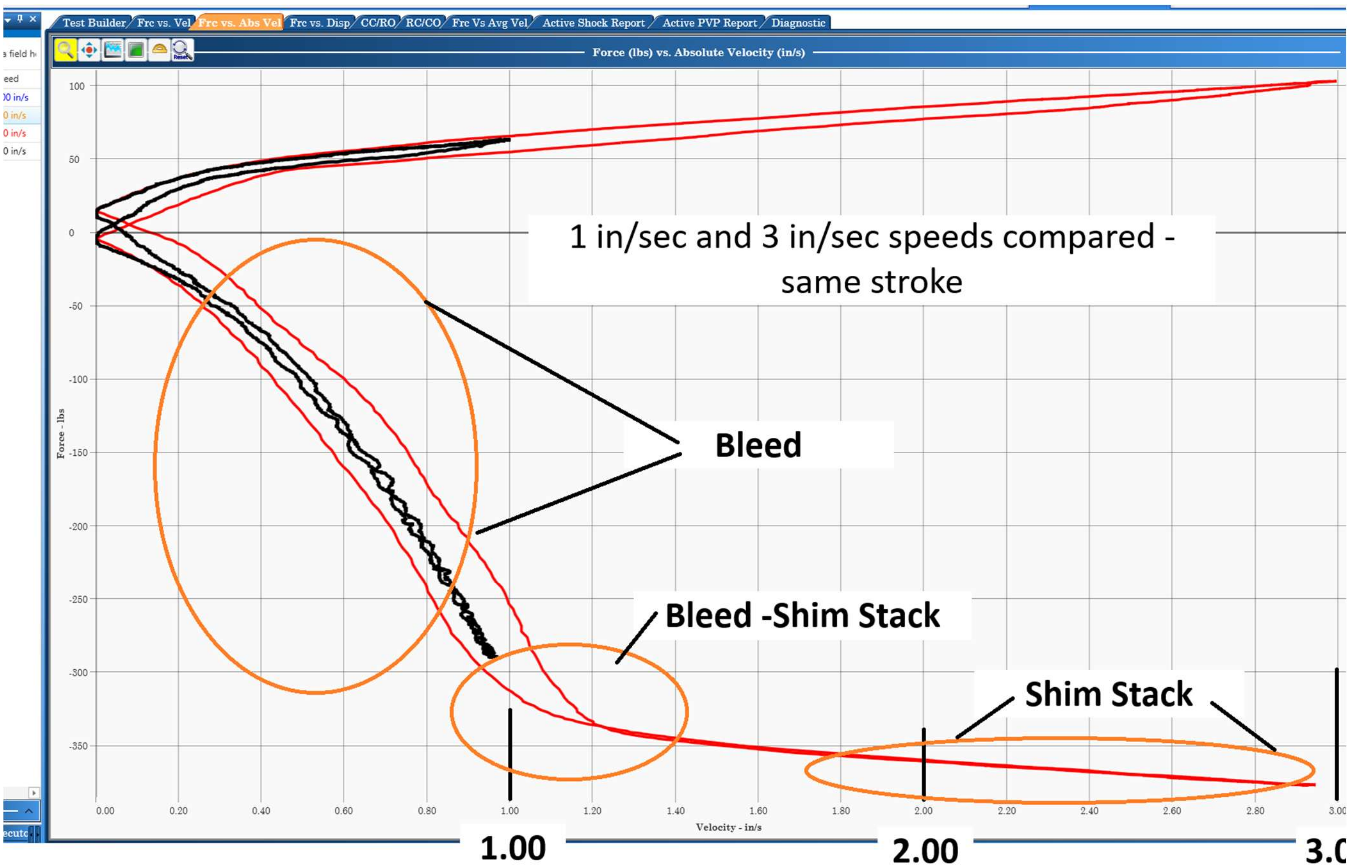

Figure 4: 1 and 3 in/sec

Understand that the damper on your car, bike, ATV, etc.. operates at different velocities and that means different accelerations. Here, Figure 5, are the force signals from this damper run at (4) speeds. It should be obvious that you cannot use the 10 in/sec trace to estimate what the force is at 1 in/sec. If you want to know what the damper does at 1 in/sec then you must run the damper at 1 in/sec. You cannot run it at 10 in/sec and then use the data at 1 in to define the forces and effects. THEY ARE DIFFERENT.

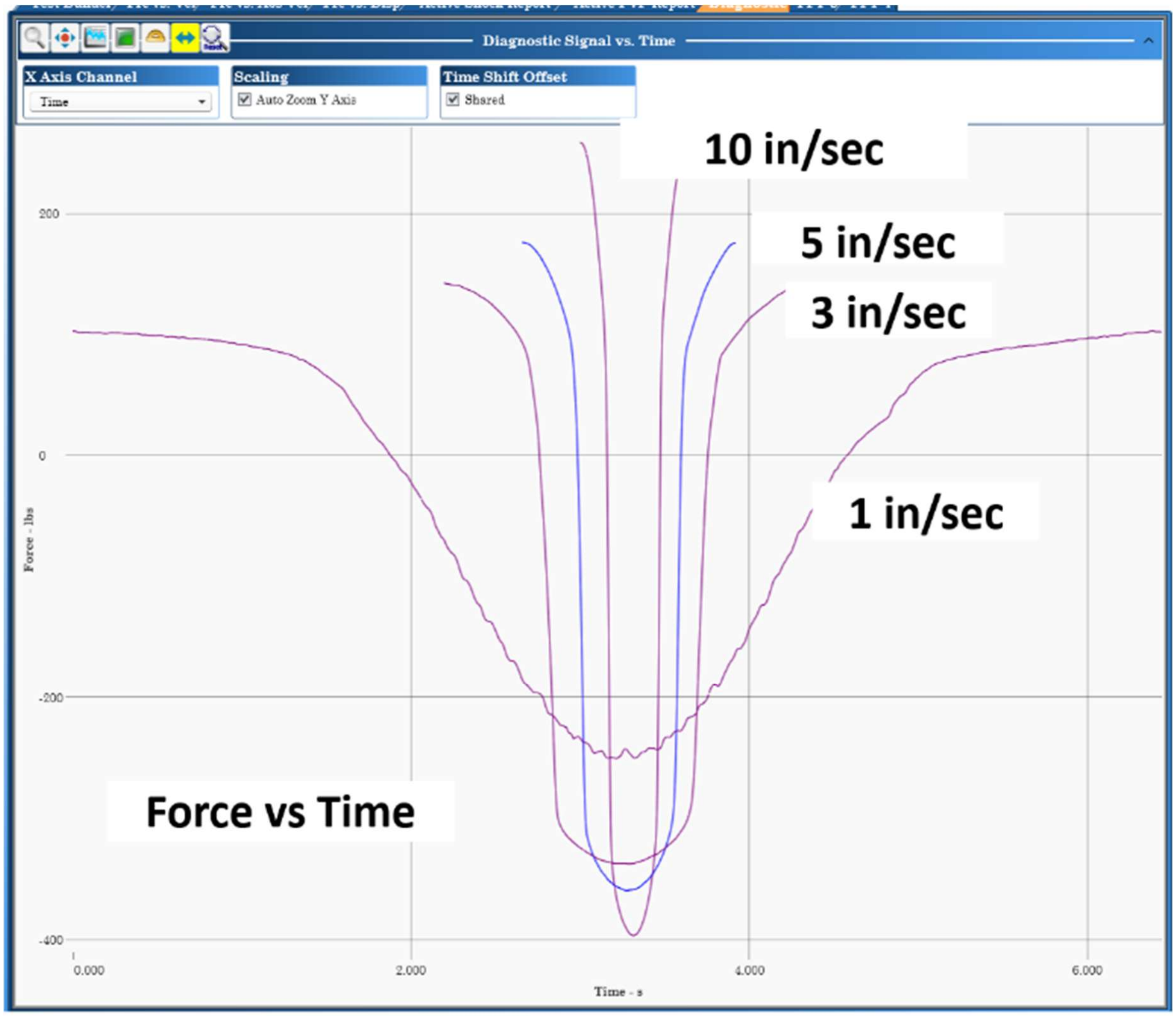

Figure 5: Force vs Time of 4 Speeds

Next up…we go through running your damper on different strokes but at the same speed.

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"Don't Panic"