Understanding the Rod Force, Multi-Point and Seal Drag

Part 1 - **Rod Force**

CTW Probe has various ways of measuring the resultant force generated by the damper shaft displacing fluid as it moves in and out of the damper body.

The Rod Force is a measure of the internal pressures in the damper, created by the displacement of fluid by the damper shaft moving into the body. This displacement occurs when the damper is compressed during the installation in the dyno and the preloading of the crossbar. Further, if the Rod Force is done above BDC (bottom dead center) this also displaces additional fluid and further creates a reaction force to expel the shaft. In the case of a thru-rod damper, there is no rod force as there is no displaced fluid. Also, a few other types have very small rod forces. Primarily this is the classic damper, dividing piston and gas (nitrogen) chamber.

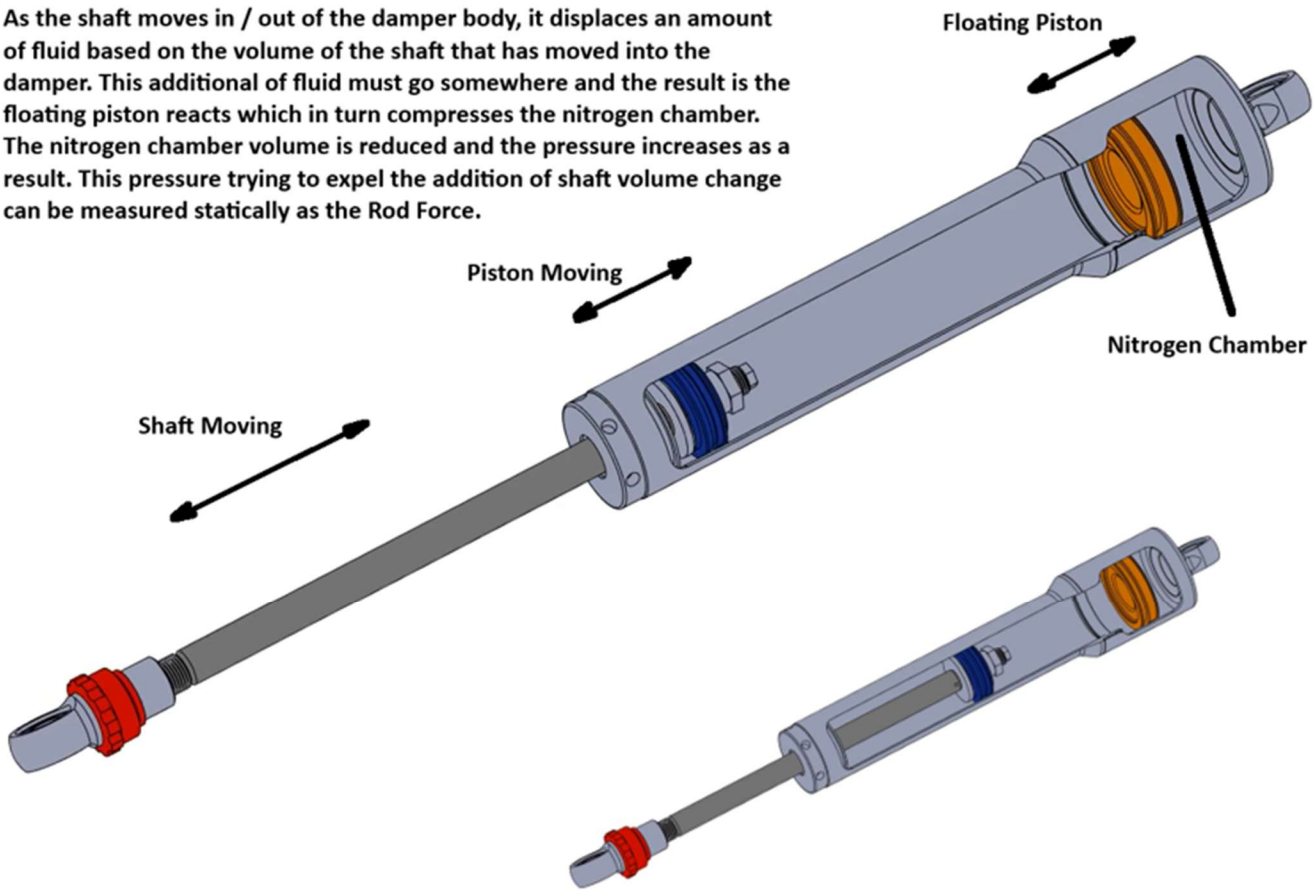


Figure 1: The shaft moving in/out of the damper body and the effects

The Rod Force command measures the static force generated by the damper in reaction to the displacement of fluid as a result of the initial preload and the dyno moving to mid-stroke.

This force is measured in one of two (2) ways. The first is a measurement at BDC. This is a legacy feature carried over from the very early days of Roehrig Shock software, and it works by taking a reading after mounting the damper and setting the crossbar preload. CTW added this feature based on customer requests to deal with low (or no) bleed in the damper. In some extreme damper builds, just moving slowly builds up too much pressure that cannot reach a steady state in a short amount of time. The second rod force method is to move to mid-stroke in the compression direction and pause, before taking a force reading and then moving to the other side and doing the same in the extension direction. The pause is added to help the damper reach a steady state before taking the force reading. With low (to no) bleed, this could take longer than practical (see end of paper). There are cases when you could have the bleed adjuster open for the *Rod Force* command and then use the *Prompt User* command to set the damper after.

Note - always be careful in this manner to add some cycles to let the damper reach its steady state with the bleed adjuster set.

The Rod Force can be imagined as a "static spring" to be measured and then removed from the data. It is affected by the gas pressure, shaft diameter and installed preload on the damper. The same thing happens when the damper is installed on the vehicle, bike, motorcycle, etc... This force is dealt with when you set the ride height. If, after setting the ride heights you were to add 100 psi to each damper, you would likely have to adjust the spring perches to get back to your desired heights. Something to think about, as a gas gets hotter in a chamber the pressure increases. This is just one reason you might want to run as little gas pressure as possible because as the damper gets hot, the pressure increases and that static rod force increases; that spring affect increases. This could result in the front of your car being higher than you want as the race progresses. This is similar to tire pressures, starting low with the understanding that the temperature will increase and hence the pressure. Conversely, raising the rear of the vehicle might develop a better aero platform on the track. People have played with the effects of the nitrogen chamber for a very long time and the formula PV = nRT (Ideal Gas Law) is what is happening in real time. Throw out "n" and "R" and you see that the Pressure x Volume = Temperature. And pressure is equal to force divided by area. As temperature increases, pressure increases, for a given volume, and there is your force.

Note – if you ran a test with 100 psi and then again with 200 psi, while the dynamic dampening curves would be very close, one graph would be further up the Y-axis than the other. By measuring and removing the Rod Force, you are able to better compare the dynamic forces.

We will now go through the various ways that you can measure the Rod Force using CTW Probe© software. The first method is a holdover from Roehrig Shock5 and 6 (and earlier) where the Rod Force is measured at BDC after the damper is installed and the crossbar preloaded, thus moving the shaft into the body. This method is very important with No bleed (or very low bleed) dampers. In no-bleed dampers, compliance issues can lead to unsteady force results during the normal rod force testing.

Read Average Constant – single point after loading and preloading the crossbar. Use this for low bleed dampers.

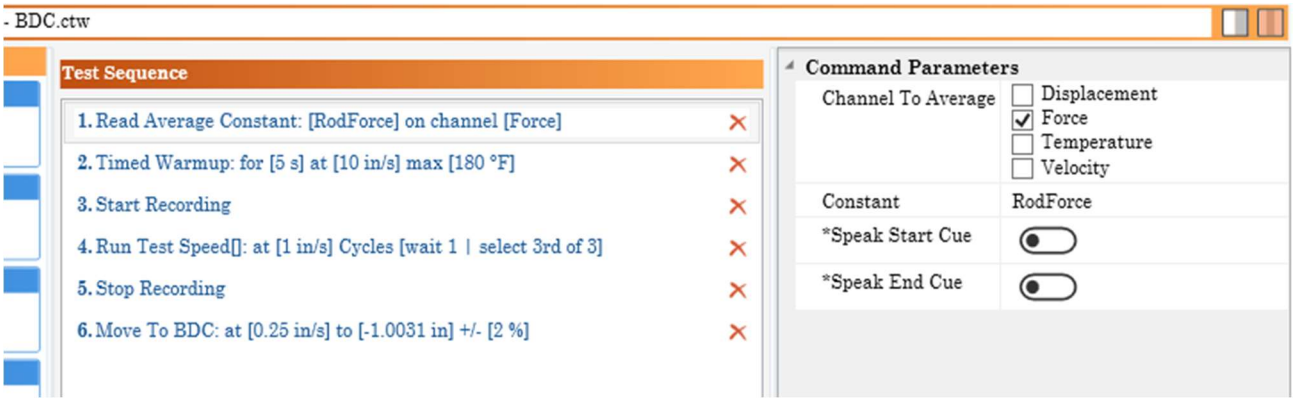


Fig 2: Rod Force Command - BDC example – Read Average Constant – Force

The standard Rod Force method is done at mid-stroke, not at BDC.

Rod Force – force reading taken at mid-stroke in the compression and extension directions. These are added together and divided by 2 to achieve the result. The User defines the speed the dyno goes from one side to the other and then how long the machine stops before measuring the force. The speed and settle time are important to understand and can affect the results. Being repeatable is the important factor.

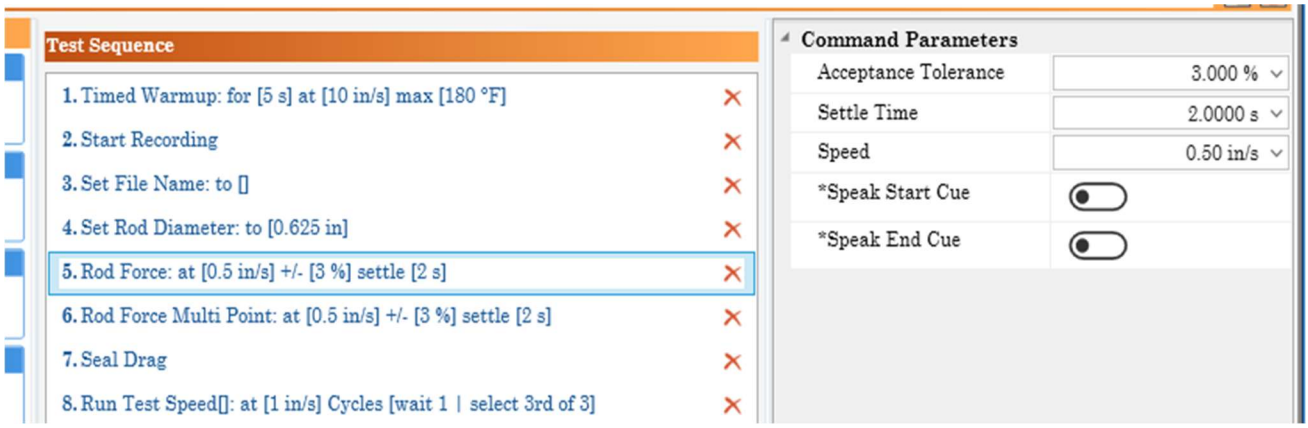


Fig 3: Rod Force Command – mid-stroke version

This is what the Rod Force command looks like as Displacement vs Time plot. The User sets the Settle Time and the Speed to move from one side to the next. A high bleed damper could use a 1 second pause, while a damper with less bleed might use 3 or 4 seconds. Achieving a repeatable result is the key.

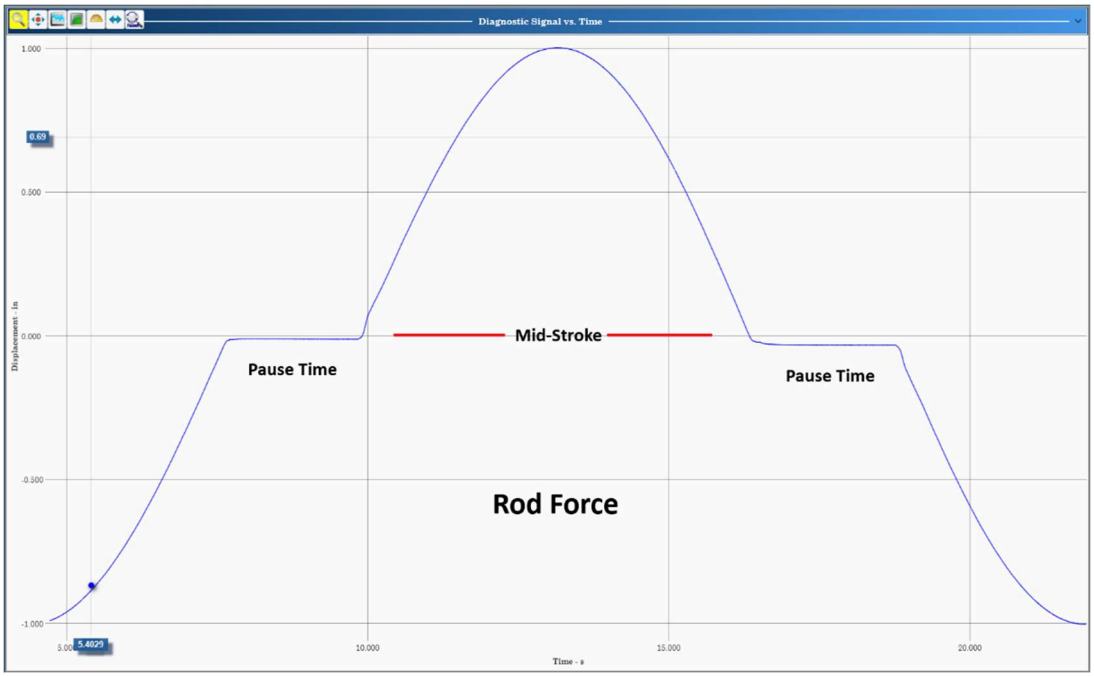


Fig 4: Rod Force visual using Displacement vs Time

The Math as a visual.

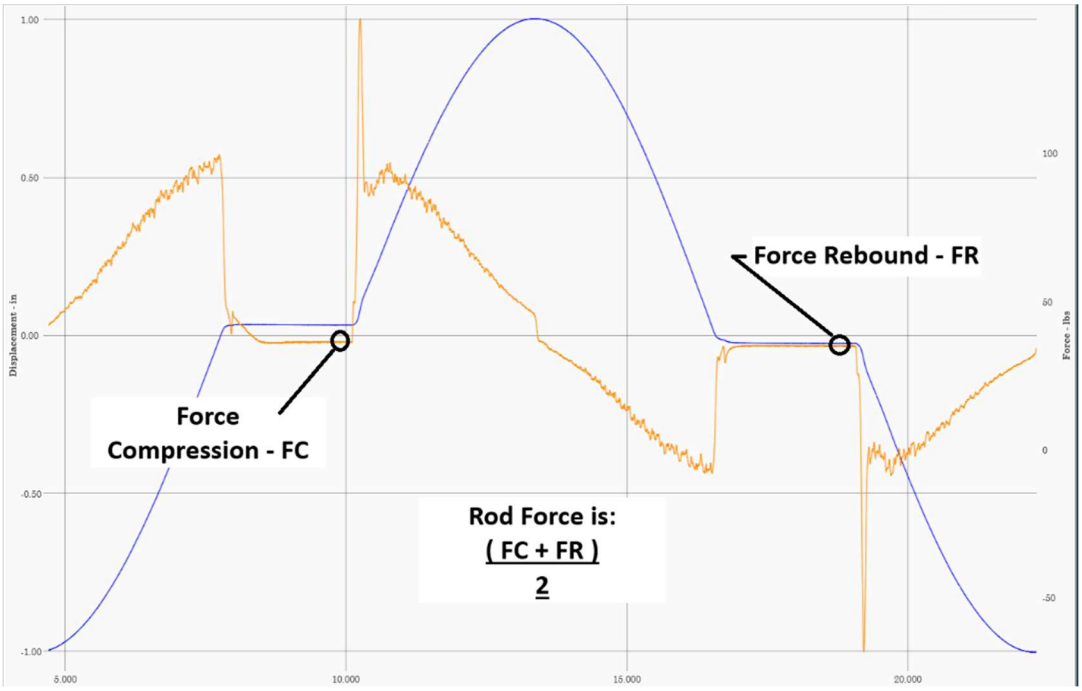
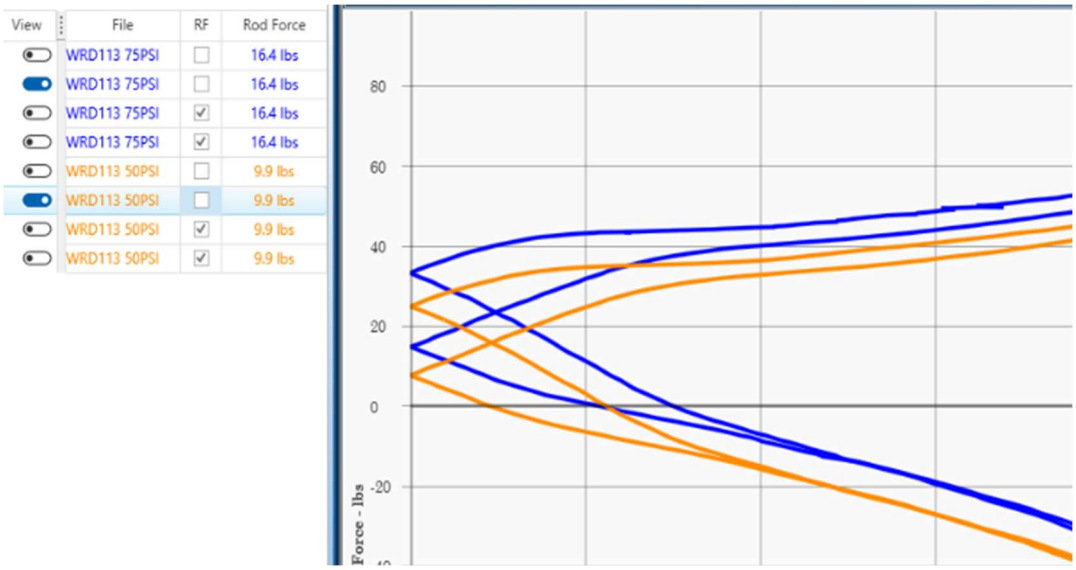


Figure 5: The Displacement Signal During the Rod Force

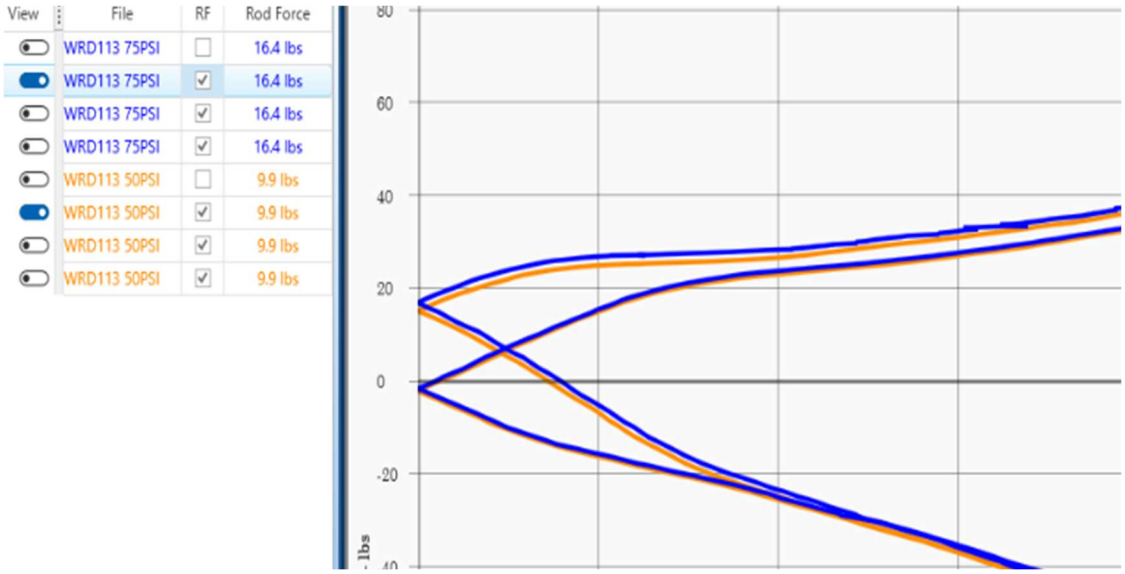
Additional Information

If you do not measure the Rod Force and remove it from the dynamic data, then you will encounter difficulty when comparing dampers charged with different pressures including the same damper with (2) different pressures. You can also do this by preloading the dampers to different positions, thus creating a higher rod force just from the crossbar preload. We present a case of a damper with 50 and 75 PSI.

Graphs below are the exact same damper tested at 5 in/sec. The orange trace is at 50 psi, and the blue trace is at 75 psi. The valving is the same, but the Rod Force is different based on the chamber pressure difference. The 50-psi test has a lower Rod Force value than the 75-psi test. If you do not account for the pressure difference, using the Rod Force command, then you can see the higher-pressure test is simply higher up the Y-Axis, more "static spring" force. This is key to testing. If you were not aware of this, then you might be inclined to re-valve to get them to match!!



A Damper tested at 2 different pressures and the rod Force NOT removed



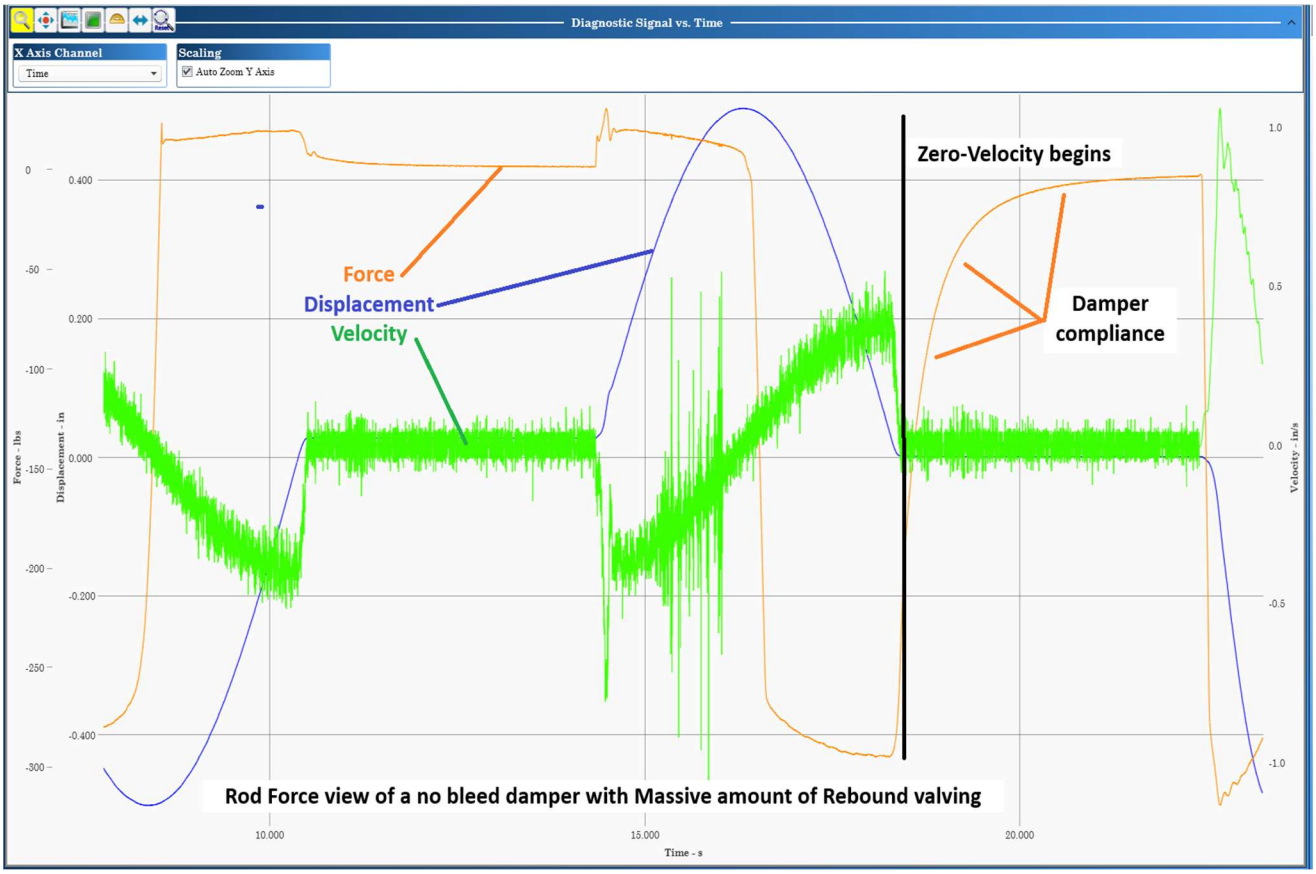
A Damper at 2 different pressures and WITH the Rod Force removed

The Extreme Case of No Bleed Damper / Tie-Down Rebound

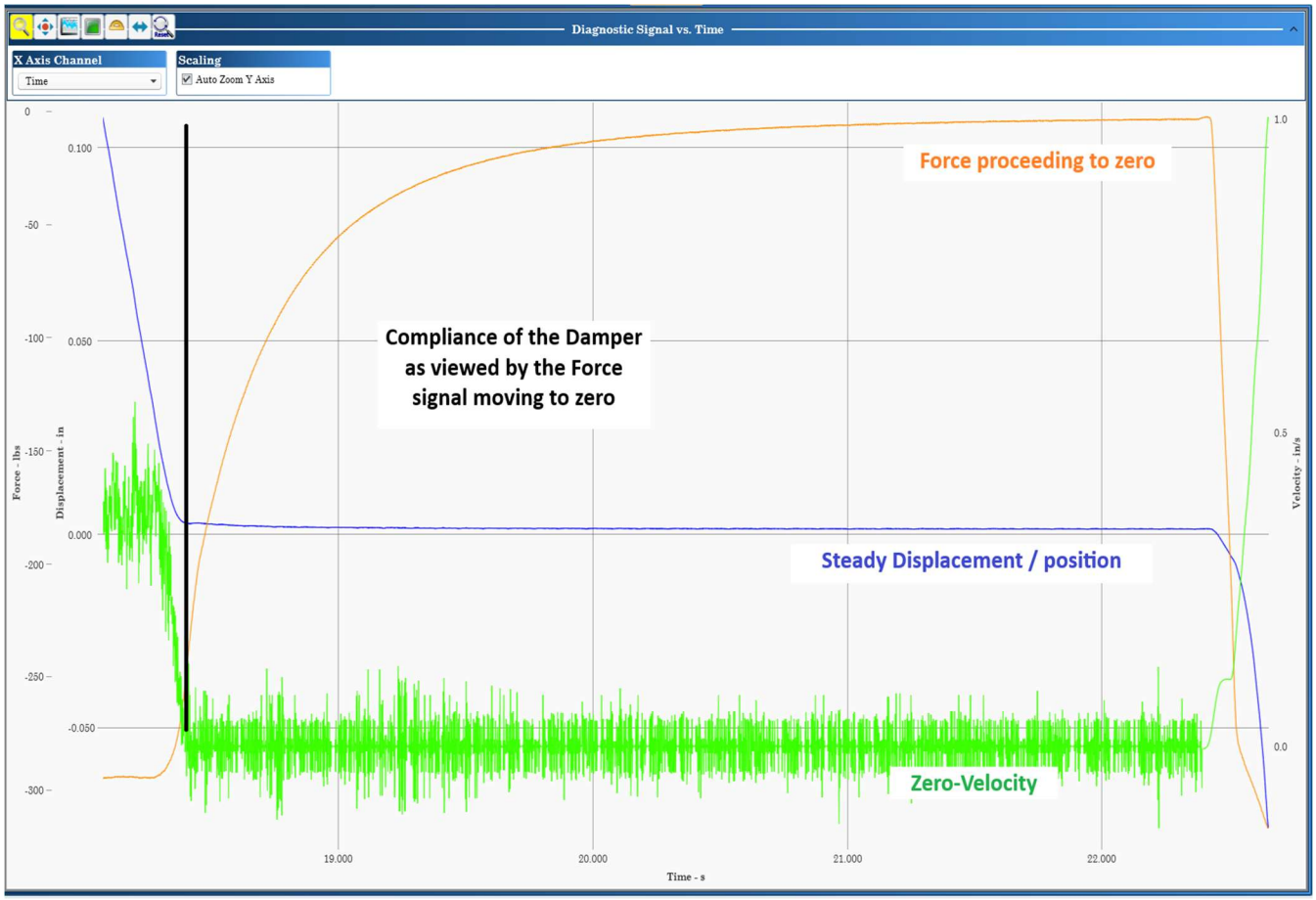
A classic damper will not generate a force if it is not moving. However, there are cases where the damper undergoes extreme conditions that put emphasis on every part to the point that there is compliance in the system that results in lag and this can be measured. The following is an example of a low bleed damper as viewed in the Diagnostic mode. This is a view of how the internal forces take time to equalize internally, well beyond the classical picture of the damper. This is relevant to American short track racing, no bleed and massive amounts of rebound. This is not generally practiced elsewhere, and it is used here as an extreme condition to help with understanding potential internal conditions to be aware of and take into account.

If we view the diagnostic signals during the Rod Force command we see the force in the compression direction is normal and settles almost instantly when the dyno stops at mid-stroke for the first Rod Force measurement.

But, in the extension direction the force takes time to settle, reach a steady state because of the extreme internal pressures built up during the move from one side to the other.



Viewing the Rod Force in Time - Overall



The Extension side of the Rod Force measurement vs Time

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Next up…Multi-Point Rod Force

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“Don’t Panic”