



CTW Automation Probe Software for the RD Series

Rev E

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This manual is for the CTW Probe Analysis Software to be used with the RD series of machines designed, built, and manufactured by CTW Automation. It is intended for the purposes of our customers and their RD machines. It is not intended for mass distribution or publication by anyone other than CTW Automation. It is setup to first go through all the Tabs and screens before proceeding to building and executing a Test.	
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Introduction

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As with all our products and services, CTW Automation wants you to be able to use the equipment and obtain results you can use to develop and characterize your shocks, springs and test specimens. To that end, we want to help you get the most out of the equipment and for you to be happy to use it.

Technical Help

Your machine was delivered with a full one-year Support contract. This allows the owner e-mail / phone and remote access help via CTW TeamViewer license. Any time after training, if you have questions or concerns, contact CTW for help.

To get the best help, it is important you try to use the following avenues:

E-mail to: Service@ctwautomation.com

Send your name, location and a number to reach you

Please include your serial number, for example RD3-043

Or

Phone: 336-542-5252

We are located on the East Coast in the Eastern Standard Time zone.

- If you have questions about data or a graph, PLEASE attach the data file to the e-mail. We can open it on our computer and understand more than just sending a picture.
- If you have questions about a particular Test you created, it could be helpful to attach that to the e-mail so we can see what you are using for commands.
- TeamViewer should be loaded on your computer during calibration or install. If you need a copy it can be found on our website: www.ctwautomation.com and go to the Software tab.

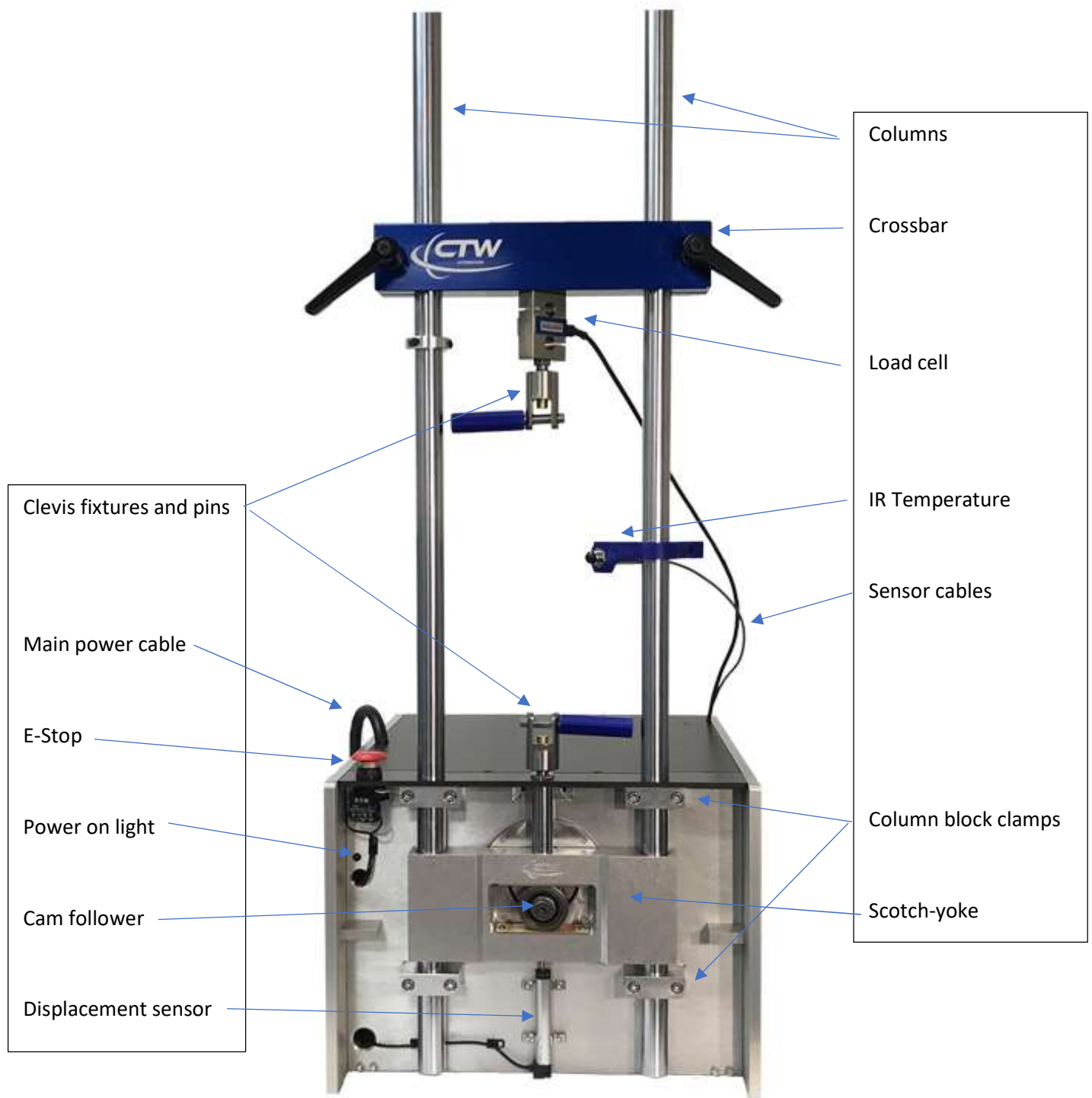
Overview of the RD Series of Rotary Actuators – the crank dyno

The RD series is a scotch-yoke type design for creating linear motion. This system delivers a pure sine wave input to the damper or test specimen. Several factors in each model type determine the possible testing envelope including stroke, velocity and force.

- 1 – Stroke is changed manually by the User by inserting the cam follower bolt into various holes in the crank head. The table top machines have stroke up to 2.0" or 50mm while the free-standing machines can reach 4.0" or 100mm.
- 2 – Velocity of each machine covers a very wide range. Testing can go from the very slow speeds to very high all within one Test to get the best "picture" of the damper.
- 3 – Power and force vary based on each model with the general design to keep increasing as you go through the CTW range. From as low as 2 HP and up to 10 HP.
- 4 – Table top to free standing models to allow for the correct sizing for any application.



Table top RD2-3 and 5 vs. the Floor mount RD7.5 and RD10 Models



RD Dyno Overview

What does the shock dyno do?

Before we start running test we should think a little bit about what the shock dyno does and how the data is collected.

The scotch yoke type dyno uses a motor controller to command an AC motor to run at some defined RPM. This will move the actuator and the shock shaft connected to it, to a user defined peak velocity. The dyno has sensors that collect data during the test and the data card and software takes the voltage put out by these sensors and turns it into traces on the graph. The dyno uses a system called a “scotch yoke” to turn the rotary motion of the motor and crank into the linear motion we need to push the shock. If you look at the front of the dyno the large bearing in the center of the yoke is bolted at an offset on the crank head where the amount of offset defines the stroke the dyno will run. So if the crank bolt is located 1 inch from the center of the crank head, the total stroke would be 2 inches.

When the user creates a test, he is giving the software a series of commands on how and when to run the dyno. The stroke is defined by the position of the crank bolt so really the main thing the user is defining is the actual peak speed the shock will be run to. The software collects data from zero velocity up to the peak requested velocity and plots all that data on the graph. Your CTW dyno is collecting data at 1000 samples per second, so that means 1000 times a second the software is checking the displacement, velocity, force and temperature, and it plots force vs the displacement or force vs velocity to give us the graphs we are going to look at.

When the dyno is started, the motor turns the crank at the correct rpm to produce the requested peak velocity at the shock shaft. The peak velocity is at the midpoint of the stroke when the crank is at its highest offset to the sides. Zero velocity occurs at top dead center (TDC) and bottom dead center (BDC), when the shock shaft changes direction, going from the rebound stroke to the compression stroke at BDC, or the compression stroke to the rebound stroke at TDC. There is one point where there is not linear motion and that is where the dyno collects data at zero velocity. It is important to remember that the zero velocity point plotted on the graph is collected dynamically as the shock changes direction.

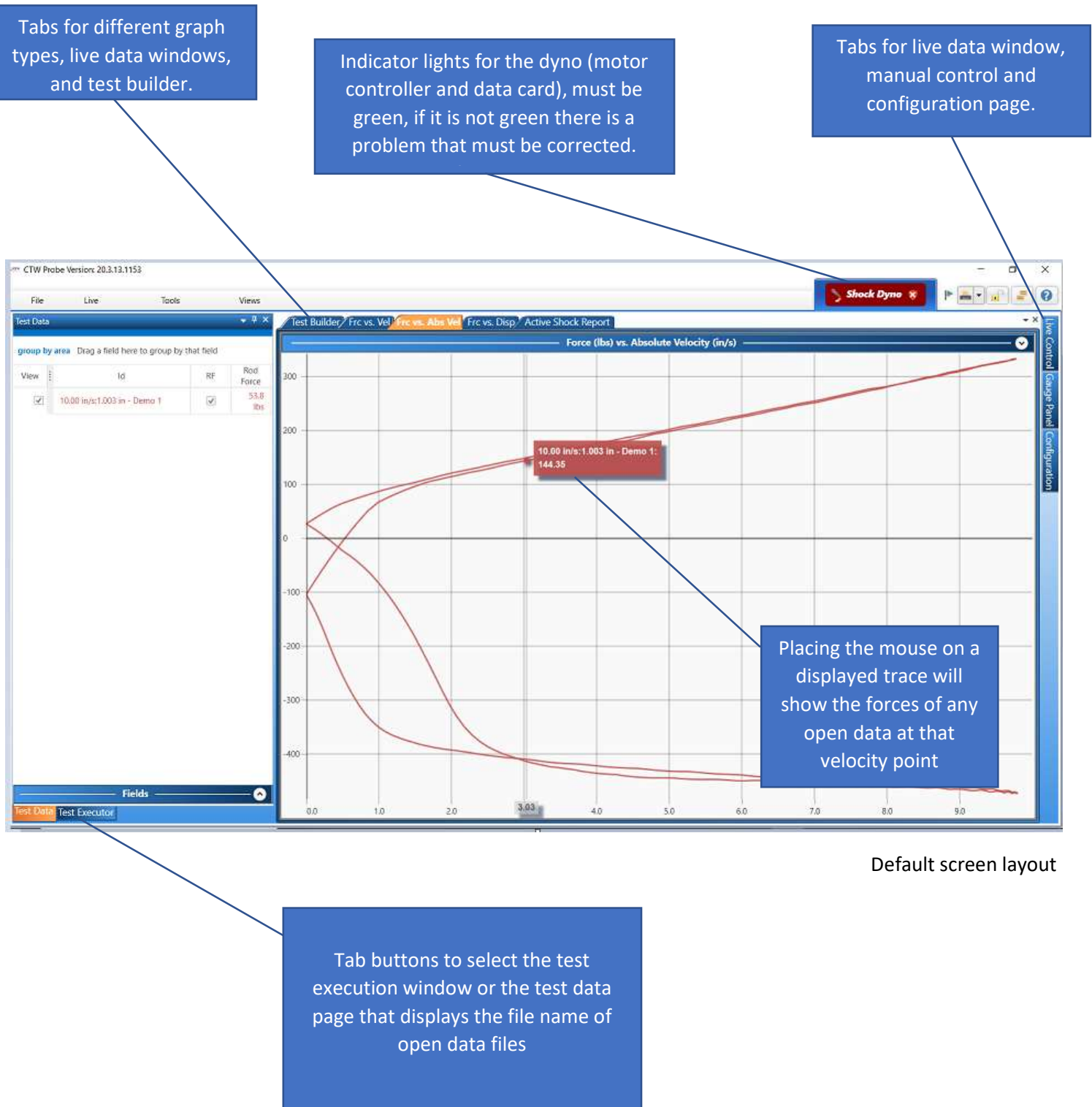
Data between the zero point and peak velocity point is collected as the dyno runs a sine wave over the stroke. A quality scotch yoke dyno is very good for comparing changes to the shock, or to different shocks because the dyno does the exact same thing every test. So we know that any change in the traces are related to the change on the shock.

Once you have collected a test of a shock, that file can be opened at any time to compare with a later run on that same shock or to different shocks.

As soon as we have collected data on a shock we can compare that data to a later run on the same shock to make sure nothing has changed. We can also start to correlate the changes in the shock graph to the vehicle handling and what changes to the shock and data effects what part of the track.

Layout of the software.

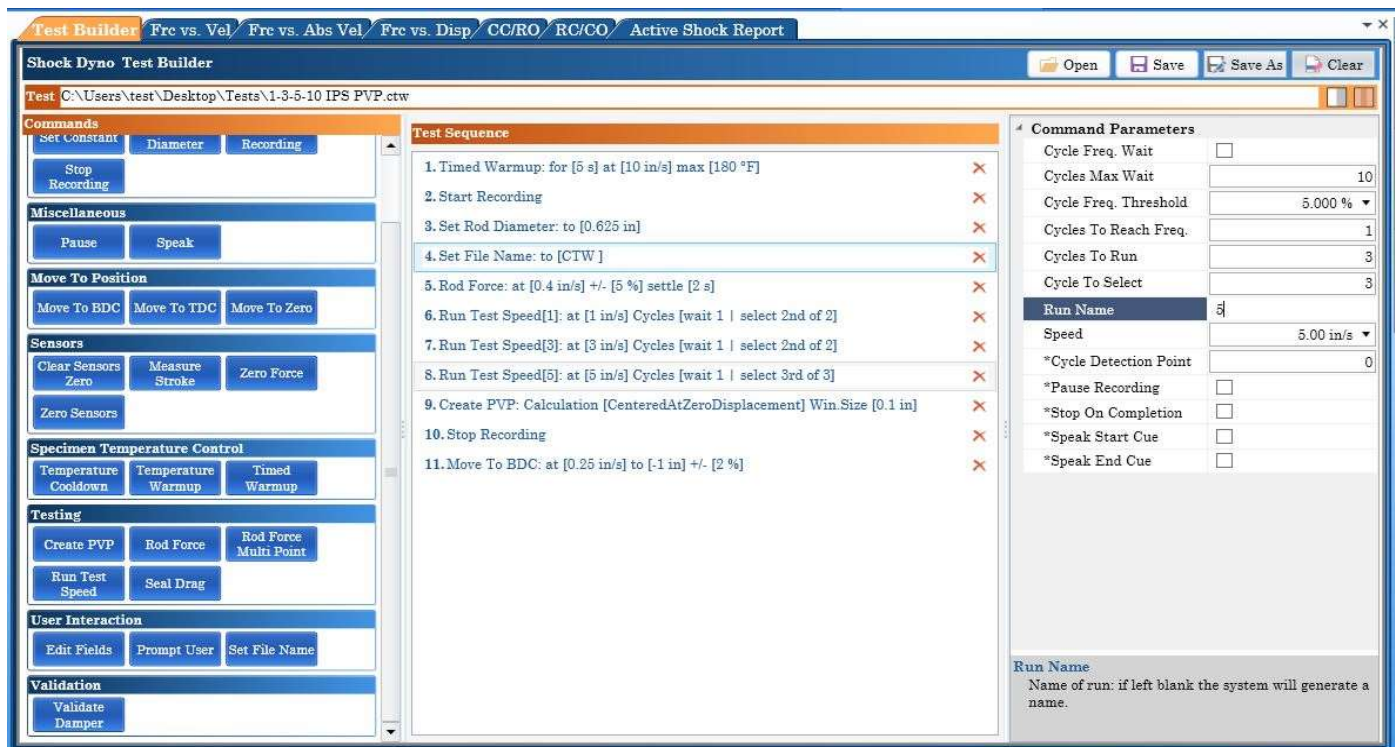
CTW software has different windows or pages depending on what function you are executing. Almost everything the user needs to run a test and display data is on this one window.



Default screen layout

Building a Test using Test Builder

You build the Test you want to run using the CTW Probe test Builder. It puts all the commands at your finger-tips to create the exact Test and procedure you want to run. It is very flexible and allows for a far greater ability to gather information than the other commercial software on the market.



Test Builder - Command screen

Clicking on the Test builder tab at the top of the page will open the window to create or modify a test. You can click on buttons to add steps to your test. When you click on a command in the “commands” column it adds that command to the “test sequence” column.

If you want to modify an existing test click the “Open” button and select the test from your test folder.

If you create or modify a test it will automatically load in the test execution window when you save the test.

Some commands need definition; for instance, the “Test Velocity” (Run Test Speed) button allows you to select the peak velocity you wish to test to, how many cycles you want to run and what cycle you want to use for the data display.

A Standard Test

Your Test can have multiple speeds, notes, rod force and many other commands but it must have (3) things. After these three commands, you can add more.

1 - Start Recording

2 - Run Test Speed

3 - Stop Recording

That is it, nothing more; simple. You started the recording of data, ran a speed and then stopped the recording.

But.....a good and useful Test should have several other features and we will describe those next. Everything about a good Test is about consistency; being able to compare data from damper to damper today and in 6 months time. It is knowing you did the same thing, started from the same baseline and that all similarities and differences are real and need to be examined.

- 1) You should always run the damper a few cycles, minimum, before moving forward to collect data. A damper will change with temperature and some even need a priming / cycling to equalize due to a twin tube design. Running before collecting data can make your testing far more consistent.
 - a. *Temperature warmup* - warm the damper to a temperature before moving to the next step
 - b. *Timed warmup* - run the damper for a few seconds to get the fluid moving inside
 - i. It is critical to get your dampers to the same state so that data and testing is more consistent and equal. Having all your dampers run to 90 deg F means you are testing your dampers based on the same temperature.
- 2) You should always run a Rod Force test whether you have a gas charge, thru-rod or twin tube. Again, it is a good way to start at the same point for everything you do.
 - a. *Rod Force* measures the force the damper (gas chamber, air bag) is pushing on the shaft. It counts.
 - b. Add the *Set Rod Diameter* so that the Probe software can calculate the internal gas pressure. It is not required but it is another potential data point in understanding your damper.
- 3) You can add notes / fields to your Test while it is running. This means you can have additional information saved with the data.
 - a. *Edit Fields* command
- 4) You can add your data file name during the Test as well. Because the User can work with Probe even while the Test is running; You save time.
 - a. *Set File Name*
- 5) You can run multiple speeds, as many as you want.
 - a. *Run Test Speed (s)*
- 6) You can create a PVP out of any group of speeds by adding the command at the end of the Run Test Speeds
 - a. *Create PVP* and then use one of three methods
 - i. A window around mid-stroke
 - ii. Peak force
 - iii. Peak velocity
- 7) You can have the dyno move to BDC (or even TDC) at the end of the Test so that the machine is ready for the next damper / spring / pull bar.
 - a. *Move to BDC (damper)*
 - b. *Move to TDC (pull bar, extension spring)*

Test Sequence	
1. Timed Warmup: for [5 s] at [10 in/s] max [180 °F]	X
2. Start Recording	X
3. Set Rod Diameter: to [0.625 in]	X
4. Set File Name: to [CTW]	X
5. Rod Force: at [0.4 in/s] +/- [5 %] settle [2 s]	X
6. Run Test Speed[1]: at [1 in/s] Cycles [wait 1 select 2nd of 2]	X
7. Run Test Speed[3]: at [3 in/s] Cycles [wait 1 select 2nd of 2]	X
8. Run Test Speed[5]: at [5 in/s] Cycles [wait 1 select 3rd of 3]	X
9. Create PVP: Calculation [CenteredAtZeroDisplacement] Win.Size [0.1 in]	X
10. Stop Recording	X
11. Move To BDC: at [0.25 in/s] to [-1 in] +/- [2 %]	X

Timed warm-up / Temperature:

Start Recording:

- Everything after this will be recorded for the User to view and use

Set Rod Diameter:

- This allows the Probe software to calculate the gas pressure based on the rod force

Set File Name:

- You can get the "Save" prompt while the Test is running to save the data files

Rod Force:

- Measures the force the damper exerts pushing the shaft out of the damper body.

Run Test Speed(s):

- Your speeds for testing; one (1) or many

Create PVP:

- Turn the speed data into a PVP graph

Stop Recording:

- Ends the data collection

Move to BDC:

- Take the dyno back to bottom at the end of the Test, or to the Top for a pull-bar.

General Structure of a normal Test

Running a test

The “Test Executor” window is the panel you perform a standard dyno test from. You must properly load the shock into the dyno and select the test you want to perform, then execute the test.

Before running a test make sure the Shock Dyno light in the upper right-hand corner is green. If this light is red, the dyno will not run the test. Locate the problem with the data or controller systems before proceeding.

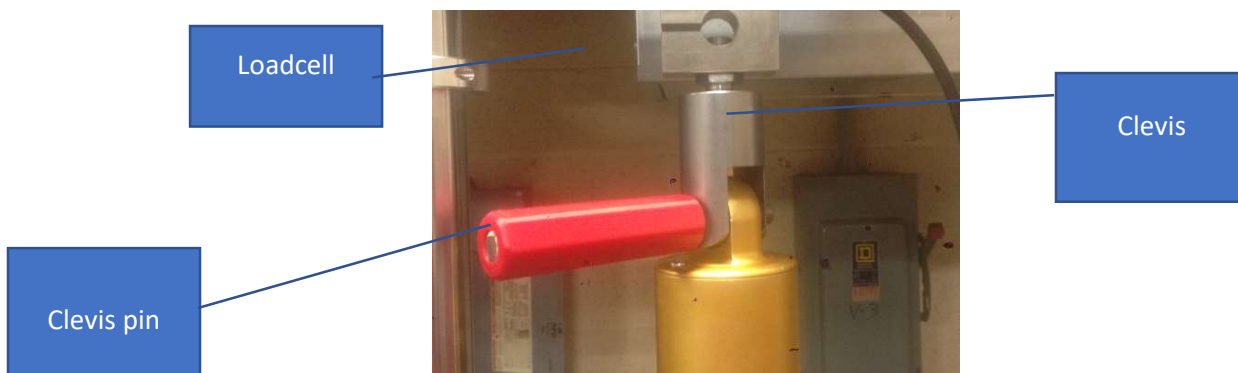


Loading a Shock in the dynamometer.

Before installing a shock in the dyno make sure the dyno is at BDC (bottom dead center). If you are not sure if the dyno is all the way down click the “Move To BDC” button on the test execution page. The dyno will start and run until the yoke has reached the bottom when you click this button. **Always make sure the dyno is at BDC before loading a shock!**

The shock also must be fully extended before it is installed in the dyno. If you are testing twin tube non-pressurized shocks pull the shock shaft out of the body until fully extended. **Always make sure the shock is fully extended before loading in the dyno!**

1. Hang the shock from the upper clevis by sliding the clevis pin through the clevis and shock eye, do not tighten the clevis.



2. From the “test execution” page lick the “zero force” button. This zeros the weight of the shock or any offset in the loadcell out of the data.



3. Loosen the cross-bar handles and lower the crossbar until you can install the lower clevis pin into the shock. If you are testing a mono tube gas pressurized shock the shock will hold the crossbar up while you insert the lower pin, if it is an unpressurized shock you will need to tighten one crossbar handle.
4. Lower the crossbar to compress the shock slightly, this prevents the shock from becoming over extended. Tighten the crossbar handles.
5. Tighten the clevis by turning clevis handles clockwise until snug. Check to make sure you have enough shock travel to prevent bottoming out the shock. If you are on a 2” stroke you should have at least 2.25” of shock shaft exposed.

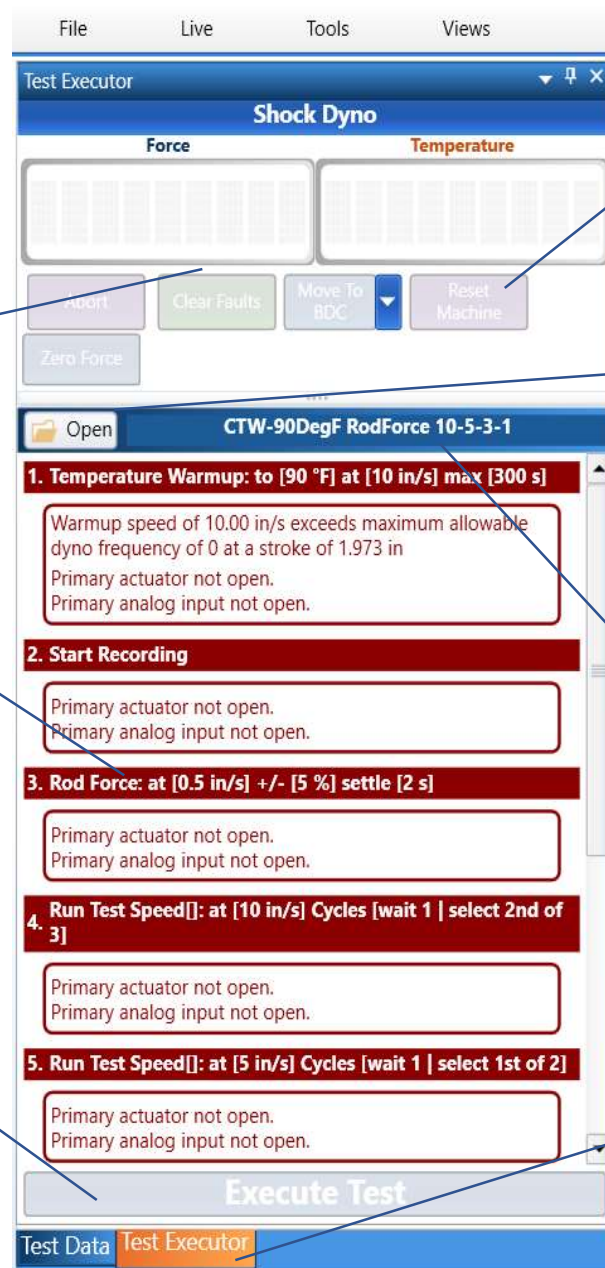
You are now ready to run your test.

Executing a test

Once you have the shock properly loaded into the dyno you are ready to run a test and collect data.

1. From the “Test execution” window on the left side of the page, click the “Open” button to select a test. If you have no test created see the “create test” section of the manual; you can create as many tests as you like. Keep in mind a test is just a series of commands, the collected data from those commands is what we will be looking at. Tests are stored your computers document folder at ‘Documents/CTW Automation/Tests’. Tests can be copied and pasted into other computers.
2. To start the dyno and perform the selected test click the “Execute Test” button at the bottom. This will start the dyno and automatically step through each step of the test. Each step will be highlighted as the dyno runs that step.
3. At the end of the test when the dyno has completed all steps, the “save” window will open. Name the test when the “save test” window appears after the test is complete. As a default, your data will be saved in a data folder in ‘Documents/CTW Automation/Data’. You can save data anywhere you wish. Data is saved just like any document in Windows so you can save data to any location.

Test Execution Window



If command buttons are greyed out (inactive) that means there is a problem and test will not run, make sure power is turned on and all cable are connected

Click "reset " button to reset inverter after an e-stop or error message

Load button will load the test you select

Test sequencer lists each step of the test. Notice in our example some steps are red, this indicates the dyno cannot perform that step

Name of the test you have selected

Execute button will start the test

Click these tabs to open the test executor or test data column

Create test options

Data commands



Set rod diameter - Select this button if you want to define your rod diameter and have the software save that number with the test. If a proper rod diameter is entered the software will record the gas pressure in the shock. This is based on the rod force recorded during a test (you must do a rod force test to get gas pressure).

Start and stop recording - tells the software when to start recording data and when to stop. If you forget to include the start/stop commands in your test, the dyno will run the test but not save any data. If you run a test and no data appears on your screen make sure you started and stopped the collection.

Move to commands



These buttons are used to tell the dyno where to park at the end of the test. For most users, select the Move to BDC button at the end of your test so the dyno will always return to the bottom of the stroke.

Sensor commands



Sensor commands tells the software to do something with sensor data before or during the test. For most tests, none of these commands would be used during a normal test.

Temperature commands



These buttons allow the user to warm the shock up before the test. You can warm up for a time or to a defined temperature. You can also run the shock slowly to allow it to cool down before removing. Once the button is selected and moved into the sequencer list double click on the button to open the parameters for that command.

Test commands



Test commands are steps that will record data.

Rod Force will stop and record the gas (or rod) force of the shock.

Rod Force Multi Point will stop and record the gas (or rod) force of the shock at several user defined points.

Pause will stop the dyno until told to restart, this is helpful if you are running a series of test and changing the adjuster between runs.

Create PVP will draw a PVP (Peak velocity plot) composite graph of all the speeds in the test sequence list.

Run Test Speed (or speeds) This step will be the speed the data will be collected at, defined as the peak speed the dyno will reach. Select the "Run Test Speed" button. If you want a multi CVP collection (more than on speed) click the "Run Test Speed" button for each requested speed. For each run you will define the cycles to reach peak speed, cycles to collect and the speed to collect at.

User interaction



Edit Fields allows the operator to modify the field he will be saving with the data run.

Prompt will allow you to pause the test. This is helpful when making adjustments to a damper between test velocities.

Set File Name defines the file name before the test is saved.

Displaying and viewing data after a collection.

After running and saving a test the data will display automatically. You can also open saved data by using the FILE/OPEN DATA pull down menu.

The graph below depicts the data on the force vs absolute velocity graph compared to the position of the crank bearing on the yoke. We break one cycle of the crank head into four quadrants. Each defines what is happening to the shock in that quarter.

The shock shaft (and shock piston) is constantly being accelerated or decelerated by the offset bolt in the dyno yoke. When the dyno changes direction, from compression to rebound at the top of the stroke and rebound to compression at the bottom of the stroke, there is a momentary pause between the up and down direction. At that point, the dyno records the zero velocity points. When the crank bearing is at its highest offset, mid stroke, that is where the dyno records the peak velocity. With a sample rate of 1000 sample per second, the software is checking the velocity and the force 1000 times each second and putting a point on the graph at that force and velocity intersection. The line we look at on the graph is really a series of collected points that the software connects with a line.

Four quadrants

Compression open – From BDC to mid stroke in the compression direction the shock is being accelerated, the graphs shows the force related to that increase in velocity. As velocity increases force increases. The parts inside the shock define how quickly the force changes. Sometime in this quarter the compression valve stack will open.

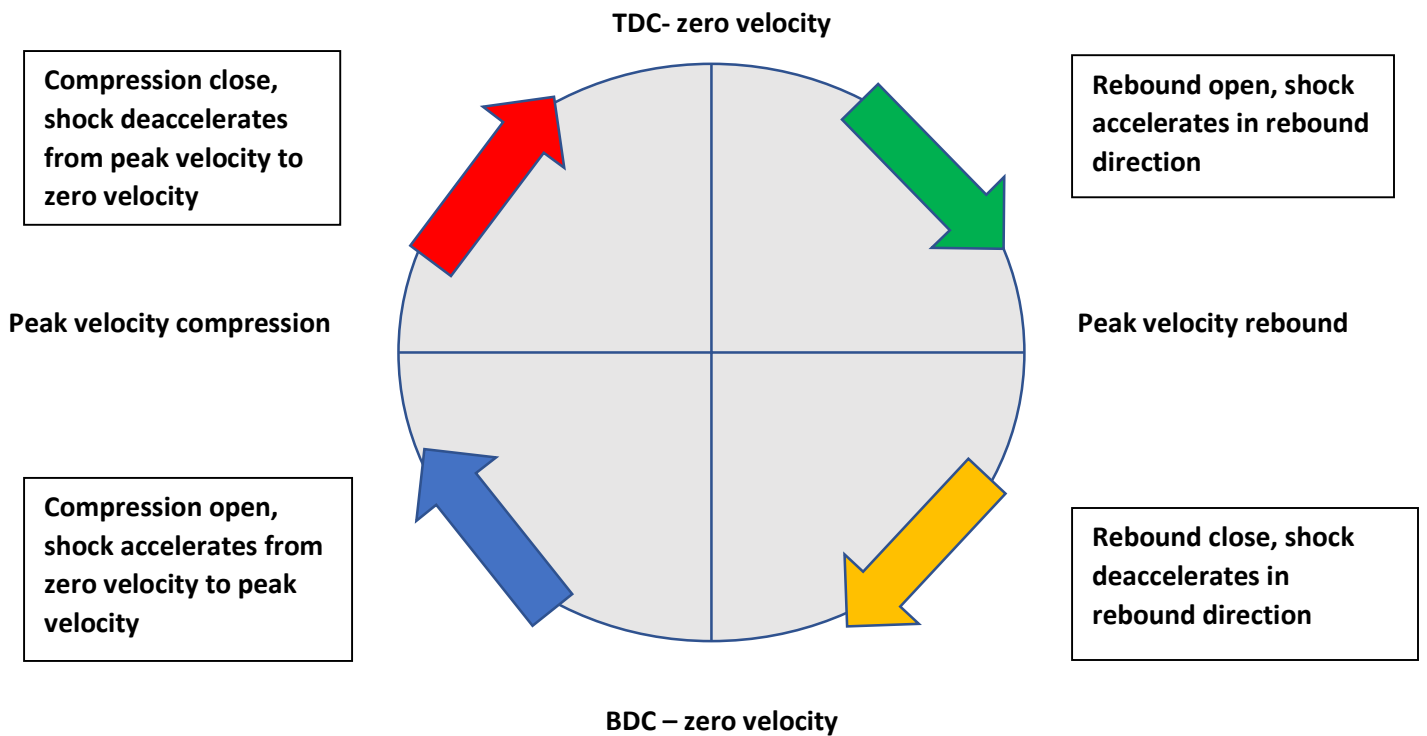
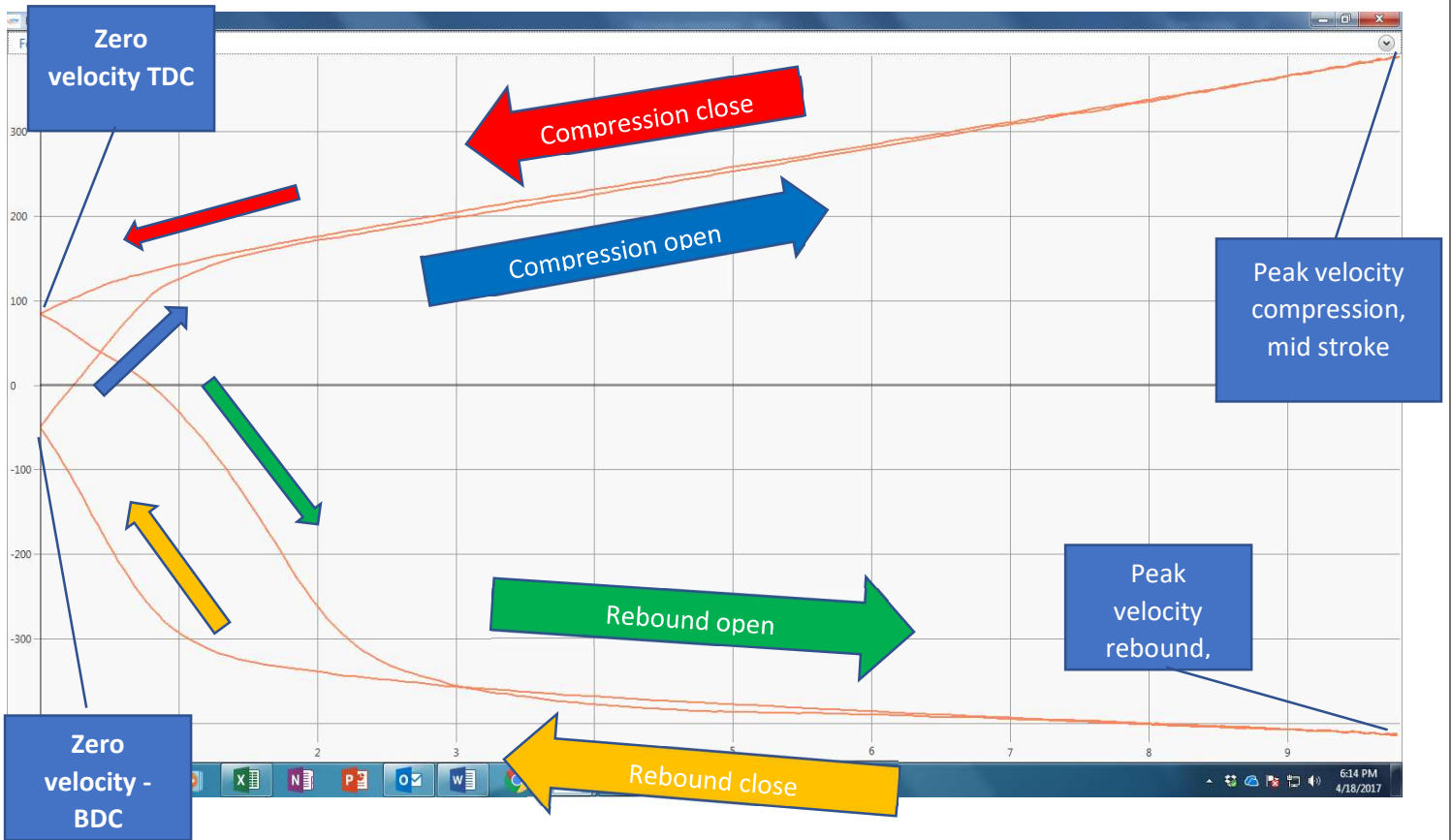
Compression close - At mid stroke the shock has reached its peak velocity and then must slow down to go back to zero velocity at TDC. As the shock slows down the shim stack in the shock will close

Rebound open – From top dead center the dyno and shock move back down pulling the shock shaft in the rebound direction. The shim stack on the rebound side of the piston opens in this quarter.

Rebound close – Finally the shock slows down from peak velocity at mid stroke in rebound back to zero velocity at BDC. One complete cycle has been run and graphed.

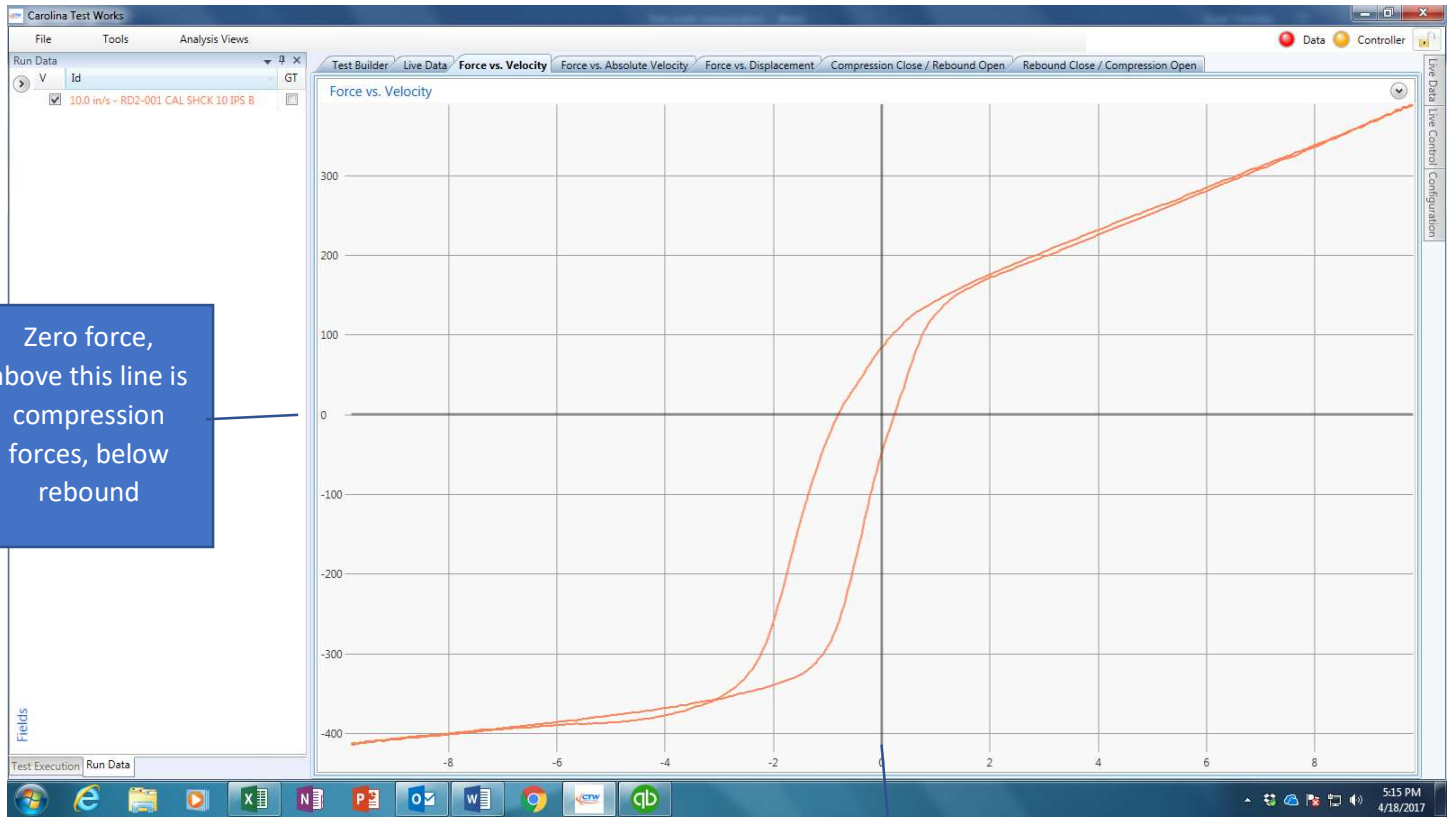
A scotch yoke dyno is running a sine wave pattern, so the acceleration and deacceleration is always at a constant rate. Although the crank is turning at a constant RPM, the yoke and shock shaft is being accelerated and de-accelerated at all times. This constant speed change is what allows us to see data not only at the peak points but at any point from zero to that peak velocity. If the speed of the dyno was to change the test data might be affected.

force vs absolute velocity graph



Data can be viewed in several different graphs. Data can also be viewed as a table from a report.

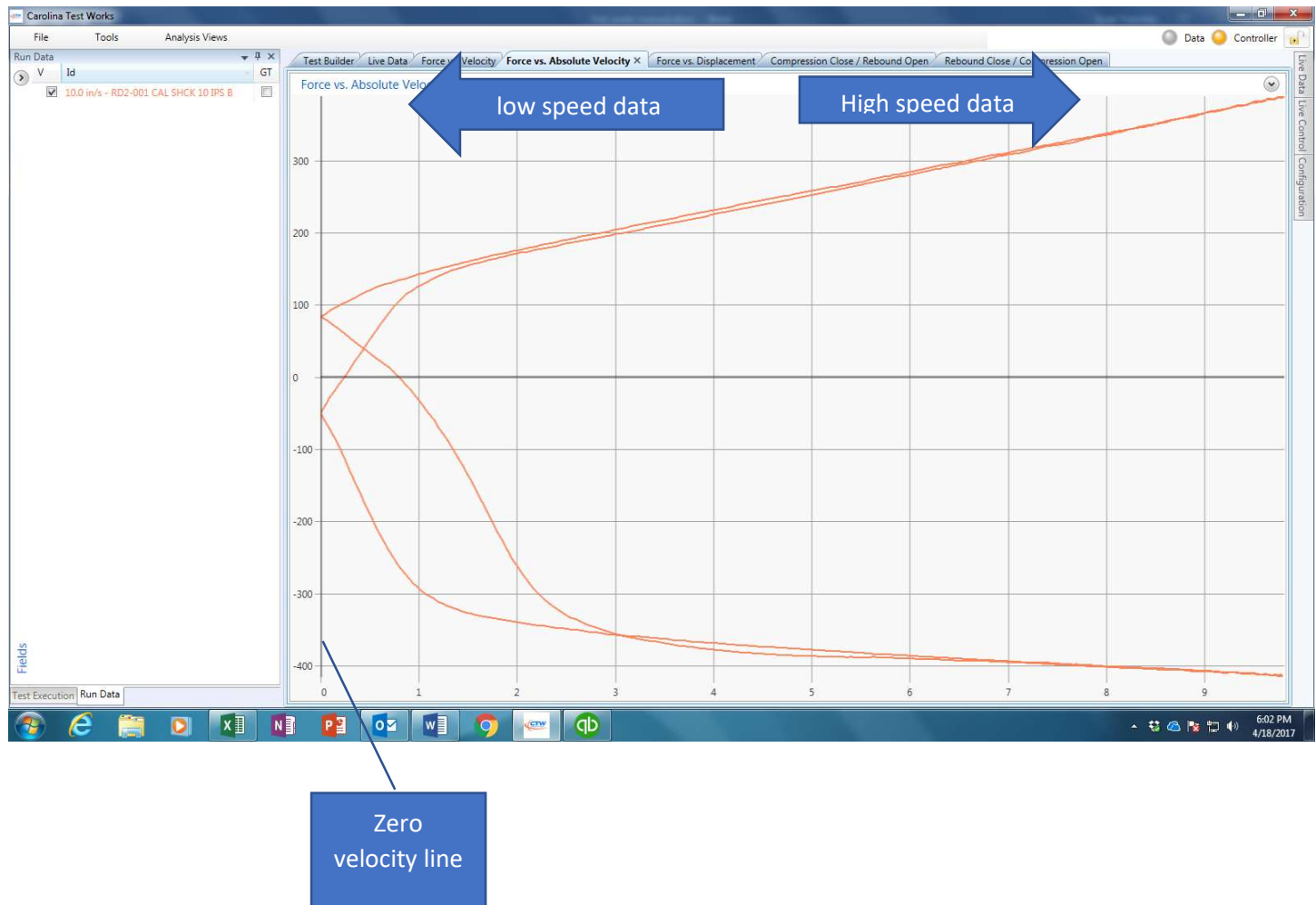
Force vs velocity – This graph displays a complete cycle of data, one complete revolution of the crank and one complete stroke of the yoke and shock, from BDC back to BDC. Forces above the zero force line are forces produced moving in the compression direction, while below the zero line are forces produced as the shock shaft is moved in the rebound direction. Rebound velocity is a negative number.



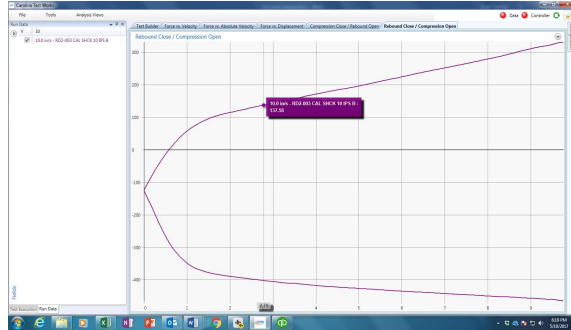
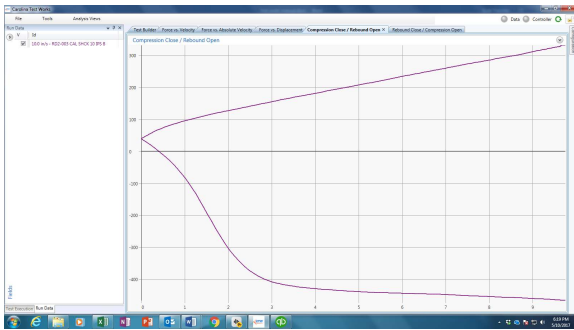
Zero force,
above this line is
compression
forces, below
rebound

Zero velocity line, to the
left are rebound
velocities, to the right
compression

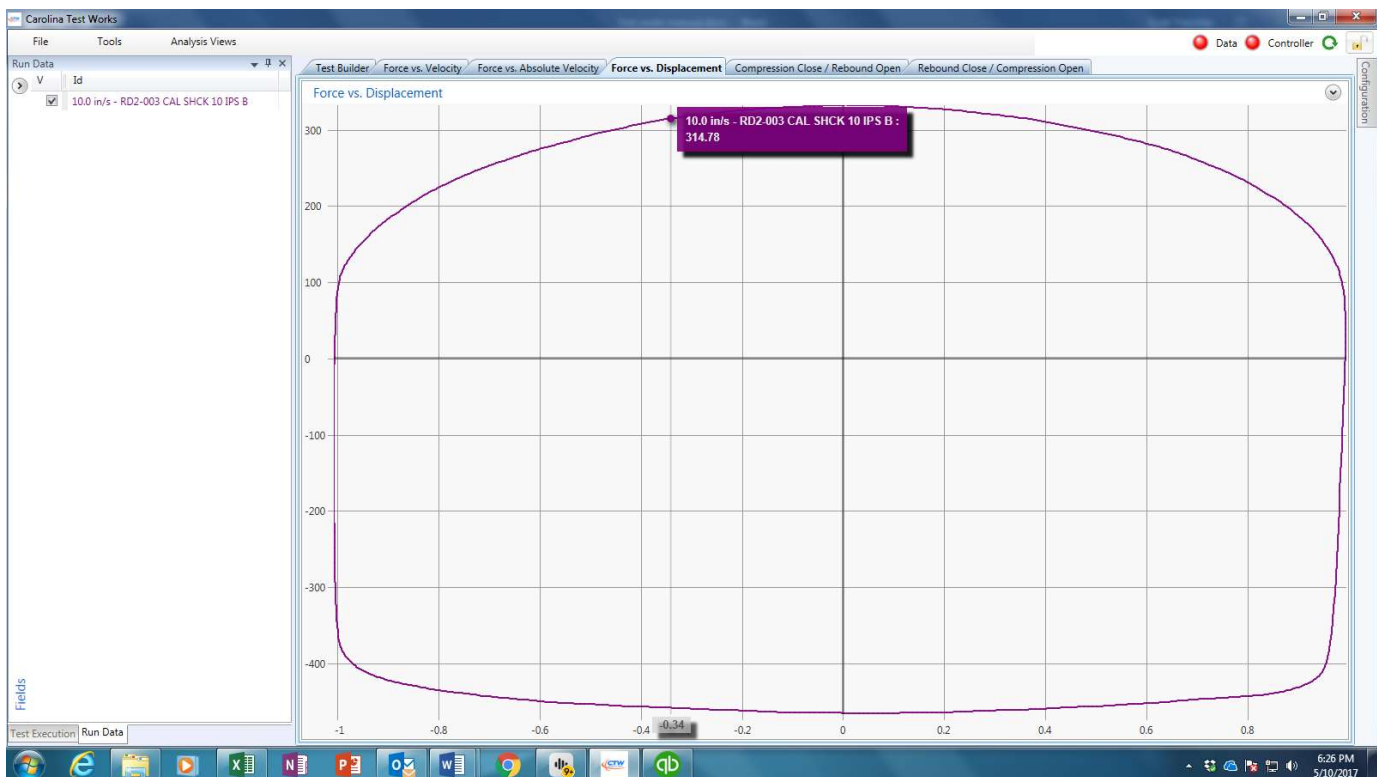
Force vs absolute velocity – The most common graph type used for shock analysis. This graph displays the exact same data as the Force vs velocity graph above. The zero velocity line is moved to the left of the graph, so the rebound lines are “folded over” and all the velocities are in a positive direction. Just like for F vs V graph all forces above the zero force line are compression forces, while forces below are rebound.



Compression open/rebound close, rebound open/compression close - Both these graphs are the force vs absolute velocity graph just cut in half. The graph is cut at the peak velocity points. It is the same data as Force vs absolute velocity, just displayed in two graphs.



Force vs Displacement - This graph still displays the force on the Y axis but now displacement is on the X axis. So we are looking at the force at any given displacement.



Other features and tools

Scaling - As a default, the program will “auto scale” the graph to fit the data trace just inside of the paper. So the scaling on the page will increase or decrease depending on the velocity or force your shock produces. If you want to lock the graph scaling you can do that by clicking on the arrow in the upper right-hand side of the graph, this will open the scaling page. Remove the check from auto scale, type in your minimum and maximum for each axis, and hit apply when done. Each graph type scales independently. You can also select the number of target lines for both the X and Y axis.



Units - In the file menu click “Unit System” to select US standard or metric units. Use the “unit preferences” to define which metric units your prefer (mm,m,cm) and unit precision.

Layout - The “layout” selection under the file pull down menu allows the user to reset his software layout to a factory default or save and reload a custom layout.

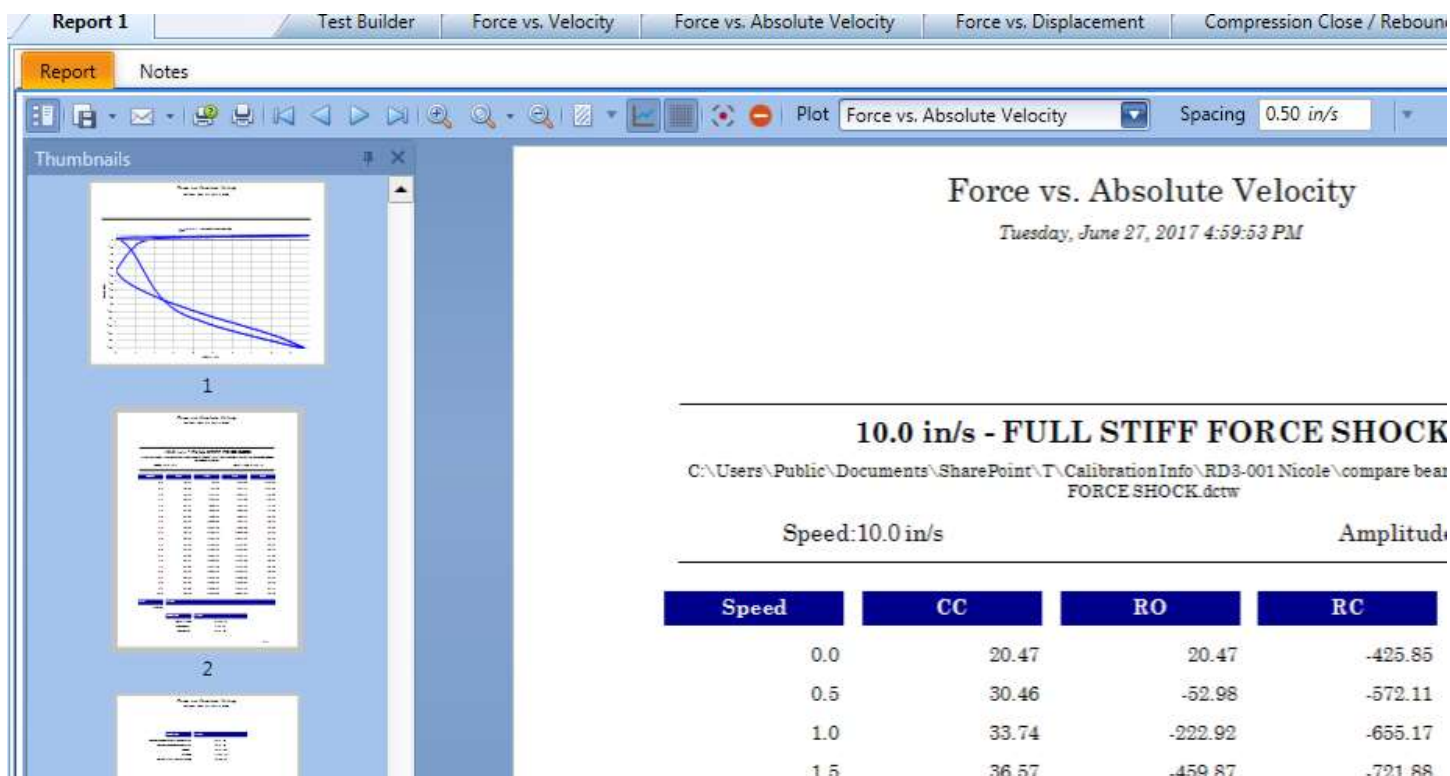
Check for updates - If your computer is connected to the internet you can click on check for updates” in the file pull down menu to find and download any software updates that may be available.

Report - Collected data can be displayed as a text report. In the “Test Data” column right click on any open data file’s name. You will be able to select any or all of the open data files to produce a report. Reports show up as a tabbed page at the top of the screen. If you have a lot of reports open the “thumbnail button at the top of the page will list the page as thumbnails on the left side of the report. You can also export or email the reports from tool bar buttons at the top of the report page. There is also an “Active Report” tab in the default layout that will do the same for any data files that are open or “active”.

Print - Printing is done from the report page using two tool bar buttons at the top of the report page. Quick print will print whatever graph or report you have displayed using the default printer settings. Custom print allows the user to select print features and pages.

If you want to add notes to your printed graph page click on the “notes” tab at the top of the page. Notes will be added above the graph.

Add logo - The add logo tool bar button allows the user to import their company or team logo to print on the reports.



Report and print page

MAINTENANCE PROGRAM

Keep columns clean and lubricated. The easy way is to wipe them with a cloth rag after a day of working with dampers and oil. A very light coating helps to stay clean, allows the crossbar to move freely and keep away imperfections.

Crossbar studs are used many times per day, they can be lubricated lightly with any type of anti-seize compound.

Wear plates and cam follower - this is the most highly loaded item / bearing on the machine. The plates are made of a "plastic" - DO NOT use a cleaner, brake clean or other solvent as it will destroy the material.

1 - Remove the cam follower or rotate it by hand to the side and simply wipe clean with a cloth or paper towel. Repeat in the other direction (top and bottom).

2 - Apply new Mobil 1 bearing type grease, a lithium complex. You can do this once a year.

CTW uses a Mobil SHC Mobilith SHC 220 Lithium Complex (red) bearing grease commonly found in the auto store.

Inside the machine, there are industrial bearings that all have grease fittings that can be used along with a grease gun for lubricating. This does not need to be done but once every three years under normal operating of the machine.



CALIBRATION PROGRAM

The simple answer for calibration is your machine will not change unless something happens to make it change. Now understand this is a general statement but the load cell, displacement and the mechanicals have no reason to change over time and their calibration has no reason to change. We have been able to service old machines in the field, load their settings and they match a brand new machine right away. The calibrations are simple and the sensors are high quality from leading manufacturers.

Your machine was originally calibrated by CTW to a few exacting measurements. A static calibration as well as a dynamic calibration was done. We used devices and dampers that can be traced back to every other dyno as well as a NIST traceable sensor assortment. These calibrations are on file at CTW and you **MUST** load them when you get your dyno operating for the first time.

Displacement is a linear look-up based on gauge blocks and voltage. The user can verify the displacement by simply using the Live Control and the Measure Stroke command. Once it is run, it reports to the User the measured stroke. If you are on the 2.00" stroke, it should measure within a few (+/-0.001) thousands of an inch. Additionally, you can always check your data files. The Force v Displacement should be displaying the stroke you are using.

Force is also a simple linear look-up table based on a "zero volt" (no load) and then a peak negative and peak positive force. Using the Interface load cell certification, CTW simply expands to a 10 volt window in each direction: compression and extension.

Both of these measurements are traced back to sensors and equipment that are calibrated to a NIST specification on a yearly basis.

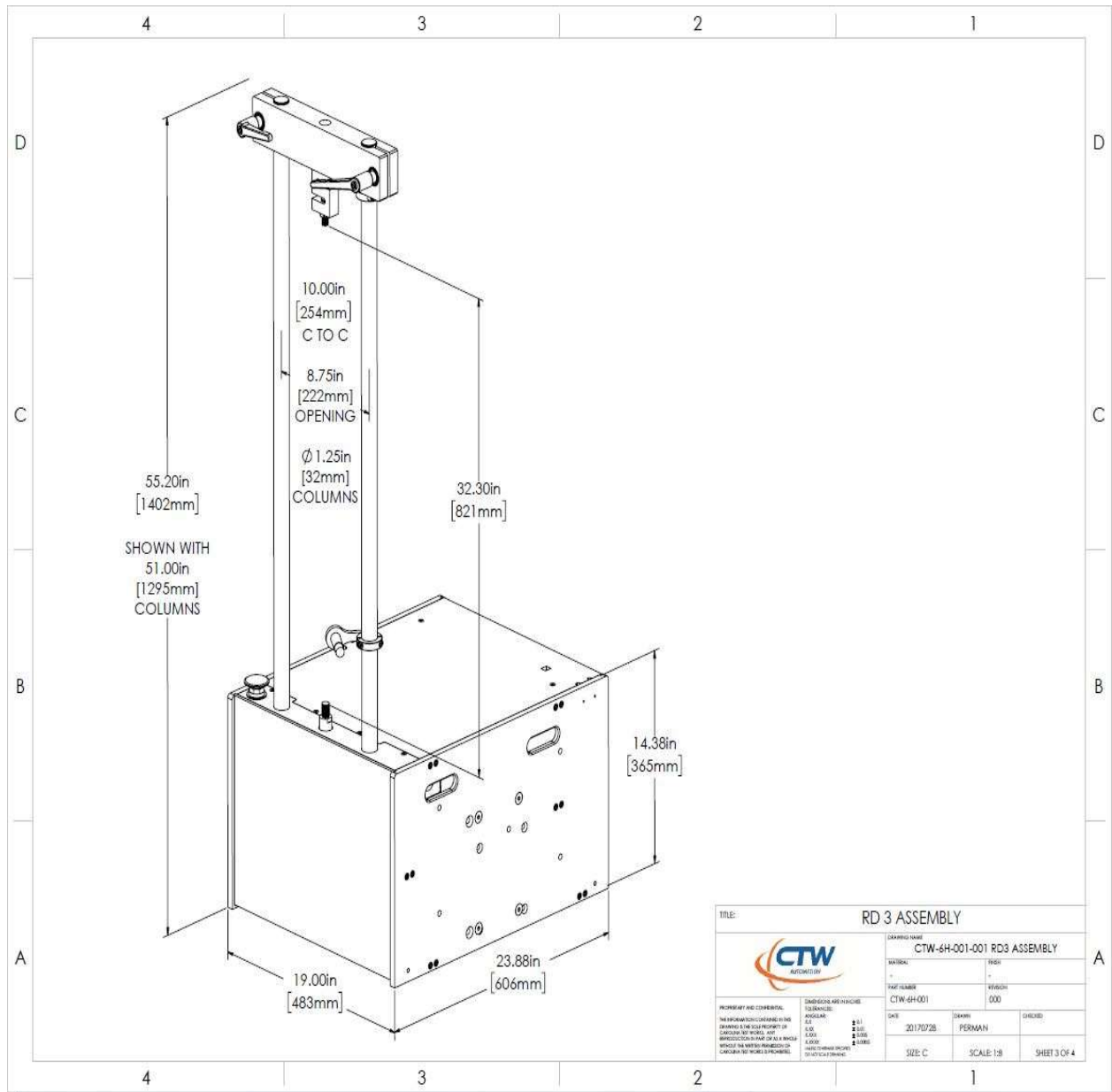
CTW allows the User to define if they want their calibrations checked. We have customers that are required (by their customers) to be certified on a yearly basis. We have customers that never check their equipment, relying on their pool of data files and use to keep up with how their dyno is measuring over time. We are here to help you in any of your requirements.

For a simple program, every 3 / 4 or 6 months

- 1 - Once every three months, go to Live Control and run the Measure Stroke. You can see the reported result and even compare it to a measurement you would take at the actuator as it goes up and down. Then go to configuration and click "Save" to have it recorded in Probe.
- 2 - Use the "Backup Settings" feature located under the Preferences selection on the toolbar. This will create a Zip folder of your calibrations to keep as a backup in case your laptop fails. These are specific to your dyno. Keep a copy off of the computer in a safe place.
- 3 - Keep a copy of your "Test" folder as well, off of the computer in a safe place, hopefully with your "Settings.zip" folder. This can be found in Documents/CTW Automation area on your computer.

CTW POWER REQUIREMENTS

<u>Dyno Model</u>	<u>Input Voltage/Phase</u>	<u>Amperage in</u>
RD2	200-240VAC/Single Phase (only)	17.8
RD3	200-240VAC/Single Phase	24
RD3	200-240VAC/3 Phase	14.9
RD3	380-500VAC/3 Phase	8.8
RD5	200-240VAC/Single Phase	38.3
RD5	200-240VAC/3 Phase	23.8
RD5	380-500VAC/3 Phase	13.7
RD7.5	200-240VAC/3 Phase	35.6
RD7.5	380-500VAC/3 Phase	20.7
RD10	200-240VAC/3 Phase	46.1
RD10	380-500VAC/3 Phase	26.6



General Dimensional Outline of RD2 and RD3

Edits

Rev E: 4-2021 - adding maintenance and calibration information.