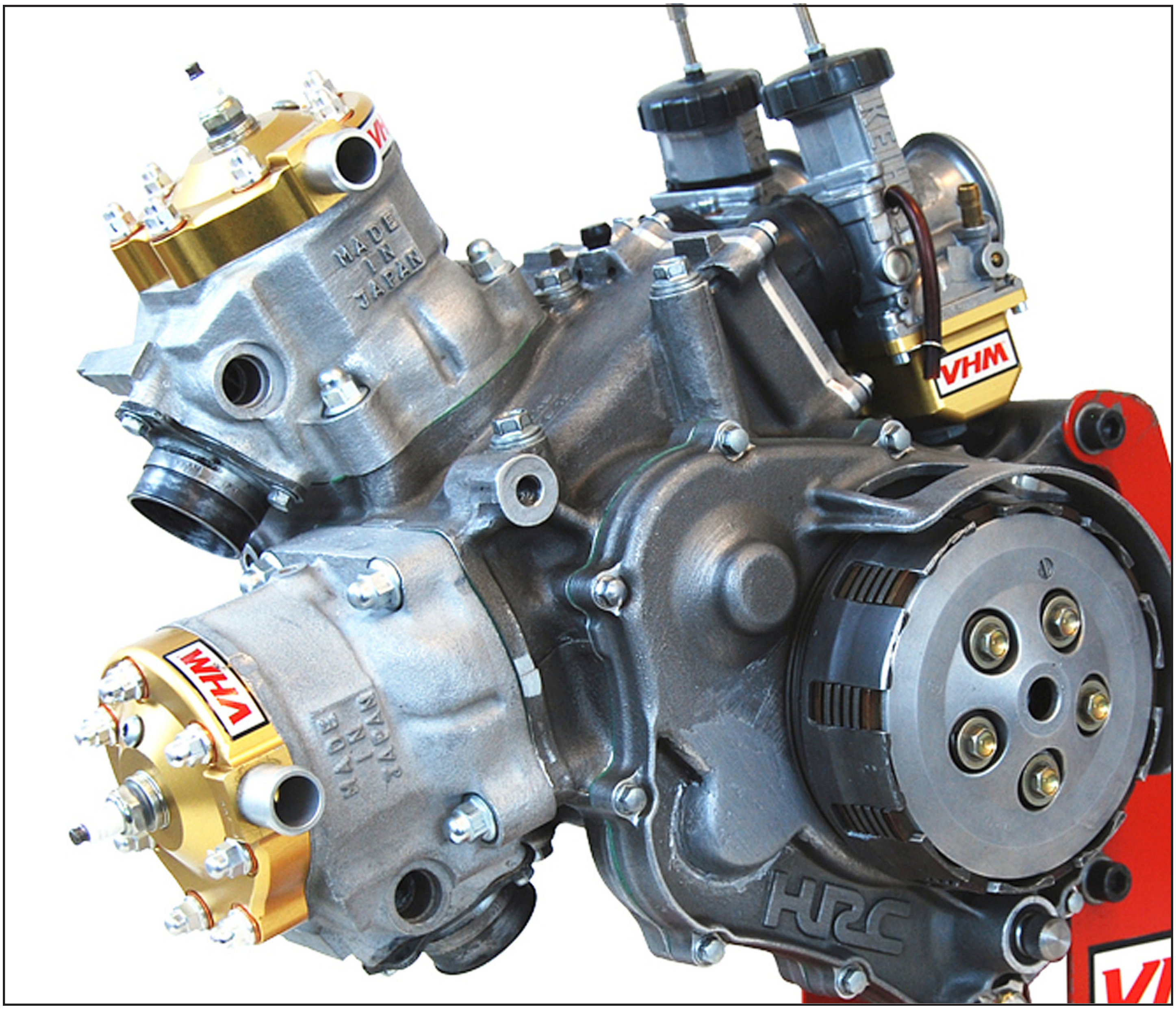
DynomationTwoStroke

Wave-Dynamics Simulation

Program User's Guide

And Simulation Tips For Optimizing Program Operation



Two-Stroke Simulation

v. 1.10, 6/2014

Requires Windows98 or Windows XP (SP2, x86, 32-bit)

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Anaheim, CA 92808
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Audie Thomas, Owner of Audie Technology, Inc., developer of many software and hardware tools used by amateur and professional engine enthusiasts. One of the programmers of the original DOS-Dynomation and DynomationTwoStroke, Audie graciously contributed his valuable time and expert advice during the update of this software to Windows98/XP.

Brent Erickson, Simulation Designer, Windows, C, C++, Assembler Programmer. Brent's positive "can-do" attitude is backed up by his ability to accomplish what many dismiss as impossible. Brent developed many new simulation models and interface improvements for Dynomation and other Motion Software, Inc., simulation packages.

Our Beta Testers And Dedicated Dynomation Enthusiasts—There are hundreds of individuals that use Dynomation-5 and DynomationTwoStroke that have graciously given their time to provide suggestions, test new features, and help our development team improve our programs. Many of these individuals treat have treated Dynomation as if it was their own, truly caring about making it the best possible simulation. To these dedicated enthusiasts, many of which run their own companies and have limited time to give, we offer our sincerest thanks. We could not have done it without you!

And thanks to **Heikki van den Berg** at VHM (www.whm.eu) for providing the awesome engine photo used on the cover of this User Guide.

Larry Atherton, Pres., CEO
Motion Software, Inc.

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INTRODUCTION

Note: If you can't wait to start using DynomationTwoStroke, feel free to jump ahead to ***INSTALLATION***, then make sure to read ***Using DynomationTwoStroke***. The following ***INTRODUCTORY*** information provides background on the design and development of DynomationTwoStroke that you may find helpful in understanding and using the program.

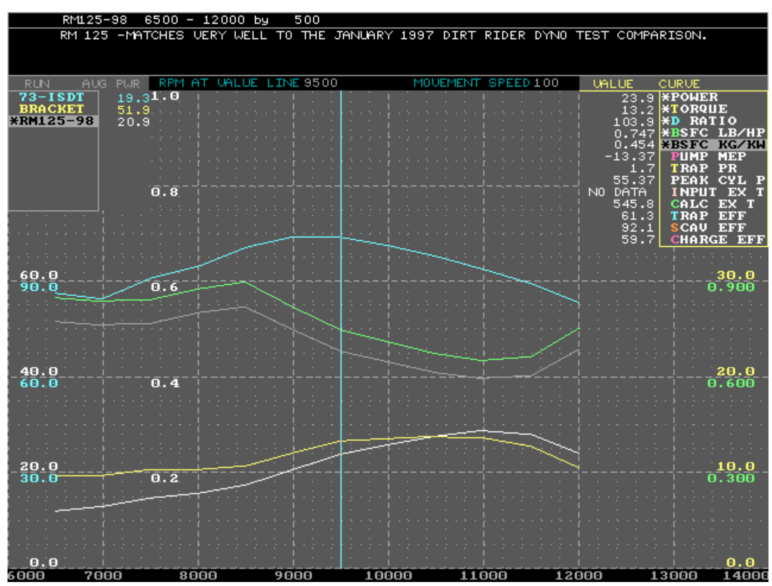
Thank you for purchasing DynomationTwoStroke™ for Windows98/XP from Motion Software, Inc.

First, a little background into this simulation. This software was originally developed and released in the mid-1990's. A great deal of time and effort was expended in the design and development of this comprehensive wave-action simulation. The original developers hoped that a sufficient quantity would be sold to make a profit and support ongoing development. Unfortunately, worldwide effort in two-stroke development was on the decline. There was no question that the businesses and individuals that purchased the original Dynomation 2 Stroke program were pleased with the capability of the software to help them with their engine development. Most reported back with very positive feedback. Despite that, limited two-stroke interest curtailed program development.

Jump forward to 2014. Motion Software, Inc., announces a new release of DynomationTwoStroke that lets users install and run the program under Windows98 or WindowsXP (SP2, x86, 32-bit). Support for Windows not only makes the program easier to use, but it also allows the growing number of new two-stroke enthusiasts to use this powerful simulation on Windows platforms.

NOTE: WindowsXP is the last Windows OS that directly emulated DOS and, therefore, XP is the latest Windows OS compatible with Dynomation TwoStroke; later versions of Windows do not support DOS and will not run this release of DynomationTwoStroke).

Even though DynomationTwoStroke installs and runs under Windows, it is basically a DOS program. This means that it uses DOS to execute its program code and create screens, menus, and graphs (see photo on right and others throughout this manual). For example, once launching the program...using the common Windows START metaphor, desktop icons, or other standard Windows methods...DynomationTwoStroke operates very similar to the original DOS-based program, including the display of "full-screen" DOS graphics. Most menu and component inputs are made using key-



Typical DOS screen takes over the entire monitor display space. Most data entry and screen selection in DynomationTwoStroke is made with the keyboard.

board keys, while individual program screens are selected with the Function Keys, Escape Key, and SpaceBar Key (rather than the mouse). While this older program interface may feel awkward at first, with a little practice, you will soon become proficient and gain access to the powerful two-stroke technology offered by this wave-action simulation. Most users tell us that it only takes a day to become "comfortable" with the simulation.

Why Is The Program Still DOS?

The answer to that question is easy: cost!

While the interest in two-stroke engines is growing, the worldwide interest in a professional two-stroke engine simulation is still limited. The cost to convert this program into a full Windows program (like our Dynomation-5, four-stroke simulation) would prevent it from ever being released! So, the best alternative was to update the program and modify the code to run INSIDE of Windows98 or WindowsXP. To complement the release of DynomationTwoStroke, we produced this new User Guide and we offer Motion Software support for new DynomationTwoStroke customers (support@motionsoftware.com).

Welcome to DynomationTwoStroke. Please let us know what you think of this product. Send us your ideas, critical analysis and how the program helped your engine development efforts. We really appreciate your feedback!

DynomationTwoStroke In A Nutshell

DynomationTwoStroke is a full-cycle simulation, meaning that it calculates the complete fluid-dynamic, thermodynamic, wave-dynamic, and frictional conditions that exist inside the cylinders and runners throughout the entire 360 degrees of the two-cycle process. It keeps track of the pressure waves moving in the intake and exhaust systems and their effects on port/pipe pressures and flow. The program performs hundreds of millions of calculations at each rpm test point throughout the engine-analysis process. Despite internal program complexity, the simulation is straightforward and easy to use. You can count on DynomationTwoStroke to produce solid, accurate predictions of engine performance characteristics.

DynomationTwoStroke can model a wide variety of two-stroke engines:

- Number of Cylinders: 1 to 3 (firing into joined chambers; unlimited firing into individual chambers)
- Engines with Piston-Port Induction, Reed-Valve Induction, and Rotary-Valve Induction
- Select Carbon Fiber, Fiberglass, and Steel Reeds
- Model Two to Six Transfer Ducts
- Exhaust Temp Can Be Calculated or Manually Entered
- Uses Sophisticated Combustion and Ignition Timing Modeling with BSFC Compensation
- Various Intake Tract Lengths and Sizes
- Exhaust Modeling With Individual or Shared Expansion Chambers
- And Much More!

Program Outputs and Graph Results:

- Power and Torque
- BSFC (Brake Specific Fuel Consumption)
- Pumping MEP (Mean Effective Pressure)
- Peak Cylinder Pressure
- Trapped Pressure Ratio
- Delivery Ratio (same a VE in a four-stroke engine)
- Trapping Efficiency
- Scavenging Efficiency (a measure of charge purity in the cylinder)
- Charging Efficiency
- Exhaust Temperature
- Piston Speed
- %EO to EC (percentage span through exhaust phase used for diagnosing Expansion Chambers)

DYNOMATION ENGINE SIMULATION

Professional Wave-Action Simulation

INSTALLATION

DynomationTwoStroke Program Requirements

• A Windows-compatible PC with a CD-ROM drive.
• A fast system processor (3GHz or faster)
• Windows98 or XP with Service Pack 2, 32-bit, x86
• GB of RAM (random access memory) for WindowsXP. More memory will improve performance.
• A USB Port for the Security Key (see INSTALLATION for more information on program security).
• Hard Disk Drive
• VGA monitor of 800 x 600 resolution or higher
• Printouts with a printer connected to local LPT: port
Recommended printers for direct LPT connection; circa-1995 Laser, HP DeskJet, or Epson printers
Printouts can also be created from program Report Files (using any Windows Word Processor)

Program Installation Steps

1) Close all other applications before you begin this installation!

2) Insert the DynomationTwoStroke CD-ROM into your CD drive.

3) The DynomationTwoStroke installer will open on your Desktop within 5 to 30 seconds. Follow the on-screen instructions to complete the installation.

> **Note:** If the software Installation Menu does not automatically appear on your desktop within 30 to 60 seconds, double-click the My Computer icon on your desktop. Then double-click your CD Drive Icon (make sure the DynomationTwoStroke install CD is inserted in your CD drive). Finally, double-click on Setup.exe to launch the installer.

4) When the main installation is complete, the program will start the USB HASP Security Key driver installer.

5) A series of dialog boxes will guide you through the installation of the HASP driver. After the USB key driver has been installed, the basic DynomationTwoStroke program installation is complete.

Installing The USB Security Device

If you haven't already, plug the USB Security Key (the small USB "plug" supplied with Dynomation) into an available USB port on your computer. This key is licensed to you, the purchaser of this software, and will allow you to run DynomationTwoStroke on any of your computer systems. You are licensed to install Dynomation on as many computers as you wish, however, Dynomation will only run on one system at a time; the computer that has the Security Key installed in a USB port.

Note: If you do not have an available USB port (your computer must have at least one USB port to use Dynomation), you can install a USB Card or Hub to extend the number of available USB ports. The Dynomation Security Key normally will function properly in both direct USB ports and in ports on a USB Hub.

Solving USB Security Key Issues

If Dynomation displays an error message that the HASP Security Key is missing, here are some quick steps you can follow to isolate and correct this issue:

a) Make sure the Security Key is, in fact, properly connected to a functioning USB port on your computer or has been plugged in a USB hub that is connected to your computer. Normally, when the Security Key is properly installed and the device driver has been recognized, a red LED will illuminate in the Key.

b) If you plugged the Key to a hub (rather than into a USB port on the computer), try connecting it directly to a port on your computer system.

c) Make sure your USB port is functioning correctly by disconnecting all other USB devices from your system. Then reconnect the Security Key (try a port you haven't used). If that works, try a different USB device in the port that did not work to confirm that the port is defective.

d) Try reinstalling the Security Key drivers. Open the Windows Start menu, select Motion Software Simulations, DynomationTwoStroke, and select either the Windows98 or WindowsXP HASP Driver Installer. Make sure you RESTART your computer after the driver installation to properly register the new driver with Windows.

e) If your computer experiences technical difficulties, such as non-functional devices, spontaneous rebooting, numerous error messages, etc., the device drivers for our Security Key may not properly install on your system. You must have a "stable" computer system and a "clean," virus-free Windows installation to properly use DynomationTwoStroke.

f) Try installing DynomationTwoStroke and the Security Key on a secondary computer system to determine if your primary computer is at fault.

Starting DynomationTwoStroke

To start DynomationTwoStroke, open the Windows Start menu, select All Programs, then choose Motion Software Simulations, DynomationTwoStroke, and finally click on the DynomationTwoStroke icon displayed in that folder (alternatively, you can double-click the DynomationTwoStroke program icon that was installed on your Desktop). Accept the "Y" option to use the existing .CFG configuration file. The program will then display the Main Menu Screen (see *Quick Program Walkthrough* on page 11 for a brief tutorial on using DynomationTwoStroke).

Viewing The User Manual

To view this DynomationTwoStroke User Manual, open the Windows Start menu, select All Programs, then choose Motion Software Simulations, DynomationTwoStroke, and finally click on the ***DynomationTwoStroke User Manual*** icon displayed in that folder (alternatively, you can double-click the ***DynomationTwoStroke User Manual*** program icon that was installed on your Desktop). If the user manual does not open properly, install Adobe Reader using one of the installers provided on the program CD (see *Adobe Reader Installers*, below).

Adobe Reader Installers: This **User Guide** requires Adobe Reader (a free on-screen reading tool from Adobe Systems). If you need to install (or re-install) Adobe Reader on your computer, there are Four installers on the DynomationTwoStroke CD. Two are for Windows98 and two are for WindowsXP. Try to install the latest version for your OS; if it displays an error message during installation, revert to the earlier version. Version 5 and 6 are in the AdobeReaderWin98 folder and versions 8 and 9 are in the Adobe ReaderWinXP folder.

USB Security Key Issues: If Dynomation displays an error message indicating that the Security Key (HASP) is missing or cannot be found, refer to the previous section for help. If you cannot find a solution, contact Motion Software Technical Support: **support@motionsoftware.com**.

Getting The Latest Program Code

You can check Motion Software's website to obtain the most up-to-date program code. Refer to the SUPPORT page at: **www.motionsoftware.com**.

Un-Install DynomationTwoStroke

You can un-install DynomationTwoStroke by either:

For Windows98: Use the program-removal feature in Windows98 (*Windows Start, Settings, Control Panel, Add or Remove Programs*).

For WinXP: Use the program-removal feature in WindowsXP (*Windows Start, Control Panel, Add or Remove Programs*) **or** use the Un-Installer placed in the Dynomation folder (*Windows Start, All Programs, Motion Software Simulations, Dynomation TwoStroke*, and finally click on the *DynomationTwoUnInstall* icon).

Solving Installation And Operational Problems

You can obtain technical support and program updates by visiting (www.MotionSoftware.com) or by opening the Start menu, select Programs, Motion Software, Inc., Dynomation Engine Sim, then click on the Tech Support Website. Contact our Tech Support staff by sending an e-mail to **support@motionsoftware.com**.

If you experience problems installing or using Dynomation, please review the information presented in this Users Manual and check online for program updates (www.MotionSoftware.com). If you cannot find a solution, contact Motion Software Technical Support: **support@motionsoftware.com**.

Send any mail correspondence to:

Motion Software, Inc.
222 South Raspberry Lane
Anaheim, CA 92808-2268

Other contact information:

Voice Line: 714-231-3801
Web: www.MotionSoftware.com
Tech Support (Preferred Contact Method) Email: support@motionsoftware.com
Tech Support Fax: 714-974-5389
Tech Support Email: support@motionsoftware.com

E-mail is the best way to reach DynomationTwoStroke tech support quickly. Always attach any **.DY2** and **.SM2** engine and simulation files that may help diagnose the problem. Include a thorough explanation of the issue (then review your explanation to make sure we will understand the details).

DYNOMATION ENGINE SIMULATION

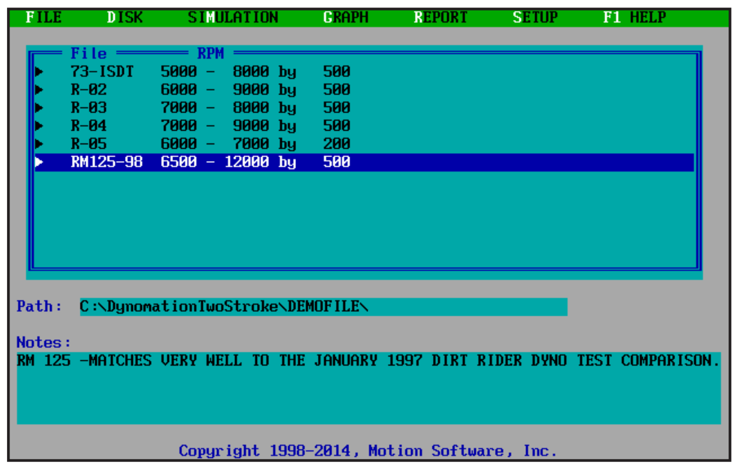
Professional Wave-Action Simulation

Program QuickStart

DynomationTwoStroke Walkthrough

After you have installed and started DynomationTwoStroke (see previous chapter), you can begin to use the program to simulate power output and other characteristics of two-stroke engines. The following steps provide a quick walkthrough of program features, functionality, and results.

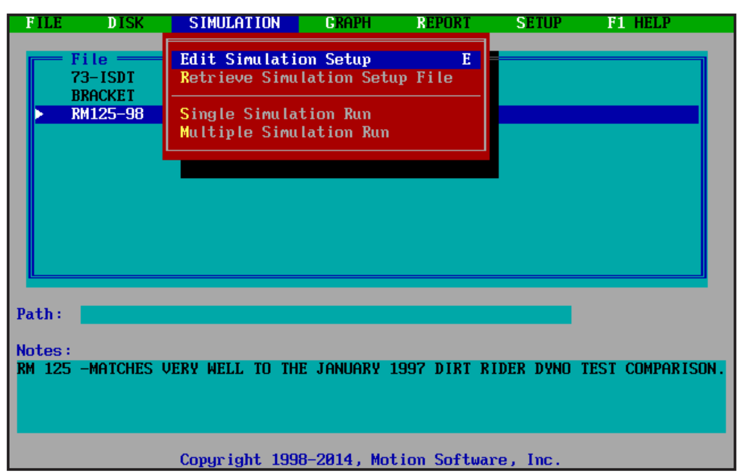
First, refer to the Main Menu Screen (photo on right). Here the following menu options are presented at the top of the screen: **FILE, DISK, SIMULATION, GRAPH, REPORT, SETUP,** and **F1 HELP**. To begin this program walkthrough, use the **M** keyboard key to open the **SIMULATION** menu (shown in the lower, right photo). The menu provides four selections: **Edit, Retrieve, Single,** and **Multiple**. The Edit selection allows you to modify engine component data for the currently-loaded engine file (a .DY2 file containing engine component specs). The Retrieve selection loads a previously saved engine component file into the simulation.



The *Main Menu Screen* includes all program drop-down menus along the top of the screen (FILE, DISK, SIMULATION, GRAPH, REPORT, SETUP, and F1 HELP). The large "window" below the menus displays the currently loaded .SM2 (Sim-Data Run Files).

IMPORTANT NOTE: There are three main file types used in DynomationTwoStroke. Becoming familiar with these file types is essential to efficiently using this program:

1) **Engine Component Specs File (.DY2):** Contain all component specifications for the currently selected engine (e.g., bore, stroke, port specs, etc.). **.DY2** files are usually given the name of the engine (e.g., MyEngine.DY2), and are created and saved when you exit the component **Edit** screens displayed from the SIMULATION menu (more on this later).



The SIMULATION menu is opened by pressing the "M" keyboard key. The choices in this menu allow loading and editing engine specification files (.DY2) and beginning a simulation run.

2) **Sim-Data Run File (.SM2):** Contain the results of a completed simulation run. .SM2 file names match the engine name used in the .DY2 files (e.g., MyEngine.SM2) and must be present and complete before the program will display simulation results

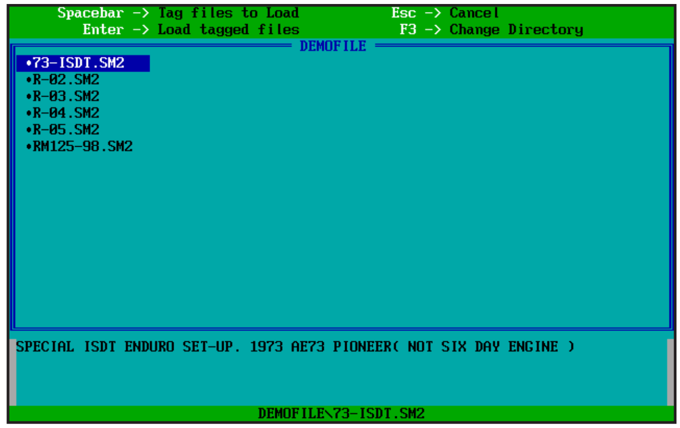
in graphs or printouts. .SM2 files are automatically generated and saved by DynomationTwoStroke after each successfully completed simulation run.

3) **Program Configuration File (.CFG):** This file type is used by DynomationTwoStroke to store current program "defaults," such as the list of engine results files displayed in the File List on the Main Program Screen, all program settings from the SETUP menu, and other program configurations. The .CFG files can, for example, return DynomationTwoStroke to the same configuration it had at the end of your current work session, making it easy to continue your development where you "left off." Program .CFG files are covered in more detail in **USING DYNOMATION** on page 15.

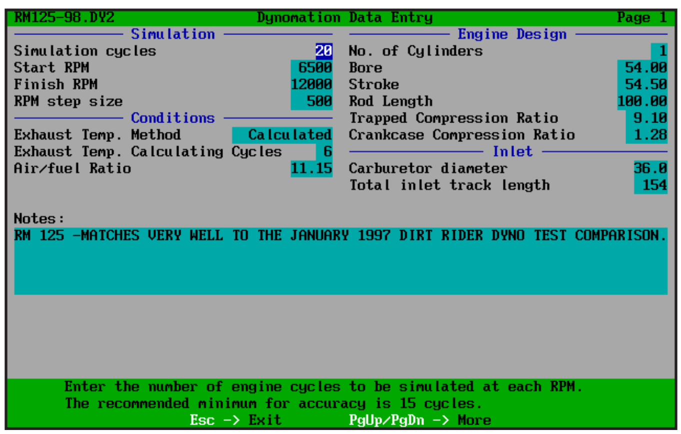
Continue the program walkthrough by retrieving the existing **Rm125-98.DY2** engine file supplied with DynomationTwoStroke. With the SIMULATION menu open, use the **R** keyboard key, to activate the **Retrieve** function. This opens a file dialog box (see photo, right). Use the cursor arrow keys to highlight the RM125-98.DY2 file, then press **Enter** to load the file into the simulation. **NOTE:** If you don't see the RM125-98.DY2 engine file in the File List, you are looking in the wrong directory. Press **F3** and choose the **DEMOFILE** directory from the list. Then press **Esc** (the **Escape** key) to return the Main Screen. Re-select the **SIMULATION** menu, press the **R** key, and select and open the RM125-98.DY2 file.

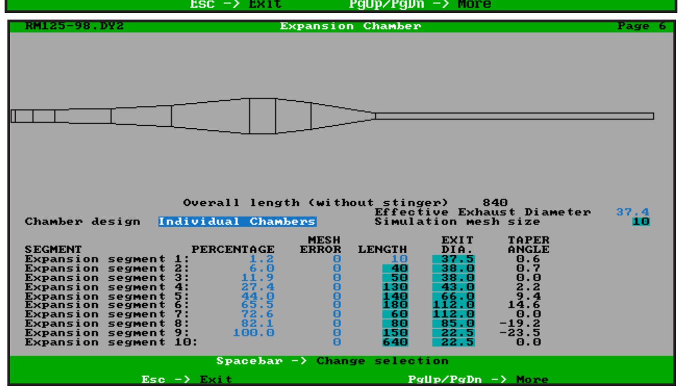
After you have loaded the engine file, use the **E** key (with the SIMULATION menu open) to Edit and view engine specs (use the **Up**, **Down**, **Left** and **Right Cursor Arrow** keys to move through component fields). You can select and change any of the engine data fields on any of the nine data pages (you may have access to less than nine screens, since only the screens that address specific components used on the current engine will be displayed). Move to the next data screen by pressing the **PageDown** keyboard key. When you are finished viewing or editing engine component data, press the **Esc** (Escape) key. If you have changed any engine specification, you will receive a prompt for a new filename; you can keep the existing name and OVERWRITE the previous file, or you can use a new filename and store the modified engine data in the program directory (in the new .DY2 engine file), or simply choose **No** to exit without saving changes..

The **Single** selection from the lower portion of the SIMULATION menu begins a simulation run for the currently loaded engine configuration file (i.e., using the current .DY2 file data). The Multiple selection allows the user to queue several engine simulations and automatically run all of them in "batch" mode (more on this in the next chapter).

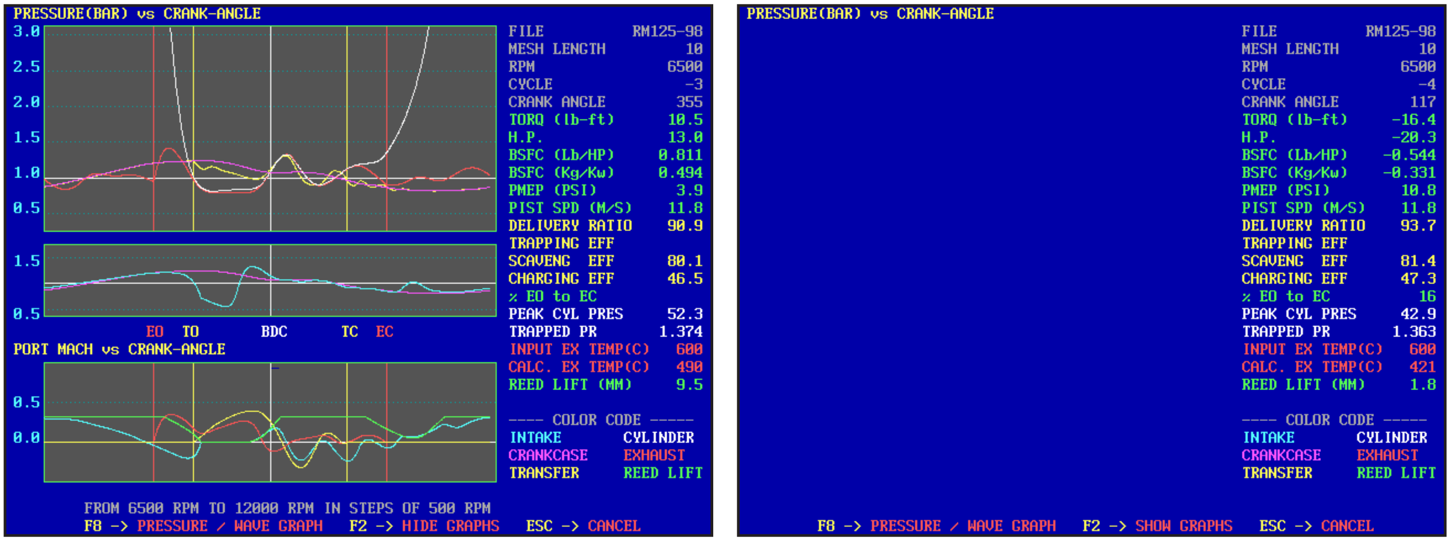


The file-open dialog presents a list of engine configuration files (.DY2) located in the DEMOFILE directory (in this case, it's the C:\DynomationTwoStroke\DEMOFILE directory. Highlight the RM125-98.DY2 file using the cursor arrow keys and press Enter to load that file into the simulation.





Two of the possible nine engine component entry and editing screens are shown here (available from the SIMULATION menu Edit selection. Only the screens that address specific components used on the current engine will be displayed. When you press *Esc* to leave the data entry screens, new entries or changes to components will produce a prompt for a new filename (or permission to overwrite the existing .DY2 engine component file).



The *Simulation Calculation Screen* shows intermediate results of the simulation in both tables and graphs. The complete display is shown on the left; the right screen has the graphs "hidden" to optimize calculation time (by pressing the *F2* Function key). Current simulation status is shown at the top of the screen, in the Gray table. The Green table values are the current values of calculated power, torque, fuel usage, and other primary simulation values. Additional secondary calculated values are shown in the Yellow table, and pressures are shown in White. At the bottom of the table is a color key for the graph data lines. The top graph shows cylinder, exhaust, crankcase, and transfer pressures. The center graph shows a comparison of intake and crankcase pressures. And the bottom graph is a particle-velocity display of intake, exhaust, and transfer flows. In addition, the green data line indicates reed lift (on engines with reed valve induction).

Begin the engine simulation for the Rm125-98 engine by selecting **Single Simulation Run** from the SIMULATION menu (or press the **S** key while the SIMULATION menu open).

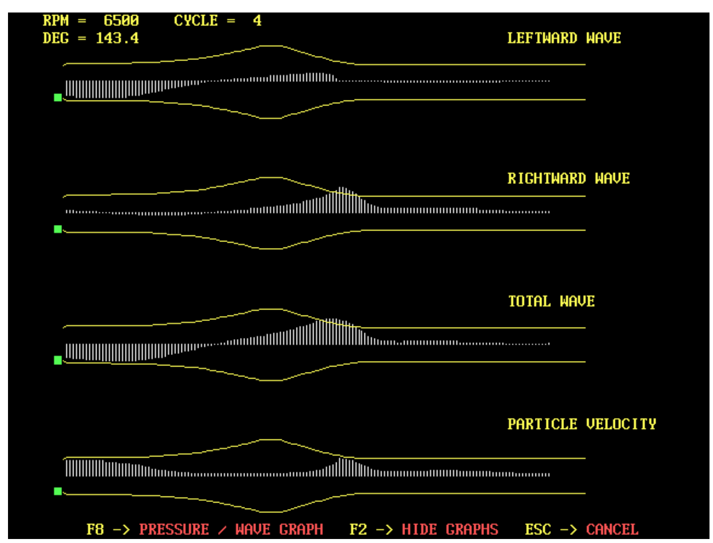
Simulation Calculation Screen

During the simulation run, a Calculation Screen will open and display the intermediate results and overall progress of the engine simulation. The accompanying photos illustrate the extensive data provided during the simulation process. Tables show simulation status, calculated values, and the pressures and flow values inside the engine. As the simulation begins, during negative (or low-value) cycle counts, the initial values of temperature, pressure, and flow are calculated. Then, as the cycle count enters the positive phase, the simulation uses these initial values to zero in on the actual power values produced at each rpm point.

"Live" Pressure-Wave Calculation Display

If you press the **F8** Function key during a simulation, the display will switch to a "live" view of the pressure waves traveling in the exhaust system. The exhaust port/valve opening and closing is indicated by the green "bar" at the left of the tubes. The Leftward, Rightward, and Total (Superposition) waves are all shown. Plus, the lower graphic shows the overall particle velocity in the system. This display is much more than just fascinating to watch; it can provide a real insight into, otherwise invisible, pressure-wave influences in these passages.

If you press the **F2** Function key, active graphics are blanked, speeding up the simulation to optimize calculation times. In addition, you can stop/pause the simulation at any time by pressing the **Esc** key. This gives you opportunity to study data intermediate val-

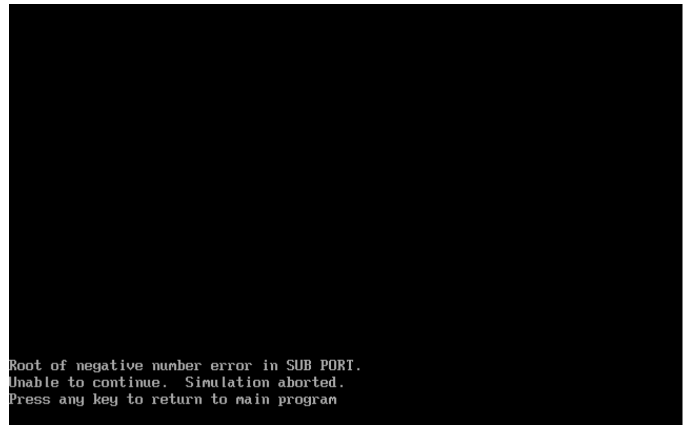


By pressing the *F8* Function key, the *Simulation Calculation Screen* switches to a "live" view of exhaust pressure waves in the expansion chamber and exhaust tubing. This display is more than just fascinating to watch, it can provide a real insight into, otherwise invisible, pressure-wave influences in these passages.

ues at that point in the simulation process. Resume the simulation by pressing the **Esc** key (or any other key). Terminate the simulation from the Pause screen by pressing the **F10** key.

Simulation Calculation Errors

During the simulation, incorrect data values for engine components may not cause an error immediately (or, sometimes, at all). Usually, incorrect values used in the simulation tend to "percolate" through the equations until their values are magnified to such a degree that they cause a math error and put a halt to the simulation process. At this point, it is almost impossible to work backwards through the (sometimes millions of) calculations to find out where the error entered the process. The simulation can only display a message indicating what type of fatal error occurred (see photo). The best way to respond to a error of this type is to carefully review all data values entered in the Engine Component Screens (select Edit from the SIMULATION menu). If you cannot find an error, try reviewing other engines that use similar component combinations to see where the current setup is substantially different.



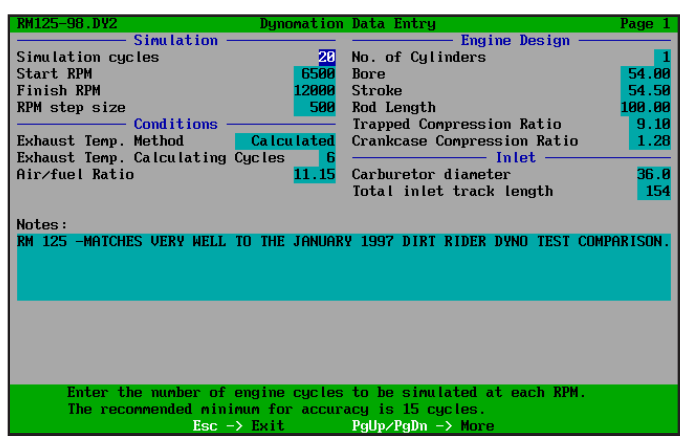
If a simulation error occurs, typically from a component value that drives the sim to an error condition (such as incorrect Rotary Valve Port timing, etc.), the simulation will halt and display an error message. If this happens, carefully check your engine specification values.

Simulation Calculation Times

Simulation calculation times are directly related to the following variables:

1) **Processor System Clock Speed.** The faster your CPU, the faster DynomationTwoStroke will run.
2) **The Number of RPM Points** in the calculated simulation sweep, which is determined by the equation: **(Finish RPM - Start RPM) / Step RPM**
   The more rpm points calculated, the greater the simulation time required. Try using a 1000- or even 2000-RPM steps for initial testing of a new combination. If it looks promising, reduce the step value to 500 or even lower to obtain the highest accuracy.
3) **The Number of Simulation Cycles.** A "cycle" is the single, complete calculation of engine performance at one rpm point. Multiple, repeating cycles allow a simulation to use initial values calculated in previous cycles to begin the next cycle calculation. This process is repeated until the start values stabilize; this is called convergence. The recommended number of cycles for DynomationTwoStroke is 20 for typical engines. However, for initial testing you might consider using 10 cycles to more quickly work through various combinations.
4) **The Simulation Mesh Size.** DynomationTwoStroke was calibrated with a Mesh Size of 10. To maintain the highest accuracy, do not change this value.
5) **The System Graphics Overhead.** The Graphics Overhead is the amount of time it take your computer to display the graph lines on the Calculation Screen as the simulation is running. If you press the **F2** key, the graphs will be blanked, speeding up the simulation process (the amount of speed increase is system dependant).

By adjusting these speed-dependant variables in your favor, you should be able to obtain simulations of initial engine setups in 5 minutes or less. Optimum accuracy for well worked out combinations may take 3 to 5 times longer.



The Simulation Cycles, Start RPM, Stop RPM, and Step RPM have the greatest affect on simulation calculation times. Use fewer steps and cycles for "rough" engine approximations. Then zero-in on a final combination with more steps and cycles for higher accuracy.

DYNOMATION ENGINE SIMULATION — Professional Wave-Action Simulation

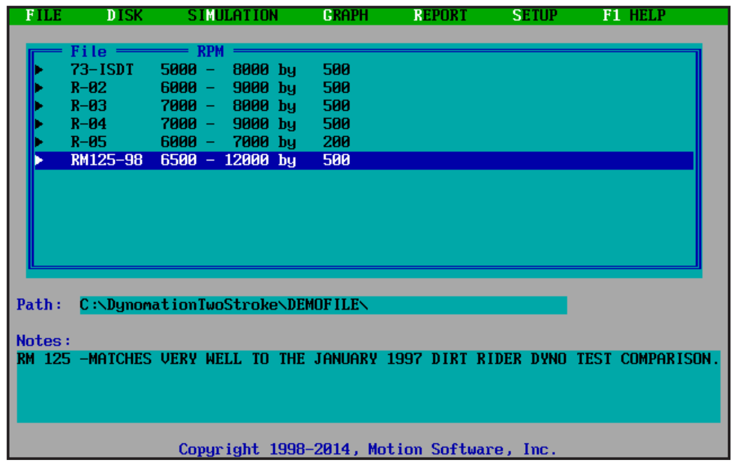
USING DYNOMATION

Using Program Features And Working With DynomationTwoStroke Files

Main Program Screen Details

The Main Menu Screen includes the following features:

1) Program *Drop-Down Menus* Are Located Along Top Of Screen
2) *File List Box* (large box that displays .SM2, Simulation Results Data Files)
3) *File Path* Indicator
4) *Notes* Related To Highlighted .SM2 File

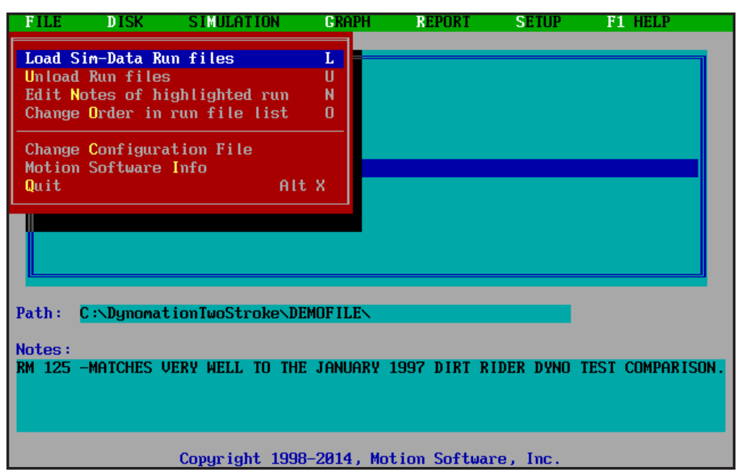


Seven drop-down menus are provided along the top of the Main Program Screen (FILE, DISK, SIMULATION, GRAPH, REPORT, SETUP, and F1 HELP). The large *File List* "window" displays the currently loaded .SM2 files (Sim-Data Run Results files). Below that is the *Path* field that indicates the directory path of any file highlighted in the File List. If there are user notes associated with a highlighted file, they will be displayed in the *Notes* field.

Program Drop-Down Menus

DynomationTwoStroke main functions are activated by seven function menus located at the top of the Main Program Screen: **<u>F</u>ILE, <u>D</u>ISK, SI<u>M</u>ULATION, <u>G</u>RAPH, <u>R</u>EPORT, <u>S</u>ETUP,** and **<u>F1</u> HELP**. To activate any of these menus, use the keyboard "hot-key" letters **<u>F</u>** (for <u>F</u>ile), **<u>D</u>** (for <u>D</u>isk), **<u>M</u>** (for Si<u>m</u>ulation), **<u>G</u>** (for <u>G</u>raph), **<u>R</u>** for (<u>R</u>eport), **<u>S</u>** (for <u>S</u>etup), or **F1** for Help.

—FILE Menu: The **FILE** menu includes choices for <u>L</u>oading and <u>U</u>nloading Sim-Data Run files (an .SM2 file type containing simulation results). In addition, you can use the **FILE** menu to modify or add <u>N</u>otes to any file, change the Simulation Run-File <u>O</u>rder in the File List box, change the **C**onfiguration file currently used by the simulation (.CFG files store program Setup and File List defaults), display **I**nformation about Motion Software, Inc., and begin the program <u>Q</u>UIT function.



The FILE menu includes choices for Loading and Unloading Sim-Data Run files (.SM2 file type). In addition, you can modify or add Notes to any file, change the Simulation Run File order, change the .CFG Configuration file (which stores Setup and File List defaults), display information about Motion Software, Inc., and initiate a program QUIT.

Loading .SM2 Sim-Data Run Files: The **File List** in the middle of the Main Program Screen displays

DynomationTwoStroke simulation results files (Sim-Data files, having the .SM2 file type). Generally, files must be Loaded into this list from a disk directory to be Graphed or Printed by the simulation (please note that these files are RESULTS files, not engine COMPONENT files...component files have .DY2 extension and will be discussed later). Simulation Results files can only be successfully loaded when the results they contain are valid (requiring a fully completed simulation run). Highlighting a file in this list (with the cursor arrow keys) directs the simulation to use the data in that file for the generation of all subsequent Results GRAPHs and Print REPORTs.

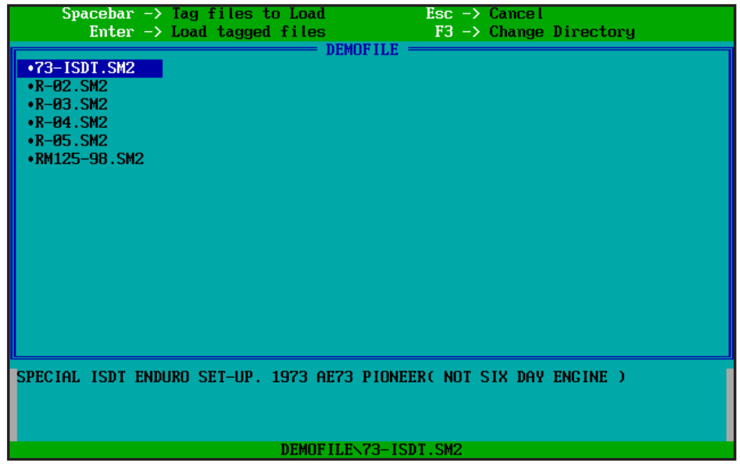
When you use the Load choice from the FILE menu, you are presented with a list of .SY2 data files in the current directory (that's the directory last used to load files...its reference was stored in the .CFG file saved during program shutdown, or Quit). Files that already have been loaded into the File List on the Main Program Screen will have a dot next to them. Specific information about each highlighted file is displayed at the bottom of this dialog box (good place to look to ensure that the file contains valid data and can be successfully loaded).

NOTE-1: To display files from a different directory press **F3**. DynomationTwoStroke will display a list of program directories. Choose a directory by pressing the letter next to it, or by highlighting it and pressing **Enter**. You can modify any of the directory names in this list (***use UPPER CASE only; names must be no longer an Eight characters and must follow standard DOS conventions for file/directory names***). For more information on DOS paths and directory names, consult a DOS user guide.

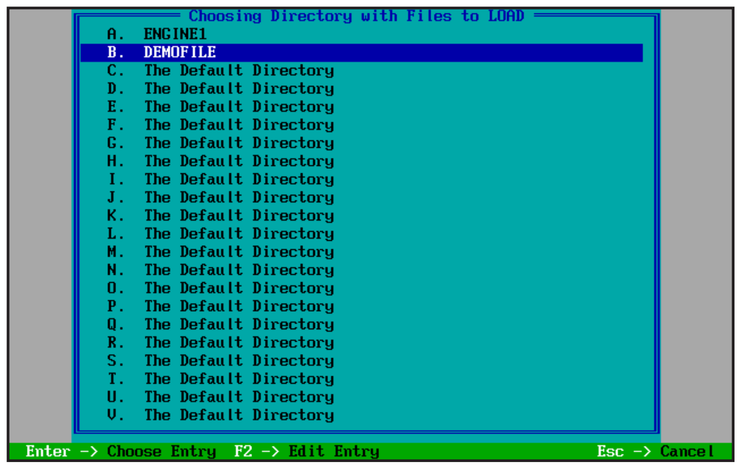
NOTE-2: If you enter a directory name that is not legitimate or you just wish to close the directory list, use the **Cursor Arrow** and **Delete** keys to blank the entire name. Then press **Esc** to close the list; the modified-then-blanked directory entry will remain unchanged.

Unloading .SM2 Sim-Data Run Files: To Unload a simulation data file from the File List, use the Unload menu choice in the **FILE** menu. Highlight the file you wish to unload, then press the **Spacebar** to place the unload tag next to the item name. Press **Enter** to complete the unload of all tagged items.

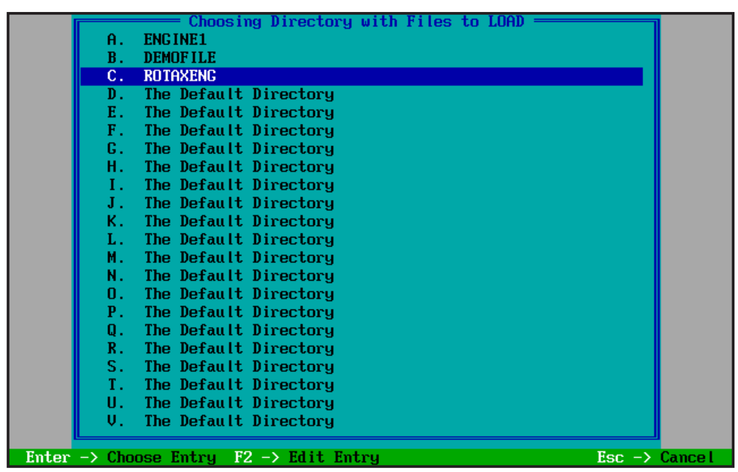
NOTE: If you use Windows Explorer to create, rename, and delete directories, Dynomation TwoStroke will not automatically include those direc-



When you use *Load* from the FILE menu, you are presented with a list of .SY2 data files in the current directory (that's the directory last used to load files...its reference was stored in the .CFG file saved at the last program Quit). Highlight a file and press *Enter* to add it to the Main Screen File List. Press F3 to change the current directory.

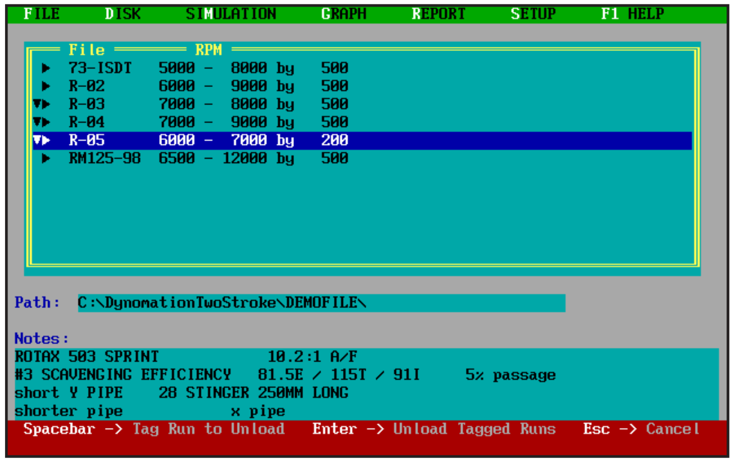


To display files from a different directory press F3 (from the screen shown in the top photo). A list of possible directories will be provided. Choose a directory by pressing the letter next to it, or by highlighting it and pressing *Enter*. You can directly modify any of the directory names in this list. Make sure to use standard DOS directory name conventions.



Modify any of the directory names in the list to "add" a new directory reference. If you would like to close this dialog in the middle of entering a name, use the *Arrow* and *Delete* keys to blank the field, then press *Escape* to close the dialog, leaving the field unchanged.

tory changes in the program directory list. Providing you have used standard DOS format names (while using Windows File Explorer), you can include these changes in the program directory list by selecting Load or Unload from the **FILE** menu (to gain access to the program directory list) and then modify the program list to match your directory changes. You can also access the Directory List from the SETUP menu.



To Unload Sim-Data Run (.SM2) files from the File List on the Main Program Screen, use the Unload menu choice from the FILE menu. Highlight the file you wish to unload, then press the Spacebar to place the unload tag next to the item name. Press Enter to Unload all tagged items.

Re-Ordering Sim-Data Run Files: To change the order of the .SY2 Sim-Data Run files shown in the Main Screen **File List**, select **Change Order** from the **FILE** menu (make sure you press **O** for **O**rder, not **C** for **C**hange...**C** will load the Change **C**onfiguration dialog instead). After you activate the Change Order function, follow these simple steps to move the location of .SM2 Sim-Data Run files in the File List:

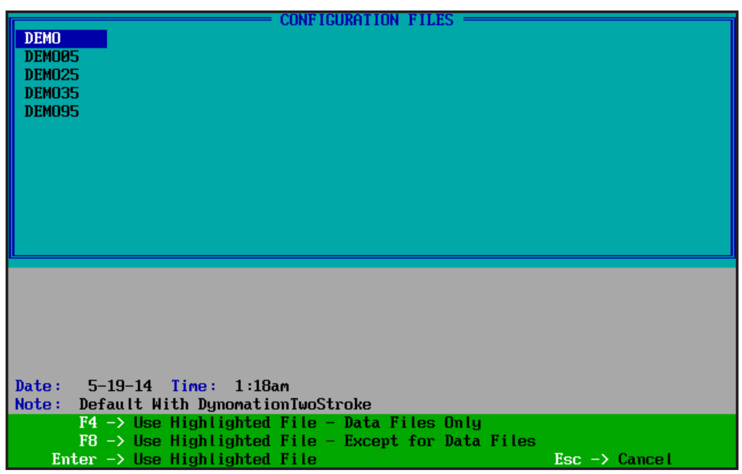
1) Highlight a file you would like to move and press **Enter** or the **Spacebar**. The simulation .SM2 file will begin blinking.
2. Move the highlight to the location where you would like the file to appear and press **Enter** or the **Spacebar**. The simulation file will move to the new position in the File List.

NOTE-1: Changing the order of the Sim-Data Run files in the File List is a purely aesthetic effect; it has no affect on the way the simulation performs any operations.
NOTE-2: To change the order that .DY2 Engine Component files are executed in a Batch-Mode simulation run, see the **Multiple** selection from the **SIMULATION** menu discussed later in this chapter.

Edit Notes For Sim-Data Run Files: To add or modify the **Notes** associated with any .SY2 Sim-Data Run files shown in the Main Screen File List, select Edit **Notes** from the **FILE** menu (make sure you press **N** for **N**otes, not **E** for **E**dit). This will move the cursor to the first character of the Notes field at the bottom of the Main Program Screen. Use the cursor arrow keys and the Delete key to modify or add information to the Notes about the simulation run file. Typical information included in **Notes** are some of the critical engine components used during the test. This is quite useful since file **Notes** are displayed on the Main Program Screen and in file-access dialog boxes, they help you identify the characteristics of previous simulation runs BEFORE you load the file.

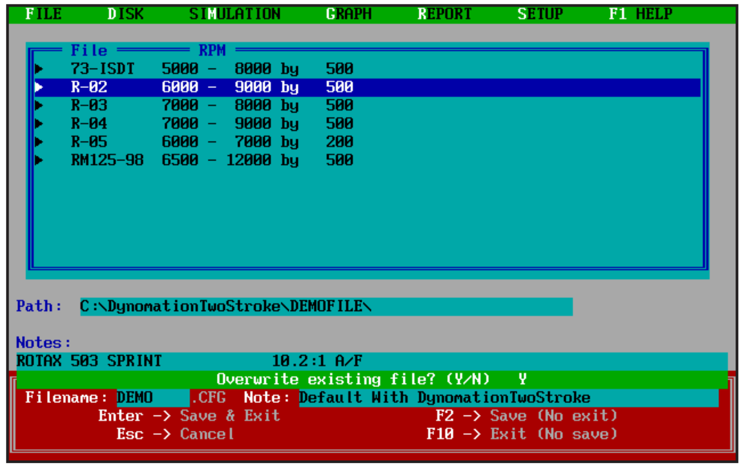
Changing Configuration Files: Program settings and functional aspects of the program (for example names of Sim-Data files open in the File List, the Report type last used, etc.) are stored in program Configuration file(s) that have the .CFG extension. Normally you update the current configuration file when you quit Dynomation (see **QUIT** The Program, below). Experienced DynomationTwoStroke users may find it helpful to have several configuration files, each with its own unique program setups and file lists that best suit the testing of specific engine groups.

You may change configuration files in the middle of a DynomationTwoStroke session by selecting **Change Configuration** from the **FILE** menu. First highlight the configuration file that you wish to



Change configuration files in the middle of a simulation session by selecting Change Configuration from the FILE menu. Highlight the configuration file that you wish to import. Import ALL of the data within the highlighted (.CFG) file by pressing *Enter*. Alternatively, you can press *F4* to only import .SY2 Sim-Data Run file references. Press *F8*, to import all of the new program configuration file data, EXCEPT for the .SY2 Sim-Data Run file references.

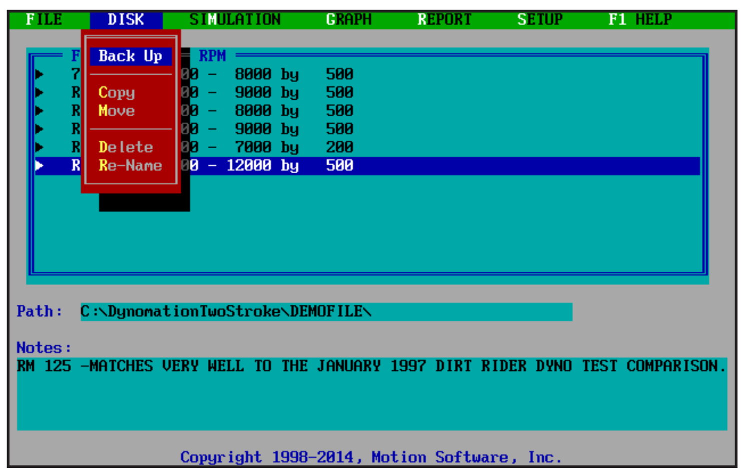
import. You have the option of accepting ALL of the data within the highlighted (.CFG) file by pressing **Enter**. Alternatively, you can press **F4** instead, and only the .SY2 Sim-Data Run file references will be loading into the current configuration. And if you press **F8**, all of the program configuration file data, EXCEPT for the (.SY2) Sim-Data Run file references will be loaded into the current configuration. **NOTE:** Program Configuration files are always located in the Main Program Directory on your hard drive (***C:\DynomationTwoStroke***).



When you Quit DynomationTwoStroke, you will be asked to save (or re-save) the Configuration file. Typically, to later return to DynomationTwoStroke in the same configuration as it was at the end of your current work session, you would accept YES to this prompt. If you prefer to return to the program as it was when you last started it, choose NO or Change the name of the configuration file to retain both the previous and current configurations.

QUIT The Program: To begin the shutdown sequence for DynomationTwoStroke, select **Quit** from the **FILE** menu. Quit can also be invoked directly from the Main Program Screen (without opening the FILE menu) by using the **Q** keyboard shortcut key. **NOTE:** When you Quit DynomationTwoStroke, you will be asked to save (or re-save) the Configuration file for the current simulation setup. Typically, if you wish to return to DynomationTwoStroke in the future using the same configuration, you would accept **YES** at this prompt. If you made changes to the way the program functions, such as changing the number of files displayed in the File List, or RPM ranges for the Results Graphs, etc., and you do NOT wish to SAVE these changes, you can either choose **NO** or Change the name of the configuration file to retain both the previous and current program configurations.

—DISK Menu: The DISK menu includes choices for **Backing Up** your current data files, Copying, Moving, Deleting, and Re-naming Sim-Data Run files (.SM2) and Engine Specification files (.DY2). Before we cover the details of these menu functions, here is a quick review of the three types of files used by DynomationTwoStroke.



The DISK menu includes choices for Copying, Moving, Deleting, and Renaming Sim-Data Run files (.SM2) and Engine Specification files (.DY2). You can also do these operations directly in Windows, but remember to abide by standard DOS filename conventions. Filenames that do not follow these naming rules will not be readable by DynomationTwoStroke.

DynomationTwoStroke Files (.SM2, .DY2, and .CFG file types)

1) **Engine Component Specification File (.DY2):** Contain all component specifications for the currently selected engine (e.g., bore, stroke, port specs, etc.). **.DY2** files are usually given the name of the engine (e.g., MyEngine.DY2), and are *automatically created and saved* when you exit the component Edit screens available in the SIMULATION menu (more on this later).

2) **Sim-Data Run File (.SM2):** Contain the results of a completed simulation run. .SM2 file names match the engine name used in the .DY2 engine-component file (e.g., MyEngine.SM2) and must be complete and valid before the program will display simulation results in graphs or printouts. *.SM2 files are automatically generated and saved* after each successful simulation run. The File List located on the Main Program Screen lists valid .SM2 files that have been Loaded through the FILE menu.

3) **Program Configuration File (.CFG):** This file type is used by DynomationTwoStroke to store current program "defaults," such as the specific Sim-Data files displayed in the File List on the Main Program Screen, all program settings from the SETUP menu, Results Graph settings, and other program configurations. These files are created/saved when you **Quit** DynomationTwoStroke. Just before the program exits, you will be asked to save (or re-save) the current Configuration file. Typically you would accept **YES** at this prompt. .CFG files can be used to return DynomationTwoStroke to the same configuration it had at the end of your previous work session. This can make it easier to continue your development work exactly where you "left off."

Using The DISK Menu

Open the **DISK** from the Main Program Screen by pressing the **D** keyboard shortcut key. Use this menu to: 1) Create and Remove directories, 2) Copy, Move, Delete, and Rename files, 3) and to perform Backups. To choose an action from the menu, press the corresponding keyboard shortcut key or move the highlight to the desired menu item and press **Enter**.

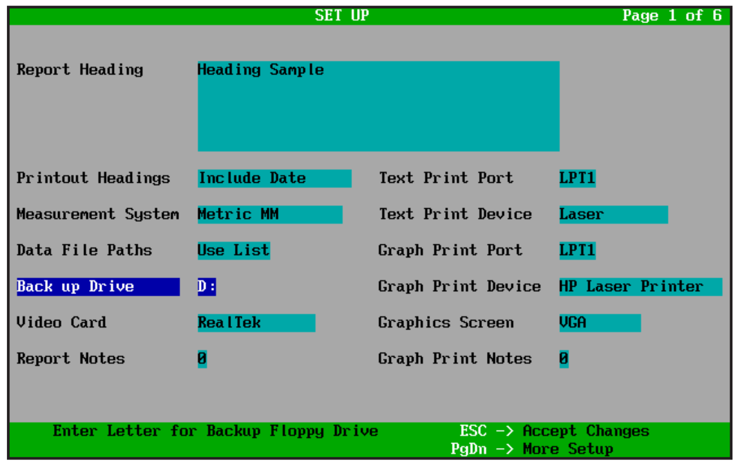
NOTE-1: All disk and file operations performed in the **DISK** menu (and elsewhere in DynomationTwoStroke) will only work properly with files and directories that have been named using standard DOS filename and directory name conventions (a maximum of eight letters/numbers with no special characters). The only exception to this is the DynomationTwoStroke MAIN directory (C:\DynomationTwoStroke).

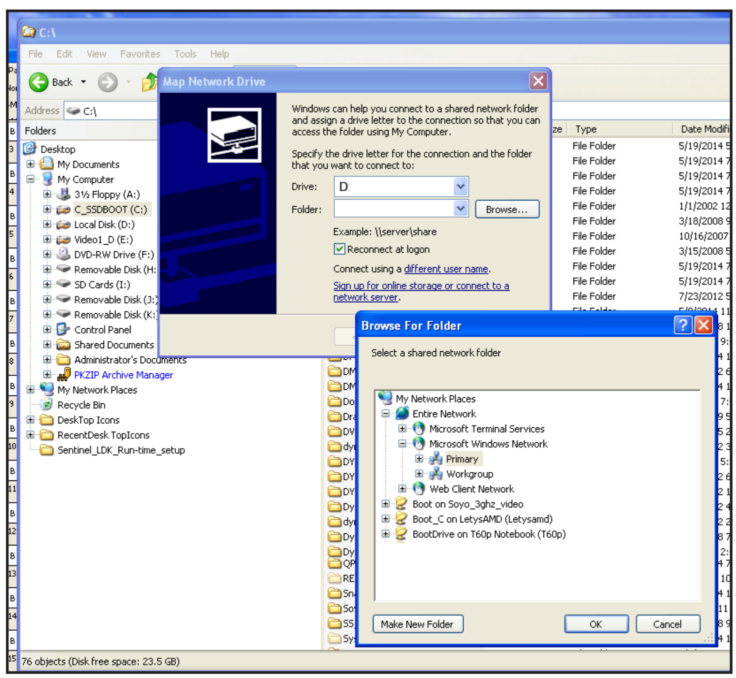
Backing Up Your Data Files: **Back Up** performs an incremental or complete backup of files located in C:\DynomationTwoStroke on your hard disk (**Note:** an incremental backup only writes files to your backup storage device that are new or have changed since the last backup was performed).

Files backed up by this function **MUST** be located in the C:\DynomationTwoStroke directory and/or any of its sub-directories. Set a pointer to your backup storage drive using the **SETUP** menu (the backup device must be assigned a drive letter (A:, B:, C:, D:, E:, and F: are permitted) to be recognized within DynomationTwoStroke). Use the ***Map Network Drive*** function from the **Tools** menu in *Windows Explorer* to link a drive letter to a storage space).

When a backup is performed, files and directories in the program "home" directory are copied to the backup device. Files in subdirectories are placed in same subdirectories in the destination location.

NOTE-1: All files and directories within the C:\DynomationTwoStroke directory that you wish to back up must be named using the standard DOS filename/directory naming conventions (a maximum of eight letters/numbers with no special characters). While these restrictions may be a bit cumbersome, especially considering the advanced backup features in programs available today, you may find that





Specify the backup storage drive using the SETUP menu shown in the top photo (the backup device must be assigned a drive letter, such as D:, E:, F:, etc. in order to be recognized by DynomationTwoStroke). Use the *Map Network Drive* function from the *Tools* menu in Windows Explorer to link the assigned drive letter to a storage space, either local or on your network. WindowsXP screens are shown here.

the humble **Back Up** feature in the program is worth using since it's super fast and a easy to invoke. Anything that can prevent data loss is worth considering.
NOTE-2: As is common with backup programs, DynomationTwoStroke uses the file archive bit to determine if a file has been previously backed up.

Copy Files: The **Copy** function copies files from one directory or disk to another directory or disk. When you choose Copy, DynomationTwoStroke asks you to pick the SOURCE directory (where the files are currently located). (**Note:** you can modify/add to the "recognized" list of directories using the **F2** key.) After you select the SOURCE directory, DynomationTwoStroke displays a list of the SOURCE files found in that directory. Move the highlight to the each file that you wish to Copy and press the **Spacebar** to tag them. To un-tag a file, press the Spacebar again. When you are finished selecting files, press **Enter** to accept the tagged SOURCE files. Dynomation TwoStroke next displays a list of possible DESTINATION directories. When the DESTINATION is selected, press **Enter** to complete the copy process.

Move Files: **Move** files works just like the **Copy** function described above, except the SOURCE files are deleted after they are copied to the DESTINATION.

Delete Files: The **Delete** function lets you delete specific files from a selected directory. When you choose Delete, Dynomation asks you to pick the directory from which you wish to delete files. Chose a directory from the list. (**Note:** you can add to the "recognized" list of directories using the **F2** key.) After you select the directory, DynomationTwoStroke displays a list of the files found in that directory. Move the highlight to the each file that you wish to Delete and press the **Spacebar** to tag them. To un-tag a file, press the Spacebar again. When you are finished selecting files, press **Enter** to delete the files or **Esc**ape to cancel the delete operation.

Rename Files: The **Rename** function lets you rename specific files in a selected directory. When you choose **Rename**, Dynomation displays a list of "recognized" directories. Chose a directory from the list. (**Note:** you can add to the "recognized" list of directories using the **F2** key.) After you select the directory, DynomationTwoStroke displays a list of the files found in that directory. Move the highlight to the files that you wish to Rename and press the **Spacebar** to tag them. To un-tag a file, press the Spacebar again. When you selected the target files, press **Enter** and you will be prompted for new names for each of the tagged files. You can use DOS wild-cards (***** and **?**) in the renaming process. The **?** wildcard means use the letter found in this position from the original filename. The ***** wildcard means use the letters from the original filename from this position to the period delimiter or to the end of the filename. Here are a few examples:

CHEVYBT.FST	renamed as **FORD?.BIG**	becomes **FORDY.BIG**
CHEVYBT. FST	renamed as **FORD*.BIG**	becomes **FORDYBT.BIG**
CHEVYBT.FST	renamed as **FORD***	becomes **FORD.FST**
CHEVYBT.EST	renamed as **FORD.B***	becomes **FORD.BST**
CHEVYBT.FST	renamed as **?OR*.***	becomes **CORVYBT.FST**
CHEVYBT.FST	renamed as ***.BIG**	becomes **CHEVYBT.BIG**

—SIMULATION Menu: Open the **SIMULATION** menu with the **M** keyboard shortcut key. The **SIMULATION** menu includes choices for **Edit, Retrieve, Single,** and **Multiple**. The **E**dit selection lets you to modify engine component data for the currently loaded (**R**etrieved) engine file (this is a .DY2 file containing engine component specs; the name of the file that was retrieved is displayed at the top of each of the Component Edit Screens). The **R**etrieve selection loads a previously saved engine component file (.DY2) into the simulation. Finally, the **S**ingle and **M**ultiple choices instruct the program to begin a simulation run of a single or a "batch" of engine files. Each of these choices are discussed below.

Editing a Simulation Setup: To edit engine component parts and specifications for the currently **R**etrieved .DY2 engine file (the name of the file is displayed at the top of each of the Component Edit Screens), choose

Edit Simulation Setup from the **SIMULATION** menu. Several data entry screens contain the components and specifications for the current engine; use the **PageUp** and **PageDn** keys to view each data screen. Depending on the selections in various data fields, some component values may be blank or “dimmed,” indicating that they are not active for the current engine configuration.

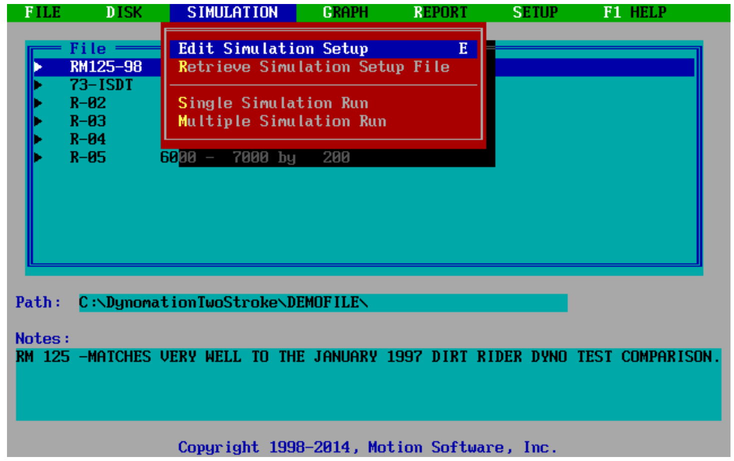
IMPORTANT NOTE: For details about all engine component fields and the numeric results of the simulation, refer to the next chapter, **Simulation *Inputs And Results***.

Retrieve a Simulation Setup: To Retrieve a previously-saved engine component setup file (a .DY2 engine file) choose **Retrieve Simulation Setup File** from the **SIMULATION** menu. Dynomation TwoStroke will display a list of the engine component files located in the directory that was last used to load engine files. If you want to view the contents of a different directory press **F3**. The path of any highlighted .DY2 file will appear at the bottom of the dialog box. If the **File List** Box becomes full, scroll bars will appear to allow horizontal scrolling. To load any highlighted engine file, press **Enter**.

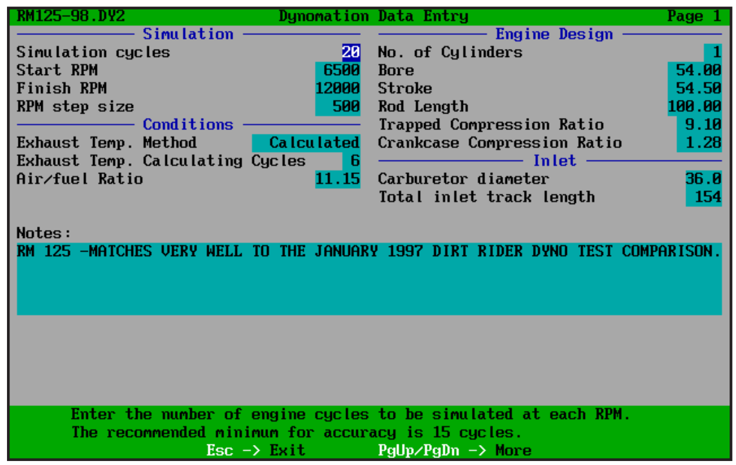
IMPORTANT NOTE: Create A New Engine Simulation File. There is no direct menu selection to create an “empty” .DY2 engine file. Instead, **Retrieve** any existing engine file (a Demo file, for example), and modify at least one component field or specification. When you press **Escape**, Dynomation TwoStroke will recognize that a component field has changed and prompt you to accept the changes and save the existing file or enter a new filename. In this case, enter a new or modified filename that describes the new engine you wish to model. After the new file has been saved, you can **Retrieve** (if is not currently loaded in the simulation) and **Edit** it at any time to further optimize component specifications.

Running A Single Simulation: After you have **Retrieved** a .DY2 engine file, you can choose **Single Simulation Run** from the SIMULATION menu. DynomationTwoStroke will begin a simulation based on the components and specifications provided in the .DY2 file. When the simulation is running, the **Simulation Progress Screen** is displayed.

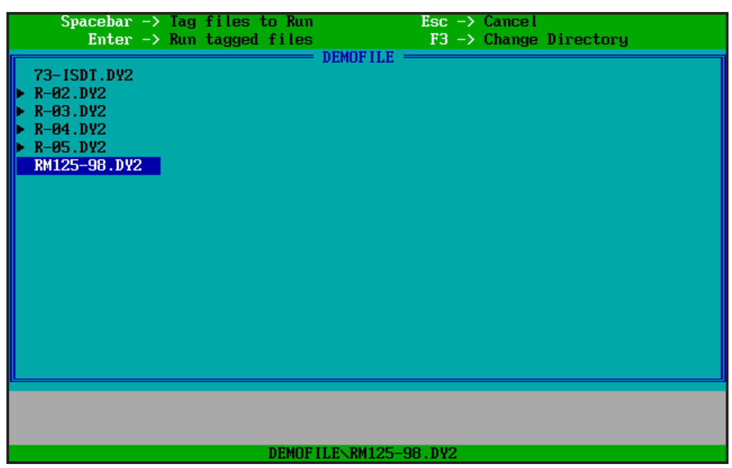
Running Multiple Simulations: If you have several engine configurations (perhaps, each with a slight tweak to a component), you can run them as a batch (while you are away or overnight). Running multiple



To open the SIMULATION menu, use the M keyboard shortcut key. The SIMULATION menu includes choices for Edit, Retrieve, Single, and Multiple. Each of these choices are detailed in the accompanying text.

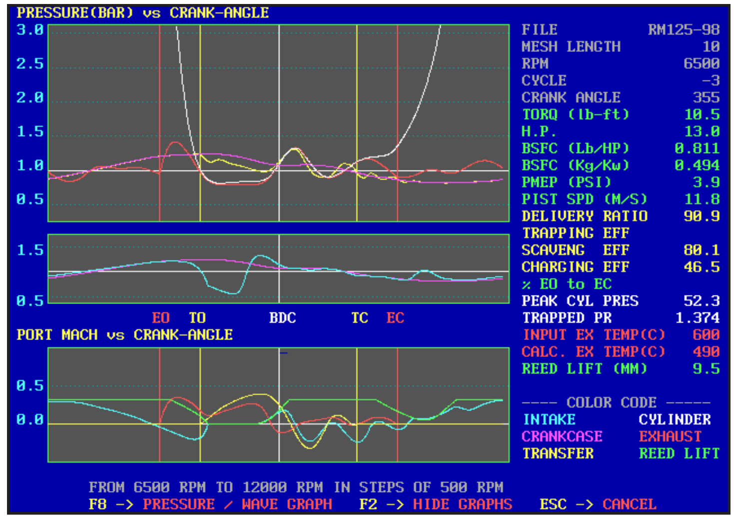


There is no direct way to create an “empty” NEW simulation engine file (.DYN engine component file). Instead, Retrieve any existing engine file and modify at least one component field (like the Simulation Cycles shown above, say from 20 to 22). When you press *Escape*, enter a new filename at the prompt and save the new file.



To run multiple engine simulations in batch-mode, select Multiple from the SIMULATION menu. Tag the files you would like to include in the run (as shown here). Then press Enter to begin the multiple simulation runs. The last 10 completed simulations will be displayed in the File List on the Main Program Screen.

simulations is easy; First <u>E</u>dit each engine component setup you want to evaluate and save each as a separate file (unique .DY2 filename). Place all the engine files in the same directory. Choose **<u>M</u>ultiple Simulation Run** from the SIMULATION menu. A list of the files will appear. If you need to select another directory press **F3**. Specific information on each highlighted file appears at the bottom of the screen. Press the **Spacebar** to tag each file you wish to include in the simulation batch run. To un-tag a file press the **Spacebar** a second time. You may tag up to 100 .DY2 engine files. Press **Enter** to begin the batch simulation run. If no files were tagged when you pressed Enter, a single simulation run will be performed using the currently highlighted engine file. The last ten simulations completed will be displayed in the .SM2 **File List** on the Main Program Screen.

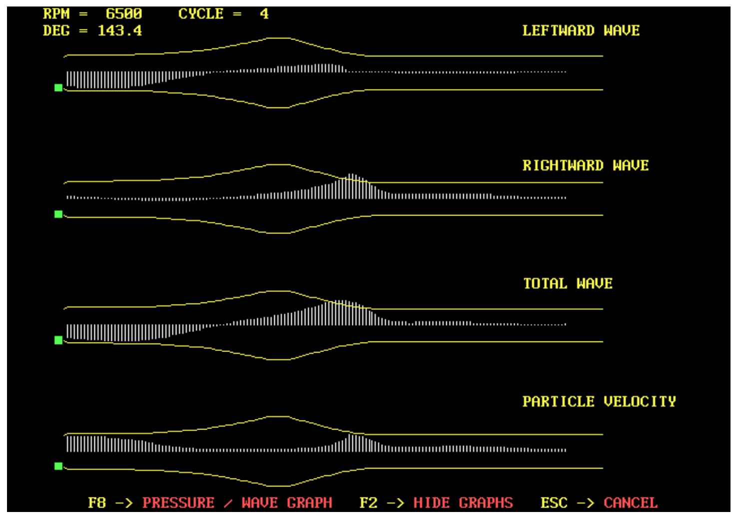


When a simulation is running, a crank-angle Simulation Progress Screen is displayed. Consider this to be your "dashboard" of the running simulation. Current simulation status is displayed in the upper-right, intermediate results are displayed in the graphs and tables. You can also switch to a pressure-wave Simulation Screen (see text and photo below).

The Simulation Progress Screens: When the simulation (calculation) is taking place, one of two **Simulation Progress Screens** can be displayed. Consider these screens to be your "dashboard" of the running sim. Current status is displayed in the upper-right, intermediate results are displayed in the graphs and tables. For additional details about the values being displayed, refer to the next chapter, **Simulation *Inputs And Results***.

The two progress screens are:

- **A <u>Crank-Angle Display</u> Of Particle Speed and Pressures**
- **<u>Pressure-Wave</u> And Particle Flow Display In Exhaust Ducting**

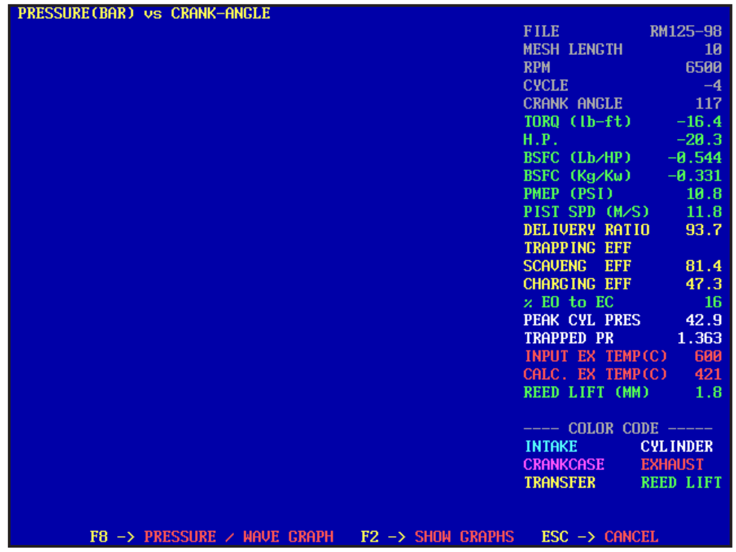


By pressing the F8 key, you can switch the Crank-Angle Display to a Pressure-Wave screen. This screen visualizes the pressure pulses in exhaust ducting, giving you unprecedented access to pressure-wave interactions as the pulses move through varying pipe diameters. The Green indicator shows the status of the exhaust port.

Crank-Angle Progress Display: This is the default display for a running simulation. It consists of three graphs, a table of 21 simulation variables, and a Color Code chart to help interpret the graph data lines. All data and graphs are "live," that is they show intermediate results of the simulation process, allowing you to observe how the simulation reaches convergence and how the data varies for each simulation cycle and at each rpm point. The top two graphs display **Pressures** (in **Bar**) as they vary throughout 360 degrees of crank rotation during which the processes of intake flow, cylinder and crankcase compression, combustion, and exhaust flow are all performed. The center graph is a comparison of Crankcase and Intake pressures, giving you insight into the balance between these critical pressures. The vertical lines marked with **EO**, **TO**, **TC**, and **EC** indicate the timing of the Exhaust Opening, Transfer Opening, Transfer Closing, and Exhaust Closing points. The lower graph indicates **Particle Velocity** (in **Mach**) for Intake, Exhaust, and Transfer Flows. On reed-valve engines, reed-lift is also plotted on this graph. For a further explanation of internal engine pressures and flows, refer to the chapter on ***Wave Dynamics Theory***.

Pressure-Wave Progress Display: Switch to the **Pressure-Wave** display by pressing the **F8** function key. This screen shows pressure pulses in exhaust ducting, giving you unprecedented access to pressure-wave interactions. The display shows pressure pulses moving through varying pipe diameters "live" as the simulation is calculated. There are three representations of the pressure pulses (**Left-Moving**, **Right-Moving**, and **Total** (or Superposition) **Waves**. The graphic display at the bottom of the screen shows the resulting **Particle** movement (velocity). The **Green** indicators on the left show the status of the exhaust port (opening, closing, etc.).

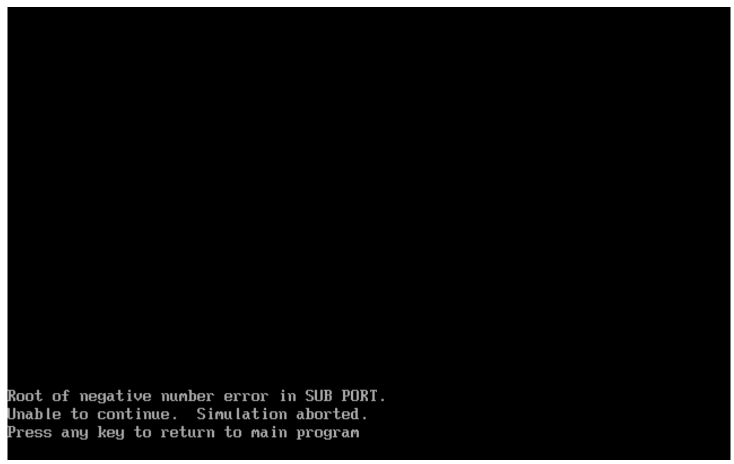
NOTE: You can speed up the simulation process somewhat by pressing the **F2** key. This blanks the graphic portion of both the Crank-Angle and Pressure-Wave display screens, reducing graphics display overhead and allowing your computer to dedicate more time to simulation math. Return active graphics to both screens by pressing **F2** again.



You can increase the calculation speed of the simulation by pressing the F2 key which blanks the graphic portion of both the Crank-Angle and Pressure-Wave display screens.

Simulation Crashes and Halts: The simulation of pressure waves in two-stroke engines is a very complex process that involves hundreds of millions of calculations, the input to which is often derived from the previous series of calculations. So, if pressure or flow values begin to "drift" outside of the normal range, it may take several million additional calculations before the increasingly-bogus values eventually drive the simulation into a fatal error. To correct these subtle issues, the programmer must trace back though all those calculations, back to the point where things began to go awry.

DynomationTwoStroke has been carefully designed, tested, and debugged, eliminating many of the causes of unstable simulations. However, if you specify component values or parameters that are incorrect or outside of "normal" values, the simulation can reach an unstable condition that will result in a crash or halt. When the simulation is terminated in such a fashion, the program will usually display a basic error message that provides some information about the final cause of the fault. If you encounter the same crash repeatedly, jot down the error message exactly as it was displayed and send it to the development team at Motion Software, Inc., along with the .DY2 engine file that caused the error (email: support@motionsoftware.com).



If you begin a simulation with engine component values or parameters outside of "normal" values, the simulation can reach an unstable condition that will result in a crash or halt. When the simulation is terminated in such a fashion, an error message will be displayed that provides some basic information about the error. If you repeatedly encounter the same crash, jot down the message and send it to the development team at Motion Software, Inc., along with the .DY2 engine file that caused the error (email: support@motionsoftware.com).

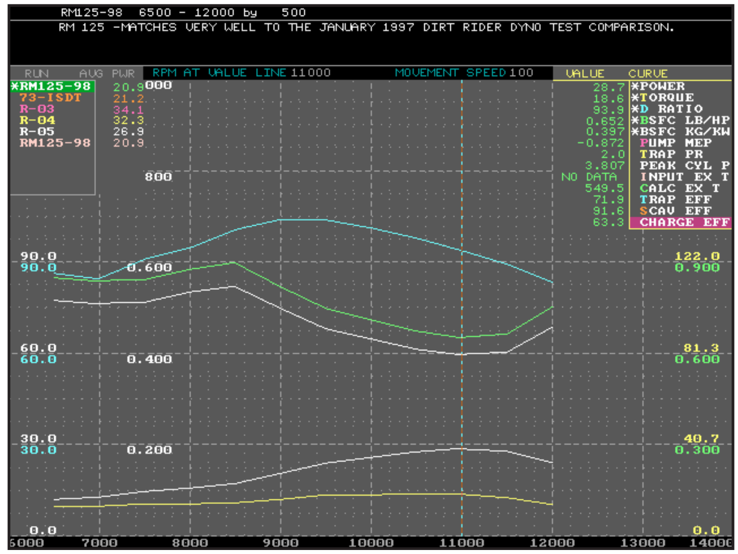
IMPORTANT NOTE: To help avoid crashes and to easily recover if you encounter a simulation error during your engine development process, please consider the following recommendations:

1) Start with a stable engine setup and make only small changes to ONE parameter at a time. If you change several things at once in the engine setup and the program crashes, you will no idea what caused the problem without going back and running each change individually (which is the best way to find the problem).

2) If you see "strange" results in graphic output of pressures, flows, power or any other variable, you may be seeing the start of program instabilities. Those unstable intermediate results may be limited to early setup

cycles, when the simulation is calculating the starting values for subsequent cycles, or they may occur during the final cycles of analysis, which may indicate that one or more engine-component setups are unstable.

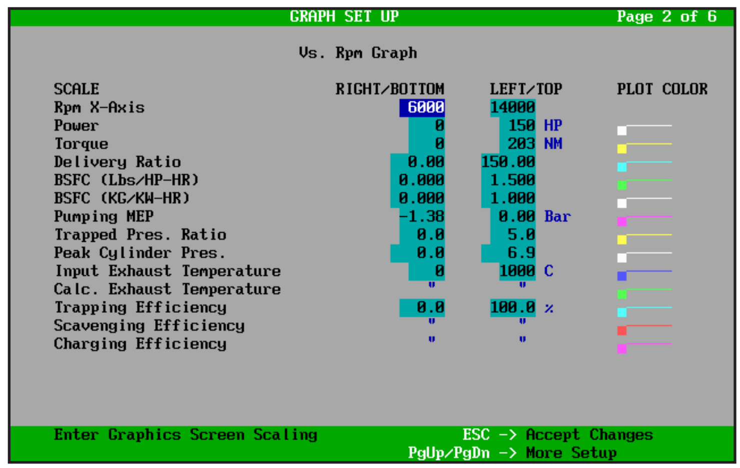
3) Running a series of small changes on ONE parameter often can be accomplished efficiently using the **Multiple** simulation selection from the **SIMULATION** menu (see *Running Multiple Simulations* earlier in this chapter).



DynomationTwoStroke has a very versatile and capable simulation results display capability. Data from up to 10 engines can be compared, and you have full control over which data sets you wish to display.

—GRAPH Screen: Display the results of any completed simulation (i.e., any valid .SM2 file that is listed in the File Box on the Main Program Screen) by pressing the **G** shortcut key from the Main Program Screen (**G** activates the **GRAPH** screen). This will transfer simulation results data to the ***Results Graph*** for display.

Setting Graph Scale And Other Defaults: The Results Graph does not automatically scale to display simulation results for each engine (this would make engine-to-engine comparisons impossible). In most cases, you need to establish the rpm range to match simulation results, at least, to properly display simulation output. For example, for a high-rpm Go-Kart engine, you might set the graph rpm range from 10,000 to 18,000rpm, and the horsepower range from zero to 40. On the other hand, for a watercraft engine, more appropriate selections might be 3,000 to 7,000rpm with horsepower spanning from zero to 200.



While displaying the Results Graph, press the F5 function key at any time to open a series of SETUP pages, allowing you to customize the scales and ranges for any of the display variables.

To change graph defaults (while the Results Graph is displayed), press the **F5** function key to open the first **GRAPH SETUP** page. From this page, use the **PageDow**n key to quickly access each of several additional SETUP pages. When you have entered your desired setup, press the **Esc** key to return to the Results Graph with the new parameters applied.
NOTE: These Setup pages are also available from the Main Program Screen by pressing the **S** key to activate the **SETUP** menu (more on **SETUP** later in this chapter).

Using The Results Graph: The Results Graph includes two list boxes that can be modified to select the exact data values you wish to display on the current graph. The **Engine Selection List Box**, in the upper-left corner, includes a list of .SM2 simulation results files (mirrors the File List on the Main Program Screen). Any or all of these simulation data sets can be included on the graph. Use the left-and-right cursor arrow keys to move the highlight to the Engine List Box, then using the and up-and-down keys, highlight the Result file you wish to include on the graph. Press the **Spacebar** to place an **asterisk** (*) next to the file name, which also includes simulation results on the graph. Press the **Spacebar** again to remove the data display for that engine. Up to 10 engine data sets can be displayed and compared.

The second **Data Selection List Box** is located in the upper-right corner. Here you can select simulation results **Data-Sets** that you wish to add to the graph. Choices include Horsepower, Torque, BSFC (Brake Specific Fuel Consumption), Trapping Efficiency, and several more. Again, use the **Spacebar** to “turn on” or "turn off" any data set for any selected engine. If data from multiple engines is displayed on the graph at once, then the data set for the selected engine will blink (the engine highlighted the upper-left list box). As you use these powerful Graph setup and display features, you will quickly become proficient in displaying and comparing simulation results from multiple engine tests.

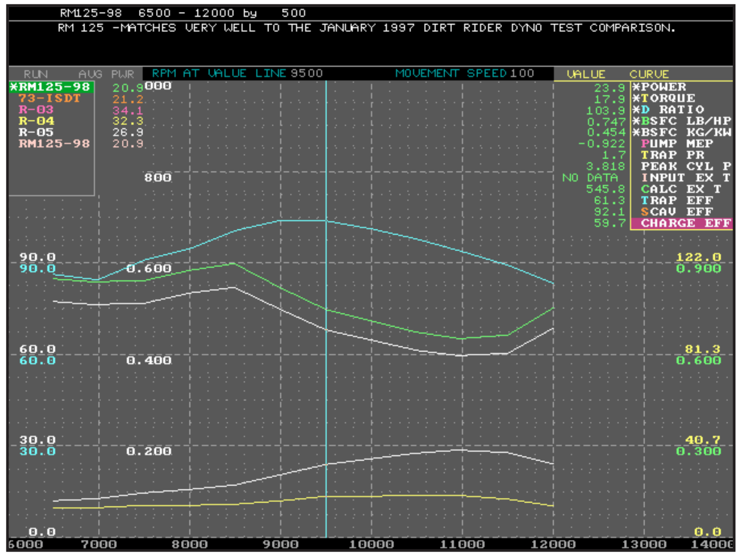
Results Graphs also include an Information Line at the top and a Notes field positioned below that. The information displayed in those areas is for the engine highlighted in the upper-left **Engine Selection List Box**.

Exact Simulation Results: The Results Graph also includes a moveable, vertical **Cursor Value Line** to pinpoint precise values from any of the data lines displayed on the graph. Use the **Plus(+)** and **Minus(-)** keys to move the cursor line (you do not need to press the Shift key). As you move the Cursor Line left and right in the graph, its current position is described, near the top of the graph, in a line that reads: **RPM AT VALUE LINE: xxxxx**. This is a very helpful indicator when the Cursor Line is positioned off screen. When the Cursor Line is located over any of the simulation results lines, the exact values of the underlying data are displayed next to the upper-right **Data Selection List Box**. Notice that the color of listed data values matches the color of the current engine (.SM2) file highlighted in the upper-left **Engine Selection List Box**.
NOTE: As you move the Value Line, you can increase individual RPM "jumps" by pressing the **F** key (for **F**ast) and reduce the "jumps" by pressing the **S** key (for **S**low). Repeated pressing of the **F** or **S** keys will increase their effect.

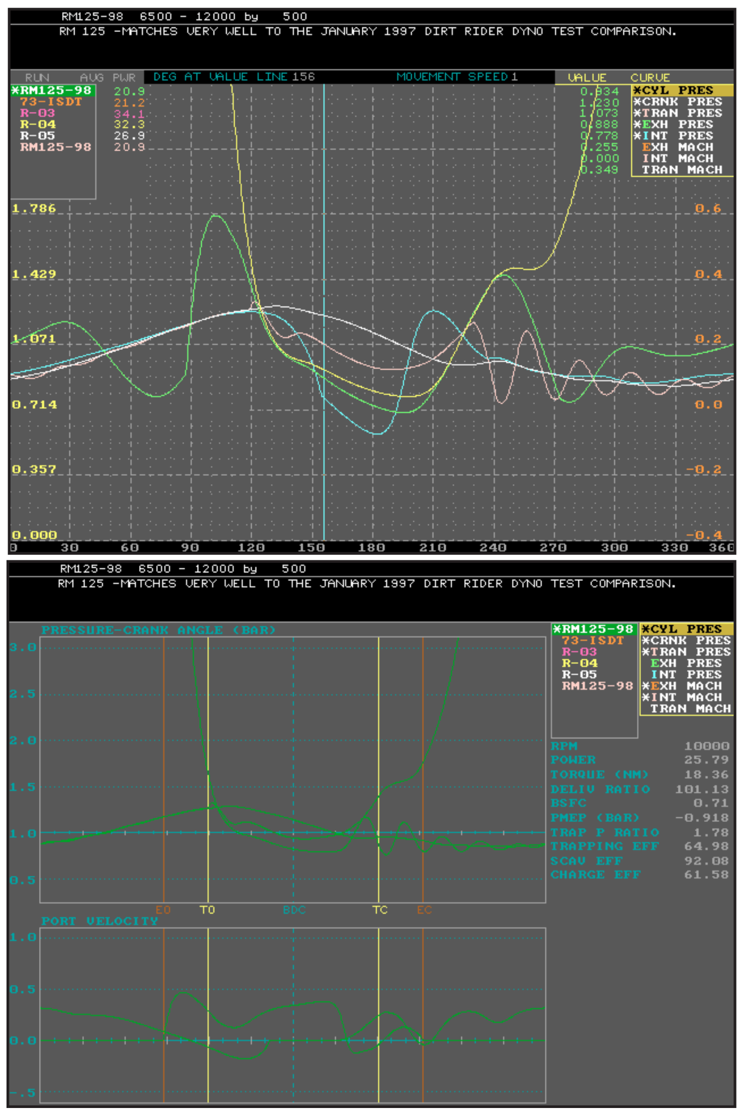
Three Results-Graph Screens: Dynomation TwoStroke can display simulation results on three unique results graph screens. Press **F6** to switch between these displays:

- **Graph Screen 1:** Default, Rpm Based (Power Values, Pressures, etc.)
- **Graph Screen 2:** Crank-Angle Based (Pressure Waves, Particle Velocities)
- **Graph Screen 3:** Crank-Angle Based (With Separate Pressure-Wave And Particle-Velocity Graphs)

NOTE-1: To view Crank-Angle Data at any RPM point, one method is to position the Cursor Line at



The RPM-based Results Graph also includes a vertical Cursor Value Line (shown here in blue). Use the Plus(+) and Minus(-) keys to move the line to the left or right on the graph. For each Value Line position, the exact values of engine results at that RPM point are displayed (next to the upper-right Data Selection List Box). The exact RPM of the Value Line is shown near the top of the graph in the field *RPM AT VALUE LINE:*.



DynomationTwoStroke can display simulation results on three different graph screens. One is RPM-based, and the other two are Crank-Angle-based. Screen 2 is shown in the upper photo with Screen 3 below.

the desired RPM in Graph Screen 1, then press the **F6** key to switch to the first Crank-Angle Graph (Graph Screen 2). While displaying Crank-Angle Data on Screen 2, you can move the Vertical Cursor Line to display exact crank-angle values by pressing the **Plus** and **Minus** keys. If you would like to change the RPM point at which the crank-angle data being displayed was recorded, press the **SHIFT-Plus** and **SHIFT-Minus** keys. This lets you easily see how the crank-angle data changes as engine speed changes.

Now switch to Screen 3 (by pressing **F6** again). On this display, you can still use the **Plus** and **Minus** keys to display the exact values. But using the **SHIFT-Plus** and **SHIFT-Minus** keys on this screen, displays a series of "shapshots" of pressure and velocity values, giving you an overall view of the changes throughout the rpm range.

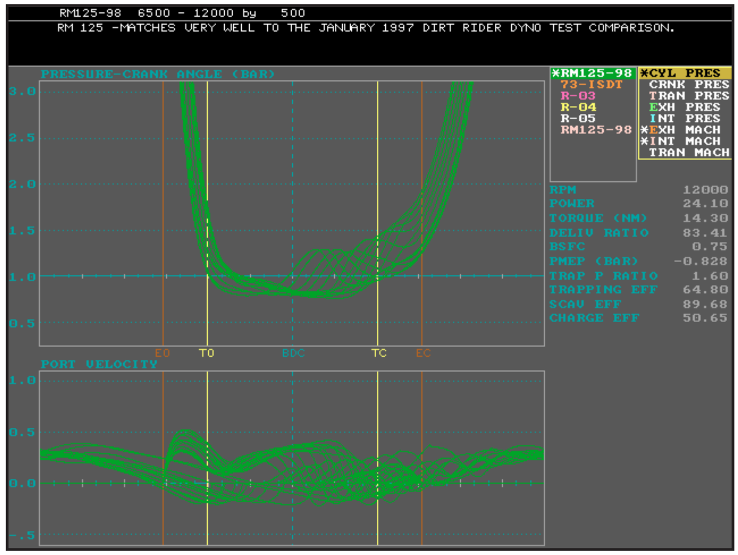
Press the **F6** key to switch to another Graphics Screen or **Esc** to return the Main Program Screen.

NOTE-2: It's obvious that there are a great many ways to display simulation results in Dynomation TwoStroke. To make it as easy as possible to access these features, you can quickly display a **Graph Help Screen** by pressing the **F1** key (when any of the Results Graphs are displayed). Also refer to the **Graphics Keystroke Summary** on page 28 and on the back cover of this manual.

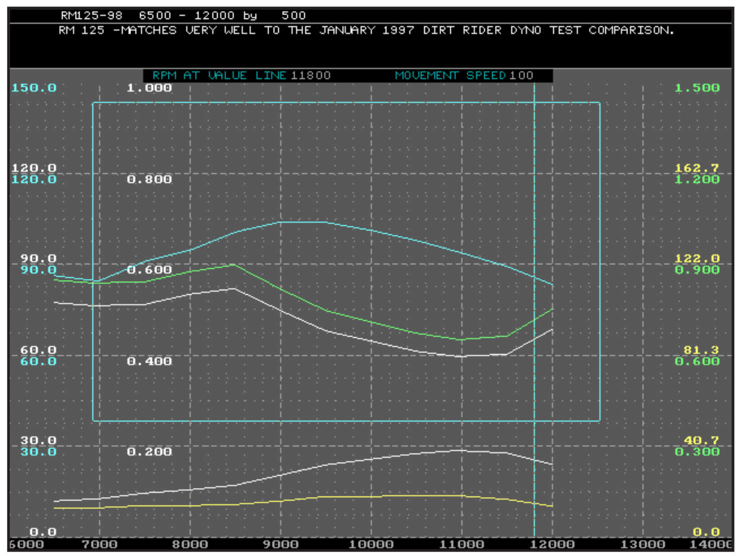
Graph ZOOM: DynomationTwoStroke can generate a **Zoom View** of any portion of the Power Graph on Screen 1 and of the Crank-Angle graph on Screen 2 (Screen 3 does not support the Zoom feature). To use this feature, activate and move the **Zoom Selection Box** by pressing the **Cursor Arrow** keys while holding down the **Ctrl** (control) key. When the zoom box is located in the correct position, press the **F9** key to zoom in on the selected area. This process can be repeated several times to get closer and closer to the desired zoom level. **F10** undoes each zoom step, one at a time. **SHIFT-F10** returns the screen to normal magnification.

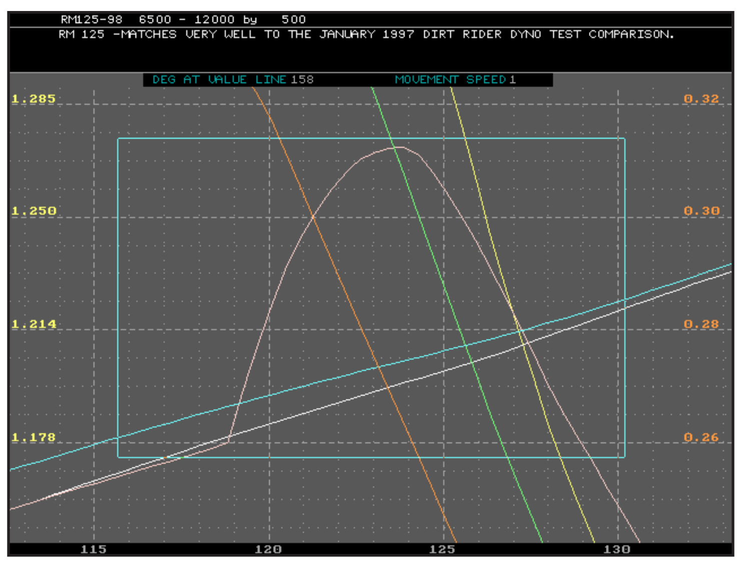
NOTE: You can change the default size of the **Zoom Selection Box** on page 2 of the **SETUP** screens (**F5** takes you directly from the **Results Graphs** to the **SETUP** screens).

List Boxes On And Off, Screen Refresh: In **Results Graph** Screens 1 and 2, use **F2** to turn the **Engine Selection List Box** and the **Data Selection List Box** on and off; useful if part of a data curve is



Graph Screen 3 has can display changing crank-angle data in a series of "snapshots," that show how these pressures and velocities change as engine RPM changes. Use the *Shift-Plus*, *Shift-Minus* keys to trigger this display.





You can activate the Zoom feature on Graph Screen 1 (upper photo) and Screen 2 (lower photo). Use the *Cursor Arrow* keys while holding down the *Ctrl* (control) key. When the zoom box is located in the correct position, press the *F9* key to zoom in on the selected area.

being covered by a list box.

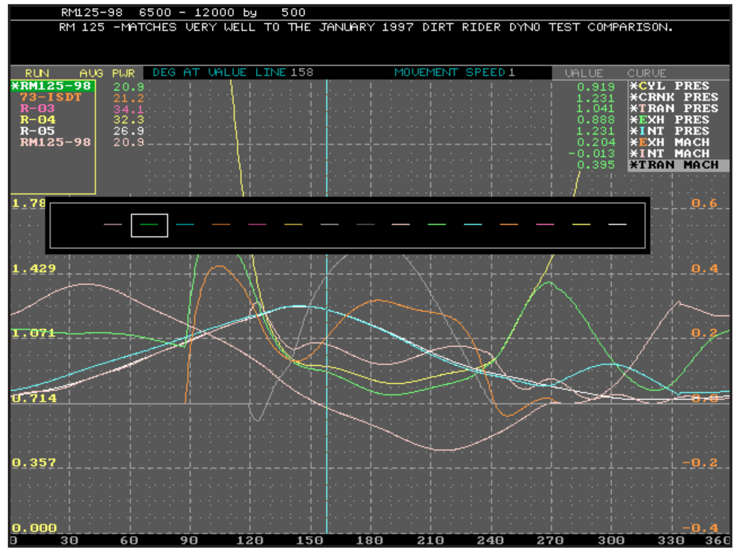
NOTE: Pressing **F2** twice has the net effect of re-drawing the graph screens (works on screens 1, 2, and 3) .

Highlighting/Blinking Power Curves: Graph data lines for the *highlighted* item in the **Data Selection List Box** are brighter than other plots. In addition, the data line of the *highlighted* engine with a *highlighted* data-set also blinks. You may need to adjust your monitor to best view blinking data lines. Also, the color formulas on SETUP page 5 affect blink appearance.

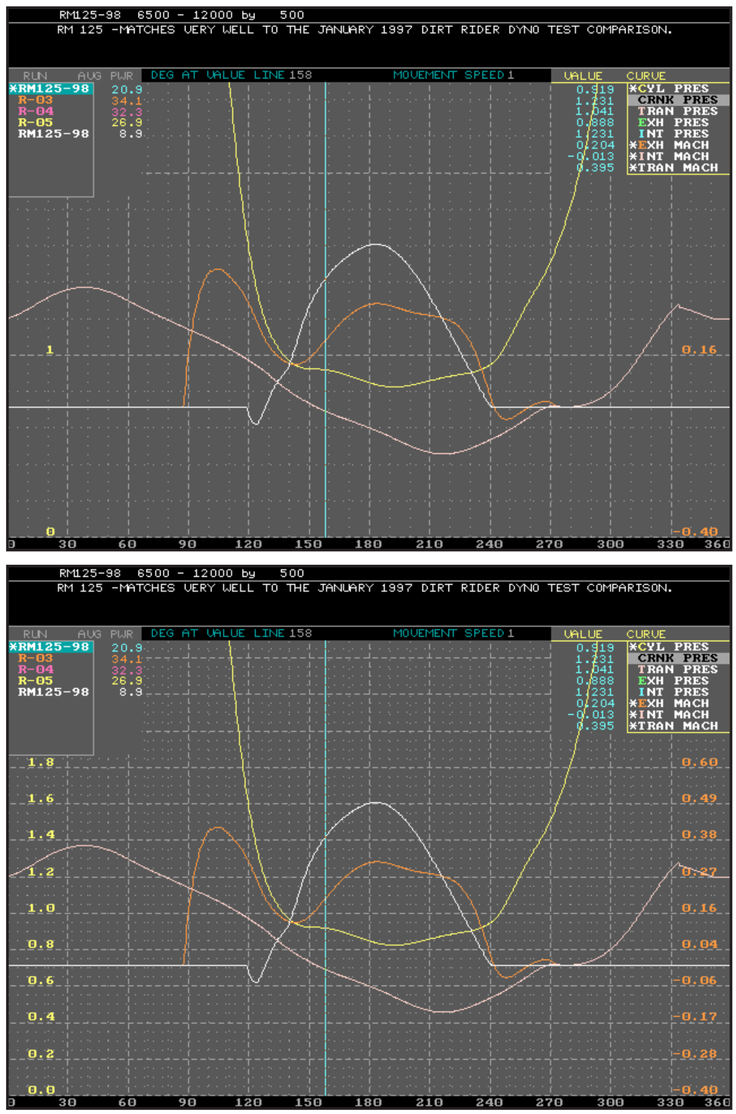
Color Of .DY2 Engine Data Files: You can press **Ctrl-C** to change the color of a highlighted engine data file shown in the **Engine Selection List Box** in the Upper-Left corner of the Results Screens (except on Screen 3, where the Engine Component Files are positioned on the Right). The colors of the exact values pointed to by the Value Line for that specific engine will also be changed to match. When the color-selection box appears, use the arrow keys to make a new selection, then press **Enter**.

Scale and Grid Lines: The vertical **Scale** of the data curves is set by entering the **Right/Bottom** and the **Left/Top** for the values of each data-set that can be graphed (page 2 on the SETUP screen). The **RPM Scale** determines the left-and-right placement of the curves on the RPM-based **Screen 1** Results Graph.

Grid Threshold (on page 2 of the SETUP screens) determines the fineness of grid-line spacing for the highlighted data curve. **Grid Threshold** changes how horizontal grid lines are drawn on the graph. The default Grid Threshold is three. A value higher will display more grid lines and show finer vertical resolution on axis labels (see photos on right).



You can change the color of the data values shown in the table next to the upper-right choice box by press Ctrl-C. Color choice changes only affect the table values, not the data curves themselves.



The Grid Threshold in SETUP (page 4) changes how horizontal grid lines are drawn on the graph. A value of two, shown on the upper screen, limits horizontal scale lines to about three. While a grid setting of 10 shows nearly 13 horizontal lines. The default for Grid Threshold is three.

DynomationTwoStroke
Graph Keystroke Summary

F2..**Turn List Boxes On and Off, Except for Screen 3**

F2 Twice..**Re-draw The Graph**

F5..**Go to Graph SETUP Screen**

F6..**Switch Between Graph Screens 1, 2 and 3**

F9..**Zoom In To Zoom Box Dimensions**

F10...**Zoom Out Step By Step**

SHIFT-F10...**Zoom Out To Standard Magnification**

Ctrl Arrow-Keys..**Move the Zoom Box**

Esc..**Return to Main Program Screen**

SpaceBar..**Tag or Un-Tag (Graph Data of Tagged Items)**

S.. **Slow Marker-Line Movement, Graph Screen 1 and 2**

F...**Speed Up Marker-Line Movement, Graph Screen 1 and 2**

M........... **Anchor/Un-Anchor a Marker, Read Differential Values, Graph Screen 1 and 2**

+ or **-**... **Move Value Line Left And Right**

Alt Left or **Alt Right**...**Move Value Line (same as +** or **-)**

Shift + or **Shift -**.. **Fix Value Line, Increase/Decrease RPM**

Shift Alt Left or **Shift Alt Right**........ **Fix Value Line, Change RPM (same as Shift + or -)**

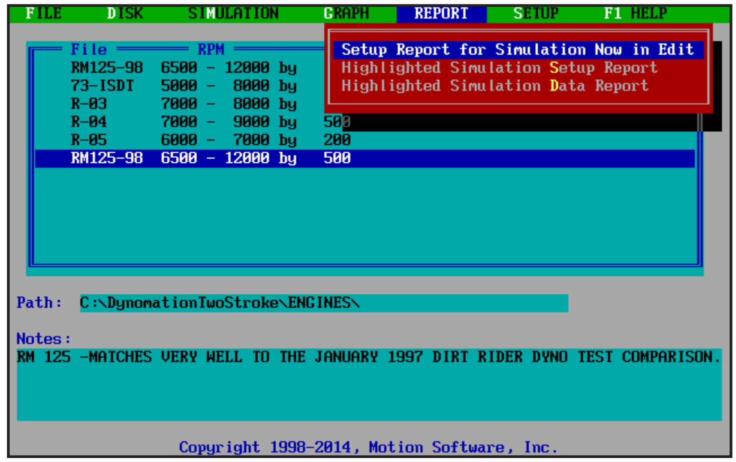
Ctrl-C............................**Change color of highlighted Filename and Comparison Values**

—REPORT Menu: Open the **REPORTS** menu by using the **R** keyboard shortcut key. The **REPORTS** menu includes choices for:

Setup Report For Simulation Now In Edit
Highlighted Simulation Setup Report
Highlighted Simulation Data Report.

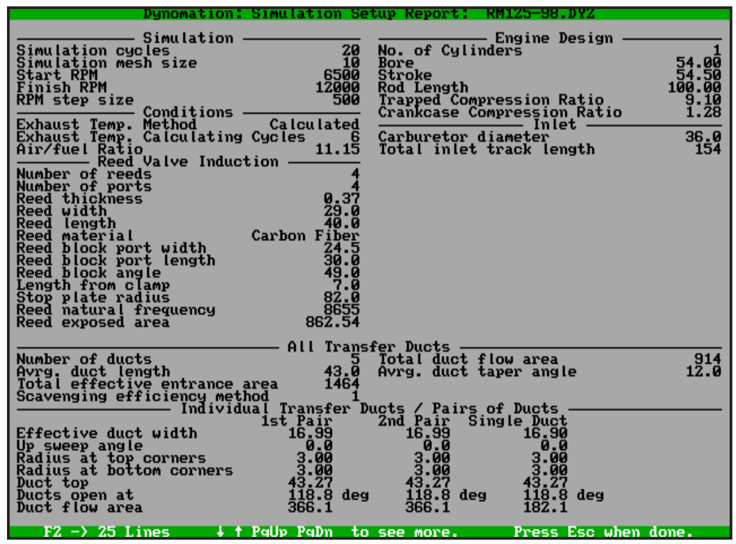
The **Edit** selection generates an engine component listing (contents of a .DY2 engine file) for the engine last **Retrieved** (refer to the earlier section on the **SIMULATION Menu** in this chapter for **Retrieve** function details). The **Setup** selection from the **REPORTS** menu generates an Engine Component report (from .DY2 component data), except for the engine currently highlighted in the **File List** on the Main Program Screen. Finally, the **Data** selection generates a Simulation Results report (from .SM2 results data) for the engine currently highlighted in the **File List**.

NOTE: The **REPORT** menu uses the term "Setup" to mean the *Engine Component Setup* and "Data" to mean *Simulation Results Data*. The "Setup" is stored in .DY2 engine component files and "Data" is stored in .SM2, simulation-results files.



The REPORTS menu generates engine component reports (from .DY2 data) and simulation results reports (from .SM2 data). The reports can be viewed on screen, stored to a file, or sent to a printer. The only printers supported are those directly connected to the LPT ports on the Windows system running DynomationTwoStroke. For more information about printing, see the next section on program SETUP.

Viewing And Printing Reports: Dynomation TwoStroke creates the selected reports and displays them on your monitor. If your video card is compatible with the program, you can switch between 25 and 42 line displays by pressing **F2**. Press **Esc** when you have finished reviewing the report; you will be presented with the options of Saving the report to a file or Printing it to the selected printer (see the next section on using the SETUP menu for printer configuration).



Press the *F2* key when viewing any of the Reports on Screen to switch between the (default) 25 line display and a 43 line display. When you press Esc to close the screen, you will be presented with options to save or print the data.

If you send the report to a file, the program will ask you for a filename (must be in standard DOS, eight character format). (Once a report has been stored in a file, you may use your Windows word processor or other any other text software to modify or print the reports.)

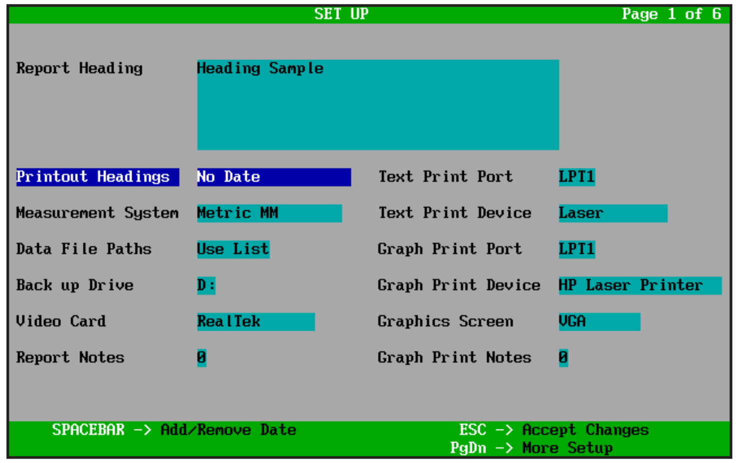
If you are have trouble directly printing a report from DynomationTwoStroke, review the following:

1) Is the parallel printer set online (to properly communicate with the computer)?
2) Is the **Text Printer Port** configured properly (connected the correct LPT port; see **SETUP**, below)?
3) Is your printer a "basic" output device; one that does not require a special printer driver? If the printer requires a driver to perform basic printing functions, you will have save reports to disk in Dynomation-TwoStroke then use a Windows Word Processor, like Notepad or Microsoft Word, to open and print the files to your normal Windows printer.

—SETUP Screens: Open the **S**ETUP screens by using the **S** keyboard shortcut key from the Main Program Screen. If you are currently viewing one of the Results Graphs, jump directly to **SETUP** with the **F5** key. Use **PageUp** and **PageDown** keys to display all SETUP pages.

How SETUP Selections Are Stored: The SETUP settings and other aspects of the program (described in this section and visible on the six SETUP pages) are stored in Configuration (.CFG) files created/saved when you **Quit** the program. Refer to the earlier section in this chapter on Configuration files for details on how to use .CFG files to save time and speed engine development in DynomationTwoStroke.

SETUP Page 1, Basic Program Setup



View the program SETUP screens by using the S keyboard shortcut key from the Main Program Screen. The settings on the six pages that address program SETUP (page one is shown above) are stored in Configuration (.CFG) files that are created/saved when you Quit the program.

—Report Heading: A Report Heading appears at the top of printouts. You can include your company name and contact info. Maximum heading size is five lines. Blank lines are not printed on reports unless they proceed a non-blank line.

—Date on Printouts: You select whether to include the Current Date near the top of printouts (**Note:** This field is currently reset to "No Date," when the program is started).

—Data File Paths: This path field is currently NOT used in DynomationTwoStroke. Changes to this field will have no affect on the program.

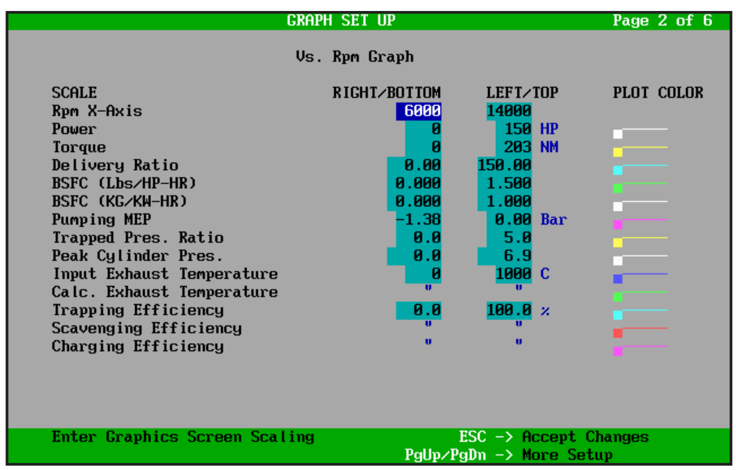
—BackUp Drive: This is the disk drive to which backup data is written when you choose the **Back Up** from the **DISK** menu.

NOTE-1: You can only specify a drive letter for the backup Drive (not a path); backup files are copied to the "root" of the BackUp Drive. However, you can assign a drive letter to any directory using the ***Map Network Drive*** function located in the **TOOLS** menu in Windows Explorer. With this capability, <u>you can backup Dynomation TwoStroke files to any directory on your computer or on your network</u>.

NOTE-2: The **BackUp** feature backs up files from the DynomationTwoStroke home directory (**C:\DynomationTwoStroke**) to the device specified on SETUP Page 1. It does **NOT** back up directories located **OUTSIDE** of C:\DynomationTwoStroke. To get the most protection from the **BackUp** feature, only create data directory structures **INSIDE** the DynomationTwoStroke home directory.

—Text Print And Graph Print Ports: Port is a virtual "connector" for the computer to direct output to a printer or other interface device. DynomationTwoStroke only directly "talks" to parallel port(s) on your computer. The printer attached to the Text Printer Port receives printed reports. The Graph Print Port is not currently supported in DynomationTwoStroke.

—Graphics Screen And Video Card: Changes to either of these fields are NOT required in Windows (the OS handles graphic display).



Page 2, 3 and 4 of the SETUP menu allow you to specify graph defaults, including the minimum and maximum displayed values for every simulation result, the colors of the result curves, the number of grid lines, and other graph default specifications.

SETUP Pages 2, 3 and 4, Graph Screen Set Up:

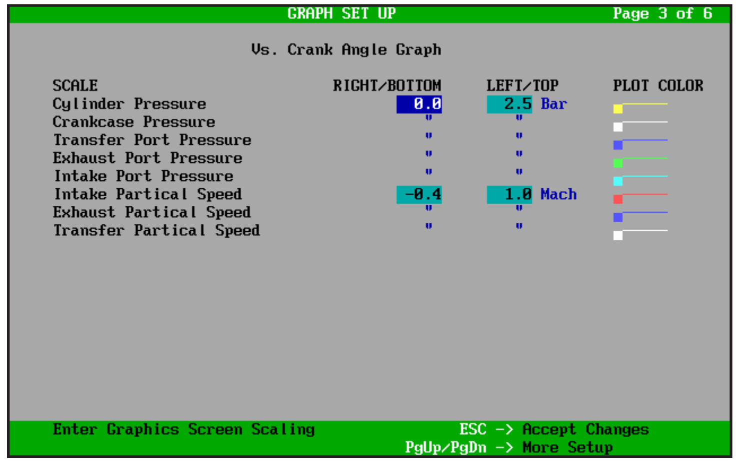
—Graph Scale: On page 2 on the SETUP screen, the <u>vertical scale</u> of the data curves is set by entering the **Right/Bottom** and the **Left/Top** for the values of each data-set that can be graphed. The

RPM X-Axis Scale determines the horizontal scale (left-and-right placement of the curves on the RPM-based **Screen 1** Results Graph).

—Plot Colors: These are the initial colors given to curves stored in .SM2 files. You can change any data set to any color available in the Dynomation-TwoStroke palette. Also see SETUP page 5 where you can modify the color formula for each available **Plot Color**. Changes will be saved in the .CFG file when you Quit the program.

—Zoom Box Size: This determines the size of the **Zoom Box** that can displayed on **Results Graphs 1** and **2** (use the **Ctrl Arrow** keys to open the box and to move it to the desired location). **Zoom Box Size** is entered as a percentage that determines how much of the existing screen will be contained within the Zoom Box and enlarged to full-screen. Larger percentages make the **Zoom** box larger and *reduce* the overall enlargement (press **F9** when the **Zoom Box** is visible to complete the Zoom).

—Grid Threshold: Located on page 4 of the SETUP screen, **Grid Threshold** determines the fineness of grid-line spacing for the highlighted data curve. This changes how horizontal grid lines are drawn on the graph. The default **Grid Threshold** is three. A value higher will display more grid lines and show finer vertical resolution on axis labels (see photos on page 27).



SETUP Pages 3 and 4 continue the settings that establish the look of simulation results graphs.

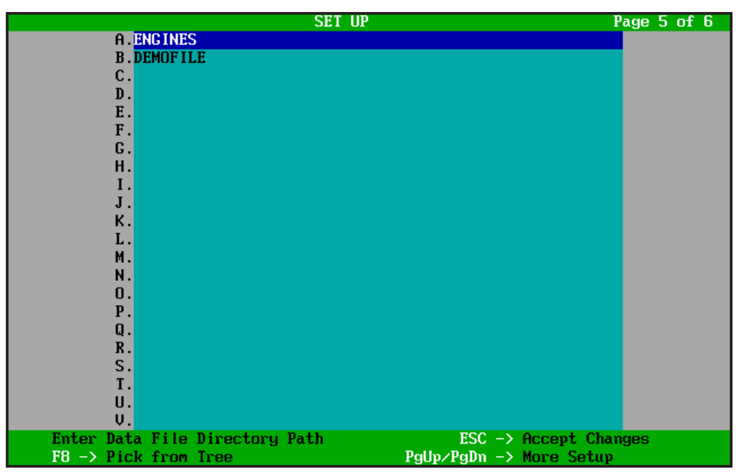
SETUP Page 5, Data-Directory Screen

Use **SETUP Screen 5** as a “central clearing house” to create and name data directories in Dynomation TwoStroke. Please note, ONLY directories present in this **SETUP List** are accessible from within Dynomation-TwoStroke. If you create a directory using Windows Explorer, you must ALSO add that same directory to the SETUP list if you wish to access it inside of DynomationTwoStroke.

NOTE-1: Remember the eight-character, directory-name limitations imposed by the underlying DOS system used by this simulation. If you create a long directory name outside of the program, you will not be able to add it to the **SETUP List** or access its contents. Keep your directory names simple and in upper case (eight character maximum for directories [e.g., **BESTENG1**] and eight-dot-three maximum for filenames [e.g., **MYFILE12.DY2**])!

NOTE-2: Pressing **F3** from any one of the several other file-open dialog boxes within the program will jump to **SETUP Screen 5**.

With **SETUP Screen 5** displayed, you can scroll through the current list of Dynomation accessible directories using the **Arrow Keys** (these are the directories currently accessible by Dynomation TwoStroke, not a list of all directories on your stor-

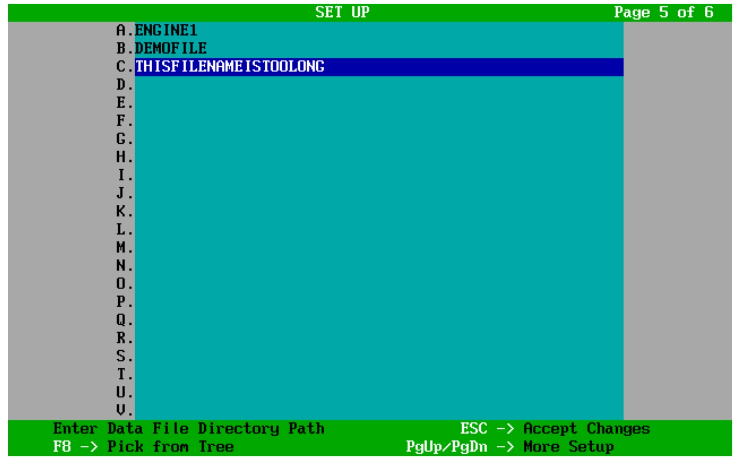


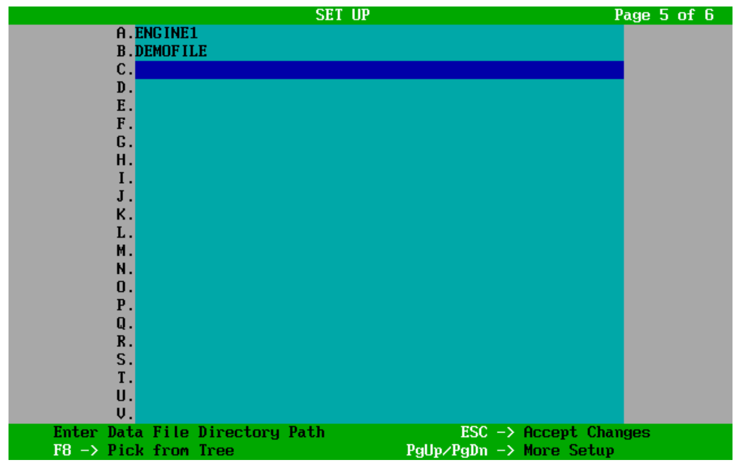
SETUP Screen 5 is the “central clearing house” for creating and naming data directories in DynomationTwoStroke. ONLY directories present in this list are accessible from within the program. Use features on this screen to add and change program directories.

age device or even in the program "home" folder).

You can add a new directory or modify any of the existing directory names. If you enter a new name (and it is valid), the program will check to see if that directory exists. If it does not currently exist, it will prompted you to create it. If the directory already exists, it will switch program access to the new directory. The previous directory will not be removed from your hard drive, nor will its files be affected in any way. You simply have switched access from the previous directory to the one you just entered. *You cannot delete data files or directories using functions in this **SETUP** page.*

NOTE-3: If you enter a directory name that is not legitimate or you just wish to close the directory list after you have modified a directory line, use the cursor **Arrow** and **Delete** keys to blank the entire line, then press **Esc** to close the list; the modified-then-blanked directory entry will remain unchanged.





Remember the eight-character, directory-name limitations imposed by the underlying DOS system. Keep your directory names simple and in upper case. If you enter an invalid name, use the Cursor Arrow and Delete keys to blank the entire name, then press Esc or Enter. The modified directory entry will remain unchanged.

Organizing Your Project Files

Directories are "folder" subdivisions on your storage device. They contain data files and can even contain other folders. You can envision them as folders in a file cabinet. To keep your work organized (as in a file cabinet), you should put engine simulation files for different development projects in different directories.

In many cases, it is most convenient to use simple directory names and locations. Such as those consisting of a single path name, like **DEMOFILE**, **ENGINE1**, **ROTAX1**, etc. These single-name directories will be stored in the DynomationTwoStroke "home" directory (**C:\DynomationTwoStroke**).

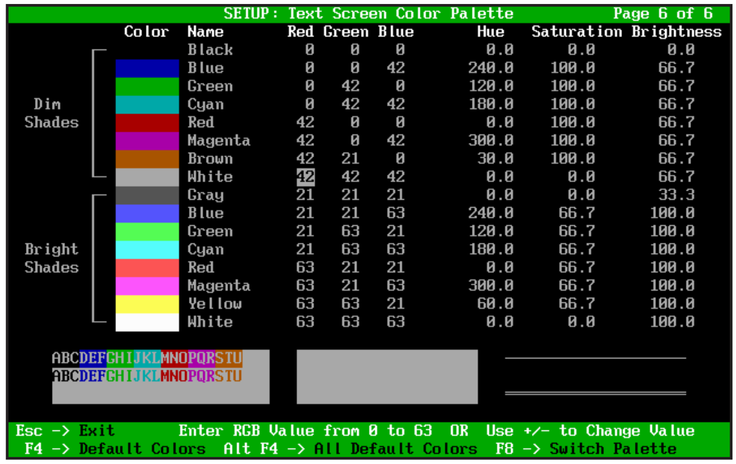
NOTE: The program home directory is a "special" place where the name of the folder (**C:\Dynomation TwoStroke**) is not limited to the eight-character DOS filename restrictions.

It is also possible to create "nested" directories (such as, **ENGINES\ROTAX\RACE**) using the "backslash" character to mark the separation between one directory specifier (name) and the next. If this directory "tree" did not already exit, DynomationTwoSTroke would prompt you for permission to create three directories, **ENGINES** inside the Dynomation home directory, **ROTAX** inside **ENGINES**, and **RACE** inside **ROTAX**. Each of these locations could be used to store files and, because they all follow the DOS naming restrictions, they would all be "legal" directory names in DynomationTwoStroke.

We recommend that you store all your directories and engine files within the DynomationTwoStroke home directory. While it is possible to create a directory OUTSIDE of the home directory, such as **C:\NEWPATH\ENGINES**, (this would create two folders starting from the "root" of **C:**), to keep program operation simple and straightforward, and to make file backups using the **Back U**p function from the **DISK** menu work properly, locate all your data directories inside the DynomationTwoStroke home directory.

IMPORTANT NOTE: The **Back Up** feature available from the **DISK** menu backs up files from the DynomationTwoStroke home directory to the device specified on **SETUP Page 1**. It does **NOT** back up directories located **OUTSIDE** of **C:\DynomationTwoStroke**. To get the most protection from the **Back Up** feature, only create data directories **INSIDE** of the DynomationTwoStroke home directory. For in-depth information on paths and directories consult a DOS user manual.

Setup Up page 6, Color Palette



The color palette defaults is found on page 6 of the SETUP screens. Here you can adjust the composition formulas used to create each of the 16 colors displayed by DynomationTwoStroke. Some colors that look great as text may not look right on a graph. Use these options to fine-tune the look of the program.

The color palette **SETUP** screen (page 6) allows you to adjust the composition formulas used to create each of the 16 colors displayed by Dynomation TwoStroke. Since colors that look great on a text screen may not look good on a graph, the program uses separate palettes for the graph and the rest of the program. Use **F8** to switch between the SETUP for the two palettes. The **Screen Title** indicates which palette you are currently editing. You can use two different systems of color formulas, the **RGB** (Red, Green, Blue) system, and the **HSB** (Hue, Saturation, Brightness) system. **RGB** is default the system used by your computer. **HSB** is can be somewhat easier to understand. You may use either system interchangeably. As you make changes in one system the program will change the formula for the other system to match. The **Color Test Areas** at the bottom of the screen display your selected color.

Here are some hints to help you get the best results when selecting colors:

1) Maintain black as pure black, and white as pure white.
2) When DynomationTwoStroke displays blinking curves on the Result Graphs, it uses bright and dim shades of the same color. You should keep these color pairs similar but distinct.
3) Some monitors display the standard dim version of yellow as brown. With some adjustment, it's possible to change the brown to a true dim yellow.
4) DynomationTwoStroke uses dark gray as the background for the graphs and as the labels for inactive data entry fields on the SETUP screens.

—F1 HELP Screens:

Context Sensitive Help is available within DynomationTwoStroke program. To view help related to the screen you are currently viewing, press the **F1** key.

INPUTS AND RESULTS

Simulation Inputs

The following variables are used to "build up" an engine for DynomationTwoStroke to simulate. They are presented in the same order (approximately) as they appear on the **Edit** Screens opened from the **SIMULATION** menu.

SIMULATION CYCLES: Gas dynamic simulations require several repeating cycles of calculation at each data point (in this case, each RPM point) in order to converge on a solution. The number of **Simulation Cycles** sets the minimum number of cycles the overall simulation must complete while it is working toward convergence.
SIM-TIP: We recommended setting this value at 20. Some simulations may require more cycles, although rarely will fewer cycles convergence. Observe the Horsepower values displayed on the **Simulation Progress Screen** as the program works through each cycle. If the Horsepower shows continuing increases in the last couple of cycles, the solution has not yet converged. In these cases, try increasing the **Simulation Cycles** value to 22 or more.

START RPM: This is the beginning rpm for the simulation run.

FINISH RPM: This is the ending rpm for the simulation run.

RPM STEP SIZE: This is the RPM increase that the simulation increments between test points throughout the RPM test range.

EXHAUST TEMPERATURE CALCULATION METHOD: DynomationTwoStroke includes two distinct methods of determining exhaust-gas temperature. These methods are displayed as **USER ENTERED** and **CALCULATED**. If you select **User Entered**, page down to **Edit Screen 9** and enter the corresponding exhaust temperatures throughout the RPM test range.
NOTE: The exhaust-gas temperature should be entered in Celsius. If you have not measured the exhaust gas temperatures for the engine under simulation, select **Calculated** instead. When **Calculated** is used, the simulation will run several pre-simulation cycles (displayed with negative Cycle-Count Values) to establish an appropriate exhaust gas temperature based on the engine configuration. Make sure to enter the number of **Calculation Cycles** to be used in this determination. DynomationTwoStroke developers recommended no less than SIX cycles when using the **Calculated** method.
IMPORTANT NOTE: Exhaust-gas temperatures should be measured at the middle of the divergent cone section of the exhaust system. The **Calculated** method only determines temperatures for continuous duty, non water-injected or water-cooled pipes. Examples of this are MX bikes, road-racing bikes and cross-country snowmobile engines. Engines that should **NOT** use the calculated technique are water-injected or water-jacketed pipes or drag racing pipes. In these situations, you should directly measure the exhaust-gas temperatures for best accuracy. Do not be overly concerned about obtaining exact temperature values. Providing a reason-

ably close estimate will give good solutions to the speed-of-sound reference calculations for which the exhaust temperatures are primarily being used.

The speed of sound is a square-root function of temperature. If you encounter square-root errors in simulation runs (indicated by the error message displayed when the simulation halts), exhaust temperature determination may be the cause. Try changing the number of calculation cycles and/or switch to **User Entered** temperature values (report consistent errors to support@motionsoftware.com, and include your .DY2 and .SM2 files in the email to help us test your combination).

AN ERROR TO AVOID WHEN YOU CHANGE RPM: If you are using manually entered exhaust-gas temperatures entered in the table on Page 9 of the **Edit** Screens from the SIMULATION menu, be careful when you modify the **START** or **FINISH RPM** points. If you do not make a similar update to the exhaust-gas temperature table, simulation results may not be correct, since exhaust-gas temperatures may not be applied at the intended RPM.

AIR-FUEL RATIO : This is an extremely important subject when performing simulations on two-stroke engines. To ensure an accurate simulation results you can use on reliable, real-world engines, you MUST closely monitor Brake Specific Fuel Consumption (BSFC). This is just as critical in the simulation as it is in the real-world during a dynamometer test.

Two-stroke engines are very sensitive to air-fuel ratio; running too lean can cause excessive temperatures, detonation, and unpredictable drops in engine power. It is quite possible to build a high output engine, but have it produce that power for only a few seconds. This may be acceptable for drag-racing applications, but it would never work in a road-race engine.

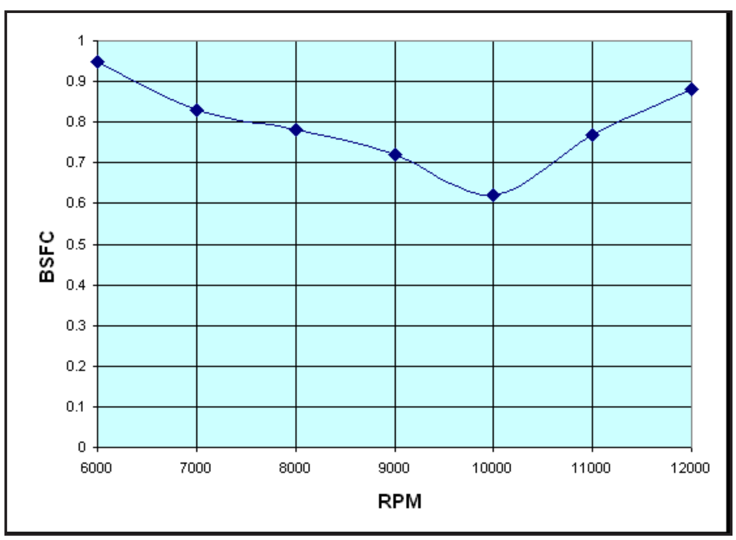
One of the major problems in setting optimum fuel flow throughout the RPM range is that BSFC changes with RPM and fuel characteristics. Fortunately, DynomationTwoStroke has a sophisticated combustion and ignition timing model that allows the BSFC to behave as would in the real world with Air-Fuel ratio changes. So the model you develop in the simulation should perform similarly in the the real world!

> **VERY IMPORTANT:** This is perhaps the single most important piece of information in this entire manual: Generally, BSFC must be adjusted to a value of 0.650 lbs/hp-hr (0.400 kg/kw-hr) at peak horsepower, then increased 0.150 lbs/hp-hr (0.100 kg/kw-hr) for each 1000 RPM above the peak power speed. Below peak power, the BSFC should increase 0.150 lbs/hp-hr (0.100 kg/kw-hr) for each 2000 RPM below peak-power speed. Refer to the accompanying graph to illustrate this important tuning consideration.

Tuning to obtain these target BSFC values will require several simulations to dial in fuel flow with air-fuel ratio values. To help you with this task, **BSFC** is a simulation result variable that can be displayed on the Results Graphs. Air-fuel ratio can be fixed at a single value throughout the RPM range or given a unique value at each RPM test point (change **Air-Fuel Ratio** to *Use Individual Ratios* by pressing **F7** on page 1 under **Edit** in the **SIMULATION** menu).

Fortunately once you have worked out what is required to obtain the optimum BSFC values, you probably will not have to adjust them again for that specific engine. *However, you should monitor the BSFC values if you apply further modifications to the engine.*

In some applications the target BSFC value



To avoid engine damage and power-robbing thermal overload on typical performance two-stroke engines, BSFC must be set to a value of 0.650 lbs/hp-hr at peak horsepower (shown here at 10,000 RPM), then increased 0.150 lbs/hp-hr for each 1,000 RPM above the peak power speed. Below peak power, the BSFC should increase 0.150 lbs/hp-hr for each 2,000 RPM below peak-power speed.

of .650 can be reduced. You will have to let your own experience guide you in these decisions. The following table can help find an acceptable BSFC at maximum power for the type of fuel that the user may be using.

BSFC (lbs/hp-hr)	**Application**
0.700 or higher	**Safe with pump gasoline for long runs**
0.650 to 0.690	**Requires 92+ octane**
0.550 to 0.640	**Requires 100+ octane aviation or racing gasoline for long circuit or road-race applications**
0.500 to 0540	**Ok for drags using 100+ octane. Road race application should use 110+ octane racing gasoline**
Less than .049	**"Twilight Zone" reliability. Drag racing use only with 110+ octane racing gasoline**

NOTE: As a general rule, the larger the engine bore, the more you can reduce the air-fuel ratio at peak power. Small bore engines with 80- to 125-cc displacement require approximately 11.5:1 air-fuel ratios, while engines 350cc and larger can use 10.0:1 and even lower air-fuel ratios.

NO. OF CYLINDERS: Dynomation can model up to three cylinders either firing into individual chambers (three chambers total) or into a single shared chamber, e.g., many watercraft engines. Dynomation assumes that a twin has a 180 degree firing order and a triple uses 120-degree cylinder firing.
IMPORTANT NOTE: The stability of the program and the number of cylinders are directly related. A single cylinder engine is very stable and will rarely if ever "crash" when performing a simulation. A two-cylinder engine firing into a single pipe (share) is not quite as stable due to the complicated wave interactions occurring at the pipe junctions. A three cylinder engine firing into a single pipe (shared) is even less stable then the two cylinder simulation. In fact, the three cylinder engine can be downright impossible to simulate with certain combinations.
NOTE: If all cylinders fire into individual chambers, you can model any multiple-cylinder engine by modeling a single cylinder in DynomationTwoStroke (which is a very stable simulation) and multiplying the results by the number of cylinders. Make sure to adjust induction flow (if necessary) to match the flow conditions of each cylinder in a multi-cylinder engine.

BORE: Cylinder Bore in Millimeters (the Metric system is always used for engine dimensions).

STROKE: Stroke in Millimeters.

ROD LENGTH: Rod length from center to center in Millimeters.

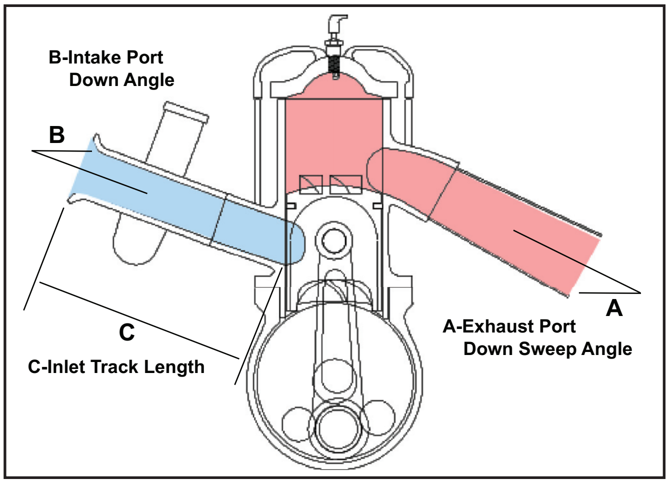
TRAPPED COMPRESSION RATIO: This is the compression ratio calculated from the point of exhaust port closing to piston TDC (similar to the mechanical compression ratio of a four-stroke engine multiplied by the engine VE, sometimes referred to as the *dynamic compression ratio*).
IMPORTANT NOTE-1: This value will change if the exhaust port timing is changed!
IMPORTANT NOTE-2: As Trapped Compression Ratio increases, the squish velocity will increase. If the squish velocity reaches a critical point, the engine may suffer from pre-ignition and/or detonation. Dynomation-TwoStroke does not model squish velocity or detonation; the simulation assumes combustion is stable and normal. Tom turner of TSR offers a program to calculate squish velocities based on combustion chamber dimensions—available for free download, as of 5/2014, from:
http://atom007.heimat.eu/tmt/gsf_dyno_download.html

CRANKCASE COMPRESSION RATIO: This is the induced "compression ratio" from the rotary motion of the crankshaft and the reciprocating motion of the piston in the crankcase (acts as a small supercharger). Changing rod length without changing piston-pin location will change the Crankcase Compression Ratio.

CARBURETOR DIAMETER: Carburetor bore diameter for each cylinder in Millimeters.

INDUCTION METHOD: DynomationTwoStroke can model three induction designs: Reed Valve, Rotary Valve, and Piston Port. Use the **SpaceBar** to change induction methods.

TOTAL INLET-TRACK LENGTH: This is the total length of the inlet tract from the carburetor/injector bellmouth to reed block tip. If engine uses a piston-port design, then this length is measured from the bellmouth to the cylinder liner. If the engine you are modeling uses a rotary valve, then the total track length is measured from the bellmouth to the rotary valve plate. This dimension establishes the *reflection-boundary distance* in the inlet tract. Intake track length shown on the engine illustration on the right is **C,** in Millimeters.



PISTON-PORT INDUCTION DIMENSIONS

PISTON PORT DOWN-SWEEP ANGLE: This is the angle of the intake or exhaust port runner relative to a horizontal reference line (at 90-degrees from the cylinder centerline). These angles are shown on the engine illustration on the right are **A** and **B**, in degrees.

SKIRT LENGTH: This is the length of the piston skirt. Measure from the top of piston to the bottom of the skirt in Millimeters. This is the **A** dimension in *Diagram 2*.

PORT TOP: This is the distance from the top of the cylinder to the top of the port in Millimeters. This is the **C** dimension in *Diagram 2*.

PORT BOTTOM: This is the distance from the top of the cylinder to the bottom of the port in Millimeters. This is the **B** dimension in *Diagram 2*.

EFFECTIVE PORT WIDTH: This is the measured port width in Millimeters. This is the **D** dimension in *Diagram 2*.

RADIUS OF TOP: The corner radii at the top of the port in Millimeters. This is the **E** dimension in *Diagram 2*.

RADIUS OF BOTTOM: The corner radii at the bottom of the port in Millimeters. This is the **F** dimension in *Diagram 2*.

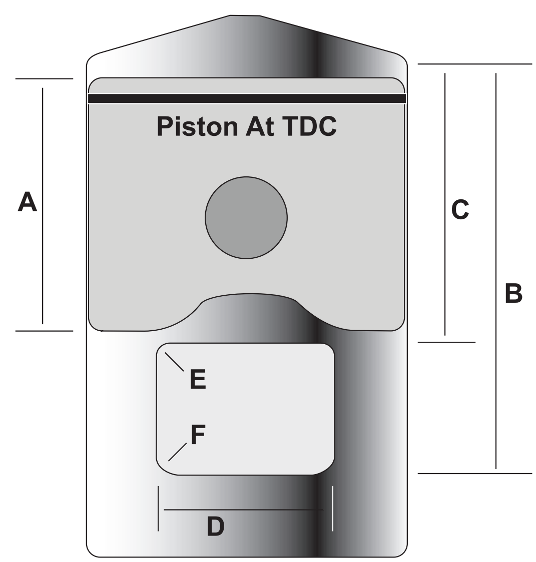


Diagram 2, Piston-Port Dimensions

A Piston Skirt Length
B Port Bottom Distance
C Port Top Distance
D Port Width
E Port Top Corner Radii
F Port Bottom Corner Radii

ROTARY-VALVE INDUCTION DIMENSIONS

OPENS @ DEG: Valve opening point in degrees BTDC (Before Top Dead Center)

CLOSE @ DEG: Valve closing point in degrees ATDC (After Top Dead Center)

PORT DIAMETER: Use the width of the port opening as measured from the midpoints of the port height in Millimeters (the **G** dimension in *Diagram 3* on the right). It is typically the same as (or very close to) the diameter of the bore in the carburetor/injector mounting plate. Enter the smaller of the two dimensions to best model port restriction.

CENTER RADIUS FROM CRANK: This is distance from the center of the rotary port (**H** dimension in *Diagram 3* on the right) to the center of the crankshaft, in Millimeters.

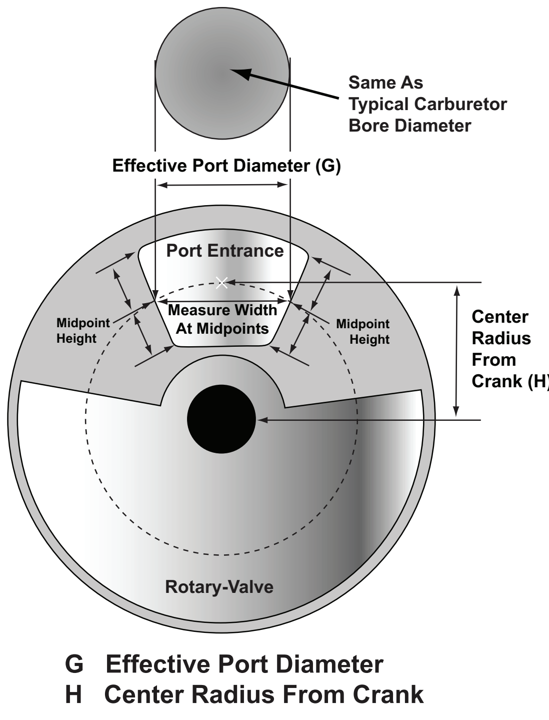


Diagram 3, Rotary-Valve Dimensions

REED-VALVE INDUCTION DIMENSIONS

NUMBER OF REEDS: Number of Reeds that can individually open/close. In *Diagram 4*, below, the number of Reeds is four.

NUMBER OF PORTS: Number of individual ports in Reed Block. In *Diagram 4* on the right, the Number Of Ports is four.

REED THICKNESS: Thickness of Reed material in Millimeters. This is **J** in *Diagram 4, **below***.

REED WIDTH: Width of Reed material in Millimeters. This is **Q** in *Diagram 4*, below.

REED LENGTH: Length of Reed material from edge of Reed to start of hold-down bracket in Millimeters. This is **N** in *Diagram 4*, below.

REED MATERIAL: Use the **SpaceBar** to select Carbon Fiber, Fiberglass, or Steel.

REED BLOCK PORT WIDTH: Width of Reed-Block Port in Millimeters. This is **R** in *Diagram 4,* below.

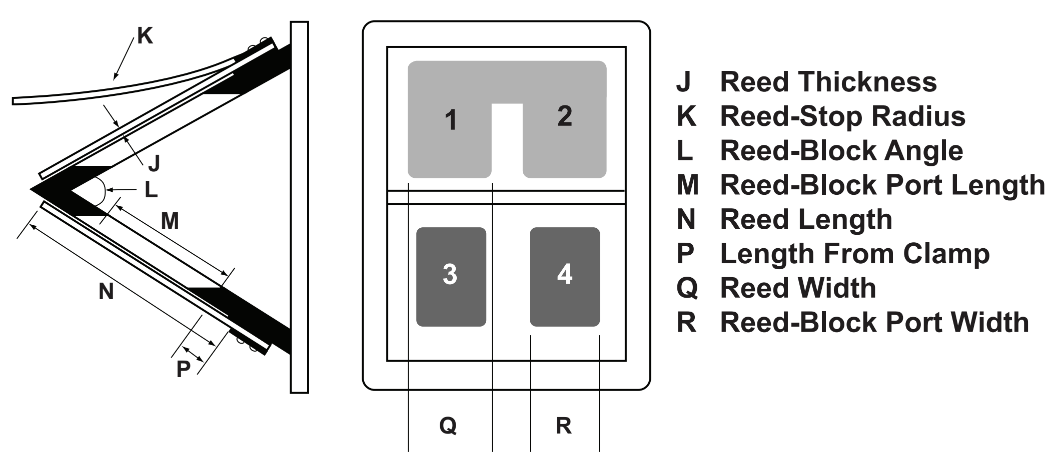
REED BLOCK PORT LENGTH: Length of Reed Block Port in Millimeters. This is **M** in *Diagram 4,* below.

REED BLOCK ANGLE: Angle of Reed Block in Degrees. This is **L** in *Diagram 4,* below.

LENGTH FROM CLAMP: Distance from the edge of the clamp bracket to the start of the Reed-Block Port in Millimeters. This is **P** in *Diagram 4,* below.

STOP PLATE RADIUS: Radius of the Reed-Block Stop Plate in Millimeters. This is **K** in *Diagram 4,* on the right.

Diagram 4, Reed-Valve Dimensions



TRANSFER-DUCT SPECIFICATIONS

NUMBER OF DUCTS: Number transfer ducts per cylinder.

AVERAGE DUCT LENGTH: This is the average length of the transfer ducts in Millimeters, starting at the crankcase and ending at the transfer port window in the liner. This is **S** in *Diagram 5*, on the right.

TOTAL EFFECTIVE ENTRANCE AREA: This is the **sum** of all transfer-duct entrance areas in Square Millimeters; each is measured at the crankcase opening. This is the sum of all **T's** in *Diagram 5*, on the right.
IMPORTANT NOTE: This **Effective Entrance Area** should be 1.0 to 1.5 times larger than the sum of all transfer-duct discharge opening areas. Use this comparison to double-check your area calculations.

SCAVENGING EFFICIENCY: This is numeric representation of the scavenging efficiency of all transfer ports in each cylinder. **Best** efficiency is defined as (**1**); **Worst** efficiency is four (**4**). Enter the efficiency values by pressing the **SpaceBar** to toggle between the values (**1**, **2**, **3**, **4**).
IMPORTANT NOTE: As a general rule, larger bore diameters reduce scavenging efficiency. Small-bore engines typically have an Efficiency of **ONE** (the best). The most efficient 250cc engines sometimes scavenge with an efficiency of **ONE**, but often fall in the **TWO** category. Big-bore engines should use an Efficiency of **TWO** (for the very best engines) and **THREE** (in more typical cases). Typical cross-flow engines should use **Four**.

EFFECTIVE TRANSFER-DUCT WIDTH: The *Effective* flow widths of each transfer-duct discharge port in Millimeters. Do not simply use the chordal width (largest possible measurement of port width), instead measure the width along the axis of discharge. See *Diagram 6*, on the right.

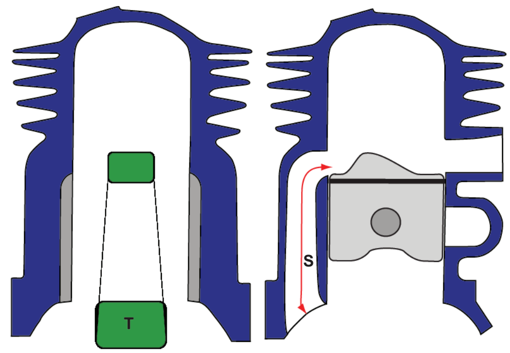
UP-SWEEP ANGLE: Effective angle in degrees at which each transfer-duct port directs flow into the cylinder. See *Diagram 7* on the right.

RADIUS AT TOP CORNERS: Radius in Millimeters at top corners of each transfer-duct discharge port in cylinder. This is **U** in Diagram 8 on the right.

RADIUS AT BOTTOM CORNERS: Radius in Millimeters at bottom corners of each transfer-duct discharge port in cylinder. This is **V** in Diagram 8 on the right.

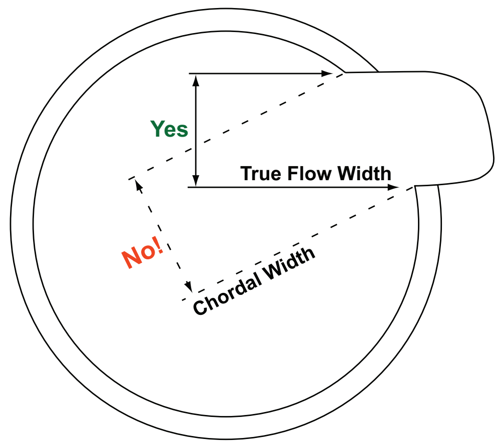
DUCT TOP: Distance in Millimeters from top of piston at TDC to top of transfer port. This is **W** in Diagram 8 on the right.

Diagram 5, Transfer Duct Dimensions



S Transfer Duct Length
T Effective Entrance Area

Diagram 6, *Effective Flow* Port Width



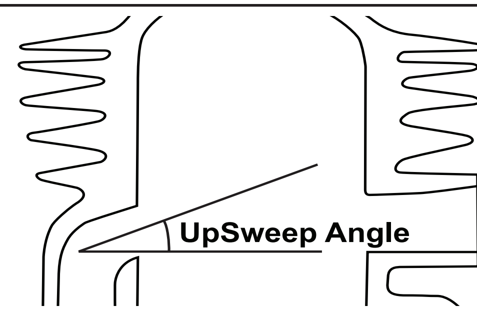
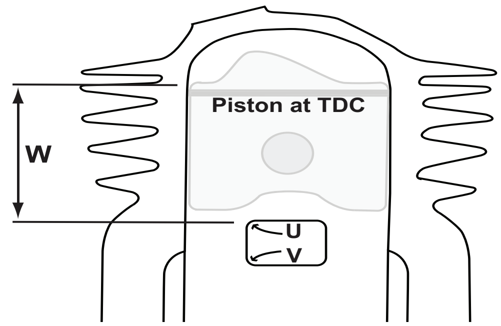


Diagram 7, Transfer Duct Up-Sweep Angle

Diagram 8, Discharge-Port Dimensions



U Top Discharge Radius
V Bottom Discharge Radius
W TDC To Top Of Discharge

EXHAUST PORT SPECIFICATIONS

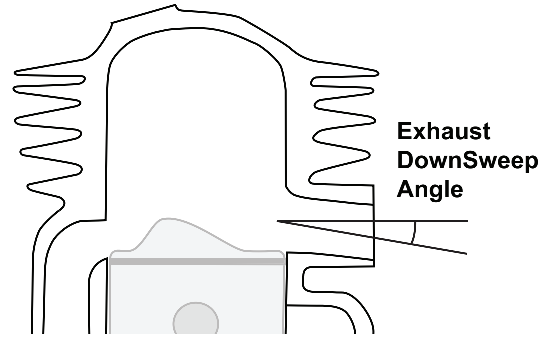


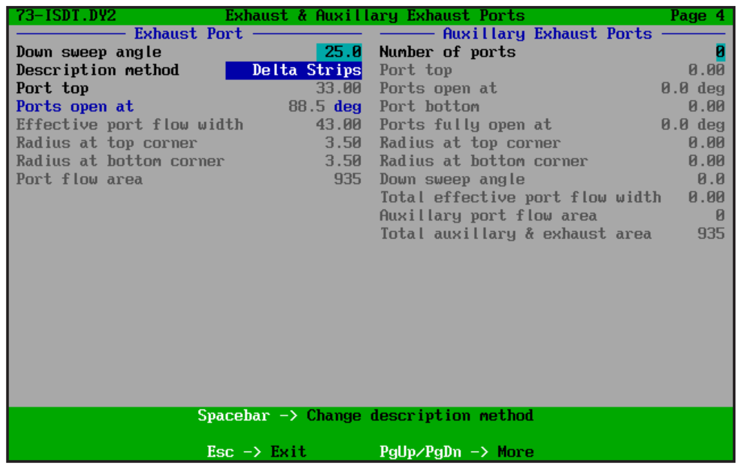
Diagram 9, Exhaust Port Down-Sweep Angle

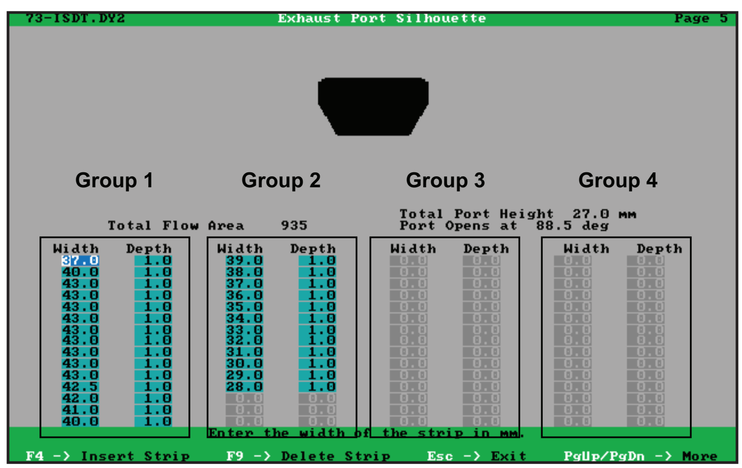
DOWN SWEEP ANGLE: Effective angle (in degrees) at which the exhaust port discharges flow from the cylinder as measured from a horizontal baseline (90-degrees from the cylinder bore centerline). See *Diagram 9*, on the right.

DESCRIPTION METHOD: Dynomation incorporates two methods of describing the exhaust port shapes for the simulation. The ***Effective Width*** method and the ***Delta Strip*** method. If the exhaust port is a simple rectangular shape with typical corner radii, then the ***Effective Width*** method will work well. If the exhaust ports in your engine have a more complicated shape, the ***Delta Strip*** method can be used to "build-up" a the port shape using horizontal "strip" segments of variable width and thickness.

Switch to the exhaust-port definition method on page 4 of the **SIMULATION Edit** screen. Press the **Space-Bar** to toggle the *Description Method* field between ***Effective Width*** and ***Delta Strips*** methods.

When the ***Delta Strips*** method is selected, **PageDown** to Screen 5 to view a table of four groups of two columns each, each containing 15 rows (90 total entry pairs). Use each pair of data fields to define one "strip" of the port (start in Group 1). When you have defined the first port strip measurements in Millimeters, press **Enter** to move down the columns one row at a time. When the first Group is full, you will be directed to the top of the next two columns (Group 2) to continue your data entry. Up to 90 strips can be defined. If you wish to **INSERT** data at any place in the table, position the highlight in the row **ABOVE** the insertion point. When you press **F4**, a new row will be inserted (and initially loaded with the same values as the previous row). You can delete any row with the **F9** key. And use the **Cursor Arrow** keys to move through the table to access any values. Press **Esc** to leave this screen and save or abandon any data entered.





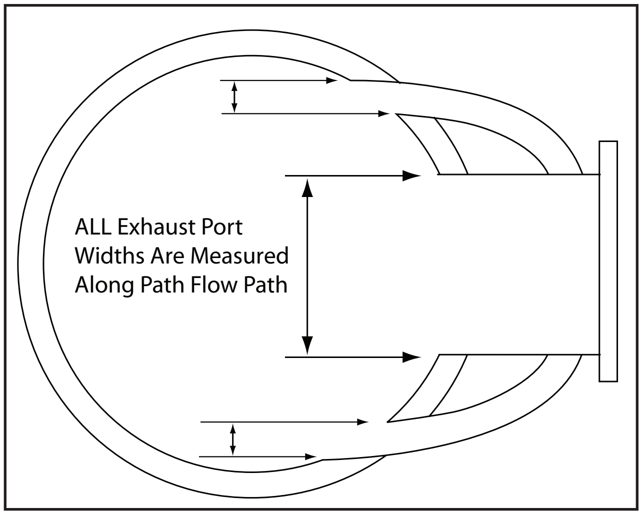
If you select the *Delta Strips* method of defining exhaust-port shape (on *SIMULATION Edit* Screen page 4), *PageDown* to view a table of four groups of two columns each in 15 rows (90 total). Here you can define the shape of any exhaust port by entering a series of "strip" descriptions in each row pair (start in the left two columns). This S-shaped exhaust port was defined in 27 strips, each 1mm high. Rows can be added using the *F4* function key, deleted with the *F9* key, and by using the *Cursor Arrow* keys, you can move through the table to edit any values. Press *Esc* to leave this screen and save or abandon any change.

IMPORTANT NOTE: If the exhaust port includes a "bridge," simply subtract the bridge width from the values entered for those strip widths. Also keep in mind that the true, effective flow width is often determined by a width slightly smaller that the actual port width (due to port tapering at the exist).

PORT TOP: The top of the exhaust port is a measurement of the distance from top of the piston at TDC to the top of the port opening in Millimeters. This data value can only be entered when the **Effective Width** mode of exhaust port description is used (see **DESCRIPTION METHOD**, above).

EFFECTIVE PORT WIDTH: This is the effective exhaust port flow width in Millimeters. This data value can only be entered when the **Effective Width**

mode of exhaust port description is used (see **DESCRIPTION METHOD**, above).
IMPORTANT NOTE: Measure *EFFECTIVE* exhaust port widths along flow axis. See illustration at right.



RADIUS AT TOP: Radius of upper exhaust-port corners in Millimeters. This data is required when **Effective Width** mode is used (see **DESCRIPTION METHOD**, above).

RADIUS AT BOTTOM: Radius of lower exhaust-port corners in Millimeters. This data is required when **Effective Width** mode is used (see **DESCRIPTION METHOD**, above).

AUXILIARY EXHAUST PORT SPECIFICATIONS

NUMBER OF (AUXILIARY) EXHAUST PORTS: The number of auxiliary exhaust ports used per cylinder. For most engines, this is two.

PORT TOP (Of Auxiliary Port): The the auxiliary exhaust Port Top is a measurement of the distance from top of the piston at TDC to the top of the port opening. This data is required when the **Effective Width** mode of exhaust port description is used (see **DESCRIPTION METHOD**, above, and *Diagram 2*, on page 37).

PORT BOTTOM (Of Auxiliary Potr): The auxiliary exhaust port bottom is a measurement of the distance from top of the piston at TDC to the bottom of the port opening. This data is required when the **Effective Width** mode of exhaust port description is used (see **DESCRIPTION METHOD**, above, and *Diagram 2*, on page 37).

RADIUS AT TOP CORNER (Of Auxiliary Port): This is the radius of the upper corners of the auxiliary exhaust ports. This data value is required when the **Effective Width** mode of exhaust port description is used (see **DESCRIPTION METHOD**, above, and *Diagram 2*, on page 37).

RADIUS AT BOTTOM CORNER (Of Auxiliary Port): This is the radius of the lower corners of the auxiliary exhaust ports. This data is required when the **Effective Width** mode of exhaust port description is used (see **DESCRIPTION METHOD**, above, and *Diagram 2*, on page 37).

DOWN SWEEP ANGLE (Of Auxiliary Port): Enter the down sweep angle (in Degrees) of the auxiliary exhaust ports.This data value can only be entered when the **Effective Width** mode of exhaust port description is used (see **DESCRIPTION METHOD**, above, and *Diagram 9*, on page 40).

EFFECTIVE FLOW WIDTH (Of Auxiliary Port): This is the effective auxiliary exhaust-port flow width. This data value is required when the **Effective Width** mode of exhaust port description is used (see **DESCRIPTION METHOD**, above).
IMPORTANT NOTE: All EFFECTIVE port flow widths are measured along the flow axis. See illustration at top of this page and *Diagram 6*, on page 39.

EXPANSION-CHAMBER SPECIFICATIONS

SIMULATION MESH SIZE: In order to trace a pressure wave though ducting, it is necessary to partition the duct into segments of equal lengths. These partitioned segments are called a ***mesh***.
IMPORTANT NOTE: *DynomationTwoStroke was calibrated with a mesh length of 10mm.* The only reason to use a different mesh length would be to model an engine with very long or very short intake and exhaust duct

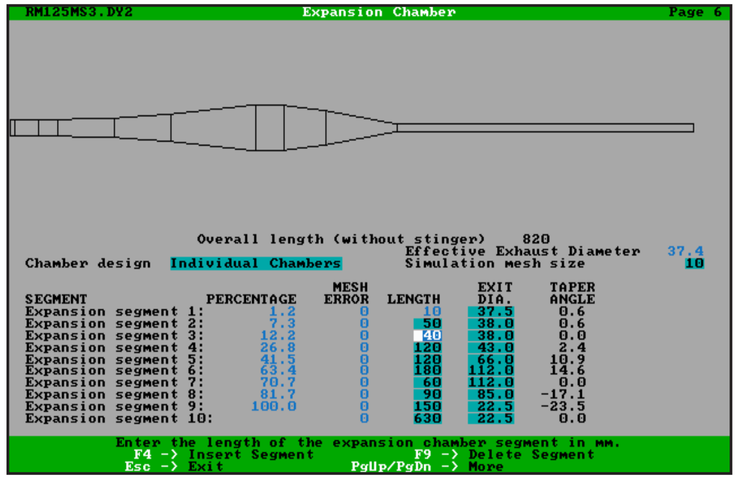
lengths. In those unique cases, you will have to validate the simulation on your own with a known good combination to determine what new mesh length will produce accurate results. Bottom line: Stick with 10mm unless you have data on hand to do simulation validation testing.

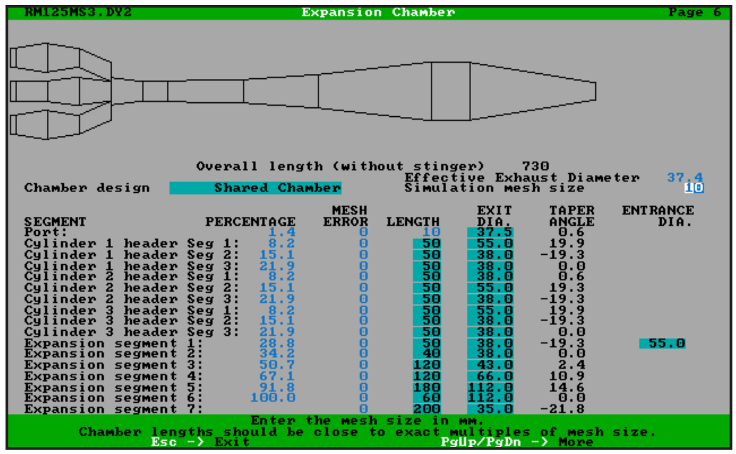
Also keep in mind that the mesh length is directly related to the TIME it takes for the simulation to complete an analysis. A mesh length of 5 will take twice as long; a mesh length of 20 will take half the time.

EXHAUST CHAMBER DESIGN: Use the **SpaceBar** to select an exhaust configuration of **Iindividual Chambers** for each cylinder or select **Shared Chambers** where all cylinders share a single expansion chamber.

LENGTH: Enter the length of each individual pipe segment in Millimeters.

IMPORTANT NOTE: For best results when designing chambers ensure that each of the sections are evenly divisible by the mesh length (10mm). For example a 100mm pipe section is evenly divisible by the 10mm mesh, whereas, a 105mm section will leave 5mm outside the pressure array in the simulation (can cause simulation halts and reduces accuracy). As an aid to prevent these errors, DynomationTwoStroke displays a calculated **MESH ERROR**. Before you run the simulation, make sure that all **MESH ERROR**s are zero (see **MESH ERROR**, below).





Two types of Exhaust Chamber pipe designs can be modeled in DynomationTwoStroke: *Individual Chambers* where each cylinder has its own, independent exhaust system, or *Shared Chambers* where all cylinders share a single expansion chamber. Setup screens for both types of exhaust systems include calculated PERCENTAGE, MESH ERROR, TAPER ANGLE, and ENTRANCE DIAMETER. See the text for more information about these values.

MESH ERROR (calculated value): The mesh error calculated by the simulation when entering exhaust system specifications.

IMPORTANT NOTE: The length of each pipe section should be evenly divisible by the mesh length (default 10mm). Before you run the simulation, adjust pipe section lengths to ensure that all calculated **MESH ERROR**s are zero (otherwise, the simulation may halt, or overall accuracy may be reduced).

EXIT DIAMETER: The exit diameter in Millimeters of each pipe section in the exhaust system.

PERCENTAGE (calculated value): These values can be helpful if you need to locate problems that develop during the simulation of the pressure waves in the expansion chamber. During a simulation run, **%EO to EC** is calculated and displayed in the table on the right of the Simulation Progress screen. When you see possible problems in the **EXHAUST** pressure or velocity traces in the crank-angle graphs, note the corresponding **%EO to EC** value (press **Esc** [pauses the Sim] any time during the simulation process to study intermediate results). Compare the **%EO to EC** with the **PERCENTAGE** value calculated on the Expansion Chamber Screen. Matching percentages point to the problem section.

TAPER ANGLE (calculated value): This is the calculated taper angle of the individual sections. The value is an included angle (angle created by the convergence or divergence of the two conical sides).

Simulation Outputs

Power: Power is displayed in Horsepower as defined by the standard Imperial Unit system. Dynomation TwoStroke assumes that ambient conditions are 68 degrees F, zero humidity, and zero altitude.

Torque: Torque is displayed in lb-ft (pound-force-feet), as defined by the standard Imperial Unit system. Simulation assumes that ambient conditions are 68 degrees F, zero humidity, and zero altitude.

BSFC: Brake Specific Fuel Consumption. Displayable in both Imperial (lb/hp-hr) and Metric (g/Kw-hr) units. BSFC is the rate of fuel consumption divided by the power produced; it measures the efficiency at which fuel is converted to power. BSFC allows the fuel efficiency of different engines to be directly compared.

Pumping MEP: Pumping Mean Effective Pressure (also PMEP). There is a whole family of MEP values and these can be confusing. In nutshell, the PMEP is the average pressure in the crank case working against the engine (reduces power output). The engine must physically compress the charge in the crankcase as the piston moves down the bore. And this requires power to accomplish. As the piston moves up the bore, the drop in pressure produced in the crankcase draws in fresh charge, and this also consumes power. To calculate the power lost by PMEP in a two-stroke engine, use the following formula:

$$\text{Pumping Horsepower} = \frac{\text{Displacement} \times \text{RPM} \times \text{PMEP}}{396{,}000}$$

Where, Displacement is in cubic inches, and PMEP is in psi (pounds per square inch).

Piston Speed: This calculated result is the *average piston speed* at the rpm being tested. Engine developers use this data to help determine peak engine speeds and to evaluate whether the engine would be producing peak power at an RPM that significantly reduces reliability.

Peak Cylinder Pressure: This simulation result can be used as a rough guide to determine fuel requirements and provides an indication of when detonation might occur.

Trapped Pressure Ratio: This is the *Cylinder Pressure Ratio* exactly at the moment of exhaust-port closing. This value is important because excessive trapped pressure usually indicates that the expansion chamber has shoved too much hot residual exhaust gas back into the cylinder. The added heat often contributes to detonation. Watch this value closely, and use your best judgement to decide if exhaust ducting needs to be modified.

IMPORTANT NOTE: The following terms can be difficult to understand, yet mastering them can substantially improve your ability to get the most from simulations performed using DynomationTwoStroke. The following brief descriptions will help you get started working with these variables. Consult two-stroke engine design books for details about these important concepts.

Delivery Ratio: This is the mass of fresh charge delivered to the cylinder (**Mfad**) divided by the mass of fresh charge that would just fill cylinder displacement at ambient pressure, excluding combustion-chamber volume (**Mfc**).

DR= Mfad/Mfc
DR is the same concept as volumetric efficiency (**VE**) in a four-cycle engine.

%EO to EC: Percentage of current progress through the exhaust-port-open phase, the duration of which ranges from **EO** (Exhaust Opening) to **EC** (Exhaust Closing). A value of 50% is equivalent to the middle of the exhaust phase. This value is useful in diagnosing Expansion Chamber and Pipe pressure issues, see **PERCENTAGE** on page 42.

Trapping Efficiency: This defines the percentage of fresh charge that remains inside the cylinder after the exhaust port closes. Some of the fresh charge will be drawn through the cylinder and lost with exhaust flow ("short circuits" through the engine) while the exhaust port is open. This number indicates the percentage remainder of fresh charge that flowed into the cylinder. It is calculated through the following equation:

TE = Mfar/Mfad

Where, **Mfar** = Mass of fresh charge remaining, and
Mfad = Mass of fresh charge delivered.

Scavenging Efficiency: The fresh charge remaining in the cylinder (Mfar) at exhaust port closing will be mixed ("spoiled") with remaining exhaust gases. The scavenging efficiency is the percentage of the mass of fresh charge that remains in the cylinder compared to the total mass of all products in the cylinder. It is essentially the ***Purity*** of the charge in the cylinder.

SE = Mfar/(Mfar + Mreg)

Where, **Mfar** = Mass of fresh air remaining, and
Mreg = Mass of remaining exhaust gas.

Charging Efficiency: For all practical purposes, this value is the most important engine analysis variable. **Charging Efficiency** is similar to the **Delivery Ratio** discussed earlier, except that it uses the mass of fresh charge remaining (**Mfar**) instead of the mass of fresh charge delivered (**Mfad**). In addition, instead of just using the mass required to fill the cylinder a reference mass, it also includes the mass required to fill the combustion chamber. Essentially, this indicates how much of fresh charge is present in the cylinder at when the exhaust port closes.

CE = Mfar/(Mfc + Mfcc)

Where, **Mfar** = Mass of fresh charge remaining,
Mfc = Mass of air required to fill the displacement volume, and
Mfcc = Mass of charge required to fill the combustion chamber volume.

DYNOMATION ENGINE SIMULATION
Professional Wave-Action Simulation

WAVE DYNAMICS THEORY

If you read the previous chapters, you've discovered some of capabilities of DynomationTwoStroke and its ability to model gas dynamics in the two-stroke IC (Internal Combustion) engine. This chapter takes you deeper into the theory of finite-amplitude waves and offers help in interpreting wave-dynamic results from the simulation.

THE IC ENGINE: AN UNSTEADY FLOW MACHINE

The air-fuel mixtures and exhaust gasses that move within the passages of the internal-combustion (IC) engine behave in an *unsteady* manner. The gases are constantly changing pressure, temperature, and velocity throughout the two-cycle processes. For example, when the intake port is closed, the gas velocity at the port is zero. When the port begins to open, a difference in pressure between the cylinder and the port begins to accelerate gas particles into (or out of) the cylinder. This gas motion—and all other gas particle motion within the engine—starts and stops, squeezes and decompresses, heats up and cools down. To analyze and simulate these actions, designers and programmers rely on the discipline of *Unsteady Gas Dynamics*. A basic knowledge of this subject and the ability to visualize wave interactions (and calculate them using simulations) inside the IC engine is probably the single most important "tool" available to the modern engine builder.

The application of Unsteady Gas Dynamics does not require that we cover the development of gas-flow equations (thank goodness!!), but a general description of the mechanisms that apply to the IC engine are essential.

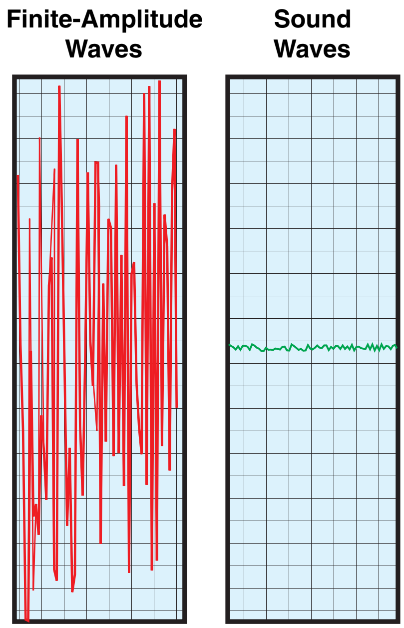
Acoustic Waves Vs. Finite-Amplitude Waves

The sounds we hear around us are actually small pressure disturbances in the air. We call these pressure "pulses" *acoustic waves*. The pressure amplitudes (equivalent to volume) of these waves is very small. As an example, the volume at which you will begin to experience pain from sound occurs around 120 decibels and creates a peak pressure of only 0.00435psi above the ambient, undisturbed air. Since sea-level air pressure (barometric pressure) is about 14.7psi, then the *pressure ratio* at which sound becomes painful is:

Pr = P / Pa
where
P = 14.7 + 0.00435 Psi
Pa = 14.7 Psi
so:
Pr = 14.70435 / 14.7
Pr = 1.0003 or a 0.03% Increase In Pressure

That is a pressure ratio increase of three one-hundredths of one percent increase over atmospheric pressure!

Obviously, very "loud" acoustic waves create very small pressure disturbances. There are waves that produce substantially higher pressure ratios than even loud sound waves. These powerful energy-charged waves are called *finite-amplitude waves*. Pressure disturbances at these higher intensities can be found in the induction and exhaust passages of the IC engine. Remarkably, pressure ratios of 2.5 can be readily measured (that's a pressure ratio almost 10,000 times greater than painfully loud sound waves—certainly something you would never want to "hear"). This enormous difference in intensity between acoustic and finite-amplitude waves gives some insight into why the misnomer "acoustic theory" (still commonly used) for calculating optimum "tuned lengths" of intake and exhaust passages is misapplied (more on this later).



Finite Amplitude Waves In IC Engine Are 10,000 Times Stronger Than Sound Waves

Very loud acoustic waves create small pressure disturbances. *Finite-amplitude waves* found in the IC engine, however, create pressure disturbances 10,000 times greater than even painfully-loud sound waves. Because of this huge difference in amplitude, finite-amplitude waves exhibit their own, unique characteristics, requiring a radically different mathematical analysis than sound waves.

Compression And Expansion Waves

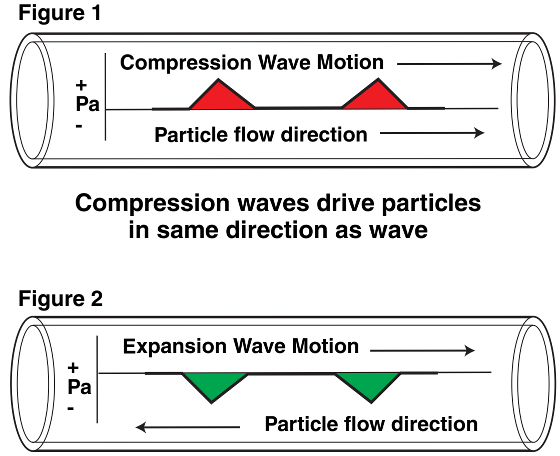
Finite-amplitude waves take two forms within the IC engine: *Compression* and *Expansion*. The *Compression* wave is a positive pressure disturbance that will always have a pressure ratio greater than one. The *Expansion* wave is a strong drop below ambient pressure, and therefore will always have a negative pressure ratio (less than one). Expansion waves are known by other names, such as "rarefaction waves" or "suction waves," however, they all refer to the identical phenomenon.

Compression and expansion waves act in similar—but uniquely different—ways as they move through IC engine passages. Understanding how these waves move and how they interact with their surroundings is an important part of understanding how gasses move inside the IC engine. The first piece of the puzzle is illustrated in **Figure-1**. This drawing depicts a positive compression wave traveling from left to right through a pipe. As the pressure waves travel rightward, they drive gas particles in the same rightward direction. However, the velocity of the gas is considerably slower than the speed of the pressure waves. There are many analogs to this in everyday life. For example, consider logs that are pushed ashore by waves on the surface of a lake. The waves wash through floating logs driving them forwards but at a much slower rate than the speed of the waves.

An expansion wave is shown in **Figure-2**. This low-pressure wave is also traveling from left to right. However, as it passes through gas particles, its lower pressure gradient draws particles toward the wave, in effect, driving particle flow in the *opposite* direction, in this case, leftward.

In addition, both compression and expansion waves change their character when they encounter sudden transitions in area. Area changes within engine ducting occur at an open end, a closed end, or at transition to smaller or larger diameter passages. Perhaps the most familiar area change occurs at the Expansion Chamber where a primary exhaust tube rapidly transitions into a much larger flow area. Beyond this very visible transition, there are many other area changes in engine ducting. For example, where the intake runner transitions into the

Figure 1

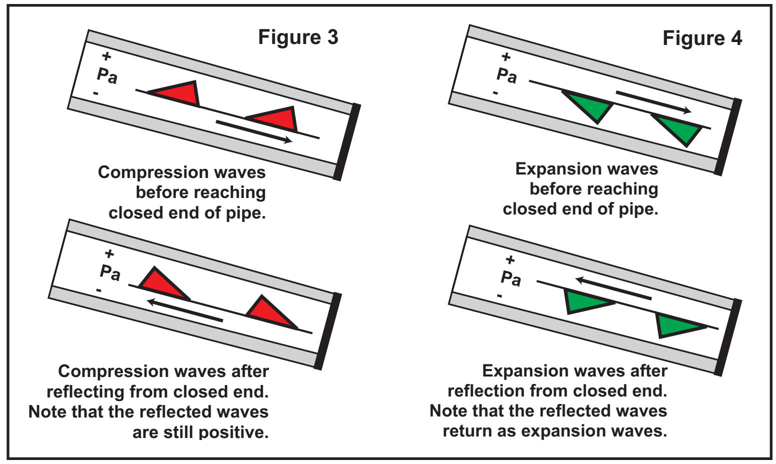


Compression waves drive particles in same direction as wave

Expansion waves drive particles in opposite direction of wave

As positive compression waves travel from left to right through a pipe (top), they drive gas particles in the same rightward direction. When expansion waves (lower) travel from left to right, they pass through gas particles in the pipe and propel them in the *opposite* direction, in this case, leftward.

atmosphere a substantial area change occurs. In addition, the intake and exhaust ports are located at one end of a “pipe” that is either closed or partially open depending on piston or valve location. What happens when a finite-amplitude wave reaches one of these area transitions?

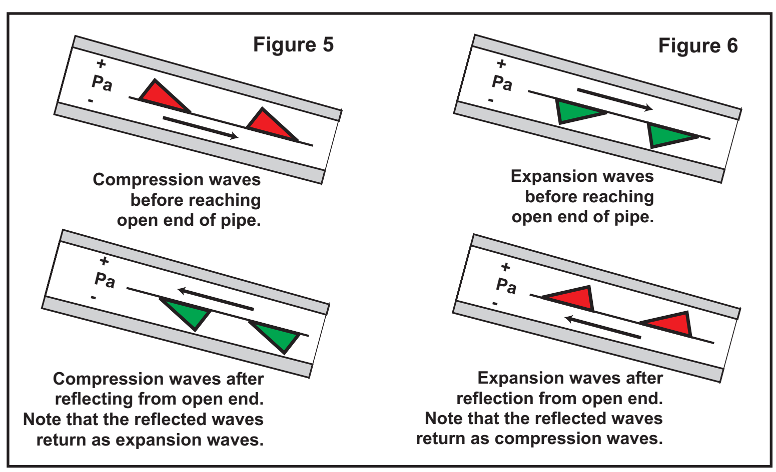


Positive pressure compression waves striking the closed end of a passage return with their original profile intact. Expansion waves behave similar to compression waves. Net particle motion is zero.

First, let’s examine a case where pressure waves reach the closed end of a pipe. **Figure-3** illustrates a positive-pressure compression wave striking the closed end of a passage. It returns with its original profile intact. The only change is that the pressure wave is now moving in the opposite direction. Consider how this affects gas particle motion. When the compression wave travels rightward, it nudges the gas particles toward the right. After reflection, the compression wave nudges the particles leftward. The gas particles are returned to their original position; there is no net flow in the pipe. This is exactly what you would expect to find in a pipe that is closed at one end! **Figure-4** depicts an expansion wave as it travels rightward within the same closed-end pipe. Similar to a compression wave, the reflected leftward moving wave remains an expansion wave with the same profile. Net particle motion is, again, zero.

Now let’s explore the interesting actions of finite-amplitude waves as they move within an open-end pipe. **Figure-5** shows the arrival of a compression wave at a transition to a larger area. Notice that *rightward-moving* compression wave is reflected as a *leftward-moving expansion wave*. This has fascinating implications for particle movement. Initially, while the compression wave traveled leftward, it helped propel gas particles in the same rightward direction, toward the pipe end. When the expansion wave is created at the open end of the port and it begins leftward movement, it continues to drive particles in the rightward direction (because expansion waves move particles in the opposite direction of wave travel). *Finite-amplitude compression waves moving toward the open end of a pipe provide a “double assist” to particle movement in the same direction.* Now consider the same open-end pipe, but this time a rightward moving *expansion* wave is illustrated in **Figure-6**. As the expansion wave approaches the open end, it moves particles in the opposite direction, away from the end of the pipe. When the expansion wave reaches the pipe end, it is reflected as a compression wave and moves leftward, driving particles in the same leftward direction. S*o expansion waves “double-assist” particle movement away from the open end of the pipe.*

These pressure-wave phenomena, particularly as they apply to the exhaust system, were not understood until the 1940s. Until that time, it was assumed that a high-pressure gas-particle “slug” moved through the header pipe and created a vacuum behind it that helped to draw out residual gases. This “Kadenacy” theory—named after its inventor—is analogous to the compression waves traveling through a “Slinky™” coil-spring toy; a tight group of coils (representing high pressure waves) moves along the spring followed by an open group of coils (representing low-pressure waves). Despite the fact that this theory was conclusively proven to be incorrect over 60 years ago, it is still believed by some engine “experts” to this day!



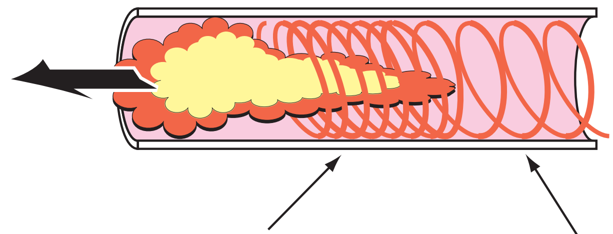
A rightward-moving compression wave is reflected as a *leftward-moving expansion wave* when it reaches the open end of a pipe (figure 5). Particle movement is rightward in both cases. A rightward moving expansion wave is reflected as a *leftward-moving compression wave* (figure 6). Particle movement is leftward in both cases.

Pressure Waves And Engine Tuning

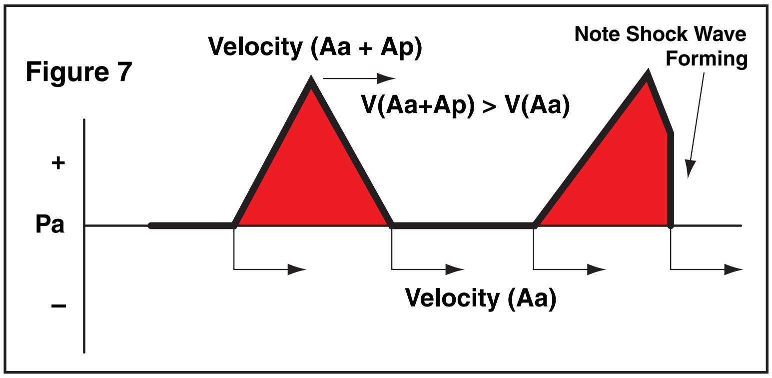
The goal of the high performance engine builder is to tune the lengths of IC engine passages so that the reflected waves reach the cylinder at the most effective times, either assisting exhaust-gas outflow or induction-charge inflow. If there ever was a statement that qualified for the adage "easier said than done," then this is it! There are many factors that affect the arrival of these waves. A short list would include valve timing, cam profiles, piston speed, pipe lengths, valve discharge coefficients, and cylinder blowdown pressures. To make matters worse, the peaks of finite amplitude waves travel faster than the base of the waves, causing wave profiles to distort as they travel through engine passages (see **Figure-7**). This can ultimately cause the waves to "tumble" over themselves, forming shock waves and converting their energy into heat. All of these complex interactions occur simultaneously and make it easy to see why the simple *acoustic* formulas that engine builders have traditionally used to determine "tuned lengths and pipe diameters" are not applicable.

There are only two practical methods to determine effective pipe lengths and diameters. One is to build the engine, install it on a dyno, connect pressure-reading transducers to the intake and exhaust passages and cylinders and record pressure data. By analyzing these pressure signatures and running a series of tests with various component combinations, the engine builder can develop an effective engine for the desired purpose. The problem with this method is the associated high costs in time and money. Another method of finding effective pipe lengths and "zeroing in" on optimum component combinations is to *simulate* the pressure waves and particle flow that occurs within the IC engine.

Incorrect "Kadenacy" Theory For Exhaust Gas Dynamics



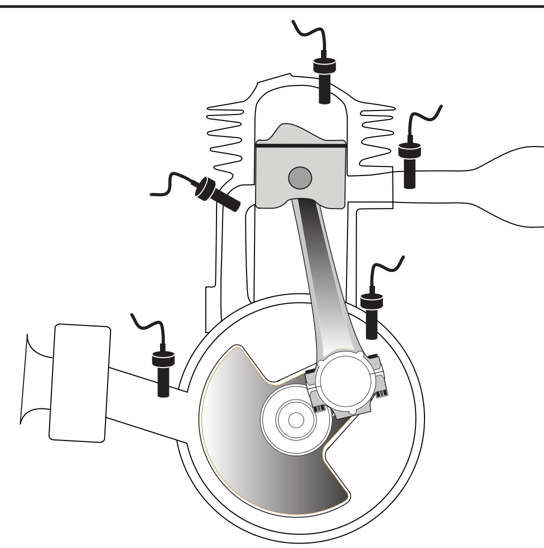
In an effort to explain gas flow in the exhaust system, it was believed that when the exhaust valve opened, a high pressure "slug" of gas blasted out of the port and down the header pipe. As this pluse moved, it created a low-pressure "wave" behind it. This *Kadenacy* theory was conclusively disproved nearly 60 years ago. Despite this, it is still believed by some "experts" to this day!



The peaks of finite amplitude waves travel faster V(Aa + Ap) than the base of the waves (Aa) acoustic velocity, causing wave profiles to distort as they travel through engine passages. This can ultimately cause the waves to "tumble" over themselves forming shock waves and converting their energy into heat.

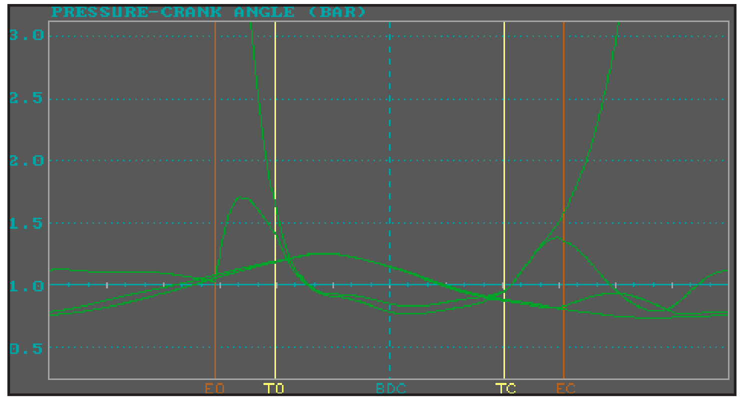
Pressure-Time Histories

The direct measurement of engine pressures can reveal a great deal about engine function. An analysis of engine pressures—throughout the two-cycle process—reveals the combined effects of all mechanical components, plus the thermodynamic effects of heat transfer, the results of all finite-wave interactions, and mass flow of induction and exhaust gasses within the engine. The measurement of these pressures and velocities requires the precise placement of transducers in the



Engine pressures can be directly measured with special transducers precisely positioned in the intake, transfer and exhaust passages and directly in the cylinder. Intake and exhaust transducers are often located near the ports. The cylinder pressure transducer is located in the cylinder head, protruding into the combustion chamber.

intake and exhaust passages and directly in the cylinders of the engine. The intake, transfer and exhaust sensors are often positioned close to the ports. A cylinder pressure transducer is located in the cylinder head, protruding into the combustion chamber. The typical pressures recorded by these transducers are illustrated on the **Simulation Progress Screens** in DynomationTwoStroke (see photo on right).



This is one of the displays shown on the Simulation Progress Screen. It is referred to as a *pressure crank-angle graph* or *pressure-time-history diagram*. The zero crank degree point is located on the left of the graph (it is TDC just before the power stroke). The first vertical line indicates Exhaust Port Opening point (EO, Red), Transfer Port Opening (TO, Yellow) follows then Transfer Port Closing (TC, Yellow) and finally the last vertical line marks Exhaust Port closing (EC, Red). The dotted blue line in the center of the graph marks BDC after the power stroke. The crank-angle diagram ends at 360 degrees with the piston back at TDC, at the end of the compression stroke.

This results plot is referred to as a pressure crank-angle graph or pressure-time-history diagram. The horizontal axis displays the crank position throughout the 2-cycles from 0-360 degrees. The zero point on the left of the graph starts at TDC just before the power stroke. Moving rightward, the first vertical line (Red) indicates the Exhaust Port Opening point (**EO**), typically occurring around 95 crank degrees. Continuing rightward, the next vertical line pinpoints Transfer Port Opening (**TO**) around 115 degrees. Transfer Port Closing (**TC**) occurs about 245 degrees. Finally, the last vertical line marks Exhaust Port closing (EC) around 265 degrees. The crank-angle diagram ends at 360 degrees with the piston back at TDC, marking the end of the compression stroke. The vertical axis of the diagram indicates pressure ratio (or *Bar*). A value of 1.0 represents standard atmospheric pressure (Pa). A value below this indicates sub-atmospheric pressure or *expansion* waves. Values above 1.0 are positive pressures above atmospheric and represent *compression* waves.

DynomationTwoStroke
Graph Keystroke Summary

F2..Turn List Boxes On and Off, Except for Screen 3

F2 Twice..Re-draw The Graph

F5..Go to Graph SETUP Screen

F6..Switch Between Graph Screens 1, 2 and 3

F9..Zoom In To Zoom Box Dimensions

F10..Zoom Out Step By Step

SHIFT-F10...Zoom Out To Standard Magnification

Ctrl Arrow-Keys...Move the Zoom Box

Esc..Return to Main Program Screen

SpaceBar...Tag or Un-Tag (Graph Data of Tagged Items)

S.. Slow Marker-Line Movement, Graph Screen 1 and 2

F..Speed Up Marker-Line Movement, Graph Screen 1 and 2

M........... Anchor/Un-Anchor a Marker, Read Differential Values, Graph Screen 1 and 2

+ or **-**... Move Value Line Left And Right

Alt Left or **Alt Right**...Move Value Line (same as + or -)

Shift + or **Shift -**... Fix Value Line, Increase/Decrease RPM

Shift Alt Left or **Shift Alt Right**........ Fix Value Line, Change RPM (same as Shift + or -)

Ctrl-C............................Change color of highlighted Filename and Comparison Values