ProRacing Sim, LLC.

DynoSim

Racing Software

Advanced
Engine
Simulation

Users Guide

And Engine Builder's Handbook

For Windows95/98/Me/2000/XP

ProRacing Sim, LLC.
3400 Democrat Road, Suite 207
Memphis, TN 38118

For Tech Support Contact: 901-259-2355
Web: www.ProRacingSim.com
Email: support@proracingsim.com

DynoSim Simulation v4.11, 6/04 Release 1

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ProRacing Sim, LLC.
3400 Democrat Road
Memphis, TN 38118

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Lance Noller, Lead Programmer. A special thanks for his dedication to the DynoSim project. His programming skills, tenacious troubleshooting and creative problem solving made the DynoSim reliable and easy-to-use.

Curtis Leaverton, Simulation Designer. Curtis Leaverton developed the simulation used in DynoSim. His engine computer simulations have changed the way performance enthusiasts approach engine building.

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. Developed new mathmatical models for the DynoSim, and is principal architect of FastLapSim.

Trent Noller, Marketing/Sales Manager. Trent excels at problem solving and there were more than a few problems that required his creative skills during the development and deployment of the DynoSim. My friend for many years, Trent Noller was, in may ways, responsible for the success of this project.

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Ron Coleman, His enthusiasm for this software and the building of an outstanding marketing network made this entire project possible.

"Scooter" Brothers, He was the first to see special value in simulation software. A multi-talented engineer and camshaft expert, Scooter's insight and dedication to excellence is greatly appreciated.

And thanks to the many other individuals who have contributed to the successful development and marketing of this software.

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

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INTRODUCTION

Note: *If you can't wait to start the DynoSim™, feel free to jump ahead to* **INSTALLATION** on page 10, *but don't forget to read the rest of this manual when you have time. Also, make sure you mail in your registration card—it entitles you to receive a* ***FREE Resource CD****, upgrades, and other information and support.*

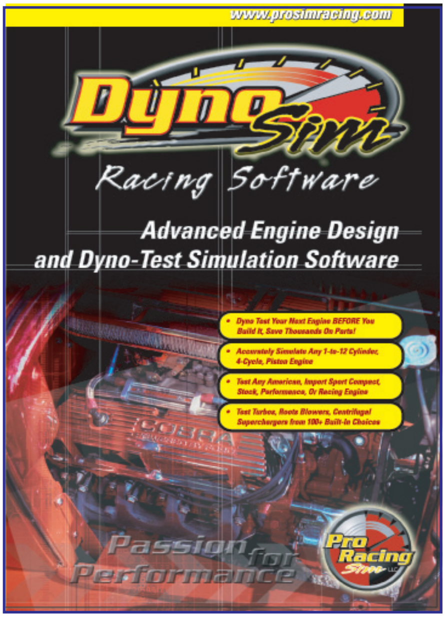
Thank you for purchasing the DynoSim™ for IBM®-compatible computers. This software is the result of several years of development and testing. We hope it helps you further your understanding and enjoyment of engines, performance, and racing technology.

HOW IT WORKS

The DynoSim is a Windows95/98/Me/2000/XP, 32-bit program based on the *Filling-And-Emptying* method of engine power simulation. We chose this family of mathematical models because of their excellent power prediction accuracy and fast processing times. The DynoSim is a *full-cycle* simulation. This means that it calculates the complete fluid-dynamic, thermodynamic, and frictional conditions that exist inside each cylinder throughout the entire 720 degrees of the four-cycle process.

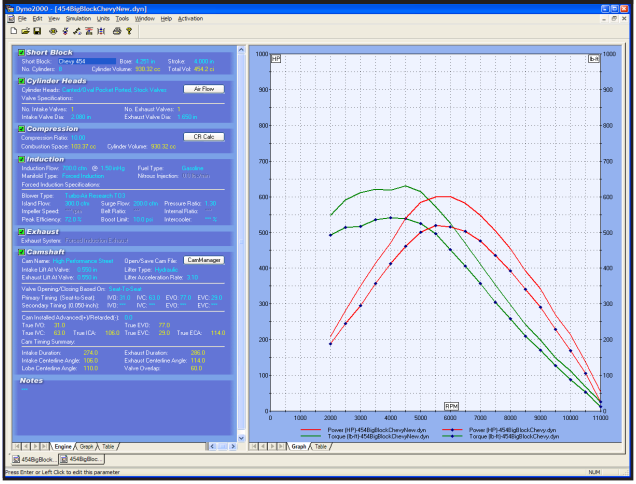
You will find that many other simulation programs on the market (even a few that sell for several times the price of the DynoSim) are not true engine *simulations*. Rather, they calculate the volumetric efficiency (VE) and then derive an estimate of torque and horsepower. There are many shortcomings to this

The DynoSim is the most advanced engine simulation ever offered to the performance enthusiast. It combines ease of use, rapid calculation times, powerful Iterative Testing™, and detailed graphics.



Introduction To The DynoSim

DynoSim Main Component Screen



Dyno2000 - [454BigBlockChevyNew.dyn]

Short Block
Short Block: Chevy 454 Bore: 4.251 in Stroke: 4.000 in
No. Cylinders: 8 Cylinder Volume: 930.32 cc Total Vol: 454.2 ci

Cylinder Heads
Cylinder Heads: Canted/Oval Pocket Ported, Stock Valves
Valve Specifications:
No. Intake Valves: 1 No. Exhaust Valves: 1
Intake Valve Dia: 2.080 in Exhaust Valve Dia: 1.650 in

Compression
Compression Ratio: 10.00
Combustion Space: 103.37 cc Cylinder Volume: 930.32 cc

Induction
Induction Flow: 700.0 cfm @ 1.50 inHg Fuel Type: Gasoline
Manifold Type: Forced Induction Nitrous Injection: 0.0 lbs/min
Forced Induction Specifications:
Blower Type: Turbo-Air Research T03
Island Flow: 300.0 cfm Surge Flow: 200.0 cfm Pressure Ratio: 1.30
Impeller Speed: *** rpm Belt Ratio: *** Internal Ratio: ***
Peak Efficiency: 72.0 % Boost Limit: 10.0 psi Intercooler: *** %

Exhaust
Exhaust System: Forced Induction Exhaust

Camshaft
Cam Name: High Performance Street Open/Save Cam File: CamManager
Intake Lift At Valve: 0.550 in Lifter Type: Hydraulic
Exhaust Lift At Valve: 0.550 in Lifter Acceleration Rate: 3.10
Valve Opening/Closing Based On: Seat-To-Seat
Primary Timing (Seat-to-Seat): IVO: 31.0 IVC: 63.0 EVO: 77.0 EVC: 29.0
Secondary Timing (0.050-inch): IVO: *** IVC: *** EVO: *** EVC: ***
Cam Installed Advanced(+)/Retarded(-): 0.0
True IVO: 31.0 True EVO: 77.0
True IVC: 63.0 True ICA: 106.0 True EVC: 29.0 True ECA: 114.0
Cam Timing Summary:
Intake Duration: 274.0 Exhaust Duration: 286.0
Intake Centerline Angle: 106.0 Exhaust Centerline Angle: 114.0
Lobe Centerline Angle: 110.0 Valve Overlap: 60.0

Notes
***

Press Enter or Left Click to edit this parameter

The DynoSim incorporates a clean, intuitive user interface. If you wish to change a component, simply click on the component name and select a new component from the drop-down list. The comprehensive data display graphs are fully customizable. Multiple engine and/or data value comparisons are possible. All components and graphics displays can be printed in full color.

technique. The two greatest drawbacks are: 1) since cylinder pressure is not determined, it is impossible to predict the pressure on the exhaust valve and the subsequent mass flow through the port when the exhaust valve opens, and 2) the inability to accurately determine the pumping horsepower (energy needed to move gasses into and out of the engine) from the predicted horsepower.

Since the DynoSim incorporates both filling-and-emptying *and* full-cycle modeling that includes frictional and pumping-loss calculations, extensive computation is required for each power point. In fact, the program performs several million calculations at each 500rpm test point on the power curve (a full power-curve simulation consists of 41 test points). This in-depth analysis offers unprecedented accuracy over a vast range of engines. The DynoSim has been successfully used to model single-cylinder "lawn mower" engines, light aircraft engines, automotive engines, modern Pro Stock drag-racing powerplants, and multi-thousand horsepower supercharged, nitrous-oxide injected "mountain motors."

WHAT'S NEW IN THE DynoSim

The features in DynoSim include substantial enhancements to simulation modeling, including new short-stroke and small-bore models. The DynoSim will simulate engines with strokes as short as 1.5-inches and bores as small as 2.000-inches. To accommodate engines with short stroke applications, the peak rpm testing speed extends to 14,500rpm.

Another new addition to the DynoSim is a powerful, but easy-to-use *Iterative Testing*™ feature called the ***Quick Iterator***™. An exclusive feature of ProRacing Sim simulations, *Iterative Testing* allows you to automatically perform thousands of dyno tests, keep track of all the results, and locate the best component combination that matches your search criterion. In the past, setting up *Iterative Testing* could be a time-consuming process. Now, the ***Quick Iterator™*** allows one-button testing, making this powerful tool available with a single mouse click!

In addition to these major enhancements, you will find hundreds of other improvements to the DynoSim. In fact, two years of programming and design were devoted to the DynoSim simulation. Updated features include a new, overall (WindowsXP) look, improved menu selections, more airflow and camfiles, a substantially expanded users manual, optional ***ProTool™ Kit™*** described in the next section, and much more.

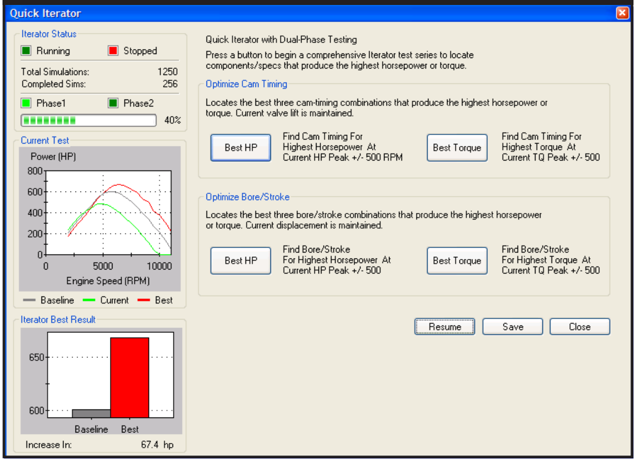
ProTools™ (Optionally Activated) FEATURES

The DynoSim incorporates a set of software "Tools" that can help you perform advanced engine analysis and simulation studies. This ***ProTool Kit™*** can be activated by opening the ***Product Activation*** menu in the DynoSim and following the simple steps described on the activation screen. The ***ProTool Kit*** contains the following features:

- The ***ProIterator™:*** A comprehensive ***ProTool*** for serious horsepower seekers. While the *Quick Iterator™*—provided with the DynoSim—is powerful and fast, the ***ProIterator*** permits custom testing, evaluation of area under any power or torque curve (in addition to locating peak values), single- and dual-phase Iteration, bore/stroke analysis, comprehensive naturally-aspirated induction testing, and much more. If you're an engine pro, you will find the ***ProIterator*** an indispensable tool in locating the best combination for virtually any application.
- Graph ***DataZones™:*** Let you to set colored ranges on any simulation results graph to mark target power, torque, volumetric efficiency, or values of any other variables. ***DataZones*** also can be used to graphically indicate piston speeds overlaid on torque, horsepower, IMEP, and other rpm-based data-sets. ***DataZones***

***Iterative Testing™* is a powerful feature of the DynoSim. This screen illustrates a test that is evaluating a series of components (over 200 dyno tests were performed). Using this powerful tool it is possible to automatically run thousands or even hundreds of thousands of tests to find the best combinations. The DynoSim keeps track of all the results and displays the best matches to your test criterion.**

DynoSim *Quick Iterator™ Testing*



Total Simulations: 1250
Completed Sims: 256

Increase In: 67.4 hp

Quick Iterator with Dual-Phase Testing

Press a button to begin a comprehensive Iterator test series to locate components/specs that produce the highest horsepower or torque.

Locates the best three cam-timing combinations that produce the highest horsepower or torque. Current valve lift is maintained.

Find Cam Timing For Highest Horsepower At Current HP Peak +/- 500 RPM

Find Cam Timing For Highest Torque At Current TQ Peak +/- 500

Locates the best three bore/stroke combinations that produce the highest horsepower or torque. Current displacement is maintained.

Find Bore/Stroke For Highest Horsepower At Current HP Peak +/- 500

Find Bore/Stroke For Highest Torque At Current TQ Peak +/- 500 produce professional-looking graphs, isolate engine characteristics, help detect excess pressures or rod-bending stresses, and add color to any graphic display or printout.

- ***ProTools*** also includes additional simulation data that is calculated and displayed in the table of test results (available by selecting the **Table** tab at the bottom of the graph screen). The following data is displayed for each rpm test point when ***ProTools*** is activated: Indicated Horsepower, Frictional Horsepower, Pumping Horsepower, Mechanical Efficiency, Piston Speed, Gas Force On Piston, Induction Airflow, and PMEP (pumping mean effective pressure).
- ***ProPrinting™:*** Features allow you to printout a comprehensive test report of any simulated engine. This professional report includes a custom cover page with the name of your business or engine designer, all engine data, flow data, camshaft data, and all extended data available with ***ProTools*** (as described above). Use this eye-popping report to make the best presentation possible of your latest engine simulation designs. (Note: *Pro-Printing*™ will be available as a free upgrade to *ProTools*™ users on 4/1/03).

DynoSIM REQUIREMENTS

Make sure you have the basic hardware and software required to run the DynoSim.

- An IBM compatible PC with a CD-ROM drive.
- 32MB of RAM (random access memory) for Windows95/98/Me; 64MB for WindowsNT; 128MB for Windows2000/XP.
- Windows95/98/Me or Windows NT/2000/XP (NT version 4.0 with SP6 or later)
- A video system capable of at least VGA (640 x 480 resolution). Recommend 1024 x 768 or higher to optimize screen display of engine components and performance analysis graphics.
- A fast system processor (1GHz or faster) will improve processing speeds; especially helpful for Iterative analysis. However, the DynoSim will operate on any Windows95/98/Me/NT/2000/XP system, regardless of processor.
- A mouse.
- Any Windows compatible printer (to obtain dyno-test printouts).

REQUIREMENTS—ADDITIONAL CONSIDERATIONS

Windows95/98/Me/NT/2000/XP: The DynoSim is a full 32-bit program designed for Windows95 through WindowsXP (all versions). The DynoSim is also compatible with WindowsNT (we recommend that if you use WindowsNT, use version 4.0 with service pack 6 or later). If you use an early version of Windows95, make sure to install the latest service packs for both Windows and for Internet Explorer (use the Windows Update feature available in the Start Menu or visit www.microsoft.com to locate updates and service packs for your operating system).

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Video Graphics Card And Monitor: Virtually any Windows compatible monitor and video display card will work with the DynoSim. Systems with SVGA or better graphics (800 x 600 resolution or higher) provide more screen "real estate." This additional display space is very helpful in component selection and power-curve analysis.
Note 1: See FAQ on page 126 for help in changing the screen resolution of your system and monitor.

System Processor: The DynoSim is extremely calculation-intensive. Over 50 million mathematical operations are performed for each complete power-curve simulation. While the program has been written in fast C++ and hand-tuned assembler to optimize speed, a faster processor will improve data analysis capabilities. Furthermore, the DynoSim incorporates powerful *Iterative Testing* that can perform an analysis of hundreds or thousands of dyno tests. To reduce calculation times and extend the modeling capabilities of the program, use the fastest processor possible.

The following table gives an approximation of the time required to complete a 100 dyno-run *Iterative* test on various current and "antique" PC systems (this 100-cycle test is a very short run; *Iterative* tests can consist of hundreds or thousands of simulated dyno runs or more):

Computer	Math Coprocessor	Calc. Time For 100-Test *Iterator*™ Run
Pentium 3.0Ghz	Built-In	2 Seconds
Pentium 1.8Ghz	Built-In	4 Seconds
Pentium 400Mhz	Built-In	17 Seconds
Pentium 200Mhz	Built-In	75 Seconds
Pentium 133Mhz	Built-In	112 Seconds
Pentium 60Mhz	Built-In	4.3 Minutes
80486DX 33Mhz	Built-In	13.5 Minutes
80386DX 25Mhz	Yes (added)	49 Minutes
80486SX 25Mhz	No	6.4 Hours
80386DX 33Mhz	No	9.4 Hours
80286 at 10Mhz	No	24 Hours
8088 at 8Mhz	Yes (added)	3.2 Hours

Mouse: A mouse (trackball, or other pointer control) is required to use the DynoSim. While most component selections can be performed with the keyboard, several operations within the DynoSim require the use of a mouse.

Printer: The DynoSim can print a comprehensive "Dyno-Test Report" of a simulated dyno engine on any Windows-compatible printer. If you use a color printer, the data curves and component information will print in color (see page 117 for more information about DynoSim printing).

DynoSim Racing Software

Advanced Engine Simulation

INSTALLATION

Installation Tips

DynoSim installation is a quick and easy process. Review these points and follow the installation steps below:

- The DynoSim requires Windows 95/98/Me® or Windows NT/2000/XP® and at least 64MB of installed memory (see page 9 in the Users Manual for more information about system requirements).
- The software SETUP program will install DynoSim onto the **C:** drive in the **DynoSim** directory. Placing program files within this directory will ensure that future upgrades and enhancements will install correctly. Please accept the default installation path for trouble-free operation.

Read and perform each of the following steps carefully:

1) Start Windows, if necessary.

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

3) An installation Welcome screen will appear on your desktop within 5 to 30 seconds (depending on the speed of your CD drive). Proceed to **step 5**.

4) If the DynoSim installation Welcome screen does not automatically display on your desktop within 30 to 60 seconds, run the **Setup** program included on the DynoSim CD-ROM. (Choose ***Settings*** from the ***Start*** menu, select ***Control Panels***, then double click ***Add/Remove Programs***, finally click on ***Install***.)

5) Click ***Next*** to view the ProRacing Sim License Agreement. Read the Agreement and if you agree with the terms, click ***I Accept...***, then click ***Next*** to continue with the installation.

6) A *Readme* file includes the latest changes made to this software and information not available at the time this *Users Manual* was published. After you have reviewed

the *Readme*, click ***Next*** to proceed with the installation.

7) The **Setup Type** window will present three installation options:

Typical—Installs DynoSim, sample files, Users Manual, demo software/updates, and tutorials and videos.

Minimal—Installs DynoSim, sample files, and Users Manual only.

Custom—Allows you to select the installed elements.

*We recommend you select **Typical***, and press ***Next*** to continue the installation.

8) The **Ready To Install** screen gives you a chance to review installation choices. Press ***Back*** to make any changes; press ***Install*** to begin copying files to your system.

9) When main installation is complete, the **Setup Complete** screen will be displayed. Click ***Finish*** to close this window and a final dialog box will ask for permission to install a Camtasia™ Codec on your system (needed to display tutorial and help files). Choose ***Install*** to complete FastLapSim installation.

Starting DynoSim

10) To start DynoSim, open the Windows **Start** menu, select **Programs**, then choose ***ProRacing Sim Software***, ***DynoSim Engine Simulation***, and finally click on the ***DynoSim Engine Simulation*** icon displayed in that folder.

11) When you first start the program, a Registration dialog will be displayed. Please fill in the requested information, including the serial number found on page 4 of this QuickStart Guide. Then press the ***Proceed*** button. If you have an Internet connection, your registration will be submitted to ProRacingSim automatically. If you do not have an Internet connection, you will be presented with other registration options. If you do not register this simulation, you will not qualify for tech support nor will you be able to participate in any of the exciting contests that will be conducted in the weeks and months ahead.

Note: Demos of the new *DragSim* and *FastLapSim* have been included with DynoSim. Start the demos by opening the ***Start*** menu, select ***Programs***, ***ProRacing Sim Software,*** then choose the ***DragSim DragStrip Simulation*** or ***FastLapSim Vehicle Simulation***. These demo programs can be *Activated* to the **Advanced** or **ProTools™** versions by using the *Product Activation* menu within each program (see page 121).

12) You can also access additional information about our simulation software and obtain technical support by visiting (www.ProRacingSim.com) or by opening the ***Start*** menu, select ***Programs***, ***ProRacing Sim Software,*** then click on ***Tech Support Website***.

13) Please review the remainder of this Users Manaul for more information on menu selections, program functions, and simulation tips.

14) If you experience installation problems, please review program requirements on pages 9-10 and take a few minutes to look over the following sources of information before you contact technical support:

- The FAQs on page126 provide additional installation and operational questions-and-answers.
- Visit the Tech Support section of the ProRacing Sim Software website for additional tips and FAQs.

If you cannot find a solution to your problem, use the mail-in form on page 143. Mail the completed form to:

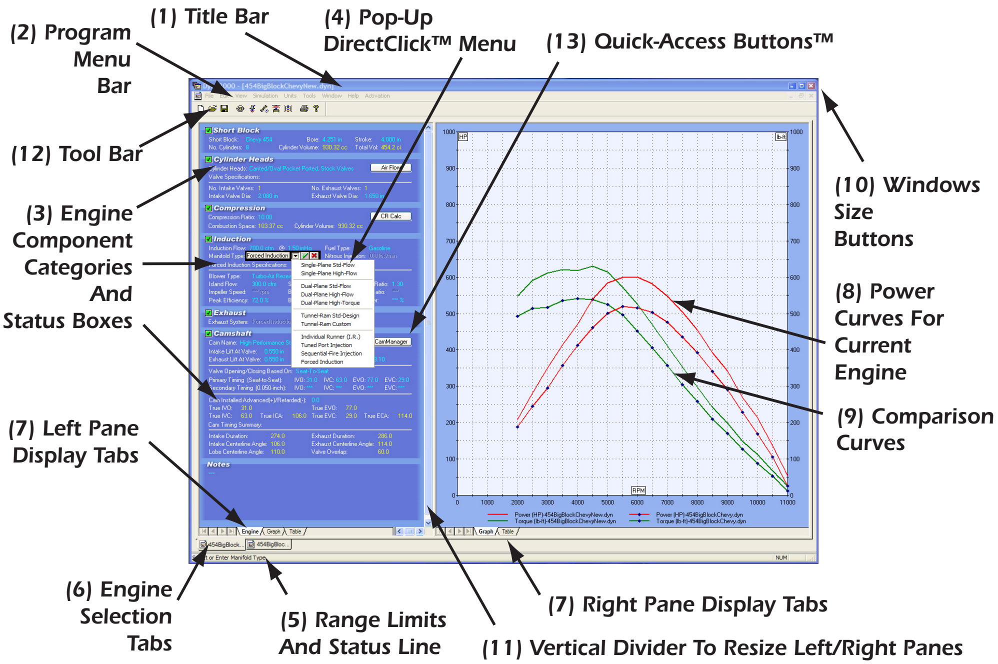
ProRacing Sim Software, LLC.
3400 Democrat Road, Suite 207
Memphis, TN 38118
Tech: 901-259-2355, or visit our
Web: www.proracingsim.com
Email: support@proracingsim.com

Note: Tech support will only be provided to registered users. Please fill in the *Registration Form* that appears when you first start your software to qualify for technical support from the ProRacing Sim Software staff.

DynoSim Racing Software

Advanced Engine Simulation

OVERVIEW



THE MAIN PROGRAM SCREEN

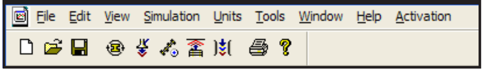
The **Main Program Screen** allows you to select engine components, dimensions, and specifications. In addition, engine power curves and/or simulation data is displayed in graphical and chart form. The Main Program Screen is composed of the following elements:

1) The **Title Bar** displays the program name followed by the name of the currently-selected engine.

2) The **Program Menu Bar** contains pull-down menus that control overall program function. Here is an overview of these control menus, from left to right (detailed

Program Overview

Program Menu Bar



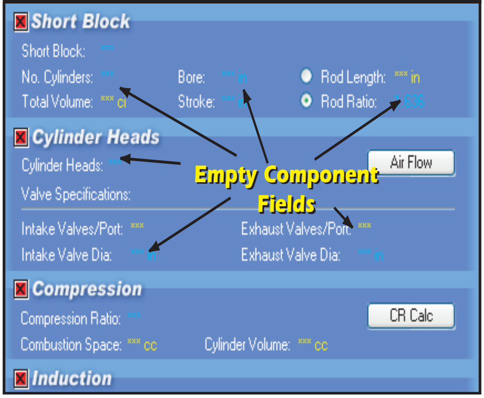
Program Menu Bar contains eight pull-down menus that control overall program function.

information on menu functions is provided in the next section, beginning on page 22):

File—Opens and Saves dyno test files, exports Dyno files to other DeskTop software, prints engine components and power curves, allows the quick selection of the most recently used Dyno files, and contains a program-exit function.
Edit—Clears all component choices from the currently-selected engine (indicated by the *Engine Selection Tab* currently in the foreground; see **Engine Selection Tabs**, later in this section).
View—Allows you to turn the ***Toolbar***, ***Status Bar*** and ***Workbook*** layout on (default) or off.
Simulation—***Run*** forces an update of the current simulation. ***Auto Run*** enables or disables (toggles) automatic simulation updates when any engine component is modified.
Units—Selects between US and Metric units.
Tools—Opens the *Iterative Testing* window, the *Cam Manager* screen, or one of the build-in, engine-math calculators.
Window—A standard Windows menu for arranging and selecting engine display windows.
Help—Gives access to this Users Guide, Registration, Contest Entry, and related program help features.
Product Activation—Activates optional features of the DynoSim, such as ProTools™, ProIterator™ and other optional features.

Component fields that do not yet contain valid entries are marked with a series of asterisks. This indicates that the field is empty and can accept data input. Most numeric fields accept direct keyboard entry and/or selections from the provided drop-down menus. Text selection fields (like the Cylinder Head choice menu) only accept selections from the associated drop-down menu. When a valid selection has been made, it will replace the asterisks and will be displayed next to the field names.

Incomplete Component Fields



Short Block: ***
No. Cylinders: ***
Total Volume: *** ci
Bore: *** in
Stroke: *** in
○ Rod Length: *** in
● Rod Ratio: 1.636

Cylinder Heads: ***
Valve Specifications:
Intake Valves/Port: ***
Intake Valve Dia: *** in
Exhaust Valves/Port: ***
Exhaust Valve Dia: *** in

Compression Ratio: ***
Combustion Space: *** cc
Cylinder Volume: *** cc

Empty Component Fields

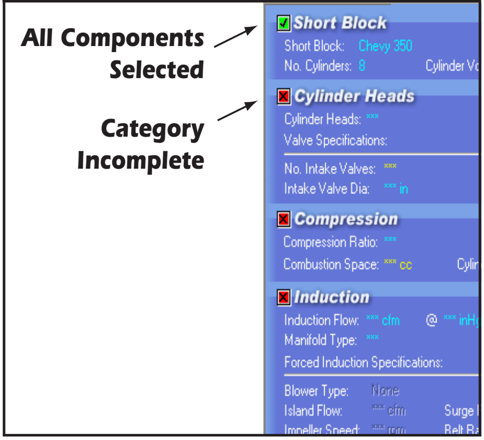
Program Overview

3) The **Engine Component Categories** are made up of the following groups:

SHORTBLOCK—Select the bore, stroke, and number of cylinders in this category (see page 22).
CYLINDER HEADS—Select the cylinder head type, port configuration, and valve diameters. Direct entry of flowbench data is also supported (see page 24).
COMPRESSION—Select the compression ratio (see page 34).
INDUCTION—Selects the airflow rate through the induction system, the type of fuel, nitrous flow rate, intake manifold, and a forced induction system (see page 42).
EXHAUST—Selects the exhaust-system configuration (see page 64).
CAMSHAFT—Selects the camshaft type, lifter type, and allows direct entry of valve timing and lift data (see page 70).
NOTES—Enter any comments about the current simulation. Notes are saved with the engine *.DYN* file.

Note: Each component category (except *NOTES*) contains a **Status Box** located in the upper left corner. These boxes either contain a red boxed **X**, indicating that the category is not complete (inhibiting a simulation run), or a green-boxed checkmark ✔, indicating that all components in that category have been selected. When all component categories have green checks, a simulation will be performed using the current data values and the results will be displayed in the graph on the right pane of the Main Program Screen (the simulation run and data plot will occur automatically providing **Autorun** is checked in the **Simulation** drop-down menu [the default setting], see **Simulation Menu** described on the previous page).

Component Status Boxes

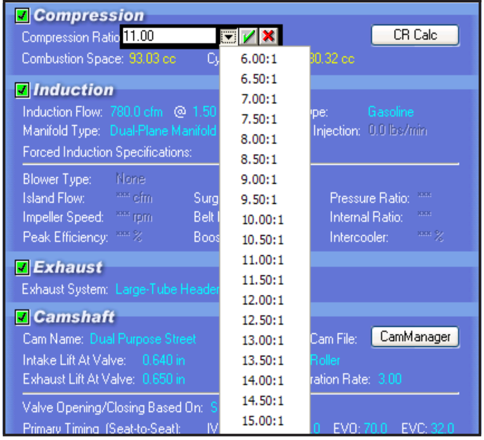


☑ **Short Block**
Short Block: Chevy 350
No. Cylinders: 8 Cylinder Vo
☒ **Cylinder Heads**
Cylinder Heads: ***
Valve Specifications:
No. Intake Valves: ***
Intake Valve Dia: *** in
☒ **Compression**
Compression Ratio: ***
Combustion Space: *** cc Cylin
☒ **Induction**
Induction Flow: *** cfm @ *** inHg
Manifold Type: ***
Forced Induction Specifications:
Blower Type: None
Island Flow: *** cfm Surge
Impeller Speed: *** rpm Belt Ra

A Status Box is located in the upper left corner of each Component Category. These boxes either contain a red boxed X, indicating that the category is not complete (inhibiting a simulation run), or a green-boxed checkmark ✔, indicating that all components in that category have been selected

Program Overview

Direct-Click™ Component Menus



Compression Ratio 11.00
Combustion Space: 93.03 cc

Induction Flow: 780.0 cfm @ 1.50
Manifold Type: Dual-Plane Manifold
Gasoline
Injection: 0.0 lbs/min
Forced Induction Specifications:
Blower Type: None
Island Flow: **** cfm
Impeller Speed: **** rpm
Peak Efficiency: **** %
Pressure Ratio: ****
Internal Ratio: ****
Intercooler: **** %

Exhaust System: Large-Tube Header

Cam Name: Dual Purpose Street
Cam File:
Intake Lift At Valve: 0.640 in
Exhaust Lift At Valve: 0.650 in
Roller
Valve Opening/Closing Based On:
Primary Timing (Seat-to-Seat):
EVO: 70.0 EVC: 32.0

The Direct-Click™ Component Menus contain components and specifications for each Component Category item. Click on any component specification to open its menu. The menu will close when a selection is complete (or accept the current selection by clicking on the green ✔). If you wish to close the menu before making a new selection, click the red X next to the drop-down box or press the Escape key until the menu closes.

4) The **Drop-Down Component Menus** contain components and specifications for each of the Component Category choices. Click on any component specification to open its menu. The menu will close when a selection is complete. If you wish to close the menu before making a new selection, click the red **X** next to the drop-down box or press the **Escape** key until the menu closes.

5) Several Component Category menus allow direct numeric entry. During direct data entry, the range of acceptable values will be displayed in a **Range Limit Line** within the **Status Box** at the bottom of the screen.

6) The DynoSim can simulate several engines at once. Switch between “active” engines by selecting any open engine from the **Engine Selection Tabs**, just above the **Status Box** (see photo, page 16). The currently-selected engine is indicated on the foreground Tab. The name of the currently-selected engine is also displayed in the **Title Bar**.

7) The Main Program Screen window is divided into two panes. The left and right panes contain **Screen Display Tab** groups. Use these tabs to switch the pane display to component lists, tables, graphics, or other data displays.

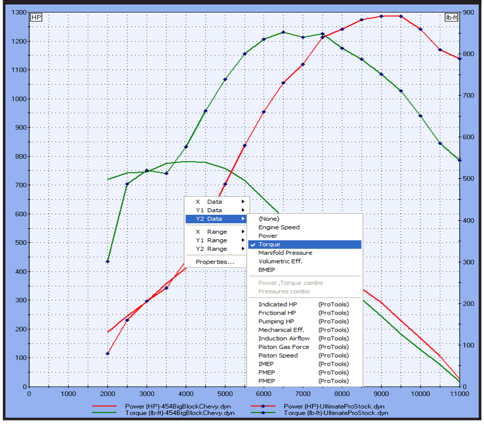
8) The **Current Engine Power Curves** window displays the horsepower and torque for the currently-selected engine. Horsepower and torque are the default curves, however, the graphic data display can be customized by right-clicking on the graph and reassigning each curve in the **Graph Options Box**.

9) Use **Properties...** in the **Graph Options Box** to create direct comparisons between up to four “open” engines.

Program Overview

The Right-Hand Power Curves Box displays the horsepower and torque for the currently-selected engine. Horsepower and torque are the default curves, however, the data displayed can be customized by right-clicking on the graph and reassigning each curve in the *Graph Options Box*. In addition, you can use *Properties...* to setup comparisons between any "open" engines. Note: A second, Left-Hand graph is available under the component selection screen (to activate this display, use the Left-Pane *Screen Display Tabs* at the bottom of the component screen).

Graph Options Box



10) The Main Program Screen also incorporates **Windows Size Buttons**. These buttons provide standard maximizing, minimizing, and closing functions common to all Windows applications. Refer to your Windows documentation for more information on the use of these buttons.

11) The widths of all program panes are adjustable. Simply drag the V**ertical Screen Divider** to resize the Component-Selection and Graphics-Display panes. By dragging the **Vertical Screen Divider** to the left screen edge, the power-curve display can be enlarged to full screen for maximum resolution.

12) The **Tool Bar** contains a series of icons that speed up the selection of commonly used program functions and features. The **Tool Bar** in the DynoSim contains the following icons: Create New Engine, Open Saved Engine, Open Quick Iterator, Open Pro Iterator (ProTool™), Open Cylinderhead Airflow (Port Flow) Dialog, Open CamMath Calculator, Open Compression-Ratio Calculator, Open Airflow-Conversion Tool, Open Cam Manager, Print Current Engine, Display Program "About Box."

13) Several component categories contain **QuickAccess Buttons**™ that give "one-click" access to important data-entry functions and calculators. The **CYLINDERHEAD** category contains an ***Airflow*** button that opens the Port-Airflow dialog box, allowing direct entry of flowbench data; the **COMPRESSION** category contains a ***CR Calc*** button that opens the Compression-Ratio Calculator, a tool that can save time and improve accuracy in determining engine compression ratio; and the **CAMSHAFT** category contains a ***Cam Manager*** button that opens the powerful Cam Manager dialog box giving unprecedented control over camshaft

selection and timing specifications.

USING THE MOUSE OR KEYBOARD TO BUILD A TEST ENGINE

A common starting point for an engine-design project using the DynoSim is to “assemble” a test engine from component parts. For example, here’s how to select bore and stroke specifications by using the **Short Block** pull-down menu. Activate the menu by:

Mouse

1) If necessary, start the DynoSim; if the DynoSim is already running, select ***New*** from the **File** menu. All component categories begin empty, as indicated by a string of asterisks (***) next to each incomplete component field.

2) Move the mouse cursor into the ***SHORTBLOCK*** component category and click the left mouse button on the asterisks in the highlighted ***Short Block*** field. (**Note**: all fields will automatically highlight when the mouse cursor passes over them).

3) When the component-menu bounding box appears (see photo, page 20), click on the ▼ symbol to open the SHORTBLOCK selection menu.

4) Move the mouse pointer through the menu choices.

5) When a submenu opens, move the mouse cursor over your selected choice in the submenu.

6) Click the left mouse button on your selection. This loads the engine name, bore, stroke, and number of cylinders into the ***SHORTBLOCK*** category. Note that the red boxed **X** (Component Category Status Box) on the left of the ***SHORTBLOCK*** category changed to a green-boxed checkmark ✓, indicating that all components in that category have been selected.

7) Alternatively, to close the menu without making a selection, click the red **X** on the right of the menu bounding box or press the **Escape** key until the menu closes.

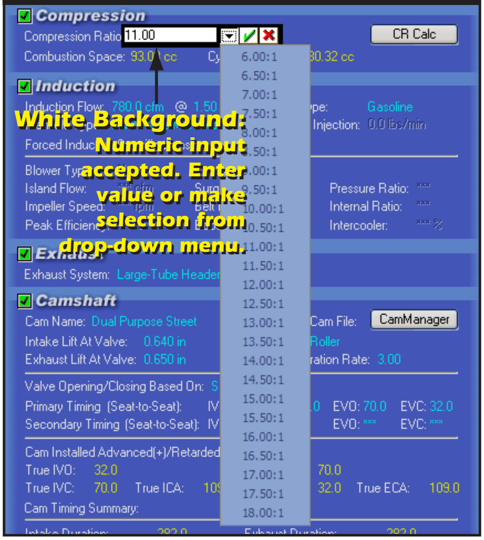
8) Continue making component selections until all the ***Component Category Status Boxes*** have switched to green. At this point an engine simulation will be performed and the results will be displayed on the graph or chart on the right pane of the Main Program Screen.

Keyboard

1) Press and release the **Alt** key followed by the **F** key to highlight and open the File

Program Overview

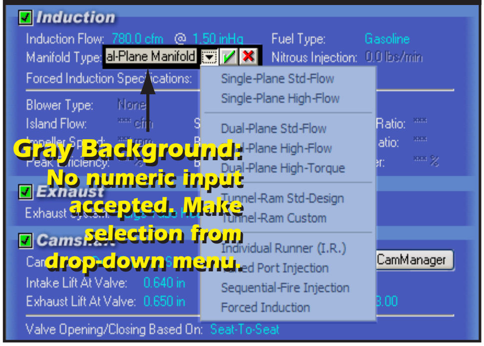
Fields Accepting Direct Input



White Background: Numeric input accepted. Enter value or make selection from drop-down menu.

Component fields that support direct numeric entry have white bounding boxes (left). When the only selection possible is a choice from the drop-down menu, the bounding box will have a gray interior (below).

Fields Not Accepting Direct Input



Gray Background: No numeric input accepted. Make selection from drop-down menu.

menu. Use the cursor-arrow keys to select ***New***, then press **Enter** to create a new, blank component screen. All component categories start off empty, indicated by strings of asterisks (***) next to each incomplete component selection. **Note:** You can activate other menu choices—e.g., *Edit*, *View*, *Simulation*, etc., by pressing the **Right-Arrow** or **Left-Arrow** keys or by using the menu shortcuts (e.g., open the *Edit* menu by pressing **Alt E**).

2) A component menu bounding box is positioned around the **Short Block** component field in the ***SHORTBLOCK*** category.

3) Press Enter to activate the box. Then press Tab to move the highlight (focus) to the ▼ symbol. Then press the **Spacebar** to open the **Short Block** selection menu.

4) Use the **Up-Arrow** or **Down-Arrow** keys to scroll through the menu choices. When the menu selections include submenus (a small arrow points to the right at the end of the menu line), use the **Right-Arrow** key to open the submenu.

5) When you have highlighted your choice, press **Enter** to make the selection. This loads the engine name, bore, stroke, and number of cylinders into the ***SHORTBLOCK*** category. Note that the red boxed **X** (Status Box) on the left of the ***SHORTBLOCK*** category changed to a green-boxed checkmark ✔, indicating that all components in that category have been selected.
Note: Alternatively, to close the menus without making a selection, press the

Escape key.

6) Use the **TAB** key to move the component-selection bounding box to the next blank field (Cylinder Heads). Continue making component selections until all the Component Category Status Boxes have switched to green. At this point an engine simulation will be performed and the results will be displayed on the graph or chart in the right pane of the Main Program Screen.
Note: The **Shift Tab** key combination will move the bounding box backwards to the previous component field.

DIRECT-ENTRY™ MENU CHOICES

The Bore, Stroke, Number Of Cylinders, Valve Size, Compression Ratio, Induction Airflow, and several other menus permit direct numeric entry. When a component field supports direct entry, the bounding box will have a white interior. If the only entry possible is a choice from the drop-down menu, the bounding box will have a gray interior (see above photos). Choosing a new numeric value will replace the currently displayed value. When you press **Enter** the new value will be tested for acceptability, and if it passes, it will be used in the next simulation run. If you press **Enter** without entering a new value, the currently displayed value is left unchanged.

Data entry into any component field on the component-selection screen is limited to values over which the DynoSim can accurately predict power. The range limits are displayed in the **Range Limit Line** within the **Status Line** at the bottom-left of the Main Program Screen (see page 13). If you enter an invalid number, the DynoSim will play the Windows error sound and wait for new input.

THE MEANING OF SCREEN COLORS

The colors used on the component-selection screen provide information about various engine components and specifications. Here is a quick reference to screen color functionality:

White Component Names: Engine component names and specification fields are displayed in white. If the data in those fields is light blue, it can be changed or customized. If the data is yellow, it indicates values are automatically calculated by program and cannot be directly altered.

Yellow Numeric Values: Yellow engine specifications indicate that they are automatically calculated by program and cannot be directly altered. For example, the ***Cylinder Volume*** shown in the ***SHORTBLOCK*** category is calculated based on the current bore and stroke. While you cannot directly alter ***Cylinder Volume***, changing the bore or the stroke will alter the displayed value for ***Cylinder Volume***.

Light Blue: All engine specifications that can be changed through direct data entry or through pull-down menus are displayed in light blue. For example, the cylinder ***Bore*** field in the ***SHORTBLOCK*** category will accept direct numeric input (within the range of values displayed in the ***Range Limit Line***).

DynoSim
Racing Software

Advanced
Engine
Simulation

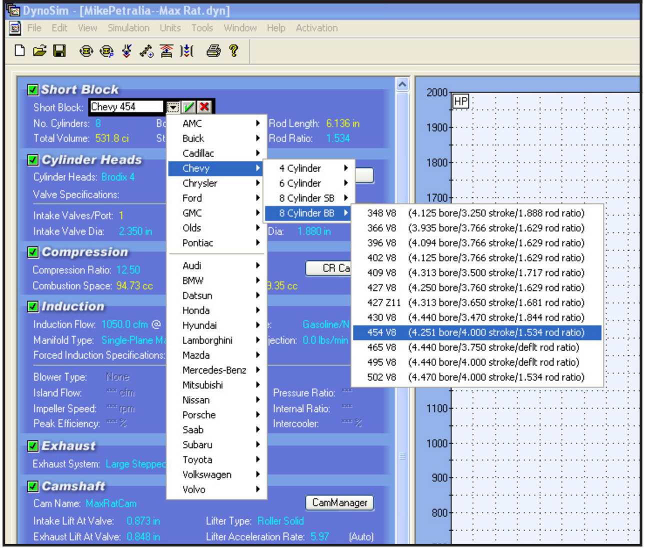
COMPONENT MENUS

THE SHORTBLOCK COMPONENT CATEGORY MENUS

The **Short Block** menu is located on the upper-left of the **SHORTBLOCK** component category on the Main Program Screen. By opening this menu, you are presented with a variety of domestic and import “predefined” engine shortblock configurations. If any one of these choices is selected, the appropriate bore, stroke, rod ratio, and number of cylinders will be loaded in the **SHORTBLOCK** category. In addition to selecting any predefined engine configuration, you can directly enter any short block name (description) in the **Short Block** field (plus you can enter any Stroke, Bore, Rod Ratio, and Number Of Cylinders—within the acceptable range limits of the program indicated at the bottom of the screen in the **Range Limit And Status Line**—in these fields in the SHORTBLOCK category).

The *Short Block* component menu contains over 300 bore and stroke combinations of popular domestic and import engines that you can instantly use in any engine simulation. In addition, you can directly enter a custom description of any engine into the *Short Block* field.

Short Block Component Menu



☑ Short Block
Short Block: Chevy 454
No. Cylinders: 8
Total Volume: 531.8 ci
Rod Length: 6.136 in
Rod Ratio: 1.534

☑ Cylinder Heads
Cylinder Heads: Brodix 4
Valve Specifications:
Intake Valves/Port: 1
Intake Valve Dia: 2.350 in
Dia: 1.880 in

☑ Compression
Compression Ratio: 12.50
Combustion Space: 94.73 cc

☑ Induction
Induction Flow: 1050.0 cfm @
Manifold Type: Single-Plane Ma
Gasoline/N
jection: 0.0 lbs/min
Forced Induction Specifications:
Blower Type: None
Island Flow: **** cfm
Impeller Speed: **** rpm
Peak Efficiency: **** %
Pressure Ratio: ****
Internal Ratio: ****
Intercooler: **** %

☑ Exhaust
Exhaust System: Large Steppec

☑ Camshaft
Cam Name: MaxRatCam
Intake Lift At Valve: 0.873 in
Exhaust Lift At Valve: 0.848 in
Lifter Type: Roller Solid
Lifter Acceleration Rate: 5.97 (Auto)

Block, Bore, and Stroke Menus

What's A SHORTBLOCK

When a particular engine combination is selected from the **Short Block** menu, the bore, stroke, rod ratio, and the number of cylinders are "loaded" into the **SHORTBLOCK** category. These values are subsequently used in the simulation. The menu choices presented in the **Short Block** menus should be considered a "handy" list of common engine cylinder-bore and crankshaft-stroke values, ***NOT*** a description of engine configurations (e.g., V8, V6, straight 6, V4, etc.), material composition (aluminum vs. cast iron), the type of cylinder heads (hemi vs. wedge) or any other engine characteristics. The **Short Block** menu only loads **Bore**, **Stroke**, **Rod Ratio**, and the **Number Of Cylinders** into the engine "parts" database.

Entering Rod Ratio And/Or Rod Length

Each of the **Short Block** menu selections will also load the exact (or a default) value for Rod Ratio; the length of the connecting rod divided by the stroke length. This value is commonly used to help determine rod angularity (rod angularity drives the piston into the cylinderwall producing the single greatest source of friction within the engine). By default, the **SHORTBLOCK** category will also allow direct entry of Rod Ratios and show a calculated value for Rod Length. But, by clicking the radio button next to the Rod Length, this field will become editable and allow direct entry of Rod Length data, switching the Rod Ratio field to calculated values. If you know the exact Rod Length for a particular shortblock, "activate" the Rod Length filed by clicking its radio button and directly enter the rod-lenght value.

Bore And Stroke And Its Effects On Compression Ratio

After selecting the Bore, Stroke, Rod Ratio, and Number-Of-Cylinders, the swept cylinder volume and the total engine volume (displacement) will be displayed. The swept cylinder volume measures the volume displaced by the movement of a single piston from TDC (top dead center) to BDC (bottom dead center). This "full-stroke" volume is one of the two essential values required in calculating compression ratio. We'll discuss compression ratio in more detail later, but for now let's take a quick look at how compression ratio is calculated:

$$\textbf{Compression Ratio} = \frac{\textbf{Swept Cylinder Volume + Combustion Space Volume}}{\textbf{Combustion Space Volume}}$$

The total volume that exists in the cylinder when the piston is located at BDC (this volume includes the Swept Volume of the piston plus the Combustion Space Volume) is divided by the Combustion Space Volume (the area above the piston at TDC).

Bore and stroke dimensions greatly affect cylinder volumes and, therefore, compression ratio. When the stroke, and to a lessor degree the bore, is increased while

Cylinder Head Menu

Cylinder Head Menu

The *Cylinder Head* menu contains a wide range of head/port choices, from stock to all-out racing. In addition, the Custom Port Flow selection allows the direct entry of flow bench data. This feature allows the simulation and testing of virtually any cylinder head for which flow data is available.

maintaining a fixed combustion-space volume, the compression ratio will rapidly increase. And if the compression ratio is held constant—as it is in the DynoSim, since the compression ratio is a ***fixed*** engine specification selected by you—the combustion space volume must be increased to maintain the desired compression ratio.

This may be easier to understand when you consider that **if** the combustion-space volume (volume at TDC) did **not** increase, a larger swept cylinder volume would be compressed into the same final combustion space volume, resulting in an increase in compression ratio.

THE CYLINDER HEAD AND VALVE DIAMETER MENUS

The **Cylinder Head** pull-down menu is located in the **CYLINDER HEAD** category, and selections from this menu allow the DynoSim to simulate various cylinder head designs and a wide range of airflow characteristics. The menu lists general cylinder head characteristics, including restrictive low-performance ports, typical wedge- and canted-valve configurations, and 4-valve cylinder heads. Each type of head/port includes several stages of modifications from stock to all-out race configurations.

In addition, the **Custom Port Flow** choice at the bottom of the Cylinder Head menu allows the direct entry of flowbench data, allowing the DynoSim to model any cylinder head for which flow data is available. This option will be described in more detail later (see page 30).

Basic Flow Theory

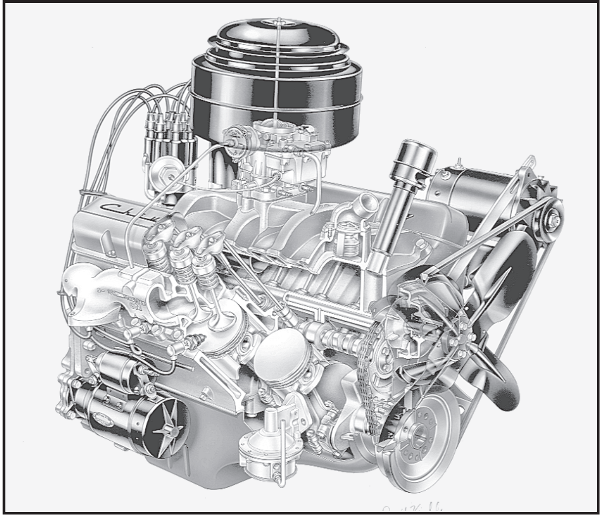
A selection from the **Cylinder Head** menu is the first part of a two-step process used by the simulation to accurately model cylinder head flow characteristics. The initial selection of a cylinder head determines the airflow restriction generated by the ports. That is, the menu choices establishes *how much less air than the theoretical maximum peak flow will pass through each port*. What determines peak flow? That's determined by the selection of **Intake** and **Exhaust Valve Diameters**. The valve-diameter menus allow you to select valve sizes that fix the theoretical peak flow (called *isentropic* flow) of each port. Most cylinder heads flow only about 50% to 70% of this value.

Note: You can enable the **Auto Calculate Valve Size** feature to allow the DynoSim to automatically determine valve diameters based on bore size and the degree of cylinder head porting/modifications. The various **Cylinder Head** menu choices load airflow data into the simulation, but this flow data is not directly used to determine the airflow capacity of the cylinder heads.

There are several reasons for this. First of all, flow generated in the ports of a running engine is vastly different than the flow measured on a flow bench. Airflow on a flow bench is steady-state flow, measured at a fixed pressure drop (it's also dry flow, but a discussion of that is beyond the scope of this manual). A running engine will generate rapidly and widely varying pressures in the ports. These pressure differences directly affect—in fact, they directly cause—the flow of fuel, air, and exhaust gasses within the engine. The DynoSim calculates these internal pressures at each degree of crank rotation throughout the four-cycle process. To determine mass flow into and out of the cylinders at any instant, the flow that occurs as a result of these changing pressure differences is also calculated. Since the variations in pressure, or pressure drops, within the engine are almost always different than the pressure drop used on a flow bench, flow bench data cannot directly predict flow within the engine.

While it is impractical to use cylinder head flow data directly in an engine simulation, measured cylinder head flow figures are, nonetheless, an excellent starting

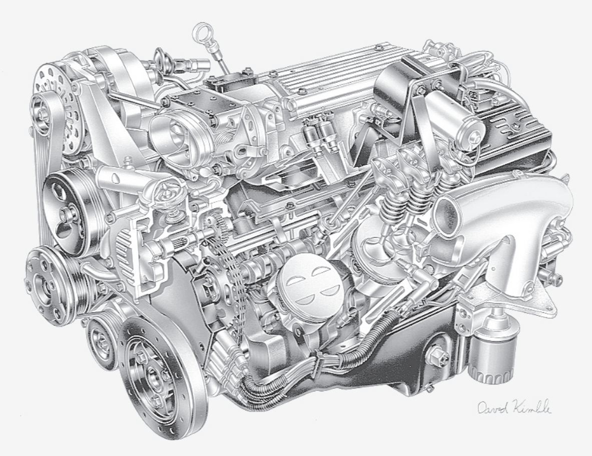
Typical Low-Performance Cylinder Heads



The *Low Performance* cylinder head choices are intended to model cylinder heads that have small ports and valves. Heads of this type were often designed for low-speed, economy applications, with little concern for high-speed performance. Early 260 and 289 smallblock Ford and to a lessor degree early smallblock Chevy castings fall into this category.

Cylinder Head Menu

Typical Wedge Cylinder Heads



The *Wedge Cylinder Head* menu choices model cylinder heads that have ports and valves sized with performance in mind, like the heads on this LT1 smallblock Chevy.

point. Flowbench data can be used as a means to compare the measured flow of a particular port/valve configuration against the calculated isentropic (theoretical maximum) flow. The resulting "ratio," called the **discharge coefficient**, has proven to be an effective link between flowbench data and predicted mass flow moving into and out of the cylinders. Furthermore, the discharge coefficient also can be used to predict the changes in flow for larger or smaller valves and for various levels of port modifications. In other words, the discharge coefficient provides a practical method to simulate mass flow within a large range of engines under a wide range of operational conditions.

Sorting Out Cylinder Head Menu Choices

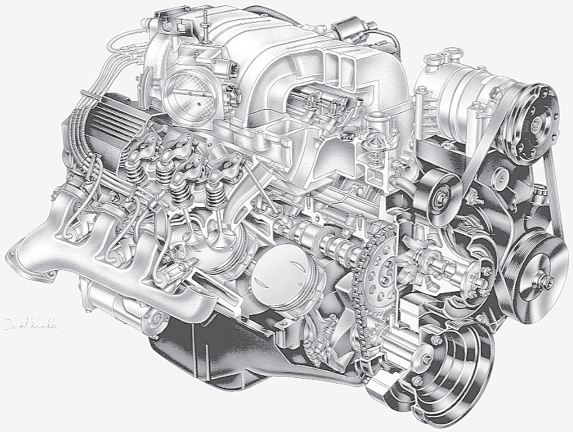
Now that some of the basic flow theory behind the choices in the **CYLINDER HEAD** category menus has been exposed, here's some practical advice that will help you determine the appropriate selections for your application.

Low Performance Cylinder Heads—There are three ***Low Performance*** cylinder head selections listed at the top of the **Cylinder Head** menu. Each of these choices is intended to model cylinder heads that have small ports and valves relative to engine displacement. Heads of this type were often designed for low-speed, economy applications, with little concern for high-speed performance. Early 260 and 289 smallblock Ford and to a lessor degree early smallblock Chevy castings fall into this category. These choices use the lowest discharge coefficient of all the head configurations listed in the menu. Minimum port cross-sectional areas are 85% of the valve areas or somewhat smaller and, if **Auto Calculate Valve Size** has been selected, relatively small (compared to the bore diameter) intake and exhaust valve diameters will be used.

The first low-performance choice models an unmodified production casting. The

Cylinder Head Menu

Typical Canted-Valve Cylinder Heads



The *Canted-Valve Cylinder Head* selections have ports with generous cross-sectional areas and valves that angle toward the port mouths. The first three menu choices model oval-port designs. The final two selections simulate performance rectangular-port heads. This L29 bigblock Chevy would be best modeled by the second or third menu choice—the fourth menu choice models a head with flow capacity beyond the capabilities of L29 castings.

second ***Low Performance/Pocket Porting*** choice adds minor porting work performed below the valve seat and in the "bowl" area under the valve head. The port runners are not modified. The final choice ***Low Performance/Ported, Large Valves*** incorporates the same modifications plus slightly larger intake and exhaust valves and some modest work in the port runners.

Note: If you are using the Auto-calculate valve size feature with ***Low Performance/Ported, Large Valves*** heads, the valve diameter increases, but sizes are always scaled to a proportion that will install in production castings without extensive modifications.

The low-performance choices have the ability to model some flathead (L-head & H-head) and hybrid (F-head) engines. While the ports in these engines are even more restrictive, by selecting ***Low-Performance*** and manually entering the valve sizes, the simulation will, at least, give you an approximate power output to evaluate changes in cam timing, induction flow, and other components.

Wedge Cylinder Heads—The wedge-chamber and canted-valve choices comprise the two main cylinder head categories. Choices from these two groups are applicable to a majority of all performance engine applications.

The first three basic wedge selections model heads that have ports and valves sized with performance in mind. Ports are not excessively restrictive for high-speed operation, and overall port and valve-pocket design offers a good compromise between low restriction and high flow velocity. The stock and pocket-ported choices are best for high-performance street to modest racing applications.

The fourth wedge head ***Wedge/Fully Ported, Large Valves*** moves away from street applications. This casting has improved discharge coefficients, greater port cross-sectional areas, and increased valve sizes. Consider this head to be an extensively modified, high-performance, factory-type casting that has additional modifications to provide optimum flow for racing applications. It does not incorporate "exotic" modifications, like raised and/or welded ports that require custom-fabricated intake manifolds.

The last choice in the wedge group is ***Wedge/ProStock Porting And Mods***. This selection is designed to model state-of-the-art, high-dollar, ProStock drag-racing cylinder heads. These custom pieces are designed for one thing: Maximum power. They usually require hand-fabricated intake manifolds, have excellent valve discharge coefficients, and the ports have the largest cross-sectional areas in the smallblock group. This head develops sufficient airflow speeds for good cylinder filling only at high engine rpm.

Canted-Valve (and Hemi) Cylinder Heads—All canted-valve selections are modeled after heads with "canted" valves. That is, the valve stems are tilted toward the outside of the cylinder heads to improve the discharge coefficient and overall airflow. All ports have generous cross-sectional areas for excellent high-speed performance.

The first three choices are based on an oval-port configuration. These smaller cross-sectional area ports provide a good compromise between low restriction and high flow velocity for larger displacement engines. The stock and pocket-ported choices are suitable for high-performance street to modest racing applications.

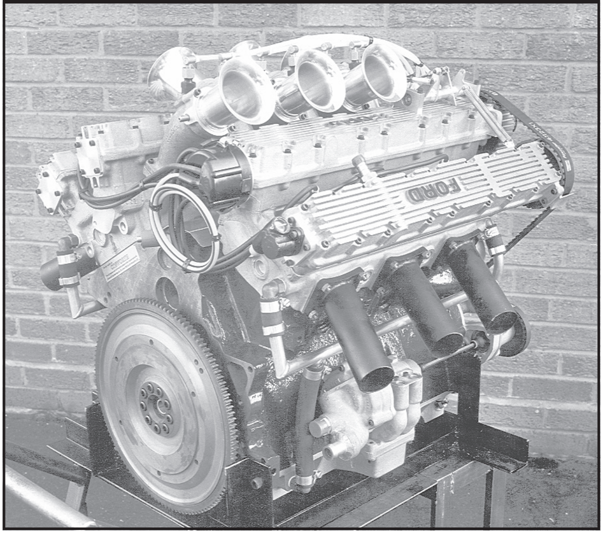
The final two selections simulate extensively modified rectangular-port heads. These choices model, primarily, all-out, bigblock heads, however, they closely model other extremely aggressive high-performance racing designs, like the Chrysler Hemi head and all-out ProStock designs. As with the smallblock category, the ***Canted/Rectangular Ports/Fully Ported*** heads are not suitable for most street applications. These castings have high discharge coefficients, large port cross-sectional areas, and increased valve sizes. This head is basically a factory-type casting but extensively improved. However, it does not incorporate "exotic" modifications, like raised and/or welded ports that require custom-fabricated manifolds.

The last choice in the canted-valve group is ***Canted/Rectangular ProStock Ports/Mods***. This selection is designed to model state-of-the-art, ProStock (and Hemi) drag-racing cylinder heads. These custom pieces, like their wedge-design counterparts, are built from the ground-up for maximum power. They require hand-fabricated intake manifolds, have optimum valve discharge coefficients, and the ports have the largest cross-sectional areas in the entire **Cylinder Head** menu, except for 4-valve heads (discussed next). These specially fabricated cylinder heads only develop sufficient airflow for good cylinder filling with large displacement engines at very high engine speeds.

4-Valve Cylinder Heads—The next three selections in the Cylinder Head submenu model 4-valve cylinder heads. These are very interesting choices since they simulate the effects of very low-restriction ports and valves used in many sport-compact performance applications. The individual ports in 4-valve heads begin as single, large openings, then neck down to two Siamesed ports, each having a small (relatively) valve at the combustion chamber interface. Since there are two intake and two exhaust valves

Cylinder Head Menu

Typical 4-Valve Cylinder Heads



The *4-Valve Cylinder Head* selections model cylinder heads with two intake and two exhaust valves. These heads can offer more than 1.5 times the curtain area of the largest 2-valve heads. This large valve flow area, combined with high-flow, low-restriction ports greatly improves air and fuel flow into the cylinders at high engine speeds.
These Cosworth heads were designed for the English Ford V6. When they were raced in England, they regularly beat V8s.

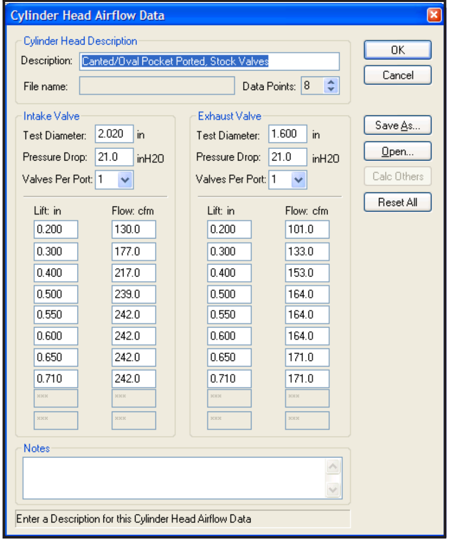
per cylinder, valve curtain area (area exposed around an open valve through which air/ fuel can pass) is considerably larger than with the largest single-valve-per-port designs. In fact, 4-valve heads can offer more than 1.5 times the curtain area of the largest 2-valve heads. This large flow area, combined with high-flow, low-restriction ports greatly improves air and fuel flow into the cylinders at low valve lifts and at high engine speeds. Unfortunately, the ports offer an equally low restriction to reverse flow (reversion) that occurs at low engine speeds when the piston moves up the cylinder from BDC to Intake Valve Closing (IVC) on the final portion of the intake stroke. For this reason, 4-valve heads, even when fitted with more conservative ports and valves, can be a poor choice for small-displacement, low-speed engines, unless camshaft timing is carefully designed to complement the low-lift flow capabilities of these cylinder heads. On the other hand, the outstanding flow characteristics of the 4-valve head put it in another “league” when it comes to horsepower potential on high-speed racing engines.

The first choice in the 4-valve group is ***4-Valve Head/Stock Ports And Valves***. This simulates a 4-valve cylinder head that would be “standard equipment” on factory high-performance or sport-compact engines. These heads offer power comparable to high-performance 2-valve castings equipped with large valves and pocket porting. However, because they still have relatively small ports, reasonably high port velocities, and good low-lift flow characteristics, they often show a boost in low-speed power over comparable 2-valve heads.

The next choice, ***4-Valve Head/Ported With Large Valves*** incorporates mild performance modifications. Larger valves have been installed and both intake and exhaust flow has been improved by pocket porting. However, care has been taken not to increase the minimum cross-sectional area of the ports. These changes provide a significant increase in power with only slightly slower port velocities. Reversion has

Custom Port Flow Dialog

Custom Port Flow Dialog



Cylinder Head Airflow Data

Cylinder Head Description

Description: Canted/Oval Pocket Ported, Stock Valves

File name:

Data Points: 8

Intake Valve			Exhaust Valve		
Test Diameter:	2.020	in	Test Diameter:	1.600	in
Pressure Drop:	21.0	inH20	Pressure Drop:	21.0	inH20
Valves Per Port:	1		Valves Per Port:	1	

Lift: in	Flow: cfm	Lift: in	Flow: cfm
0.200	130.0	0.200	101.0
0.300	177.0	0.300	133.0
0.400	217.0	0.400	153.0
0.500	239.0	0.500	164.0
0.550	242.0	0.550	164.0
0.600	242.0	0.600	164.0
0.650	242.0	0.650	171.0
0.710	242.0	0.710	171.0

Notes

Enter a Description for this Cylinder Head Airflow Data

The *Custom Flow Dialog Box* allows the direct entry of flow bench data. From 4 to 10 data points for each port can be entered. Virtually any test valve diameter, valve lift and pressure drop can be used with the DynoSim. For multiple valves-per-port, flow data is measured as both (or all) valves in each port are opened simultaneously. Load and save airflow (.FLW) files using this program feature.

increased, but overall, these heads should show a power increase throughout the rpm range on most engines.

The final choice, ***4-Valve Head/Race Porting And Mods***, like the other Race-Porting-And-Mod choices in the **Cylinder Head** menu, models an all-out racing cylinder head. This selection has the greatest power potential of all. The ports are considerably larger than the other choices, the valves are larger, and the discharge coefficients are the highest possible. These heads suffer from the greatest reversion effects, especially with late IVC timing on low-speed, small-displacement engines.

Note: If the ***Auto Calculate Valve Size*** option is selected, these heads, like all choices provided in the **Cylinder Head** menu, use valves that are "scaled" to engine size, so that smaller engines automatically use appropriately smaller valves.

Pro Simulation Tip: If you would like to know what "hidden" power is possible using any particular engine combination, try this cylinder head choice. It is safe to say that the only way to find more power, with everything else being equal, would be to add forced induction, nitrous-oxide injection, or use exotic fuels.

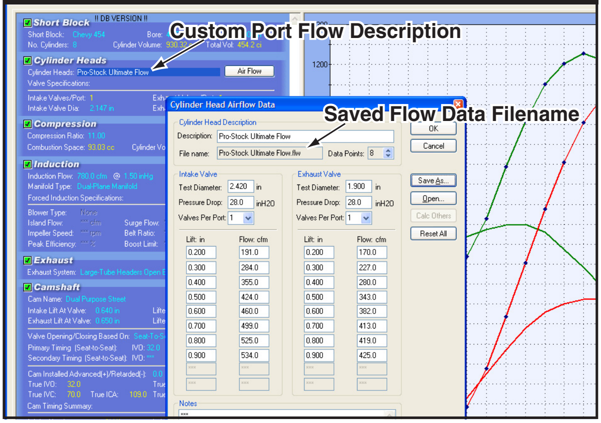
Custom Port Flow—The DynoSim will accept flowbench data, determined from testing virtually any port, with any valve size, at any pressure drop. Selecting ***Custom Port Flow*** opens the airflow-dialog box (see photo, above).

Note: If you open the **Custom Port Flow** dialog after you have selected one of the "generic" heads from the **Cylinder Head** menu, the flow data for that cylinder head will be displayed.

To enter custom flowbench data, first enter a suitable name for the flow data in the ***Description*** field. Then select the number of data points in your flowbench test into the ***Data Points*** field (click up to increase, down to decrease). Next, enter the valve

Custom Port Flow Dialog

Custom Port Flow Description And Filename



☑ **Short Block**
Short Block: Chevy 454
No. Cylinders: 8
Cylinder Volume: 930.32
Total Vol: 454.2 ci

☑ **Cylinder Heads**
Cylinder Heads: Pro-Stock Ultimate Flow
Valve Specifications:
Intake Valves/Port: 1
Intake Valve Dia: 2.147 in

☑ **Compression**
Compression Ratio: 11.00
Combustion Space: 93.03 cc

☑ **Induction**
Induction Flow: 780.0 cfm @ 1.50 inHg
Manifold Type: Dual-Plane Manifold
Forced Induction Specifications:
Blower Type: None
Island Flow: *** cfm
Impeller Speed: *** rpm
Peak Efficiency: *** %

☑ **Exhaust**
Exhaust System: Large-Tube Headers Open E

☑ **Camshaft**
Cam Name: Dual Purpose Street
Intake Lift At Valve: 0.640 in
Exhaust Lift At Valve: 0.650 in
Valve Opening/Closing Based On: Seat-To-S
Primary Timing (Seat-to-Seat): IVO: 32.0
Secondary Timing (Seat-to-Seat): IVO: ***
Cam Installed Advanced(+)/Retarded(-): 0.0
True IVO: 32.0
True IVC: 70.0 True ICA: 109.0
Cam Timing Summary:

Cylinder Head Airflow Data

Cylinder Head Description
Description: Pro-Stock Ultimate Flow
File name: Pro-Stock Ultimate Flow.flw
Data Points: 8

Intake Valve		Exhaust Valve	
Test Diameter: 2.420 in		Test Diameter: 1.900 in	
Pressure Drop: 28.0 inH20		Pressure Drop: 28.0 inH20	
Valves Per Port: 1		Valves Per Port: 1	
Lift: in	Flow: cfm	Lift: in	Flow: cfm
0.200	191.0	0.200	170.0
0.300	284.0	0.300	227.0
0.400	355.0	0.400	280.0
0.500	424.0	0.500	343.0
0.600	460.0	0.600	382.0
0.700	499.0	0.700	413.0
0.800	525.0	0.800	419.0
0.900	534.0	0.900	425.0
***	***	***	***
***	***	***	***

Notes
***

When a cylinder head has been selected or an airflow file is loaded (selected using the *Airflow Dialog Box*) a short Description of the cylinderhead/ flow-test is displayed in the *Cylinder Head* field. To load and save airflow data, click on the *Airflow Button*.

Test Diameters, the ***Pressure Drop*** (in inches of H_20) at which the tests were performed, and the number of ***Valves Per Port*** for both the intake and exhaust ports. Finally enter the ***Flow*** and ***Valve-Lift*** data obtained from flowbench testing.

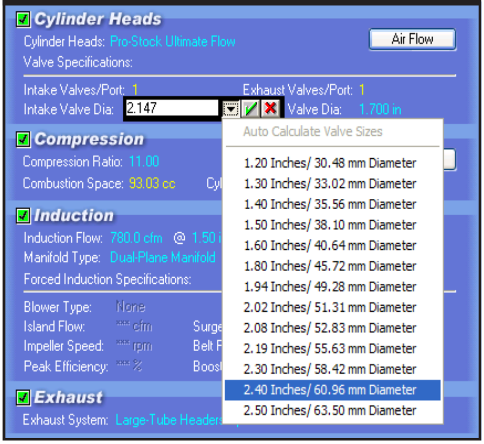
Note 1: If you press the ***Calc Others*** button after entering two valve-lift points, the DynoSim will fill in the remaining lift fields with the same "step" value that was established in the previous two fields.

Note 2: If you have fewer data points for one of the valves, simply repeat the highest measured flow value to "flush out" the remaining data points. This technique has been shown to produce accurate simulation results.

Note 3: For cylinder heads with more than one valve per port, the flow values measured on the flowbench, and entered in the Custom Flow Dialog Box, assume that both (or all) valves in each port are opened to the same lift when the airflow rate is

Select valve sizes for the intake and exhaust valves of the simulated engine from drop-down menus. These specs indicate the diameters of the valves used in the simulated engine; they need not be the same size as the valves used during flowbench testing and entered into the Airflow Dialog Box. If they are a different size than the flowbench test valves, airflow used in the simulation will be accurately scaled up or down to accommodate the actual valve sizes.

Intake And Exhaust Valve Sizes



☑ **Cylinder Heads**
Cylinder Heads: Pro-Stock Ultimate Flow
Valve Specifications:
Intake Valves/Port: 1
Exhaust Valves/Port: 1
Intake Valve Dia: 2.147
Valve Dia: 1.700 in

☑ **Compression**
Compression Ratio: 11.00
Combustion Space: 93.03 cc

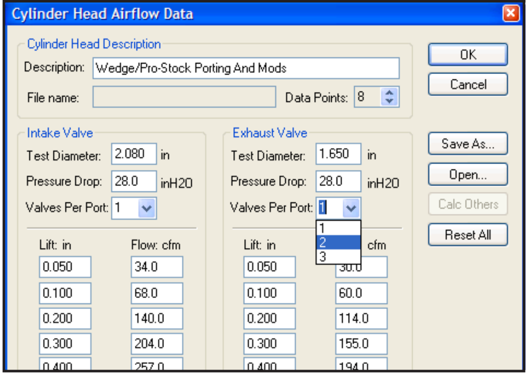
☑ **Induction**
Induction Flow: 780.0 cfm @ 1.50
Manifold Type: Dual-Plane Manifold
Forced Induction Specifications:
Blower Type: None
Island Flow: *** cfm
Impeller Speed: *** rpm
Peak Efficiency: *** %

☑ **Exhaust**
Exhaust System: Large-Tube Headers

Valve Size Menus

The DynoSim will accept 1, 2, or 3 valves-per-port cylinderhead designs. Since multiple-valve-per-port cylinder heads are airflow tested by opening *all valves in each port* to the same lift while recording the flow rates, the number of valves-per-port is directly linked to the flowbench data for any specific cylinder head. It is for this reason that the number of valves-per-port can only be changed by opening the Airflow Dialog Box (by pressing the *Airflow Button* in the CYLINDER HEAD component category).

Select Number Of Valves Per Port



Description: Wedge/Pro-Stock Porting And Mods

File name:

Data Points: 8

Intake Valve: Test Diameter: 2.080 in; Pressure Drop: 28.0 inH20; Valves Per Port: 1

Exhaust Valve: Test Diameter: 1.650 in; Pressure Drop: 28.0 inH20; Valves Per Port: 1

Lift: in	Flow: cfm	Lift: in	cfm
0.050	34.0	0.050	30.0
0.100	68.0	0.100	60.0
0.200	140.0	0.200	114.0
0.300	204.0	0.300	155.0
0.400	257.0	0.400	194.0

measured. *The recorded flow must be the combined flow for all valves in the port.*

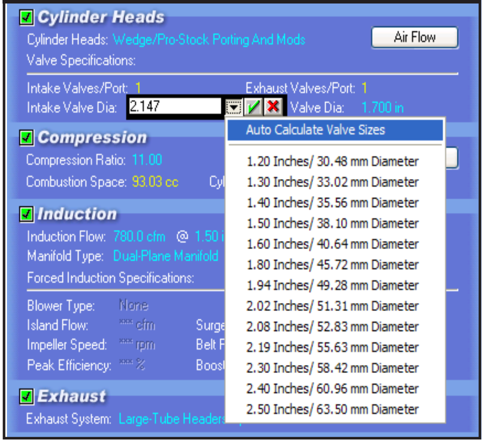
You can save flow data in a separate file at any time by pressing the ***Save As*** button (data will be saved in a separate **.FLW** file of your choosing—however, even if you do not create a separate .FLW file, head flow data is saved with the current engine in its **.DYN** file). Recall previously saved flow data (**.FLW** files) with the ***Open*** button.

Pressing ***OK*** will load the new test data into the engine simulation database and display the ***Description*** of the flow test (entered in the **Description** field of the **Airflow Dialog Box**) in the **CYLINDER HEAD** category of the main component screen.

Valves-Per-Port And Valve Diameters

The ***Valves Per Port*** display-only fields in the **CYLINDER HEAD** category indicate the number of intake and exhaust valves located in each port. Four-valve heads typically have two intake and two exhaust valves per port, while three-valve heads

Auto Calculate Valve Sizes



Cylinder Heads: Wedge/Pro-Stock Porting And Mods

Intake Valves/Port: 1

Exhaust Valves/Port: 1

Intake Valve Dia: 2.147

Valve Dia: 1.700 in

Compression Ratio: 11.00

Combustion Space: 93.03 cc

Induction Flow: 780.0 cfm @ 1.50

Manifold Type: Dual-Plane Manifold

Blower Type: None

Island Flow: *** cfm

Impeller Speed: *** rpm

Peak Efficiency: *** %

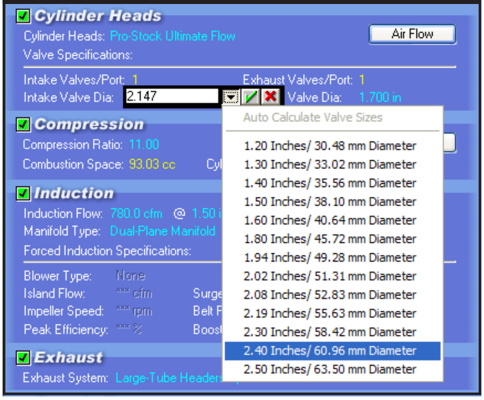
Exhaust System: Large-Tube Headers

The first selection in the Valve Diameter Menus is *Auto Calculate Valve Size* (active when any of the “generic” cylinder heads have been selected). This feature determines the nominal intake and exhaust valve diameters based on an assessment of the bore diameter and the cylinderhead selection. *Auto Calculate Valve Size* will always select valves of an appropriate diameter for the cylinder heads under test and ensure that valve sizes (especially in multiple valves-per-port applications) are never too large for the current bore diameter. *Note: This selection is dimmed whenever custom airflow values have been entered in the AirFlow Dialog Box.*

Valve Size Menus

Selecting a specific valve size will disable the *Auto Calculate Valve Size* feature. You can select from the provided sizes (displayed in both US and Metric measurements), or you can directly enter any valve dimension within the range limits of the DynoSim (range limits are shown in the *Status and Range Limit Line*, as described on page 16).

Manually Selecting Valve Sizes



Cylinder Heads: Pro-Stock Ultimate Flow
Valve Specifications:
Intake Valves/Port: 1
Exhaust Valves/Port: 1
Intake Valve Dia: 2.147
Valve Dia: 1.700 in
Compression Ratio: 11.00
Combustion Space: 93.03 cc
Induction Flow: 780.0 cfm @ 1.50 i
Manifold Type: Dual-Plane Manifold
Forced Induction Specifications:
Blower Type: None
Island Flow: **** cfm
Impeller Speed: **** rpm
Peak Efficiency: **** %
Exhaust System: Large-Tube Headers

designs often have two intake valves and one exhaust valve per port. Since multiple-valve-per-port cylinder heads are airflow tested by opening <u>*all valves in each port*</u> to the same lift before recording the flow rates, the number of valves-per-port is directly linked to (and stored with) the flowbench data for each cylinder head.

Note: If you wish to change the number of valves-per-port, click the ***AirFlow Button*** to open the **AirFlow Dialog Box**; here you can modify all flow data, including the number of valves-per-port.

The ***Valve Diameter*** menus are located in the lower portion of the **CYLINDER HEAD** category. The first selections are ***Auto Calculate Valve Size***. This feature instructs the DynoSim to determine the nominal intake and exhaust valve diameters for use with the current engine based on an assessment of the bore diameter and the cylinderhead selection. When the ***Auto Calculate*** function is activated, ***Auto*** will be displayed next to the calculated sizes, and it will remain active on the current engine until turned off (by selecting ***Auto Calculate*** a second time).

Note: ***Auto Calculation*** is turned **OFF** by default when the DynoSim is started and whenever ***Clear Components*** is chosen from the **Edit** menu.

Auto Calculate Valve Size is especially helpful if you are experimenting with several different bore and stroke combinations or you're comparing different engine configurations. **Auto Calculate** will always select valves of an appropriate diameter for the cylinder heads under test and ensure that valve sizes (especially for multiple

Compression ratio is calculated by dividing the total volume within the cylinder when the piston is located at Bottom Dead Center (BDC) by the volume that exists when the piston is positioned at Top Dead Center (TDC).

Basic Compression Ratio Equation

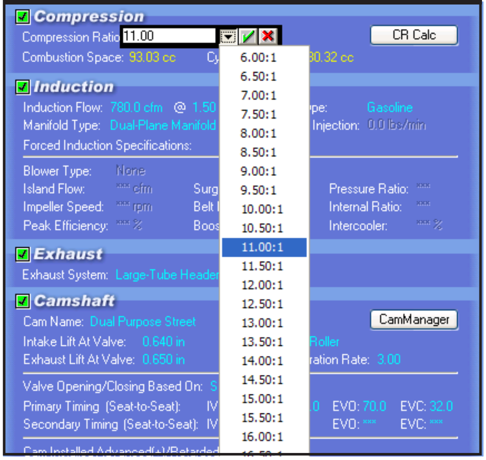
Compression Ratio =

$$\frac{\text{Swept Cyl Vol} + \text{Combustion Space Vol}}{\text{Combustion Space Vol}}$$

Compression Ratio Menu

The Compression Ratio of the engine is a comparison of the geometric volume that exists in the cylinder when the piston is located at BDC (bottom dead center) to the "compressed" volume when the piston reaches TDC (top dead center). Passenger car engines often have 8 to 10:1 compression ratio, while racing engines can have a compression ratio as high as 18:1.

Compression Ratio Menu



☑ Compression

Compression Ratio 11.00

Combustion Space: 93.03 cc

☑ Induction

Induction Flow: 780.0 cfm @ 1.50

Manifold Type: Dual-Plane Manifold

Forced Induction Specifications:

Blower Type: None

Island Flow: *** cfm

Impeller Speed: *** rpm

Peak Efficiency: *** %

Pressure Ratio: ***

Internal Ratio: ***

Intercooler: *** %

Gasoline

Injection: 0.0 lbs/min

☑ Exhaust

Exhaust System: Large-Tube Header

☑ Camshaft

Cam Name: Dual Purpose Street

Intake Lift At Valve: 0.640 in

Exhaust Lift At Valve: 0.650 in

Roller

ration Rate: 3.00

Primary Timing (Seat-to-Seat): EVO: 70.0 EVC: 32.0

Secondary Timing (Seat-to-Seat): EVO: *** EVC: ***

valves) are never too large for the current bore diameter (also, see page 77 for information on the related ***Auto Calculate Valve Lift*** feature).

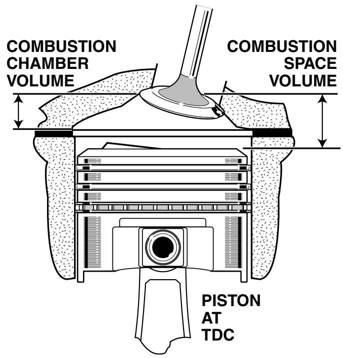
While ***Auto Calculate Valve Size*** is helpful during quick back-to-back testing, it may not "guess" the precise valve sizes used, and therefore, not simulate power as accurately as possible. In these situations refer to the additional choices on the ***Valve Diameter*** menus. Here you will find a list of exact diameters commonly used for automotive intake and exhaust valves. In addition, you can directly enter any valve-diameter dimension within the range limits of the program.

THE COMPRESSION-RATIO COMPONENT CATEGORY MENU

The **Compression Ratio** menu is located in the **COMPRESSION** component cat-

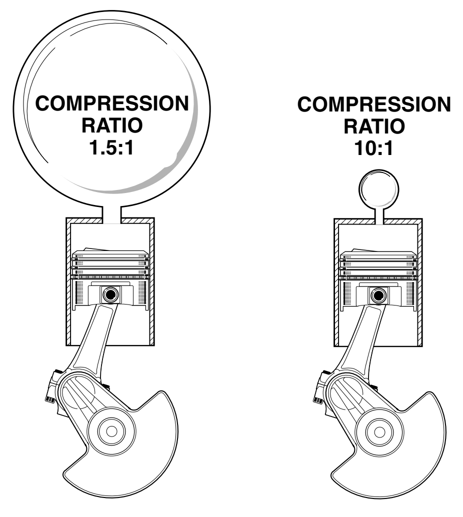
While *combustion-chamber volume* is simply the volume of the chamber in the cylinder head, the *combustion-space volume* is the <u>total enclosed volume</u> when the piston is located at TDC. This space includes the volume in the combustion chamber, plus any volume added by the piston not rising to the top of the bore, the volume within any valve pockets, and the head-gasket thickness, less any volume due to the piston or piston dome protruding above the top of the bore.

Top Dead Center Volumes



Compression Ratio Menu

High Compression Boosts Power



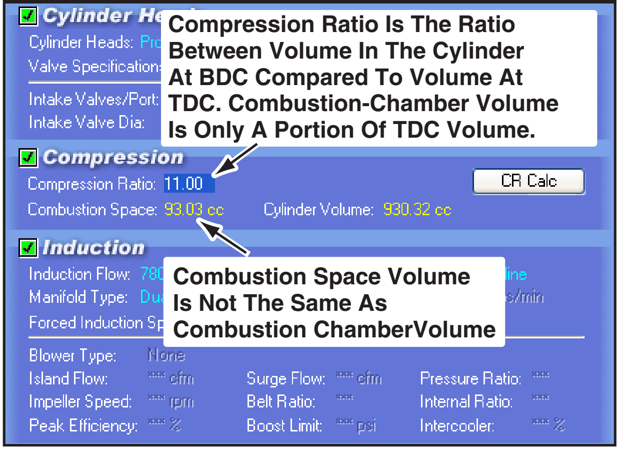
Why does higher compression ratio produce more horsepower? Try to answer this question before you read the remainder of this caption. A combustion space containing twice as much volume as the cylinder produces a 1.5:1 compression ratio. Peak cylinder pressures after ignition will be about 250psi. With a combustion space about 1/10th of the volume of the cylinder, the compression ratio will be 10:1. Peak pressures reach about 1500psi. It is easy to see that the higher compression ratio generated much higher cylinder pressures. And these higher pressures exerted against the piston throughout the first half of piston travel from TDC to BDC on the power stroke increase torque and horsepower.

egory. A selection from this menu establishes the compression ratio for the simulated engine (the DynoSim range of compression ratios is 6:1 to 18:1). As mentioned earlier, compression ratio is a comparison of the geometric volume that exists in the cylinder when the piston is located at BDC (bottom dead center) to the “compressed” volume when the piston reaches TDC (top dead center).

Compression Ratio Basics

The compression-ratio equation shown on the previous page contains two variables: 1) swept-cylinder volume, and 2) combustion-space volume. *These volumes are the*

Combustion Space Volume



Compression Ratio: 11.00

Combustion Space: 93.03 cc

Cylinder Volume: 930.32 cc

Blower Type: None

Island Flow: *** cfm

Surge Flow: *** cfm

Pressure Ratio: ***

Impeller Speed: *** rpm

Belt Ratio: ***

Internal Ratio: ***

Peak Efficiency: *** %

Boost Limit: *** psi

Intercooler: *** %

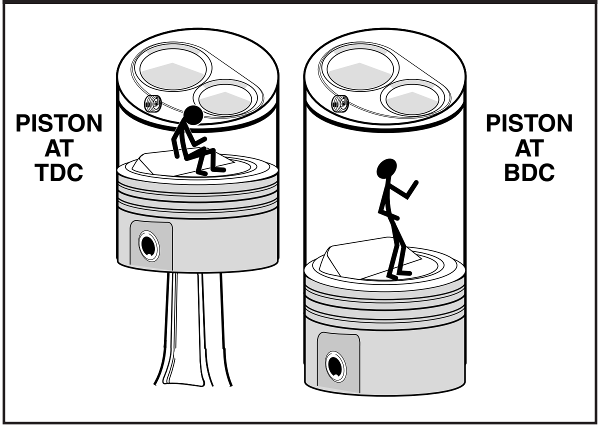
Compression Ratio Is The Ratio Between Volume In The Cylinder At BDC Compared To Volume At TDC. Combustion-Chamber Volume Is Only A Portion Of TDC Volume.

Combustion Space Volume Is Not The Same As Combustion ChamberVolume

An 11:1 compression ratio (as shown here) means that the sum of the Swept Cylinder Volume and the Combustion Space Volume is eleven times greater than the volume in the Combustion Space alone.

Compression Ratio Menu

Exploring Compression Ratio And Volumes



A good way to visualize compression ratio volumes is to imagine yourself as a "little guy" wandering around inside the engine. You would see the combustion chamber above you like a ceiling. Your floor would be the top of the piston (see text for a further description of cylinder volumes).

only two volumes that affect compression ratio. That said, however, each of these volumes is made up of multiple volumes, so the first step in exploring compression ratio must be to understand these volumes in detail.

Swept cylinder volume is the most straightforward to understand. As you discovered previously, the swept cylinder volume is calculated by the DynoSim—and displayed in the **SHORTBLOCK** category—as soon as the bore and stroke have been selected for the test engine. Swept volume is simply the three-dimensional space displaced by the piston as it "sweeps" from BDC to TDC, and is determined solely by the bore diameter and stroke length.

The other main variable in the compression-ratio equation is *combustion-space volume*. This is the total volume that exists in the cylinder when the piston is positioned at TDC. This space includes the volume in the combustion chamber, the volume taken up by the thickness of the head gasket, plus any volume added by the piston not rising fully to the top of the bore plus any valve-pocket volume, less any volume displaced by the piston or piston dome protruding above the top of the bore. The complexity of volumes often is a stumbling block in understanding compression ratio. However, the following explanation should clarify these important concepts.

A good way to visualize these volumes is to imagine yourself as a "little guy" wandering around inside the engine. Let's take a walk inside the combustion space. Picture in your mind what you would see in the cylinder with the piston at TDC. The combustion chamber would look like a ceiling above you. The floor would be the top of the piston. If the piston (at TDC) didn't rise completely to the top of the cylinder, you would see a bit of the cylinderwall around the edges of the floor, with the head gasket sandwiched between the head and block like trim molding around the room. There may be notches (valve pockets) in the top of the piston just under your feet (don't trip!). If the piston had a dome, it might act as a small room divider rising from the floor, to, perhaps, knee high. The combustion space would be larger if the piston was positioned lower down the bore or if the notches under your feet were deeper, and it would be smaller if the room divider (dome) volume was larger. This entire space is "home" for the compressed charge when the piston reaches TDC. This is the volume that makes up the combustion space, the denominator of the compression-ratio calculation equation. Now let's continue our "tour" of compression spaces, but this time we'll explore what we see inside the cylinder when the piston is located at BDC. The very same volumes that we just described (chamber, dome, notches, gasket, etc.) are still there, but are now located well above our head. It looks like the room has been stretched, like the elevator ride in the Haunted House at Disneyland. This "stretched" volume is described in the numerator of the compression-ratio equation. It's simply the original combustion volume plus the volume added by the "sweep" of the piston as it traveled from TDC to BDC. The ratio between these volumes is the compression ratio.

Changing Compression Ratio

A quick look at the compression-ratio equation reveals that if engine displacement (swept volume) is increased, either by increasing the bore or stroke, the compression ratio will rise. In fact, with everything else being equal, a longer stroke will increase compression ratio much more quickly than increasing bore diameter. This is due to the fact that a longer stroke not only increases displacement, but it tends to decrease combustion space volume, since the piston moves higher the bore (in our "little guy" example, raising the floor closer to the ceiling). This "double positive" results in rapid increases in compression ratio for small increases in stroke length. On the other hand, increasing cylinder-bore diameter also increases compression ratio but less significantly. This is due, in part, to the increase in combustion volume that often accompanies a larger bore (our "little guy" would see more floor space because of the increasing diameter of the room—plus a larger bore often accompanies an increase in the size of the ceiling, i.e., the combustion chamber), partially offsetting the compression-ratio increase from greater swept cylinder volume.

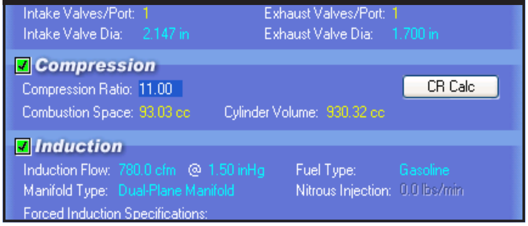
Changing combustion space, the other element in the compression-ratio equation, will also alter the compression ratio. Anything that reduces the combustion volume, while maintaining or increasing the swept volume of the cylinder, will increase the compression ratio. Some of the more common methods to accomplish this are decreasing the volume of the combustion chambers (by replacing or milling the heads), using thinner head gaskets, changing the location of the piston-pin or rod length to move the piston closer to the combustion chamber, installing pistons with larger domes, etc. These modifications and others can be explored in the DynoSim using the built-in **Compression-Ratio Calculator**.

THE COMPRESSION-RATIO CALCULATOR

The DynoSim engine simulation allows the selection and testing of virtually any compression ratio. But many engine builders need to directly enter combustion-chamber volumes, head-gasket thickness, etc., to determine their effects on compression ratio. The ***Compression-Ratio Calculator***, built-in to the DynoSim, quickly performs these functions. But this tool is more than a "enter-the-numbers-into-the-equation"

Compression-Ratio Math Calculator

Compression-Ratio Math Calculator



Intake Valves/Port: 1
Exhaust Valves/Port: 1
Intake Valve Dia: 2.147 in
Exhaust Valve Dia: 1.700 in

☑ **Compression**

Compression Ratio: 11.00
Combustion Space: 93.03 cc
Cylinder Volume: 930.32 cc

☑ **Induction**

Induction Flow: 780.0 cfm @ 1.50 inHg
Fuel Type: Gasoline
Manifold Type: Dual-Plane Manifold
Nitrous Injection: 0.0 lbs/min
Forced Induction Specifications:

Activate the Compression-Ratio Calculator by selecting *Compression Ratio Math* from the Tools menu, clicking on the *Compression Ratio Icon* in the Tool Bar, or by clicking on the *Compression-Ratio Button* in the COMPRESSION category.

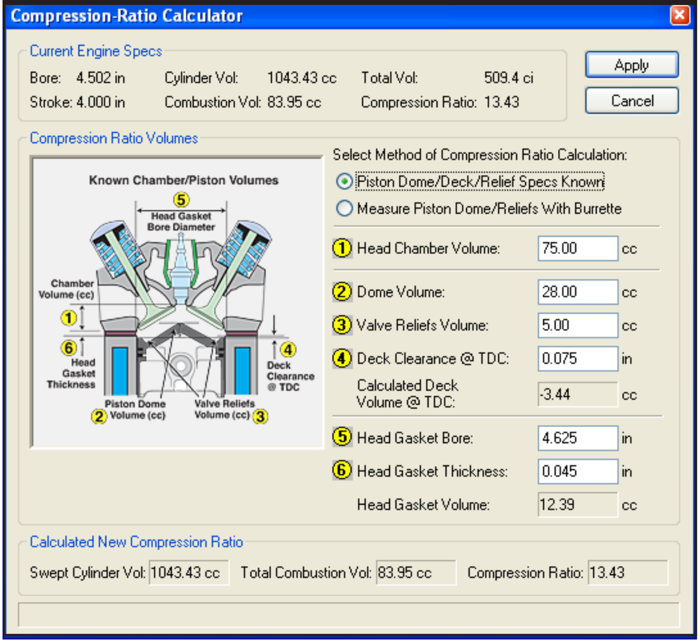
calculator. This tool “intelligently” adjusts itself to the needs of the engine builder, changing the way it functions depending on whether combustion volumes are known ahead of time or need to be derived from measurement.

After you have specified the bore, stroke, and number of cylinders for the engine under test, activate the ***Compression-Ratio Calculator*** by selecting either ***Compression-Ratio Math*** from the **Tools** menu, or by clicking the ***Compression-Ratio Button*** in the **COMPRESSION** component category. When the calculator is first activated, it defaults to the *Known Volumes* mode. This is the most straightforward model for calculating compression ratio. Simply enter the needed values in the ***Compression-Ratio Calculator*** and the compression-ratio will displayed.

Using The Calculator With Known Dome/Dish/Deck/Chamber Volumes

If an engine builder is provided with the exact volumes displaced in the dome and

CR Math Calculator—*Known Volumes Mode*



Compression-Ratio Calculator

Current Engine Specs
Bore: 4.502 in
Cylinder Vol: 1043.43 cc
Total Vol: 509.4 ci
Stroke: 4.000 in
Combustion Vol: 83.95 cc
Compression Ratio: 13.43

Compression Ratio Volumes

Select Method of Compression Ratio Calculation:
● Piston Dome/Deck/Relief Specs Known
○ Measure Piston Dome/Reliefs With Burrette

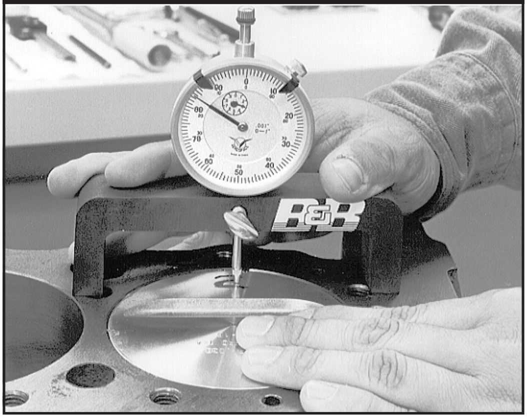
① Head Chamber Volume: 75.00 cc
② Dome Volume: 28.00 cc
③ Valve Reliefs Volume: 5.00 cc
④ Deck Clearance @ TDC: 0.075 in
Calculated Deck Volume @ TDC: -3.44 cc
⑤ Head Gasket Bore: 4.625 in
⑥ Head Gasket Thickness: 0.045 in
Head Gasket Volume: 12.39 cc

Calculated New Compression Ratio
Swept Cylinder Vol: 1043.43 cc
Total Combustion Vol: 83.95 cc
Compression Ratio: 13.43

When the *Compression-Ratio Calculator* is first activated, it defaults to the *Known Volumes* mode. This is the most straightforward model for calculating compression ratio. Simply enter the needed values in fields 1 through 6, and the *Compression-Ratio Calculator* will determine the compression ratio.

Compression-Ratio Math Calculator

Measuring Deck Height



Use a dial indicator and stand to measure how far down the bore the piston is positioned at TDC. Enter a positive number for "down-the-bore" distances and a negative number if the piston protrudes above the deck surface. A typical value might be +0.040, indicating that the piston comes to a rest at TDC 0.040-inch <u>below the deck surface</u>.

valve pockets by the piston manufacturer, and the volumes of the combustion chamber, the deck height, and the specifications for the head gaskets are also known, a simple, numeric-only method can be used to calcuate the compression ratio. This proceedure is explained next. However, in those cases where piston specifications are unknown (not provided by the manufacturer or machine work has been performed on the dome/pockets), the engine builder must directly measure dome/pocket volumes. In these situations, refer to the next section for the ***Burrette-Measured Volume Mode*** of the *Compresssion-Ratio Calculator*.

Here is the procedure for using the DynoSim compression-ratio calculator in the ***Known-Volumes Mode***. Start off by verifying that the calculator is in the ***Known-Volume Mode*** by ensuring that the upper radio button ***Piston Dome/Deck/Relief Specs Known*** is activated. Next, enter the combustion-chamber volume (in cubic centimeters—cc's) in the first ***(1) Head Chamber Volume*** data box. Next, enter the ***(2) Dome Volume*** and the ***(3) Volume*** displaced by all the ***Valve Reliefs*** in one piston. If your piston manufacturer provided one value for both of these volumes, enter the supplied volume in the ***(2) Dome Volume*** field and enter zero in field **3**.

Note: If any of these values are unknown, they must be manually measured (with a burrette (see the next section for *Burrette-Measured Volumes*).

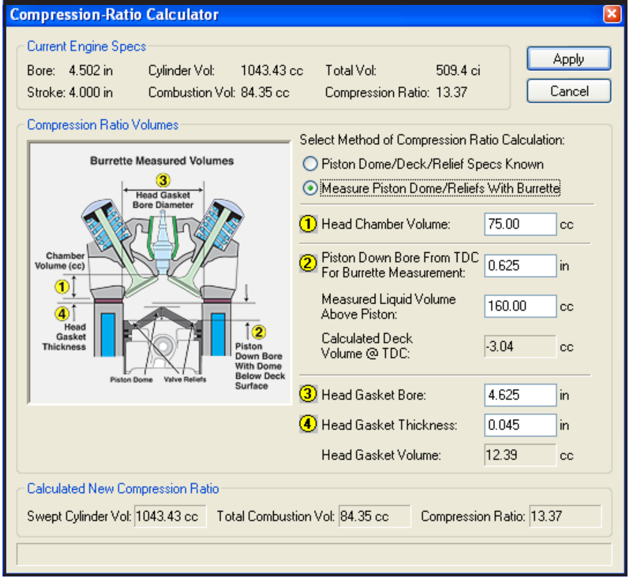
The next data entry field is ***(4) Deck Clearance @ @ TDC***. This dimension indicates how far down the bore the piston is located when positioned at TDC (see above photo). Enter a positive number for "down-the-bore" distances and a negative number if the piston protrudes above the deck surface. A typical value might be +0.040-inch, indicating that the piston comes to a rest at TDC at 0.040-inch <u>below the deck surface</u>.

Important Note: A positive ***Deck Clearance @ TDC*** indicates the piston is positioned below the deck surface and this volume <u>adds</u> to the combustion space at TDC; a negative number indicates the piston protrudes above the deck surface at TDC and <u>reduces</u> the combustion space.

The next two data-entry boxes are used to calculate the volume added to the

Compression-Ratio Math Calculator

CR Math Calculator—*Burrette Measured Mode*



Current Engine Specs

Bore: 4.502 in
Stroke: 4.000 in
Cylinder Vol: 1043.43 cc
Combustion Vol: 84.35 cc
Total Vol: 509.4 ci
Compression Ratio: 13.37

Compression Ratio Volumes

Select Method of Compression Ratio Calculation:
○ Piston Dome/Deck/Relief Specs Known
● Measure Piston Dome/Reliefs With Burrette

① Head Chamber Volume: 75.00 cc
② Piston Down Bore From TDC For Burrette Measurement: 0.625 in
Measured Liquid Volume Above Piston: 160.00 cc
Calculated Deck Volume @ TDC: -3.04 cc
③ Head Gasket Bore: 4.625 in
④ Head Gasket Thickness: 0.045 in
Head Gasket Volume: 12.39 cc

Calculated New Compression Ratio

Swept Cylinder Vol: 1043.43 cc
Total Combustion Vol: 84.35 cc
Compression Ratio: 13.37

When the Compression-Ratio Calculator is switched to the *Burrette Measured* Mode, the data fields are redefined to allow the engine builder to input the direct measurement of a volume (*Calculated Deck Volume @ TDC*) equivalent to the sum of the dome, dish, and relief volumes of the piston. To determine this volume, the piston is lowered down the bore until the dome is entirely below the deck surface (2), and a direct measurement is taken of the cylinder volume using a burette. After entering this volume and the head gasket specs, the compression-ratio is displayed.

combustion space by the head gasket that is compressed between the cylinder head and the block deck surface. The data box marked ***(5)*** accepts the ***Head Gasket Bore*** diameter (in the appropriate Metric or U.S. units system). Most head gaskets have a “bore-circle” or “bore diameter” larger than the cylinder-bore diameter. For gaskets with bore-circles of odd shapes, simply estimate the bore circle by averaging the larger and smaller dimensions. Next, enter the compressed ***(6) Head Gasket Thickness***. This dimension is often available from the head-gasket manufacturer. When the compressed thickness is entered, the ***Head Gasket Volume*** and the ***Compression Ratio*** are calculated.

At this point, you can move to any of the previous fields (by clicking in them or using the Tab and/or the SHIFT-Tab keys) and change any values to determine their effect on compression ratio. At any time, you can click on the **Apply** button to load the new calculated compression ratio into the **COMPRESSION** component category and save all entered values for the simulated engine. Alternately, you can press the **Cancel** button to discard all entries and leave any previously entered compression ratio value intact.

Using The Calculator With Burrette-Measured Volume

If you are using pistons with domes, dishes, or valve-pockets/reliefs of unknown volumes, determing the compression ratio is a bit more complicated. Each of these volumes must be accurately determined so that the net effect of all “positive” (domes) and “negative” (pockets, reliefs) can be calculated.

Start off by verifying that the calculator is in the ***Burrette-Measured Mode*** by

Measuring Dome/Deck Volume

Measure the volume above the piston while the highest portion of the piston dome is positioned below the deck surface. Enter this value in the *Measured Liquid Volume Above Piston* field. The difference between this volume and the volume of a simple cylinder [of a height equal to the value entered in field (2)] is the *Calculated Deck Volume At TDC*. This volume is equivalent to the sum of all the dome, dish, and relief volumes of the piston. A negative *Deck Volume At TDC* indicates that the dome reduces the combustion space and will increase the compression ratio over a flattop piston. A positive value indicates that the sum of all dome/dish/relief/deck volumes will increase the combustion volume and decrease the compression ratio over a flattop piston.

verifying that the lower radio button ***Measured Piston Dome/Reliefs With Burrette*** is activated. Enter the combustion chamber volume (in cubic centimeters—cc's) in the first ***(1)*** ***Head Chamber Volume*** data box.

Note: As mentioned earlier, if unknown, the combustion-chamber volume must be measured with a burette.

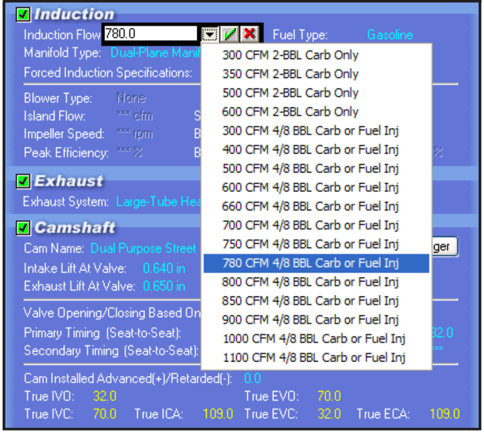
The next entry, ***(2)*** ***Piston Down From TDC For Burrette Measurement***, is a more-or-less arbitrary distance down the bore (measured from the deck surface) that you can position the piston at which the highest part of the piston dome is located below the deck surface. Typical values may be 0.100-inches or 0.250-inches depending on the height of the piston dome (any distance is acceptable as long as the entire dome resides below the deck surface). At this depth, a direct measurement is made of the ***Volume Above The Piston*** in the cylinder. This measurement is taken by the engine builder (see photo, above) using a burette to fill the space above the piston (a flat Plexiglas plate is often used to seal the top of the bore; grease is used to seal the piston to the bore). The volume of liquid dispensed typically will be less than the volume for a simple cylinder of the same height. The liquid volume dispensed from the burette is entered in field ***Measured Liquid Volume Above Piston***. The difference between this volume and the volume of a simple cylinder (of a height equal to the value entered in field **(2)**) is the ***Calculated Deck Volume At TDC***, a volume equivalent to the sum of the dome, dish, relief, and deck volumes of the piston.

Important Note: A negative ***Calculated Deck Volume At TDC*** indicates that the total dome/deck/relief volumes reduce the combustion space and will, therefore, increase the compression ratio over a flattop piston. A positive value indicates that the sum of all dome/dish/relief volumes will increase the combustion space volume and decrease the compression ratio over a similar flattop piston (with the same deck height at TDC).

The next two data-entry boxes are used to calculate the volume added to the

Induction Menus

Induction Airflow Menu



☑ **Induction**

Induction Flow: 780.0

Fuel Type: Gasoline

Manifold Type: Dual-Plane Manif

Forced Induction Specifications:

Blower Type: None

Island Flow: **** cfm

Impeller Speed: **** rpm

Peak Efficiency: **** %

☑ **Exhaust**

Exhaust System: Large-Tube Hea

☑ **Camshaft**

Cam Name: Dual Purpose Street

Intake Lift At Valve: 0.640 in

Exhaust Lift At Valve: 0.650 in

Valve Opening/Closing Based On

Primary Timing (Seat-to-Seat):

Secondary Timing (Seat-to-Seat):

Cam Installed Advanced(+)/Retarded(-): 0.0

True IVO: 32.0

True EVO: 70.0

True IVC: 70.0

True ICA: 109.0

True EVC: 32.0

True ECA: 109.0

The Induction Airflow menu selects the flow rate and pressure drop through the induction system. It also establishes the airflow restriction for induction modeling. For the purposes of the simulation, everything upstream of the intake ports, including the intake manifold, carburetor/fuel-injection system, venturis, any supercharger or turbocharger, and the openings to the atmosphere is considered the induction system. The Airflow menu consists of four 2-barrel-carburetor selections (at 3.0-in/Hg) and thirteen 4-barrel-carburetor/fuel-injection choices (at 1.5-in/Hg). In addition, you can directly specify any rated airflow from 100 to 4000cfm.

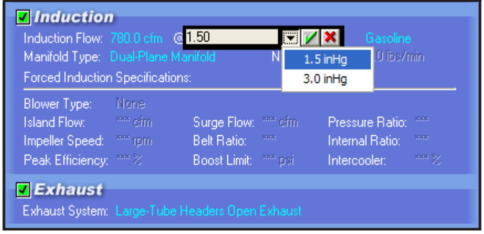
combustion space by the head gasket that is compressed between the cylinder head and the block deck surface. The data box marked ***(3)*** accepts the ***Head Gasket Bore*** diameter (in the appropriate Metric or US units system). Most head gaskets have a "bore-circle" or "bore diameter" larger than the cylinder-bore diameter. For gaskets with bore-circles of odd shapes, simply estimate the bore circle by averaging the larger and smaller dimensions. Next, enter the compressed ***(4)*** ***Head Gasket Thickness***. This dimension is often available from the head gasket manufacturer. When the compressed thickness is entered, the ***Head Gasket Volume*** and ***Compression Ratio*** are calculated.

At this point, you can move to any of the previous fields and change any values to determine their effect on compression ratio. At any time, you can click on the **Apply** button to load the new calculated compression ratio into the **COMPRESSION** component category and save all entered values with the simulated engine. Alternately, you can press the **Cancel** button to discard all entries and leave any previously entered compression ratio value intact.

THE INDUCTION COMPONENT CATEGORY MENUS

The next main component category establishes an **INDUCTION** system for the

Induction Pressure-Drop Menu



☑ **Induction**

Induction Flow: 780.0 cfm @ 1.50

Gasoline

Manifold Type: Dual-Plane Manifold

Forced Induction Specifications:

Blower Type: None

Island Flow: **** cfm

Surge Flow: **** cfm

Pressure Ratio: ****

Impeller Speed: **** rpm

Belt Ratio: ****

Internal Ratio: ****

Peak Efficiency: **** %

Boost Limit: **** psi

Intercooler: **** %

☑ **Exhaust**

Exhaust System: Large-Tube Headers Open Exhaust

Use the Induction Airflow Pressure Drop menu to select between 1.5-inches of mercury (1.5-in/Hg), a measurement standard for 4-barrel carburetors and injection systems, and the two-barrel carburetor standard of 3.0-inches of mercury (3.0-in/Hg).

simulated engine. An induction system, as defined in the DynoSim, is everything upstream of the intake ports, including the intake manifold, common plenums (if applicable), carburetor/fuel-injection-throttle-body, venturis (if used), any supercharger or turbocharger, and openings to the atmosphere. DynoSim induction menus are divided into two main groups: 1) ***Induction Airflow***, ***Pressure Drop***, ***Fuel***, and ***Manifold Type***, and 2) ***Forced Induction***. Next, we'll examine the choices in the first group, then forced-induction modeling will be discussed (on page 60).

Airflow Selection And Pressure Drop

The first two **INDUCTION** menus select the rated airflow for the induction system and the pressure drop at which it's measured. The ***Induction Flow*** menu consists of four 2-barrel-carburetor selections and thirteen 4-barrel-carburetor/fuel-injection choices. In addition, you can directly specify any rated airflow from 100 to 4000cfm.

Note: The flow ratings for 2-barrel carburetors are measured at a pressure drop twice as high as the pressure used to rate 4-barrel carburetors and most fuel-injection systems. The higher pressure drop increases the measurement resolution for smaller carburetors and "shifts" the flow numbers toward the range commonly found in automotive applications (roughly, 100 to 700cfm). Rated airflow for 2-barrels is typically measured at a pressure drop of 3 inches of mercury (3.0-in/Hg), while the pressure drop for 4-barrel carburetors is 1.5-inches of mercury (1.5-in/Hg). This pressure drop is the pressure differential maintained across the carburetor during airflow measurement at wide-open throttle. The pressure drop is displayed as **3-in/Hg** or **1.5-in/Hg** in the **Pressure Drop** menu (**Hg** is the symbol for mercury as used in the Periodic Table). See the **Airflow Math Calculator** (next page) for quick conversions between any airflow measured at any pressure drop.

The two-barrel **Induction Flow** menu selections "install" a 300-, 350-, 500-, or 600-cfm 2-bbl carburetor on the test engine (at 3.0-in/Hg). These are the only 2-barrel selections directly available in the menu, however, you can manually enter any cfm flow rate (from 100 to 4000cfm). The last thirteen choices in the **Induction Flow** menu are labeled **4/8-Bbl Carb Or Fuel Inj**. These airflow selections set a pressure drop at 1.5-in/Hg. **4/8-BBL** indicates that the induction system can consist of single or multiple carburetors or a fuel-injection system capable of the rated airflow. Again, in addition to the menu selections, you can manually enter any cfm flow rate from 100 to 4000cfm.

Note: The important thing to remember about airflow selection is that the DynoSim *makes no assumption about the type of restriction* used in the induction system. The airflow is simply a measure of the restriction of the entire induction system.

Airflow Menu Assumptions

As higher airflow levels are selected from the **Induction Flow** menu, the simulation lowers the restriction within the induction system. This decrease in restriction increases charge density within the cylinders. To keep things consistent, the DynoSim assumes that *the air/fuel ratio is always at the precise proportion for optimum power*. While optimum air/fuel ratios are more achievable with fuel-injection systems, a carefully tuned carburetor also can come remarkably close to ideal fuel metering. Regardless of whether the simulated engine uses carburetors or fuel injection, the power levels predicted by the simulation can be considered optimum, achievable when the engine is in “peak” tune and the induction system is working properly.

The airflow selected from the **Induction Flow** menu is the *total rated airflow into the engine*. On dual-inlet or multiple-carburetor systems, the Induction Airflow is the sum of all rated airflow devices. So a manifold equipped with twin 1100cfm Holley Dominators would have a rated airflow of 2200cfm. If an air cleaner is used, total airflow must be adjusted to compensate for the increase in restriction (contact the element manufacturer or flow test the carburetor/air-cleaner as an assembly).

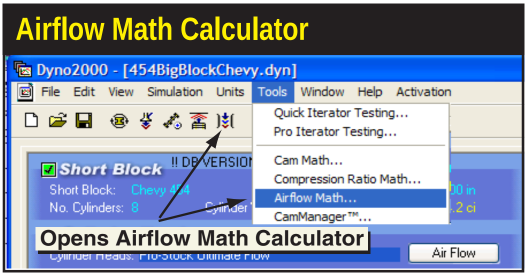
Note About IR Manifolds: Keep in mind the unique way airflow capacities are handled on Individual Runner (IR) manifolds (additional details on page 57). On these induction systems, each cylinder is connected to a single “barrel” or injector stack with no connecting passages that allow the cylinders to “share” airflow from other barrels. The total rated flow for these induction systems is divided among the number of cylinders. For example, a smallblock V8 equipped with 4 Weber carburetors (having 8 barrels) may have a total rated flow of 2000cfm. To properly model this system, enter 2000cfm directly into the Induction Airflow field. When an **IR** manifold is selected from the **Manifold Type** menu, the airflow is equally divided into all cylinders (i.e., 250cfm per cylinder).

THE AIRFLOW MATH CALCULATOR

As discussed previously, the DynoSim will accept induction airflow (cfm) measured at a pressure drop of either 1.5-In/Hg or 3.0-In/Hg. For those instances where an induction system, injector, or carburetor was flow tested at a different pressure drop, or whenever you would like to convert flow values from one pressure-drop rating to another, the **Airflow Math Calculator** easily performs these conversion functions. The **Airflow Math Calculator** can also convert flow ratings measured in inches-of-mercury (in/Hg) to and from airflow values rated in inches-of-water (in/H_2O).

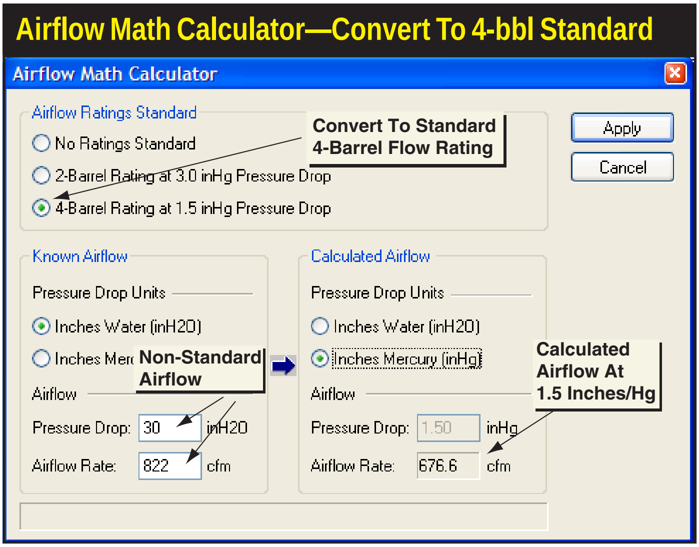
Note: A pressure drop of 1.5-in/Hg is equivalent to 20.3-in/H_2O.

The **Airflow Math Calculator** has three basic modes of operation: 1) Convert to the 4-Barrel Standard, 2) convert to the 2-Barrel Standard, and 3) calculate airflow



The Airflow Math Calculator is a general-purpose tool that will convert airflow to/from any pressure-drop standard. Activate the Airflow Math Calculator by either selecting *Airflow Math* from the Tools menu or by clicking on the *Airflow Math Calculator Icon* in the Toolbar.

Airflow Math Calculator



Airflow Math Calculator—Convert To 4-bbl Standard

Airflow Ratings Standard
○ No Ratings Standard
○ 2-Barrel Rating at 3.0 inHg Pressure Drop
● 4-Barrel Rating at 1.5 inHg Pressure Drop

Known Airflow
Pressure Drop Units
● Inches Water (inH20)
○ Inches Merc
Airflow
Pressure Drop: 30 inH20
Airflow Rate: 822 cfm

Calculated Airflow
Pressure Drop Units
○ Inches Water (inH20)
● Inches Mercury (inHg)
Airflow
Pressure Drop: 1.50 inHg
Airflow Rate: 676.6 cfm

When the calculator is first activated, the *Airflow Ratings Standard* is set to *1.5-in/Hg* (20.3-in/H_2O). To convert any known airflow to this flow (the standard for 4-barrel carburetors), enter the known airflow and pressure drop in the *Known Airflow* category. The calculated airflow will be displayed in the *Calculated Airflow* category.

between any two pressure drop ratings. Each of these methods are described below. Activate the **Airflow Math Calculator** by either selecting ***Airflow Math*** from the **Tools** drop-down menu or click on the **Airflow Icon** located in the **Toolbar**.

Using The Airflow Math Calculator
Mode 1: Convert Any Flow To 1.5-in/Hg, The 4-Barrel Standard.

When the calculator is first activated, the 1.5-in/Hg ***Airflow Ratings Standard*** “radio button” is selected. The ***Calculated Airflow*** category also defaults to a pressure drop of 1.5-in/Hg or 20.3-in/H_2O (these pressure drops are identical). To convert any known airflow measured at any pressure drop to the 1.5-in/Hg, 4-barrel standard, enter the measured airflow and pressure drop in the ***Known Airflow*** category (if needed, you can switch between Inches-of-Mercury(Hg) and Inches-of-Water (H_2O) buy clicking on the appropriate radio buttons in the ***Known Airflow*** and ***Calculated Airflow*** categories). The converted airflow will be displayed in the ***Airflow Rate*** field (see photo, above). You can move to any of the previous fields (by clicking on them or using the Tab or SHIFT-Tab keys) to make changes and explore their effects on calculated airflow. At any time, you can click the ***Apply*** button to load the new calculated airflow into the **Induction Flow** field on the Component Selection screen, saving all entered values. Alternately, you can press **Cancel** to discard all entries and keep any previously entered flow values.

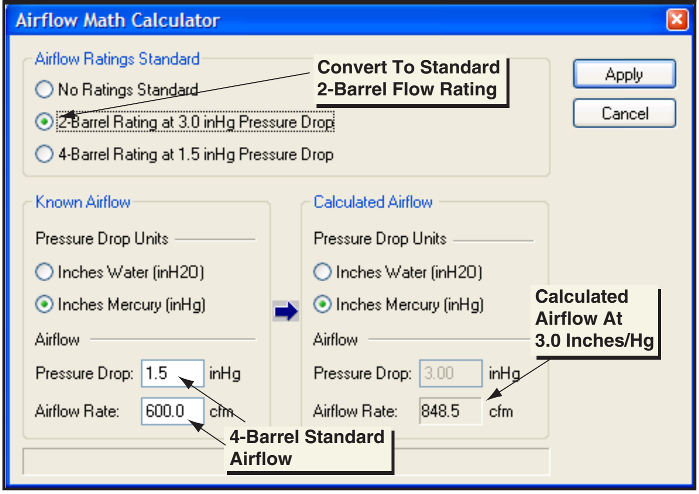
Using The Airflow Math Calculator
Mode 2: Convert Any Flow To 3.0-in/Hg, The 2-Barrel Standard.

Switch the ***Airflow Ratings Standard*** category selection to the radio button marked

Airflow Math Calculator

Switch the ***Airflow Ratings Standard*** to ***3.0-in/Hg***. This the default pressure drop of 3.0-in/Hg (40.7-in/H_2O), a pressure drop commonly used for rating 2-barrel carburetors. Enter the measured airflow and pressure drop in the ***Known Airflow*** category. The new calculated airflow is displayed in the ***Airflow Rate*** field.

Airflow Math Calculator—Convert To 2-Bbl Standard



Airflow Math Calculator

Airflow Ratings Standard

○ No Ratings Standard

● 2-Barrel Rating at 3.0 inHg Pressure Drop

○ 4-Barrel Rating at 1.5 inHg Pressure Drop

Known Airflow

Pressure Drop Units

○ Inches Water (inH20)

● Inches Mercury (inHg)

Airflow

Pressure Drop: 1.5 inHg

Airflow Rate: 600.0 cfm

Calculated Airflow

Pressure Drop Units

○ Inches Water (inH20)

● Inches Mercury (inHg)

Airflow

Pressure Drop: 3.00 inHg

Airflow Rate: 848.5 cfm

Convert To Standard 2-Barrel Flow Rating

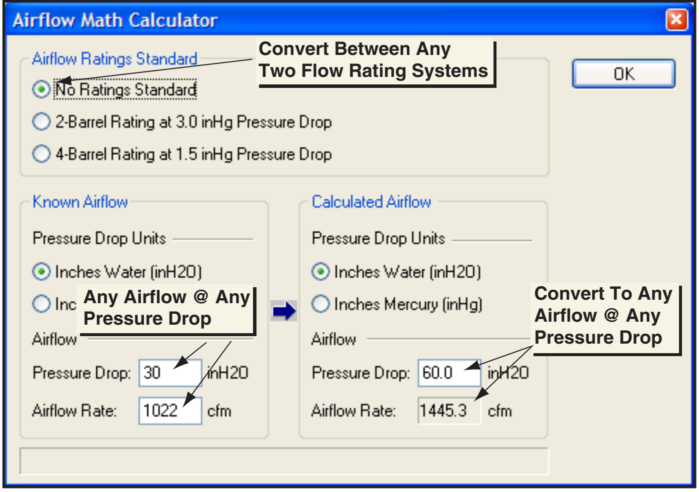
Calculated Airflow At 3.0 Inches/Hg

4-Barrel Standard Airflow

2-Barrel Rating of 3.0-in/Hg Pressure Drop. This changes the "result," or ***Calculated Airflow*** category to 3.0-in/Hg (40.7-in/H_2O). To convert any known airflow measured at any pressure drop to the 3.0-in/Hg, 2-barrel standard, enter the measured airflow and pressure drop in the ***Known Airflow*** category (you can switch between Inches-of-Hg and Inches-of-H_2O buy clicking on the appropriate radio buttons in the ***Known Airflow*** and ***Calculated Airflow*** categories). The calculated airflow at 3.0-in/Hg pressure drop will be displayed in the ***Airflow Rate*** field (see photo, next page). You can move to any of the previous fields (by clicking on them or using the Tab or SHIFT-Tab

Switch the ***Airflow Ratings Standard*** to ***No Ratings Standard***. The ***Calculated Airflow*** can now be set to any pressure drop measured in Inches of Hg or H_2O. Select the desired ***Pressure Drop Units*** and enter the known airflow and pressure drop. Enter the desired pressure drop in the ***Calculated Airflow*** category. The equivalent airflow will be displayed in the ***Airflow Rate*** field.

Convert To/From Any Pressure Drop



Airflow Math Calculator

Airflow Ratings Standard

● No Ratings Standard

○ 2-Barrel Rating at 3.0 inHg Pressure Drop

○ 4-Barrel Rating at 1.5 inHg Pressure Drop

Known Airflow

Pressure Drop Units

● Inches Water (inH20)

○ Inc

Airflow

Pressure Drop: 30 inH20

Airflow Rate: 1022 cfm

Calculated Airflow

Pressure Drop Units

● Inches Water (inH20)

○ Inches Mercury (inHg)

Airflow

Pressure Drop: 60.0 inH20

Airflow Rate: 1445.3 cfm

Convert Between Any Two Flow Rating Systems

Any Airflow @ Any Pressure Drop

Convert To Any Airflow @ Any Pressure Drop

keys) make changes and explore their effects on calculated airflow. At any time, you can click **Apply** to load the new, calculated airflow into the **Induction Flow** field on the Component Selection screen, saving all entered values. Alternately, you can press **Cancel** to discard all entries and keep any previously entered values.

Using The Airflow Math Calculator
Mode 3: Convert Any Airflow To Equivalent Flow At Any Pressure-Drop.

Note: Since the DynoSim **Induction Flow** field only accepts induction airflow rated at either 1.5- or 3.0-in/Hg (20.3- or 40.7-in/H_2O), the **Apply** button is not shown when the ***No Ratings Standard*** is selected. If you wish to use the new calculated values in a dyno test, select either the ***4-Barrel Rating at 1.5-in/Hg Pressure Drop*** or ***2-Barrel Rating at 3.0-in/Hg Pressure Drop*** choices in the ***Airflow Ratings Standard*** category.

Switch the ***Airflow Ratings Standard*** category selection to the radio button marked ***No Ratings Standard***. This allows the ***Calculated Airflow*** to be set to any pressure drop measured in Inches of Hg or Inches of H_2O. Enter the known airflow and pressure drop in the ***Known Airflow*** category. Then enter the desired pressure drop in the ***Calculated Flow*** category. The calculated equivalent airflow will be displayed in the ***Airflow Rate*** field (see photo, previous page). You can move to any of the previous fields (by clicking on them or using the Tab or SHIFT-Tab keys) to make changes and examine their effects on calculated airflow.

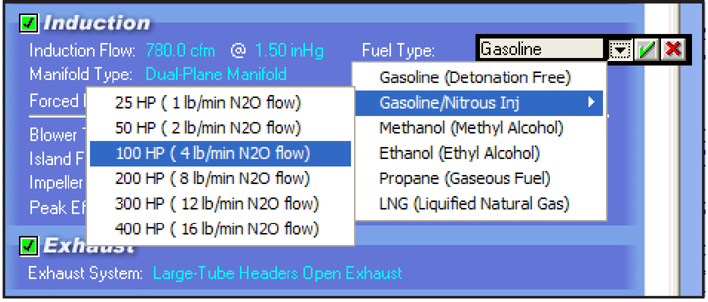
FUEL MENU

The DynoSim can model five automotive fuels plus Nitrous-Oxide injection during a simulated dyno test.

Select any of the available fuels from the ***FUEL*** menu:

- **Gasoline (Detonation Free)**
- **Methanol (Methyl Alcohol)**
- **Propane (Gaseous fuel)**
- **Gasoline W/Nitrous Injection**
- **Ethanol (Ethyl Alcohol)**
- **LNG (Liquefied Natural Gas)**

Fuel And Nitrous-Oxide Selection Menu



Induction Flow: 780.0 cfm @ 1.50 inHg

Manifold Type: Dual-Plane Manifold

Fuel Type: Gasoline

Exhaust System: Large-Tube Headers Open Exhaust

The DynoSim allows a selection of fuels for dyno testing. When any of these fuels have been selected, the air/fuel ratio is automatically adjusted to ensure optimum power.

Nitrous-Oxide Injection Menus

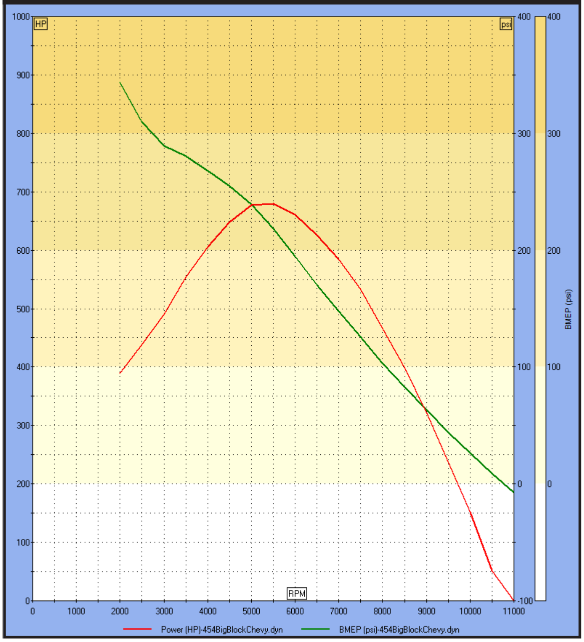
When any of these fuels have been selected, the DynoSim readjusts the air/fuel ratio for optimum power. Since combustion *flame-travel* is not modeled in the DynoSim (an accurate flame-travel model requires a full 3D map of the combustion chamber and piston dome), detonation and/or variations in combustion efficiency are not calculated. However, the predicted power will accurately match dyno figures on engines that are setup properly to use these fuels.

Nitrous-Oxide Injection

There are many ways to boost engine power. However, nitrous-oxide injection is a uniquely effective method. Developed during World War II for piston-driven fighter aircraft, nitrous-oxide gas—an oxygen-releasing substance—allows an engine to ingest more fuel while maintaining optimum air(oxygen)/fuel ratios. When injected into the cylinders with additional fuel, the effect is similar to instantaneous supercharging but without the losses from a belt- or exhaust-gas-driven device. Remarkable as it may seem, as much horsepower as desired can be added, with the limitations being excessive cylinder pressure, detonation, and component failure. There are no subtleties here: Add more nitrous and fuel; produce more horsepower.

Most nitrous systems inject a fixed amount of nitrous and fuel, regardless of engine speed. In other words, when the nitrous "switch" is turned on, the engine will immediately produce a boost in power, solely determined by the amount of injected fuel and

Nitrous-Oxide vs. Cylinder Pressure (BMEP)



This graphic comparison shows how cylinder pressures (BMEP shown by green line) increase after a 200-horsepower nitrous system is activated (this pressure comparison and the colored DataZones™ requires ProTools™ activation). Since the DynoSim models a fixed-flow nitrous system, cylinder loads increase as engine speed decreases (the longer time the intake valve is open, the greater nitrous load is injected into the cylinder). Below 2700rpm, BMEP exceeds 300psi (shown as the top, orange band). To maintain engine reliability, nitrous-system activation should be delayed until 3000rpm.

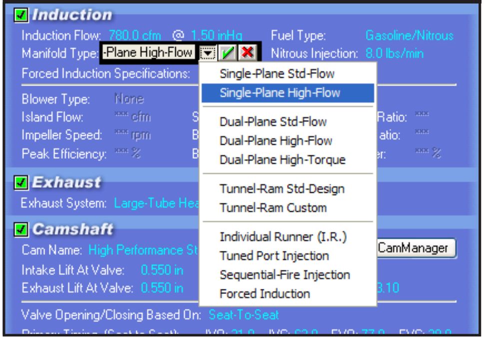
nitrous. A nitrous injection system designed to add 100 horsepower (flowing about 4 pounds per minute of nitrous oxide and additional fuel to maintain the correct air/fuel ratio), will produce a 100 horsepower boost instantly upon triggering the system. Remarkably, it will continue to produce a 100 horsepower increase across the entire rpm range. In other words, a 100hp nitrous system activated at 2000rpm (when the engine may have been producing only about 70hp) can virtually double or even triple power output!

But these huge power boosts at low engine speeds (when each cylinder must ingest a large “dose” per power cycle) can send cylinder pressures through the roof. So, fixed-flow-rate systems are often designed to delay activation until the engine reaches sufficient speed to reduce the nitrous load in each cylinder to safe levels. Maintaining cylinder pressures below a critical level helps prevents detonation and mechanical failure.

The DynoSim models a typical, constant-flow nitrous/gasoline injection system. During engine testing with nitrous augmentation, you should monitor cylinder pressures (BMEP) to make sure dangerously high pressures are avoided at lower engine speeds (a BMEP greater than 300psi is usually considered excessive). For example, the DynoSim test graph shown on the previous page illustrates a 350 smallblock equipped with a 200hp nitrous system. Note that BMEP pressures below 3000rpm exceed 300psi. (BMEP is an “average” cylinder pressure; when this average pressure exceeds 300psi, peak cylinder pressures are much higher and can result in detonation and mechanical failure—for more information about BMEP, refer to the ***DeskTop Dynos*** book, available at many bookstores and at www.ProRacingSim.com or www.cartechbooks.com).

One of the ways to reduce low-speed cylinder pressure is to altering cam timing. It has long been known that increasing valve duration and overlap will lower cylinder pressures at lower engine speeds. While this usually-unwanted phenomenon reduces low speed power, combined with a nitrous-oxide injection system, it can permit earlier nitrous flow while optimizing power at higher rpms. Other variables that can decrease low-speed cylinder pressures are reduced compression ratios, increased exhaust-system back pressure, reduced induction airflow, less efficient induction manifolding,

Manifold Type Menu



Induction Flow: 780.0 cfm @ 1.50 inHg
Fuel Type: Gasoline/Nitrous
Manifold Type: -Plane High-Flow
Nitrous Injection: 8.0 lbs/min
Blower Type: None
Island Flow: *** cfm
Impeller Speed: *** rpm
Peak Efficiency: *** %
Exhaust System: Large-Tube Hea
Cam Name: High Performance St
Intake Lift At Valve: 0.550 in
Exhaust Lift At Valve: 0.550 in
Valve Opening/Closing Based On: Seat-To-Seat

Each of the ten naturally-aspirated manifolds in the *Manifold Type* menu applies a unique tuning model to the induction system. While these ten manifolds are only a small sample of the intake manifolds available for IC engines, these six discrete models accurately simulate the performance potential of most intake manifolds available today to professional and amateur engine builders and performance enthusiasts.

and larger engine displacement.

It is a simple matter to simulate and test a variety of component combinations with the DynoSim to determine the maximum nitrous load that can be injected at any engine speed.

You can add nitrous injection by selecting ***Gasoline/Nitrous Injection*** from the induction menu. You will see the following choices:

- **25 HP (1 lb/min N_2O flow)**
- **100 HP (4 lb/min N_2O flow)**
- **300 HP (12 lb/min N_2O flow)**
- **50 HP (2 lb/min N_2O flow)**
- **200 HP (8 lb/min N_2O flow)**
- **400 HP (16 lb/min N_2O flow)**

These six selections allow nitrous flow rates from 25hp (1-lb/min flow) to 400hp (16-lb/min flow). You can also manually enter flow rates from 0.1- to 20-lb/min in the ***Nitrous Flow Rate*** field.

MANIFOLD TYPE MENU

The **Manifold Type** menu consists of ten naturally-aspirated intake manifold choices and a ***Forced Induction*** selection (***Forced Induction*** modeling is discussed in the next section, beginning on page 60). Each of the ten naturally-aspirated manifolds applies a unique tuning model to the induction system. While these manifolds are only a small sample of the intake manifolds available for IC engines, the list should be interpreted as ten discrete models that accurately simulate most of the manifolds available today for both professional and amateur, racing and street applications. If you are interested in a manifold that falls “in between” two menu selections, you can often use the ***trend*** method to estimate power for a hybrid design. For example, run a test simulation using manifold Type A, then set up a comparison and study the differences in power attributed to manifold Type B. The changes will indicate trends that should give you insight into how a hybrid manifold Type A/B *might* perform. Because a rigorous analysis of pressure waves is not performed by the DynoSim, some the data you obtain might not match real-world dyno data with unique manifold configurations (look into ProRacing Sim Software’s *Dynomation*™ engine simulation series, available in 2004, for more comprehensive intake and exhaust system modeling). In general, however, the trends and overall accuracy should be within 10%.

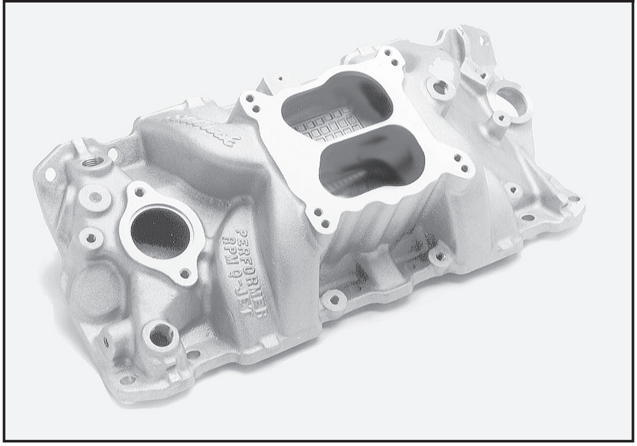
The following sections provide an overview of each manifold model included in the DynoSim, a description of the assumptions used in the model, and recommendations associated with that individual design.

Dual-Plane, Maximum-Torque, Standard-Flow, High-Flow, and Max-Flow Manifolds—The ***Dual-Plane Max-Torque Manifold*** Induction Type menu selection models dual-plane manifolds with smaller runners, such as those designed for towing, economy and other high-torque, applications. The Dual-Plane Max-Torque model will tune for a lower peak engine speed, due mainly to runner and plenum restrictions. The ***Standard-Flow Dual-Plane Manifold*** selection represents the majority of street-ori-

Dual-Plane Manifold Modeling

The Edelbrock Performer Q-Jet represents a typical dual-plane manifold design (of “Standard-Flow” capability). This manifold is said to have a 2nd degree of freedom. A powerful resonance multiplies the force of the pressures waves, simulating the effects of long runners, boosting low- and mid-range power.

Dual-Plane Manifold



ented dual-plane manifolds available to performance enthusiasts (including many OEM manifolds). The Standard-Flow model will accurately simulate street and performance engines with “as-cast” dual-plane manifolds. The ***Dual-Plane High-Flow*** and ***Max-Flow Manifold*** selections model modified, large-port, (and even custom-fabricated) dual-plane manifolds, as used on high-performance and all-out racing engines.

Remarkably, the well-known and apparently straightforward design of the dual-plane manifold is, arguably, the most functionally-complex manifold to model. An intake manifold is considered to have an effective dual-plane configuration when 1) the intake runners can be divided into two groups, so that 2) each group alternately receives induction pulses, and 3) the pulses are spaced at even intervals. If all of these criteria are met, the manifold is said to have a 2nd degree of freedom, allowing it to reach a unique resonance producing oscillations within the entire manifold. During this resonance, pressure readings taken throughout the manifold will be in “sync” with one another. Full-manifold resonance multiplies the force of the pressures waves, simulating the effects of long runners. Since longer runners typically tune at lower engine speeds, the dual-plane manifold is most known for its ability to boost low-end power.

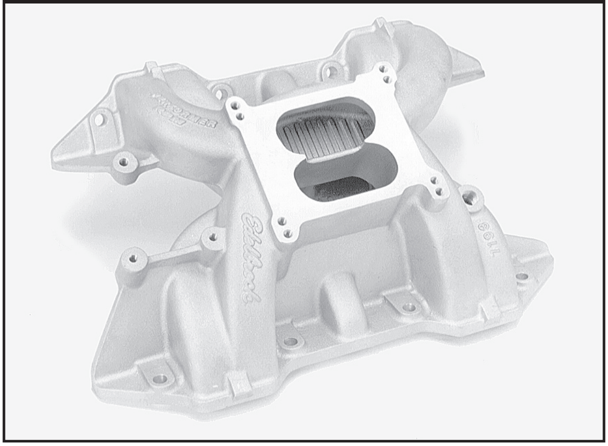
The divided plenum is key feature of dual-plane manifolds that boosts low-end power. Since each side of the plenum is connected to only one-half of the cylinders (4-cylinders in a V8), each cylinder in the engine is “exposed” to only one-half of the carburetor. This maximizes wave strength and improves low-speed fuel metering (these effects are less pronounced with throttle-body fuel-injection systems). However, the restriction inherent in a divided plenum can reduce peak power at higher speeds.

The main benefits of the dual-plane design are its low-speed torque-boosting capability, compact design, and wide availability for use with both carburetors and injection systems. However, not all engines are capable of utilizing a dual plane configuration. Typically, engines that do not have an even firing order or have too many cylinders to generate a resonance effect will not benefit from a dual-plane manifold. While there are some exceptions, engines having 2 or 4 cylinders work best with this manifold. Since

Dual-Plane Manifold Modeling

Many dual-plane manifolds are hybrids. This Edelbrock dual-plane manifold is designed for the 440 Chrysler engine and has a partially open plenum. In manifold such as this, the opening adds mid-range and high-speed performance with, typically, a slight sacrifice in low-speed torque. Not all hybrid designs are as successful as this one. In situations where you are not familiar with specific engine or manifold characteristics, it may be worthwhile to stick with "plane-vanilla" designs.

Hybrid Dual-Plane Design



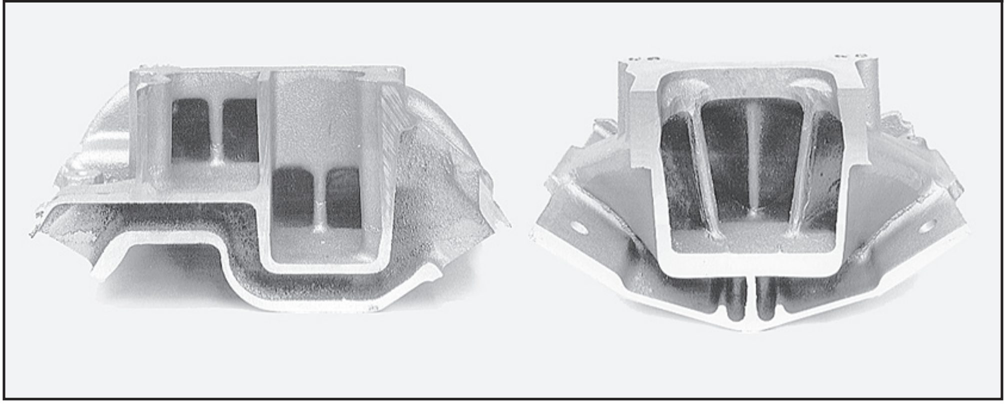
most V8 engines are basically two 4-cylinder engines on a common crankshaft, even-firing V8s benefit from the resonance effects of the dual-plane manifold. The DynoSim does not prevent the selection of a dual-plane manifold on engines that will not develop a full resonance effect. For example, you can install a dual-plane manifold on a 5-cylinder engine, but the results—a low-end power boost—are not reproducible in the real world, since an effective dual-plane manifold cannot be built for this engine. This simulation is best utilized by modeling dual-plane manifolds combinations that already exist rather than testing theoretical fabrications.

Many dual-plane manifolds are hybrids incorporating facets of other manifold designs. Especially common is the use of an undivided or open plenum typically associated with single-plane manifolds. These "mixed" designs are attempts at harnessing the best features of both manifolds while eliminating the drawbacks of each. Sometimes the combinations are successful, adding more performance without much sacrifice in low-speed driveability. With these designs, you can successfully use the "trend" method described earlier to estimate engine torque and power. Unfortunately, there is no shortage of manifolds that can reduce power without giving anything back in driveability or fuel economy. In fact, some of the worst designs are remarkably bad. It is impossible to determine which of these combo designs is better than others using the DynoSim simulation. Only a simulation that models intake passages, including the complex effects of multi-cylinder interference, can perform this analysis (details of ProRacing Sim's *Dynomation* engine simulation series is available on the web at www.ProRacingSim.com). Unless you can perform actual dyno testing on these manifolds to determine what works and what doesn't, it may be worthwhile to stick with more "plain-vanilla" designs that produce predictable results.

Single-Plane, Standard-Flow, High-Flow, and Max-Flow Manifolds—The ***Standard-Flow Single-Plane Manifold*** Induction Menu selection represents the majority of single-plane manifolds sold to performance enthusiasts. The Standard-Flow selec-

Single-Plane Manifold Modeling

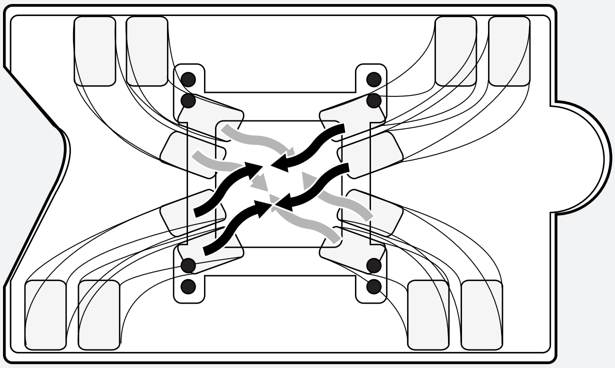
Dual-Plane vs. Single-Plane Design



The basic differences between single- and dual-plane manifolds are clearly illustrated here. The dual-plane (left) divides the plenum in half, with the runners grouped by firing order. Each cylinder "sees" only one-half of the carburetor, transferring a strong signal to the venturis. This manifold design is said to have a 2nd degree of freedom, allowing it to reach a unique resonance that makes its short runners act as if they were longer and boosts low-speed power. The single-plane manifold (right) has short, nearly equal-length runners with a large open plenum, much like a tunnel ram laid flat across the top of the engine. The manifold has excellent high-speed performance, but its design prevents full-manifold resonance. That reduces low-speed torque, which can impair driveability and fuel economy.

tion accurately simulates street and performance engines with "as-cast," single-plane manifolds. The ***Single-Plane High-Flow*** and ***Max-Flow Manifolds*** models simulate modified, large-port, air-gap, and/or custom-fabricated single-plane manifolds, as used on high-performance and all-out racing engines.

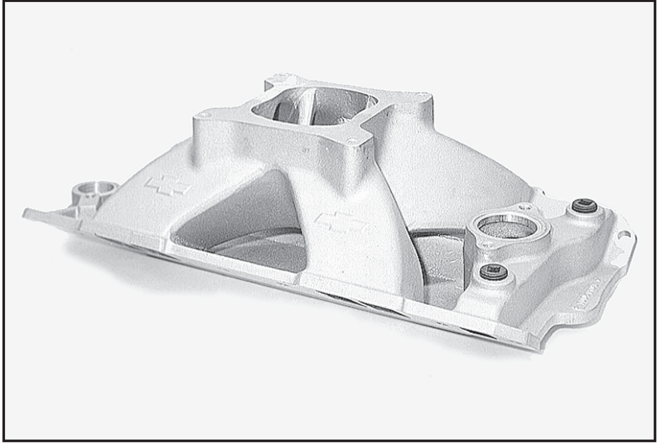
Single-Plane Pulse Interference



The typically compact, low-profile design of the single-plane manifold has some drawbacks. The runners are connected to a common plenum. This arrangement tends to create unpredictable interference effects as pressure pulses moving through the runners meet in the plenum and stir up a complex brew, sometimes creating irregular fuel-distribution.

Single-Plane Manifold Modeling

Single-Plane Manifold



A single-plane manifold is simply a low-profile tunnel ram. The design combines short, nearly equal-length runners with an open plenum, but "lays" the entire configuration flat across the top of the engine. The single-plane manifold combines improved flow capacity, higher charge density, and short runners to build substantial horsepower at higher engine speeds.

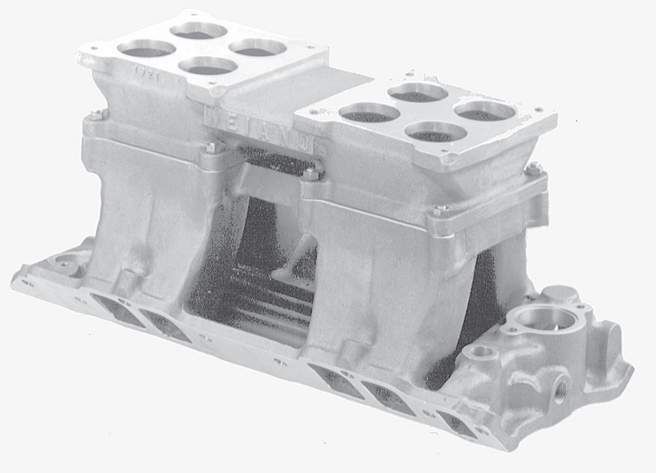
In a very real sense, a single-plane manifold, as used on most V8 engines, is simply a low-profile tunnel ram. The tunnel-ram manifold (discussed next) is a short-runner system combined with a large common plenum; a design that optimizes power on all-out racing engines where hood clearance is not an issue. The single-plane manifold combines short, nearly equal-length runners with an open plenum, but "lays" the entire configuration flat across the top of the engine. The results are quite predictable. The runner design prevents full-manifold resonance (found in dual-plane manifolds). That reduces low-speed torque, and depending on the size of the plenum and runners, single-plane manifolds can also reduce driveability and fuel economy. Furthermore, a large-volume, undivided plenum often contributes to low-speed performance problems by presenting every cylinder to all barrels of the carburetor, lowering venturi signal and low-speed fuel metering accuracy (again, this drawback is minimized on fuel-injection systems). On the other hand, the single-plane manifold (like the tunnel ram) combines improved flow capacity, potentially higher charge density, and short runner lengths to build substantially more horsepower at higher engine speeds.

As a high-performance, high-speed manifold, the single-plane design has many advantages, however, it's compact, low-profile design also has drawbacks. The runners are connected to a common plenum like spokes to the hub of a wheel. This arrangement tends to create unpredictable interference effects as pressure pulses moving through the runners meet in the plenum (or travel down the opposite runner) and stir up a complex brew. Large plenum volumes help cancel some these negative effects, but open-plenum, single-plane manifolds may produce unexpected anomalies in fuel distribution and pressure-wave tuning with specific camshafts, headers, or cylinder heads (to some degree, these effects are present in all manifold designs). Predicting these will-o'-the-wisp anomalies requires rigorous modeling. Currently, pinning down these problems requires dyno testing with temperature and pressure probes to measure fuel distribution accuracy throughout the rpm range.

Designers and engine testers have experimented with hybrid single-plane manifold

Tunnel-Ram Manifold Modeling

Tunnel-Ram Manifold



This Weiand/Holley BB Chevy tunnel ram manifold is a single-plane induction system designed to produce optimum power on all-out racing engines. It has a large common plenum and short, straight, large-volume runners. The tunnel ram manifold menu selection has the potential to produce the highest peak horsepower of all the naturally-aspirated manifolds listed in the *Induction* menu.

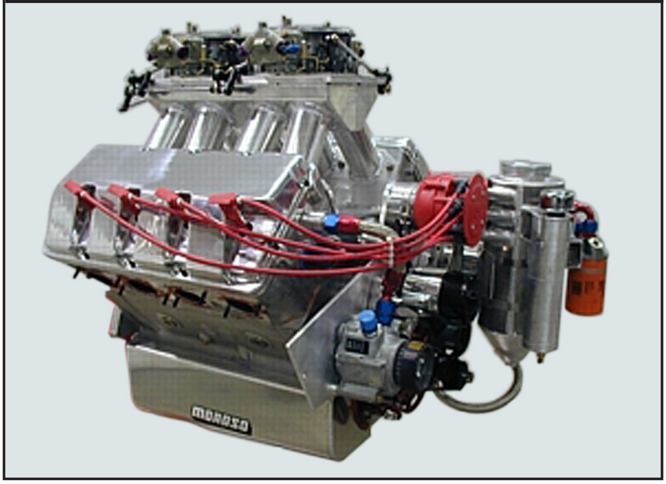
designs that incorporate various dual-plane features. One common modification is dividing the plenum of a single-plane manifold into a pseudo dual-plane configuration. While this does increase signal strength at the carburetor, uneven firing pulses presented at each side of the plenum do not allow 2nd degree of freedom resonance. This modification can cause sporadic resonances to occur throughout the rpm range with unpredictable results. Spacers between the carburetor and plenum are also commonly used with single-plane manifolds often with positive results, particularly in racing applications. Spacers typically increase power for two reasons: 1) By increasing plenum volume they tend to reduce unwanted pressure-wave interactions, and 2) a larger plenum improves airflow by reducing the angle at which air/fuel must negotiate a transition from “down” flow through the carburetor to “side” flow into the ports. While there is no way to use trend testing to evaluate the effects of a divided plenum, spacers can be simulated. The increase in plenum volume tends to transform the single-plane manifold into a “mini” tunnel ram, so horsepower gains tend to mimic those obtained by switching to a tunnel ram design (i.e., performance improvements, when found, usually occur at high rpm).

Since the single-plane manifold typically reduces low-speed torque and improves high-speed horsepower, it is often the best compact manifold design for applications where wide-open-throttle engine speed rarely falls below 4000rpm. If the engine commonly runs through low speeds, a dual-plane, individual runner, sequential-fire injection system, or tuned-port injection system will usually provide better performance, driveability, and fuel economy.

Tunnel-Ram: Standard, High-Flow, and Max-Flow Designs—The ***Standard Tunnel-Ram Manifold*** Induction Menu selection represents the a realtively small runner, tunnel-ram manifold that has application in high-performance street (roadster) and mild racing applications. This selection simulates performance applications with “as-cast,”

Individual-Runner Manifold Modeling

Custom Fabricated Tunnel-Ram Manifold



This custom-fabricated tunnel-ram manifold (by Jon Kraase Racing Engines) has the potential to produce the highest peak horsepower of all naturally-aspirated induction systems. Combined with the proper cam timing, compression, and other components, the large cross-sectional areas, straight runners, and short tuned lengths make this custom manifold a "no compromise" racing design.

tunnel-rams with dual or single carburetors or throttle bodies. The ***High And Max. Flow Custom Tunnel-Ram Manifold*** models simulate extensively-modified, large-port, and/or custom-fabricated tunnel-ram manifolds, as seen on ProStock and other "exotic" racing engines.

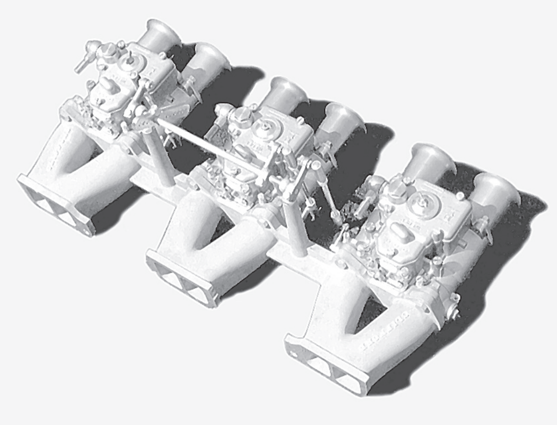
This tunnel-ram intake manifold is a single-plane induction system designed to produce optimum power on all-out racing engines. The advantages of the tunnel ram derive from its combination of a large common plenum and short, straight, large-volume runners. The large plenum accommodates one or two carburetors, potentially flowing 2200cfm or more. The large plenum also minimizes pressure-wave interaction and fuel distribution issues. The short runners can be kept cooler than their lay-flat, single- and dual-plane counterparts, and they offer a straight path into the ports, optimizing ram-tuning and minimizing flow restriction.

Tunnel-ram applications are quite limited because of their large size; vehicles using tunnel-ram manifolds usually require a hole in the hood and/or a hood scoop to provide manifold and carburetor clearance. While a protruding induction system may be a "sexy" addition to a street rod, in single-carburetor configurations, the tunnel ram offers very little potential power over a well-designed, single-plane manifold. Only at very high engine speeds, with multiple carburetors, will the advantages in the tunnel ram contribute substantially to power.

The tunnel-ram selections in the DynoSim can also accurately model fuel-injection systems with medium-to-large, individual stacks. Strictly speaking, while the simulation reproduces the effects of short runners and a large-volume plenum, this design also mimics short injector stacks that open to the atmosphere. For one-barrel-per-cylinder Weber carburetion or very-small-diameter, individual-injector systems, use the Individual Runner manifold described next. However, for medium-to-large-diameter injectors, like Hillborn or Crower systems, the Standard and Max. Custom tunnel-ram manifold models—along with the appropriate airflow selection (for all cylinders com-

Individual-Runner Modeling

Individual Runner Manifold



A manifold that connects each cylinder to a single carburetor barrel *with no interconnecting passages that share flow* is considered an individual (or isolated) runner system (IR for short). Multiple Weber or Mikuni carburetor systems are well-known examples of this type of induction system. This IR manifold was designed for early OHC Pontiacs.

bined)—provides an accurate induction simulation.

The ***Standard*** and ***Max., Custom Tunnel Ram*** manifold selections have the potential to produce the highest peak horsepower of all naturally-aspirated induction systems listed in the Induction menu. The large cross-sectional areas, straight runners, and short tuned lengths make this manifold a “no compromise” racing design.

Large/Small Injector Stacks and The Individual Runner Manifold—A method of connecting each cylinder to one “barrel” of single or multiple carburetors or to individual injector stacks—*with no shared-flow or interconnecting passages*—is considered an individual (or isolated) runner system (I.R. for short). A multiple Weber or Mikuni carburetor setup is a well-known example of this type of induction system. Individual injector stacks are another example of an I.R. system; once commonplace in drag racing, these systems are now limited to specific classes, such as methanol and fuel-burning, naturally-aspirated engine competition.

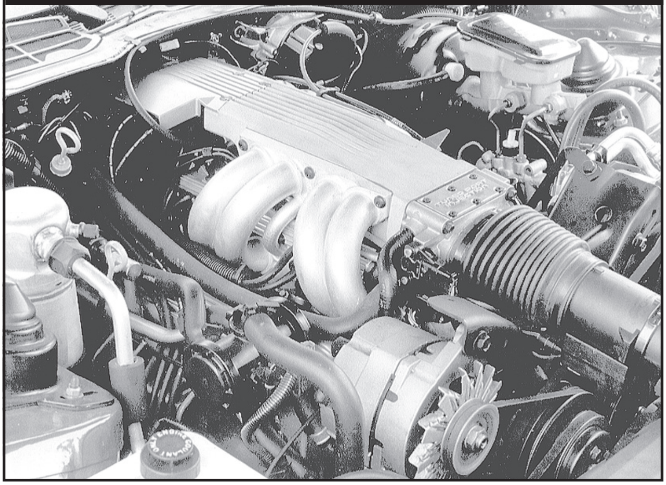
On a V8 engine, four, twin-barrel Webers or even small individual injector stacks make an impressive sight, and at first glance they may appear to offer more airflow potential than any engine needs, particularly any street engine. While it may look like overkill, the one-barrel-per-cylinder arrangement often has substantial horsepower limitations due to airflow restriction! A typical Weber 48IDA carburetor flows about 330cfm per barrel. While the sum total of all eight barrels is over 2600cfm (a flow rating equivalent to two Holley Dominators), the important difference is that each cylinder can draw from only one 330cfm barrel. In a single- or even a dual-plane manifold, each cylinder has access to more than one carburetor barrel, reducing restriction during peak flow and increasing high-speed horsepower. While an IR system offers substantial low-end performance benefits (more on that next), at 5000rpm and higher in typical applications, flow restriction can drive power below the levels of an average single four-barrel, 780cfm induction system!

While I.R. induction can restrict peak flow, at low-speed, the same one-barrel-per-cylinder arrangement transmits strong pressure waves to each carburetor barrel, producing ideal conditions for accurate fuel metering (this has little affect on injectors). Furthermore, the pressure waves moving in the runners are not dissipated within a plenum and don't interact with other cylinders. This ensures that the reflected waves strongly assist cylinder filling and reduce reversion. The combination of these effects makes individual-runner induction an outstanding induction choice for low-speed to medium/high-speed engine applications. Unfortunately, the high cost of these systems—and current emissions regulations—prevents their wider acceptance.

The simulation model for the ***Individual Runner*** and ***Small Injector Stacks*** selections assume that the runner sizes (and/or the carburetor venturi) diameters are of "small-to-medium" dimensions. The ***Large Injector Stack*** selection, virtually eliminates flow restriction by increasing the size of the runner to intake-port entrance dimensions. Runner length, that is, the distance from the head of the valves to the top of the stacks (or carburetors), is assumed to be "mid-length" for in all applictions. The DynoSim induction model for all I.R. applications retains a mid-range rpm power bias. These assumptions work well with most I.R. applications, since this type of induction system is more offten used in applications that require good throttle response and a wide power band (such as road racing).

Tuned-Port Injection—This manifold was introduced by automakers in the mid 1980's. It represents the first mass-produced induction system that clearly incorporates modern wave-dynamic principals. To optimize low-speed torque and fuel efficiency, the TPI manifold has very long runners (some configurations measure up to 24-inches from valve head to airbox). The runners on most TPI systems are also quite small in diameter—again, to optimize low-speed power—and, unfortunately, create considerable restriction at higher engine speeds. Characteristic power curves from this type of manifold are slightly to significantly above a dual-plane up to about 5000rpm,

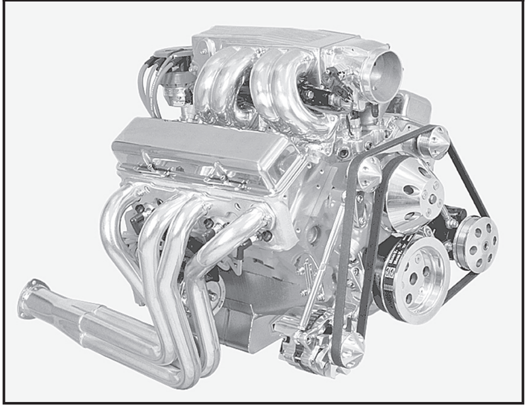
Tuned-Port Injection Manifold



The TPI manifold was introduced by automakers in the mid 1980's. It represents the first mass-produced induction system that clearly incorporated modern wave-dynamic principals.

LS1/LS6 Composite Induction

Modern "TPI" Injection Systems



Many TPI and EFI (electronic fuel injection) packages are based on short-runner, high-flow TPI models. Some longer-runner systems, like this manifold from Induction Technology, allow much greater airflow than the original factory TPI and still provide substantial low-speed torque. Model this induction systems with the *Standard* or *High-Flow Single Plane* manifold selections.

then runner restriction and an out-of-tune condition substantially lowers peak power.

The TPI is a "single-plane" design that functions like a long-runner tunnel ram. Each runner is completely isolated until it reaches the central plenum. This design tends to maximize pressure-wave tuning and minimize wave interactions. Since fuel is injected near the valve, the TPI system delivers precise air/fuel ratios with no fuel distribution or puddling problems.

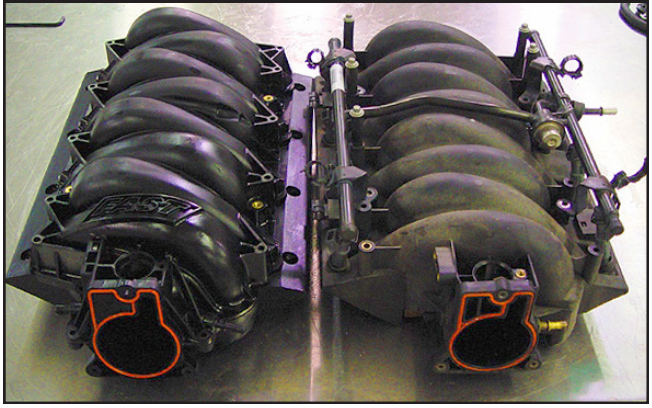
The ***Tuned-Port Injection*** Induction menu selection models a stock TPI. However, a wide range of aftermarket parts have been developed for the TPI system, including enlarged and/or Siamesed runners, improved manifold bases, high-flow throttle bodies, and sensor/electronic modifications. These higher flow systems are often best modeled with the ***Standard-Flow Single-Plane*** choice for small-runner systems or the ***High-Flow Single Plane*** model for large-runner packages.

LS1/LS6 Stock Composite and LS1/LS6 HP Runner/Mods Manifolds—Since the mid 1980's, engine simulation programs have been used by engine manufacturers to take advantage of the wave dynamics developed inside the intake passages of the IC engine. These pressure waves can have a marked effect on engine performance. When unharnessed, they can produce non-uniform fuel distribution, prevent cylinder filling, and adversely affect driveability. On the other hand, when an induction system has been carefully designed to harness pressure wave dynamics, the engine can benefit from improved airflow and cylinder filling at the desired engine speeds. Using this technology, engine builders have produced "designer" power and torque curves to optimize overall engine performance within the desired rpm ranges and within fuel economy and emissions requirements.

The fully composite manifold developed by GM for their "new" smallblock engine is a good example of this design. It is biased toward power at higher rpms, while maintaining good torque throughout the rpm range. Installed in many performance vehicles, particularly the Z06, 405hp Corvette, the new composite design allows high power while maintaining good driveability and low emissions. This new manifold can

LS1/LS6 Composite Induction

LS1/LS6 Composite FAST HP vs Stock Manifold

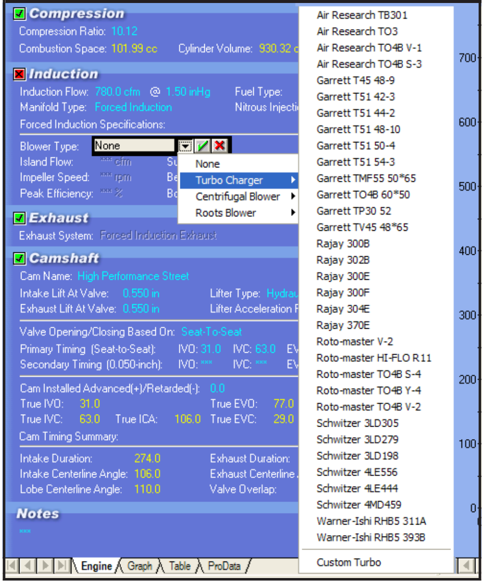


Composite intake manifolds have become standard equipment on many modern IC engines. They allow designs that could not be easily replicated in aluminum, and some offer unique performance opportunities. The stock GM LS1/LS6/Z06 induction, shown on the right, and the *FAST* version illustrates how changes in runner length and volume can improve power in HP applications.

be modeled in DynoSim by selecting the ***LS1/LS6 Composite Stock*** choice from the **Induction** menu. Despite the fact that this manifold packs its runners in a small package designed to fit under the low-profile hoods of modern vehicles, the generous flow capacity produces good peak power.

Aftermarket companies have taken this concept a bit further to provide more performance for the automotive enthusiast. High-performance versions of this manifold have been shown to add from 3% to 12% more power with very little sacrifice in bottom-end torque. You can test a performance design with the ***LS1/LS6 HP Runner/Mod*** induction selection in the DynoSim. This induction model was based on the

Forced Induction Menus

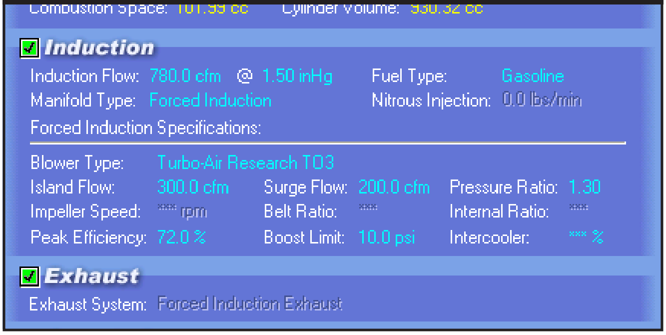


Compression Ratio: 10.12
Combustion Space: 101.99 cc   Cylinder Volume: 930.32 c
Induction Flow: 780.0 cfm @ 1.50 inHg   Fuel Type:
Manifold Type: Forced Induction   Nitrous Injecti
Forced Induction Specifications:
Blower Type: None
Island Flow: *** cfm
Impeller Speed: *** rpm
Peak Efficiency: *** %
Exhaust System: Forced Induction Exhaust
Cam Name: High Performance Street
Intake Lift At Valve: 0.550 in   Lifter Type: Hydrau
Exhaust Lift At Valve: 0.550 in   Lifter Acceleration F
Valve Opening/Closing Based On: Seat-To-Seat
Primary Timing (Seat-to-Seat): IVO: 31.0 IVC: 63.0
Secondary Timing (0.050-inch): IVO: *** IVC: ***
Cam Installed Advanced(+)/Retarded(-): 0.0
True IVO: 31.0   True EVO: 77.0
True IVC: 63.0   True ICA: 106.0   True EVC: 29.0
Cam Timing Summary:
Intake Duration: 274.0   Exhaust Duration:
Intake Centerline Angle: 106.0   Exhaust Centerline
Lobe Centerline Angle: 110.0   Valve Overlap:
***

The DynoSim includes nearly 100 forced induction choices (Turbos, shown here, Centrifugal, and Roots blowers). Selecting a supercharger from any of the three submenus will load the specifications for that device into the INDUCTION category. You may change these values at any time to determine their affect on engine power. In addition, you can select *Custom* from the bottom of any of the supercharger menu and directly enter all supercharger specifications.

Forced Induction Modeling

INDUCTION Category With Forced Induction



Combustion Space: 101.99 cc Cylinder Volume: 930.32 cc

☑ **Induction**

Induction Flow: 780.0 cfm @ 1.50 inHg
Fuel Type: Gasoline
Manifold Type: Forced Induction
Nitrous Injection: 0.0 lbs/min
Forced Induction Specifications:

Blower Type: Turbo-Air Research T03
Island Flow: 300.0 cfm
Surge Flow: 200.0 cfm
Pressure Ratio: 1.30
Impeller Speed: **** rpm
Belt Ratio: ****
Internal Ratio: ****
Peak Efficiency: 72.0 %
Boost Limit: 10.0 psi
Intercooler: *** %

☑ **Exhaust**

Exhaust System: Forced Induction Exhaust

The INDUCTION Category includes forced-induction selections. Directly click on any field to change values and evaluate the effects on power, torque, and manifold pressure.

FAST manifold recently released from development.

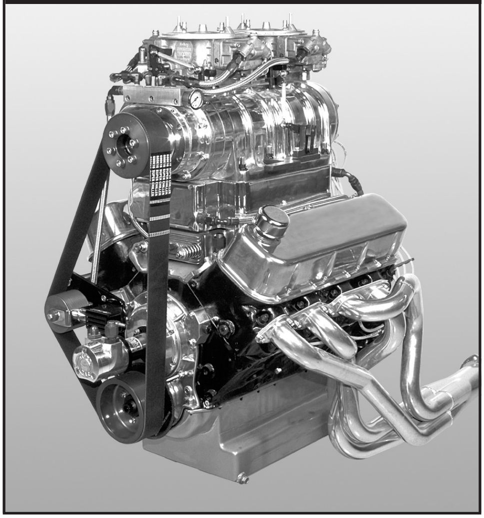
FORCED-INDUCTION MENUS

The ***Forced Induction*** choice included in the **Manifold Type** menu considerably expands the modeling power of the DynoSim. In an instant, you can add a positive displacement Roots-type blower, a centrifugal blower (like a Paxton or Vortech), or a turbocharger to any engine. In addition, you can vary maximum boost—or blow-off (wastegate) pressure—pulley ratios, and you can even change blower pressure ratios, surge cfm, and more. And finally, you can test the effects of an intercooler on any of the forced-induction systems.

Because a positive-pressure induction system changes the flow dynamics within

Both centrifugal and roots blowers are mechanically driven by the engine. The Belt Gear Ratio (external drive) is the mechanical connection between the engine crankshaft rpm and blower input rpm. This bigblock Chevy pulley setup provides an overdrive (a Belt Ratio of 1.20:1).

Belt Gear Ratio



the engine, forced induction cannot be used with other manifold types. And, as is detailed in the next section, the exhaust system choices are also overridden with a ***Forced Induction Exhaust*** display. The modeling applied to both the intake and exhaust systems for forced induction simulate many free-flowing, high-performance designs. The exhaust model is designed to simulate open exhaust, or at least a low-restriction muffler system with large-diameter tubing.

Selecting ***Forced Induction*** activates the lower half of the **INDUCTION** category. Double-click on the **Blower** field to open a menu containing ***Turbocharger***, ***Centrifugal***, and ***Roots*** blower choices. When a selection of any of the nearly 100 forced induction devices is made, specific fields will become active depending on the type of supercharger that was chosen. Here is a quick overview of these fields, the superchargers to which they apply, and how they affect forced induction performance:

Flow (Island Flow)—(Turbos, Centrifugals, Roots) This is the flow rate at which the supercharger is most efficient, also commonly called the *Island Flow*. **Note: This flow rate is not the peak flow of the supercharger.** Typically, smaller superchargers have lower Island Flow, meaning that they perform most efficiently at lower flow rates. While high Island Flow is commonly a characteristic of larger superchargers, and ideal supercharger would have high Island Flow (be efficient at high flow rates) and have a small physical size (making it more efficient at low speeds and low-flow delivery rates).

Pressure Ratio—(Turbos, Centrifugals) This is the ratio of compressor pressures (ambient vs. output) at the *Island Flow* point (the flow rate at which the supercharger is most efficient). The higher this number, the more efficient the device performs as an “air compressor.” Note: Roots blowers are a positive-displacement device (theoretically, the same volume of air is driven through the supercharger for each rotation of the impellers), so pressure ratio, as used here, does not apply.

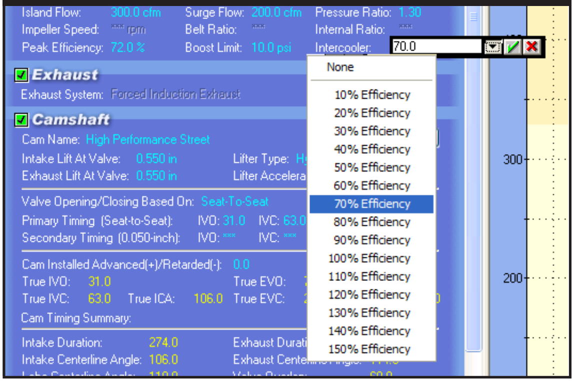
Boost Limit—(Turbos, Centrifugals, Roots) This is the pressure at which the wastegate or blow-off valve is activated, maintaining peak induction pressure at or below this value. Note: Boost limit is an arbitrary pressure, set the user, and not a measure of the capability of the supercharger, i.e., the blower may not be able to develop sufficient pressure to activate the wastegate.

Speed—(Centrifugals only) This value is the rotational speed (rpm) at which centrifugal superchargers reaches peak efficiency. There is a similar speed value applicable to turbochargers, however, the simulation currently incorporated in the DynoSim does not support this model turbochargers.

Belt Gear Ratio—(Centrifugals, Roots) Both centrifugal and roots blowers are mechanically driven by the engine. The Belt Gear Ratio (external) is the mechanical connection ratio between the engine crankshaft and blower input shaft. This value is multiplied by the Internal Gear Ratio on centrifugal superchargers to determine

Intercooler Modeling

Intercooler Menu



Island Flow: 300.0 cfm
Surge Flow: 200.0 cfm
Pressure Ratio: 1.30
Impeller Speed: *** rpm
Belt Ratio: ***
Internal Ratio: ***
Peak Efficiency: 72.0 %
Boost Limit: 10.0 psi
Intercooler: 70.0

☑ Exhaust
Exhaust System: Forced Induction Exhaust

☑ Camshaft
Cam Name: High Performance Street
Intake Lift At Valve: 0.550 in
Exhaust Lift At Valve: 0.550 in
Lifter Type:
Valve Opening/Closing Based On: Seat-To-Seat
Primary Timing (Seat-to-Seat): IVO: 31.0 IVC: 63.0
Secondary Timing (0.050-inch): IVO: *** IVC: ***
Cam Installed Advanced(+)/Retarded(-): 0.0
True IVO: 31.0
True EVO:
True IVC: 63.0 True ICA: 106.0
True EVC:
Cam Timing Summary:
Intake Duration: 274.0
Intake Centerline Angle: 106.0

The DynoSim includes an intercooler model that can be activated with any forced-induction system. An intercooler reduces induction temperatures that, otherwise, substantially reduce performance.

internal rotor speed.

Surge Flow—(Turbos) The surge flow is the airflow within the Island (most efficient) pressure ratio at which turbocharger flow and internal momentum can "resonate" and produce a pulsing in the induction system. This phenomenon reduces efficiency and engine power output, and it can even damage the turbocharger.

Efficiency—(Turbos, Centrifugals, Roots) This is a measure of the power consumed by the supercharger compared to the increase in induction pressure *at the point of highest efficiency*. Roots blowers are often the least efficient, however, they deliver substantial induction pressure at low speeds. On the other hand, turbochargers are more efficient, but require more time to "spin up" to an efficient operating speed.

Internal Gear Ratio—(Centrifugal) Centrifugal superchargers are driven by a mechanical connection to the engine crankshaft. Internal rotor speed is increased by the external Belt Gear Ratio (described earlier), but this speed increase is insufficient for most centrifugal superchargers to reach their optimum operating speeds (35,000rpm and higher). An internal gear train is commonly used to further increase rotational speed. The ratio of this internal gearing determines how much faster the turbine rotates over input-shaft rpm. To determine the internal speed of the centrifugal turbine, multiply crankshaft rpm by the **Belt Gear Ratio**, then multiply that by the **Internal Gear Ratio**.

Selecting a supercharger listed in any of the three **Blower Type** submenus will load the specifications for that device into the **INDUCTION** category. You may edit these values at any time to determine their effect on engine power. In addition, you can select ***Custom*** from the bottom of any of the supercharger menus. This option permits direct entry of all supercharger specifications.

Intercoolers

Exhaust System Modeling

One of the drawbacks to any method of supercharging is the resulting increase in induction temperatures. High boost pressures can quickly raise charge temperatures more than 200-degrees(F)! These higher temperatures, common on blowers with pressure ratios of 2.0 or higher, can cost more than lost horsepower. Higher temperatures can lead to detonation, increase octane requirements, and require a reduction in ignition timing advance. While induction cooling can improve performance directly from increased charge density (more oxygen and fuel per unit volume of inducted charge), the additional benefits of reduced detonation and increased reliability make charge cooling an attractive addition to any supercharged high-performance engine.

Charge cooling is accomplished much in the same way that heat is removed from the engine itself. A radiator, called an intercooler, is placed in air ducting between the supercharger and the intake manifold. Everything from outside air to ice water and even evaporating pressurized liquefied gas (like Freon or nitrous oxide) have been used to remove heat from an intercooler. The average efficiencies for these devices are:

Air-To-Air	**25%**	**Air-To-Cooler Ducted Air**	**50%**
Air-To-Water	**75%**	**Air-To-Cooled Water**	**100%**
Air-To-Ice Water	**120%**	**Air-To-Evaporating Liquid**	**120+%**

The DynoSim includes an intercooler model that can be activated with any forced induction system. Simply double-click on the **Intercooler** field and select an intercooler efficiency from the drop-down list (or directly enter a custom value).

Note: When methanol evaporates it cools the intake charge more than gasoline (the latent heat of vaporization of methanol is greater than gasoline). Therefore, intercooling is somewhat less effective when methanol has been selected from the **Fuel Type** menu.

THE EXHAUST-SYSTEM COMPONENT CATEGORY MENU

The **EXHAUST** category establishes a manifold or header exhaust system for the

Exhaust System Menu

Peak Efficiency: 72.0 % Boost Limit: 10.0 psi Intercooler: 70.0 %

☑ Exhaust

Exhaust System ers With Mufflers

☑ Camshaft

Cam Name: High Performance Stre

Intake Lift At Valve: 0.550 in

Exhaust Lift At Valve: 0.550 in

Valve Opening/Closing Based On:

Primary Timing (Seat-to-Seat):

Secondary Timing (0.050-inch): IVO: IVC: EVO: EVC:

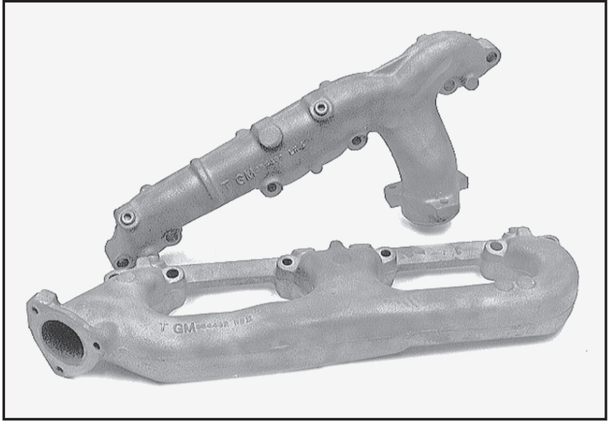
Cam Installed Advanced(+)/Retarded(-): 0.0

True IVO: 31.0 True EVO: 77.0

Exhaust-system flow restrictions (back pressure) are accurately modeled using "pressure-drop" techniques. The DynoSim can also predict engine power changes from various exhaust manifolds and headers of large and small tubing diameters (these sizes are relative to the exhaust-valve diameter of the engine under test).

Exhaust System Modeling

“Log-Type ” Exhaust System Manifolds



The first choice in the Exhaust menu simulates typical, production, cast-iron, “log-type” exhaust manifolds, where all ports connect at nearly right angles to a common “log” passage. These manifolds are designed to provide clearance for various chassis and engine components and provide considerably less than optimum exhaust flow.

simulated test engine. The menu includes seven selections, four of which include mufflers. Since the DynoSim is designed to simulate the power levels for an engine mounted on a dyno testing fixture, the exhaust system for muffled engines ends at the outlet of the muffler and does not include additional tubing commonly used to route exhaust gasses to the rear of a vehicle.

Each of the exhaust system selections apply a unique tuning model to the simulation. (Refer to the *DeskTop Dynos* book available from Motion Software for a more rigorous look at the theory of exhaust-system tuning.)

Exhaust Menu Selections

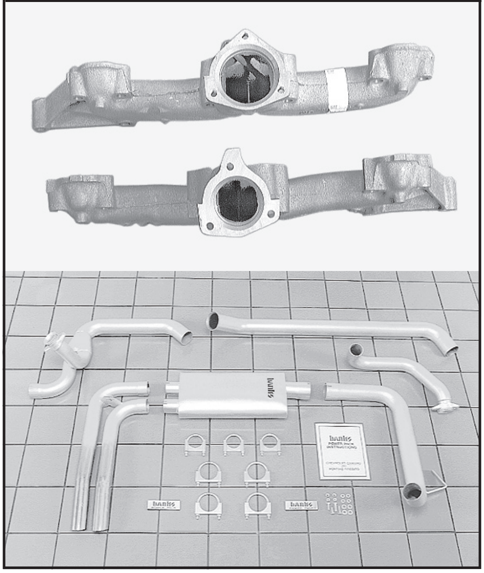
The exhaust system—perhaps more than any other single part of the IC engine—is a virtual “playground” for high-pressure wave dynamics. The interactions of these complex wavefronts require sophisticated, computationally-intensive simulation methods that are only partially modeled in the DynoSim (a much more detailed modeling of these interactions is done in the *Dynomation* engine simulation series available from ProRacing Sim Software in 2004). While flow restriction (back pressure) is entirely modeled using “pressure-drop” techniques, the DynoSim simulation does not resolve specific header dimensions. However, the DynoSim can accurately predict engine power changes from various exhaust manifolds and headers of “large” and “small” tubing diameters (sizes are relative to the exhaust-valve diameter of the engine under test).

The exhaust menu choices are described in the following sections. Use this information to make the most appropriate choice for your test engine.

Stock Manifolds And Mufflers—The first choice in the Exhaust menu simulates the most restrictive exhaust system. It assumes that the exhaust manifolds are a typical, production, cast-iron, usually a “log-type” design, where all ports connect at nearly right angles to a common passage. These manifolds are designed more to

Exhaust System Modeling

HP Manifolds And Mufflers



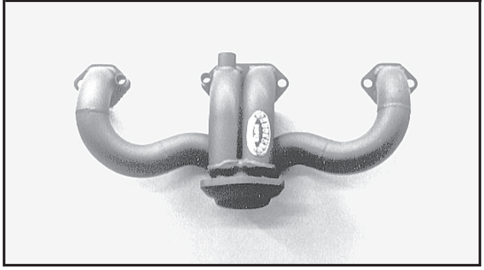
The *HP Manifolds And Mufflers* exhaust-system choice offers a measurable improvement over the stock-exhaust selection. High-performance exhaust manifolds are designed to improve exhaust gas flow and reduce system restriction. They are usually a "ram-horn" or other "sweeping" design with fewer sharp turns and larger internal passages. The connecting pipes to the mufflers are large diameter and the mufflers generate less back pressure.

minimize clearance problems with various chassis and engine components than to optimize exhaust flow. Exhaust manifolds of this type have widespread application on low-performance production engines.

The ***Stock Manifolds And Mufflers*** selection assumes that the exhaust manifolds are connected to twin mufflers with short sections of pipe. Because the engine environment is a simulated dyno cell, the exhaust system terminates at the muffler outlets.

The exhaust manifolds and mufflers cancel all scavenging effects, and the system is a completely "non-tuned" design. Any suction waves that might be generated are fully damped or never reach the cylinders during valve overlap. The restriction created by this system mimics most factory muffler and/or catalytic-converter-with-muffler combinations. Back pressure levels in the exhaust system nearly cancel the blow-down effects of early EVO timing and increase pumping work losses during the

Custom HP "Manifolds"



Here is an excellent example of high-performance "manifolds" from Hooker Headers. The low-restriction custom-built tubing design fits 1992-1995 Corvettes with an LT1 engine. When used with mufflers, model this system using the *H.P. Manifolds And Mufflers* menu selection.

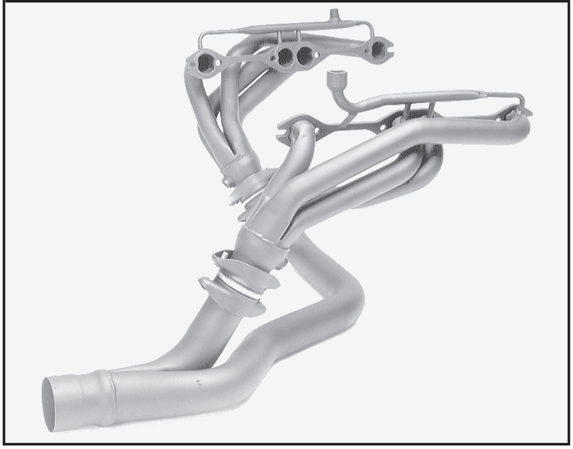
exhaust cycle.

H.P. Manifolds And Mufflers—This choice offers a measurable improvement over the stock exhaust system modeled in the previous selection. The high-performance exhaust manifolds simulated here are designed to improve exhaust gas flow and reduce system restriction. They are usually a “ram-horn” or other less-restrictive designs with fewer sharp turns and larger internal passages. The connecting pipes to the mufflers are large diameter and the mufflers generate less back pressure and produce a louder exhaust note.

While this system is a “high-performance” design, it offers little tuning effects and all suction waves are fully damped or never reach the cylinders during valve overlap. Virtually all performance benefits from this selection are due to a decrease in passage restrictions and lower system back pressure. System pressure levels mimic factory high-performance mufflers and/or catalytic-converter-with-muffler combinations. This exhaust system may allow some benefits from early-EVO timing blowdown effects (depending on the engine component combination) and overall pumping work losses are slightly reduced by lower back pressures.

IMPORTANT NOTE ABOUT ALL HEADER CHOICES: *Some engines, in particular, 4- or 2-cylinder applications, can develop a “full resonance” in the exhaust system—a phenomenon similar to that of full-induction resonance seen in dual-plane manifolds; see the previous discussion of dual-plane manifolds for information about “full” system resonance. This phenomenon can derive scavenging benefits (although some studies have revealed that the benefits are relatively small) from suction waves created in the collector by adjacent cylinders. This “one-cylinder-scavenges-another” tuning technique is not modeled in the DynoSim simulation. Instead, the headers are assumed to deliver a scavenging wave only to the cylinder that generated the initial pressure wave.*

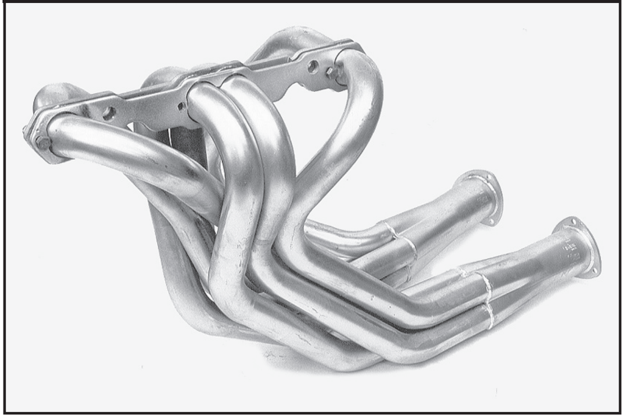
Small-Tube Headers



This is the first exhaust-system selection that begins to harness the tuning potential of wave dynamics in the exhaust system. While the system pictured here is not a “true” header, this tubular exhaust system from Edelbrock for late model cars and trucks offers some wave-dynamic scavenging.

Exhaust System Modeling

Large-Tube Headers



Typical large-tube headers are designed for high-performance street and racing applications in mind. The better pieces have 3- to 4-inch collectors and 1-3/4- to 2-3/8-inch primary tubes (depending on whether they were designed for smallblocks or bigblocks).

Note About Tubing Sizes For All Header Choices: The following rules of thumb give approximations of tubing diameters used by the simulation: Headers with tubes that measure 95% to 105% of the exhaust-valve diameter are considered “small” for any particular engine; tubes that measure 120% to 140% of the exhaust-valve diameter are “large” tube headers.

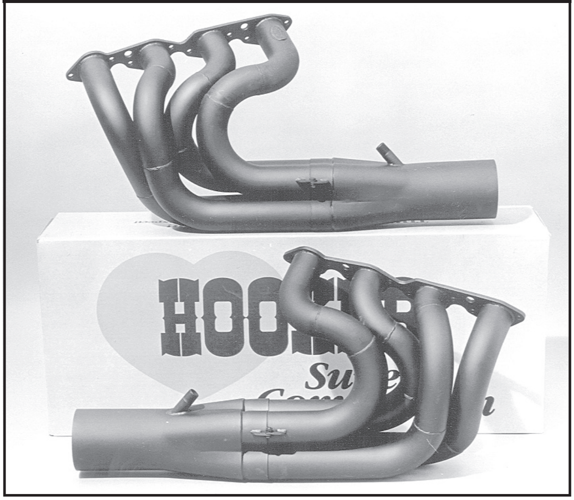
Small Tube Headers With Mufflers—This is the first component selection that begins to harness the tuning potential of wave dynamics in the exhaust system. These simulated headers have primary tubes that individually connect each exhaust port to a common collector. The collector—or collectors, depending on the number of cylinders—terminates into a high-performance muffler(s). Suction waves are created in the collector, but are somewhat damped by the attached muffler.
Note: Since exact tubing lengths are not simulated, the program assumes that the primary tube will deliver the scavenging wave to the cylinder during the valve-overlap period. The primary tubes modeled by this Exhaust menu selection are considered “small,” and should be interpreted to fall within a range of dimensions that are commonly associated with applications requiring optimum power levels at or slightly above peak-torque engine speeds. These headers show benefits on smaller displacement engines, and may produce less power on large displacement engines.

Small-Tube Headers Open Exhaust—This menu selection simulates headers with “small” primary tubes individually connecting each exhaust port to a common collector. The collector—or collectors, depending on the number of cylinders—terminates into the atmosphere. Strong suction waves provide a substantial boost to cylinder filling and exhaust gas outflow. Since exact tubing lengths are not simulated, the program assumes that the primary tube will deliver the scavenging wave to the cylinder during the valve-overlap period.

The primary tubes modeled by this menu selection are considered “small,” and should be interpreted to fall within a range of dimensions that are commonly associ-

Exhaust System Modeling

Large Tube Stepped Racing Headers



Large-tube stepped headers have large-diameter primary tubes with several transitions to slightly larger tubing diameters. These "steps" can reduce pumping work and improve horsepower on large displacement and/or high-rpm applications. These Hooker ProStock BB Chevy headers have 2-3/8-inch primary tubes that step to 2-1/2-inch as they reach the 4-1/2-inch collectors.

ated with applications requiring optimum power levels at or slightly above peak-torque engine speeds. These headers show benefits on smaller displacement engines but may produce less power on large-displacement, bigblock engines.

Large-Tube Headers With Mufflers—This menu selection simulates headers with "large" primary tubes individually connecting each exhaust port to a common collector. The collector—or collectors, depending on the number of cylinders—terminates into a high-performance muffler(s). Suction waves are created in the collector, but are somewhat damped by the attached muffler.

The primary tubes modeled by this selection are considered "large," and should be interpreted to fall within a range of dimensions that are commonly associated with applications requiring optimum power at peak engine speeds. These headers typically show benefits on high-rpm racing smallblocks or large displacement engines. These headers may produce less power on small-displacement engines operating in the lower rpm ranges.

Large-Tube Headers Open Exhaust—This menu selection simulates headers with "large" primary tubes individually connecting each exhaust port to a common collector. The collector—or collectors, depending on the number of cylinders—terminates into the atmosphere. Strong suction waves are created in the collector that provide a substantial boost to cylinder filling and exhaust gas outflow.

The primary tubes modeled by this menu selection are considered "large," and should be interpreted to fall within a range of dimensions that are commonly associated with applications requiring optimum power at peak engine speeds. These headers typically show benefits on high-rpm racing smallblocks or large-displacement bigblock engines. These headers may produce less power on small-displacement engines, particularly those operating in the lower rpm ranges.

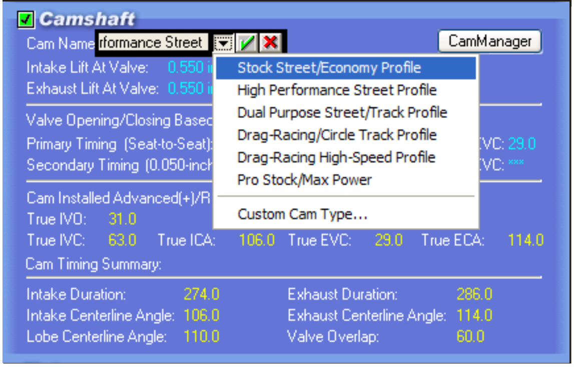
Large Stepped-Tube Race Headers—This menu selection simulates headers with “large” primary tubes individually connecting each exhaust port to a common collector. Each primary tube has several transitions to slightly larger tubing diameters as it progresses towards the collector. These “steps” can reduce pumping work and improve horsepower as described below. The collector—or collectors, depending on the number of cylinders—terminates into the atmosphere. Strong suction waves are created in the collector that provide a substantial boost to cylinder filling and exhaust gas outflow.

The “stepped” design of the primary tubes can reduce pumping work on some engines. As high-pressure compression waves leave the port and encounter a step in the primary tube, they return short-duration rarefaction waves. These low-pressure “pulses” moves back up the header and assists the outflow of exhaust gasses. When rarefaction waves reach the open exhaust valve, they help depressurize the cylinder and lower pumping work. This can generate a measurable increase in horsepower on large displacement and/or high-rpm engines.

The primary tubes modeled by this menu selection are considered “large,” and should be interpreted to fall within a range of dimensions that are commonly associated with applications requiring optimum power at peak engine speeds.

Forced Induction Exhaust—This is an “automatic” menu selection that is enabled whenever ***Forced Induction*** is selected from the **Induction Type** menu. When displayed in the **EXHAUST** category, it is shown “dimmed,” indicating that it has been selected automatically by the DynoSim and cannot be changed (except by choosing an different, non-forced induction, systems from the **Induction Type** menu. This exhaust model simulates an open-exhaust, free-flowing system with a turbocharger or supercharger. Because exhaust system backpressure and wave-dynamic tuning can have significant effects (both positive and negative) on the efficiency of superchargers, especially turbochargers, this exhaust model is “simplified” to allow a more direct

Camshaft Component Menus



☑ Camshaft

Cam Name rformance Street

Intake Lift At Valve: 0.550 i

Exhaust Lift At Valve: 0.550 i

Valve Opening/Closing Basec

Primary Timing (Seat-to-Seat): VC: 29.0

Secondary Timing (0.050-inch VC: ***

Cam Installed Advanced(+)/R

True IVO: 31.0

True IVC: 63.0 True ICA: 106.0 True EVC: 29.0 True ECA: 114.0

Cam Timing Summary:

Intake Duration: 274.0 Exhaust Duration: 286.0

Intake Centerline Angle: 106.0 Exhaust Centerline Angle: 114.0

Lobe Centerline Angle: 110.0 Valve Overlap: 60.0

The CAMSHAFT component menus allows the selection of the single most important part in the IC engine: the camshaft, considered the “brains” of the IC engine. Cam timing directs the beginning and ending of all four engine cycles. The DynoSim has hundreds of new enhancements and features that improve cam-timing and valvetrain motion analysis.

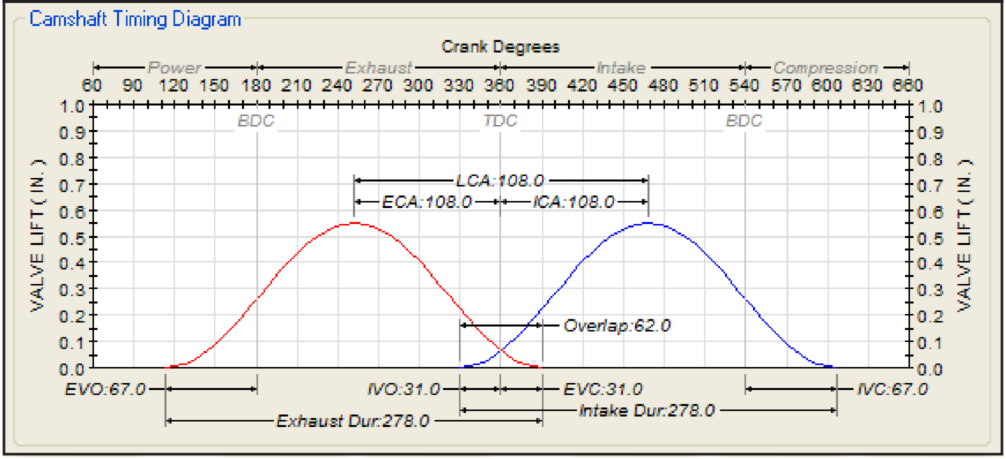
comparison of various forced-induction blowers. The power produced by this model provides a good "target" for open-exhaust systems, but is still a value that some well-designed, low back pressure, muffled systems can obtain.

THE CAMSHAFT COMPONENT CATEGORY MENUS

The **CAMSHAFT** component category allows the selection of the single most important part in the IC engine: the camshaft. For many enthusiasts and even professional engine builders, the subtleties of cam timing defy explanation. Add in all the "standards" of measurement and advertising hype, and the reason for this confusion is understandable. The camshaft is the "brains" of the IC engine, directing the beginning and ending of all four engine cycles. Even with a good understanding of all engine systems, the interrelatedness of the physics within the IC engine can make the tuning results of cam timing changes read like a mystery story. In many cases there are only two ways to determine the outcome of a modification: 1) run a real dyno test or 2) run a simulation. Since the camshaft directly affects several functions at once, e.g., exhaust and intake scavenging, induction signal, flow efficiency, cylinder pressures, etc., using a computer-based engine simulation program is often the only way to *accurately predict* the outcome.

The DynoSim makes it possible to test the effects of cam timing in seconds. The

Valve Motion Diagram

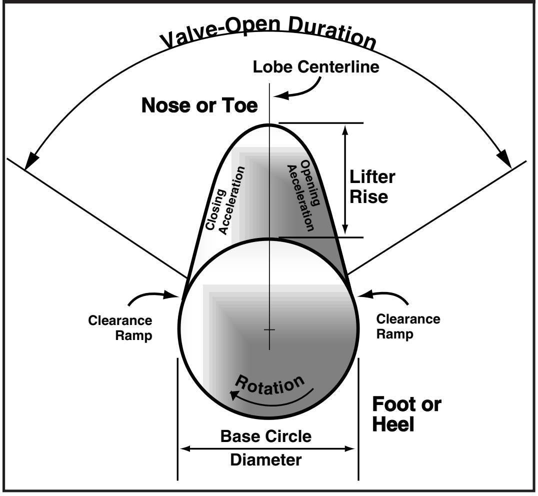


The best way to visualize camshaft timing is to picture this "twin-hump" event diagram (as drawn by the *DynoSim CamManager*, described on page 87). It shows valve motion for the exhaust lobe on the left and the intake lobe on the right. Also illustrated are the valve-timing points, duration, valve overlap, valve lift, centerlines, lobe center angle, and "ideal" engine-cycle timing, all relative to TDC at the center of the drawing. Study this picture. It will help you evaluate cam timing and visualize how individual cam-timing events relate to one another.

Camshaft Modeling

The camshaft is a round shaft incorporating cam *lobes*. The *base circle diameter* is the smallest diameter of the cam lobe. *Clearance ramps* form the transition to the *acceleration ramps*. The lifter accelerates up the clearance and acceleration ramps and continues to rise as it approaches the *nose*, then begins to slow to a stop as it reaches maximum *lift* at the *lobe centerline*. Maximum *lifter rise* is determined by the height of the *toe* over the *heal*. *Valve-open duration* is the number of <u>crankshaft</u> degrees that the valve or lifter is held above a specified height (usually 0.006-, 0.020-, or 0.050-inch). A symmetric lobe has the same lift curve for opening and closing.

Cam Lobe Basics



ability of the program to take the myriad elements that affect airflow and cylinder pressures into consideration and "add up these effects over time" is key to accurately predicting the results of camshaft timing changes.

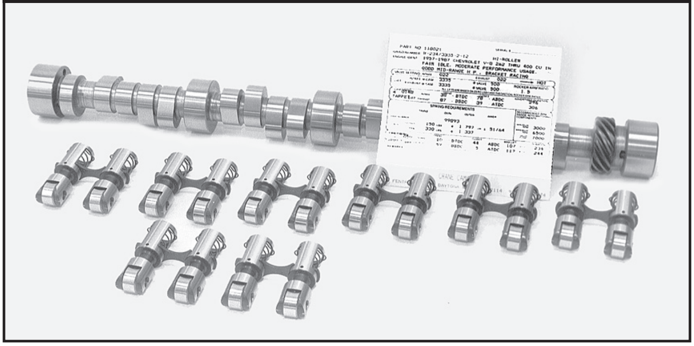
Cam Basics

In the simplest terms, the camshaft is a straight steel or iron shaft with eccentric lobes. It is connected to the crankshaft with a chain or gear train and is usually rotated at one-half crank speed. Lifters (or cam followers)—and in the case of in-block cam locations, pushrods, and rockerarms—translate the rotary motion of the cam into an up-and-down motion that opens and closes the intake and exhaust valves. This entire assembly must function with high precision and high reliability. Street engines driven hundreds-of-thousands of miles operate their valvetrain components *billions of cycles*. If the overall camshaft and valvetrain design is good, a precision micrometer will detect only negligible wear!

The camshaft controls the valve opening and closing points by the shape and rotational location of the lobes. Most cams are ground to a precision well within one crankshaft degree, ensuring that the valves actuate exactly when intended. Timing variations of several degrees can develop in the cam drive, especially in chain-drive systems, but racing gear drives reduce variations to within one or two crank degrees, or less, of indicated timing. Camshaft lobe height (heal-to-toe height) and the multiplying ratio of the rockerarms (if used) determines how far the valves will lift off of the valve seats. The rates at which the valves are accelerated open and then returned to their seats are also "ground into" cam lobe profiles. Only a very specific range of contours will maintain stable valve motion, particularly with high-lift, racing profiles.

Camshaft Modeling

Common "Cam Card" Timing



Long before engine simulations were widely used, cam manufacturers established a methodology for identifying and classifying camshafts. Unfortunately, these "catalog" specs place the emphasis on the span between the valve events rather than on the events themselves.

Unstable profiles or excessive engine speed will force the valvetrain into "valve float," leading to rapid component failure.

Valve Events

There are six basic cam timing events ground into the lobes of every camshaft. These timing points are:

1—Intake Valve Opening (IVO)
2—Intake Valve Closing (IVC)
3—Exhaust Valve Opening (EVO)
4—Exhaust Valve Closing (EVC)
5—Intake Valve Lift
6—Exhaust Valve Lift

These six points can be "adjusted" somewhat (we'll discuss which and how cam timing events can be altered in the next section), but for the most part they are fixed by the design of the cam. Other timing numbers are often discussed, but they are always derived from the above, basic six events. Derivative events are:

7—Intake Duration
8—Exhaust Duration
9—Lobe Center Angle (LCA)
10—Valve Overlap
11—Int. Center Angle (ICA)
12—Exh. Center Angle (ECA)

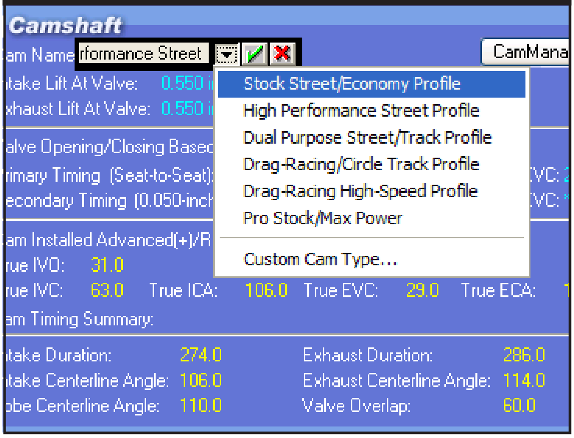
The first four basic timing points (IVO, IVC, EVO, EVC) pinpoint the "true" beginning and end of the four engine cycles. These valve opening and closing points indicate when the function of the piston/cylinder mechanism changes from intake to compression, compression to power, power to exhaust, and exhaust back to intake. For a more in-depth analysis of cam timing, refer to the *DeskTop Dynos* book available from Motion Software (www.motionsoftware.com).

Camshaft Menu Choices

The **Cam Name** menu contains six camshaft "grinds" that are listed by application:

Camshaft Modeling

***Cam Name* Menu Selections**



am Name rformance Street

take Lift At Valve: 0.550 i

xhaust Lift At Valve: 0.550 i

alve Opening/Closing Basec

rimary Timing (Seat-to-Seat):

econdary Timing (0.050-inch

am Installed Advanced(+)/R

rue IVO: 31.0

rue IVC: 63.0 True ICA: 106.0 True EVC: 29.0 True ECA: 1

am Timing Summary:

take Duration: 274.0 Exhaust Duration: 286.0

take Centerline Angle: 106.0 Exhaust Centerline Angle: 114.0

obe Centerline Angle: 110.0 Valve Overlap: 60.0

The DynoSim can evaluate cam timing changes in seconds. Several "generic" cam profiles are included in the Cam Name drop-down menu, plus you can easily input any custom timing and valve lift specifications. Test cams from specifications in manufacturer catalogs or load CamFiles directly using the new, built-in *CamManager™*. *CamDisk3™* (optional, see page 81) increases your test-cam library to over 3500 profiles.

1) *Stock Street/Economy Profile*, 2) *High Performance Street Profile*, 3) *Dual Purpose Street/Track Profile*, 4) *Drag-Race/Circle-Track Profile*, and 5) *Drag-Race High-Speed Profile*, and 6) *Pro Stock/Max Power Profile*. When any of these camshafts is selected, the ***Intake Lift At Valve*** and ***Exhaust Lift At Valve***, the seat-to-seat ***Cam Timing*** (the IVO, IVC, EVO, EVC), the ***Lifter Type***, and the ***Lifter Acceleration*** are loaded into the appropriate fields in the **CAMSHAFT** category. In addition, the ***Intake*** and ***Exhaust Centerlines***, the ***Lobe Center Angle***, the ***Intake*** and ***Exhaust Duration***, and the ***Valve Overlap*** are calculated and displayed.

Stock Street/Economy Profile—(modeled after CompCams 01-405-8) This first cam selection is an OEM-replacement street cam. While this cam uses roller-hydraulic lifters, lifter acceleration rate (explained in detail on page 79) is only 2.90 (on a 1.00 to 6.00 scale), which indicates that valve motion for this cam falls in the range of stock OEM to mild street performance. Rated valve lift is 0.510-inch for both the intake and exhaust.

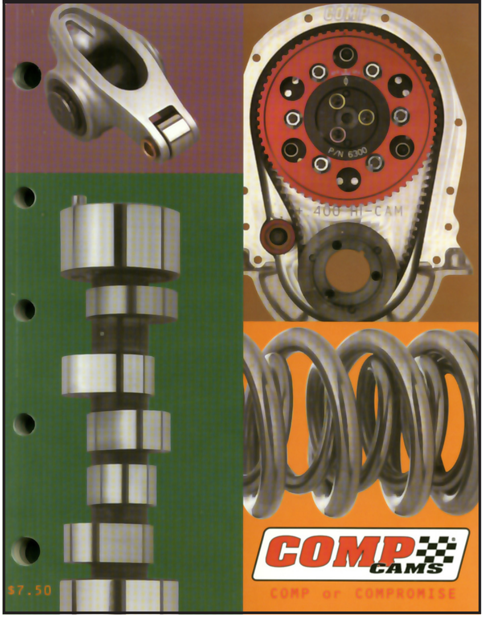
The EVO timing maintains combustion pressure late into the power stroke and early IVC minimizes intake flow reversion. Late IVO and early EVC produce 38 degrees of overlap, enough to harness some scavenging effects but restricted enough to prevent exhaust gas reversion into the induction system. The characteristics of this cam are smooth idle, good power from 600 to 4600rpm, and good fuel economy. This cam works well in high-torque demand applications.

High Performance Street Profile—(modeled after CompCams 11-246-3) This profile is designed to simulate a high-performance "street" camshaft. This cam uses hydraulic lifters and produces an acceleration rate of 3.10, indicating that valve motion falls in the range of a typical mild, street-performance cam. Rated valve lift is 0.552-inch for the intake and 0.555-inch for the exhaust.

This camshaft uses relatively-late EVO to fully utilize combustion pressure and

Camshaft Modeling

CompCams Catalog



The “generic” camshafts available in the DynoSim *Cam Name* menu were modeled after profiles developed by CompCams.

early IVC minimizes intake flow reversion. IVO and EVC produce 60 degrees of overlap, a profile that is clearly intended to harness exhaust scavenging effects. The modestly-aggressive overlap allows some exhaust gas reversion into the induction system at lower engine speeds, affecting idle quality and low-speed torque. The characteristics of this cam are fair idle, good power from 1800 to 6000rpm, and good fuel economy. This cam develops considerable power from 3000- to 5500rpm. The *High Performance Street Profile* choice can be used higher acceleration rates (to 3.5) to model slightly more aggressive profiles.

Dual Purpose Street/Track Profile—(modeled after CompCams 35-771-8) This profile simulates a high-performance aftermarket camshaft designed for street and mild track applications. This cam uses roller-solid lifters and produces an acceleration rate of 3.90, indicating that valve motion falls in the range of a high-performance street and mild racing. Rated valve lift is 0.608-inch for the intake and 0.614-inch for the exhaust.

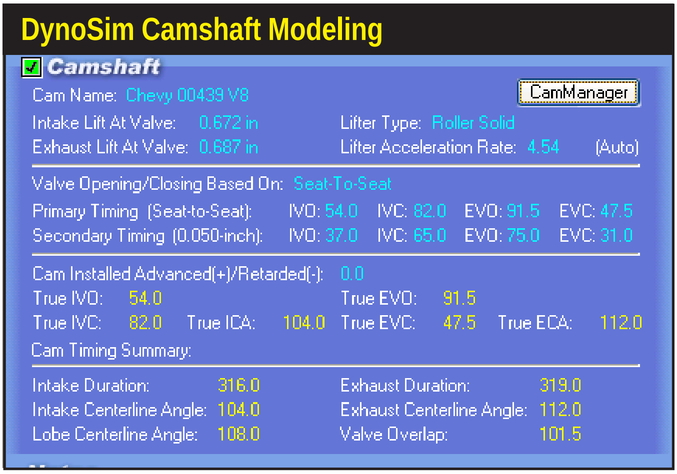
EVO timing on this camshaft is beginning to move away from specs that would be expected for optimum combustion pressure utilization, with more of an emphasis on blowdown and minimizing exhaust-pumping losses. The later IVC attempts to strike a balance between harnessing the ram effects of the induction system while minimizing intake flow reversion. IVO and EVC produce 63 degrees of overlap, a profile designed to harness exhaust scavenging. The modestly aggressive overlap allows some exhaust gas reversion into the induction system at lower engine speeds, affecting idle quality and low-speed torque. The characteristics of this cam are lopey idle, good power from 2500 to 6500rpm, and modest fuel economy. This cam develops considerable power at higher engine speeds and is especially effective in lightweight vehicles.

Drag-Race/Circle-Track Profile—(modeled after CompCams 35-747-7) This profile is designed to simulate an aftermarket high-performance competition camshaft. This cam uses solid lifters and produces an acceleration rate of 4.30, indicating that valve motion falls in the lower portion of the range normally used in competition-only engines. This camshaft would produce good power while keeping valve acceleration somewhat lower for extended life. Rated valve lift is 0.656-inch for the intake and 0.640-inch for the exhaust.

EVO timing on this racing camshaft places less emphasis on utilizing combustion pressure and more emphasis on beginning early blowdown to minimize exhaust-pumping losses. The later IVC attempts to strike a balance between harnessing the ram effects of the induction system while minimizing intake flow reversion. IVO and EVC produce 91 degrees of overlap, intended to optimize exhaust scavenging effects. This aggressive overlap is designed for higher engine speeds with open headers and allows exhaust gas reversion into the induction system at lower rpm, affecting idle quality and torque below 4000rpm. The characteristics of this cam are very lopey idle, good power from 6600 to 8600rpm, with no consideration for fuel economy. This cam develops substantial power at higher engine speeds and is especially effective in lightweight vehicles.

Drag-Race High-Speed Profile—(modeled after CompCams 23-732-9) This profile is designed to simulate a competition aftermarket camshaft. This cam uses roller-solid lifters and produces an acceleration rate of 4.60, indicating that valve motion falls in the range normally used in competition-only engines. Rated valve lift is 0.692-inch for both the intake exhaust.

All timing events on this camshaft are designed to optimize power on large displacement engines at very high engine speeds with large-tube, open headers, and high



Cam Name: Chevy 00439 V8
Intake Lift At Valve: 0.672 in
Lifter Type: Roller Solid
Exhaust Lift At Valve: 0.687 in
Lifter Acceleration Rate: 4.54 (Auto)
Valve Opening/Closing Based On: Seat-To-Seat
Primary Timing (Seat-to-Seat): IVO: 54.0 IVC: 82.0 EVO: 91.5 EVC: 47.5
Secondary Timing (0.050-inch): IVO: 37.0 IVC: 65.0 EVO: 75.0 EVC: 31.0
Cam Installed Advanced(+)/Retarded(-): 0.0
True IVO: 54.0 True EVO: 91.5
True IVC: 82.0 True ICA: 104.0 True EVC: 47.5 True ECA: 112.0
Cam Timing Summary:
Intake Duration: 316.0 Exhaust Duration: 319.0
Intake Centerline Angle: 104.0 Exhaust Centerline Angle: 112.0
Lobe Centerline Angle: 108.0 Valve Overlap: 101.5

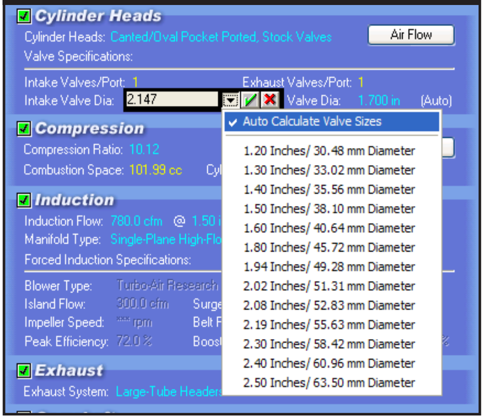
There are thousands of cam profiles and lifter/valvetrain combinations for any typical performance engine. Determining the best cam for any application often required extensive dyno testing. Today, with tools like the DynoSim, you can "zero-in" on the right cam for your engine <u>before</u> you spend money on the wrong parts.

compression ratios. This camshaft may not be effective in small displacement engines. EVO timing on this racing profile places the utilization of combustion pressure on the “back burner” and focuses emphasis on beginning early blowdown to minimize pumping losses during the exhaust stroke. This technique will help power at very high engine speeds, especially on large-displacement engines that do not easily discharge the high volume of exhaust gasses they produce. The late IVC attempts to harness the full ram effects of the induction system while relying on intake pressure wave tuning to minimize intake-flow reversion. IVO and EVC produce 104 degrees of overlap, a profile that is clearly intended to utilize exhaust scavenging effects. This very aggressive overlap seriously affects idle quality and torque below 4500rpm. A 5000rpm stall torque converter is recommended for automatic transmission applications. The characteristics of this cam are extremely lopey idle, good power from 4500 to 7200rpm, with no consideration for fuel consumption.

Pro Stock/Max Power Profile—(modeled after CompCams 11-728-9) This profile is designed to simulate an all-out, maximum-power competition camshaft. This cam uses roller-solid lifters and produces an acceleration rate of 5.40, indicating that valve motion falls in the high range normally used in competition-only engines. Valvetrain loads will be substantial, and frequent replacement of valvesprings and other components may be required. Rated valve lift is 0.867-inch for the intake and 0.816-inch for the exhaust.

This ProStock cam is designed for one thing: maximum power at all costs. It is designed to optimize power on very-large displacement engines at very high engine speeds with large-tube, open headers, and very-high compression ratios. EVO timing focuses emphasis on beginning early blowdown to minimize pumping losses, a technique that helps large-displacement engines discharge the high volume of exhaust gasses they produce. The late IVC attempts to harness the full ram effects of the induction system while relying on intake pressure wave tuning to minimize intake-flow reversion. IVO and EVC produce 110 degrees of overlap. This very aggressive overlap

Valve Lift Menu



☑ Cylinder Heads
Cylinder Heads: Canted/Oval Pocket Ported, Stock Valves
Valve Specifications:
Intake Valves/Port: 1
Exhaust Valves/Port: 1
Intake Valve Dia: 2.147
Valve Dia: 1.700 in (Auto)

☑ Compression
Compression Ratio: 10.12
Combustion Space: 101.99 cc

☑ Induction
Induction Flow: 780.0 cfm @ 1.50 i
Manifold Type: Single-Plane High-Flo
Forced Induction Specifications:
Blower Type: Turbo-Air Research
Island Flow: 300.0 cfm
Impeller Speed: *** rpm
Peak Efficiency: 72.0 %

☑ Exhaust
Exhaust System: Large-Tube Headers

Selecting (placing a check mark next to) *Auto Calculate Valve Lift* will automatically calculate appropriate valve lifts for camshafts listed in the Camshaft Type drop-down menu. To manually select valve lift from the drop-down menu, or to directly enter a custom value, make sure that the Auto Calculate Valve Lift feature is turned off (no check mark next to Auto Calculate).

basically has no idle quality or torque below 6000rpm. The characteristics of this cam are extremely lopey idle, and awesome power from 7000 to 9000rpm.

Note: Each of the previous application-specific cams can be modified in any way by directly entering custom valve-event timing or other cam specifications (more on this in the next few sections).

The Valve-Lift Menus And The *Auto Calculate Valve Lift* Feature

Typically, the **Intake** and **Exhaust Lift-At-Valve** menus display the valve lift (maximum lift at valve) for the currently-selected camshaft, regardless of whether the cam was chosen from the **Cam Name** menu or loaded from as CamFile using the **CamManager** (see page 87). At any time you may manually enter custom valve-lift values in either menu and instantly see the results in the simulated power and torque curves displayed on the right side of the main program screen. You may select any of the predetermined valve lifts listed in the menus, or you may select ***Auto Calculate Valve Lift*** (turned off, by default) that is available as the first choice from either **Lift-At-Valve** menu. When Auto Calculate is enabled, the DynoSim will automatically calculate intake and exhaust valve lifts, a useful feature if you wish to enter custom cam timing for which you do not know specific valve lifts, or if you wish to "scale" the valve lift of a known camshaft to better match the current engine (for example, if you use a bigblock cam in a smallblock engine). In these cases, ***Auto Calculate Valve Lift*** will provide the appropriate intake and exhaust valve lift heights based on current valve-head diameters and camshaft timing. The Auto-Calculation feature can be suspended and, instead, fixed lift values will be used for any camshaft when you re-select **Auto Calculate Valve Lifts** (to turn it off by "unchecking" it).

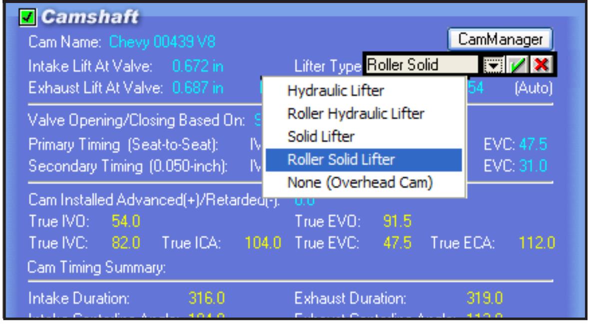
Note 1: ***Auto Calculate Valve Lifts*** *will be turned off automatically when any CamFile is loaded, since each CamFile usually represents a "real-world" cam that has specific valve lifts associated with it (ground-in by the manufacturer).* However, you can turn valve lift Auto-Calculation back on at any time by reselecting it from the menus.
Note 2: If **Valve Diameters** are also being automatically calculated (see page 33)—cylinder-bore diameter and a cylinderhead selection must be completed before the program can calculate valve diameters and, consequently, valve lifts.

Lifter Menu

Earlier versions of the DynoSim relied on the lifter selection to determine valvetrain acceleration. A hydraulic lifter activated a low-acceleration model, solid lifters increased the acceleration, and roller lifters applied the highest acceleration model. The latest version of the DynoSim (v.4 and later) has a completely new method of modeling valvetrain acceleration that is NOT based on lifter selection (more details on this new

Camshaft Modeling

Lifter-Type Menu Selections



☑ Camshaft

Cam Name: Chevy 00439 V8

Intake Lift At Valve: 0.672 in

Exhaust Lift At Valve: 0.687 in

Lifter Type: Roller Solid

(Auto)

Valve Opening/Closing Based On:

Primary Timing (Seat-to-Seat): EVC: 47.5

Secondary Timing (0.050-inch): EVC: 31.0

Cam Installed Advanced(+)/Retarded(-):

True IVO: 54.0 True EVO: 91.5

True IVC: 82.0 True ICA: 104.0 True EVC: 47.5 True ECA: 112.0

Cam Timing Summary:

Intake Duration: 316.0 Exhaust Duration: 319.0

Lifter type is often associated with the description of a particular camshaft, e.g., Hydraulic Cam 123. The DynoSim offers five lifter descriptions that can be associated with the current cam, however, these selections DO NOT affect the simulation. Instead, a lobe profile is calculated and acceleration rates are determined based on published seat-to-seat and 0.050-inch timing specifications (see text).

feature is provided in the next section).

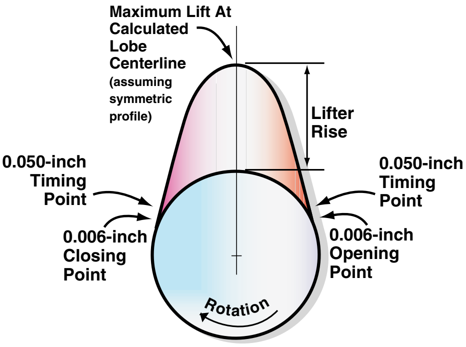
However, the type of lifters used with any particular camshaft are often part of the description of that cam (e.g., a Hydraulic Cam 123, or a Roller Cam 345). To keep the lifter type associated with the camshaft, the lifter can be selected from the **Lifter Type** menu. The following five choices are available:

1) None—Overhead Cam
2) Hydraulic Flat-Tappet Lifters
3) Roller Hydraulic Flat-Tappet Lifters
4) Solid Flat-Tappet Lifters
5) Roller Solid Flat Tappet Lifters

Note: The ***Lifter Type*** selection is used for informational purposes only; it does not affect the simulation. However, the lobe profile (sometimes related to the lifter type) does affect engine power output. The lobe profile is calculated by the DynoSim based

The DynoSim models valve motion and calculates valve acceleration from five data points for each lobe: 1) the seat-to-seat opening point, 2) the 0.050-inch opening timing point, 3) the point of maximum lift, 4) the 0.050-inch closing timing point, and 5) the seat-to-seat closing point. An exclusive feature of the DynoSim is an entirely unique analysis of this data to accurately predict valvetrain acceleration. A simple range of valvetrain acceleration values from 1.00 (very low acceleration) to 6.00 (very high acceleration) let's you determine, at-a-glance, the performance characteristics of any cam profile.

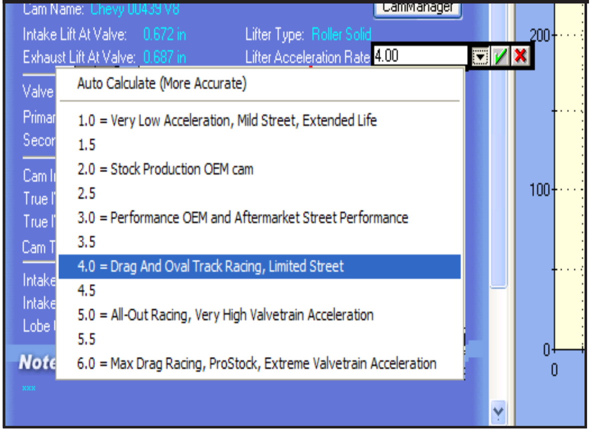
Valve Motion Curves & Acceleration



Lobe Profiles Are Calculated From Seat-To-Seat and 0.050-inch Opening and Closing Points, And The Point Of Maximum Lift

Camshaft Modeling

Lifter-Acceleration Menu Selections



Cam Name: Chevy 00439 V8

Intake Lift At Valve: 0.672 in

Lifter Type: Roller Solid

Exhaust Lift At Valve: 0.687 in

Lifter Acceleration Rate 4.00

The DynoSim can automatically determine the Lifter Acceleration rate by performing an analysis of valve timing specifications for the current camshaft. To enable this feature, select *Auto Calculate* from the Lifter Acceleration menu. If you cannot find all ten timing points, use the guidelines provided in the text to assist you in selecting the most appropriate rate (a value from 1.00 to 6.00).

on the ten timing points (five for each lobe) published by the cam manufacturer. For more information on lobe profiles and lifter acceleration rates, refer to the next section.

Lifter-Acceleration Menu

As mentioned, the DynoSim uses an entirely new model to simulate lifter- and valvetrain acceleration. The ten common timing points associated with most camshafts (seat-to-seat and 0.050-inch valve opening and closing points plus peak valve lift points) are analyzed by the simulation to predict ramp-rate and overall valvetrain acceleration. From this analysis (and the valve opening an closing points, discussed in the next sections) the DynoSim creates valve-motion curves that pinpoint valve position at each degree of crank rotation. The acceleration of the cam is rated with an overall value from 1.00 (very-low acceleration) to 6.00 (very-high acceleration). While previous models that produced only three steps of acceleration, the new technique provides a 500-step granularity that much more accurately models valvetrain acceleration rates generated by cams designed for street to ProStock applications. Using this easy-to-interpret value, you can determine, at-a-glance, the general performance characteristics of any camshaft.

Use the following guidelines to evaluate **Lifter Acceleration Rates** that can range from 1.00 to 6.00:

1.00	**Very Low Acceleration, Mild Street, Extended Valvetrain Life**
2.00	**Stock Production, OEM Camshafts**
3.00	**Performance OEM and Aftermarket Street Performance**
4.00	**Drag and Oval Track Racing, Limited Street**
5.00	**All-Out Racing, Very High Valvetrain Acceleration**
6.00	**Maximum Drag Racing, ProStock, Limited Valvetrain Life**

Note: While the new algorithms used in this model have proven to be remarkably

The new *CamDisk3™* from ProRacing Sim Software includes over 3500 camfiles and all cam timing information required for the DynoSim to automatically calculate the *Lifter Acceleration* rates. Use the new CamManager™ and Quick Iterator™ with CamDisk3 to automatically locate optimum profiles for any engine. CamDisk3 and the DynoSim are, simply, the most powerful tools you can use to find the best cams for any application.

CamDisk3™ With 3500+ CamFiles

accurate, you should keep in mind that valve motion curves for both the intake and exhaust valves are calculated from only ten data points, five for the intake valve and five for the exhaust valve. Furthermore, the DynoSim develops a valve motion curve that is biased toward symmetric (meaning that the “opening” side of the lobe has a nearly identical shape as the “closing” side). Asymmetric modeling is limited with only five data-input points per lobe, fortunately, performance differences between symmetric and asymmetric valve motions are often quite small. In most cases, the predicted ramp rates and valve motions within the DynoSim are very accurate, but without knowing the precise shape of the cam at each degree of rotation, it is not possible to ensure accuracy 100% of the time.

Making The Best Lifter-Acceleration Choices

The DynoSim can determine the Lifter Acceleration rate by performing an analysis of the valve-timing specifications for the current camshaft. To enable this feature, select ***Auto Calculate*** from the **Lifter Acceleration** menu. In order to complete the lobe-profile analysis, the DynoSim must have all ten data points for the current cam (seat-to-seat and 0.050-inch opening and closing points plus peak valve lift points, entered in the **CAMSHAFT** Category, see photo on page 79). If all ten points are not available, the program will indicate a discrepancy. When all the points have been entered, Lifter Acceleration will be calculated and displayed in the **Lifter Acceleration** menu.

Note: All sample CamFiles provided with the DynoSim and the 3500+ additional CamFiles included on ***CamDisk3™*** have complete cam specifications that allow the DynoSim to automatically calculate Lifter Acceleration rates. For information on how to use and search for CamFiles, refer to **Using The CamManager™** on page 87).

Manually Determining Lifter-Acceleration Rates

If you do not know all ten timing points for the current cam, the DynoSim will be unable to automatically calculate the Lifter Acceleration, and therefore, it will not perform an engine simulation and display power and torque curves. In this case, you must manually enter Lifter Acceleration based on your understanding of the intended application of the camshaft. Use the guidelines provided in the previous section to assist you in selecting the most appropriate rate (a value from 1.00 to 6.00 must be entered in the **Lifter Acceleration** field in the **CAMSHAFT** component category).

If you are trying to determine the Lifter Acceleration for a specific camshaft (for which you lack timing specs), matching the intended application with the guidelines, as mentioned above, will generally give good results. However, testing has shown that some camshafts that “should” have higher acceleration (in the range of 3.5 to 4.5), in fact have considerable lower rates (from 2.5 to 3.5 or even lower). These camshafts will probably produce less power than similar cams with the same duration and lift, however, they may have been specifically designed for increased valvetrain reliability rather than optimum power. You may also come across camshafts that have actual acceleration rates considerably higher than you might have guessed by their applica-

Comparing Cam Descriptions With Actual Acceleration Rates

Cam Type	Manufacturer Description	Guess Based On Guidelines	Calculated Acceleration	Comments
Solid-Roller For BigBlock Ford	Competition only, good upper RPM torque and HP, Bracket Racing, auto trans w/Drag Racing converter, 12.5 min. comp. ratio advised. Basic RPM 4400-7800.	4.5 to 5.2	5.0	The description of this cam is easy to analyze. Cam has acceleration that is typical for the application. Guess is accurate.
Solid Lifter For BigBlock Chrysler	Rough idle, performance usage, good upper RPM HP, Bracket Racing, auto trans w/3500+ converter, 11.0 to 12.5 compression ratio advised. Basic RPM 4200-7200.	4.0 to 4.5	2.5	This is a HP cam designed for drag racing. The low acceleration reduces potential performance but increases valvetrain life. Guess is too high.
Solid-Roller For BigBlock Ford	Rough idle, performance usage, good mid-range torque and HP, Bracket Racing, auto trans w/Drag Racing converter, 11.5 minimum compression ratio advised. Basic RPM 4000-7000.	4.0 to 4.5	5.6	This cam also requires high-stall converter, high-compression, etc. But this profile has very-high acceleration rates. A clue is the somewhat lower max rpm and claim of good mid-range. Guess is too low.
Hydraulic Lifter For Small Mopar	For street high performance and racing applications only, not heavy vehicles.	3.0 to 3.5	2.0	This is a HP cam designed for high performance. The low acceleration cuts a good chunk of power potential from this cam. Guess is too high.
Hydraulic Lifter For Small AMC	Good idle, moderate performance usage, good mid-range HP, Bracket Racing, 3200-3600 cruise RPM, 9.5 to 11.0 compression ratio advised. Basic RPM 2500-5500	2.3 to 3.0	2.4	The description fits the average acceleration for the category. Guess is accurate.
Solid Lifter For Ford Cleveland	Hot Street/E.T. Brackets. 10.5-11.5:1 compression using modified cylinder heads, large valves, Victor Jr. style intake, 750 cfm 4-barrel, and 3" diameter, free flowing exhaust produce good top end power. Automatic cars use 4,000 RPM converter and low gears. OK with nitrous!	3.5 to 4.2	2.7	Described as a performance camshaft requiring high compression, large valves, and a performance intake, you would expect this cam to have a more agressive acceleration rate. Will be low on mid-range power but easier on the valvetrain. Guess too high.
Solid Lifter For Small Chevy	Torque and mid-range power for Drag Racing and Oval Track. RPM Power Range: 2500 to 6500 / Redline: 7000 maximum.	3.8 to 4.5	4.1	Lower peak rpm and good mid-range power indicates higher acceleration. Wide rpm range suggets milder racing cam. Guess is accurate.
Solid-Roller For 351 Ford	Good for weekend cruiser w/9.0 comp, 2000 stall, and lower gears. Has noticeable idle. 2000-6000 RPM.	2.8 to 3.5	4.1	Here’s a sleeper cam. But hints of good power with lower compression and limited top speed suggest higher acceleration. Guess too low.

The DynoSim models valve motion and calculates Lifter Acceleration based on five timing points per lobe. If these timing specs are not available, you must “guess” an acceleration rate before the simulation can be completed. In many cases, you can accurately guess Lifter Acceleration (a value between 1.00 and 6.00) from a description of the intended application and from the guidelines presented in the text (cams that fall into this category are as shown in the green rows in above table). In some cases, the manufacturer’s description may lead you to believe that the cam generates higher acceleration than it does (see the blue rows). And in other cases, the camshaft description can understate the aggressive profiles used by the manufacturer (see the red rows). If you cannot obtain the timing points required for the DynoSim to perform a mathematical analysis of the cam (the most accurate method of estimating the Lifter Acceleration), keep in mind that estimates of acceleration may cause the simulation results to fall outside of the typical ±5% accuracy.

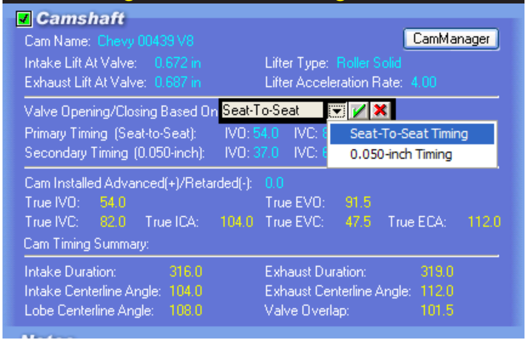
tion alone. In these circumstances, the acceleration value that you apply may produce as much as 10% higher (or lower) horsepower than real-world testing would reveal. Just because a camshaft has been given a name like “Ultimate High Performance” does not mean that it will have exceptional valvetrain acceleration. Similar cams from two different manufacturers may have very different acceleration values. So, if you have to “guess” the **Lifter Acceleration** value—and it is not possible to locate the missing timing points that would allow the DynoSim to automatically calculate this value—keep in mind that you may be increasing potential variabilities in simulated power from ±5% to ±10% (even a really “bad guess” of Lifter Acceleration rarely affects power more than this).

If you are trying to determine Lifter Acceleration rates, don’t be misled by the type of lifters the cam was designed to use. If the cam you’re modeling is a street, roller-lifter grind, it probably incorporates a low-acceleration profile. In these cases, keep acceleration values between 1.50 and 3.00. On the other hand, if the cam is a high-performance grind with roller lifters, acceleration is probably between 2.80 and 4.00. If you are modeling a solid-lifter racing cam, like some “mushroom” lifter grinds or a special SuperStock cam, the acceleration rates of these camshafts may be quite high, ranging from 4.0 to 5.5 or even higher. On the other hand, if the solid-lifter cam was developed as a replacement for a factory high-performance application, rates will be much lower, from 2.0 to 3.0.

Camshafts with high acceleration rates sometimes have a lower maximum rpm before valve float. If the engine is over-revved even slightly over the valvetrain limit, the damage from valve float can be severe. Since there are exceptions to just about everything, consider ProStock cams. Many of these cams have very high acceleration rates, but allow valvetrain speeds up to 9500rpm. How is this possible? Extreme valvespring pressures and constant valvetrain maintenance make this seemingly impossible situation, possible. However, if the performance cam you are analyzing is rated at a rather low peak speed, it may be an indicator that it has higher Lifter Acceleration rates than those indicated in the previous guidelines.

VALVE OPENING/CLOSING

Selecting The Cam Timing Method



Cam Name: Chevy 00439 V8
Intake Lift At Valve: 0.672 in
Lifter Type: Roller Solid
Exhaust Lift At Valve: 0.687 in
Lifter Acceleration Rate: 4.00
Valve Opening/Closing Based On Seat-To-Seat
Primary Timing (Seat-to-Seat): IVO: 54.0 IVC:
Secondary Timing (0.050-inch): IVO: 37.0 IVC:
Cam Installed Advanced(+)/Retarded(-): 0.0
True IVO: 54.0
True EVO: 91.5
True IVC: 82.0 True ICA: 104.0
True EVC: 47.5 True ECA: 112.0
Cam Timing Summary:
Intake Duration: 316.0
Exhaust Duration: 319.0
Intake Centerline Angle: 104.0
Exhaust Centerline Angle: 112.0
Lobe Centerline Angle: 108.0
Valve Overlap: 101.5

The DynoSim will simulate camshaft motion for both Seat-To-Seat and 0.050-inch cam timing. However, the internal simulation requires seat-to-seat event timing to accurately calculate the beginning and end of mass flow in the ports and cylinders and must *derive* seat-to-seat timing from 0.050-inch figures. Unfortunately, this cannot be done perfectly. So, whenever possible enter seat-to-seat timing to obtain the most accurate simulation results.

Camshaft Modeling

AND TIMING-METHOD MENUS

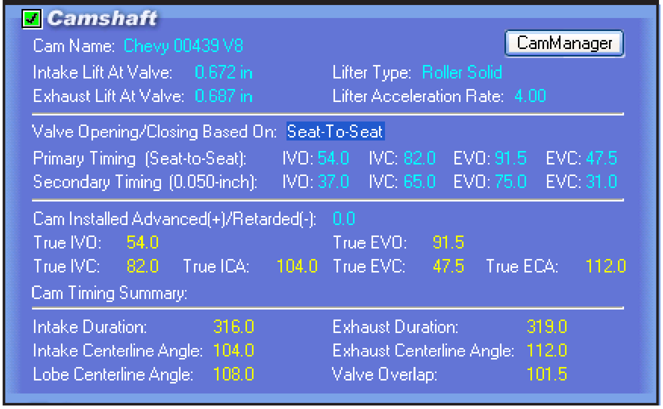
In addition to calculating (or manually entering) the acceleration rate of the lifter, and, therefore, categorizing the ramp rates of the cam profile, the DynoSim simulation must determine the opening and closing points of the intake and exhaust valves in order to accurately predict valve motion at each degree of crankshaft rotation throughout the entire four-stroke process (720-degrees of crank rotation). The simulation can determine the opening and closing points using two basic methods:

1) **Using *Seat-To-Seat cam timing* as the *Primary* valve event timing to directly establish valve opening and closing points. This is the most reliable and accurate way to determine valve-event timing for simulation purposes.**

2) **Using *0.050-inch cam timing* as the *Primary* valve events to *approximate* seat-to-seat timing that subsequently establishes valve opening and closing points. Only use this method when Seat-To-Seat timing values are not available. Since the DynoSim must first "guess" the seat-to-seat timing from 0.050-inch values, this method inherently is less accurate.**

The method used to determine valve opening and closing points is selected with the **Valve Opening/Closing Based On:** menu. The notation "**Primary**" will be placed next to either the **Seat-To-Seat** or **0.050-inch timing** groups (below the Valve Opening/Closing timing menu) to indicate the current timing used by the simulation. If you change the **Primary** timing method, a warning message will be displayed and the ***Primary*** notation will be moved to the other event-timing group. Changing the **Primary** valve-event timing affects not only the simulation results, but also the calculated values displayed in the lower portion of the **CAMSHAFT** category: including *True IVO*, *True IVC*, *True EVO*, *True EVC*, *True ICA*, *True ECA*, *Intake Duration*, *Exhaust*

The DynoSim will accept both Seat-To-Seat and 0.050-inch cam timing specifications. The timing set that is currently used to determine valve opening/closing points is marked as *Primary*. If both sets of timing data and the intake- and exhaust-valve lifts are entered, the DynoSim can automatically calculate the Lifter Acceleration rate, as discussed in the previous section.



Seat-To-Seat and 0.050-inch Cam Timing Groups

☑ Camshaft

Cam Name: Chevy 00439 V8

Intake Lift At Valve: 0.672 in
Lifter Type: Roller Solid
Exhaust Lift At Valve: 0.687 in
Lifter Acceleration Rate: 4.00

Valve Opening/Closing Based On: Seat-To-Seat

Primary Timing (Seat-to-Seat): IVO: 54.0 IVC: 82.0 EVO: 91.5 EVC: 47.5
Secondary Timing (0.050-inch): IVO: 37.0 IVC: 65.0 EVO: 75.0 EVC: 31.0

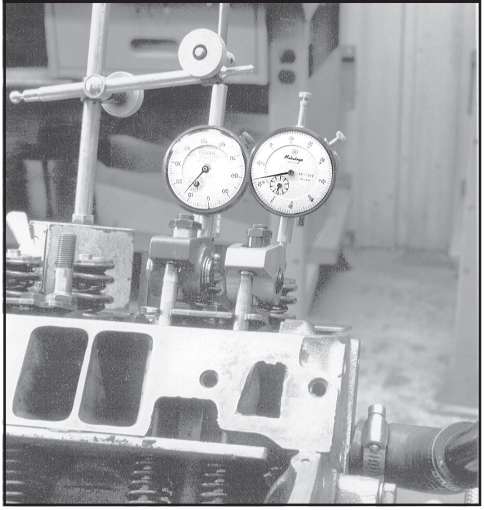
Cam Installed Advanced(+)/Retarded(-): 0.0
True IVO: 54.0
True EVO: 91.5
True IVC: 82.0
True ICA: 104.0
True EVC: 47.5
True ECA: 112.0

Cam Timing Summary:

Intake Duration: 316.0
Exhaust Duration: 319.0
Intake Centerline Angle: 104.0
Exhaust Centerline Angle: 112.0
Lobe Centerline Angle: 108.0
Valve Overlap: 101.5

Camshaft Modeling

Seat-To-Seat Timing Method



Seat-to-seat timing measures the valve timing—relative to piston position—when the valve has just begun to open. Here dial indicators are positioned on the valvespring retainers and are measuring <u>valve rise</u>, which is the most common technique used with seat-to-seat timing (0.020-inch LIFTER rise is a notable exception used for solid lifter camshafts to compensate for lash in the valvetrain). Timing specs measured using these methods are meant to approximate the actual valve opening and closing points that occur within the running engine. Because of this, seat-to-seat valve events are often called the *advertised* or *running* timing and will always produce the most accurate simulations.

Duration, *Intake Centerline (ICA)*, *Exhaust Centerline (ECA)*, *Lobe Center Angle (LCA)*, and *Valve Overlap*.

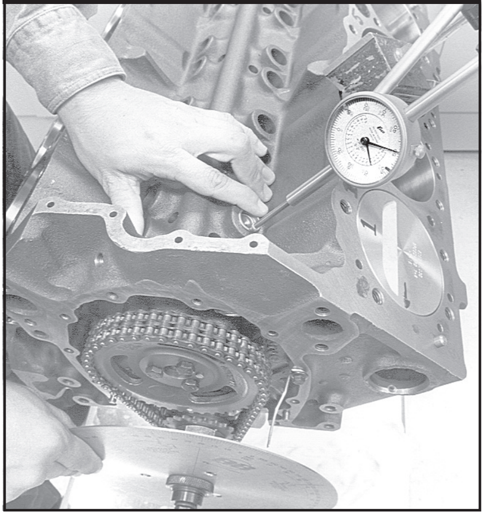
The following sections explain these common camshaft timing methods and gives useful advise on how to improve camshaft simulation accuracy by optimizing profile modeling in the DynoSim.

Seat-to-seat timing method—This timing method measures the valve timing—relative to piston position—when the valve or lifter has only just begun to rise or has *almost* completely returned to the base circle on the closing ramp. Unfortunately, there are no universal seat-to-seat measuring standards used in the camshaft-manufacturing industry. These are some of the more common seat-to-seat timing methods:
0.004-inch LIFTER rise for both intake and exhaust (SAE Standard)
0.006-inch VALVE rise for both intake and exhaust (SAE Standard)
0.007-inch open/0.010-close VALVE rise for both valves
0.010-inch VALVE rise for both intake and exhaust
0.020-inch LIFTER rise for both intake and exhaust (For Solid Lifters)

The timing specs measured using these methods are meant to approximate the actual valve opening-and-closing points that occur within the running engine. Because of this, seat-to-seat valve events are often called the *advertised* or *running* timing. The DynoSim needs this event information to fix the beginning and end of mass flow into and out of the ports and cylinders, a crucial step in the process of determining cylinder pressures and power output. ***Because of this, selecting Seat-To-Seat timing specifications as the <u>Primary</u> method for the simulation to determine valve opening and closing will produce the most accurate results.***

Camshaft Modeling

0.050-Inch Timing Method



The 0.050-inch lifter rise cam timing method measures valve timing when the lifter has risen 0.050-inch off of the base circle of the cam. In the setup pictured here, the dial indicator is positioned on an intake lifter; the 0.050-inch valve timing point can now be read directly off of the degree wheel attached to the crankshaft. Timing specs measured using this method are not meant to approximate the actual valve opening and closing points, instead their purpose is to permit accurate cam installation. All 0.050-inch timing specs entered into the DynoSim are internally converted to seat-to-seat timing. Because there is no way to precisely perform this conversion, always try to obtain and use seat-to-seat event timing to optimize simulation accuracy.

Note: There is a seat-to-seat measuring standard (the SAE 0.004-inch Lifter Rise or 0.006-inch Valve Rise), but there is also a great deal of variation from this standard from cam manufacturers for "cataloging" or "advertising" purposes. These variations can easily confuse for anyone trying to enter timing specs into an engine simulation program. If you use seat-to-seat timing specifications that fall into any of the categories shown above, you should obtain accurate results. *Any timing specifications obtained at less than 0.004-inch lifter rise or 0.006-inch valve rise will not produce accurate results in the DynoSim.*

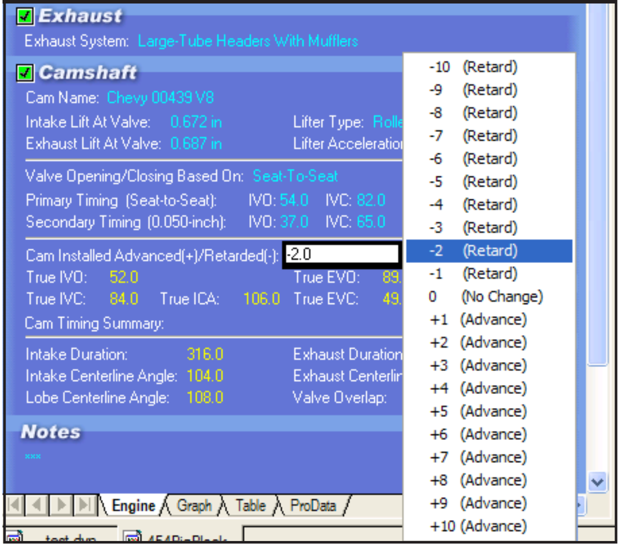
0.050-inch cam timing—This timing method is widely used and standardized by cam manufacturers. 0.050-inch cam timing points are always measured at:

0.050-inch LIFTER rise for both intake and exhaust.

This measurement technique is based on the movement of the cam follower (lifter) rather than the valve. Since the lifter is well into the cam acceleration ramps at 0.050-inch lift, this technique provides an accurate "index" for cam-to-crank positioning, and is a wonderful way to verify the installation (index) of a camshaft. However, 0.050-inch timing does not pinpoint when the intake and exhaust valves open or close; the essential data needed to perform an engine simulation. While you will always find 0.050-inch-lifter-rise timing points published on the cam cards and in many cam manufacturer's catalogs, if you chose 0.050-inch timing as the ***Primary*** timing method, the DynoSim simulation must convert 0.050-timing to seat-to-seat values. And unfortunately, this often introduces some error into valve-motion calculations. ***Whenever possible, use Seat-To-Seat timing specifications as the Primary method to obtain the most accurate simulation results.***

Camshaft Advance/Retard

Advance/Retard Menu



☑ **Exhaust**

Exhaust System: Large-Tube Headers With Mufflers

☑ **Camshaft**

Cam Name: Chevy 00439 V8

Intake Lift At Valve: 0.672 in

Lifter Type: Rolle

Exhaust Lift At Valve: 0.687 in

Lifter Acceleratio

Valve Opening/Closing Based On: Seat-To-Seat

Primary Timing (Seat-to-Seat): IVO: 54.0 IVC: 82.0

Secondary Timing (0.050-inch): IVO: 37.0 IVC: 65.0

Cam Installed Advanced(+)/Retarded(-): -2.0

True IVO: 52.0

True EVO: 89.

True IVC: 84.0 True ICA: 106.0

True EVC: 49.

Cam Timing Summary:

Intake Duration: 316.0

Exhaust Duration

Intake Centerline Angle: 104.0

Exhaust Centerlir

Lobe Centerline Angle: 108.0

Valve Overlap:

Notes

***

The DynoSim allows direct entry of camshaft advance or retard. Changing this specification from zero (the default) to a positive value advances the cam; negative values retard the cam. See text for more information on how these changes affect engine output.

The DynoSim **CAMSHAFT** Category displays both the Seat-To-Seat and 0.050-inch cam timing points. As mentioned earlier, if you enter both sets of timing values, the simulation can automatically calculate **Lifter Acceleration** (select ***Auto Calculate*** from the **Lifter Acceleration** menu). The calculated lifter acceleration, combined with Seat-To-Seat ***Primary*** timing points (always use Seat-To-Seat for the Primary method when this data is available), allows the DynoSim to most accurately model valve motion. This will produce the most accurate predicted power and torque for the simulated engine.

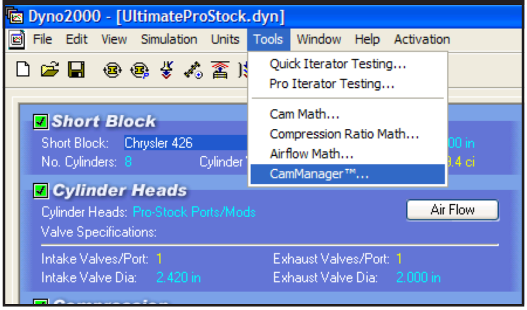
CAMSHAFT ADVANCE/RETARD MENU

The DynoSim allows direct entry of a camshaft advance or retard value. Changing this specification from zero (the default) to a positive value advances the cam (in crank degrees) while negative values retard the cam. The *Advance/Retard* function “shifts” all the intake and exhaust lobes the same advanced or retarded amount relative to the crankshaft. Why is this done? It is just about the only valve-timing change available to the engine builder after the camshaft has been purchased. While it’s possible to “tune” the cam using offset keys, special bushings, or multi-indexed sprockets, let’s investigate what happens when all the valve events are advanced or retarded from the cam manufacturer’s recommended timing.

It is generally accepted that advancing the cam improves low-speed power while retarding the cam improves high-speed power. When the cam is advanced, IVC and EVC occur earlier and that tends to improve low-speed performance; however, EVO and IVO also occur earlier, and these changes tend to improve power at higher engine speeds. The net result of these conflicting changes is a slight boost in low-speed

Using The *CamManager*™

Opening The *CamManager*



Dyno2000 - [UltimateProStock.dyn]

☑ Short Block

Short Block: Chrysler 426

No. Cylinders: 8

☑ Cylinder Heads

Cylinder Heads: Pro-Stock Ports/Mods

Valve Specifications:

Intake Valves/Port: 1

Intake Valve Dia: 2.420 in

Exhaust Valves/Port: 1

Exhaust Valve Dia: 2.000 in

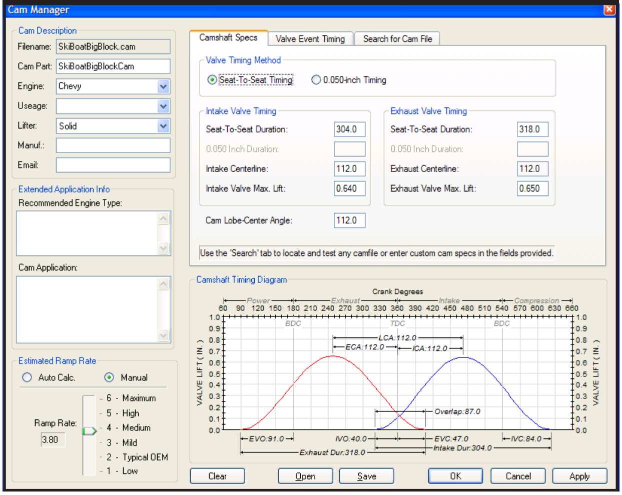
Open the *CamManager* from the Tools drop-down menu. This tool will help you understand, analyze, create, and modify camshafts for any engine application.

power. The same goes for retarding the cam. Two events (later IVC and EVC) boost high-speed power and two (later EVO and IVO) boost low-speed performance. The net result is a slight boost in high-speed power.

Advancing or retarding a camshaft has the overall affect of reducing valve-timing efficiency in exchange for slight gains in low- or high-speed power. Consequently, most cam grinders recommend avoiding this tuning technique. If advancing or retarding allows the engine to perform better in a specific rpm range, the cam profile was probably not optimum in the first place. More power can be found at both ends of the rpm range by installing the right cam rather than advancing or retarding the wrong cam. However, if you already own a specific camshaft, slightly advanced or retarded timing may "fine tune" engine output to better suit your needs.

Using The CamManager™

The *CamManager*™



Cam Manager

Cam Description

Filename: SkiBoatBigBlock.cam

Cam Part: SkiBoatBigBlockCam

Engine: Chevy

Useage:

Lifter: Solid

Manuf.:

Email:

Extended Application Info

Recommended Engine Type:

Cam Application:

Estimated Ramp Rate

○ Auto Calc. ● Manual

Ramp Rate: 3.80

Camshaft Specs

Valve Timing Method

● Seat-To-Seat Timing ○ 0.050-inch Timing

Intake Valve Timing

Seat-To-Seat Duration: 304.0

0.050 Inch Duration:

Intake Centerline: 112.0

Intake Valve Max. Lift: 0.640

Exhaust Valve Timing

Seat-To-Seat Duration: 318.0

0.050 Inch Duration:

Exhaust Centerline: 112.0

Exhaust Valve Max. Lift: 0.650

Cam Lobe-Center Angle: 112.0

Use the 'Search' tab to locate and test any camfile or enter custom cam specs in the fields provided.

The new *CamManager*™ is a powerful "mini-application" built into the DynoSim. This comprehensive cam-analysis tool offers complete control and visualization of all cam timing specifications. Use this tool to convert published cam-timing specs (like duration) to valve-events (like IVO, IVC, etc.). Enter and modify any cam-related information or technical specifications. Select the Primary timing method. And use the powerful search features to locate a "real-world" camshaft that matches any range of timing values.

Using The *CamManager™*

The DynoSim incorporates a powerful, new tool: ***The CamManager™***. This feature, available by clicking on the ***CamManager*** button in the **CAMSHAFT** category (or selecting ***CamManager*** from the **Tools** menu) will help you understand, analyze, create, and modify camshafts for any engine application. The *CamManager* is also the "central clearing house" through which you can load, save, and search for *CamFiles™* (camshaft data files ending in **.CAM** specifically designed for the DynoSim). Before we present a detail look into the capabilities of the *CamManager*, here is a quick overview of how to use the main features of this cam-analysis tool:

—Loading CamFiles: Open the *CamManager*, click on the ***Open*** button at the bottom of the dialog box, locate the **CamFile (.CAM)** folder (or one of its subfolders) and select the CamFile you wish to test. Press the ***Apply*** or ***OK*** button to load the CamFile into the **CAMSHAFT** Category and update the simulation with the new cam specs.

—Saving CamFiles: Open the *CamManager*, click on the ***Save*** button at the bottom of the dialog box, locate the **CamFile (.CAM)** folder (or one of its subfolders) and save the current CamFile to your hard drive.

Important Note: If you enter or change any cam specifications within the *CamManager* after saving or retrieving CamFiles, the *CamFile* ***data*** *will automatically be saved with the engine (.DYN) file* when you click on the ***Apply*** or ***OK*** buttons. However, the *CamFile itself will not be updated* unless you click on ***Save*** and update the CamFile on your hard disk.

—Entering or Modifying "Published" Cam Specifications: Open the *CamManager*, if necessary, click on the ***Camshaft Specs*** tab (top of screen), chose the ***Primary*** valve timing method by selecting either the ***Seat-To-Seat*** or the ***0.050-inch Timing*** radio button, enter or change any displayed ***Valve-Timing*** specifications. Press the ***Apply*** or ***OK*** button to load the new/modified cam specifications into the **CAMSHAFT** Category and update the simulation.

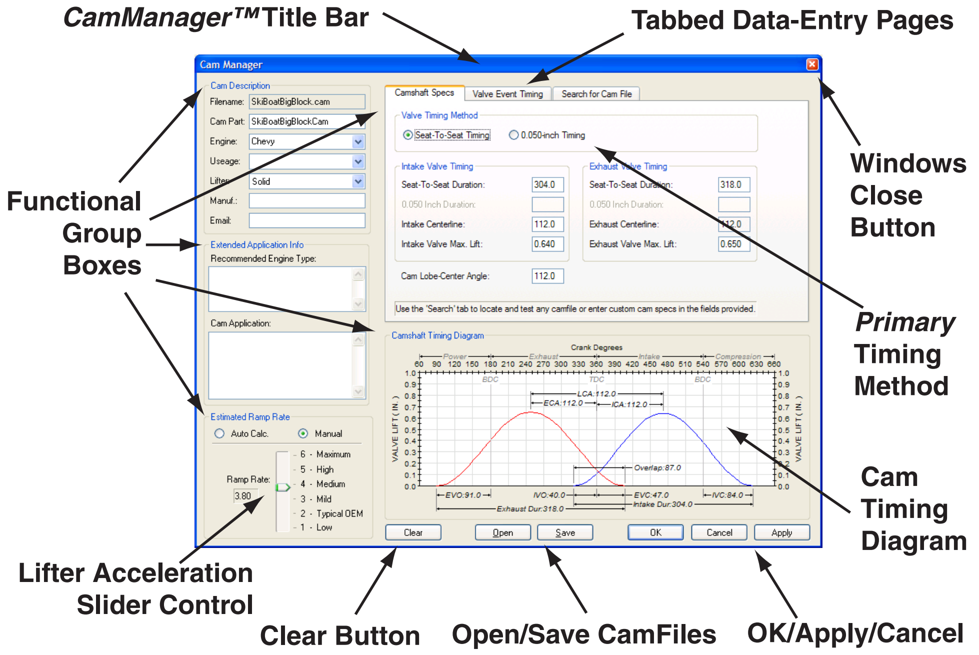
—Entering or Modifying Valve-Timing Events: Open the *CamManager*, if necessary, click on the ***Valve Event Timing*** tab (top of screen), chose the *Primary* valve timing method by selecting either the ***Seat-To-Seat*** or the ***0.050-inch Timing*** radio button, enter or change any displayed ***Valve-Event Timing*** specifications. Press the ***Apply*** or ***OK*** button to load the new/modified cam specifications into the **CAMSHAFT** Category and update the simulation.

Important Note: If you enter or change any cam specifications within the *CamManager*, the *CamFile* ***data*** *will automatically be saved with the engine (.DYN) file* when you click on the ***Apply*** or ***OK*** buttons. However, the *CamFile itself will not be updated* unless you click on ***Save*** and update the CamFile on your hard disk.

—Searching For CamFiles: Open the *CamManager*, if necessary, click on the ***Search For CamFile*** tab (top of screen), enter search terms if you would like to search for a specific filename or cam description, if you wish to locate cams that closely match the current valve timing leave the "***Find the following specs***" box checked, then press the ***Search*** button. Select a cam from the results list. Press

Using The *CamManager*™

The *CamManager*™ Features And Functional Groups



Cam Description
Filename: SkiBoatBigBlock.cam
Cam Part: SkiBoatBigBlockCam
Engine: Chevy
Useage:
Lifter: Solid
Manuf.:
Email:

Extended Application Info
Recommended Engine Type:
Cam Application:

Estimated Ramp Rate
○ Auto Calc. ● Manual
Ramp Rate: 3.80
6 - Maximum
5 - High
4 - Medium
3 - Mild
2 - Typical OEM
1 - Low

Valve Timing Method
● Seat-To-Seat Timing ○ 0.050-inch Timing

Intake Valve Timing
Seat-To-Seat Duration: 304.0
0.050 Inch Duration:
Intake Centerline: 112.0
Intake Valve Max. Lift: 0.640

Exhaust Valve Timing
Seat-To-Seat Duration: 318.0
0.050 Inch Duration:
Exhaust Centerline: 112.0
Exhaust Valve Max. Lift: 0.650

Cam Lobe-Center Angle: 112.0

Use the 'Search' tab to locate and test any camfile or enter custom cam specs in the fields provided.

The *CamManager*™ incorporates a wide range of functionality that has never been available to the performance enthusiast as one integrated package. Great care was used in the design to make this tool as intuitive and easy-to-use as possible. To this end, the *CamManager* is divided into functional "groups"; each group is displayed within a titled box or on a "tabbed" page.

the ***Apply*** or ***OK*** button to load the new CamFile into the **CAMSHAFT** Category and update the simulation.

The *CamManager*™ In Detail

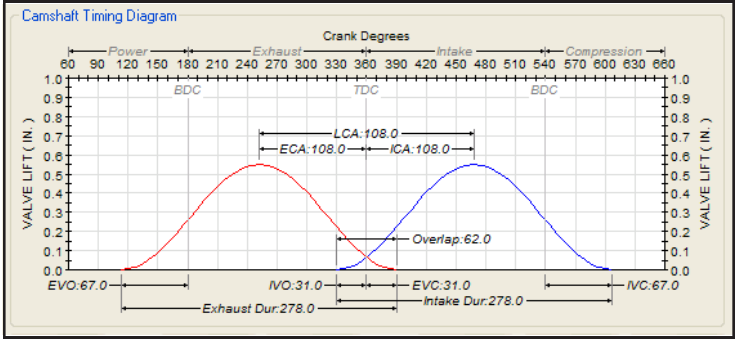
The *CamManager* incorporates a wide range of functionality that has never been available to the performance enthusiast in one integrated package. In fact, the *CamManager* alone consists of more programming code than the entire first version of this engine simulation (DeskTop Dyno released in 1984). Great care was used in the design of this feature to make it as intuitive and easy-to-use as possible. To optimize usability, the *CamManager* is divided into functional "groups"; each group is displayed within a titled box or on a "tabbed" page. For example, when the *CamManager* is first opened (by clicking on the *CamManager* button in the CAMSHAFT category, or by selecting *CamManager* from the Tools menu, or by clicking on the *CamManager Icon* in the Toolbar), you will see the ***Cam Description*** group in the upper-left corner of the dialog box. Below that are the ***Extended Application Info*** and ***Estimated Lifter Acceleration*** groups. There are three ***Tabs*** available in the top-center of the dialog box that access the ***Camshaft Specs***, ***Valve-Event Timing***, and ***Search For CamFiles*** pages. In the lower portion of the dialog is the ***Camshaft Timing Diagram***. This dynamic graphic shows all critical valve-timing specifications and is updated immediately when any timing specification is changed. Each group within the *CamManager* has a distinct function that is detailed below:

Cam Description Group (upper-left corner)—Basic information about the current cam is displayed in this group. The ***Filename*** field contains the name of the displayed CamFile, if saved on your hard disk, the ***Cam Name*** is a short description, the ***Engine*** field indicates the engine family for which the camshaft was designed, the ***Usage*** field indicates the intended application, the ***Lifter*** field displays the lifter technology used with this cam, the ***Manufacturer*** field shows the manufacturer/designer of the cam, and the ***Email/Web*** field provides a contact address. The ***Engine***, ***Usage***, and ***Lifter*** fields have suggested entries available in drop-down menus. And although you can enter any data into the fields in this group (except for the Lifter field), we recommend that you select choices from the drop-down menus whenever possible. This will help maintain consistency that will improve the accuracy of CamFile searches in the future.

Extended Application Info (left-center of screen)—A more detailed description of the intended usage and the operational characteristics of the cam and engine are provided in this group. The ***Recommended Engine Type*** field lists the specific engines for which the cam was designed. The ***Cam Application*** field contains detailed descriptions of cam specs, operation, requirements, and characteristics. The information in this group has often been obtained from cam manufacturer's catalog listings. You can edit, modify, or add information to both of these fields.

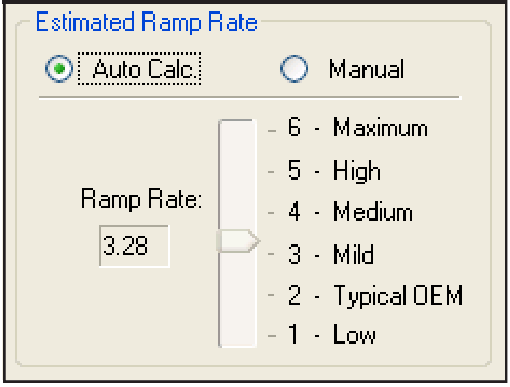
Camshaft Timing Diagram (lower-right on screen)—This graph, often called a

"Twin-Hump" Valve Timing Diagram



The "Twin-Hump" valve motion diagram in the CamManager is dynamically updated whenever any timing specification is changed, even *Lifter Acceleration* (see text).

Estimated Lifter Acceleration



Estimated Ramp Rate

● Auto Calc ○ Manual

Ramp Rate: 3.28

If the DynoSim has sufficient data (all ten timing points, as mentioned in text), it will calculate and display the Lifter Acceleration (the *Auto Calc* radio button will be selected). You can disable automatic calculation by activating the *Manual* radio button. Then move the slider to any desired value. Changes in acceleration will be reflected in the valve-motion curves.

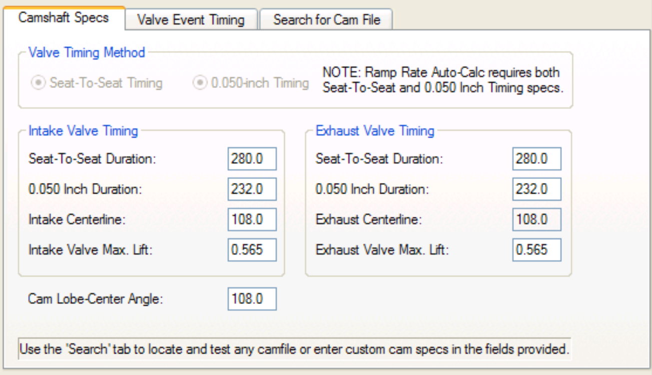
two-hump diagram, shows valve position throughout the 720 degrees of crank rotation (Note: The 120-degrees of crank rotation during which the intake and exhaust valves are closed is not illustrated). Exhaust valve motion is shown on the left in red; the intake valve motion is in blue on the right. The valve timing points (IVO, IVC, EVO, and EVC), overlap, duration, centerlines, and lobe-center angle are all detailed on the graph. In addition, maximum valve lift is illustrated by the height of the curves. This dynamic graphic is updated immediately when any timing specification is changed, even *Lifter Acceleration*. To see the effects of changing *Lifter Acceleration*, click on the ***Manual*** button in the *Estimated Lifter Acceleration* group and move the ***Slider*** up and down. You will see the curves get "fatter" for higher acceleration valves and "thinner" for low acceleration.

Estimated Lifter Acceleration (lower-left of screen)—As discussed earlier, the DynoSim can estimate Lifter (valve) acceleration. The acceleration is used to determine the "shape" of the valve-motion curve. The greater the acceleration, the larger the area under the curve and the higher average valve lift throughout the valve-motion cycle. However, in order to calculate Lifter Acceleration, the DynoSim needs both the *Seat-To-Seat* and *0.050-inch Valve-Event Timing* points, in addition to the maximum valve lift for both the intake and exhaust valves. If both data sets are available, the ***Auto Calc*** radio button can be activated and ***Lifter Acceleration*** will be calculated and displayed. If the DynoSim does not have sufficient data, an error dialog will indicate the discrepancy. Regardless, you can click on the ***Manual*** radio button and directly select the Acceleration by dragging the ***Slider*** to the desired point. The results of changing the acceleration, as mentioned above, will be visible in the changing shape of the curves displayed in the **Camshaft Timing Diagram**.

Tabbed Data Pages (upper-right portion of screen)—Three data entry- and display-pages are available as tabbed screens at the top of the *CamManager*.

Using The *CamManager*™

Camshaft Specs "Tabbed" Data Page



Valve Timing Method
● Seat-To-Seat Timing ● 0.050-inch Timing
NOTE: Ramp Rate Auto-Calc requires both Seat-To-Seat and 0.050 Inch Timing specs.

Intake Valve Timing		Exhaust Valve Timing	
Seat-To-Seat Duration:	280.0	Seat-To-Seat Duration:	280.0
0.050 Inch Duration:	232.0	0.050 Inch Duration:	232.0
Intake Centerline:	108.0	Exhaust Centerline:	108.0
Intake Valve Max. Lift:	0.565	Exhaust Valve Max. Lift:	0.565

Cam Lobe-Center Angle: 108.0

Use the 'Search' tab to locate and test any camfile or enter custom cam specs in the fields provided.

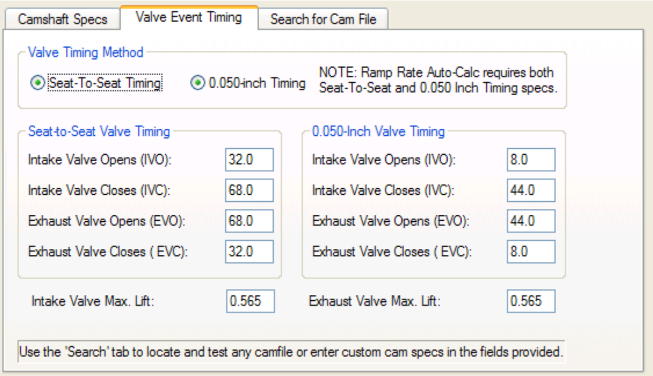
This page, displayed by default whenever the *CamManager* is opened, shows seat-to-seat and 0.050-inch "published" cam specifications found in many manufacturer's catalogs. Included are *Duration, Centerline, Overlap*, and *Valve Lift* values. Data entered on this page will update the *Valve-Event Timing* (next) tabbed page.

Camshaft Specs* Tabbed Page**—The first tabbed page, displayed as default whenever the *CamManager* is opened, shows the typical "published" cam specs found in manufacturer's catalogs. Included are ***Centerline, ***Overlap***, and ***Valve Lift*** values. If you enter this data (except *Overlap*, which is calculated), and <u>either</u> the seat-to-seat or 0.050-inch ***Duration*** values for both the intake and exhaust valves, the DynoSim will calculate the valve-event timing (IVO, IVC, EVO, EVO, etc., displayed on the *Valve-Event Timing* tabbed page). If you enter <u>both</u> seat-to-seat and 0.050-inch ***Duration*** values (completing all data fields on this tabbed page), the DynoSim will calculate ***Lifter Acceleration*** in addition to valve-event timing (***Auto Calc*** must be selected in the *Estimated Lifter Acceleration* group).

Valve-Event Timing* Tabbed Page**—The second tabbed page shows the valve-event timing for both seat-to-seat and 0.050-inch timing methods. Included are ***IVO**, **IVC**, **EVO**, and **EVC; in addition ***Maximum Valve Lifts*** are also displayed for convenience. If you enter this data for seat-to-seat and/or 0.050-inch timing values, the DynoSim will calculate the Camshaft Specs (displayed on the

This data-entry page shows valve-event timing for both the seat-to-seat and 0.050-inch methods. Displayed are *IVO, IVC, EVO, and EVC*; in addition *Maximum Valve Lifts* are also displayed. When data is entered on this page, the *CamManager* will update the *Camshaft Specs* (previous) tabbed page.

Valve-Event Timing "Tabbed" Data Page



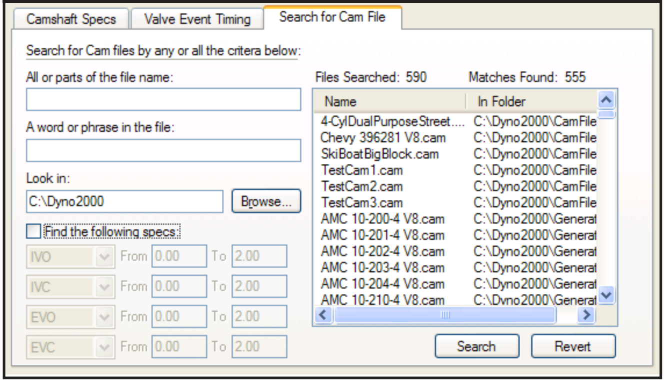
Valve Timing Method
● Seat-To-Seat Timing ● 0.050-inch Timing
NOTE: Ramp Rate Auto-Calc requires both Seat-To-Seat and 0.050 Inch Timing specs.

Seat-to-Seat Valve Timing		0.050-Inch Valve Timing	
Intake Valve Opens (IVO):	32.0	Intake Valve Opens (IVO):	8.0
Intake Valve Closes (IVC):	68.0	Intake Valve Closes (IVC):	44.0
Exhaust Valve Opens (EVO):	68.0	Exhaust Valve Opens (EVO):	44.0
Exhaust Valve Closes (EVC):	32.0	Exhaust Valve Closes (EVC):	8.0

Intake Valve Max. Lift: 0.565 Exhaust Valve Max. Lift: 0.565

Use the 'Search' tab to locate and test any camfile or enter custom cam specs in the fields provided.

Search For CamFiles “Tabbed” Data Page



Search for Cam files by any or all the critera below:

All or parts of the file name:

A word or phrase in the file:

Look in: C:\Dyno2000

☐ Find the following specs

IVO From 0.00 To 2.00
IVC From 0.00 To 2.00
EVO From 0.00 To 2.00
EVC From 0.00 To 2.00

Files Searched: 590 Matches Found: 555

Name	In Folder
4-CylDualPurposeStreet....	C:\Dyno2000\CamFile
Chevy 396281 V8.cam	C:\Dyno2000\CamFile
SkiBoatBigBlock.cam	C:\Dyno2000\CamFile
TestCam1.cam	C:\Dyno2000\CamFile
TestCam2.cam	C:\Dyno2000\CamFile
TestCam3.cam	C:\Dyno2000\CamFile
AMC 10-200-4 V8.cam	C:\Dyno2000\Generat
AMC 10-201-4 V8.cam	C:\Dyno2000\Generat
AMC 10-202-4 V8.cam	C:\Dyno2000\Generat
AMC 10-203-4 V8.cam	C:\Dyno2000\Generat
AMC 10-204-4 V8.cam	C:\Dyno2000\Generat
AMC 10-210-4 V8.cam	C:\Dyno2000\Generat

The *Search For CamFiles* data page provides unprecedented power in locating CamFiles for your test engine. Search through thousands of CamFiles and locate only those that meet your criterion. A powerful feature allows you to find “real-world” cams that match or nearly-match any custom timing you may have discovered using the DynoSim *Iterator*™!

previous *Camshaft Specs* tabbed page). If you enter _both_ seat-to-seat and 0.050-inch valve timing values (completing all the data fields on this tabbed page), the DynoSim also will be able to calculate ***Lifter Acceleration*** (***Auto Calc*** must be selected in the *Estimated Lifter Acceleration* group).

Primary Timing Method Selection—As discussed earlier (see pages 83 to 86), the ***Primary*** timing method establishes how the simulation determines valve opening and closing points. You an select the ***Primary*** method from within the *CamManager* on either the *CamShaft Specs* or *Valve-Event Timing* Tabbed Pages (duplicates function of selecting ***Valve Opening/Closing Based On*** in the CAM-SHAFT component category). Using ***Seat-To-Seat Timing*** as ***Primary*** valve event timing directly establishes the valve opening and closing points. This is the most reliable and accurate way to determine valve-event timing for engine simulation purposes. Using ***0.050-inch Timing*** as ***Primary*** event timing forces the simulation to perform *approximations*. Only use this method when *Seat-To-Seat* timing values are not available.

Note: Using ***0.050-inch Timing*** as ***Primary*** event timing forces the DynoSim to “guess” seat-to-seat timing from 0.050-inch values. This method is less accurate. Whenever possible, use *Seat-To-Seat cam timing* specifications as the ***Primary*** timing method to obtain the most accurate simulation results.

Search For CamFiles Tabbed Page—The third tabbed data page provides unprecedented versatility in locating CamFiles for your test engine. Search through thousands of CamFiles and locate only those that meet any criterion you establish. For example, find all the Bracket-Racing cams designed for a Smallblock Chevy, or locate all cams that closely match the specifications discovered in an ***Iterator***™ test series (more on the *Iterator* on pages 103 and 106). To use this powerful tool, first (this step is optional) enter any search terms into the ***Criteria*** fields if you would like to search for specific filenames or cam descriptions. Next, if you would like to locate CamFiles that fall within a range of timing values

centered around the current camshaft timing (the current cam is the cam currently installed in the simulated engine); if so, check the ***Find The Following Specs*** checkbox. Finally, click the ***Search*** button to locate all CamFiles starting in the folder listed in the ***Look In*** field *and in any folders that are nested below that folder* (a full *recursive* search is performed). When a list of matching CamFiles is presented, simply click on any file to view its characteristics (you may use the up-and-down arrow keys to quickly move through the results list). Transfer any CamFile into the **CAMSHAFT** component category on the *Main Program Screen* and into the simulated engine by clicking ***Apply*** ("installs" the cam and leaves the *CamManager* open) or ***OK*** ("installs" the cam and quits the *CamManager)*.
Note: If you would like to extend the search capabilities of the CamManager, the ***CamDisk3***™ will add more than 3500 CamFiles to those supplied with the DynoSim (***CamDisk3*** is an optional data resource CD available from ProRacing Sim, LLC., see page 81 for information on optional program features).

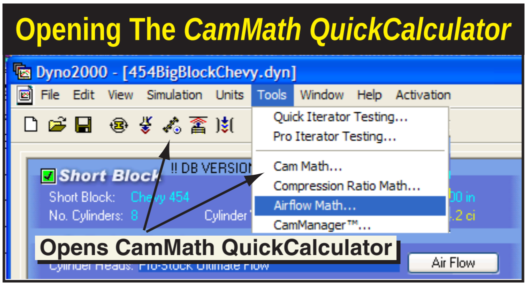
Important Note: If you change any cam specification within the *CamManager* after saving or retrieving CamFiles, the *CamFile **data** will automatically be saved with the engine (.DYN) file* when you click on the ***Apply*** or ***OK*** buttons. However, the *CamFile itself will not be automatically updated* unless you click on ***Save*** and update the CamFile on your hard disk.

The *CamMath QuickCalculator*™

As discussed previously, the basic four valve events (IVO, IVC, EVO, EVC) are required for the DynoSim to pinpoint when the intake and exhaust valves open and close. The IVO and EVO signal the beginning of mass flow in the intake and exhaust ports. The closing points, IVC and EVC, mark the end of mass flow. Unfortunately, many cam catalogs and other printed materials ONLY publish the lobe center angles and duration values, leaving the conversion to IVO, IVC, EVO, and EVC up to the frustrated simulation user.

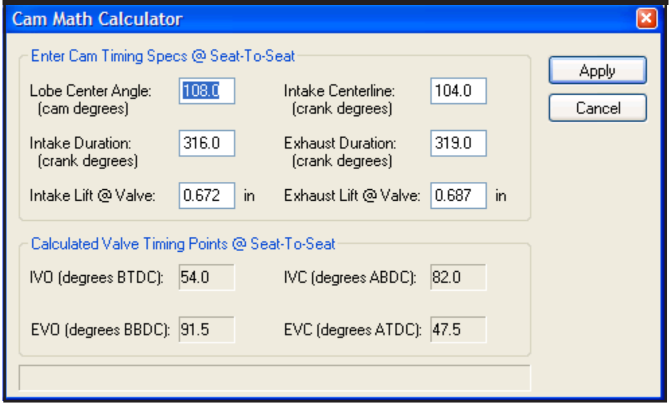
While these conversions can be accomplished in the powerful, new *CamManager*, the DynoSim has an updated version of the simple-to-use calculator called the ***CamMath QuickCalculator***™. It instantly converts the lobe-center angle, intake centerline, and the duration values into IVO, IVC, EVO, and EVC valve events. By clicking the

The *CamMath QuickCalculator* is available from the Tools menu or by clicking on the *CamMath QuickCalculator* Icon in the Toolbar.


Opening The *CamMath QuickCalculator*

The *CamMath QuickCalculator*™

Cam Math QuickCalculator



Enter Cam Timing Specs @ Seat-To-Seat
Lobe Center Angle: (cam degrees) 108.0
Intake Centerline: (crank degrees) 104.0
Intake Duration: (crank degrees) 316.0
Exhaust Duration: (crank degrees) 319.0
Intake Lift @ Valve: 0.672 in
Exhaust Lift @ Valve: 0.687 in

Calculated Valve Timing Points @ Seat-To-Seat
IVO (degrees BTDC): 54.0
IVC (degrees ABDC): 82.0
EVO (degrees BBDC): 91.5
EVC (degrees ATDC): 47.5

The *CamMath QuickCalculator* allows direct entry and conversion of cam data, as found in many cam manufacturer's catalogs. It simplifies changing lobe-center angle, intake centerline, intake and exhaust duration, into valve-event timing.

Apply button, the new event-timing values can be loaded into the **CAMSHAFT** Category and used in the simulation.

Note: In order for the ***CamMath QuickCalculator*** to determine all four valve events, BOTH the lobe-center angle AND the intake centerline must be available. Without the intake centerline, there is no way to determine how the cam is "timed" or "indexed" to the crankshaft. Many, unfortunately not all, cam manufacturer catalogs provide sufficient information to use the ***CamMath QuickCalculator*** to determine valve event timing. If you have a catalog that does not provide this information, try another cam manufacturer, or consider purchasing the ***CamDisk3*** from ProRacing Sim Software that provides over 3500 read-to-use CamFiles for the DynoSim (see page 81).

Open the ***CamMath QuickCalculator*** by selecting **CamMath** from the **TOOLS** drop-down menu or by clicking on the ***CamMath QuickCalculator Icon*** in the **Toolbar**. Next, select the cam-timing method by clicking on the appropriate radio button in the ***Valve Timing Method For Calculations*** group, located at the top of the calculator screen. This selection will establish how the timing points are calculated and (optionally) applied to the simulated engine.

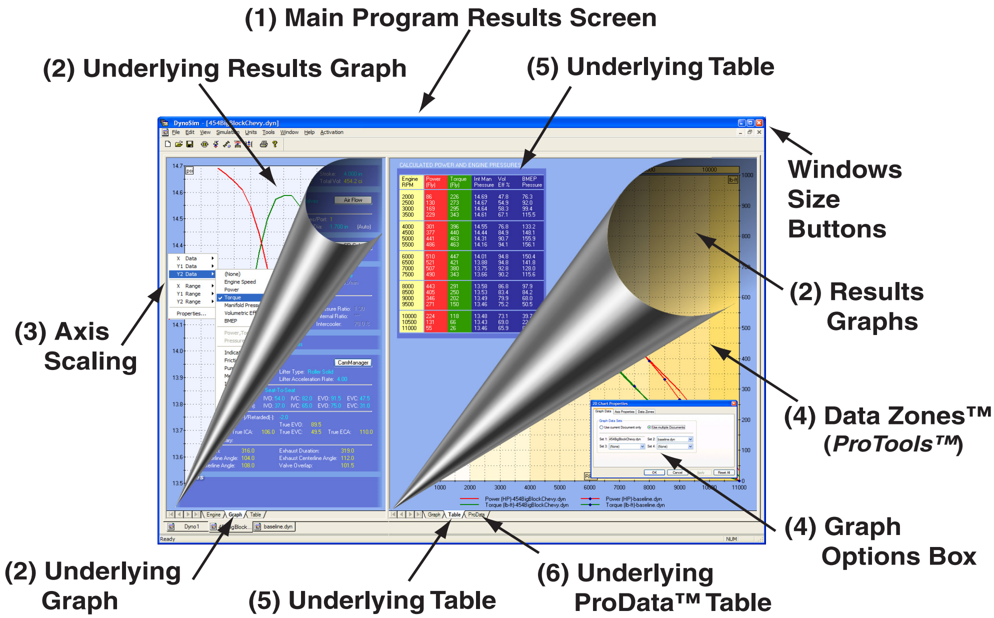
Important Note: The selection of cam timing in the ***CamMath QuickCalculator*** only applies to calculations within the calculator. It does not change the ***Primary*** method for determining valve opening/closing points used in the simulation. The ***Primary*** timing method is selected in the **CAMSHAFT** Category and in the *CamManager*.

If IVO, IVC, EVO and EVC cam timing values were already entered in the **CAMSHAFT** Category, the ***CamMath QuickCalculator*** will display the lobe-center angle, intake centerline, and duration values for the current cam and accept any changes you would like to make. On the other hand, if you have not yet entered camshaft timing, the ***CamMath QuickCalculator*** will display blank fields, and allow the input of centerline, duration, and valve-lift specs. As you fill in the fields, the corresponding IVO, IVC, EVO and EVC points will be calculated and displayed. You may then either accept the calculated values and transfer them to the **CAMSHAFT** Category by clicking the ***Apply*** button or discard the new values and close the ***CamMath QuickCalculator*** by clicking ***Close***.

DynoSim Racing Software

Advanced Engine Simulation

SIMULATION RESULTS



CALCULATED POWER AND ENGINE PRESSURES

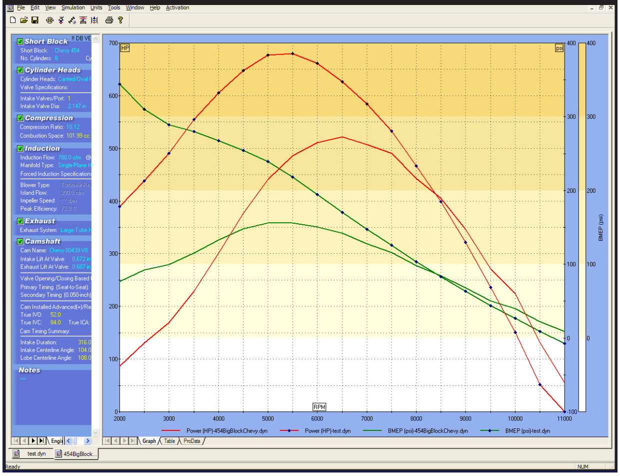
Engine RPM	Power (Fly)	Torque (Fly)	Int Man Pressure	Vol Eff %	BMEP Pressure
2000	86	226	14.69	47.8	76.3
2500	130	273	14.67	54.9	92.0
3000	169	295	14.64	58.3	99.4
3500	229	343	14.61	67.1	115.5
4000	301	396	14.55	76.8	133.2
4500	377	440	14.44	84.9	148.1
5000	441	463	14.31	90.7	155.9
5500	486	463	14.16	94.1	156.1
6000	510	447	14.01	94.8	150.4
6500	521	421	13.88	94.8	141.8
7000	507	380	13.75	92.8	128.0
7500	490	343	13.66	90.2	115.6
8000	443	291	13.58	86.8	97.9
8500	405	250	13.53	83.4	84.2
9000	346	202	13.49	79.9	68.0
9500	271	150	13.46	75.2	50.5
10000	224	118	13.48	73.1	39.7
10500	131	66	13.43	69.0	22
11000	55	26	13.46	65.9	

The speed and ease of engine component entry in the DynoSim is complemented by the power and versatility of the simulation results displays. Almost the same instant that the component categories have been completed (all categories showing green Status Boxes) the simulation results will be displayed on fully-scalable precision graphs. The display graphs can be customized to display virtually any engine variable on any axis. Auto scaling or manual axis scaling are easily established by right-clicking the graph to display the *Graph Options Menu*. Right click on the graph and select ***Properties*** to setup side-by-side comparisons of up to four engines. And comprehensive “table” displays show exact horsepower, torque, rpm, induction pressure, cylinder pressure, engine friction, and more! The DynoSim will show you the results you are looking for, fast!

The **Simulation Results** display is composed of several elements that will help you retrieve the most information from any simulation as quickly and easily as possible:

Simulation Results Displays

Moveable Vertical Screen Divider



☑ **Short Block** !! DB VE
Short Block: Chevy 454
No. Cylinders: 8

☑ **Cylinder Heads**
Cylinder Heads: Canted/Oval P
Valve Specifications:
Intake Valves/Port: 1
Intake Valve Dia: 2.147 in

☑ **Compression**
Compression Ratio: 10.12
Combustion Space: 101.99 cc

☑ **Induction**
Induction Flow: 780.0 cfm @
Manifold Type: Single-Plane H
Forced Induction Specifications
Blower Type: Turbo-Air Res
Island Flow: 300.0 cfm
Impeller Speed: *** rpm
Peak Efficiency: 72.0 %

☑ **Exhaust**
Exhaust System: Large-Tube H

☑ **Camshaft**
Cam Name: Chevy 00439 V8
Intake Lift At Valve: 0.672 in
Exhaust Lift At Valve: 0.687 in
Valve Opening/Closing Based
Primary Timing (Seat-to-Seat):
Secondary Timing (0.050-inch)
Cam Installed Advanced(+)/Re
True IVO: 52.0
True IVC: 84.0 True ICA:
Cam Timing Summary:
Intake Duration: 316.0
Intake Centerline Angle: 104.0
Lobe Centerline Angle: 108.0

Notes
***

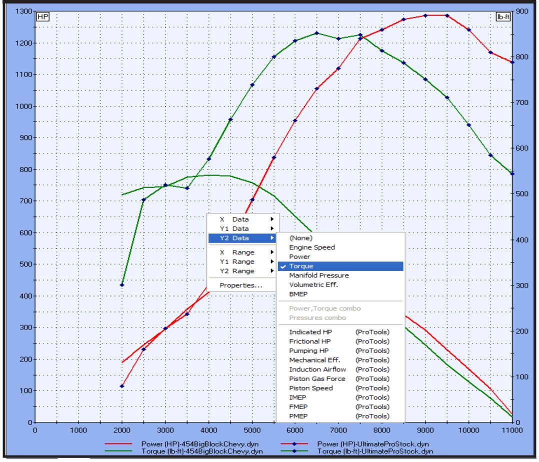
Power (HP)-454BigBlockChevy.dyn
Power (HP)-test.dyn
BMEP (psi)-454BigBlockChevy.dyn
BMEP (psi)-test.dyn

The screen divider can be moved to allow the graph more display area. Drag it all the way to the left screen margin to display graph data "full screen."

1) The *Main Program Screen* is divided into two sections (called panes), with the component selection categories on the left and the main results display on the right (by default). The center divider between each pane can be moved (click and drag) to resize the results screen to suit your requirements. The graph will redraw and rescale to take advantage of changes in display area.

2) The results graph consists of three axis, a left vertical, right vertical, and bottom horizontal axis. Each of these axis can be assigned an engine variable. The DynoSim will graph the following variables: Rpm, Horsepower, Torque, Intake

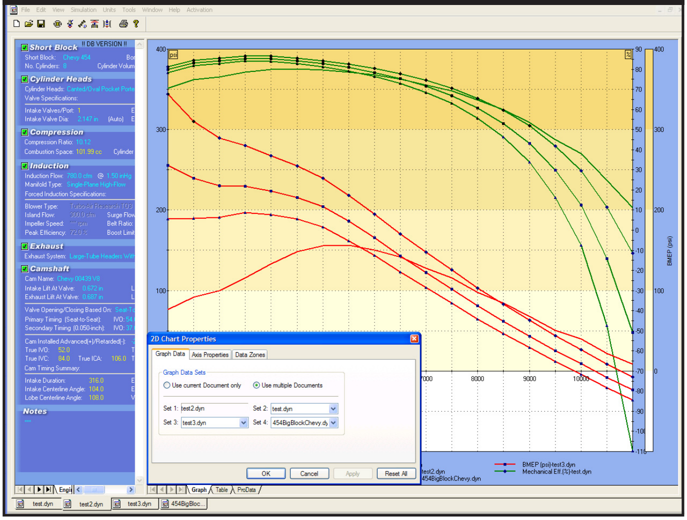
Three-Axis Graphs



The results graph consists of three axis, a left vertical, right vertical, and bottom horizontal axis. Each of these axis can be assigned an engine variable. Right click on the graph to display the *Graph Options Menu* to assign any engine variable to any of the three graph axis.

Simulation Results Displays

Compare Up To Four "Open" Engines



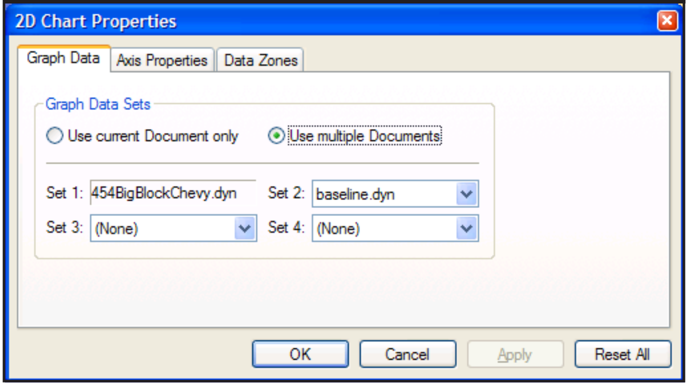
Graph Data Sets
○ Use current Document only ● Use multiple Documents
Set 1: test2.dyn
Set 2: test.dyn
Set 3: test3.dyn
Set 4: 454BigBlockChevy.dy

A comparison of four engines was setup using the Properties Box. Up to four "open" engines can be compared on any graph. This graph shows how horsepower (red) and volumetric efficiency varied for all four test engines.

Manifold Pressure, Volumetric Efficiency, Imep (Indicated Mean Effective Pressure), Bmep (Brake Mean Effective Pressure), and Fmep (Friction Mean Effective Pressure). Right click on the graph to display the *Graph Options Menu* to assign engine variables to graph axis.

3) The results graph supports several methods of axis scaling. Each axis will scale to a low, medium, and high value. Plus auto-scaling can be enabled for any axis. By default, auto-scaling is turned off. This maintains the axis values constant, establishing a fixed baseline so that changes in power or torque are easily distinguished. However, when component changes dramatically alter power (like nitrous-oxide injection or forced induction), the auto-scaling feature will ensure

Graph Properties—*Graph Data*

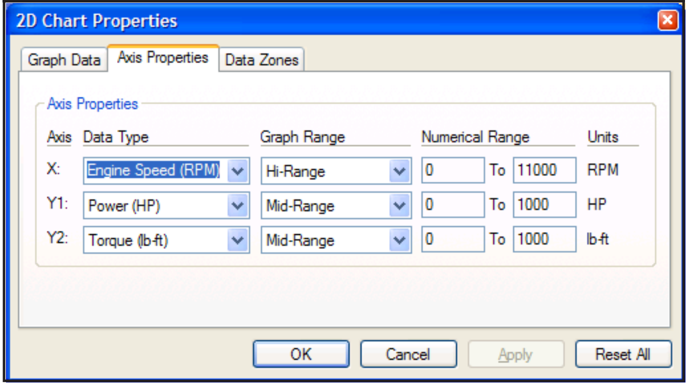


Graph Data Sets
○ Use current Document only ● Use multiple Documents
Set 1: 454BigBlockChevy.dyn
Set 2: baseline.dyn
Set 3: (None)
Set 4: (None)

Use the *Graph Data Properties* dialog box to establish on-graph comparison of up to four engines. Select the comparison engines from the *Graph Data Sets* drop-down menus.

Simulation Results Displays

Graph Properties—*Axis Properties*



Axis Properties

Axis	Data Type	Graph Range	Numerical Range			Units
X:	Engine Speed (RPM)	Hi-Range	0	To	11000	RPM
Y1:	Power (HP)	Mid-Range	0	To	1000	HP
Y2:	Torque (lb-ft)	Mid-Range	0	To	1000	lb-ft

The *Axis Properties* dialog box displays the current *Data Type*, *Graph Range*, and *Numerical Range* for the current graph. Change the characteristics of the display by modifying these properties. (*Numerical Range* modification is a *ProTool*-only feature)

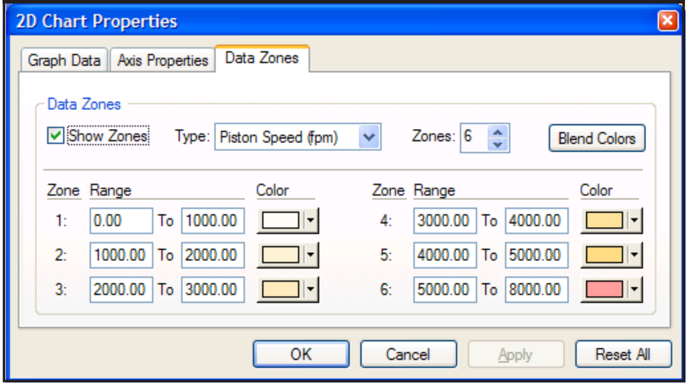
that the data curves are always visible and display at 80 to 90% of full graph height for maximum resolution.

4) Right click on the graph to open the *Graph Options Menu*, then select ***Properties***. This will open a dialog box that has allows three tabbed data pages:

Graph Data—Use the Graph Data Sets page to establish on-graph comparison of up to four engines at once. The engines you wish to include in the comparison must be “open” with active tabs in the *Engine Selection Tabs* at the bottom of the *Main Program Screen*. Use the *Graph Data Sets* drop-down menus to select from currently-open engines. When you click ***Apply*** or ***OK***, the graph will redraw with the desired data comparisons. A legend at the bottom of the graph provides a key to all graph curves.

Axis Properties—This page indicates the current *Data Type* and *Graph Range*, (*Numerical Range* modification is a ***ProTools***™-only feature) for the current display. Change the characteristics of the display by modifying any of the graph properties.

Graph Properties—*Data Zones* (*ProTools™*)



Data Zones

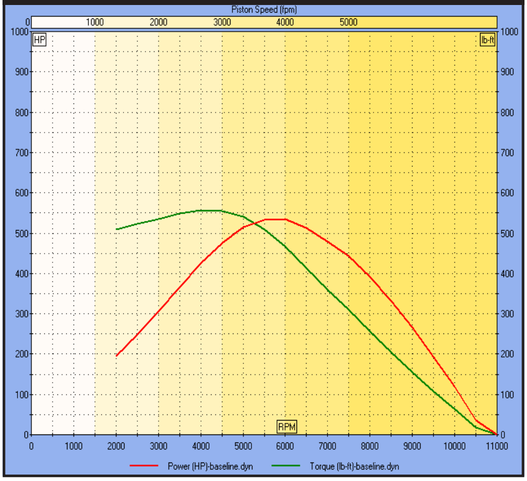
☑ Show Zones Type: Piston Speed (fpm) Zones: 6

Zone	Range			Color
1:	0.00	To	1000.00	🟨
2:	1000.00	To	2000.00	🟨
3:	2000.00	To	3000.00	🟨
4:	3000.00	To	4000.00	🟨
5:	4000.00	To	5000.00	🟨
6:	5000.00	To	8000.00	🟥

***DataZones* (*ProTools™*) extend the graphic-display and data-analysis capillarities of the DynoSim. Using this feature, you can display additional engine data, show ranges, or clearly label dangerously high pressures, engine speeds, and more.**

Simulation Results Displays

DataZones Piston-Speed Display



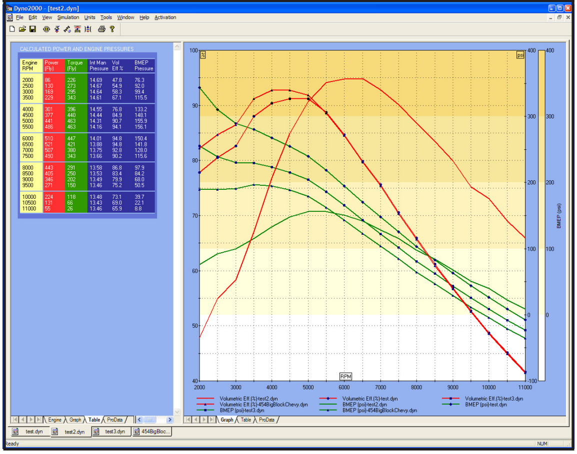
This *DataZone* display *(ProTools™)* shows Piston-Speed bands drawn on the standard HP/Torque graph. The range values are indicated at the top of the graph, and the banded area colors were blended using the *Blend Colors* feature.

Data Zones™—This ***ProTools™***-only feature displays additional data and data-ranges on the graphs (see page 121 for more information on activating optional program features). ***DataZones*** extend the graphic-display and data-analysis capabilities of the DynoSim. Using this feature, you can display additional engine data and/or show ranges for target power values or clearly label dangerously high pressures, engine speeds, and more. To setup a *DataZone* display, first select the data that you would like to display from the ***Type*** drop-down menu.

Note: *DataZone* variables must be the <u>same as</u>, or <u>directly derived from</u>, one of the variables currently displayed on the graph. For example, you can display *Piston Speed DataZones* on standard Horsepower/Torque graphs since *Piston*

In addition to 2D graphing capability, a chart display is available by clicking the *Table* tabs located at the bottom of either the left or right pane. The chart lists engine variables recorded during the simulated dyno run. The exact data values are displayed in 500rpm increments from 2000 to 11,000rpm.

Table Shows Exact Test Results

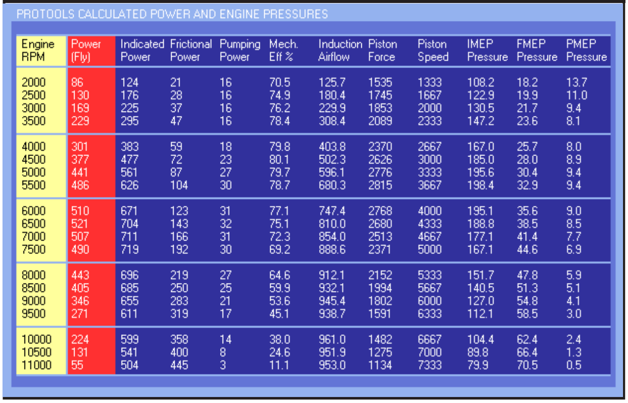


CALCULATED POWER AND ENGINE PRESSURES

Engine RPM	Power (Fly)	Torque (Fly)	Int Man Pressure	Vol Eff %	BMEP Pressure
2000	86	226	14.69	47.8	76.3
2500	130	273	14.67	54.9	92.0
3000	169	295	14.64	58.3	99.4
3500	229	343	14.61	67.1	115.5
4000	301	396	14.55	76.8	133.2
4500	377	440	14.44	84.9	148.1
5000	441	463	14.31	90.7	155.9
5500	486	463	14.16	94.1	156.1
6000	510	447	14.01	94.8	150.4
6500	521	421	13.88	94.8	141.8
7000	507	380	13.75	92.8	128.0
7500	490	343	13.66	90.2	115.6
8000	443	291	13.58	86.8	97.9
8500	405	250	13.53	83.4	84.2
9000	346	202	13.49	79.9	68.0
9500	271	150	13.46	75.2	50.5
10000	224	118	13.48	73.1	39.7
10500	131	66	13.43	69.0	22.1
11000	55	26	13.46	65.9	8.8

Simulation Results Displays

Engine-Pressures Table (*ProTools™*)



PROTOOLS CALCULATED POWER AND ENGINE PRESSURES

Engine RPM	Power (Fly)	Indicated Power	Frictional Power	Pumping Power	Mech. Eff %	Induction Airflow	Piston Force	Piston Speed	IMEP Pressure	FMEP Pressure	PMEP Pressure
2000	86	124	21	16	70.5	125.7	1535	1333	108.2	18.2	13.7
2500	130	176	28	16	74.9	180.4	1745	1667	122.9	19.9	11.0
3000	169	225	37	16	76.2	229.9	1853	2000	130.5	21.7	9.4
3500	229	295	47	16	78.4	308.4	2089	2333	147.2	23.6	8.1
4000	301	383	59	18	79.8	403.8	2370	2667	167.0	25.7	8.0
4500	377	477	72	23	80.1	502.3	2626	3000	185.0	28.0	8.9
5000	441	561	87	27	79.7	596.1	2776	3333	195.6	30.4	9.4
5500	486	626	104	30	78.7	680.3	2815	3667	198.4	32.9	9.4
6000	510	671	123	31	77.1	747.4	2768	4000	195.1	35.6	9.0
6500	521	704	143	32	75.1	810.0	2680	4333	188.8	38.5	8.5
7000	507	711	166	31	72.3	854.0	2513	4667	177.1	41.4	7.7
7500	490	719	192	30	69.2	888.6	2371	5000	167.1	44.6	6.9
8000	443	696	219	27	64.6	912.1	2152	5333	151.7	47.8	5.9
8500	405	685	250	25	59.9	932.1	1994	5667	140.5	51.3	5.1
9000	346	655	283	21	53.6	945.4	1802	6000	127.0	54.8	4.1
9500	271	611	319	17	45.1	938.7	1591	6333	112.1	58.5	3.0
10000	224	599	358	14	38.0	961.0	1482	6667	104.4	62.4	2.4
10500	131	541	400	8	24.6	951.9	1275	7000	89.8	66.4	1.3
11000	55	504	445	3	11.1	953.0	1134	7333	79.9	70.5	0.5

The *ProTools™* version of the DynoSim displays an additional *ProData™* tab at the bottom of the left and right display panes. Activating this tab will generate a detailed listing of engine pressures, piston speeds, gas forces, induction airflow, and more. In addition, engine pressures can be drawn on any of the graphs.

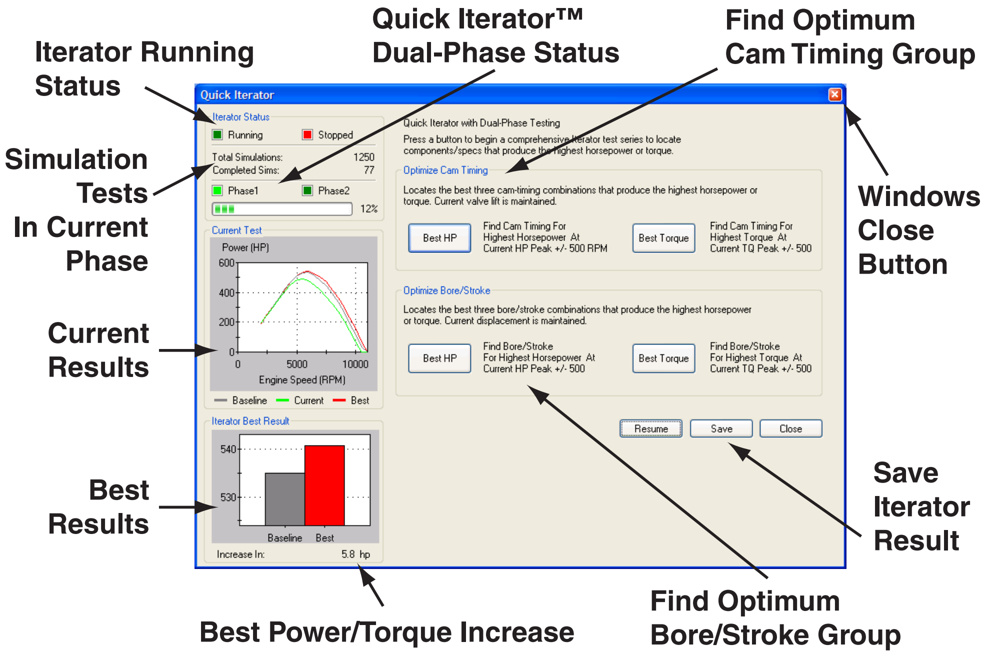
Speed is directly calculated from engine rpm (stroke is held constant), but *Manifold Pressure* cannot be displayed, since it is not *directly calculated* from engine rpm, power, or torque (the three main data sets displayed on the standard HP/Torque graph).

Next, select the number of *DataZones* you would like to display by clicking on the "up" or "down" arrows next to the ***Zones*** field. You can modify the ***Range*** values and ***Colors*** for each zone (if you set a starting and ending color, press ***Blend Colors*** to have the DynoSim build a uniform transition between these colors for intermediate zones). Click on ***Apply*** or ***OK*** to draw the specified zones on the main graphic display.

5) In addition to the graphing capability described above, a table display is available by clicking on the ***Table*** tabs located at the bottom of the left or right display pane. The chart lists all engine variables recorded during the simulated dyno run. The exact data values are displayed in 500rpm increments from 2000 to 11,000rpm.

6) If you have the ***ProTools™*** features of the DynoSim activated (see page 121 for more information on optional program features), the additional ***Pressure*** tab will be displayed at the bottom of the left and right display panes. Activating this tab will display a detailed listing of engine pressures, piston speeds, gas forces, induction airflow, and more. In addition, with ***ProTools™***, engine pressures can be drawn on any of the graphs.

QUICK ITERATOR™



Quick Iterator with Dual-Phase Testing

Press a button to begin a comprehensive iterator test series to locate components/specs that produce the highest horsepower or torque.

Locates the best three cam-timing combinations that produce the highest horsepower or torque. Current valve lift is maintained.

Find Cam Timing For Highest Horsepower At Current HP Peak +/- 500 RPM

Find Cam Timing For Highest Torque At Current TQ Peak +/- 500

Locates the best three bore/stroke combinations that produce the highest horsepower or torque. Current displacement is maintained.

Find Bore/Stroke For Highest Horsepower At Current HP Peak +/- 500

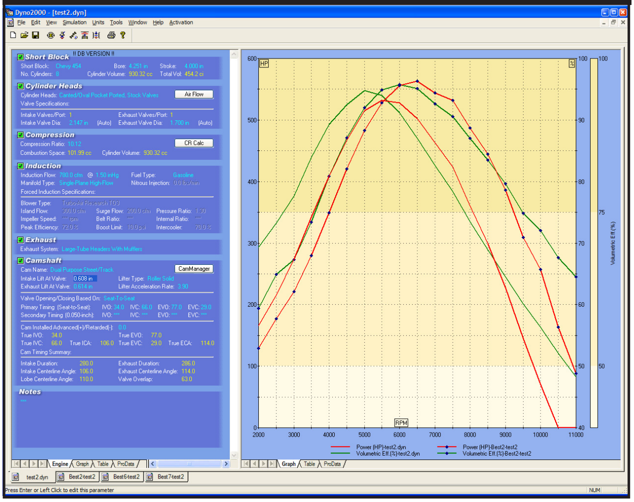
Find Bore/Stroke For Highest Torque At Current TQ Peak +/- 500

With the availability and low-cost of engine simulation software like the DynoSim, the ability to fill file cabinets with *simulated* dyno tests is available to just about anyone. In fact, many enthusiasts become “bogged down” in an overabundance of test data. Sorting through the results, analyzing the best power curves, and selecting promising component combinations can turn into a job nearly as difficult as old trial-and-error dyno testing.

The solution to the this problem was the introduction of *Iterative Testing*™, an exclusive feature of ProRacing Sim simulations. *Iterative* testing is a repeating series of simulation tests that methodically approach a final, optimum answer. The DynoSim incorporates a completely new version of the *Iterator*: ***The Quick Iterator***™. Now, click on only one button, and the DynoSim will perform a comprehensive test series to find optimum horsepower or torque for just about any application. The *Quick Iterator* uses an optimization process called ***Dual-Phase***™ testing to find the best combina-

Using The *Quick Iterator™*

Quick Iterator™ Spawned Engine



!! DB VERSION !!

☑ **Short Block**
Short Block: Chevy 454
Bore: 4.251 in
Stroke: 4.000 in
No. Cylinders: 8
Cylinder Volume: 930.32 cc
Total Vol: 454.2 ci

☑ **Cylinder Heads**
Cylinder Heads: Canted/Oval Pocket Ported, Stock Valves
Valve Specifications:
Intake Valves/Port: 1
Exhaust Valves/Port: 1
Intake Valve Dia: 2.147 in (Auto)
Exhaust Valve Dia: 1.700 in (Auto)

☑ **Compression**
Compression Ratio: 10.12
Combustion Space: 101.99 cc
Cylinder Volume: 930.32 cc

☑ **Induction**
Induction Flow: 780.0 cfm @ 1.50 inHg
Fuel Type: Gasoline
Manifold Type: Single-Plane High-Flow
Nitrous Injection: 0.0 lbs/min
Forced Induction Specifications:
Blower Type: Turbo-Air Research T03
Island Flow: 300.0 cfm
Surge Flow: 200.0 cfm
Pressure Ratio: 1.30
Impeller Speed: *** rpm
Belt Ratio: ***
Internal Ratio: ***
Peak Efficiency: 72.0 %
Boost Limit: 10.0 psi
Intercooler: 70.0 %

☑ **Exhaust**
Exhaust System: Large-Tube Headers With Mufflers

☑ **Camshaft**
Cam Name: Dual Purpose Street/Track
Intake Lift At Valve: 0.608 in
Lifter Type: Roller Solid
Exhaust Lift At Valve: 0.614 in
Lifter Acceleration Rate: 3.90
Valve Opening/Closing Based On: Seat-To-Seat
Primary Timing (Seat-to-Seat): IVO: 34.0 IVC: 66.0 EVO: 77.0 EVC: 29.0
Secondary Timing (0.050-inch): IVO: *** IVC: *** EVO: *** EVC: ***
Cam Installed Advanced(+)/Retarded(-): 0.0
True IVO: 34.0
True EVO: 77.0
True IVC: 66.0
True ICA: 106.0
True EVC: 29.0
True ECA: 114.0
Cam Timing Summary:
Intake Duration: 280.0
Exhaust Duration: 286.0
Intake Centerline Angle: 106.0
Exhaust Centerline Angle: 114.0
Lobe Centerline Angle: 110.0
Valve Overlap: 63.0

Notes
***

Press Enter or Left Click to edit this parameter

When the *Quick Iterator* has completed its analysis, you can save the results (by clicking the *Save* button). The program will spawn a new simulated engine with the component combination that produced optimum power or torque. The new engine will be added to "open" engines included in the *Engine Selection Tabs* at the bottom of the *Main Program Screen* (arrow). *Quick-Iterator*-spawned engines can be analyzed, tested, and modified in any way, just like any other engine in the DynoSim.

tion in the shortest time. The first test phase uses a wider range of values. After the best result has been found from this wide-range test, a second testing phase is performed using a much narrower range of test values. This ***Dual-Phase*** approach greatly speeds processing time, allowing the *Quick Iterator*, for example, to perform a search for optimum cam timing in only 2500 simulation runs; typically, less than two minutes of processing time (on 1.5 Ghz or faster computer systems).

Using The *Quick Iterator™*

To perform a ***Quick Iterator*** analysis, first select all the components for the baseline engine. Make sure all *Status Boxes* in each Component Category are green, and turn off **Auto Calculate Valve Size** and **Valve Lift**, if necessary. There are two testing groups in the ***Quick Iterator***, and two buttons in each group. The upper group searches for optimum cam timing for either peak horsepower or peak torque. The lower group determines the best bore and stroke combination (maintaining current engine displacement) for either peak horsepower or peak torque.

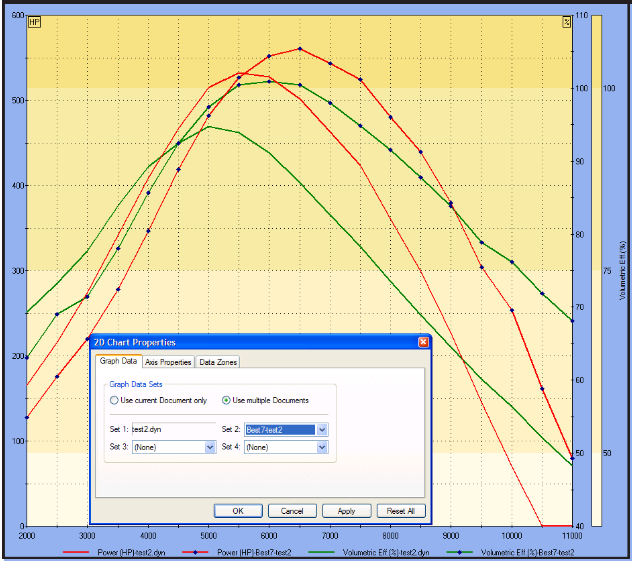
Press either the ***Best HP*** or ***Best Torque*** button in the upper group to begin an analysis of valve-event timing that will optimize horsepower or torque within ±500rpm of the current power or torque peak. The ***Quick Iterator*** assumes that the current cam in the simulated engine is a "roughly" appropriate for the intended application and uses current cam timing as a starting point. You can follow the progress of the ***Quick Iterator*** by viewing the indicators in the ***Iterator Status*** group (upper-left of the ***Quick Iterator*** screen).

To perform an analysis of cylinder-bore and crankshaft-stroke dimensions, press either the ***Best HP*** or ***Best Torque*** button in the lower group. The ***Quick Iterator*** will determine the best bore-and-stroke combination for optimum horsepower or torque

Using The *Quick Iterator*™

To pinpoint improvements located by the Iterator, you can setup back-to-back comparisons with the original, baseline engine. Right-click the graph, select *Properties*, then include the baseline engine in one of the *Data Sets*. The baseline engine curves will be drawn on the current graph, and the key-legend at the bottom of the graph will be updated.

Comparison With Baseline Engine



Graph Data Sets

○ Use current Document only ● Use multiple Documents

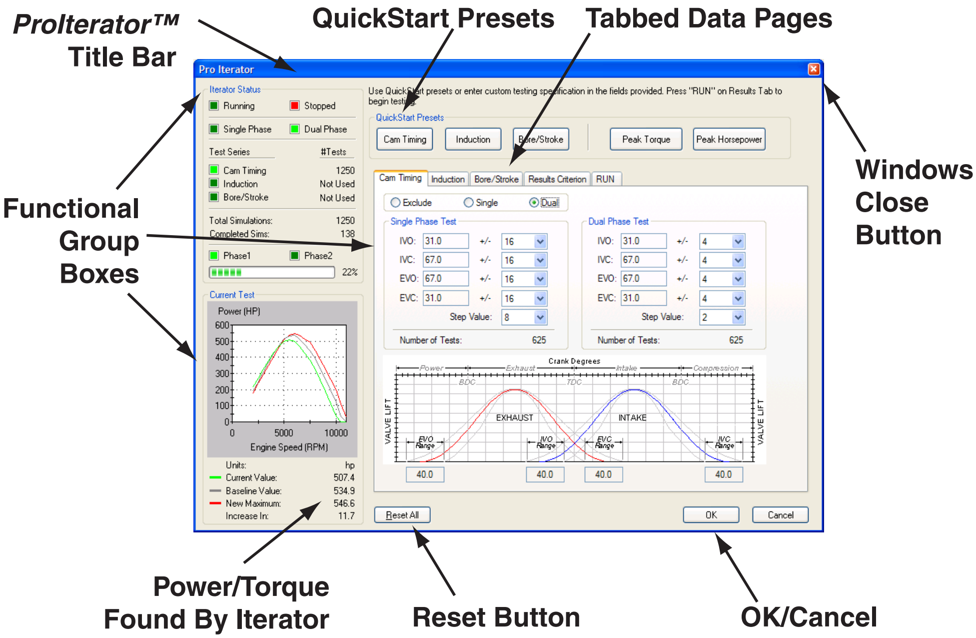
Set 1: test2.dyn
Set 2: Best7-test2
Set 3: (None)
Set 4: (None)

within ±500rpm of the current horsepower or torque peak (current displacement will be maintained).

When *Iterative* testing is complete (you can stop testing at any time by pressing the ***Stop*** button; press ***Resume*** to continue testing), the ***Iterator Best Result*** graph will show the improvement in horsepower or torque found with the new component specifications. You can keep the results by clicking ***Save***. In a few seconds, the DynoSim will "spawn" a new, simulated engine incorporating the component combination that produced optimum power or torque. Switch between the new engine and the baseline engine by using the ***Engine Selection Tabs*** at the bottom of the *Main Program Screen*. The *Quick-Iterator*-spawned engines can be analyzed, tested, and modified in any way, just like any other engine in the DynoSim. In fact, it is possible to begin a ***new*** *Quick Iterator* test to further "home in" on the desired results.

The *Quick Iterator* will almost always find more power or torque. To pinpoint the improvements, setup a back-to-back comparison with the original, baseline engine. Simply right-click on the power/torque graph of the newly-spawned engine, select ***Properties***, then include the baseline engine in one of the four ***Data Sets*** shown on the *Graph Data* page. The baseline engine curves will be included on the current graph, and the key-legend at the bottom of the graph will be updated.

PRO ITERATOR™ (Pro-Tool™)



Use QuickStart presets or enter custom testing specification in the fields provided. Press "RUN" on Results Tab to begin testing.

Test Series	#Tests
Cam Timing	1250
Induction	Not Used
Bore/Stroke	Not Used

Total Simulations: 1250
Completed Sims: 138
22%

Units: hp
Current Value: 507.4
Baseline Value: 534.9
New Maximum: 546.6
Increase In: 11.7

Single Phase Test
IVO: 31.0 +/- 16
IVC: 67.0 +/- 16
EVO: 67.0 +/- 16
EVC: 31.0 +/- 16
Step Value: 8
Number of Tests: 625

Dual Phase Test
IVO: 31.0 +/- 4
IVC: 67.0 +/- 4
EVO: 67.0 +/- 4
EVC: 31.0 +/- 4
Step Value: 2
Number of Tests: 625

40.0 40.0 40.0 40.0

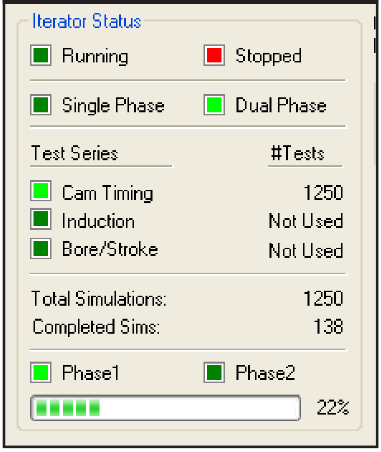
The ***Quick Iterator***™ (pronounced *IT-TER-A-TOR*—discussed in the previous chapter) provides a powerful and easy-to-use tool for anyone to optimize engine components. While this capability will satisfy most enthusiasts, the more serious engine builder needs the ability to perform Iterative tests on more than one component at a time and include the *Induction* system in the testing criterion. This, combined with greater flexibility in Iterator setup, area under the curve analysis, variable power-band ranges, and much more, is offered in the ***ProTools***™ version of ProRacing Sim Software's Iterator: ***The ProIterator***™ (***ProTools***™ must be activated to use this feature—see page 121 for more information on optional-feature activation).

Using The *ProIterator*™

Open the ***ProIterator***™ by choosing the ***ProIterator***™ selection from the **Tools**

Using The *ProIterator™*

ProIterator™ Status Group



Iterator Status

🟩 Running 🟥 Stopped

🟩 Single Phase 🟩 Dual Phase

Test Series	#Tests
🟩 Cam Timing	1250
🟩 Induction	Not Used
🟩 Bore/Stroke	Not Used

Total Simulations: 1250
Completed Sims: 138

🟩 Phase1 🟩 Phase2

22%

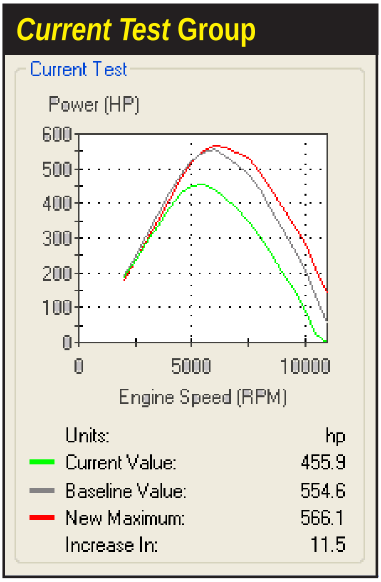
Indicators within this group clearly show current testing status. *Running* and *Stopped* are located directly above the *Single-* and *Dual-Phase™* indicators; the *ProIterator™* can use *Single-* or *Dual-Phase™* optimization to find the best combinations in the shortest time. The *Test-Series* markers that show whether a particular engine component category will be included in the test series.

menu or by clicking the ***ProIterator™ Icon*** in the **Toolbar.** The main screen consists of the following elements and groups:

Iterator Status Group (upper-left corner)—Indicators within this group clearly show current testing status. The Running and Stopped "lights" are located directly above the ***Single-*** and ***Dual-Phase™*** indicators. Like the *Quick Iterator*, the ***ProIterator™*** can use a *Dual-Phase™* optimization process to find the best combinations in the shortest time. The first phase tests over a wide range of values. After the best result is found, a second testing phase is performed using a narrower testing range. However, the ***ProIterator™*** extends this capability by allowing all variables in each Iterator phase to be fully customizable. *Dual-Phase™* and standard, *Single-Phase™* testing can even be toggled on and off as desired. Below the phase indicators are three ***Test-Series*** markers that show whether a particular engine component category will be included in current tests. The three test groups, ***Cam Timing***, ***Induction***, and ***Bore/Stroke*** correspond to the first three tabbed pages in the center of the dialog box. A light-green color indicates that this group will be included in the test series, and ***# Tests*** shows how many tests will be performed within this category. The total number of simulations is shown below, along with the number of completed test runs. At the bottom of the *Iterator Status* group are the ***Phase 1*** and ***Phase 2*** indicators (only visible when *Dual-Phase™* testing has been enabled) and a progress bar that indicates the progress of each phase in multiple-phase testing.

Current Test Group (bottom-left corner)—The graph displays three horsepower or torque curves (and area under the curves, if selected). The gray curve represents the initial, baseline power/torque; the green curve is the current Iterator test result, and the red curve is the highest power discovered up to that point in the testing series. A key-legend is provided below the graph along with the exact

Using The *ProIterator™*



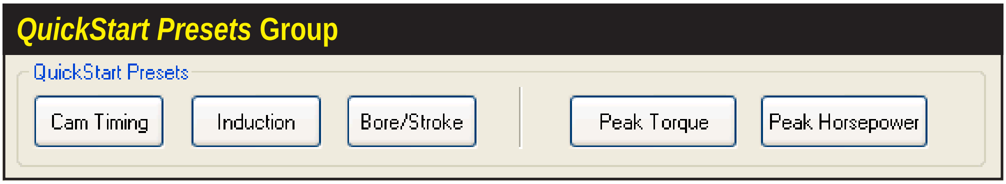
Units:	hp
🟩 Current Value:	455.9
▬ Baseline Value:	554.6
🟥 New Maximum:	566.1
Increase In:	11.5

The *Current Test* group displays three horsepower or torque curves: The gray curve represents the baseline, the green curve is the current test, and the red curve is the highest power found. Exact values for the baseline, current, maximum, and gain-or-loss in power/torque are provided at the bottom of the group box.

values for the baseline, current, maximum, and gain-or-loss in power/torque.

QuickStart Presets Group (top center)—The convenience of one-button quick testing incorporated in the *Quick Iterator™* also is part of the ***ProIterator™***. While the ***ProIterator™*** does not begin testing when a *QuickStart* button pressed, instead, it loads a "typical" set of testing parameters in the appropriate tabbed data page (the five tabbed data pages are discussed next). For example, if you click the ***Cam Timing*** and ***Peak Horsepower*** presets, the ***Cam-Timing Page*** establishes a *Dual-Phase™* cam-timing testing series based around the current camshaft and the ***Optimize-For Page*** selects *Peak Horsepower* as the principal search criterion. Use the ***Reset All*** button located at the bottom of the screen to clear all Presets and return the tabbed-pages to their default setup.

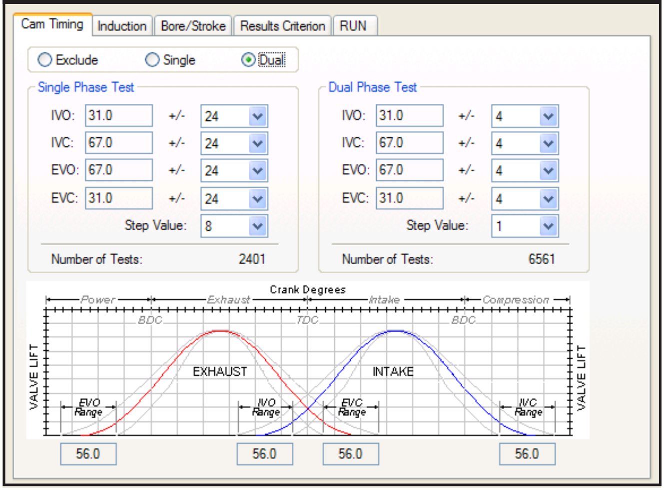
Tabbed Data Page Group (center of screen)—Five data entry- and display-pages are available as tabbed screens at the center of the ***ProIterator™***.



The convenience of one-button quick testing has been incorporated in the *ProIterator™*. Click any preset button (e.g., *Cam Timing* and *Peak Horsepower)* to establish a testing series on the appropriate tabbed data page. Use the *Reset All* button to clear all Presets and return the tabbed-pages to their default setup.

Using The *ProIterator*™

Camshaft-Timing "Tabbed" Data Page



Cam Timing | Induction | Bore/Stroke | Results Criterion | RUN

○ Exclude ○ Single ● Dual

Single Phase Test

IVO:	31.0	+/-	24
IVC:	67.0	+/-	24
EVO:	67.0	+/-	24
EVC:	31.0	+/-	24
		Step Value:	8

Number of Tests: 2401

Dual Phase Test

IVO:	31.0	+/-	4
IVC:	67.0	+/-	4
EVO:	67.0	+/-	4
EVC:	31.0	+/-	4
		Step Value:	1

Number of Tests: 6561

56.0 56.0 56.0 56.0

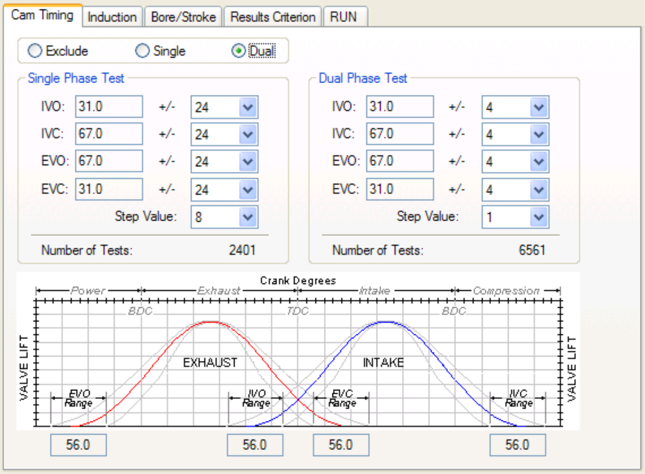
The *Cam-Timing* tabbed page establishes a *Single-* or *Dual-Phase*™ test of cam-timing changes on power or torque output. Select either the *Single-* or *Dual-Phase* radio button and enter the testing criterion in the *Single- and/or Dual-Phase Test* boxes. The range of individual cam-timing values evaluated during *ProIterator*™ testing are displayed just below the twin-hump cam-timing diagram.

Cam-Timing* Tabbed Page**—The first tabbed page and the default display when the ***ProIterator™ is opened, establishes a *Single-* or *Dual-Phase*™ test of cam-timing changes on power or torque output. Also by default, the *Cam-Timing Tabbed Page* is set to ***Exclude*** (perform no cam-timing tests) with the radio buttons at the top-left of the page. To perform cam-timing Iteration, select either the ***Single-*** or ***Dual-Phase*** radio button and enter the testing criterion in the ***Single- and/or Dual-Phase Test*** boxes, located just below the radio buttons. The range of individual cam-timing values evaluated during ***ProIterator***™ testing are displayed just below the twin-hump cam-timing diagram. You can quickly setup a more exhaustive test by clicking on the ***Cam Timing*** button in the *QuickStart Preset* group (described previously). This will perform a *Dual-Phase* test of 8,962 simulations (completed in about 5 minutes on a 1Ghz and faster computer).

Induction* Tabbed Page**—The third tabbed page sets up a *Single-Phase* test of the effects of various induction systems on power or torque output. By default, the *Induction Tabbed Page* is set to ***Exclude (perform no induction tests) with the radio buttons at the top-left of the page. To perform an Iterative test of induction systems, select the ***Include*** radio button and check the manifolds/induction-systems that you would like to include in the test series. You can quickly setup an exhaustive test of all induction systems by clicking on the ***Induction*** button in the *QuickStart Preset* group (described previously).
Note: The *Individual Runner* manifold has two additional radio-button selections: *Use Existing Airflow* and *Increase Induction Flow* to compensate for the lack of a common plenum in IR systems. If you select the ***Increase Induction Flow***

The *Induction* tabbed page sets up a *Single-Phase* test of the effects of various induction systems on power or torque output. To perform an *Iterative* test of induction systems, select the *Include* radio button and check the manifolds/ induction-systems that you would like to add to the test series.

Induction "Tabbed" Data Page



○ Exclude ○ Single ● Dual

Single Phase Test

IVO: 31.0 +/- 24
IVC: 67.0 +/- 24
EVO: 67.0 +/- 24
EVC: 31.0 +/- 24
Step Value: 8
Number of Tests: 2401

Dual Phase Test

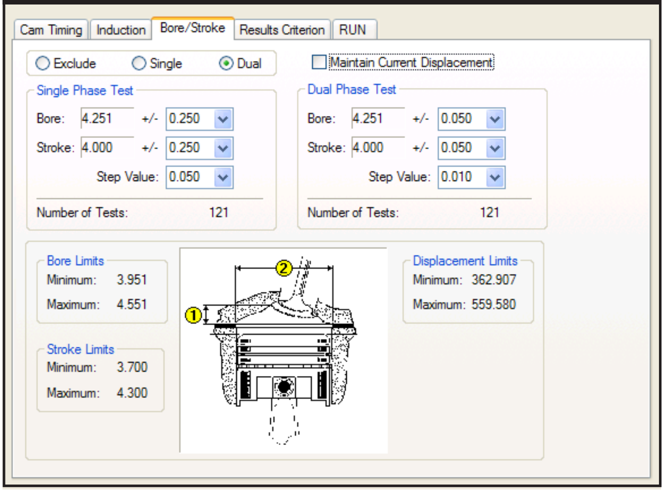
IVO: 31.0 +/- 4
IVC: 67.0 +/- 4
EVO: 67.0 +/- 4
EVC: 31.0 +/- 4
Step Value: 1
Number of Tests: 6561

56.0 56.0 56.0 56.0

button, the induction airflow (as specified in the **INDUCTION** category, see page 42) will be modified using the following formula: (number-of-cylinders x airflow)/2. This formula only will be used when the IR manifold is being simulated. When other manifolds are tested, the baseline airflow will be used. Depending on the number of cylinders and the baseline airflow value, modified airflow for the IR system can increase to as high as 4000cfm (the maximum airflow limit in the DynoSim). If you select ***Use Existing Airflow***, the baseline airflow will be used at all times. This typically results in very poor performance for the IR system, since the baseline airflow is divided by the number of cylinders to determine individual port flow. We recommend that you enable ***Increase Induction Airflow*** whenever the IR system is included in Iterative tests of mixed induction systems.

Bore/Stroke* Tabbed Page**—The third tabbed page establishes a *Single-* or *Dual-Phase*™ test of bore-and-stroke dimensional changes on power or torque output. By default, the *Bore/Stroke Tabbed Page* is set to ***Exclude (perform no bore-and-stroke tests) with the radio buttons at the top-left of the page. To perform Bore/Stroke Iteration, select either the ***Single-*** or ***Dual-Phase*** radio button and enter the testing criterion in the ***Single- and/or Dual-Phase Test*** boxes, located just below the radio buttons. You can quickly setup an comprehensive test by clicking on the ***Bore/Stroke*** button in the *QuickStart Preset* group (described previously). This will establish a 242-test *Dual-Phase* simulation series (completed in about 1 minute on a 1Ghz or faster computer).
Note: You can chose to *Maintain Current Displacement* or let engine displacement vary throughout Bore/Stroke Iterative testing. By checking the ***Maintain Current Displacement*** box, the ***Stroke*** within both ***Phase-Test*** boxes will switch to ***(Auto)***, indicating that *Stroke* will be allowed to vary as much as required to

Bore/Stroke "Tabbed" Data Page



○ Exclude ○ Single ● Dual

☐ Maintain Current Displacement

Single Phase Test

Bore: 4.251 +/- 0.250

Stroke: 4.000 +/- 0.250

Step Value: 0.050

Number of Tests: 121

Dual Phase Test

Bore: 4.251 +/- 0.050

Stroke: 4.000 +/- 0.050

Step Value: 0.010

Number of Tests: 121

Bore Limits

Minimum: 3.951

Maximum: 4.551

Stroke Limits

Minimum: 3.700

Maximum: 4.300

Displacement Limits

Minimum: 362.907

Maximum: 559.580

The *Bore/Stroke* tabbed page establishes an *Iterative* test of bore-and-stroke dimensional changes. Perform a Bore/Stroke *Iteration* by selecting either the *Single-* or *Dual-Phase* radio button and entering the testing criterion. You can chose to *Maintain Current Displacement* or let engine displacement vary throughout Bore/Stroke testing (see text for details).

keep displacement constant while the ***Bore*** varies from its current value throughout its indicated (±) Range. Alternately, you can chose to allow *Bore* (rather than Stroke) vary as much as required to keep displacement constant while *Stroke* changes from its current value throughout its (±) Range. Follow these steps to change ***(Auto)*** variables: With *Maintain Current Displacement* checked, set the *Bore (±) Range* value to zero, then set the *Stroke (±) Range* to any desired value (except zero). The ***(Auto)*** function will switch to *Bore*.

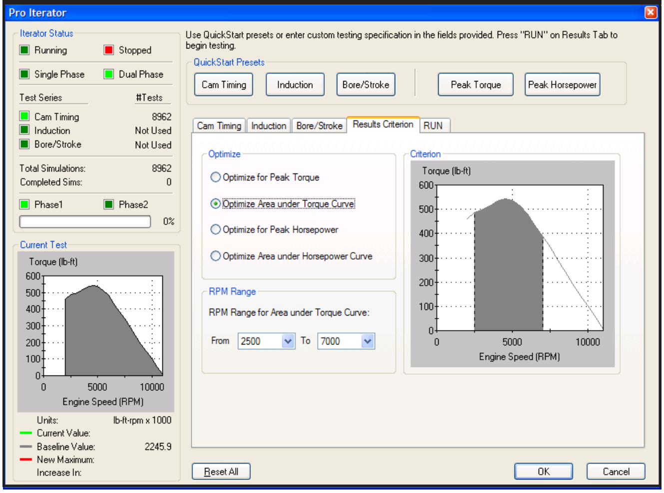
Optimize-For* Tabbed Page**—The fourth tabbed page establishes the desired result from Iterative testing. By default, the ***ProIterator™ will search for the combination of components that produces peak horsepower. Alternately, you can select *Optimize For Peak Torque*. In addition to these two options, two powerful new ***Optimize-For*** choices are available: *Maximum Area Under The Horsepower Curve* or *Torque Curve*. While the peak torque and horsepower choices will focus on absolute maximum values, the areas under the curves selections will find parts combinations that produce the greatest "volume" of horsepower or torque within the selected rpm range. Think of this area as the maximum horsepower or torque throughout the rpm range (or over time). In general, peak horsepower searches may find optimum components for narrow-rpm-band racing (like drag-racing), and maximum area under the curve may find the best components for wide-rpm band racing (like road racing).

Below the *Optimize* settings box, the ***RPM Range*** choices let you set the lower and upper limits through which the *Iterator* will search for optimum power or torque combinations. When the *Iterator* is searching for peak values, the *RPM Range* will be illustrated as dotted lines on the *Criterion* graph. When either *Area Under The Curve* choice is selected, the *RPM Range* values will be displayed as a "bounded area" under the horsepower or torque curves.

Using The *ProIterator™*

The *Optimize-For* tabbed page establishes the desired result. By default, the *ProIterator™* will search for peak horsepower. While peak torque and horsepower choices focus on absolute maximum values, the *Areas Under The Curve* selections locate parts that produce the greatest "volume" of horsepower or torque. Think of this as the maximum horsepower or torque throughout the rpm range

Optimize-For "Tabbed" Data Page



Pro Iterator

Use QuickStart presets or enter custom testing specification in the fields provided. Press "RUN" on Results Tab to begin testing.

Iterator Status

Test Series	#Tests
Cam Timing	8962
Induction	Not Used
Bore/Stroke	Not Used

Total Simulations: 8962
Completed Sims: 0

Optimize

○ Optimize for Peak Torque
● Optimize Area under Torque Curve
○ Optimize for Peak Horsepower
○ Optimize Area under Horsepower Curve

RPM Range

RPM Range for Area under Torque Curve:

From 2500 To 7000

Units: lb-ft-rpm x 1000
Current Value:
Baseline Value: 2245.9
New Maximum:
Increase In:

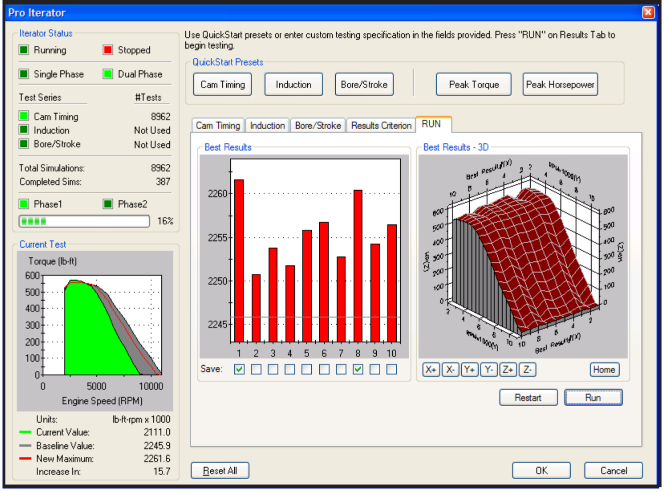
Note: Optimizing engine components for maximum area under the curve is an entirely new way to look at engine power output. There is almost no published data on this method of evaluating engine power or torque, nor is there research available on which racing applications may benefit from this analysis. Rumor has it, though, that many of Formula-1, Indy, and other "very serious" racing teams have used this method to find a winning edge. Now you can use this powerful analysis method in the ***DynoSim ProIterator™*** to your advantage!

Run/Results* Tabbed Page**—The fifth tabbed page begins an *Iterative* test series, allows you to view testing progress, and displays the top ten results. Once you have selected the testing parameters (on the *Cam Timing*, *Induction*, and *Bore/Stroke* tabbed pages), click the ***Run button to begin an *Iterative* test. As the ***ProIterator™*** finds promising results, they are displayed in the ***Best Results*** graph as vertical bars. A horizontal "baseline" on the graph indicates the power level of the current engine (built from components on the Main Component Screen). As the *Iterator* finds better and better component combinations, the bars continue to increase in height (and the graph axis will rescale as needed). If the *Iterator* finds combinations that produce more power or torque than the baseline engine, the vertical results bars will cross over the baseline indicator and grow taller (the baseline marker may rescale and move down the graph indicating a greater difference between the baseline engine and *Iterator* combinations). The top ten horsepower or torque curves that match the bar-chart results are displayed on the ***Best Results—3D graph***. You can view these curves from any prospective using the **X+**, **X-**, **Y+**, **Y-**, **Z+**, and **Z-** buttons (**Home** returns the 3D graph to its original position),

During *Iterative* testing, you can view the number of completed and remaining tests in the ***Iterator Status*** box, as discussed earlier (you can stop testing

Using The *ProIterator™*

RUN/Results "Tabbed" Data Page



Pro Iterator

Iterator Status

🟩 Running 🟥 Stopped

🟩 Single Phase 🟩 Dual Phase

Test Series	#Tests
🟩 Cam Timing	8962
🟩 Induction	Not Used
🟩 Bore/Stroke	Not Used

Total Simulations: 8962
Completed Sims: 387

🟩 Phase1 🟩 Phase2

16%

Current Test

Units: lb-ft-rpm x 1000
Current Value: 2111.0
Baseline Value: 2245.9
New Maximum: 2261.6
Increase In: 15.7

Use QuickStart presets or enter custom testing specification in the fields provided. Press "RUN" on Results Tab to begin testing.

Save: ☑ ☐ ☐ ☐ ☐ ☐ ☐ ☑ ☐ ☐

The *Run/Results* tabbed page begins *Iterative* testing, allows you to view testing progress, and lets you save any of the top ten results. When testing is complete, save any (or all) of the top ten results by clicking the *Save* boxes located below the vertical bars in the *Best Results* graph, then click the *OK* to spawn (create) these engines within the DynoSim.

at any time by pressing the ***Stop*** button; press ***Run*** to continue testing or ***Restart*** to clear current results). When testing is complete, save any (or all) of the top ten results by clicking the ***Save*** boxes located below the vertical bars in the *Best Results* graph. After deciding which engines to save, click the ***OK*** button at the bottom of the ***ProIterator™*** dialog box. The *Iterator* will close and "spawn" new engines based on the components that were used in the selected tests. You can switch to any of these engines (and continue modification and testing as you can with any DynoSim engine) by clicking on the ***Engine Selection Tabs*** at the bottom of the *Main Component Screen*.

The ***ProIterator™*** will almost always find more power or torque. To pinpoint these improvements, setup back-to-back comparisons with the original, baseline engine. Simply right-click on the power/torque graph of any of the newly-spawned engines, select ***Properties***, then include the baseline engine in one of the four ***Data Sets*** shown on the *Graph Data* page. The baseline engine curves will be included on the current graph, and the key-legend at the bottom of the graph will be updated.

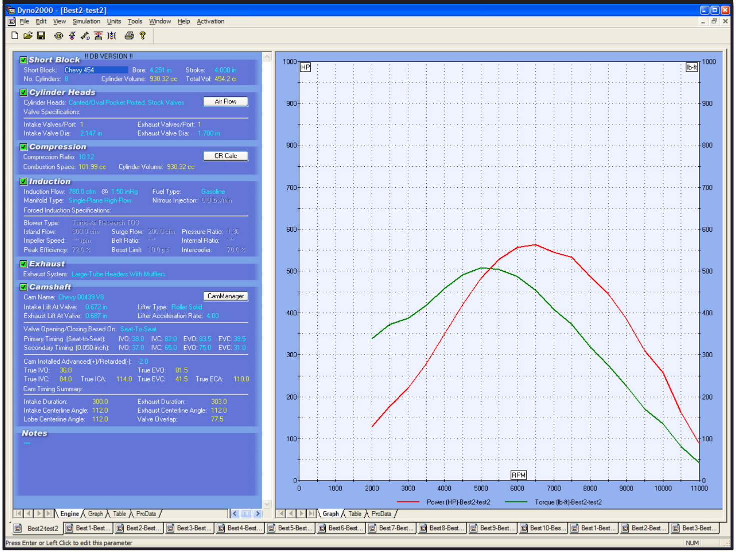
Reset All* Button** (bottom)—If you would like to return the ProIterator™ to the default state, resetting all tabbed pages to their original settings, press the ***Reset All button.

ProIterator™ Testing—A Quick Walkthrough

The first step in performing an *Iterative* test is to build the basic (or baseline) engine by selecting component parts from the *Main Program Screen Component Categories* (all component categories must display green status boxes) or by loading a completed engine (.DYN) file. When all parts have been selected, the DynoSim will

Using The *ProIterator™*

Spawned Engines Displayed In Engine Selection Tabs



☑ **Short Block**
Short Block: Chevy 454 Bore: 4.251 in Stroke: 4.000 in
No. Cylinders: 8 Cylinder Volume: 930.32 cc Total Vol: 454.2 ci

☑ **Cylinder Heads**
Cylinder Heads: Canted/Oval Pocket Ported, Stock Valves
Valve Specifications:
Intake Valves/Port: 1 Exhaust Valves/Port: 1
Intake Valve Dia: 2.147 in Exhaust Valve Dia: 1.700 in

☑ **Compression**
Compression Ratio: 10.12
Combustion Space: 101.99 cc Cylinder Volume: 930.32 cc

☑ **Induction**
Induction Flow: 780.0 cfm @ 1.50 inHg Fuel Type: Gasoline
Manifold Type: Single-Plane High-Flow Nitrous Injection: 0.0 lbs/min
Forced Induction Specifications:
Blower Type: Turbo-Air Research T03
Island Flow: 300.0 cfm Surge Flow: 200.0 cfm Pressure Ratio: 1.30
Impeller Speed: *** rpm Belt Ratio: *** Internal Ratio: ***
Peak Efficiency: 72.0 % Boost Limit: 10.0 psi Intercooler: 70.0 %

☑ **Exhaust**
Exhaust System: Large-Tube Headers With Mufflers

☑ **Camshaft**
Cam Name: Chevy 00439 V8
Intake Lift At Valve: 0.672 in Lifter Type: Roller Solid
Exhaust Lift At Valve: 0.687 in Lifter Acceleration Rate: 4.00
Valve Opening/Closing Based On: Seat-To-Seat
Primary Timing (Seat-to-Seat): IVO: 38.0 IVC: 82.0 EVO: 83.5 EVC: 39.5
Secondary Timing (0.050-inch): IVO: 37.0 IVC: 65.0 EVO: 75.0 EVC: 31.0
Cam Installed Advanced(+)/Retarded(-): -2.0
True IVO: 36.0 True EVO: 81.5
True IVC: 84.0 True ICA: 114.0 True EVC: 41.5 True ECA: 110.0
Cam Timing Summary:
Intake Duration: 300.0 Exhaust Duration: 303.0
Intake Centerline Angle: 112.0 Exhaust Centerline Angle: 112.0
Lobe Centerline Angle: 112.0 Valve Overlap: 77.5

Notes
***

Press Enter or Left Click to edit this parameter

When you close the *Iterator* screen, new "spawned" engines will be created and displayed in the *Engine Selection Tabs* at the bottom of the Main Program Screen. Each new engine can be brought into the foreground by clicking on its *Selection Tab*. Iterator-spawned engines can be analyzed, tested, and modified in any way, just like any other engine in the DynoSim.

perform a simulation and display horsepower and torque curves in the right results pane.

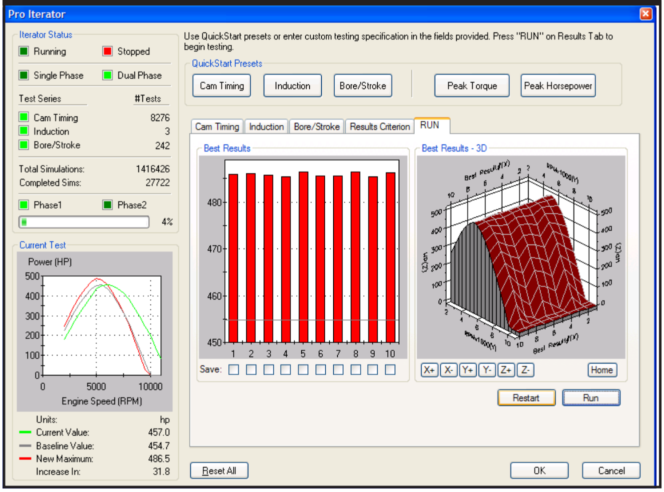
When the baseline engine simulation has been performed, you may conduct an *Iterative* test. Open the *ProIterator™* by choosing ***ProIterator™*** from the **Tools** menu or by clicking the ***ProIterator™ Icon*** in the **Toolbar**. The tabbed data-entry-and-display pages establish a component or engine-system for testing and specify a search criterion and rpm range (see the previous section for details on each tabbed data-and-setup page). As an alternative to setting up individual testing parameters, you can click on any of the *QuickStart Preset* buttons at the top of the *ProIterator™* dialog box. Each button loads a "typical" set of testing parameters on the appropriate tabbed data page.

For Example: Click the ***Cam Timing*** and ***Peak Horsepower*** presets to setup a *Dual-Phase™* cam-timing testing series on the ***Cam-Timing*** page that is based around current camshaft timing while the ***Optimize-For*** page establishes *Peak Horsepower* as the principal search criterion within an *Rpm Range* that extends below the torque peak and above the horsepower peak of the baseline engine. Use the ***Reset All*** button located at the bottom of the screen to clear all Presets and return the tabbed-pages to their program defaults.

As you make selections from either the *QuickStart Preset* buttons or the tabbed data pages, the *Iterator Status* box (upper-left of dialog) shows the component groups that have been included and the number of tests that must be performed to complete the current series. Since the DynoSim will typically perform 10 to 20 simulation tests per second (depending on the speed of your computer), keep in mind that it will take about an hour to execute 45,000 tests. Keep testing criterion limited and the range and step values as large as possible to minimize testing time.

Using The *ProIterator*™

An Extremely Long Iterator Test Series



Use QuickStart presets or enter custom testing specification in the fields provided. Press "RUN" on Results Tab to begin testing.

Test Series	#Tests
Cam Timing	8276
Induction	3
Bore/Stroke	242

Total Simulations: 1416426
Completed Sims: 27722
Phase1 Phase2 4%

Units: hp
Current Value: 457.0
Baseline Value: 454.7
New Maximum: 486.5
Increase In: 31.8

Narrowly-focused or multiple-component tests may require several thousand, or even million, test cycles to complete. A test series as large as the one shown here, can require several days of calculation time depending on the speed of your computer. Often the same results can be obtained by a more carefully designed test that takes less than half the time to complete. Use wide first-phase ranges and steps to keep the number of Iteration cycles to a minium.

After you have selected the components that you wish to evaluate, the ***Optimize For*** tabbed page establishes the search criterion and the rpm range that the *Iterator* will use to find improved power or torque. By default, the ***ProIterator***™ will search for the combination of components that produces peak horsepower. Alternately, you can select *Optimize For Peak Torque*. In addition to these two options, two powerful new ***Optimize-For*** choices are available: *Maximum Area Under The Horsepower Curve* or *Torque Curve*. While the peak torque and horsepower choices will focus on absolute maximum values, the areas under the curves selections will find parts combinations that produce the greatest "volume" of horsepower or torque within the selected rpm range. Think of this area as the maximum horsepower or torque throughout the rpm range (or over time).

Once you have selected the testing parameters (on the *Cam Timing*, *Induction*, and *Bore/Stroke* tabbed pages), click the ***Run*** button to begin an *Iterative* test. As the ***ProIterator***™ finds promising results, they are displayed in the ***Best Results*** graph as vertical bars. A horizontal "baseline" on the graph indicates the power level of the current engine (built from components on the Main Component Screen). As the *Iterator* finds better and better component combinations, the bars continue to increase in height (and the graph axis will rescale as needed). If the *Iterator* finds combinations that produce more power or torque than the baseline engine, the vertical results bars will cross over the baseline indicator and grow taller (the baseline marker may rescale and move down the graph indicating a greater difference between the baseline engine and *Iterator* combinations). The top ten horsepower or torque curves that match the bar-chart results are displayed on the ***Best Results—3D graph***. You can view these curves from any prospective using the **X+**, **X-**, **Y+**, **Y-**, **Z+**, and **Z-** buttons (**Home** returns the 3D graph to its original position).

The ***Run*** button on the ***Run/Results*** tabbed page begins *Iterative* testing, allows you to view testing progress, and lets you save any of the top ten results. You can stop testing at any time by pressing the ***Stop*** button; press ***Run*** to continue testing or ***Restart*** to clear current results. When testing is complete, save any (or all) of the top ten results by clicking the ***Save*** boxes located below the vertical bars in the *Best Results* graph. After deciding which engines to save, click the ***OK*** button at the bottom of the ***ProIterator™*** dialog box. When the *Iterator* closes, the newly spawned engines will be displayed in the ***Engine Selection Tabs*** at the bottom of the **Main Program Screen** (see page 14 for more information on Engine Selection Tabs). Each test engine can be brought into the foreground by clicking on its Tab. Iterator-spawned engines can be analyzed, tested, and modified in any way, just like any other engine in the DynoSim. In fact, it is possible to begin a *new Iterator* test using any of the spawned engines as a new baseline to further "home in" on the desired results.

Tips For Running Efficient Iterative Tests

Setting up an *Iterative* series only takes a few seconds, however, if you include too many parameters, ranges that are too wide, or step values that are too small, you will create an *Iterator* series that contains too many tests. If you create a series longer than 300 million tests (even fast computer systems will require one year or more to complete 300 million tests) the DynoSim will request that you increase step values for selected parameters.

The best way to find optimum components, especially cam timing, is to setup a Dual-Phase™ test that uses large step values (20 degrees or more) to "get in the ballpark" on the first phase, then the second *Iteration* phase with a narrower range of values (perhaps just a 2 to 4 degrees) and a smaller step value (perhaps 1 degree) precisely locates the best timing.

Narrowly-focused tests may still require several thousand test cycles to complete. A large test series may require several minutes, an hour or two, or even a day or two of calculation time depending on the speed of your computer. In these cases, you may continue to use your computer to perform other tasks. Simply use the ***Start*** menu to begin other applications or use ***Alt-Tab*** to switch between applications (see your Windows documentation for more information on program switching).

Note: If you are running Windows98/Me/2000/XP, you may also select the "DeskTop" icon (usually located close to the *Start* menu on the task bar) to "minimize" the DynoSim and regain your desktop during an *Iterator* test.

PRINTING

PRINTING DYNO DATA AND POWER CURVES

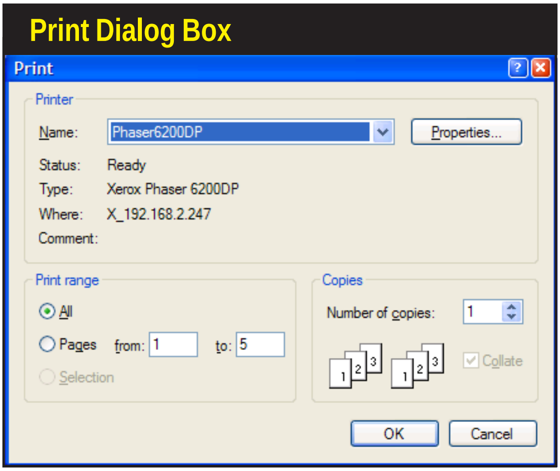
The DynoSim is capable of printing a complete list of engine components, cylinder head airflow data, exact engine test result values, and 2D graphic curves of several engine-test variables. Each of these data sets print on separate pages that comprise a complete multi-page, dyno-test document of the currently-selected engine. You can determine which pages you would like to print, preview the pages before you print, and direct the output to any installed Windows printer.

Note: If you have activated ***ProTools™*** in the DynoSim (see page 121 for more information on optional-feature activation), ***ProPrinting™*** options are available that produce comprehensive "presentation" reports of dyno test results. ***ProPrinting™*** features include special page graphics, a cover page with the name of your business (or you personal name), additional engine-data values, pressures, forces, and more.

There are three choices in the ***File*** menu (located on the *Main Program Screen*) that will help you setup your printer and print dyno data. The choices are:

Print—Opens a dialog box that allows the selection of a printer, access to printer Properties, and the Print Range of dyno-test pages. Printing can be started from this dialog box.

Print Dialog Box



Printer

Name: Phaser6200DP

Status: Ready

Type: Xerox Phaser 6200DP

Where: X_192.168.2.247

Comment:

Print range

● All

○ Pages from: 1 to: 5

○ Selection

Copies

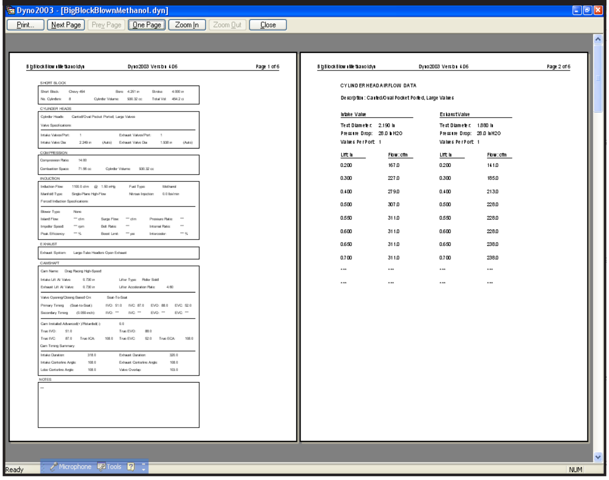
Number of copies: 1

☑ Collate

The print dialog box, accessible from the *File* menu, allows the selection of a printer, access to printer Properties, and you can enter the range of dyno-test report pages. Printing can be started from this dialog box.

Printing Dyno Reports

Print Preview Dialog Box



Print Preview, accessible from the *File* menu, provides an on-screen rendering of what each page in the basic dyno-test printout will look like when printed on the selected Windows printer. Use this feature to determine which pages you would like to include in the printout.

Print Preview—Opens the Print Preview Screen that provides an on-screen rendering of what each page in the dyno-test report will look like when printed on the selected Windows printer.

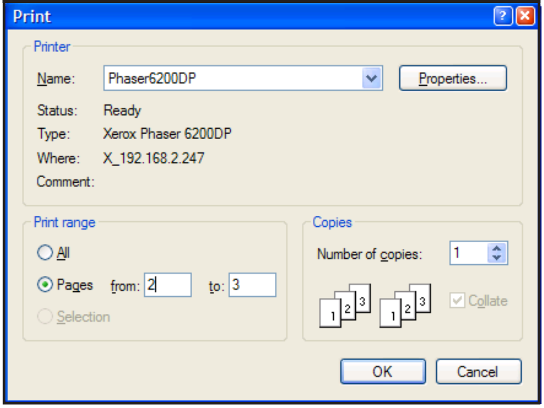
Printer Setup—Similar to the Print dialog box (allows printer selection), except printing cannot be started from this box.

The dyno-test report generated by the DynoSim consists of 5 pages. Here is description of each page:

Page 1—This page prints all the components selected for the current simulated dyno test. The appearance of the *Standard printout* is similar in layout to the *Component Selection* pane of the *Main Program Screen*.

Page 2—Displays cylinderhead airflow data used during the simulated engine test.

Printing Specific Pages



Name: Phaser6200DP
Status: Ready
Type: Xerox Phaser 6200DP
Where: X_192.168.2.247
Comment:

○ All
● Pages from: 2 to: 3
○ Selection

Number of copies: 1
☑ Collate

The print dialog box allows you to specify a range of pages to print. Here only pages 2 and 3 will print.

Printing Dyno Reports

Page 3—All calculated engine power and pressures are provided in chart form. Values are listed for each 500rpm test point throughout the full test range.

Page 4—***ProTools***™ Power and Engine Pressure data is provided in chart form. Values are listed for each 500rpm test point throughout the full test range.

Page 4 (Advanced) or 5 (ProTools™)—The first of two engine-output graphs is reproduced on this page (this is the graph located on the left side of the *Main Program Screen* under the *Component Categories*—select the ***Graph Tab*** at the bottom of the left of the pane to display this graph). Full color printing is supported.

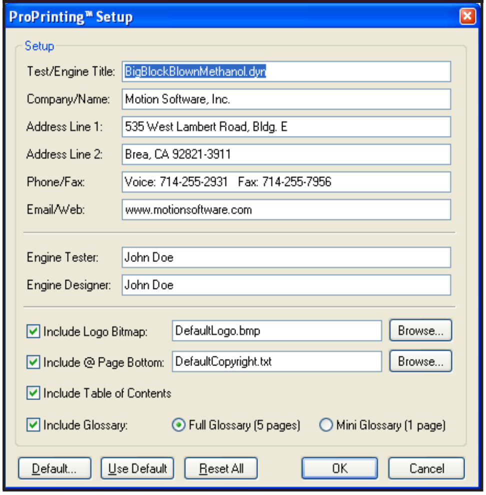
Page 5 (Advanced) or 6 (ProTools™)—The second of two graphs of engine output is reproduced on this page (this graph is located on the right side of the *Main Program Screen*).

ProTools™ Printing Features

When ***ProTools***™ have been activated (see page 121 for more information on optional-feature activation), ***ProPrinting***™ is available that will generate a comprehensive "presentation" report of engine test data. ***ProPrinting***™ features include special page graphics, a cover page with the name and address of your business (or your personal name and address) and logo, a table of contents, optional text printed at the bottom of each page (can be a disclaimer, copyright notice or any other text you wish), optional comprehensive or "mini" glossaries, and a complete listing of all test data and results. This full-color report is built within the DynoSim and delivered to your default Internet browser (e.g., Microsoft *Internet Explorer*™) for on-screen display and printing. To view a multiple-page print preview of this report, select *ProPrint Preview* from within the DynoSim, then select *Print Preview* from within your browser.

Note: Some browsers, like recent versions of Internet Explorer) do not print "background graphics" by default. This will prevent the printing of background colors in many

Pro-Printing™ Setup



ProPrinting™ Setup

Setup

Test/Engine Title: BigBlockBlownMethanol.dyn
Company/Name: Motion Software, Inc.
Address Line 1: 535 West Lambert Road, Bldg. E
Address Line 2: Brea, CA 92821-3911
Phone/Fax: Voice: 714-255-2931 Fax: 714-255-7956
Email/Web: www.motionsoftware.com

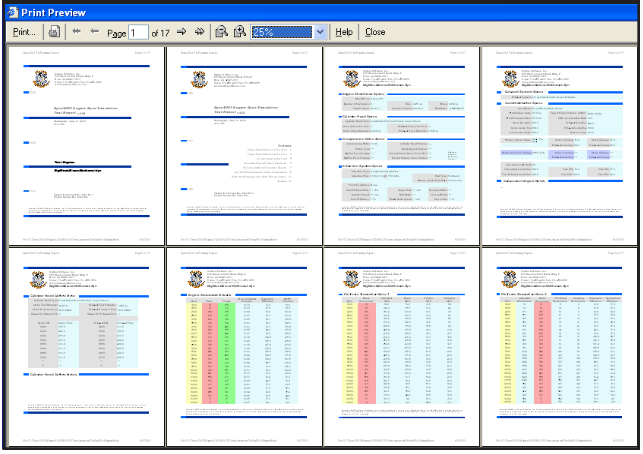
Engine Tester: John Doe
Engine Designer: John Doe

☑ Include Logo Bitmap: DefaultLogo.bmp
☑ Include @ Page Bottom: DefaultCopyright.txt
☑ Include Table of Contents
☑ Include Glossary: ● Full Glossary (5 pages) ○ Mini Glossary (1 page)

***ProPrinting*™, a *ProTools*™ feature, turns the results of any engine simulation into a professional test report. Use the *Pro-Printing*™ *Setup* dialog box, available from the *File* menu, to enable and customize *Pro-Printing*™ features. You can add your name, address, your company logo, specialized (copyright) text, a table of contents, and even a short or long glossary to your *ProPrint* report. Use the *Default...* button to save your preferences that will be applied by default to new engine simulations. The files for the Default Logo.bmp and the DefaultCopyright.txt are located in the *DynoSim/Manuals & Videos/proprint* subdirectoy. You can modify these files to suit your requirements.**

ProTools™ Printing Features

Pro-Printing™ Dyno Test Report



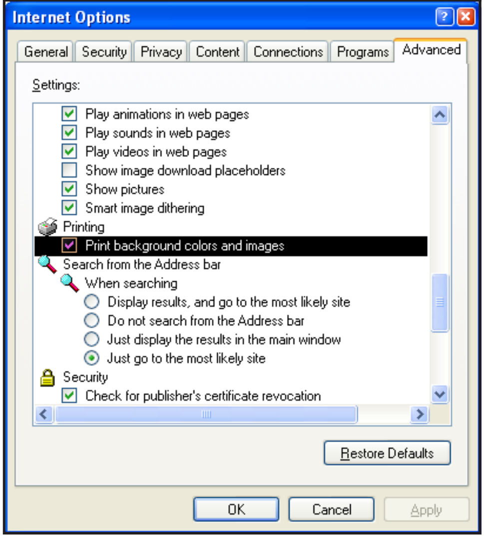
A *ProPrinting*™ report includes "presentation" graphics, a cover page with the name and address of your business (or your personal name and address) and logo, a table of contents, optional text printed at the bottom of each page, optional "full" or "mini" glossaries, and a complete listing of all test data and results. The report is delivered to your default web browser for printing (or *print previewing* as shown here).

of the data tables in the ***ProPrinting***™ report. To enable full-function printing, open the *Internet Options* menu (often located at the bottom of the *Tools* menu within Internet Explorer), choose the *Advanced* tab, and click the box (to enable) *Print background colors and images*.

Use ***ProPrinting*™ *Setup***, available from the **File** menu within the DynoSim, to enable and configure ***ProPrinting***™ features. If you activate ***Include Logo***, the logo file must be a .BMP file (should be square with the size near 100 by 100 pixels). If you activate ***Include @ Bottom Of Page***, the included file must be non-formatted text only (for example, created in Notepad) and no longer than about 50 words. You will find these files located in the *DynoSim/Manuals & Videos/proprint* directory.

Some browsers, like recent versions of *Internet Explorer)* do not print "background graphics" by default. This will prevent the printing of data table background colors in *ProPrinting*™ reports. To enable full-function printing, open the Internet Explorer *Options* menu (typically located at the bottom of the Tools menu within Internet Explorer), choose the *Advanced* tab, and click the box (to enable) *Print background colors and images*.

Pro-Printing™ IE Configuration



Settings:

- ☑ Play animations in web pages
- ☑ Play sounds in web pages
- ☑ Play videos in web pages
- ☐ Show image download placeholders
- ☑ Show pictures
- ☑ Smart image dithering
- Printing
  - ☑ Print background colors and images
- Search from the Address bar
  - When searching
    - ○ Display results, and go to the most likely site
    - ○ Do not search from the Address bar
    - ○ Just display the results in the main window
    - ● Just go to the most likely site
- Security
  - ☑ Check for publisher's certificate revocation

DynoSim Racing Software

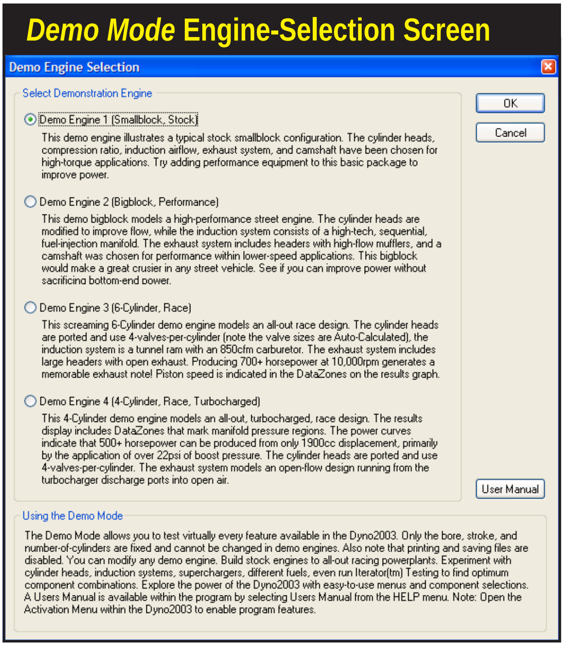
Advanced Engine Simulation

OTHER FEATURES

FEATURE ACTIVATION

The DynoSim can start-up and run in three distinct modes: 1) ***Demo***, 2) ***Advanced***, and 3) ***ProTools™ Activated***.

Demo Mode—If you have downloaded the DynoSim from an Internet site or installed the DynoSim Demo on your system along with other, purchased ProRacing Sim Software simulations, the DynoSim will start-up in the *Demo Mode*. The Demo presents a dialog box from which you can select any of several test engines. All the features of the DynoSim are available, and you can fully explore the capabilities of the program, except that the *Demo Mode* does not allow changes to the bores and strokes of test engines, and you cannot load or save files. For additional information about the *Demo Mode*, refer to the ***Help*** button on the *Demo Engine-*


Demo Mode Engine-Selection Screen

● Demo Engine 1 (Smallblock, Stock)

This demo engine illustrates a typical stock smallblock configuration. The cylinder heads, compression ratio, induction airflow, exhaust system, and camshaft have been chosen for high-torque applications. Try adding performance equipment to this basic package to improve power.

○ Demo Engine 2 (Bigblock, Performance)

This demo bigblock models a high-performance street engine. The cylinder heads are modified to improve flow, while the induction system consists of a high-tech, sequential, fuel-injection manifold. The exhaust system includes headers with high-flow mufflers, and a camshaft was chosen for performance within lower-speed applications. This bigblock would make a great crusier in any street vehicle. See if you can improve power without sacrificing bottom-end power.

○ Demo Engine 3 (6-Cylinder, Race)

This screaming 6-Cylinder demo engine models an all-out race design. The cylinder heads are ported and use 4-valves-per-cylinder (note the valve sizes are Auto-Calculated), the induction system is a tunnel ram with an 850cfm carburetor. The exhaust system includes large headers with open exhaust. Producing 700+ horsepower at 10,000rpm generates a memorable exhaust note! Piston speed is indicated in the DataZones on the results graph.

○ Demo Engine 4 (4-Cylinder, Race, Turbocharged)

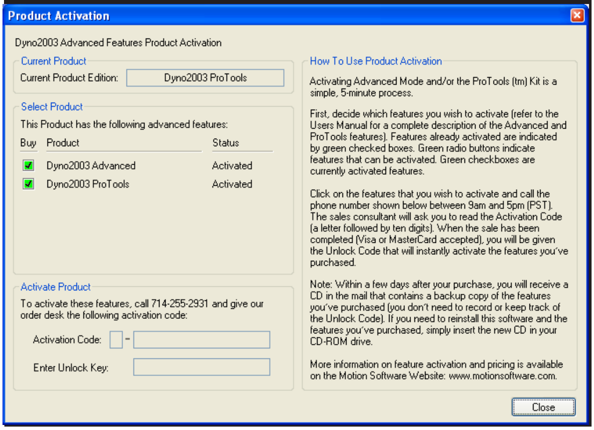
This 4-Cylinder demo engine models an all-out, turbocharged, race design. The results display includes DataZones that mark manifold pressure regions. The power curves indicate that 500+ horsepower can be produced from only 1900cc displacement, primarily by the application of over 22psi of boost pressure. The cylinder heads are ported and use 4-valves-per-cylinder. The exhaust system models an open-flow design running from the turbocharger discharge ports into open air.

The Demo Mode allows you to test virtually every feature available in the Dyno2003. Only the bore, stroke, and number-of-cylinders are fixed and cannot be changed in demo engines. Also note that printing and saving files are disabled. You can modify any demo engine. Build stock engines to all-out racing powerplants. Experiment with cylinder heads, induction systems, superchargers, different fuels, even run Iterator(tm) Testing to find optimum component combinations. Explore the power of the Dyno2003 with easy-to-use menus and component selections. A Users Manual is available within the program by selecting Users Manual from the HELP menu. Note: Open the Activation Menu within the Dyno2003 to enable program features.

If you've downloaded the DynoSim from an Internet site or installed the DynoSim Demo on your system, the program will start-up in the *Demo Mode*. The Demo presents a dialog box from which you can select any of several test engines. All the features of the DynoSim are available, except that the *Demo Mode* prevents any changes to the bores and strokes of test engines, and you cannot load or save files. For additional information about the *Demo Mode*, refer to the *Help* button on the *Demo Engine-Selection Screen* (shown here).

Demo, Advanced, and *ProTools*™ Modes

Activating Features



Product Activation

Dyno2003 Advanced Features Product Activation

Current Product

Current Product Edition: Dyno2003 ProTools

Select Product

This Product has the following advanced features:

Buy	Product	Status
☑	Dyno2003 Advanced	Activated
☑	Dyno2003 ProTools	Activated

Activate Product

To activate these features, call 714-255-2931 and give our order desk the following activation code:

Activation Code:

Enter Unlock Key:

How To Use Product Activation

Activating Advanced Mode and/or the ProTools (tm) Kit is a simple, 5-minute process.

First, decide which features you wish to activate (refer to the Users Manual for a complete description of the Advanced and ProTools features). Features already activated are indicated by green checked boxes. Green radio buttons indicate features that can be activated. Green checkboxes are currently activated features.

Click on the features that you wish to activate and call the phone number shown below between 9am and 5pm (PST). The sales consultant will ask you to read the Activation Code (a letter followed by ten digits). When the sale has been completed (Visa or MasterCard accepted), you will be given the Unlock Code that will instantly activate the features you've purchased.

Note: Within a few days after your purchase, you will receive a CD in the mail that contains a backup copy of the features you've purchased (you don't need to record or keep track of the Unlock Code). If you need to reinstall this software and the features you've purchased, simply insert the new CD in your CD-ROM drive.

More information on feature activation and pricing is available on the Motion Software Website: www.motionsoftware.com.

Activating *Advanced Mode* from the *Demo* version or activating *ProTools*™ from the *Advanced* version is a simple 5-minute process. Call the phone number shown in the *Activation Box* between 9am to 5pm (PST). A sales consultant will ask you to read the *Activation Code*, and when the sale has been completed, you will be given the *Unlock Code*.
Note: Within a few days you will receive a new CD in the mail.

Selection Screen (shown above).

Advanced Mode—(Basic Version Of DynoSim) The DynoSim contains a rich and powerful set of features that most enthusiasts will find more than sufficient to allow them to test components and determine optimum combinations for just about any application. All essential simulation features are included in the *Advanced Mode*, The ***ProTools***™ mode extends existing features to allow a more technical and/or detail analysis of engine performance.
For Example: In *Advanced Mode*, the user can measure and monitor various engine pressures and efficiencies, including Intake-Manifold Pressure and Volumetric Efficiency. The ***ProTools***™ ***Kit*** includes additional pressure and force measurements, including Indicated HP, Frictional HP, Mechanical Efficiency, Gas Force On Piston, IMEP, BMEP, FMEP, PMEP, Induction Airflow, etc.

ProTools™ Kit Activated—(Professional Version Of DynoSim) If you are a serious enthusiast, racer, or professional engine builder, you will find the additional tools and features supplied in the ***ProTools***™ ***Kit*** a valuable addition to the DynoSim *Advanced Mode*. Many features in the Advanced Mode have been enhanced with extended foundationally. In addition, some features are aimed directly at the professional, like the ***ProIterator***™, ***DataZones***™, and ***ProPrinting***™ that generates a "presentation-quality" dyno test report including the name and logo of your company.

Here is a list of ***ProTools***™ ***Kit*** contents:

ProIterator™—The one of the most powerful features of the ***ProTools***™ ***Kit***. The *ProIterator*™ retains all the simplicity and ease-of-use of the ***Quick Iterator***™ (supplied in the Advanced Mode), while adding powerful testing and analysis capability, including custom ranges, Induction-system Iteration, analysis

Demo, Advanced, and *ProTools*™ Modes

DynoSim Feature Activation

DynoSim Program Features	Program Activation Modes		
	Demo	**Advanced**	***ProTools™***
Dyno Testing Rpm Range	2,000-8,000rpm	1,500-11,500rpm	1,000-14,500rpm
Bore Limits	Fixed	2.500-7.000-in	2.000-7.000-in
Stroke Limits	Fixed	2.000-7.000-in	1.500-7.000-in
Color Dyno Test Printouts	✔	✔	✔
Fast Units Switching	×	✔	✔
CamMath ***QuickCalculator™***	×	✔	✔
Compression-Ratio Calculator	×	✔	✔
Airflow Calculator	×	✔	✔
Custom Cylinderhead Airflow Data	×	✔	✔
Iterative Testing (***QuickIterator™***)	×	✔	✔
CamManager™	×	✔	✔
Extended Color Interface	×	✔	✔
Ultra Short-Stroke Testing	×	×	✔
ProPrinting™ Dyno Reports	×	×	✔
Graph ***DataZones™***	×	×	✔
Extended Simulation Graph Data	×	×	✔
ProData™ Tables	×	×	✔
Iterative Testing (***ProIterator™***)	×	×	✔
Area Under Power/Torque Curves	×	×	✔

If you are a serious enthusiast, racer, or professional engine builder, you will find the additional tools and features supplied in the *ProTools™ Kit* a valuable addition to the DynoSim. Many features in the Advanced Mode have been enhanced with extended functionality. In addition, there are new features aimed directly at the professional, like the *ProIterator*™ and *ProPrinting*™ that generates a "presentation-quality" dyno test reports.

of areas under the power and torque curves, and much more. For a complete description of ***ProIterator***™ features, refer to page 106.

DataZones™—Extends the graphic-display and data-analysis capabilities of the DynoSim. Using this feature, you can add additional engine data and/or show ranges for target power values or clearly label dangerously high pressures, engine speeds, and more. To view ***DataZones***™ displays, see page 101.

Additional Simulation Data And Analysis—***ProTools***™ add additional simulated pressures, forces, and other data to the graphs and tables in the DynoSim. The additional data includes: *Indicated Horsepower, Frictional Horsepower, Pumping Horsepower, Mechanical Efficiency, Gas Force On Piston, Induction Airflow,* and *Piston Speed*. To support these additional variables, all graphs feature custom scaling and new multi-horsepower displays.

ProPrinting™—Turns simulation results into a comprehensive "presentation" report of dyno test data. ***ProPrinting***™ features include special page graphics, a cover page with the name and address of your business (or your personal name and address) and logo, a table of contents, optional text printed at the bottom of each page (can be a disclaimer, copyright notice or any other text you wish), optional comprehensive or "mini" glossaries, and a complete listing of all test data and results at each 500rpm point from 2000 to 11,000rpm, including additional engine-data values, pressures, forces, and more not included in a Advanced Mode. To view ***ProPrinting™*** displays, see page 123.

Activating *Advanced* Or *ProTools*™ Modes

Activating *Advanced Mode* from the *Demo Mode* or activating the ***ProTools***™ Kit from *Advanced Mode* is a simple, 5-minute process. Open the **Product Activation** dialog box (the **Activation** menu is located just to the right of the **Help** menu) and decide which features you wish to activate. Features already activated are indicated by green checked boxes. Green radio buttons indicate additional features that can be activated. Select the feature you wish to activate and call the phone number shown in the Activation box between 9am to 5pm (PST). The sales consultant will ask you to read the **Activation Code** (a letter followed by ten digits). When the sale has been completed (Visa or Mastercard), you will be given the **Unlock Code** that will instantly activate the features you've requested.

Note: Within a few days after your purchase, you will receive a new CD in the mail that contains a backup copy of the features you've purchased (you don't need to record or keep track of the *Unlock Code*). If you need to reinstall the DynoSim, including any or all of the optional features you have activated, simply insert the new CD in your CD-ROM drive.

DYNO FILE (.DYN) COMPATIBILITY

ProRacing Sim Software's DynoSim allows you to simulate building and dyno testing an engine, but in addition you can install this simulated engine in a simulated vehicle using the DragSim. With this program you can test the combination in 1/8- or 1/4-mile drag events. And using the new FastLapSim closed-course simulation, you can test any DynoSim engine on virtually any track in any vehicle. It is ProRacing Sim Software's goal to maintain file compatibility throughout our entire software line.

DynoSim engine files (.DYN files) can be directly loaded into the DragSim and FastLapSim; no file export or modification is required.

GENERAL SIMULATION ASSUMPTIONS

The DynoSim closely simulates the conditions that exist during an actual engine dyno test. The goal is to reliably predict the torque and horsepower that a dynamometer would measure throughout the rpm range while the engine and dyno are running through a programmed test.

It is well known that engine power can vary considerably from one dyno test to another if environmental and other critical conditions are not carefully controlled. In fact, many of the discrepancies between dyno tests are due to variabilities in what should have been "fixed" conditions.

Among the many interviews conducted during the research and development of

Simulation Assumptions

ProRacing Sim Software, engine-simulation software, dyno operators and engine owners readily acknowledged the possibilities of errors in horsepower measurements. Unless the dyno operator and test personnel are extremely careful to monitor and control the surrounding conditions, including calibration of the instrumentation, comparing results from one dyno cell to another (or even one test run to another) is a futile task.

Controlling these same variables in an engine simulation program is infinitely easier but, nevertheless, just as essential. Initial conditions of temperature, pressure, energy, and methodology must be established and carefully maintained throughout the simulation process. Here are some of the assumptions within the DynoSim that establish a modeling baseline:

Fuel:

1) The fuel is assumed to have sufficient octane to prevent detonation.
2) The air/fuel ratio is always maintained at the optimum power ratio.
3) The ignition timing is maintained at an optimum power setting.

Environment:

1) Air for induction is 68-degrees (F), dry (0% humidity), and of 29.92-in/Hg atmospheric pressure.
2) The engine, oil, and coolant have been warmed to operating temperature.

Methodology:

1) The engine is put through a series of “step” tests, during which the load is adjusted to “hold back” engine speed as the throttle is opened wide. The load is adjusted to allow the engine speed to rise to the first test point, 2000rpm in the case of this simulation. The engine is held at this speed and a power reading is taken. Then engine speed is allowed to increase to the next step, 1000rpm, and a second power reading is taken. This process continues until the maximum testing speed of 11,000rpm is reached.

   Note: Since some engines, especially those with cam timing designed for all-out drag racing, are not able to run at full throttle under load at very low engine speeds, the power generated at some of the lower rpm points may register as zero.
2) Since the testing procedure increases engine speed in 500rpm steps, and engine speed is held steady during the measurement, the measured power does not reflect losses from accelerating the rotating assembly (the effects of rotational inertia in the crank, rods, etc.). These processes affect power in most “real-world” applications, such as road racing and drag racing, where engine speed is rapidly changing throughout the race.

DynoSim Racing Software

Advanced
Engine
Simulation

FAQ's

FREQUENTLY ASKED QUESTIONS

The following information may be helpful in answering questions and solving problems that you encounter when installing or using the DynoSim. If you don't find an answer to your problem here, send in the **Mail/Fax Tech Support Form** on page 143 *(ProRacing Sim Software provides Mail technical service to registered users only—mail in your registration form today or register your software on our website www.ProRacingSim.com).* We will review your problem and return an answer to you as soon as possible.

INSTALLATION/BASIC-OPERATION QUESTIONS

Question: Received an "Error Reading Drive D" (or another drive) message when attempting to run or install the DynoSim. What does this mean?

Answer: This means your computer cannot read the disk in your CD-ROM drive (or hard drive). The disk may not be properly seated in your drive, the drive may be defective, or the disk may be damaged. If you can properly read other CDs in your CD-ROM drive, but the DynoSim distribution disk produces error messages, try requesting a directory of a known-good disk by entering **DIR X:** or **CHKDSK X:** (where **X** is the drive letter of your CD-ROM drive) and then perform those same operations with the DynoSim CD. If these operations produce an error message only when using the DynoSim CD, the disk is defective. Return the disk to ProRacing Sim Software for a replacement (address at bottom of Tech Support Form). Replacements are free for the first 90-days after your purchase; after that, replacement disks are $10.00 each.

Question: Encountered "Could not locate the DynoSim CD disk" error message when trying to run the DynoSim. Why?

***Answer*:** Please insert the DynoSim disk in your CD-ROM drive. Occasionally, the DynoSim may need to access the CD. Please keep the DynoSim disk handy while you use ProRacing Sim Software products.

Question: The DynoSim produced an *Assertion Failure* error. What should I do?

***Answer*:** Please note down all of the information presented in the error-message box, provide a quick synopsis of what lead up to the error, then send this information to ProRacing Sim Software. Thank you for your assistance in helping us improve the DynoSim.

SCREEN DISPLAY QUESTIONS

Question: Even though I have a 19-inch monitor, I can only see a small portion of the DynoSim screen on my monitor. What can I do so that I don't have to scroll both horizontally and vertically?

Answer: The screen resolution of your monitor (not its size) determines how much of the DynoSim you can see on screen without scrolling left and right. You can change screen resolution by ***RIGHT CLICKING*** on your desktop, then selecting ***PROPERTIES*** from the drop-down menu. Choose the ***SETTINGS*** tab and increase screen resolution by moving the ***Screen Area*** slider to the right. For more information about screen resolution, refer to the documentation that was supplied with your computer, your video graphics card, or with Windows.

BORE/STROKE/SHORTBLOCK QUESTIONS

Question: I cannot change the bore or stroke of a test engine?

Answer: The DynoSim is running in the *Demo Mode* in which you cannot change the bores and strokes of test engines, nor can dyno files (or any other files) be loaded or saved. For additional information about the *Demo Mode*, refer to the ***Help*** button on the *Demo Engine-Selection Screen* (shown on page 121).

Question: Everyone talks about longer rod lengths and potential improvements in power. Why isn't rod length one of the choices in the pull-down menus?

Answer: We realize that many actual dyno tests have shown power increases, but our simulation tests tell us that the power, when found, probably has little to do with piston dwell at TDC (and the associated thermodynamic effects) or changes in rod angularity on the crank pin. The measured power differences are most likely due to a reduction of friction on the cylinderwall from changes in side-loading on the piston. This can vary with bore finish, ring stability, piston shape, the frictional properties of the lubricant, etc. These variabilities are highly *unpredictable*. Some development, after all, can only be done in the real world on a engine dynamometer.

COMPRESSION-RATIO QUESTIONS

Question: The DynoSim calculated the total Combustion Volume at 92ccs. But I know my cylinder heads have only 75ccs. What's wrong with the software?

Answer: This confusion comes from assuming that the calculated **Total Combustion Volume** displayed in the component-selection screen is the same as your measured combustion-chamber volume. The *Total Combustion Volume* is the entire volume that remains in the cylinder when the piston reaches top dead center. See page 34 for more information about compression volumes.

Question: When using the compression calculator in the "Piston - Has Dome, Dish, or Valve Reliefs" mode, item-4 should, but does not, allow a zero entry. Wouldn't this be the correct entry if I chose to run a zero deck clearance? Next is entry item-5: Although your manual states this is a measured amount, if I know my deck clearance is zero and I know the volume of the valve reliefs in my pistons, which I do, I should be able to enter that number and get the compression ratio. What is actually happening is when I enter .100 in item-4 and 5.00 in item-5, the compression is 13.69, much too high for my engine.

Answer: The assumption in the "domed/dished" option is that there is a volume (the combination of the displacements in the domes/dishes/pockets) that is unknown to the engine builder. The only practical way to measure this is to move the piston down the bore an arbitrary amount, say 0.250, and measure the volume in the cylinder (with a burette). This is then compared to the volume of a cylinder with the same bore diameter but of 0.250 inches high, the difference is the volume in the dome/dish/pockets.

However, on your engine, you know that the flattop pistons with valve pockets you have will produce a zero deck height at TDC, and the displacement of the valve pockets is 5cc. Knowing this, you can select the Flattop piston model, set the deck height at zero, and add 5cc to the combustion chamber volume (to allow for the valve-pocket volume in the pistons). This will yield the correct compression ratio.

You can also use the "Dome/Dish" model to determine compression ratio. Set the piston down the bore 0.100. Calculate the volume in a cylinder of the same bore diameter with a height of 0.100 and add 5cc. Plug this data in the model and you'll get the same compression ratio.

INDUCTION/MANIFOLD/FUELS QUESTIONS

Question: When I choose a carburetor that is too large for an engine (for example 1200cfm on a 283 Chevy), why does the power increase without a typically seen "bog" at low speeds?

Answer: The DynoSim, along with virtually any current computer simulation program, cannot model over-carburetion and show the reduction in low-end performance that this can cause. In reality, carburetors that are too large for an engine develop fuel atomization and air/fuel ratio instabilities, phenomena that is carburetor specific and extremely difficult to model. The DynoSim assumes an optimum air/fuel ratio regardless of the selected CFM rating. While the program produces positive results from larger-and-larger induction flows (by the way, the predicted power increases are close to reality when optimum air/fuel ratios can be maintained, as is the case in electronic fuel-injection systems), you can't go wrong if you use common sense when selecting induction/carburetor flow capacities.

Question: The engine I am building uses two 660-cfm Holley carburetors. How can I simulate the airflow?

Answer: The DynoSim will simulate induction airflow from 100 to 4000cfm, rated at either standard 4-barrel pressure drop of 1.5-inches of mercury or at standard 2-

barrel pressure drop of 3.0-inches of mercury (a pressure drop of 1 inch of mercury is equivalent to 13.55 inches of water). To simulate two, 660cfm, 4-barrel carburetors, simply add the airflow and enter the total 1320cfm value into the component-selection screen (for four-barrel carburetors, make sure the pressure drop shown in the **INDUCTION** category is 1.5-in/Hg).

CAMSHAFT/VALVETRAIN QUESTIONS

Question: I built a relatively stock engine but installed a drag-race camshaft. The engine only produced 9hp @ 2000 rpm. Is this correct?

Answer: Yes. Very low power outputs at low engine speeds occur when racing camshafts are used without complementary components, such as high-flow cylinder heads, high compression ratios, and exhaust system components that match the performance potential of the cam.

Question: The horsepower produced when I enter the seat-to-seat timing on my cam card does not match the horsepower when I enter the 0.050-inch timing figures for the same camshaft. Why are there differences?

Answer: The DynoSim uses the timing specs found on your cam card, and in cam manufacturer's catalogs, to develop a valve-motion curve (and from this curve it develops the instantaneous airflow for each port at each degree of crank rotation). Unfortunately, the seat-to-seat and/or 0.050-inch timing points do not precisely describe actual valve motion (these timing values constitute only five data points per lobe). However, using this data and a mathematical analysis of the differences between timing points, the DynoSim "creates" a valve-motion curve for use in later calculations of power and torque. To optimize the accuracy of this process, always provide both seat-to-seat and 0.050-inch timing points. With both sets of timing points, the DynoSim can automatically calculate a lifter acceleration rate. If you only have access to one set of data points, seat-to-seat timing will produce more accurate results, however, you'll have to manually guess the lifter acceleration rate.

Question: How does the DynoSim allow for the different acceleration rate cams used with hydraulic, solid, and roller lifters?

Answer: The DynoSim calculates a valve acceleration rate and a valve-motion curve from both the seat-to-seat and 0.050-inch cam timing specifications (see previous answer). Since the acceleration rate of cams is no longer directly linked to the type of lifters (mild street cams often used roller lifters), the DynoSim does not use lifter-type to determine valve motion (and, subsequently, determine horsepower). See page 79 for more information about valve timing and acceleration modeling.

Question: Can I change rockerarm ratios with the DynoSim?

Answer: Yes. Simply use this formula to alter the values you enter in the ***Lift @ Valve*** fields in the **CAMSHAFT** category (the DynoSim will calculate the new valve motion throughout the lift curve):

$$\textbf{New Lift} = \textbf{Old Lift} \times \frac{\textbf{New Ratio}}{\textbf{Old Ratio}}$$

When you have calculated the new valve lifts for the intake and exhaust valves, enter these numbers directly into the ***Lift @ Valve*** fields in the **CAMSHAFT** category (make sure **Auto Valve Lift** is turned off).

Question: I found the published factory seat-to-seat valve timing for a Pontiac engine that I am building. The IVC occurs at 112 degrees (ABDC). Something goes wrong when I enter the valve events into the DynoSim.

Answer: There are so many ways that cam specs can be described for cataloging purposes that it's confusing for anyone trying to enter can-timing specs into an engine simulation program. Your Pontiac is a classic example of a lack of standards. The Pontiac cam listed in the factory manual is a hydraulic grind with seat-to-seat timing measured at *0.001-inch lifter rise*. Because the cam is designed for long life and quite operation, it has shallow opening ramps. This is the reason for the large number of crank degrees between the opening and closing points. In fact, during the first 35 degrees of crank rotation, the lifter rises less than 0.010-inch. If this wasn't the case, and the valve opened and closed at the specified timing points listed in the factory manual, the cam would have over 350-degrees duration, and it's unlikely the engine would even start! The DynoSim can use 0.004- or 0.006-inch valve rise, 0.007-open/0.010-close valve rise, or even 0.020-inch lifter rise for seat-to-seat timing. But the 0.001-inch lifter-rise figures published in your factory manual are useless for engine simulation purposes.

Question: My cam manufacturer's catalog does not list seat-to-seat, valve-event timing. But it does list seat-to-seat intake and exhaust duration, lobe-center angle, and intake centerline. Can I calculate the valve-event timing from these figures?

Answer: Yes. Use the *Cam QuickMath™ Calculator* built into the DynoSim to calculate the intake and exhaust opening and closing points. You'll need the following information:

1) **Intake Duration**
2) **Exhaust Duration**
3) **Lobe-Center Angle** (sometimes called lobe separation angle).
4) And the **Intake Centerline Angle**.

See page 95 for more information on the *Cam QuickMath™ Calculator*.

Question: I have been attempting to test camshafts from a listing in a catalog. I can find the duration and lobe center angle. The cam manufacturer won't give me the seat-to-seat timing (they act like it's a trade secret!). Can I use the available data to test their cams?

Answer: No. As stated in the previous answer, you also need the intake-center angle to relate cam lobe positions to TDC and, therefore, crank position. Freely providing seat-to-seat timing or any of the other cam specs used in the DynoSim poses no threat to any cam grinder. It takes a lot more than valve-event timing to manufacture a quality cam; full profiles of the lobes are needed to ensure mechanically and dynamically stable operation. Cam companies that refuse to provide potential customers with simple valve-event information for evaluation in programs like the DynoSim are simply living in the “dark ages.” Our suggestion is to contact another cam manufacturer and/or check out the ProRacing Sim Software’s ***CamDisk3™*** that contains 3500+ cam files you can instantly load and test in the DynoSim. Every CamFile on *CamDisk3™* has BOTH seat-to-seat and 0.050-inch timing specs, allowing the DynoSim to automatically calculate valve acceleration rates.

QUESTIONS ABOUT RUNNING A SIMULATION

Question: The DynoSim displayed an error message “The DynoSim was unable to complete the simulation. A more balanced combination of components...” What went wrong?

Answer: The combination of components you have selected produced a calculation error in the simulation process. This is often caused by using restrictive induction flow on large-displacement engines or by using radical cam timing on otherwise mild engines. Try reducing the EVO timing specs, increasing the induction flow, selecting a cam with less duration, or reducing the compression ratio. A balanced group of components should not produce this error.

Question: The DynoSim ***Quick Iterator™*** takes several seconds to complete one cycle of a several-thousand run test. A full series takes way too long. Is there a problem with my computer or the software?

Answer: The DynoSim is a full 32-bit, highly optimized Windows program, however, it uses a powerful full-cycle simulation that performs millions of calculations for each point on the power curves, and this takes some time. Refer to page 10 for more information on computation times for several computer systems.

Question: When I run a simulation, part of the horsepower and torque graph doesn’t appear on my screen. What can I do to correct the display?

Answer: Open the **Graph Options** menu (right-click on the graph) and select ***Auto Range*** for the **Y1** or **Y2** variable. See page 100 for more information about graph scaling and plotting variables.

DynoSim
Racing Software
Advanced
Engine
Simulation

MINI GLOSSARY

0.050-Inch Cam Timing Method—See **Cam Timing**, @ 0.050-inch.

ABDC or After Bottom Dead Center—Any position of the piston in the cylinder bore after its lowest point in the stroke (BDC). ABDC is measured in degrees of crankshaft rotation after BDC. For example, the point at which the intake valve closes (IVC) may be indicated as 60-degrees ABDC. In other words, the intake valve would close 60 degrees after the beginning of the compression stroke (the compression stroke begins at BDC).

Air-Fuel Ratio—The proportion of air to fuel: by weight: that is produced by the carburetor or injector.

ATDC or After Top Dead Center—Any position of the piston in the cylinder bore after its highest point in the stroke (TDC). ATDC is measured in degrees of crankshaft rotation after TDC. For example, the point at which the exhaust valve closes (EVC) may be indicated as 30-degrees ATDC. In other words, the exhaust valve would close 30 degrees after the beginning of the intake stroke (the intake stroke begins at TDC).

Atmospheric Pressure—The pressure created by the weight of the gases in the atmosphere. Measured at sea level this pressure is about 14.69psi.
Back Pressure: A pressure developed when a moving liquid or gaseous mass passes through a restriction. “Backpressure” often refers to the pressure generated within the exhaust system from internal restrictions from tubing and tubing bends, mufflers, catalytic converters, tailpipes, or even turbochargers.

BBDC or Before Bottom Dead Center—Any position of the piston in the cylinder bore before its lowest point in the stroke (BDC). BBDC is measured in degrees of crankshaft rotation before BDC. For example, the point at which the exhaust valve opens (EVO) may be indicated as 60-degrees BBDC. In other words, the exhaust valve would open 60 degrees before the exhaust stroke begins (the exhaust stroke begins at BDC).

Big-Block—A generic term that usually refers to a V8 engine with a displacement that is large enough to require a physically “bigger” engine block. Typical bigblock engines displace over 400 cubic inches.

Blowdown or Cylinder Blowdown—Blowdown occurs during the period between exhaust valve opening and BDC. It is the period (measured in crank degrees) during which residual exhaust gases are expelled from the engine before the exhaust stroke begins. Residual gasses not discharged during blowdown must be physically “pumped” out of the cylinder during the exhaust stroke, lowering power output from consumed “pumping work.”

Bore or Cylinder Bore—The internal surface of a cylindrical volume used to retain and seal a moving piston and ring assembly. “Bore” is commonly used to refer to the cylinder bore diameter, unusually measured in inches or millimeters. Bore surfaces are machined or ground precisely to afford an optimum ring seal and minimum friction with the moving piston and rings.

Brake Horsepower (bhp)—Brake horsepower (sometimes referred to as shaft horsepower) is always measured at the flywheel or crankshaft by a “brake” or absorbing unit. Gross brake horsepower describes the power output of an engine in stripped-down, “race-ready” trim. Net brake horsepower measures the power at the flywheel when the engine is tested with all standard accessories attached and functioning. Also see Horsepower, Indicated Horsepower, Friction Horsepower, and Torque.

Brake Mean Effective Pressure (bmep)—A theoretical average pressure that would have to be present in each cylinder during the power stroke to reproduce the force on the crankshaft measured by the absorber (brake) on a dynamometer. The bmep present during the power stroke would produce the same power generated by the varying pressures in the cylinder throughout the entire four-cycle process.

BTDC or Before Top Dead Center—Any position of the piston in the cylinder bore before its highest point in the stroke (TDC). BTDC is measured in degrees of crankshaft rotation before TDC. For example, the point at which the intake valve opens (IVO) may be indicated as 30-degrees BTDC. In other words, the intake valve would open 30 degrees before the intake stroke begins (the intake stroke begins at TDC).

Cam Timing @ 0.050-Lift—This method of determining camshaft valve timing is based on 0.050 inches of tappet rise to pinpoint timing events. The 0.050-inch method was developed to help engine builders accurately install camshafts. Lifter rise is quite rapid at 0.050-inch lift, allowing the cam to be precisely indexed to the crankshaft. Camshaft timing events are always measured in crankshaft degrees, relative to TDC or BDC.

Cam Timing @ Seat-To-Seat—This method of determining camshaft timing uses a specific valve lift (determined by the cam manufacturer) to define the beginning or ending of valve events. There is no universally accepted valve lift used to define seat-to-seat cam timing, however, the Society of Automotive Engineers (SAE) has accepted 0.006-inch valve lift as its standard definition. Camshaft timing events are always measured in crankshaft degrees, relative to TDC or BDC.

Camshaft Advance/Retard—This refers to the amount of advance or retard from the manufacturers recommended timing that the cam is installed in the engine. Focusing on intake timing, advancing the cam closes the intake valve earlier. This setting typically increases low-end performance. Retarded cam timing closes the intake valve later which tends to help top end performance.

Camshaft Lift—The maximum height of the cam lobe above the base-circle diameter. A higher lobe opens the valves further, often improving engine performance. Lobe lift must be multiplied by the rocker ratio (for engines using rocker arms) to obtain total valve lift. Lifting the valve more than 1/3 the head diameter generally yields little additional performance. Faster valve opening rates add stress and increase valvetrain wear but can improve performance. High lift rates usually require specially designed, high-strength components.

Centerline—An imaginary line running through the center of a part along its axis, e.g., the centerline of a crankshaft running from front-to-back directly through the center of the main-bearing journals.

Duration or **Valve Duration**—The number of crankshaft degrees (or much more rarely, camshaft degrees) of rotation through which the valve lifter or cam follower is raised above a specified height; either seat-to-seat valve duration measured at 0.006-, 0.010-inch or other valve lifts (even 0.020-inch lifter rise), or duration measured at 0.050-inch lifter rise, called 0.050-inch duration. Intake duration is a measure of all intake lobes, and exhaust duration indicates the exhaust timing for all exhaust lobes. Longer cam durations hold the valves open longer, often allowing increased cylinder filling or scavenging at higher engine speeds.

Exhaust Center-Angle/Centerline or **ECA—**The distance in crank degrees from the point of maximum exhaust valve lift (on symmetric cam profiles) to TDC during the valve overlap period.

Exhaust Valve Closing or **EVC**—The point at which the exhaust valve returns to its seat, or closes. This valve timing point usually occurs early in the intake stroke. Although EVC does not have substantial effects on engine performance, it contributes to valve overlap (the termination point of overlap) that can have a significant effect on engine output.

Exhaust Valve Opening or **EVO**—The point at which the exhaust valve lifts off of its seat, or opens. This valve timing point usually occurs late in the power stroke. EVO usually precedes BDC on the power stroke to assist exhaust-gas *blowdown*. The EVO timing point can be considered the second most important cam timing event from a performance standpoint.

Filling & Emptying Simulation—This engine simulation technique includes multiple models (e.g., thermodynamic, kinetic, etc.), and by dividing the intake and exhaust passages into a finite series of sections it describes mass flow into and out of each section at each degree of crank rotation. The Filling And Emptying method can accurately predict average pressures within sections of the intake and exhaust system and dynamically determine VE and engine power. However, the basic Filling And Emptying model can not account for variations in pressure *within* individual sections due to gas dynamic effects.

Four-Cycle Engine—Originally devised by Nikolaus Otto in 1876, the four-cycle engine consists of a piston moving in a closed cylinder with two valves (one for inlet and one for outlet) timed to produce four separate strokes, or functional cycles: Intake, Compression, Power, and Exhaust. Sometimes called the ”suck, squeeze, bang, and blow” process, this technique—combined with a properly atomized air/fuel mixture and a precisely timed spark ignition—produced an engine with high efficiency and power potential. The DynoSim is designed to simulate the functional processes of a four-cycle engine.

Horsepower—Torque measures how much work (an engine) *can* do; and power is the rate-based measurement of *how fast* the work is being done. Starting with the static force applied at the end of a torque arm (torque), then multiplying this force by the swept distance through which the same force would rotate the torque arm one full revolution determines the power per revolution: Power Per Revolution = Force or Weight x Swept Distance. James Watt (1736-1819) established the current value for one horsepower: 33,000 pound-feet per minute or 550 pound-feet per second. So horsepower is currently calculated as: Horsepower = Power Per Revolution/33,000, which is the same as Horsepower = (Torque x 2 x Pi x RPM)/33,000, or simply: Horsepower = (Torque x RPM)/5,252. The horsepower being calculated by these equations is just one of several ways to rate engine power output. Various additional methods for calculating or measuring engine horsepower are commonly used (to derive friction horsepower, indicated horsepower, etc.), and each technique provides additional information about the engine under consideration.

Induction Airflow—The airflow rating (a measurement of restriction) of a carburetor or fuel injection system. Standard automotive four-barrel carburetors are rated by the measured airflow when the device is subjected to a pressure drop equal to 1.5-inches of mercury. Two-barrel carburetors are tested at 3.0-inches of mercury.

Intake Centerline Angle—The distance in crank degrees from the point of maximum intake valve lift (on symmetric cam profiles) to TDC during the valve overlap period.

Mini Glossary

Intake Stroke—One of the four 180-degree full "sweeps" of the piston moving in the cylinder of a four-stroke, internal-combustion engine (originally devised by Nikolaus Otto in 1876). During the intake stroke, the piston moves from *TDC* to *BDC* and inducts (draws in by lowering the pressure in the cylinder) air/fuel mixture through the induction system. Note: The 180-degree duration of the intake stroke is commonly shorter than the period during which the intake valve is open, sometimes referred to as the true "Intake Cycle." The intake stroke is followed by the compression stroke.

Intake Valve Closing or **IVC**—Considered the most important cam timing event from a performance standpoint. The point at which the intake valve returns to its seat, or closes. This valve timing point usually occurs early in the compression stroke. Early IVC helps low-end power by retaining air/fuel mixture in the cylinder and reducing charge reversion at lower engine speeds. Late IVC increases high-speed performance (at the expense of low speed power) by allow additional charge to fill the cylinder from the ram-tuning effects of the induction system at higher engine speeds.

Intake Valve Opening or **IVO**—The point at which the intake valve lifts off of its seat, or opens. This valve timing point usually occurs late in the exhaust stroke. Although IVO does not have a substantial effect on engine performance, it contributes to valve overlap (the beginning point of overlap) that can have a significant effect on engine output.

Lobe-Center Angle or **LCA**—The angle in cam degrees from maximum intake lift to maximum exhaust lift. Typical LCAs range from 100 to 116 camshaft degrees (or 200 to 232 crank degrees).

Normally Aspirated—When the air-fuel mix is inducted into the engine solely by the lower pressure produced in the cylinder during the intake stroke; aspiration not aided by a supercharger.

Otto-Cycle Engine—See Four-Cycle Engine

Overlap or **Valve Overlap**—The period, measured in crank degrees, when both the exhaust valve and the intake valve are open. Valve overlap allows the negative pressure scavenge wave to return from the exhaust system and begin the inflow of air/fuel mixture into the cylinder even before the intake stroke begins. The effectiveness of the overlap period is dependent on engine speed and exhaust "tuning."

RPM—Revolutions Per Minute. A unit of measure for angular speed. As applied to the IC engine, rpm indicates the instantaneous rotational speed of the crankshaft described as the number of crank revolutions that would occur every minute if that instantaneous speed was held constant throughout the measurement period. Typical idle speeds are 300 to 800rpm, while peak engine speeds can reach as high as

10,000rpm or higher in some racing engines.

Simulation and **Engine Simulation**—A engine simulation process or program attempts to predict real-world responses from specific component assemblies by applying fundamental physical laws to “duplicate” or simulate the processes taking place within the components.

Smallblock—A generic term that usually refers to a V8 engine with a displacement small enough to be contained within a “small” size engine block. Typical smallblock engines displace under 400 cubic inches.

Stroke—The maximum distance the piston travels from the top of the cylinder (at TDC) to the bottom of the cylinder (at BDC), measured in inches or millimeters. The stroke is determined by the design of the crankshaft (the length of the stroke arm).

Top Dead Center or **TDC**—The position of the piston in the cylinder bore at its uppermost point in the stroke. Occurs twice within the full cycle of a four-stroke engine; at the start of the intake stroke and 360 degrees later at the end of the compression stroke.

Torque—The static twisting force produced by an engine. Torque varies with the length of the “arm” over which the twisting force is measured. Torque is a force *times* the length of the measurement arm: *Torque = Force x Torque Arm*, where *Force* is the applied or the generated force and *Torque Arm* is the length through which that force is applied. Typical torque values are ounce-inches, pound-feet, etc.

Valve Head and **Valve Diameter**—The large end of an intake or exhaust valve that determines the working diameter. Valve head temperature can exceed 1200 degrees(F) during engine operation and a great deal of that heat is transferred to the cylinderhead through the contact surface between the valve face and valve seat.

Valve Lift—The distance the valve head raises off of the valve seat as it is actuated through the valvetrain by the camshaft. Maximum valve lift is the greatest height the valve head moves off of the valve seat; it is the lift of the cam (lobe height minus base-circle diameter) multiplied by the rockerarm ratio (in engines equipped with rockerarms).

Valve Motion Curve or **Valve Displacement Curve**—The movement (or lift) of the valve relative to the position of the crankshaft. Different cam styles (i.e., flat, mushroom, or roller) typically have different displacement curve acceleration rates. Engine simulation programs calculate a valve motion curve from valve event timing, maximum valve lift, and other cam timing specifications.

Volumetric Efficiency—An engine measurement calculated by dividing the mass of air inducted into the cylinder between IVO and IVC by the mass of air that would fill the cylinder at atmospheric pressure (with the piston at BDC). Typical values range from 0.6 to 1.2, or 60% to 120%. Peak torque always occurs at the engine speed that produced the highest volumetric efficiency.

Dyno Testing Notes

Dyno Testing Notes

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Tech Support Request

Please use this form (or a copy) to obtain technical support for the DynoSim from ProRacing Sim, LLC. Fill out all applicable information about your system configuration and describe your problem thoroughly. We will attempt to duplicate the problem and respond to your questions as soon as possible. Mail this form and any dyno-test printouts to the address below (you may also send Tech Support requests to support@ProRacingSim.com; attach any .DYN or related files). *Note: We will only respond to problems from registered users—if you haven't already, please fill out and submit the registration form that appears when you first start DynoSim.*

Your Phone (   ) _______-__________ Your Fax (   ) _______-___________

Your Name ____

Address ______________________________ Apt. or Building __________

City __________________________ State _____ ZipCode ___________

Email ____

Brand of computer _____________________ CPU ________ Speed ________

Running Windows95 ☐ Windows9898SE ☐ Windows2000 ☐ WindowsXP ☐
(If not listed here, what version ____________________)

Version of DynoSim (see front of CDROM) ___________________________

Please describe the problem you encountered with the **DynoSim:** ____________

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Can you duplicate the problem? ____________________________________

Mail/Fax this form to:

ProSim Racing, LLC.
3400 Democrat Road, Suite 207
Memphis, TN 38118, Email: support@ProRacingSim.com

DynoSim
Racing Software

ProRacing Sim, LLC.
3400 Democrat Road, Suite 207
Memphis, TN 38118

For Tech Support Contact: 901-259-2355
Web: www.ProRacingSim.com
Email: support@proracingsim.com