ProRacing Sim, LLC.

Sport Compact DynoSim
Racing Software

DeskTop Sport Compact Dyno
DeskTop Simulation Series

Sport-Compact Engine Simulations

Users Guide

And Engine Builder's Handbook

For Windows95/98/Me/2000/XP

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SC-DynoSim Simulation v4.11.0504

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

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INTRODUCTION

Note: *If you can't wait to start this Sport Compact Engine Simulation, feel free to jump ahead to* **INSTALLATION** on page 11, *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.*

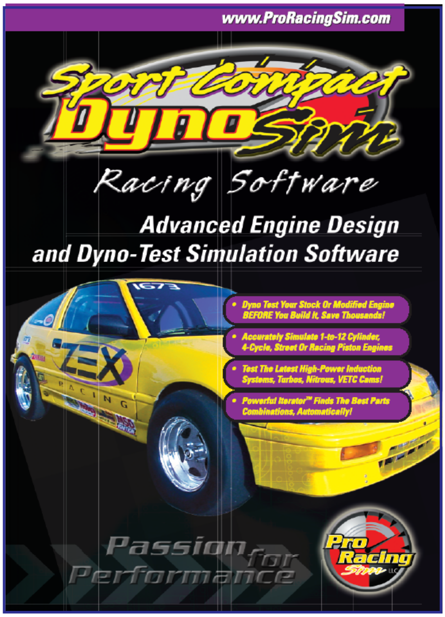
Thank you for purchasing the DeskTop SC-Dyno™ or the SC-DynoSim™ for IBM®-PC-compatible computers. This software is the result of several years of development and testing. We hope it helps you further your understanding and enjoyment of engines, performance, and racing technology.

HOW IT WORKS

The SC-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 SC-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.

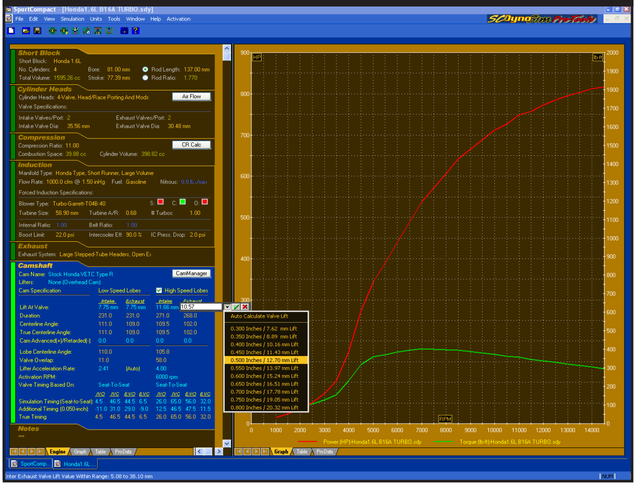
You will find that many other simulation programs on the market (even a few that sell for several times the price of the SC-DynoSim) are not true engine *simulations*. Rather, they calculate the volumetric efficiency (VE) and then derive an estimate of torque and horsepower. There are many shortcomings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

The SC-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 SC-DynoSim

SC-DynoSim Main Component Screen



Short Block

Short Block: Honda 1.6L

No. Cylinders: 4 Bore: 81.00 mm ● Rod Length: 137.00 mm

Total Volume: 1595.26 cc Stroke: 77.39 mm ○ Rod Ratio: 1.770

Cylinder Heads

Cylinder Heads: 4-Valve, Head/Race Porting And Mods

Valve Specifications:

Intake Valves/Port: 2 Exhaust Valves/Port: 2

Intake Valve Dia: 35.56 mm Exhaust Valve Dia: 30.48 mm

Compression

Compression Ratio: 11.00

Combustion Space: 39.88 cc Cylinder Volume: 398.82 cc

Induction

Manifold Type: Honda Type, Short Runner, Large Volume

Flow Rate: 1000.0 cfm @ 1.50 inHg Fuel: Gasoline Nitrous: 0.0 lbs/min

Forced Induction Specifications:

Blower Type: Turbo-Garrett-T04B-40 S: 🟥 C: 🟩 O: 🟥

Turbine Size: 58.90 mm Turbine A/R: 0.68 # Turbos: 1.00

Internal Ratio: 1.00 Belt Ratio: 1.00

Boost Limit: 22.0 psi Intercooler Eff: 90.0 % IC Press. Drop: 2.0 psi

Exhaust

Exhaust System: Large Stepped-Tube Headers, Open E›

Camshaft

Cam Name: Stock Honda VETC Type R

Lifters: None (Overhead Cam)

Cam Specification	Low Speed Lobes Intake	Low Speed Lobes Exhaust	☑ High Speed Lobes Intake	High Speed Lobes Exhaust
Lift At Valve:	7.75 mm	7.75 mm	11.66 mm	10.57
Duration:	231.0	231.0	271.0	268.0
Centerline Angle:	111.0	109.0	109.5	102.0
True Centerline Angle:	111.0	109.0	109.5	102.0
Cam Advanced(+)/Retarded(-):	0.0	0.0	0.0	0.0
Lobe Centerline Angle:	110.0		105.8	
Valve Overlap:	11.0		58.0	
Lifter Acceleration Rate:	2.41	(Auto)	4.00	
Activation RPM:			6000 rpm	
Valve Timing Based On:	Seat-To-Seat		Seat-To-Seat	

	IVO	IVC	EVO	EVC	IVO	IVC	EVO	EVC
Simulation Timing (Seat-to-Seat):	4.5	46.5	44.5	6.5	26.0	65.0	56.0	32.0
Additional Timing (0.050-inch):	-11.0	31.0	29.0	-9.0	12.5	46.5	47.5	11.5
True Timing	4.5	46.5	44.5	6.5	26.0	65.0	56.0	32.0

Auto Calculate Valve Lift

0.300 Inches / 7.62 mm Lift
0.350 Inches / 8.89 mm Lift
0.400 Inches / 10.16 mm Lift
0.450 Inches / 11.43 mm Lift
0.500 Inches / 12.70 mm Lift
0.550 Inches / 13.97 mm Lift
0.600 Inches / 15.24 mm Lift
0.650 Inches / 16.51 mm Lift
0.700 Inches / 17.78 mm Lift
0.750 Inches / 19.05 mm Lift
0.800 Inches / 20.32 mm Lift

Notes

***

Enter Exhaust Valve Lift Value Within Range: 5.08 to 38.10 mm

The SC-DynoSim incorporates a completely unique, intuitive user interface (this is just one of four color schemes available from the View menu, see page 14). If you wish to change an engine component, simply click on the component name and select a new component from the drop-down list. The comprehensive data graphs are fully customizable. Multiple engine and/or data value comparisons are possible. All components and graphics displays can be printed (in full color with ProTools™).

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 SC-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 SC-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 Sport Compact DynoSim

The features in SC-DynoSim include substantial enhancements to simulation modeling, including new short-stroke and small-bore models. The SC-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 SC-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!

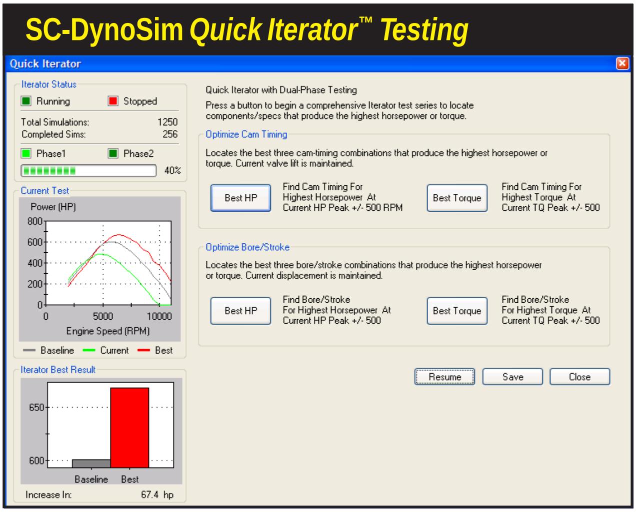
In addition to these major enhancements, you will find hundreds of other improvements to the SC-DynoSim. In fact, two years of programming and design were devoted to the SC-DynoSim simulation. Updated features include a new, overall (WindowsXP) look, improved menu selections, more airflow and camfiles, a substantially expanded users manual, optional ***Advanced*** version and ***ProTool™ Kit™*** are described on page 134.

SC-DynoSim REQUIREMENTS

Make sure you have the basic hardware and software required to run the SC-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 800 x 600 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 SC-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).

***Iterative Testing*™ is a powerful feature of the SC-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 SC-DynoSim keeps track of all the results and displays the best matches to your test criterion.**



SC-DynoSim *Quick Iterator™ Testing*

Quick Iterator

Iterator Status

Total Simulations: 1250

Completed Sims: 256

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.

Optimize Cam Timing

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

Optimize Bore/Stroke

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

Iterator Best Result

Increase In: 67.4 hp

Introduction To The SC-DynoSim

REQUIREMENTS—ADDITIONAL CONSIDERATIONS

Windows95/98/Me/NT/2000/XP: The SC-DynoSim is a full 32-bit program designed for Windows95 through WindowsXP (all versions). The SC-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).

Video Graphics Card And Monitor: An 800 x 600 resolution monitor/video card are required to use the SC-DynoSim. Systems with 1024 x 768 resolution or higher provide more screen "real estate," and this additional display space is very helpful in component selection and power-curve analysis.

Note 1: See FAQ on page 139 for help in changing the screen resolution of your system and monitor.

System Processor: The SC-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 SC-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 (without forced induction or Variable Valve Timing) 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	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 SC-

DynoSim. While most component selections can be performed with the keyboard, several operations within the SC-DynoSim require the use of a mouse.

Printer: The SC-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 130 for more information about SC-DynoSim printing).

Sport Compact DynoSim
Racing Software
Advanced Engine Simulation

INSTALLATION

Software Installation

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

- The SC-DynoSim requires Windows 95/98/Me® or Windows NT/2000/XP® and at least 64MB of installed memory (see page 9 for more information about system requirements).
- A software SETUP program will install SC-DynoSim onto the **Windows-Install** drive in the **SportCompactDynoSim** 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.

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

3) An *Installation Menu* will be displayed on your desktop within 5 to 30 seconds (depending on the speed of your CD drive). From the options provided, click on **Install Sport Compact DynoSim** (optionally, you can install demos of other ProRacing Sim software from this Menu).
   Note: If the software *Installation Menu* does not automatically appear on your desktop within 30 to 60 seconds, choose ***Settings*** from the ***Start*** menu, select ***Control Panels***, then double click ***Add/Remove Programs***, finally click on ***Install***.

4) 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.

5) 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.

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

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

7) Next you will be presented a dialog indicating the recommended install directory and/or path. If you cannot install the SC-DynoSim on the recommended drive or at the location indicated, you can click **CHANGE**, and enter an alternate location. **Note:** If you do not install this software at the recommended location, updates or upgrades to this simulation released in the future may not install properly or function correctly on your system.

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 the installation.

Starting SC-DynoSim

10) To start SC-DynoSim, open the Windows **Start** menu, select **Programs**, then choose ***ProRacing Sim Software***, ***Sport Compact DynoSim***, and finally click on the ***SC-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 the 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 or special events that will be conducted in the weeks and months ahead.

Note: Demos of the new *DragSim* and *FastLapSim* have been included on the CD-

ROM with SC-DynoSim. They can be installed from the *Installation Menu* described in Step 3 on page 12. After installation, run any of 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 134).

12) You can 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 Manual 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 page 139 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 157. Mail the completed form to:

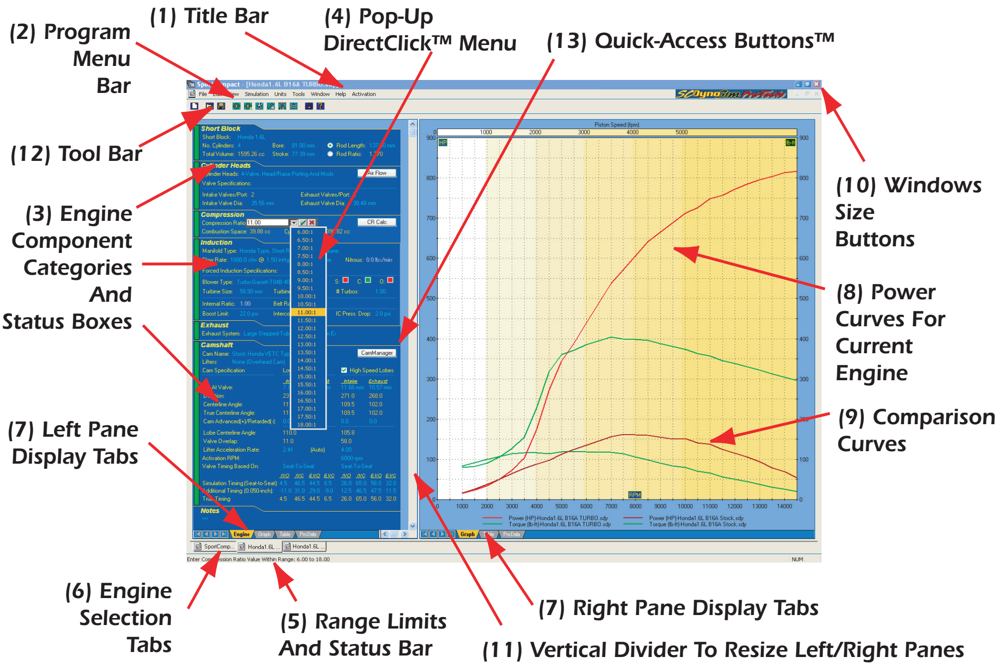
ProRacing Sim Software, LLC.
3400 Democrat Road, Suite 207
Memphis, TN 38118
Tech: 901-259-2355, or visit our
Web: www.proracingsim.com
Email: support@proracingsim.com

Note: Tech support will only be provided to registered users. Please complete the *Registration Form* that appears when you first start your software to qualify for technical support from the ProRacing Sim Software staff. If you need to change your address or any other personal information after you have registered, simply select Registration from the Help menu, make any changes, then press ***Proceed*** to send your updated info ProRacing Sim.

Sport Compact DynoSim Racing Software

Advanced Engine Simulation

OVERVIEW



THE MAIN PROGRAM SCREEN

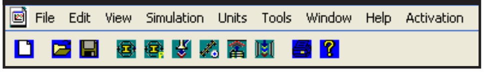
The **Main Program Screen** allows you to select engine components, dimensions, and specifications. In addition, engine power curves and/or simulation data is displayed in graphical and chart form. The Main Program Screen is composed of the following elements:

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



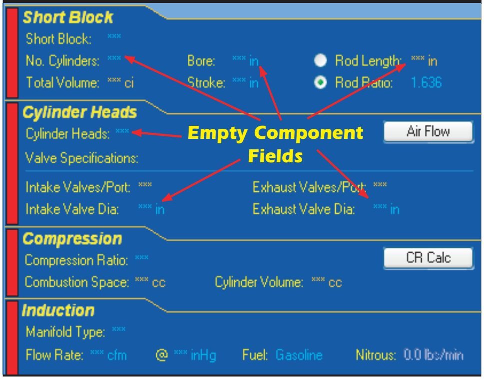
Program Menu Bar contains eight pull-down menus that control overall program function.

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. You can also select from four unique program color schemes, including *Basic Blue*, *Deep Blue, Orange Original* and *Standard Windows Colors*.
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.

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

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

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

Induction
Manifold Type: ***
Flow Rate: *** cfm @ *** inHg
Fuel: Gasoline
Nitrous: 0.0 lbs/min

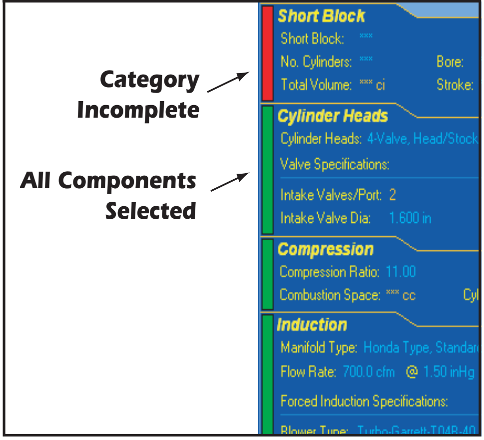
Product Activation—Activates optional features of the SC-DynoSim, such as ProTools™, ProIterator™ and other optional features.

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

SHORT BLOCK—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 35).
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 43).
EXHAUST—Selects the exhaust-system configuration (see page 73).
CAMSHAFT—Selects the camshaft type, lifter type, and allows direct entry of valve timing and lift data (see page 79).
NOTES—Enter any comments about the current simulation. Notes are saved with the engine *.SDY* file.

Note: Each component category (except *NOTES*) contains a **Status Box** located at the left of the category. These indicators display either as a red box, indicating that the category is not complete (inhibiting a simulation run), or a green-box 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

Component Status Boxes



Short Block
Short Block: ***
No. Cylinders: *** Bore:
Total Volume: *** ci Stroke:

Cylinder Heads
Cylinder Heads: 4-Valve, Head/Stock
Valve Specifications:
Intake Valves/Port: 2
Intake Valve Dia: 1.600 in

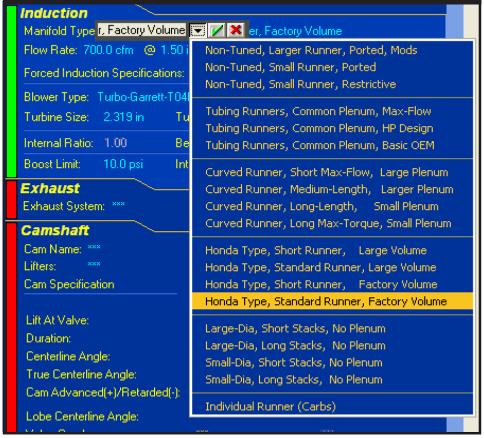
Compression
Compression Ratio: 11.00
Combustion Space: *** cc Cyl

Induction
Manifold Type: Honda Type, Standar
Flow Rate: 700.0 cfm @ 1.50 inHg
Forced Induction Specifications:
Blower Type: Turbo-Garrett-T04B-40

A Status Box is located at the left of each Component Category. These boxes are either red, indicating that the category is not complete (inhibiting a simulation run), or green indicating that all components in that category have been selected

Program Overview

DirectClick™ Component Menus



Manifold Type: r, Factory Volume ✓ ✗ er, Factory Volume
Flow Rate: 700.0 cfm @ 1.50 i
Forced Induction Specifications:
Blower Type: Turbo-Garrett-T04I
Turbine Size: 2.319 in
Internal Ratio: 1.00
Boost Limit: 10.0 psi
Exhaust System: ***
Cam Name: ***
Lifters: ***
Cam Specification
Lift At Valve:
Duration:
Centerline Angle:
True Centerline Angle:
Cam Advanced(+)/Retarded(-):
Lobe Centerline Angle:

The DirectClick™ 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.

[the default setting], see **Simulation Menu** described on the previous page).

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 Bar** at the bottom of the screen.

6) The SC-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 Bar** (see photo, page 14). 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.

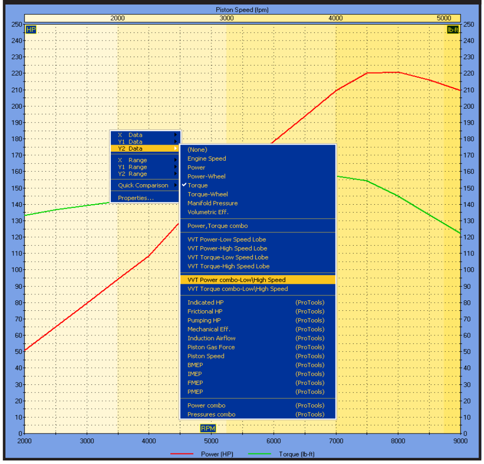
8) The **Current Engine Power Curves** window displays the horsepower and torque for the currently-selected engine. Horsepower and torque are the default curves, however, the graphic data display can be customized by right-clicking on the graph and reassigning each curve in the **Graph Options Box**.

9) Use **Properties...** in the **Graph Options Box** to create direct comparisons be-

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 Graph Tab* at the bottom of the component screen).

Graph Options Box



tween up to four "open" engines.

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 SC-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 **CYLINDER HEAD** 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 SC-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 SC-DynoSim; if the SC-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 ***SHORT BLOCK*** 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 17), 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.

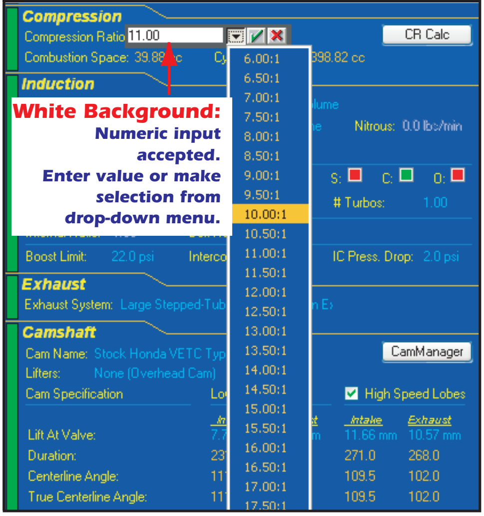
6) Click the left mouse button on your selection. This loads the engine name, bore, stroke, and number of cylinders into the ***SHORT BLOCK*** category. Note that the red boxed **X** (Component Category Status Box) on the left of the ***SHORT BLOCK*** category changed to a green-boxed checkmark ✔, indicating 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.

Program Overview

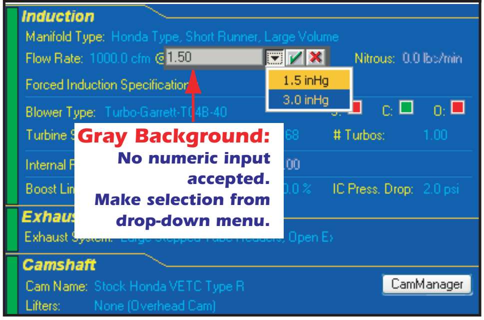
Fields Accepting Direct Input



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.

Keyboard

1) Press and release the **Alt** key followed by the **F** key to highlight and open the File 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 ***SHORT BLOCK*** 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 ***SHORT BLOCK*** category. Note that the red boxed **X** (Status Box) on the left of the ***SHORT BLOCK*** 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 SC-DynoSim can accurately predict power. The range limits are displayed in the **Range Limit Line** within the **Status Bar** at the bottom-left of the Main Program Screen (see page 14). If you enter an invalid number, the SC-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 (for the Basic Blue color scheme):

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 orange, it indicates values are automatically calculated by program and cannot be directly altered.

Orange Numeric Values: Orange 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.

Light Blue (Cyan): 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*** located in the ***Status Bar***).

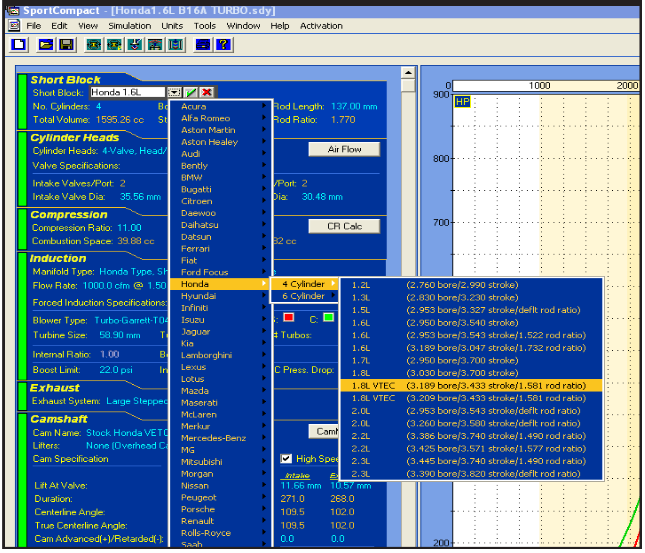
Sport Compact DynoSim
Racing Software

Advanced
Engine
Simulation

COMPONENT MENUS

THE SHORTBLOCK COMPONENT CATEGORY MENUS

The **Short Block** menu is located on the upper-left of the **SHORT BLOCK** 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 **SHORT BLOCK** 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).



Short Block Component Menu

Short Block: Honda 1.6L
No. Cylinders: 4
Total Volume: 1595.26 cc
Rod Length: 137.00 mm
Rod Ratio: 1.770
Cylinder Heads: 4-Valve, Head/
Valve Specifications:
Intake Valves/Port: 2
Intake Valve Dia: 35.56 mm
/Port: 2
Dia: 30.48 mm
Compression Ratio: 11.00
Combustion Space: 39.88 cc
Manifold Type: Honda Type, Sh
Flow Rate: 1000.0 cfm @ 1.50
Forced Induction Specifications:
Blower Type: Turbo-Garrett-T04
Turbine Size: 58.90 mm
Turbos:
Internal Ratio: 1.00
Boost Limit: 22.0 psi
C Press. Drop:
Exhaust System: Large Stepped
Cam Name: Stock Honda VETC
Lifters: None (Overhead Ca
Cam Specification
☑ High Spee

	Intake	Ex
Lift At Valve:	11.66 mm	10.57 mm
Duration:	271.0	268.0
Centerline Angle:	109.5	102.0
True Centerline Angle:	109.5	102.0
Cam Advanced(+)/Retarded(-):	0.0	0.0

1.2L	(2.760 bore/2.990 stroke)
1.3L	(2.830 bore/3.230 stroke)
1.5L	(2.953 bore/3.327 stroke/deflt rod ratio)
1.6L	(2.950 bore/3.540 stroke)
1.6L	(2.953 bore/3.543 stroke/1.522 rod ratio)
1.6L	(3.189 bore/3.047 stroke/1.732 rod ratio)
1.7L	(2.950 bore/3.700 stroke)
1.8L	(3.030 bore/3.700 stroke)
1.8L VTEC	(3.189 bore/3.433 stroke/1.581 rod ratio)
1.8L VTEC	(3.209 bore/3.433 stroke/1.581 rod ratio)
2.0L	(2.953 bore/3.543 stroke/deflt rod ratio)
2.0L	(3.260 bore/3.580 stroke/deflt rod ratio)
2.2L	(3.386 bore/3.740 stroke/1.490 rod ratio)
2.2L	(3.425 bore/3.571 stroke/1.577 rod ratio)
2.3L	(3.445 bore/3.740 stroke/1.490 rod ratio)
2.3L	(3.390 bore/3.820 stroke/deflt rod ratio)

The *Short Block* component menu contains over 500 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.

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 **SHORT BLOCK** 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 over 500 **Short Block** menu selections will 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 **SHORT BLOCK** 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

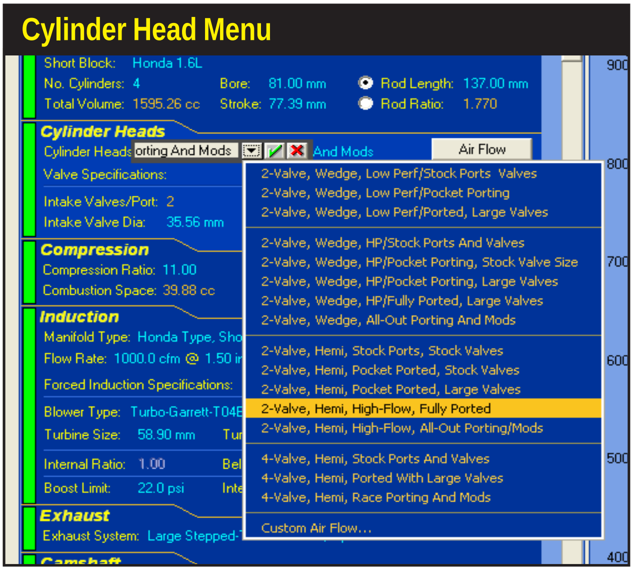
After selecting the Bore, Stroke, Rod Ratio, and Number-Of-Cylinders, the swept cylinder volume and the total engine volume (displacement) will be displayed. The swept cylinder volume measures the volume displaced by the movement of a single piston from TDC (top dead center) to BDC (bottom dead center). 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

Short Block: Honda 1.6L
No. Cylinders: 4 Bore: 81.00 mm ● Rod Length: 137.00 mm
Total Volume: 1595.26 cc Stroke: 77.39 mm ○ Rod Ratio: 1.770

Cylinder Heads
Cylinder Heads orting And Mods And Mods
Valve Specifications:
Intake Valves/Port: 2
Intake Valve Dia: 35.56 mm

Compression
Compression Ratio: 11.00
Combustion Space: 39.88 cc

Induction
Manifold Type: Honda Type, Sho
Flow Rate: 1000.0 cfm @ 1.50 in
Forced Induction Specifications:
Blower Type: Turbo-Garrett-T04E
Turbine Size: 58.90 mm Tur
Internal Ratio: 1.00 Bel
Boost Limit: 22.0 psi Inte

Exhaust
Exhaust System: Large Stepped-

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 SC-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 SC-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 SC-DynoSim to model any cylinder head for which flow data is available. This option will be described in more detail later (see page 31).

Basic Flow Theory

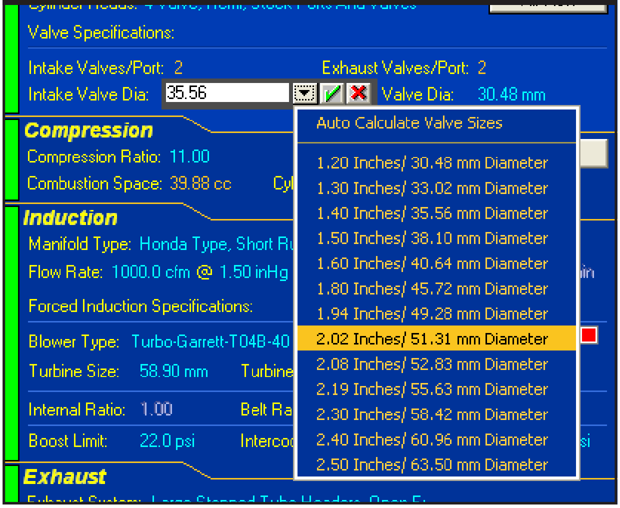
A selection from the **Cylinder Head** menu is the first part of a two-step process used by the simulation to accurately model cylinder head flow characteristics. The initial selection of a cylinder head determines the airflow restriction generated by the ports. That is, the menu choices establishes *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 SC-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 SC-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

Selecting a specific valve size fixes the theoretical peak flow (called *isentropic* flow) of each port. Most cylinder heads flow only about 50% to 70% of this value. This percentage, 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. In other words, the discharge coefficient provides a practical method to determine mass flow into the cylinder within a large range of cylinder heads under a wide range of operational conditions.

Selecting Valve Sizes



Valve Specifications:

Intake Valves/Port: 2

Exhaust Valves/Port: 2

Intake Valve Dia: 35.56

Valve Dia: 30.48 mm

Compression

Compression Ratio: 11.00

Combustion Space: 39.88 cc

Induction

Manifold Type: Honda Type, Short Ru

Flow Rate: 1000.0 cfm @ 1.50 inHg

Forced Induction Specifications:

Blower Type: Turbo-Garrett-T04B-40

Turbine Size: 58.90 mm

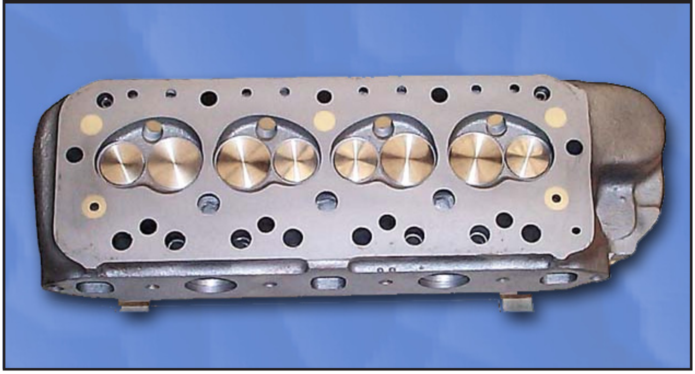
Internal Ratio: 1.00

Boost Limit: 22.0 psi

Exhaust

Cylinder Head Menu

Typical Low-Performance Cylinder Heads



The *Low Performance* cylinder head choices are intended to model cylinder heads that have restrictive ports, valves, and combustion chambers. Heads of this type were often designed for low-speed, economy applications, with little concern for high-speed performance.

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 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 predicting total mass flow moving into and out of the cylinders. Furthermore, the discharge coefficient also can be used to simulate 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 substantial range of cylinder heads 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.

2-Valve, Wedge, Low Performance—There are three ***Low Performance*** cylinder head selections listed at the top of the **Cylinder Head Type** 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. 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 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 second choice represents a ***2-Valve, Low Performance Head With Pocket Porting***.

Cylinder Head Menu

This 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 ***2-Valve, Low Performance/Ported, Large Valves*** incorporates the same modifications plus slightly larger intake and exhaust valves and some modest work in the port runners.

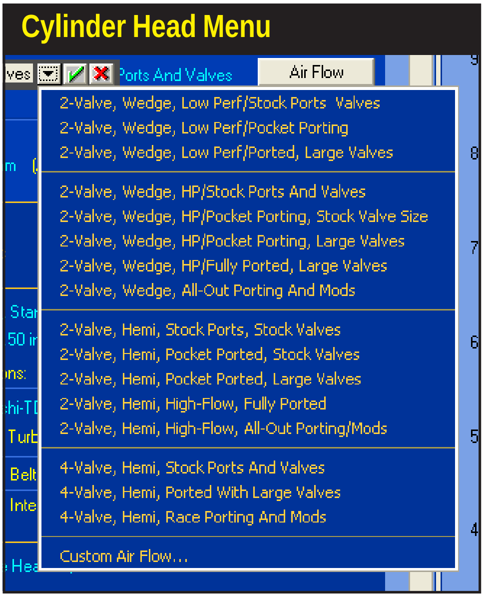
> **Note:** If you are using the Auto-calculate valve size feature with ***Low Performance/ Ported, Large Valves*** heads, the valve diameters will increase, but sizes are always scaled to a proportion that will install in production castings without extensive modifications.

The low-performance choices are intended to model production engines available in low-cost "economy sedans," primarily designed for basic transportation.

2-Valve, Wedge, HP Cylinder Heads—The wedge-chamber choices in the second group on the menu comprise the two, main cylinderhead categories. Choices from these two groups are applicable to a majority of all performance engine applications.

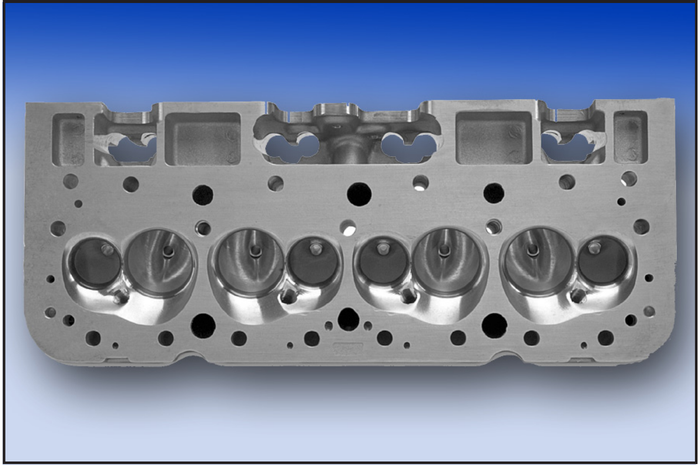
The first three basic wedge selections model heads that have ports and valves sized with performance in mind. Ports are not excessively restrictive for high-speed operation, and overall port and valve-pocket design offers a good compromise between low restriction and high flow velocity. The stock and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

The fourth wedge head ***Wedge, HP/Fully Ported, Large Valves*** begins to move 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



The *Cylinder Head* menu is divided into five groups. As you move down the menu, each group flows more air and improves engine performance. The heads most used in Sport Compact performance engines are in the fourth group, the *4-Valve, Hemi* selections. A Custom Port Flow selection is also provided that allows the SC-DynoSim to model virtually any cylinder head for which flow data is available.

Cylinder Head Menu



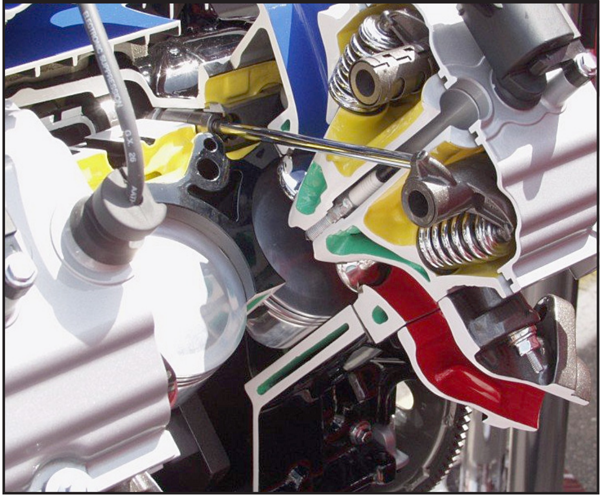
2-Valve, HP Wedge Cylinder Heads

The *2-Valve, HP Wedge Cylinder Head* selections model cylinder heads that have ports and valves sized with performance in mind, like this smallblock Chevy head from Edelbrock.

intake manifolds.

The last choice in the wedge group is ***Wedge, HP/ProStock Porting And Mods***. This selection is designed to model state-of-the-art, drag-racing cylinder heads (when the limitation is one-valve-per-port). These custom pieces are designed for one thing: High Horsepower. They usually require hand-fabricated intake manifolds, have high valve discharge coefficients, and the ports have the largest cross-sectional areas in the 2-Valve, HP/Wedge group.

2-Valve, Hemi, HP Cylinder Heads—All Hemi-Chamber “canted-valve” selections



2-Valve, Hemi, HP Cylinder Heads

The *2-Valve, Hemi, HP Cylinder Head* selections have ports with generous cross-sectional areas and valves that angle toward the port inlets (the new Dodge 5.7L Hemi is shown here). These heads have improved discharge coefficients and are the highest flowing 2-valve cylinder heads. With the exception of 4-valve designs, heads of this type have the potential of producing the highest horsepower within the first three groups in the *Cylinder Head Type* menu.

model heads with valves tilted toward the port inlets. This improves the discharge coefficient and overall airflow. All ports in this menu group have generous cross-sectional areas for excellent high-speed performance.

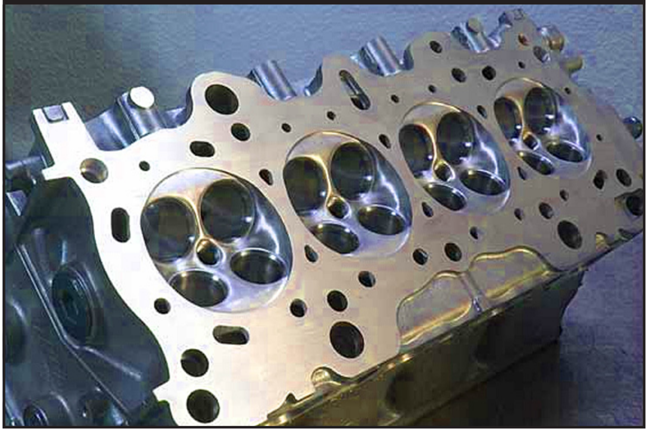
The first three choices can be considered suitable for street/performance applications. These selections model smaller cross-sectional area ports that provide a good compromise between low restriction and high flow velocity for larger displacement engines. The pocket-ported choices are suitable for modest racing applications.

The final two Hemi selections simulate extensively modified heads. These choices model, primarily, all-out, racing cylinder heads. As with the Wedge category, the ***Hemi, High-Flow, Fully Ported*** heads are not suitable 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 ***2-Valve Hemi*** group is ***Hemi, High-Flow, All-Out Porting/ Mods***. This selection is designed to model state-of-the-art, 2-valve, 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 Type** menu, except for 4-valve heads (discussed next). These specially fabricated cylinder heads only develop sufficient airflow for good cylinder filling at high engine speeds.

4-Valve, Hemi Cylinder Heads—The next three selections in the **Cylinder Head Type** submenu model the very low-restriction ports and valves used in 4-valve cylinder heads; the basic mainstay of the Sport Compact enthusiast. 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

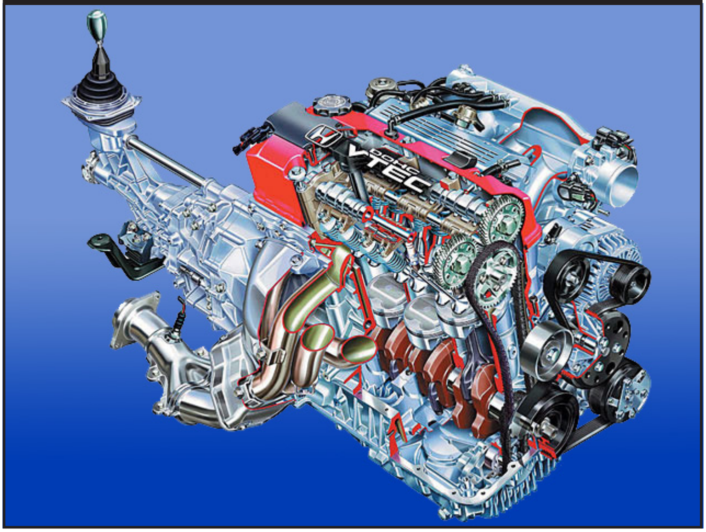
4-Valve, Hemi, HP Cylinder Heads



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.

Cylinder Head Menu

Honda VTEC, 4-Valve, Hemi Engine



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.

interface. Since there are two intake and two exhaust valves 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 can occur 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 (as is the case in VTEC engines). 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 performance engines.

The first choice in the 4-valve group is ***4-Valve, Hemi, Stock Ports And Valves***. This simulates a 4-valve cylinder head that would be “standard equipment” on factory high-performance, 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.

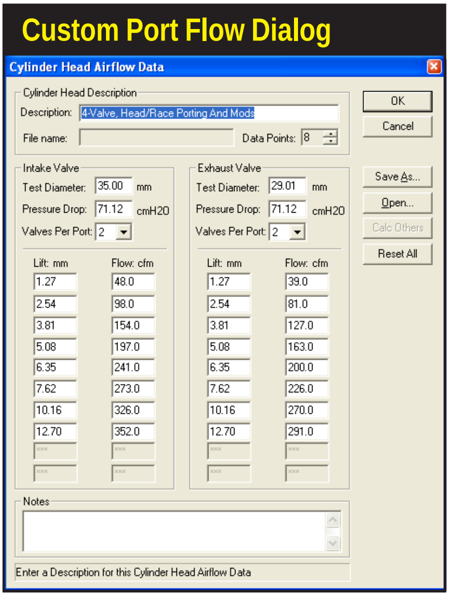
The next choice, ***4-Valve, Hemi, Ported With Large Valves*** incorporates mild performance modifications. Larger valves have been installed and both intake and exhaust flow has been improved by pocket porting. However, care has been taken not to increase the minimum cross-sectional area of the ports. These changes provide a significant increase in power with only slightly slower port velocities. Reversion has increased, but overall, these heads will show a power increase throughout the rpm range on most engines.

The final choice, ***4-Valve, Hemi, Race Porting And Mods***, like other All-Out Racing choices in the **Cylinder Head** menu, models a very efficient, high-flowing 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 Type** menu, use valves that are "scaled" to engine size, so that smaller engines (or 4-valve designs) 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 SC-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.



Cylinder Head Description
Description: 4-Valve, Head/Race Porting And Mods
File name:
Data Points: 8

Intake Valve
Test Diameter: 35.00 mm
Pressure Drop: 71.12 cmH20
Valves Per Port: 2

Exhaust Valve
Test Diameter: 29.01 mm
Pressure Drop: 71.12 cmH20
Valves Per Port: 2

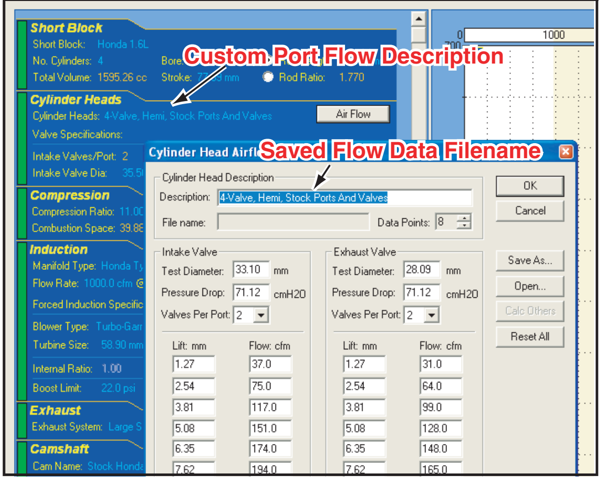
Intake Lift: mm	Intake Flow: cfm	Exhaust Lift: mm	Exhaust Flow: cfm
1.27	48.0	1.27	39.0
2.54	98.0	2.54	81.0
3.81	154.0	3.81	127.0
5.08	197.0	5.08	163.0
6.35	241.0	6.35	200.0
7.62	273.0	7.62	226.0
10.16	326.0	10.16	270.0
12.70	352.0	12.70	291.0
***	***	***	***
***	***	***	***

Enter a Description for this Cylinder Head Airflow Data

The *Custom Port Flow Dialog Box* allows the direct entry of flowbench 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 SC-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 (.SFW) files using this program feature.

Custom Port Flow Dialog

Custom Port Flow Description And Filename



Short Block: Honda 1.6L
No. Cylinders: 4
Bore:
Total Volume: 1595.26 cc
Stroke: 77.59 mm
Rod Ratio: 1.770
Cylinder Heads: 4-Valve, Hemi, Stock Ports And Valves
Valve Specifications:
Intake Valves/Port: 2
Intake Valve Dia: 35.5
Compression Ratio: 11.0
Combustion Space: 39.8
Manifold Type: Honda T
Flow Rate: 1000.0 cfm @
Forced Induction Specific
Blower Type: Turbo-Garr
Turbine Size: 58.90 mm
Internal Ratio: 1.00
Boost Limit: 22.0 psi
Exhaust System: Large S
Cam Name: Stock Honda

Cylinder Head Description
Description: 4-Valve, Hemi, Stock Ports And Valves
File name:
Data Points: 8

Intake Valve		Exhaust Valve	
Test Diameter: 33.10 mm		Test Diameter: 28.09 mm	
Pressure Drop: 71.12 cmH20		Pressure Drop: 71.12 cmH20	
Valves Per Port: 2		Valves Per Port: 2	
Lift: mm	Flow: cfm	Lift: mm	Flow: cfm
1.27	37.0	1.27	31.0
2.54	75.0	2.54	64.0
3.81	117.0	3.81	99.0
5.08	151.0	5.08	128.0
6.35	174.0	6.35	148.0
7.62	194.0	7.62	165.0

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

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 (a minimum of 4 points are required; click up to increase, down to decrease). Next, enter the ***Valve Test Diameters***, the ***Pressure Drop*** (in inches of $H_2$0) 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 SC-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.

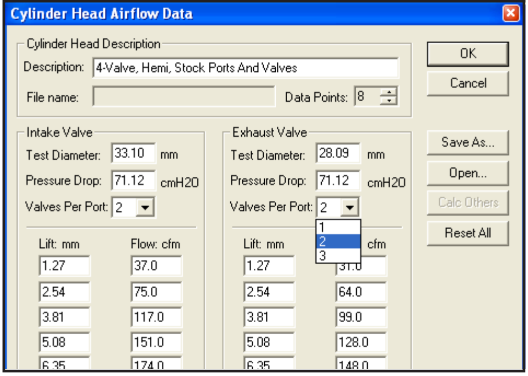
Note 3: For cylinder heads with more than one valve per port, the flow values measured on the flowbench, and entered in the Port Flow Dialog Box, assume that both (or all) valves in each port are opened to the same lift when the airflow rate is measured. *The recorded flow must be the combined flow for 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 **.SFW** file of your choosing—however, even if you do not create a separate .SFW file, head flow data is saved with the current engine in its **.SDY** file). Recall previously saved flow data (**.SFW** 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.

Valve Size Menus

The SC-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 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 Port Flow Dialog Box (by pressing the *Port Flow Button* in the CYLINDER HEAD component category).



Select Number Of Valves Per Port

Cylinder Head Airflow Data

Cylinder Head Description
Description: 4-Valve, Hemi, Stock Ports And Valves
File name:
Data Points: 8

Intake Valve
Test Diameter: 33.10 mm
Pressure Drop: 71.12 cmH2O
Valves Per Port: 2

Lift: mm	Flow: cfm
1.27	37.0
2.54	75.0
3.81	117.0
5.08	151.0
6.35	174.0

Exhaust Valve
Test Diameter: 28.09 mm
Pressure Drop: 71.12 cmH2O
Valves Per Port: 2

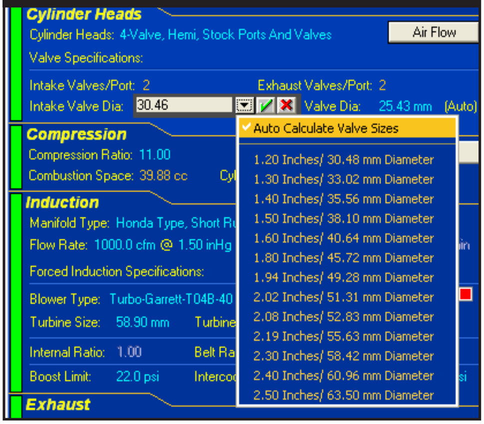
Lift: mm	cfm
1.27	31.0
2.54	64.0
3.81	99.0
5.08	128.0
6.35	148.0

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 designs often have two intake valves and one exhaust valve per port. Since multiple-valve-per-port cylinder heads are airflow tested by opening *all valves in each port* 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



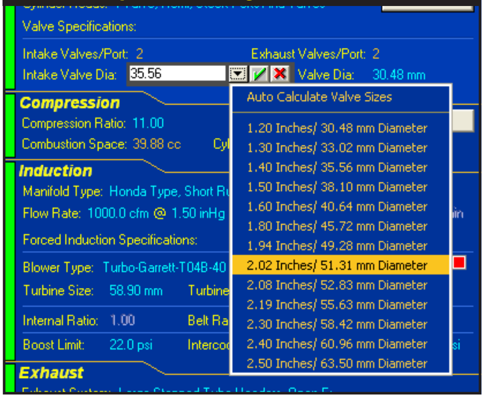
Auto Calculate Valve Sizes

Cylinder Heads: 4-Valve, Hemi, Stock Ports And Valves
Valve Specifications:
Intake Valves/Port: 2
Exhaust Valves/Port: 2
Intake Valve Dia: 30.46
Valve Dia: 25.43 mm (Auto)
Compression Ratio: 11.00
Combustion Space: 39.88 cc
Manifold Type: Honda Type, Short Ru
Flow Rate: 1000.0 cfm @ 1.50 inHg
Forced Induction Specifications:
Blower Type: Turbo-Garrett-T04B-40
Turbine Size: 58.90 mm
Internal Ratio: 1.00
Boost Limit: 22.0 psi

The first selection in the Valve Diameter Menus is *Auto Calculate Valve Size* (active only when a "generic" cylinder heads have been selected from the Cylinder Head Type menu). This feature determines nominal intake and exhaust valve diameters. *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 Port Flow Dialog Box.*

Valve Size Menus

Manually Selecting Valve Sizes



Valve Specifications:

Intake Valves/Port: 2

Exhaust Valves/Port: 2

Intake Valve Dia: 35.56

Valve Dia: 30.48 mm

Compression

Compression Ratio: 11.00

Combustion Space: 39.88 cc

Induction

Manifold Type: Honda Type, Short Ru

Flow Rate: 1000.0 cfm @ 1.50 inHg

Forced Induction Specifications:

Blower Type: Turbo-Garrett-T04B-40

Turbine Size: 58.90 mm

Internal Ratio: 1.00

Boost Limit: 22.0 psi

Exhaust

Selecting a specific valve size will disable the *Auto Calculate Valve Size* feature. You can select from the provided sizes (displayed in both Metric and US measurements), or you can directly enter any valve dimension within the range limits of the SC-DynoSim (range limits are shown in the *Status and Range Limit Line*, as described on page 14).

works only with the "generic" listed in the **Cylinder Head Type** menu. ***Auto Calculate*** instructs the SC-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 cylinder head 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) or if new Port Flow files are selected or existing Port Flow values are modified in the Port Flow Dialog box.

Note: ***Auto Calculation*** of valve diameters will only function with the cylinderhead choices provided in the **Cylinder Head Type** menu. If any modification is made to these heads, or other Port Flow files are loaded, the SC-DynoSim assumes that the sizes of the valves are known and ***Auto Calculation*** is turned off.

Note: ***Auto Calculation*** is turned **OFF** by default when the SC-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 valves per port) are never too large for the current bore diameter (also, see page 88 for information on the related ***Auto Calculate Valve Lift*** feature).

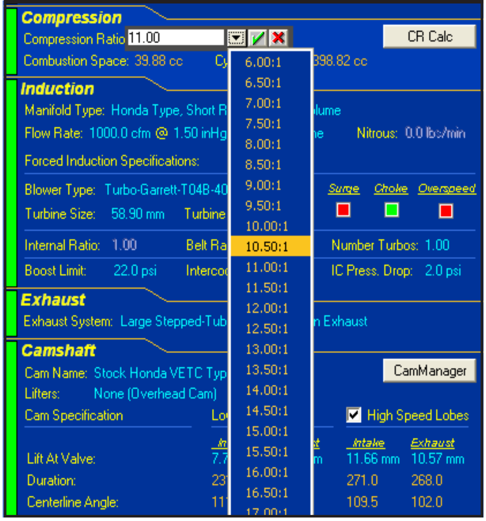
Compression ratio is calculated by dividing the total volume within the cylinder when the piston is located at Bottom Dead Center (BDC) by the volume that exists when the piston is positioned at Top Dead Center (TDC).

Basic Compression Ratio Equation

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

Compression Ratio Menu

Compression Ratio Menu



Compression Ratio 11.00
Combustion Space: 39.88 cc
Cy 398.82 cc
Manifold Type: Honda Type, Short R lume
Flow Rate: 1000.0 cfm @ 1.50 inHg ne
Nitrous: 0.0 lbs/min
Forced Induction Specifications:
Blower Type: Turbo-Garrett-T04B-40
Turbine Size: 58.90 mm
Turbine
Internal Ratio: 1.00
Belt Ra
Number Turbos: 1.00
Boost Limit: 22.0 psi
Intercoo
IC Press. Drop: 2.0 psi
Exhaust System: Large Stepped-Tub n Exhaust
Cam Name: Stock Honda VETC Typ
Lifters: None (Overhead Cam)
Cam Specification
Lo
☑ High Speed Lobes

	In	t	Intake	Exhaust
Lift At Valve:	7.7	m	11.66 mm	10.57 mm
Duration:	23		271.0	268.0
Centerline Angle:	11		109.5	102.0

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 as high as 18:1 compression.

While ***Auto Calculate Valve Size*** is helpful during quick back-to-back testing, it may not "guess" the precise valve sizes used in the "real world," and therefore, not simulate power as accurately as possible. In these situations, there is no substitute for entering the exact valve sizes in the ***Valve Diameter*** menus. Here you will find a list of 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 category. A selection from this menu establishes the compression ratio for the simulated engine (the SC-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).

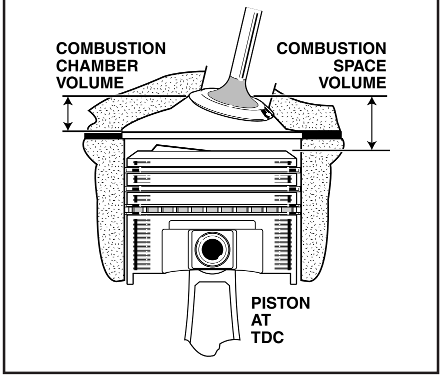
Compression Ratio Basics

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 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 discov-

Compression Ratio Menu

Top Dead Center Volumes

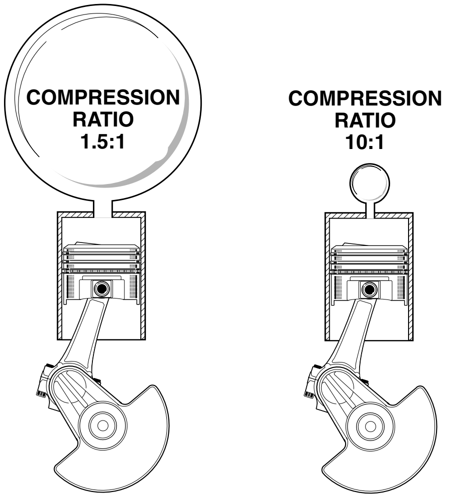


While *combustion-chamber volume* is simply the volume of the chamber in the cylinder head, the *combustion-space volume* is the total enclosed volume when the piston is located at TDC. This space includes the volume in the combustion chamber, plus any volume added by the piston not rising to the top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

ered previously, the swept cylinder volume is calculated by the SC-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.

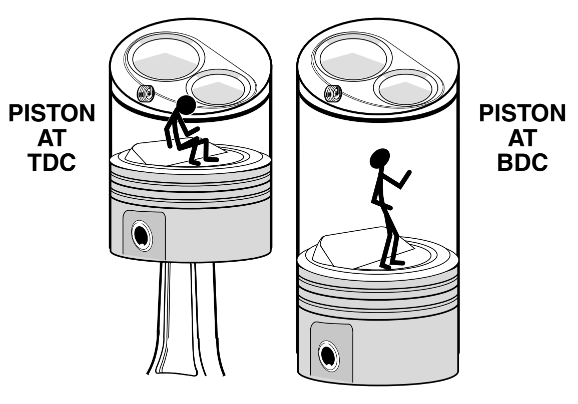
High Compression Boosts Power



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.

Compression Ratio Menu

Exploring Compression Ratio And Volumes

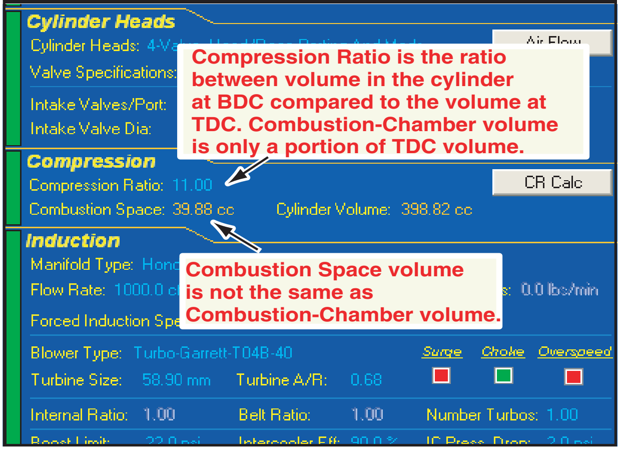


A good way to visualize compression ratio volumes is to imagine yourself as a "little guy" wandering around inside the engine. You would see the combustion chamber above you like a ceiling. Your floor would be the top of the piston (see text for a further description of cylinder volumes).

The complexity of volumes often is a stumbling block in understanding compression ratio. However, the following explanation and illustrations 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

Combustion Space Volume



Compression Ratio is the ratio between volume in the cylinder at BDC compared to the volume at TDC. Combustion-Chamber volume is only a portion of TDC volume.

Compression Ratio: 11.00

Combustion Space: 39.88 cc

Cylinder Volume: 398.82 cc

Combustion Space volume is not the same as Combustion-Chamber volume.

Blower Type: Turbo-Garrett-T04B-40

Turbine Size: 58.90 mm

Turbine A/R: 0.68

Internal Ratio: 1.00

Belt Ratio: 1.00

Number Turbos: 1.00

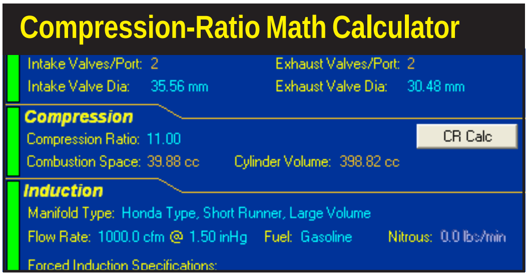
An 11:1 compression ratio (as shown here) means that the sum of the Swept Cylinder Volume and the Combustion Space Volume is eleven times greater than the volume in the Combustion Space alone.

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 two 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


Compression-Ratio Math Calculator

Intake Valves/Port: 2
Exhaust Valves/Port: 2
Intake Valve Dia: 35.56 mm
Exhaust Valve Dia: 30.48 mm

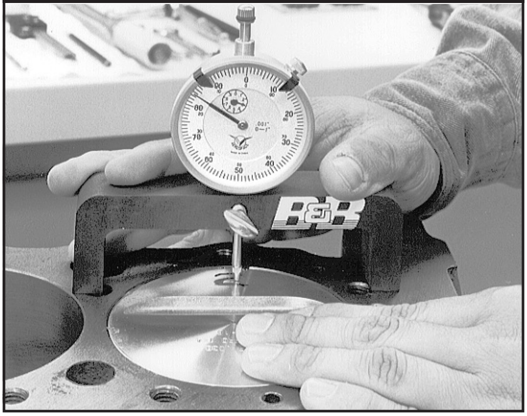
Compression
Compression Ratio: 11.00
Combustion Space: 39.88 cc
Cylinder Volume: 398.82 cc

Induction
Manifold Type: Honda Type, Short Runner, Large Volume
Flow Rate: 1000.0 cfm @ 1.50 inHg
Fuel: Gasoline
Nitrous: 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 *CR Calc* button in the COMPRESSION category.

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 below the deck surface.

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 SC-DynoSim using the built-in **Compression-Ratio Calculator**.

THE COMPRESSION-RATIO CALCULATOR

The Sport-Compact 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" 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 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*.

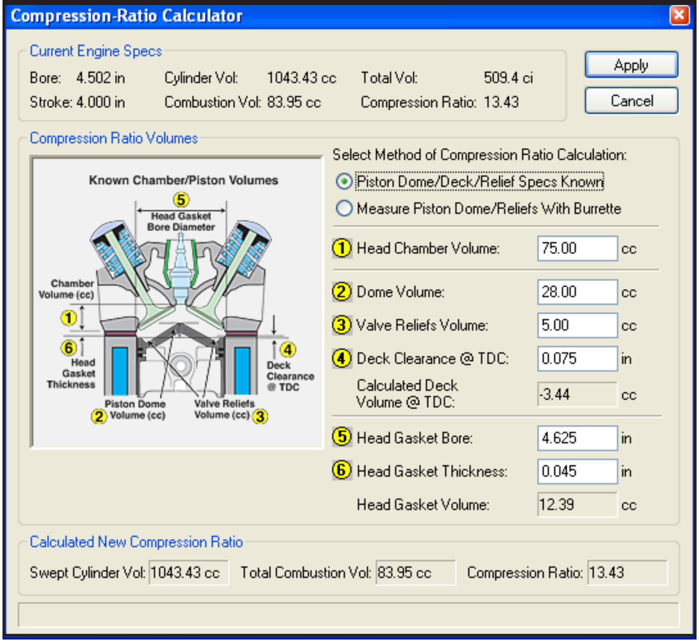
Here is the procedure for using the DynoSim compression-ratio calculator in the ***Known-Volumes Mode***. Start off by verifying that the calculator is in the ***Known-Volume Mode*** by ensuring that the upper radio button ***Piston Dome/Deck/Relief Specs Known*** is activated. Next, enter the combustion-chamber 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 below the deck surface.

Important Note: A positive ***Deck Clearance @ TDC*** indicates the piston is posi-

CR Math Calculator—*Known Volumes Mode*



Current Engine Specs

Bore: 4.502 in
Stroke: 4.000 in
Cylinder Vol: 1043.43 cc
Combustion Vol: 83.95 cc
Total Vol: 509.4 ci
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.

tioned below the deck surface and this volume adds to the combustion space at TDC; a negative number indicates the piston protrudes above the deck surface at TDC and reduces the combustion space.

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

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 field (5) *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 (4)] is the *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/deck/dish/relief volumes will increase the combustion volume and decrease the compression ratio over a flattop piston.

Compression-Ratio Math Calculator

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

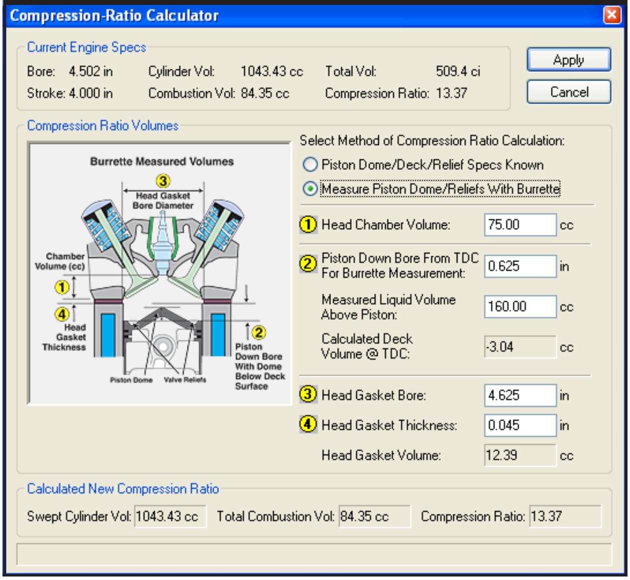
Note: As mentioned earlier, if unknown, the combustion-chamber volume must be measured with a burette.

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

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.

CR Math Calculator—*Burrette Measured Mode*



Compression-Ratio Calculator

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

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).

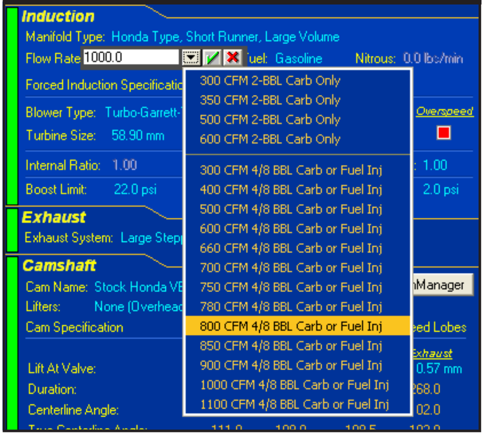
The next two data-entry boxes are used to calculate the volume added to the combustion space by the head gasket that is compressed between the cylinder head and the block deck surface. The data box marked *(3)* accepts the ***Head Gasket Bore*** diameter (in the appropriate Metric or US units system). 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 simulated engine. An induction system, as defined in the SC-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. SC-DynoSim induction menus are divided into two main groups: 1) ***Induction Airflow***, ***Pressure Drop***, ***Fuel***, and ***Mani-***

Induction Airflow Menu



Manifold Type: Honda Type, Short Runner, Large Volume
Flow Rate 1000.0
uel: Gasoline
Nitrous: 0.0 lbs/min
Blower Type: Turbo-Garrett-
Turbine Size: 58.90 mm
Internal Ratio: 1.00
Boost Limit: 22.0 psi
Exhaust System: Large Step
Cam Name: Stock Honda VE
Lifters: None (Overhead

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.

fold 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.

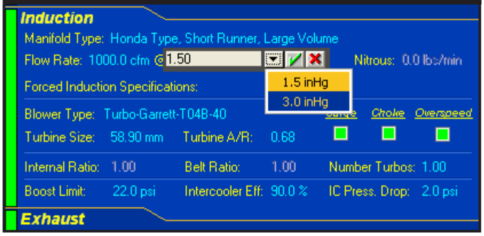
Note: The important thing to remember about airflow selection is that the SC-DynoSim *makes no assumption about the type of restriction* used in the induction system. The airflow is simply a measure of the restriction of the entire induction system.

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 SC-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, achiev-

Airflow Math Calculator

Induction Pressure-Drop Menu



Manifold Type: Honda Type, Short Runner, Large Volume
Flow Rate: 1000.0 cfm @ 1.50
Nitrous: 0.0 lbs/min
Forced Induction Specifications:
Blower Type: Turbo-Garrett-T04B-40
Turbine Size: 58.90 mm
Turbine A/R: 0.68
Internal Ratio: 1.00
Belt Ratio: 1.00
Number Turbos: 1.00
Boost Limit: 22.0 psi
Intercooler Eff: 90.0 %
IC Press. Drop: 2.0 psi

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).

able 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).

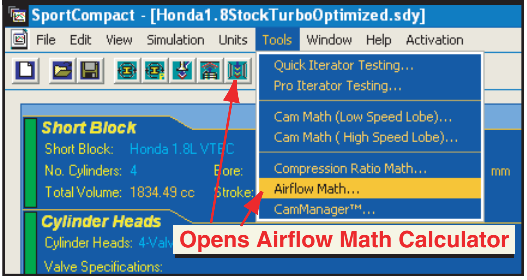
Note About IR Manifolds: Keep in mind the unique way airflow capacities are handled on Individual Runner (IR) manifolds (additional details on page 57). On these induction systems, each cylinder is connected to a single “barrel” or injector stack with no connecting passages that allow the cylinders to “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 SC-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

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 button in the* .

Airflow Math Calculator

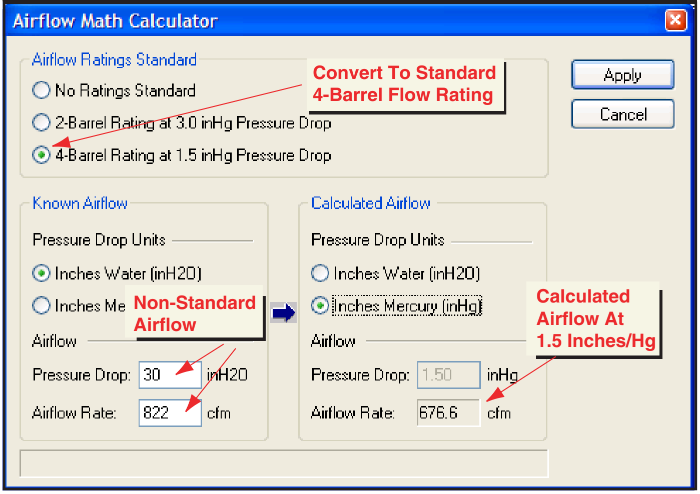


SportCompact - [Honda1.8StockTurboOptimized.sdy]
Short Block: Honda 1.8L VTEC
No. Cylinders: 4
Bore:
Total Volume: 1834.49 cc
Stroke:
Cylinder Heads: 4-Valv

Opens Airflow Math Calculator

Airflow Math Calculator

Airflow Math Calculator—Convert To 4-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 Me

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

Convert To Standard 4-Barrel Flow Rating

Non-Standard Airflow

Calculated Airflow At 1.5 Inches/Hg

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.

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.

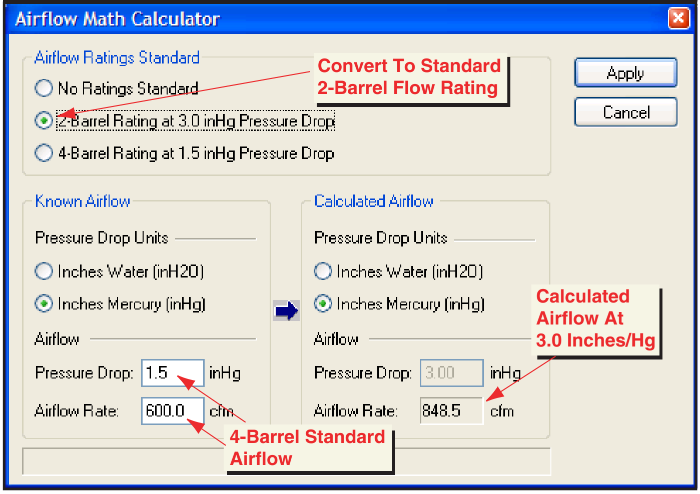
The **Airflow Math Calculator** has three basic modes of operation: 1) Convert to the 4-Barrel Standard, 2) convert to the 2-Barrel Standard, and 3) calculate airflow between any two pressure drop ratings. Each of these methods are described below. Activate the **Airflow Math Calculator** by either selecting ***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,

Airflow Math Calculator

Airflow Math Calculator—Convert To 2-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 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

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.

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.

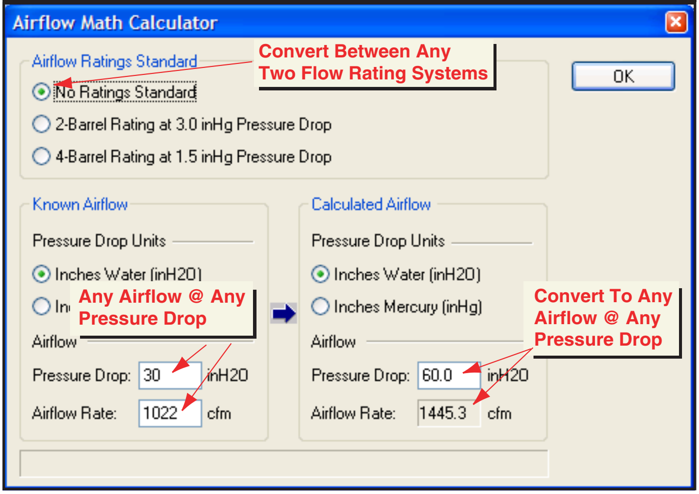
Switch the ***Airflow Ratings Standard*** category selection to the radio button marked ***2-Barrel Rating of 3.0-in/Hg Pressure Drop***. This changes the "result," or ***Calculated Airflow*** category to 3.0-in/Hg (40.7-in/H_2O). To convert any known airflow measured at any pressure drop to the 3.0-in/Hg, 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 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 SC-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

Airflow Math Calculator

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)

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

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.

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

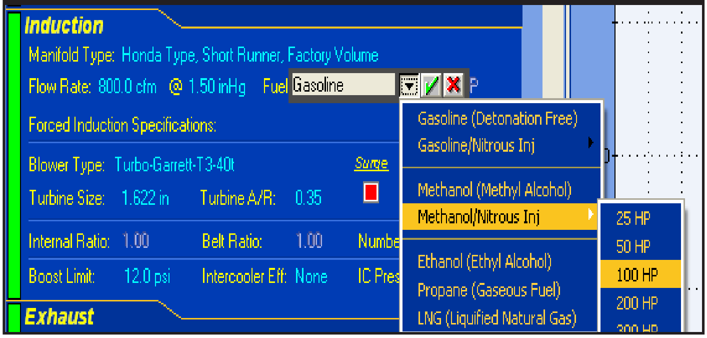
Select any of the available fuels from the ***FUEL*** menu:

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

When any of these fuels have been selected, the SC-DynoSim readjusts the air/fuel ratio for optimum power. Since combustion *flame-travel* is not modeled in the SC-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

Fuel Menu

Fuel And Nitrous-Oxide Selection Menu



Manifold Type: Honda Type, Short Runner, Factory Volume

Flow Rate: 800.0 cfm @ 1.50 inHg

Fuel Gasoline

Forced Induction Specifications:

Blower Type: Turbo-Garrett-T3-40t

Turbine Size: 1.622 in

Turbine A/R: 0.35

Internal Ratio: 1.00

Belt Ratio: 1.00

Boost Limit: 12.0 psi

Intercooler Eff: None

The SC-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.

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. 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.

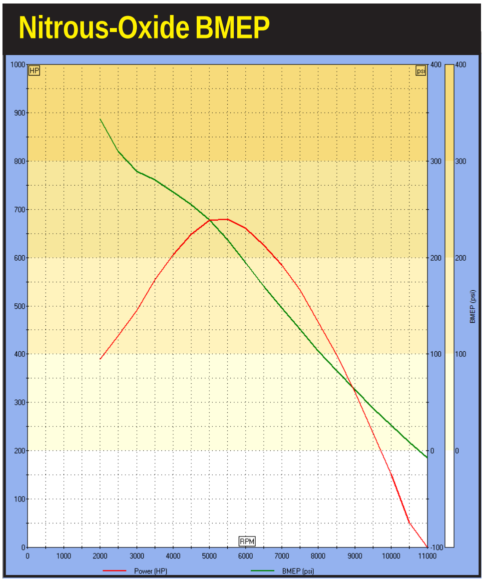
The SC-DynoSim models a typical, constant-flow nitrous/gasoline injection system. During engine testing with nitrous augmentation, you should monitor cylinder pressures (BMEP) to make sure dangerously high pressures are avoided at lower engine speeds (a BMEP greater than 300psi is usually considered excessive). For example, the SC-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, and larger engine displacement.

It is a simple matter to simulate and test a variety of component combinations with the SC-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)**
- **50 HP (2 lb/min N_2O flow)**



This graphic shows how cylinder pressures (BMEP shown by green line) increase after a 100-horsepower nitrous system is activated (this pressure comparison and the colored DataZones™ requires ProTools™ activation). Since the SC-DynoSim models a fixed-flow nitrous system, cylinder loads increase as engine speed decreases (the longer <u>time</u> 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.

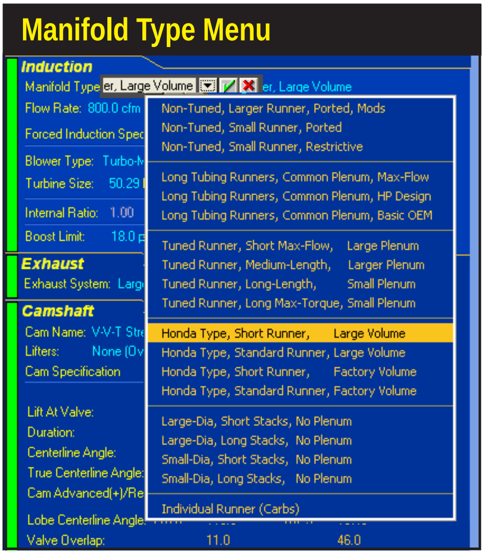
- **100 HP (4 lb/min N_2O flow)**
- **200 HP (8 lb/min N_2O flow)**
- **300 HP (12 lb/min N_2O flow)**
- **400 HP (16 lb/min N_2O flow)**

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 19 intake manifold choices. Each of these selections 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 of 19 discrete models can 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 SC-DynoSim, some induction modeling data might not exactly match real-world dyno results with unique manifold configurations (look into ProRacing Software’s *Dynomation*™ engine simulation series, available in mid 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

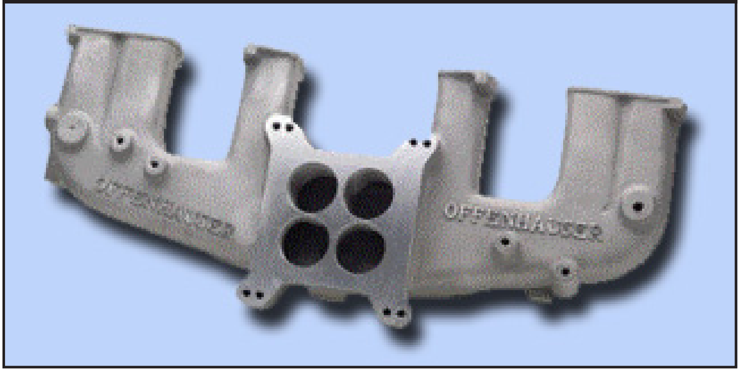


Each of the manifolds in the *Manifold Type* menu applies a unique tuning model to the induction system. While these ten manifolds are only a small sample of the intake manifolds available for IC engines, these discrete models accurately simulate the performance potential of most intake manifolds available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

Non-Tuned Intake Systems

The Non-Tuned Manifold selections model an intake manifold with small-diameter runners that connect to a central plenum with little consideration for equal length or tuning characteristics.

Non-Tuned Manifold

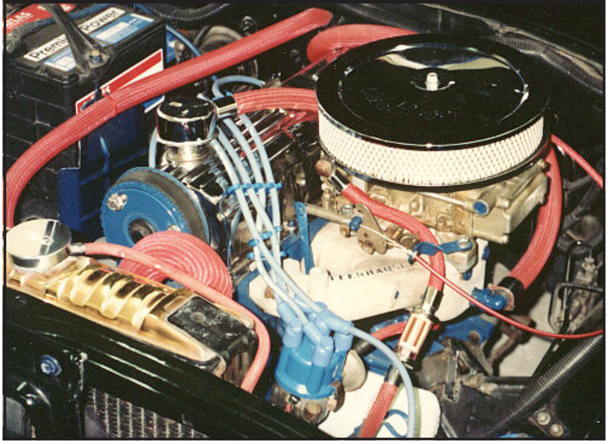


SC-DynoSim, a description of the assumptions used in the model, and recommendations associated with that individual design.

Non-Tuned, Restrictive Manifolds—The ***Non-Tuned, Small Runner, Restrictive*** selection in the **Manifold Type** menu models an intake manifold with small-diameter runners that connect to a central plenum with little consideration for equal length or tuning characteristics, such as those designed for low-performance economy vehicles or other “basic” engine configurations. In naturally-aspirated applications, this manifold produces the least power and offers least boost in torque from runner tuning. The ***Non-Tuned, Small Runner, Ported Manifold*** selection provides a slight improvement in airflow that improves power at higher engine speeds. But the same non-tuned runners provide little pressure-wave tuning and low-speed torque boost. The ***Non-Tuned, Larger Runner, Ported, Mods*** model represents an attempt to improve this simple manifold design as much as possible. By porting the runners, modifying the

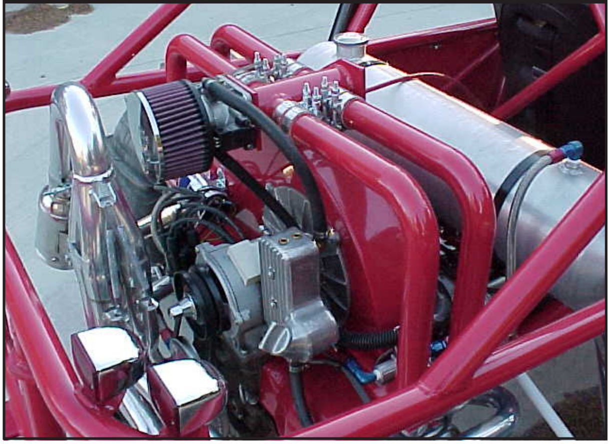
Porting the runners, modifying the plenum, and even modifying and welding the runner passages can improve performance on non-tuned manifolds. However, despite the modifications to the non-tuned manifold, OEM-type tuned induction systems will generally produce more torque and horsepower.

Short, Non-Tuned Runners



Tubing-Runner Manifolds

Long Tubing Runners With Common Plenum

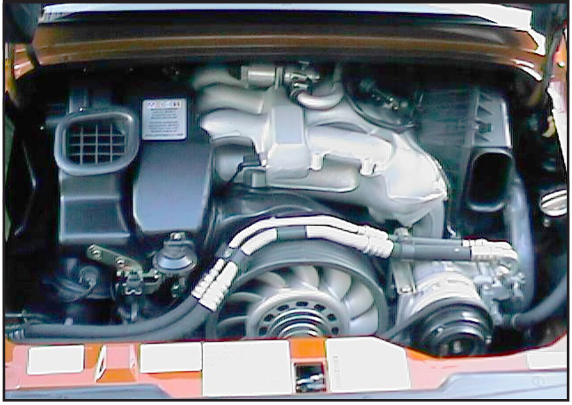


The *Long-Tubing Basic OEM* manifold selection models induction systems often used on a flat-four and flat-six engines, like the VW and lower-performance opposed-six Porsche powerplants. The length of the runners and their relatively small diameters optimize torque output, but restrict airflow at higher engine speeds.

plenum, and even modifying and welding the runner passages, this is about as much as you can expect to improve the non-tuned intake manifold. Even with this extensive work, the manifold simply cannot match the torque potential of a stock, OEM tuned induction system. For the most part, this induction model has been included in the SC-DynoSim for comparison purposes, since such basic manifolds are rarely modified to this degree.

Long Tubing Runners, Common-Plenum Manifolds—The ***Long Tubing Runners, Common-Plenum, Basic OEM Manifold*** selection in the **Manifold Type** menu models the induction system typically used on a flat-four and flat-six engines, like the original VW "Beetle" and lower-performance Porsche. The length of the runners and their relatively small diameter tune them for good torque, but offer restriction at higher engine speeds. These manifolds are particularly restrictive when used

Modern "Tubing" Long-Runner Manifold



This Porsche 993 uses a cast-aluminum equivalent of the steel-tubing manifolds of the past. However, the length of these runless qualify this induction for the "Tubing, Long-Runner" class in the SC-DynoSim, although the *HP* (for stock) or even the *Max-Flow* models (for modified) can be used with this free-flowing design.

Tubing-Runner Manifolds

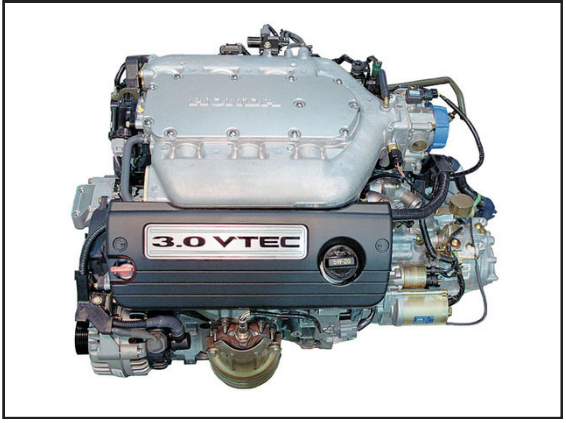
“Tubing,”Max-Flow Manifold

The *Long Tubing Runners, Common-Plenum, Max. Flow* selection models manifold designs used on high-performance engines or in racing applications, like this Porsche 928 V8. The large runner cross-sectional areas ensure cylinder filling at high engine speeds, however, the additional runner and plenum volume can reduce torque at low rpm.

on larger displacement engines (such as those with larger cylinder liners or stroker cranks). The ***Long Tubing Runners, Common-Plenum, HP Manifold*** selection introduces a considerably different induction model to the SC-DynoSim. The larger diameter runners used in this manifold offer much less restriction at high engine speeds but the increased volume dampens low-rpm tuning, often reducing bottom-end torque on all but the largest displacement engines. This model closely simulates many naturally-aspirated Porsche 911 induction systems. Finally, the ***Long Tubing Runners, Common-Plenum, Max. Flow Manifold*** selection represents manifold designs used on very high-performance engines or in racing applications. The large runner cross-sectional area ensures cylinder filling at high engine speeds, however, the increased runner and plenum volume further reduces torque at low rpm.

Tuned Runner, Large And Small Plenum Designs—All of the manifolds in this

Tuned-Runner Induction Systems



The *Tuned-Runner Manifold* group models induction systems that have slightly smaller plenums and runners than the aggressive manifolds available for the VTEC Honda 4-cylinder engines (discussed in the next group in the *Manifold Type* menu). This 3.0L V6 Honda is typical of engines that can be modeled by this group. The torque curve is usually broad and flat, while peak power occurs at an engine speed about 500 to 1000rpm lower than manifolds with shorter runners of larger cross-sectional area.

Tuned-Runner Manifold Modeling

Long Tuned-Runner Induction Systems

The *Tuned Runner, Medium Length, Larger Plenum* manifold provides a bias toward performance and higher engine speed. Manifolds of this type are commonly found on 4, V6, V8, and V12 engines in performance sedans and sports cars.

Induction Type menu group model OEM (usually cast aluminum) induction systems. The longest runners produce copious torque at low to medium speeds, while the shortest runner manifolds are commonly used on performance engines.

The ***Tuned Runner, Long Max-Torque, Small Plenum*** manifold is ideal for engines in heaver vehicles, like trucks and vans. The low-rpm tuning boosts efficiency, economy, and driveability in stock vehicles. However, while the runners are somewhat long, they are not overly restrictive and stock engines using this manifold will produce good horsepower.

The next selection (up the menu) in this group is the ***Tuned Runner, Long Length, Small Plenum*** manifold. The slightly shorter runners are capable of producing more horsepower, but torque below 3500rpm can suffer slightly. This is still an excellent manifold for heavier performance vehicles.

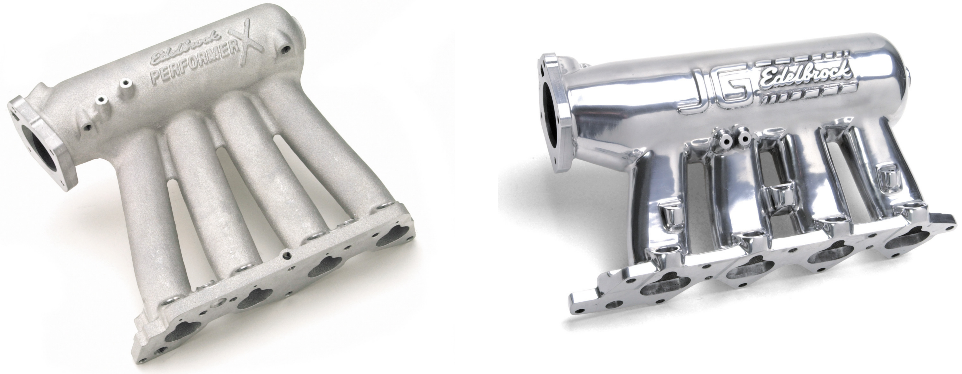
The ***Tuned Runner, Medium Length, Larger Plenum*** manifold is the first manifold in this group to offer a bias toward performance and higher engine speed. Manifolds of this type are commonly found on 4, V6, V8, and V12 engines in performance sedans and sports cars.

The most performance oriented manifold, the ***Tuned Runner, Short, Max. Flow, Large Plenum*** is an excellent choice on lightweight, performance vehicles. The tuned runners offer good pressure-wave tuning, while the low restriction and large plenum volume give excellent horsepower potential. This manifold design is used on many performance-oriented sports cars, like Aston Martin, Maseratti, and Ferrari. The only manifolds that are superior in performance to the *Tuned Runner, Medium Length, Larger Plenum* selection are the "***Honda Type***" listed in the next group that have the largest runner and plenum volumes. However, even the "Honda" manifolds may not provide as broad a range of torque and horsepower as the manifolds in this group.

Honda Type, Small And Large Plenum Designs—While the manifolds in this group are designed to model the Honda induction systems used on 4-cylinder, high-

“Honda-Type” Manifold Modeling

Honda-Type, Large Plenum, Long And Short Runners



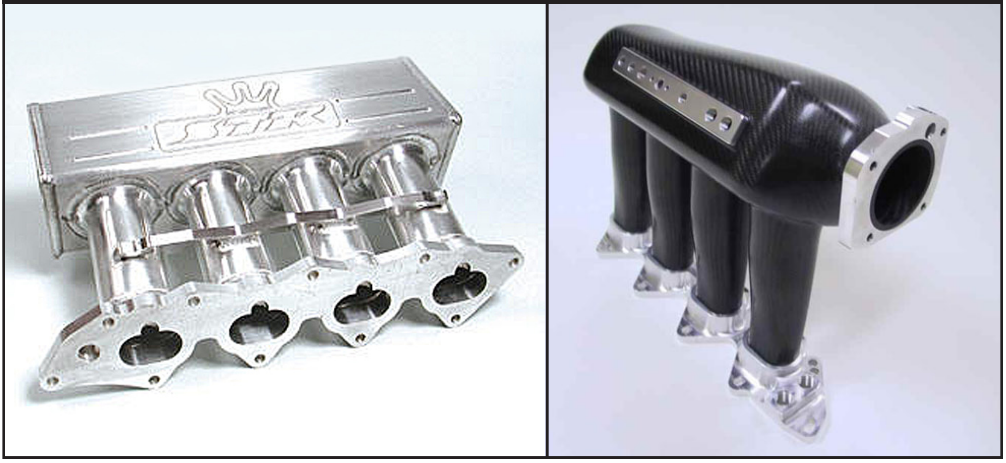
The Honda-Type manifolds are designed to model the Honda induction systems used on 4-cylinder, high-performance engines, like the B16, B18, S2000 and others. This manifold model can be applied to any engine that uses direct, high-volume runners and a large plenum. The stock-length runner designs (like the Edelbrock Performer X, shown on the left) generate a characteristic broad and flat torque curve, and its large runners and plenum volume will supply all but the largest engines with adequate airflow to well beyond 7500rpm. Manifolds with shorter runners will often lower torque below 4000- 5000-rpm and offer a slight-to-significant power gains power above 7000- to 8000rpm.

performance engines, like the B16, B18, S2000 and others, this manifold model can be applied to any engine that uses direct, high-volume runners and a large plenum. The power potential from this manifold model is similar to “all-out” induction systems, such as tunnel-ram manifolds used on bigblock engines.

The ***Honda Type, Standard*** *(Length)* ***Runner, Factory*** *(Plenum)* ***Volume*** selection models the stock Honda manifold supplied on many of its B16A high-performance engines, like the Del Sol, Civic Si, the Integra GSR, and others. This induction system generates a characteristic broad and flat torque curve, and its large runners and plenum volume will supply all but the largest engines with adequate airflow to well beyond 7500rpm. For many high-performance street vehicles, this is an excellent manifold with the only weak point being somewhat lower torque, usually below 3500- to 4000rpm, compared to the longer-runner manifolds in the previous group. But above these engine speeds, this OEM Honda-type induction system with medium-length runners is virtually unbeatable.

The next “stage” in the Honda-type manifold is the shorter-runner version of the stock B16A intake, the ***Honda Type, Short Runner, Factory*** *(Plenum)* ***Volume***. These manifolds, supplied on the Type R (originally on the 1.8L, B18C5 engine) and available in many forms from aftermarket manufacturers, will often produce a slight reduction in torque below 4000- 5000-rpm and offer a slight-to-significant gain in power above 7000- to 8000rpm. This is not the best manifold for a street-stock engine, but for a modified or “stroker” larger-displacement engine, it can offer more power and with

“Honda-Type” Manifold Modeling



Custom Racing Manifolds

The *Honda Type, Standard Or Short Runner, Large Volume* manifold models simulate manifolds that have increased cross-sectional area runners combined with a large plenum volumes. These manifolds will usually reduce low-speed torque below 5000rpm. However expect substantial gains on high-speed engines, especially above 8000rpm

little or no loss in torque.

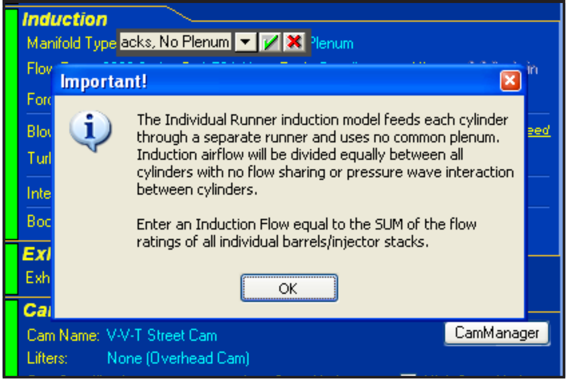
The third selection (working towards the top within this group), is the ***Honda Type, Standard*** *(Length)* ***Runner, Large*** *(Plenum)* ***Volume*** manifold model. This choice simulates a manifold (only available from the aftermarket, like the Edelbrock Performer X manifold) that has increased cross-sectional area runners of about factory length (somewhat long) combined with a large volume plenum. This manifold will show power gains above max-torque engine speeds, while the standard-length runners will usually maintain good torque at lower speeds. This may be the best manifold for a modified engine that will be operated on the street.

Finally, the ***Honda Type, Short Runner, Large*** *(Plenum)* ***Volume*** manifold model simulates many of the exotic induction systems used on racing all-motor and forced induction applications. This induction has the largest volume runners and plenum, and will reduce low-speed torque below about 5000rpm. However expect substantial gains on high-speed engines, especially above 8000rpm.

Individual Runner, Large/Small Diameter And Length Injector Stacks—For naturally-aspirated, professional racing applications, individual- (or isolated) runner (I.R.) induction systems, with separate tubes containing their own throttle plates for each cylinder, offers the ultimate in flow potential and peak power at high engine speeds. The single element that sets the I.R. system apart from any other induction models is that each “barrel” or individual “stack” *does not share flow with other stacks through interconnecting passages* (like a plenum). This characteristic means that overall induction flow is divided between all barrels (or cylinders).

Individual-Runner Modeling

Individual Runner Flow Alert



The Individual Runner induction model feeds each cylinder through a separate runner and uses no common plenum. Induction airflow will be divided equally between all cylinders with no flow sharing or pressure wave interaction between cylinders.

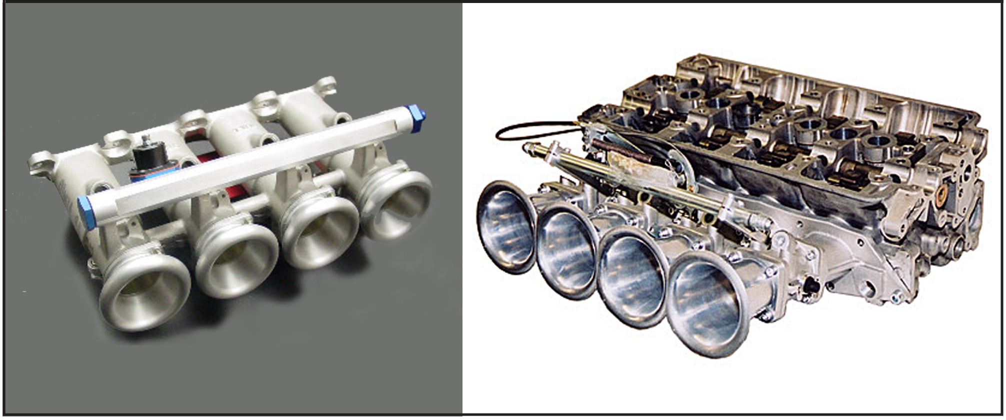
Enter an Induction Flow equal to the SUM of the flow ratings of all individual barrels/injector stacks.

An *Important!* message box will appear whenever any of the I.R. induction systems have been selected from the *Manifold Type* menu. This message box reminds you that the induction *Flow Rate* must be entered as the sum of the individual flow rates of each stack. If you mistakenly retain an airflow that may have been used for a single throttle body, the SC-DynoSim will substantially under-predict power.

All of the manifolds in the **Manifold Type** menu that we have discussed up to now have a shared flow between cylinders, typically through a plenum. And the induction flow (***Flow Rate***) field in the **INDUCTION** category specifies the maximum airflow (typically at 1.5-inches of Hg) that passes through the restriction common to all cylinders: the throttle body. On an I.R. system, however, the ***Flow Rate*** is the total airflow through all of the individual stacks. So, if an I.R. stack has a rated flow of 400cfm at 1.5-inches of Hg, the induction ***Flow Rate*** on a 4-cylinder engine would be 1600cfm (400cfm x 4-cylinders).

Note-1: An **Important!** message box will appear whenever any of the I.R. induction systems have been selected from the **Manifold Type** menu in the SC-DynoSim. This message box will remind you that the induction ***Flow Rate*** must be entered as the

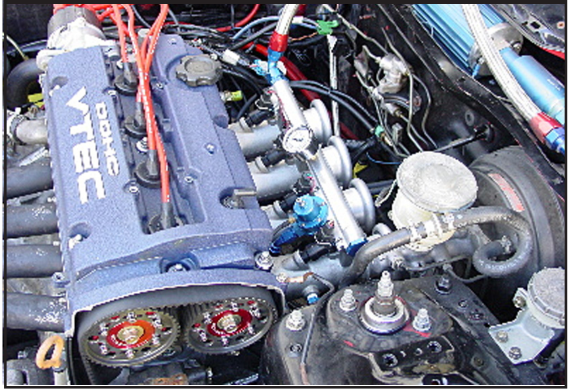
Individual Runner (Injector Stacks) Induction System



I.R. systems will only reach their full potential when the *Flow Rate*, **specified in the** INDUCTION **category (the total flow through all stacks) is at least twice the flow rate of a single throttle body induction. Careful selection of stack size, length, and flow rate are essential to building a winning I.R. induction.**

Individual-Runner Modeling

Honda VTEC IR Induction



For naturally-aspirated, professional racing applications, individual- (or isolated) runner (I.R.) induction systems, with separate tubes containing their own throttle plates for each cylinder, offers the ultimate in flow potential and peak power at high engine speeds.

sum of the individual flow rates of each stack. If you mistakenly retain the flow that may have been used for a single throttle body, the SC-DynoSim will substantially under-predict power.

Note-2: I.R. systems will only outperform a single throttle-body (plenum) system only when the flow rate of each stack is sufficiently high. When the ***Flow Rate***, specified in the **INDUCTION** category (the total flow through all stacks) is substantially greater than the flow rate through a single throttle body, the engine can produce higher top-speed power. This total flow rate should be at least twice the flow rate of the throttle body to reach the full potential of the I.R. system.

The first manifold (located at the bottom of the I.R. group) is the ***Small Diameter, Long Stacks, No Plenum*** model. This selection produces a power curve similar to the *Honda Type, Standard Runner, Factory Volume* manifold discussed in the previous section. However, the improved flow potential (see **Note-2**, above) at higher engine speeds offers improved power that will peak at a slightly higher rpm.

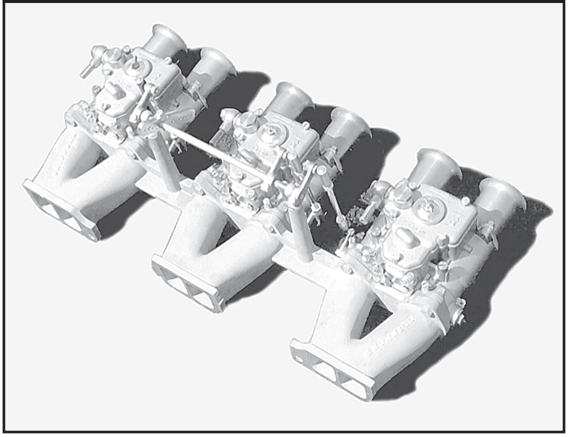
The ***Small Diameter, Short Stacks, No Plenum*** manifold is the shorter-runner version of the previous selection. It produces a power curve similar to the *Honda Type, Short Runner, Factory Volume* model discussed in the previous section. The improved flow potential (see **Note-2**, above) at higher engine speeds offers improved power that will peak at a slightly higher rpm. Expect this I.R. induction to produce power beyond 8000rpm on a properly modified race engine.

The ***Large Diameter, Long Stacks, No Plenum*** selection produces a horsepower curve similar to the *Honda Type, Standard Runner, Large Volume* manifold. The improved flow potential (see **Note-2**, above) at higher engine speeds offers improved power that will peak at a higher rpm. Expect this I.R. induction to produce power beyond 8000rpm on a properly modified race engine.

Finally, the ***Large Diameter, Short Stacks, No Plenum*** produces a horsepower curve similar to the *Honda Type, Short Runner, Large Volume* manifold. The improved flow potential (see **Note-2**, above) at higher engine speeds offers improved power that will peak at a higher rpm. Expect this I.R. induction to produce power beyond 9000rpm on a properly modified race engine.

Individual-Runner Modeling

Individual Runner W/Carburetors



A multiple Weber or Mikuni carburetor system is a well-an I.R. induction. Once commonplace in drag racing, these systems are now limited to specific classes, such as methanol and fuel-burning, naturally-aspirated engine competition.

Individual Runner Manifold For Carburetors—Like the previous I.R. induction systems, the individual- (or isolated) runner connects each cylinder to one “barrel” of a carburetor and *does not share flow with other cylinders/barrels through interconnecting passages* (like a plenum). A multiple Weber or Mikuni carburetor system is a well-known example of this type of induction; once commonplace in drag racing, these systems are now limited to specific classes, such as methanol and fuel-burning, naturally-aspirated engine competition.

The one-barrel-per-cylinder carbureted I.R. arrangement can have horsepower limitations due to airflow restriction! A typical Weber 48IDA carburetor flows about 330cfm per barrel. While the sum total of all four barrels (on a 4-cylinder engine) is over 1200cfm, the important difference is that each cylinder can draw from only one 330cfm barrel. In a typical plenum manifold, each cylinder has access to the total flow potential of the throttle body, usually twice the flow of a single Weber venturi!

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. Furthermore, the pressure waves moving in the runners are not dissipated within a plenum and don’t interact with other cylinders. This allows the reflected waves to assist cylinder filling and reduce reversion. The combination of these effects makes individual-runner induction an outstanding induction choice for carbureted, low- to medium-speed engine applications.

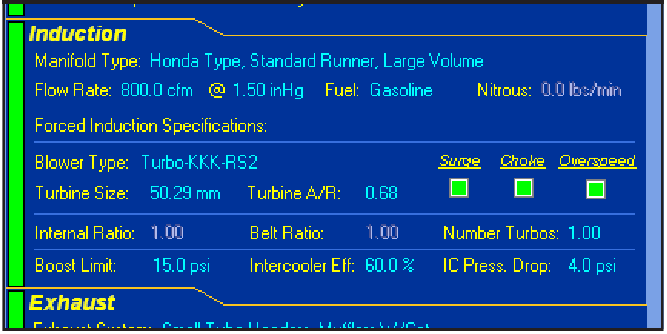
The simulation model for ***Individual Runner (Carbs)*** is a slightly restrictive version of the and *Small Diameter, Long Stacks, No Plenum* induction selection (discussed in the previous section).

FORCED-INDUCTION MENUS

The ***Forced Induction Selections*** included in the **Manifold Category** consider-

Forced Induction Modeling

INDUCTION Category With Forced Induction



Manifold Type: Honda Type, Standard Runner, Large Volume
Flow Rate: 800.0 cfm @ 1.50 inHg Fuel: Gasoline Nitrous: 0.0 lbs/min
Forced Induction Specifications:
Blower Type: Turbo-KKK-RS2
Turbine Size: 50.29 mm Turbine A/R: 0.68
Internal Ratio: 1.00 Belt Ratio: 1.00 Number Turbos: 1.00
Boost Limit: 15.0 psi Intercooler Eff: 60.0 % IC Press. Drop: 4.0 psi

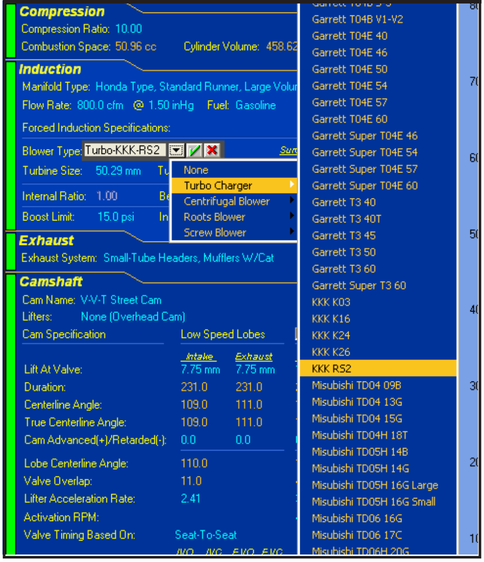
The INDUCTION Category includes forced-induction selections. Directly click on any field to change values and evaluate the effects on power, torque, and manifold pressure.

ably expands the modeling power of the SC-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 ***Turbine Size***, ***Turbine A/R*** ratio, and more. And finally, you can test the effects of an intercooler on any of the forced-induction systems.

> **Note:** When you apply any of the forced-induction systems, keep in mind that you are adding forced induction to the intake manifold selected in the ***Manifold Type*** menu. Some of these selections may not be easily reproducible on the engine. For example, adding forced induction to any of the injector-stacks selections, while possible, requires a large "plenum" over the stacks to eliminate restrictions and to prevent disrupting free airflow around the stacks.

The SC-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 Menus



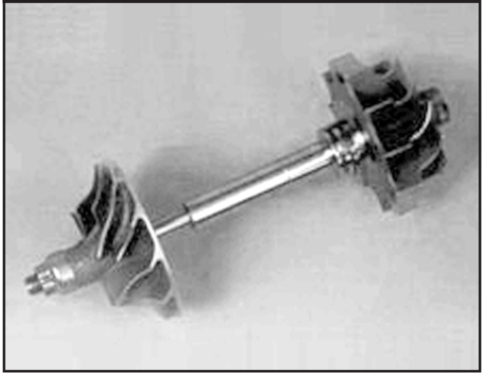
Compression Ratio: 10.00
Combustion Space: 50.96 cc Cylinder Volume: 458.62
Manifold Type: Honda Type, Standard Runner, Large Volu
Flow Rate: 800.0 cfm @ 1.50 inHg Fuel: Gasoline
Forced Induction Specifications:
Blower Type: Turbo-KKK-RS2
Turbine Size: 50.29 mm
Internal Ratio: 1.00
Boost Limit: 15.0 psi
Exhaust System: Small-Tube Headers, Mufflers W/Cat
Cam Name: V-V-T Street Cam
Lifters: None (Overhead Cam)
Cam Specification Low Speed Lobes

	Intake	Exhaust
Lift At Valve:	7.75 mm	7.75 mm
Duration:	231.0	231.0
Centerline Angle:	109.0	111.0
True Centerline Angle:	109.0	111.0
Cam Advanced(+)/Retarded(-):	0.0	0.0
Lobe Centerline Angle:	110.0	
Valve Overlap:	11.0	
Lifter Acceleration Rate:	2.41	
Activation RPM:		

Valve Timing Based On: Seat-To-Seat

Forced Induction Modeling

Turbine & Compressor Impellers

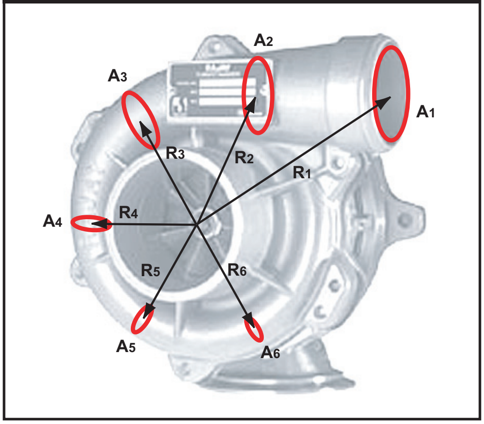


The turbine (shown on the right) is placed in the exhaust stream of an engine and is driven by a combination of exhaust flow and exhaust pressure waves. Two parameters in the SC-DynoSim adjust the performance of the turbine: the *Turbine Wheel Size* and the *Turbine Housing A/R* ratio. Modifying the turbine wheel size will make large changes in the turbine speed; the smaller the wheel, the faster the turbine (and the compressor) will rotate. The higher the turbine speed, the more airflow will be driven through the compressor.

To select any of the forced-induction options, double click the **Blower Type** field to open a menu containing ***Turbocharger***, ***Centrifugal***, ***Roots***, and ***Screw*** blower choices. When selecting of any of the nearly 100 forced induction devices, 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:

Turbine Size—(Turbos only) This is diameter of the exhaust-driven impeller. The turbine is placed in the exhaust stream of an engine and is driven by a combination of exhaust flow and exhaust pressure waves. Two parameters adjust the performance of the turbine: the ***Turbine Wheel Size*** and the ***Turbine Housing A/R*** ratio (discussed next). Modifying the turbine wheel size will make relatively large changes in the turbine speed; the smaller the wheel, the faster the turbine (and the compressor) will rotate. The higher the turbine speed, the more airflow will be

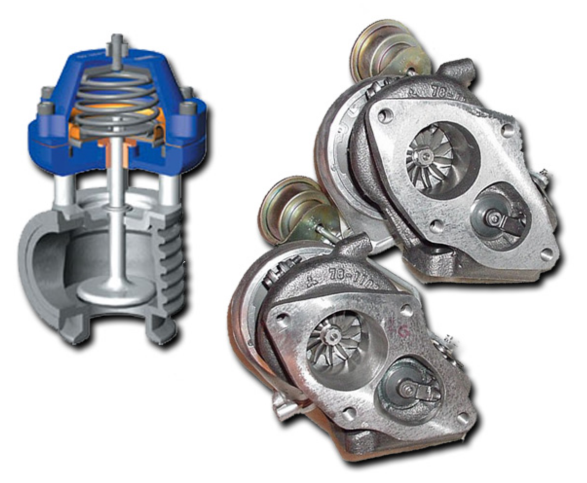
A/R Turbine Housing Ratio



The Turbine Housing A/R ratio is a comparison of the cross-sectional area of the housing inlet passage to the radius measured from the center of the passage to the turbine wheel. Unlike the *Turbine Size* (that has a dramatic affect on turbine speed), the *Turbine Housing A/R* ratio fine-tunes turbine speed and helps establish where—in the engine rpm range—the turbo begins to produce induction pressure (boost).

Forced Induction Modeling

Boost Limiter (Wastegate)



Boost Limit **is an arbitrary maximum induction pressure, established by the wastegate setting. It is 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. The SC-DynoSim incorporates a wastegate model that modulates the size of its bypass passages as the *Boost Limit* is reached.**

driven through the compressor. Smaller turbines generate boost earlier in the rpm range, however, if the turbine is too small for the application, the turbocharger shaft speed can exceed the manufacturer's recommendations (this is an ***Overspeed*** condition; see page 66).

Turbine Housing A/R Ratio—(Turbos only) This is a ratio of the cross-sectional area of the housing inlet to the radius measured from the center of the turbine wheel. Unlike the Turbine Size (that has a dramatic affect on turbine speed), the **Turbine Housing A/R** ratio fine-tunes turbine speed. Changing A/R has many effects. By going to a larger Turbine Housing A/R, the turbo produces less boost at lower engine speeds but develops more boost at a higher engine speed. The larger turbine housing increases exhaust flow capacity, reducing engine backpressure. Lower engine backpressure usually improves engine volumetric efficiency (VE) and can result in an overall power increase.

Number Of Turbos—(Turbos only) This selection divides the exhaust flow equally between all turbos (rarely do applications have more than two turbos). Compressed outflow from all turbos is directed into the induction system of the engine (through an intercooler, if selected). Multiple turbo applications are most successful when the engine produces substantial exhaust-gas volume; e.g., in large-displacement or very high-speed engines.

Boost Limit—(Turbos, Centrifugals, Roots, Screw) This is the pressure at which the wastegate or blow-off valve is activated, maintaining maximum induction pressure at or below this value.

Note: **Boost Limit** is an arbitrary pressure, set the you. It is not a measure of the capability of the supercharger, i.e., the blower may not be able to develop sufficient

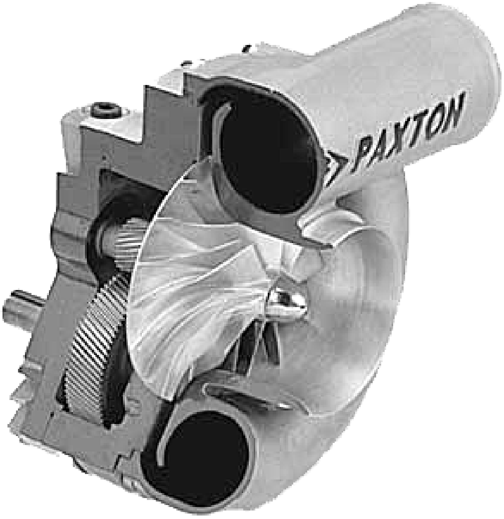
Belt Ratio

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 Jackson Supercharger pulley setup provides an overdrive (a Belt Ratio of 1.20:1).

pressure to activate the wastegate.

Belt Ratio—(Centrifugals, Roots, Screw) Centrifugal, roots, and screw superchargers are mechanically driven by the engine. The **Belt Ratio** (external ratio) is the ratio of the mechanical connection between the engine crankshaft and blower input

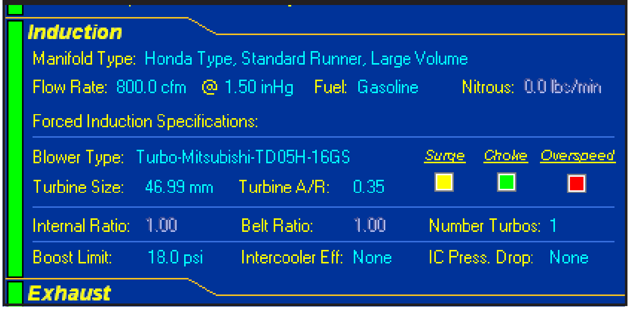
Internal Gear Ratio



Centrifugal superchargers are driven by an external *Belt Ratio*, 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.

Forced Induction Modeling

Operational Indicators



Induction

Manifold Type: Honda Type, Standard Runner, Large Volume

Flow Rate: 800.0 cfm @ 1.50 inHg Fuel: Gasoline Nitrous: 0.0 lbs/min

Forced Induction Specifications:

Blower Type: Turbo-Mitsubishi-TD05H-16GS

Turbine Size: 46.99 mm Turbine A/R: 0.35

Surge	Choke	Overspeed
🟨	🟩	🟥

Internal Ratio: 1.00 Belt Ratio: 1.00 Number Turbos: 1

Boost Limit: 18.0 psi Intercooler Eff: None IC Press. Drop: None

Exhaust

The forced induction category includes three "indicators" that will help you select the correct turbocharger, turbine wheel size, and A/R ratio. Each indicator reveals a potential operational problem with the current configuration. See the text for a definition of each indicator and tips on how to correct problems.

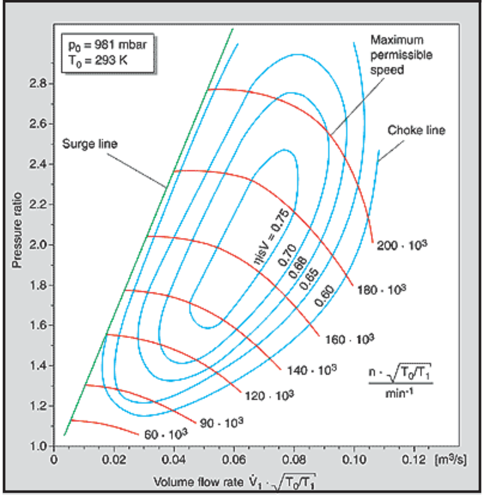
shaft. This value is multiplied by the **Internal Gear Ratio** on centrifugal superchargers to determine internal rotor speed.

Internal Gear Ratio—(Centrifugal) Centrifugal superchargers are driven by a mechanical connection to the engine crankshaft. Internal rotor speed is usually increased by the external *Belt Ratio* (described previously), 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**.

Operational Indicators—(Turbos, Centrifugals) The forced induction portion of the

This turbo compressor map shows how the compressor turbine performs at various flow rates, pressure ratios, and rpms. If engine demand (often called the "engine demand line") causes the turbo to operate "off the map" to the left, *Surge* can occur. If engine demand line falls of the right side of the map, the turbo is said to be in a *Choke* condition. And if the turbocharger speed exceeds the maximum speed on shown on the map (in this case, 200,000rpm), an *Overspeed* condition exists. Each of these abnormal operating conditions trigger indicators in the Forced Induction portion of the Induction Component Category.

Turbocharger Compressor Map



INDUCTION category includes three “indicators” that will help you select the correct turbocharger, turbine wheel size, and A/R ratio. Each indicator shows a potential operational problem, as follows:

Surge: This condition occurs when mismatched components caused unstable airflow through the compressor. If a turbo is operated consistently within surge, the additional loads can damage the turbines, shafts, and bearings. If surge is detected during operation, the ***Surge*** indicator will display either yellow or red. A yellow Surge indicator means that the turbo has entered surge only twice during the full engine rpm range. This limited-surge operation is not considered unusual and is not normally associated with shortened turbocharger life. If the indicator turns red, the turbo has entered into surge more than two times during the engine “dyno test.” The turbocharger, turbine size, or A/R ratio should be changed to eliminate this condition.

Choke: While ***Choke*** can apply to both the Compressor and Turbine impellers, ***Choke*** most often refers to the point at which compressor wheel tips reach sonic velocity, preventing further flow. The choke line on a compressor map can be recognized by the steeply descending speed lines at the right side of the map. If choke is detected during the engine rpm range, the ***Choke Indicator*** will turn from green to yellow, indicating a condition that should be corrected but is usually not associated with turbocharger damage. However, choke problems are relatively easy to correct, often disappearing with a slight reduction in shaft speed (use a larger Turbine or increase the A/R ratio).

Overspeed: If the turbocharger shaft speed exceeds the manufacture’s recommendations (the engine demand line travels off of the top of the compressor map), the ***Overspeed Indicator*** will change from green to yellow. If the overspeed condition exceeds the manufacturer’s recommended speed by over 10%, the indicator will switch from yellow to red, indicating a potentially harmful condition to the turbocharger bearings and seals. If you enter a red Overspeed condition, increase the **Turbine Size** and/or the **Turbine Housing A/R** ratio.

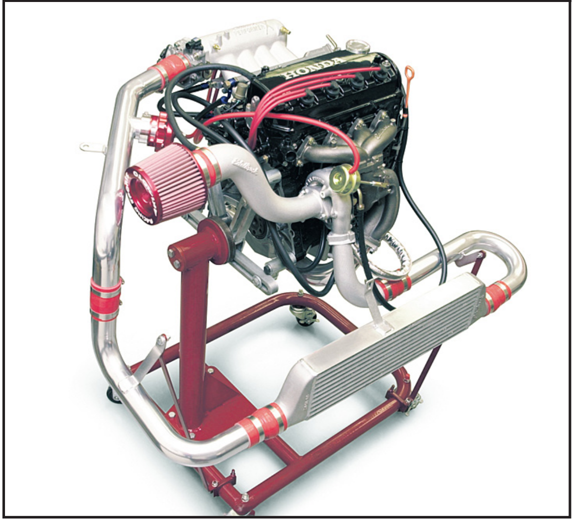
Selecting a supercharger listed in any of the three **Blower Type** submenus will load the specifications for that device into the **INDUCTION** category. You may edit these values at any time to determine their effect on engine power.

Selecting The Best Supercharger Components For Your Application

Selecting a Turbocharger—A turbocharger consists of a compressor and a turbine. The “compressor side” is selected when you choose the turbo from the main Turbo-Selection menu. The compressor acts as pump that forces air into the induc-

Forced Induction Modeling

Selecting The Best Turbocharger



A turbocharger system consists of a complex interplay between exhaust flow, induction flow, pressures and temperatures. Many of these variables are visually illustrated on a compressor map (see opposite page). While compressor-map data is often hard to locate, SC-DynoSim contains more than 40 built-in maps that cover a broad range of capacities. This functionality allows you to test various manufacturer turbo kits and even fine-tune the turbine diameters, A/R ratios, and more.

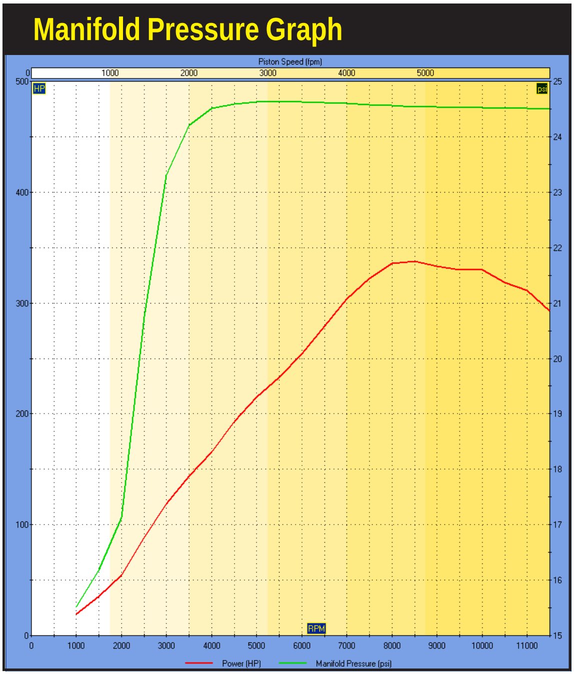
tion system of the engine. The performance of the compressor is determined by the speed of the impeller (inside the compressor housing), the shape of the housing, and the swallowing capacity of the engine. These variables are visually illustrated on a compressor map. While compressor-map data is often hard to locate, SC-DynoSim contains more than 40 maps within its simulation that cover a broad range of capacities.

The turbine side of the turbocharger is composed of a turbine wheel and the surrounding housing. The turbine is placed in the exhaust stream of the engine and is driven by a combination of exhaust flow and exhaust pressure waves. The turbine is connected to the compressor turbine through an interconnecting shaft. Two parameters modify the performance of the turbine: 1) the **Turbine Size** and, 2) the **Turbine Housing A/R** ratio. As described earlier (page 62), the **Turbine Size** has a major effect on turbine and compressor speed. In general, the smaller the wheel, the faster the turbine will rotate. The **Turbine Housing A/R** ratio acts to fine-tune the turbine speed. The smaller the **Turbine Housing A/R**, the faster the turbine will spin.

To find the optimum turbocharger for your engine, first select the turbo/compressor from the Turbo menu. For help in making an initial selection, consult with the manufacturer or visit the many performance websites that offer turbo kits and performance modifications. You will often find turbo recommendations and even suggestions for turbine-wheel diameters and A/R ratios. After you have selected the basic turbo, set the **Boost Limit** (wastegate pressure) to the desired level (use 10psi if you're not sure). Next, you need to analyze how much airflow the turbo is delivering to the engine by viewing the manifold pressure curve (shown on the graph under the Engine Component Categories—see page 68, or right-click any graph and assign ***Manifold Pressure*** to either the **Y1** or **Y2** axis).

Inspect the manifold pressure curve for the rpm point at which the pressure rises

Forced Induction Modeling



Inspect the manifold pressure curve (right click any graph, then select Manifold Pressure for either the Y1 or Y2 axis) for the rpm point at which the pressure rises to the maximum boost pressure (here, about 4000rpm). Make sure that the turbo you have selected, in fact, reaches the wastegate relief pressure chosen in the *Boost Limit* field. The manifold pressure indicated on the graph (the green curve) is an *absolute* indication, so a boost pressure of 10 psi would be shown on the graph as about 25 psi, or ambient plus boost (14.7 + 15 = 24.7psi).

to the maximum boost pressure. Make sure that the turbo you have selected, in fact, reaches the wastegate relief pressure chosen in the **Boost Limit** field.

> **Note:** The manifold pressure indicated on the graph is an *absolute* indication, so a boost pressure of 10 psi would be shown on the graph as about 25 psi, or ambient (14.7) plus boost.

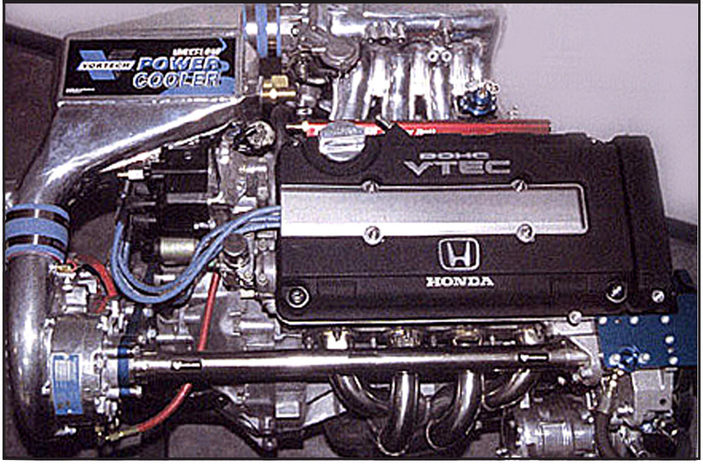
If the maximum-boost rpm point occurs considerably late in the rpm range, the boost pressure never reaches the Boost Limit, or the ***Choke*** indicator is lit, installing a smaller turbine wheel may solve the problem. On the other hand, if the pressure curve begins too early in the rpm range, or the ***Surge*** or ***Overspeed*** indicators are lit (see page 65 for more information on the operational indicators), installing a larger turbine wheel or increasing the A/R ratio may solve the problem.

Selecting a Centrifugal Supercharger—Like a turbocharger, a centrifugal supercharger consists of a compressor, but the driving force for the impeller comes from an internal gear box connected to the engine crankshaft through a drive belt. Also like the turbocharger, the centrifugal supercharger compressor element is defined in a "map" provided by the manufacturer. Because the centrifugal compressor must rotate at high speed (again, like the turbocharger), the internal "step-up" gear box increases input pulley speed by three to four times. And input pulley speed is typically 1.5- to 3-times engine speed, determined by the appropriately sized pulleys. Final impeller speed is found by multiplying the Internal Ratio by the Belt Ratio.

> **Note:** While the internal gear ratio is not usually adjustable, the SC-DynoSim allows you the freedom to experiment with this ratio in addition to all the other

Forced Induction Modeling

Centrifugal Supercharger



Like a turbocharger, a centrifugal supercharger consists of a compressor, but the driving force comes from an internal gear box connected to the engine crankshaft. Because the centrifugal compressor must rotate at high speed (again, like the turbocharger), the internal "step-up" gear box increases input pulley speed by three to four times.

tunable elements in the Forced Induction category.
The **Belt Ratio** can be calculated from the following formulas:

For Serpentine Belts:

$$\text{Belt Ratio} = \frac{\text{Crank pulley diameter}}{\text{Supercharger pulley diameter}}$$

For Cog Pulleys:

$$\text{Belt Ratio} = \frac{\text{Crank pulley teeth}}{\text{Supercharger pulley teeth}}$$

To find the optimum centrifugal supercharger for your engine, first select a centrifugal supercharger from the menu. For help in making an initial selection, consult with the manufacturer or visit the many performance websites that offer kits and performance modifications. You will often find supercharger recommendations and suggestions for belt ratios. After you have selected the basic blower, set the **Boost Limit** (wastegate pressure) to the desired level (use 10psi if you're not sure). Next select the **Belt Ratio** recommended by the manufacturer (many centrifugal blower run with approximately 2.5:1 external Belt Ratios and 3.5:1 Internal Gear Ratios). Finally, you need to analyze how much airflow the blower is delivering to the engine by viewing the manifold pressure curve (shown on the graph under the Engine Component Categories—see page 68, or right-click any graph and assign ***Manifold Pressure*** to either the **Y1** or **Y2** axis).

Inspect the manifold pressure curve for the rpm point at which the pressure rises to the maximum boost pressure. Make sure that the supercharger you have selected, in fact, reaches the wastegate relief pressure chosen in the **Boost Limit** field.

Note: The manifold pressure indicated on the graph is an *absolute* indication, so a boost pressure of 10 psi would be shown on the graph as about 25 psi, or ambient (14.7) plus boost.

If the maximum-boost rpm point occurs considerably late in the rpm range, the ***Choke*** indicator is lit, or the boost pressure never reaches the Boost Limit, increasing the Belt Ratio or installing a larger supercharger may solve the problem. On the other hand, if the pressure curve begins too early in the rpm range, or the ***Surge*** or ***Overspeed*** indicators are lit (see page 65 for more information on the operational indicators), try decreasing the Belt Ratio or installing a smaller supercharger.

Selecting a Roots or Screw Supercharger—Roots or Screw supercharger selection involves only two parameters: the flow volume and the **Belt Ratio** (these superchargers do not have internal overdrive gear boxes). The compressor-flow volume is fixed in the design of the supercharger and is indicated in the blower menu as a volume-per-revolution value.

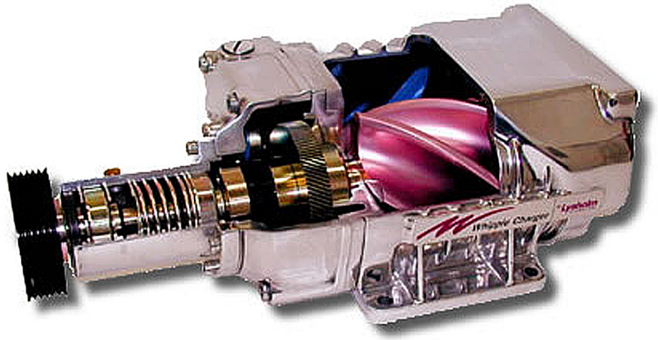
To find the optimum Roots/screw supercharger for your engine, first select a supercharger from the menu. For help in making an initial selection, consult with the manufacturer or visit the many performance websites that offer kits and performance modifications. You will often find supercharger recommendations and suggestions for belt ratios. After you have selected the basic blower, set the **Boost Limit** to the desired level, In the case of Roots and Screw superchargers, the Boost Limit is the blowoff-valve pressure, not the maximum pressure that you wish to deliver to the engine during normal operation, but rather the absolute maximum pressure the blower can generate (use 10psi if you're not sure). Next select the **Belt Ratio** recommended by the manufacturer (many Roots blower use Belt Ratios of 1.0- to 1.5:1, while Screw

Roots Supercharger

The roots supercharger is a positive displacement "pump." It really doesn't compress air, rather it pushes air into the engine. It employs 2 or 3 counter-rotating lobes to capture a fixed volume of air per revolution and deliver it to the intake manifold. Unlike the compressors of the turbocharger and centrifugal supercharger, which deliver greater boost with increased rpm, a positive displacement supercharger pumps a steady amount of air for every revolution. When properly setup, it can deliver "instant boost" even at low speed. This clean looking setup is a Jackson high-boost system for the Honda Civic Si.

Intercooler Modeling

Screw Supercharger



The screw compressor (like this model from Whipple) uses a positive-displacement design for excellent low-end torque as well as high efficiency for good top-end horsepower.

superchargers use approximately 1.5- to 2.0:1). Finally, you need to analyze how much airflow the blower is delivering to the engine by viewing the manifold pressure curve (shown on the graph under the Engine Component Categories—see page 68, or right-click any graph and assign ***Manifold Pressure*** to either the **Y1** or **Y2** axis).

Inspect the manifold pressure curve for the rpm point at which the pressure rises to the desired level. Make sure that the supercharger you have selected does not reach wastegate pressure (Boost Limit) within the usable rpm range of the engine. However, manifold pressure should reach a sufficient level to provide the performance improvement you are seeking.

> **Note:** The manifold pressure indicated on the graph is an *absolute* indication, so a boost pressure of 10 psi would be shown on the graph as about 25 psi, or ambient (14.7) plus boost.

If the desired boost pressure occurs considerably late in the rpm range or the desired pressure is never e the problem. On the other hand, if the pressure curve rises too quickly in the rpm range, or the Boost Limit pressure is reached within the usable rpm range of the engine, decrease the Belt Ratio or installing a smaller supercharger.

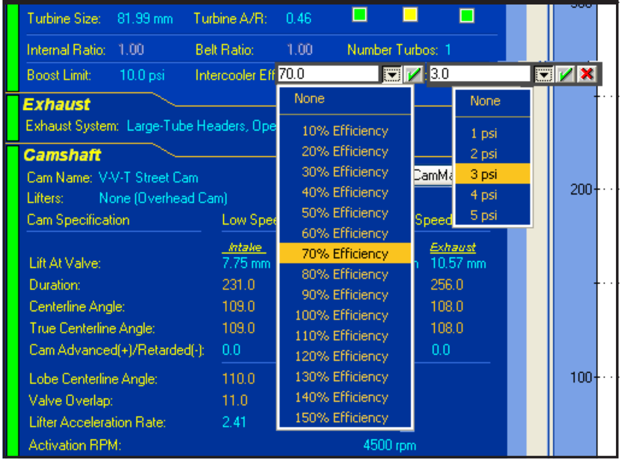
> **Note:** The ***Surge***, ***Choke***, and ***Overspeed*** indicators are not active when Roots or Screw superchargers are used.

Intercoolers

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 just lost horsepower. Higher temperatures can lead to detonation, increase octane requirements, and require a

Intercooler Modeling

Intercooler Menu



Turbine Size: 81.99 mm
Turbine A/R: 0.46
Internal Ratio: 1.00
Belt Ratio: 1.00
Number Turbos: 1
Boost Limit: 10.0 psi
Intercooler Eff 70.0
3.0

Exhaust

Exhaust System: Large-Tube Headers, Ope

Camshaft

Cam Name: V-V-T Street Cam
Lifters: None (Overhead Cam)

Cam Specification	Low Spee	Speed
	Intake	*Exhaust*
Lift At Valve:	7.75 mm	10.57 mm
Duration:	231.0	256.0
Centerline Angle:	109.0	108.0
True Centerline Angle:	109.0	108.0
Cam Advanced(+)/Retarded(-):	0.0	0.0
Lobe Centerline Angle:	110.0	
Valve Overlap:	11.0	
Lifter Acceleration Rate:	2.41	

Activation RPM: 4500 rpm

The SC-DynoSim includes an intercooler model that can be activated with any forced-induction system. An intercooler reduces induction temperatures that, otherwise, substantially reduce performance. The intercooler is selected from a menu that indicates efficiency; 100% efficient reduces induction temperature to ambient. An IC Pressure drop menu shows an automatically selected pressure drop value based on the Intercooler (can be manually changed).

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. The efficiency of an intercooler determines how much of the heat generated by charge compression is removed. The lower the efficiency of the intercooler, the less heat is removed from the induction charge. An efficiency of 100% removes all extra heat (bring charge temperature down to ambient). An efficiency of over 100% (reduces charge temperatures below ambient) is possible with water or ice. Everything from outside air to ice water and even evaporating

Intercooler

Higher induction temperatures, common on blowers with pressure ratios of 2.0 or higher, can cost horsepower and reliability. An Intercooler cools the inducted air the same way that heat is removed from the engine itself: using a radiator. Intercooling is the key to power and reliability in high-boost systems.

Intercooled VW Golf

Here’s a great ride! This turbocharged Golf uses a generously-sized intercooler. Note the cold-air inlet ducted to the hood/ cowl. The clear front end is killer—this shot was taken with the hood closed!

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	**40%**	**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 SC-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).

Every intercooler will produce a pressure drop from flow restrictions that are generated by its length, shape, and air passages. This pressure drop is usually small—in the range of 1 to 3 psi. You can adjust the Intercooler Pressure Drop by selecting a value from the ***IC Pressure Drop*** menu, however, the SC-DynoSim automatically calculates an appropriate pressure drop value based on the selected Intercooler.
Note-1: The ***IC Pressure Drop*** occurs after the Intercooler, so the ***Boost Limit*** may need to be increased to obtain the desired boost pressure at intake valve.
Note-2: 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.

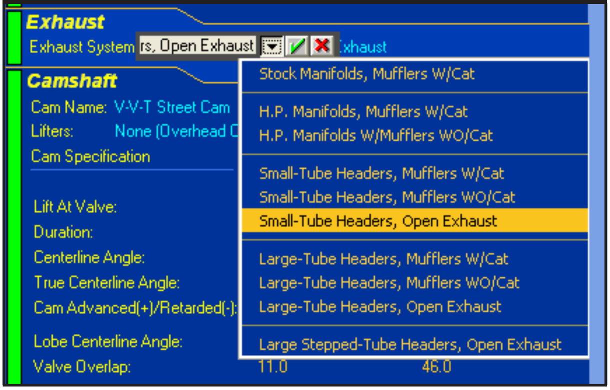
THE EXHAUST-SYSTEM COMPONENT CATEGORY MENU

The **EXHAUST** category establishes a manifold or header-type exhaust system for the simulated test engine. The menu includes ten selections, seven of which include mufflers, four include mufflers and catalytic converters.

Each of the exhaust system selections apply a unique tuning model to the simu-

Exhaust System Modeling

Exhaust System Menu



Exhaust

Exhaust System: rs, Open Exhaust

Camshaft

Cam Name: V-V-T Street Cam

Lifters: None (Overhead C

The SC-DynoSim can 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). Each group has selections to model related exhaust components, like mufflers and catalytic converters (both are considered to offer moderate restriction to exhaust flow).

lation. (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 SC-DynoSim (a much more detailed modeling of these interactions is done in the *Dynomation* engine simulation series that will be available from ProRacing Sim Software in late 2004). While flow restriction (back pressure) is modeled, the SC-DynoSim simulation does not resolve specific header dimensions. However, the SC-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 diameters of the engine under test).

The ***Exhaust System*** menu choices are described in the following sections. Use

"Log-Type " Exhaust Manifold

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 less than optimum exhaust flow.

this information to make the most appropriate choice for your test engine.

Stock Manifolds And Mufflers W/Cat—The first choice in the *Exhaust System* 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 minimize clearance problems and cost than to optimize exhaust flow. Exhaust manifolds of this type have widespread application on low-performance production engines. This exhaust-modeling selection assumes that the exhaust manifolds are connected to typical OEM mufflers and catalytic converters with short sections of pipe.

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 blowdown effects of early EVO timing and increase pumping work losses during the exhaust cycle.

H.P. Manifolds And Mufflers W/Cat and WO/Cat—This choice offers a significant improvement over the stock exhaust system modeled in the *Exhaust System* menu 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 and cat are large diameter and the mufflers generate less back pressure and, typically, produce a louder exhaust note.

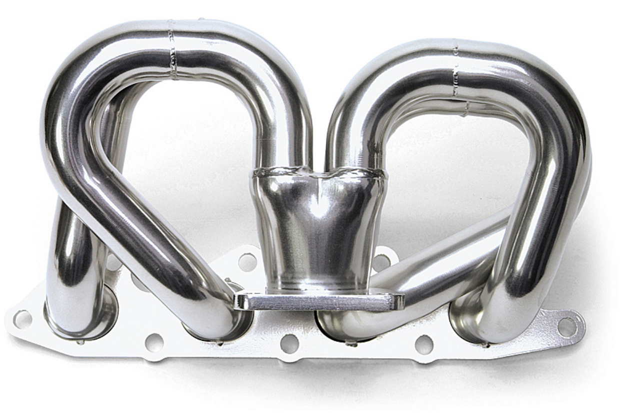
While this system is a “high-performance” design, it offers little tuning effects and virtually all suction waves are fully damped or never reach the cylinders during valve overlap. All performance benefits from this selection are due to a decrease in passage restrictions and lower system back pressure. System pressure levels mimic factory high-performance mufflers and/or catalytic-converter-with-muffler combinations. This

HP Manifolds And Mufflers

The *HP Manifolds And Mufflers* exhaust-system choices offer 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, like this manifold for the Eclipse/Laser. The connecting pipes to the mufflers are large diameter and the mufflers generate less back pressure.

Exhaust System Modeling

Custom HP "Manifolds"



Here is an excellent example of high-performance "manifolds" from Edelbrock for the Ford Focus. When used with mufflers, model this system using the *H.P. Manifolds And Mufflers* menu selection.

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-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 SC-DynoSim simulation. Instead, the headers are assumed to deliver a scavenging wave only to the cylinder that generated the initial pressure wave.*

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 (110% to 130% of the exhaust-valve diameter for two exhaust valves per port); tubes that measure 120% to 140% of the exhaust-valve diameter are "large" tube headers (130% to 160% for two exhaust valves per port).

Small Tube Headers, Mufflers W/Cat and WO/Cat—This is the first component selections that begins to harness the tuning potential of wave dynamics in the exhaust system. These simulated headers have primary tubes that connect each exhaust port to a common tube or 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 and catalytic converter, if used.

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

Exhaust System Modeling

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 racing header, this tubular exhaust system from S&S for Honda engines offers some wave-dynamic scavenging.

period. The primary tubes modeled by this *Exhaust System* 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 primary tubes individually connecting each exhaust port to a common collector or tube. 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 associated with applications requiring optimum power slightly above peak-torque engine speeds. These headers show the greatest benefits on smaller displacement engines.

Large-Tube Headers, Mufflers W/Cat and WO/Cat—This menu selection simulates headers with “large” primary tubes individually connecting each exhaust port to a common collector or tube. 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 and catalytic converter, if used.

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

Exhaust System Modeling

Large-Tube Headers And Stepped-Tube Racing Headers

Large-tube headers (shown on left) are designed for high-performance street and racing applications. The better pieces 4-into-1 collectors and 1-3/4-inch or larger primary tubes. Large-tube stepped headers (right) have large-diameter primary tubes with several transitions to slightly larger tubing diameters. These "steps" can reduce pumping work and improve horsepower on high-rpm engines.

show significant benefits on high-rpm or turbocharged engines. These headers may not increase power as much 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 *Exhaust System* 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 naturally-aspirated racing engines or turbocharged 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 *Exhaust System* 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. The collector—or collectors, depending on the number of cylinders—terminates into the atmosphere. Strong suction waves are created 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.

Camshaft Modeling

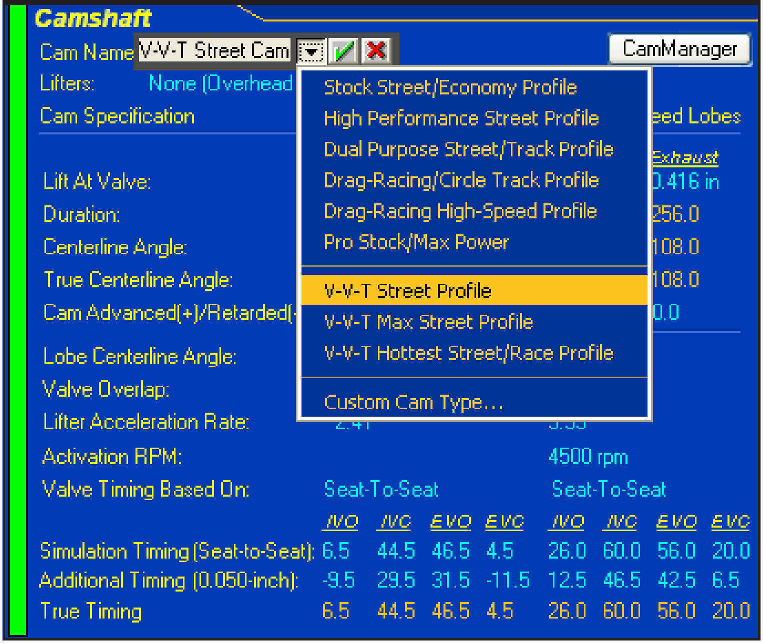
The "stepped" design of the primary tubes reduces pumping work on some engines. As high-pressure compression waves leave the port and encounter a step in the primary tube, they return short-duration rarefaction waves. These low-pressure "pulses" moves back up the header and assists the outflow of exhaust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

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 considering all the "standards" of measurement and advertising hype, 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,

Camshaft Name Menu



Cam Name V-V-T Street Cam

Lifters: None (Overhead

Cam Specification

Lift At Valve: 0.416 in

Duration: 256.0

Centerline Angle: 108.0

True Centerline Angle: 108.0

Cam Advanced(+)/Retarded(- 0.0

Lobe Centerline Angle:

Valve Overlap:

Lifter Acceleration Rate:

Activation RPM: 4500 rpm

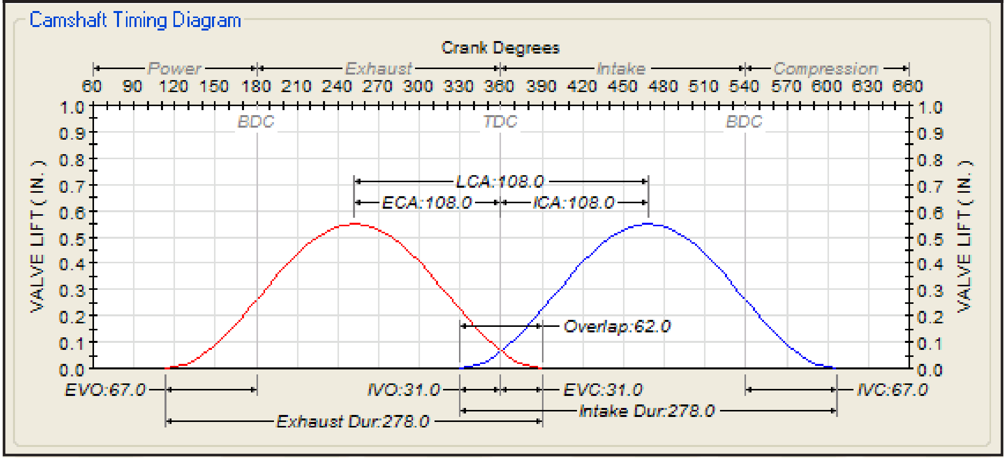
Valve Timing Based On: Seat-To-Seat Seat-To-Seat

	IVO	IVC	EVO	EVC	IVO	IVC	EVO	EVC
Simulation Timing (Seat-to-Seat):	6.5	44.5	46.5	4.5	26.0	60.0	56.0	20.0
Additional Timing (0.050-inch):	-9.5	29.5	31.5	-11.5	12.5	46.5	42.5	6.5
True Timing	6.5	44.5	46.5	4.5	26.0	60.0	56.0	20.0

The *Camshaft Name* menu 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 SC-DynoSim has hundreds of new enhancements and features that improve cam-timing and valve-train motion analysis.

Camshaft Modeling

Valve Motion Diagram



The best way to visualize camshaft timing is to picture this "twin-hump" event diagram (as drawn by the *SC-DynoSim CamManager*, described on page 99). 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.

etc., using a computer-based engine simulation program is often the only way to accurately predict the outcome.

The SC-DynoSim makes it possible to test the effects of cam timing in seconds, including Variable Valve Timing (V-V-T, also widely called VTEC, after Honda's Variable Timing Electronic Control system). The ability of the program to take the myriad elements that affect airflow and cylinder pressures into consideration and "add these effects over time" is key to accurately predicting the results of camshaft-timing changes.

Cam Basics

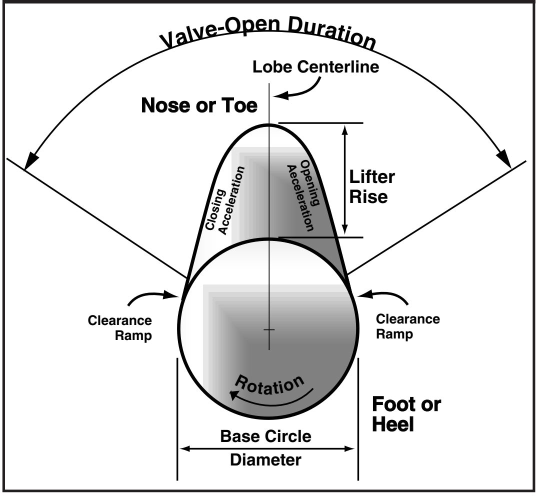
In the simplest terms, the camshaft is a straight steel or iron shaft with eccentric lobes. It is connected to the crankshaft with a chain or gear train and is usually rotated at one-half crank speed. Lifters (or cam followers)—and in the case of in-block cam locations, pushrods, and rockerarms—translate 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

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 crankshaft 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



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. 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:

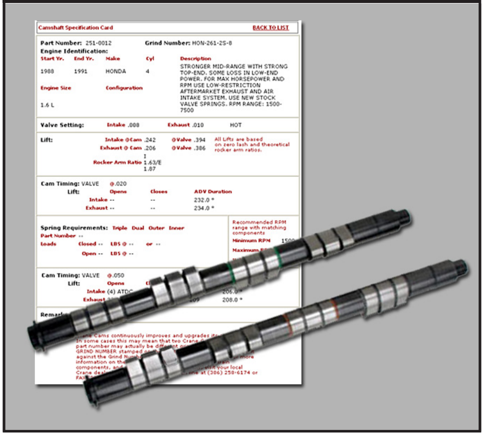
1—Intake Valve Opening (IVO) **2—Intake Valve Closing (IVC)**
3—Exhaust Valve Opening (EVO) **4—Exhaust Valve Closing (EVC)**
5—Intake Valve Lift **6—Exhaust Valve Lift**

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**

Camshaft Modeling

Common “Cam Card” Timing



Camshaft Specification Card BACK TO LIST

Part Number: 251-0012 Grind Number: HON-261-2S-8

Engine Identification:

Start Yr.	End Yr.	Make	Cyl	Description
1988	1991	HONDA	4	STRONGER MID-RANGE WITH STRONG TOP-END. SOME LOSS IN LOW-END POWER. FOR MAX HORSEPOWER AND RPM USE LOW-RESTRICTION AFTERMARKET EXHAUST AND AIR INTAKE SYSTEM. USE NEW STOCK VALVE SPRINGS. RPM RANGE: 1500-7500

Engine Size: 1.6 L

Configuration

Valve Setting: Intake .008 Exhaust .010 HOT

Lift: Intake @Cam .242 @Valve .394

Exhaust @ Cam .206 @Valve .386

All Lifts are based on zero lash and theoretical rocker arm ratios.

Rocker Arm Ratio I 1.63/E 1.87

Cam Timing: VALVE @.020

Lift:	Opens	Closes	ADV Duration
Intake	--	--	232.0 °
Exhaust	--	--	234.0 °

Spring Requirements: Triple Dual Outer Inner

Part Number --

Loads Closed -- LBS @ -- or --

Open -- LBS @ --

Recommended RPM range with matching components

Minimum RPM 1500

Cam Timing: VALVE @.050

Lift: Opens

Intake (4) ATDC 206.0 °

Exhaust 208.0 °

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

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).

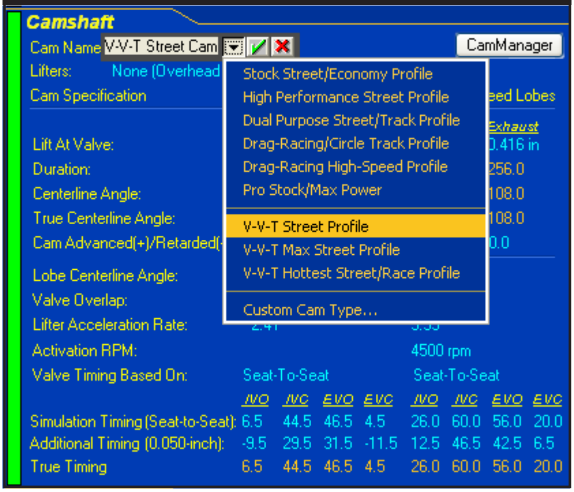
Camshaft Menu Choices

The **Cam Name** menu contains nine camshaft “grinds” that are listed by application: 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,* plus these *Variable Valve Timing* (V-V-T) profiles: 7) *V-V-T Street Profile,* 8) *V-V-T Max Street Profile,* and 9) *V-V-T Hottest Street/Race Profile*. When any of these camshafts is selected, the ***Intake Lift At Valve*** and ***Exhaust Lift At Valve***, the seat-to-seat and 0.050-inch ***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 for 2-valve engines. While this cam uses roller-hydraulic lifters, lifter acceleration rate (explained in detail on page 90) is only 2.90 (on a 1.00-to-6.00 scale), which indicates that valve motion for this cam falls

Camshaft Modeling

Cam Name Menu Selections



Cam Name V-V-T Street Cam
Lifters: None (Overhead
Cam Specification ...eed Lobes

	Exhaust
Lift At Valve:	0.416 in
Duration:	256.0
Centerline Angle:	108.0
True Centerline Angle:	108.0
Cam Advanced(+)/Retarded(-	0.0

Lobe Centerline Angle:
Valve Overlap:
Lifter Acceleration Rate: 2.41 3.33
Activation RPM: 4500 rpm
Valve Timing Based On: Seat-To-Seat Seat-To-Seat

	IVO	IVC	EVO	EVC	IVO	IVC	EVO	EVC
Simulation Timing (Seat-to-Seat):	6.5	44.5	46.5	4.5	26.0	60.0	56.0	20.0
Additional Timing (0.050-inch):	-9.5	29.5	31.5	-11.5	12.5	46.5	42.5	6.5
True Timing	6.5	44.5	46.5	4.5	26.0	60.0	56.0	20.0

The SC-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. You can test cams from specifications in manufacturer catalogs or load CamFiles directly using the new, built-in *CamManager™. SC-CamData3™* (optional, see page 92) increases your test-cam library to over 200 profiles.

in the range of stock OEM to mild street performance. Rated valve lift is 0.510-inch for both the intake and exhaust.

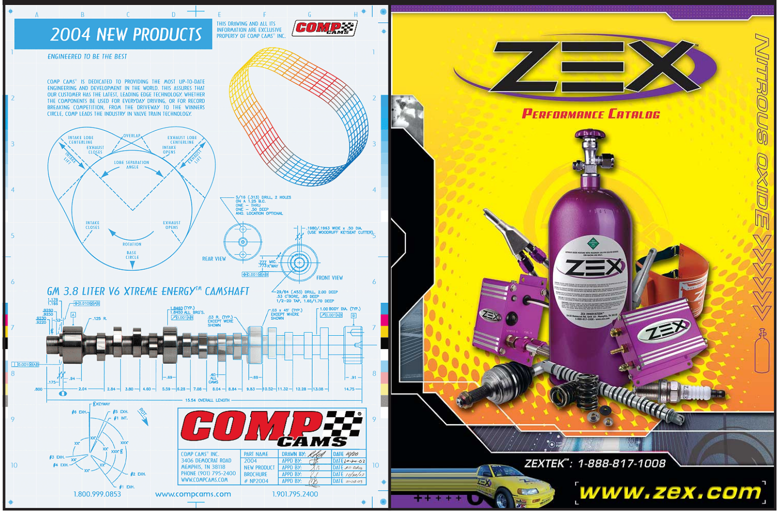
The EVO timing maintains combustion pressure late into the power stroke and early IVC minimizes intake flow reversion. Late IVO and early EVC produce 38 degrees of overlap, enough to harness some scavenging effects but restricted enough to prevent exhaust gas reversion into the induction system. The characteristics of this cam are smooth idle, good power from 600 to 5000rpm, 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 in 2-valve engines. 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 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

Sources For Sport Compact Cams



The "generic" camshafts available in the SC-DynoSim *Cam Name* menu were modeled after profiles developed by CompCams and ZEX.

mild track applications in 2-valve engines. 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.

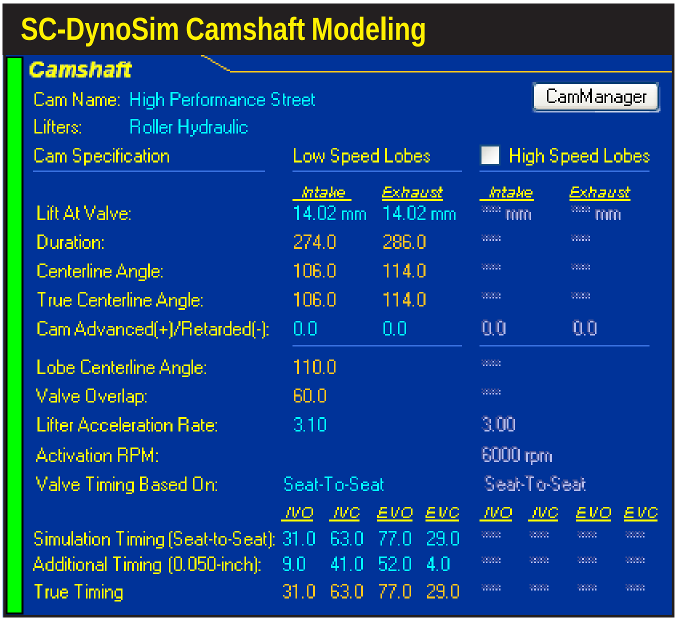
EVO timing on this camshaft is beginning to move away from specs that would be expected for optimum combustion pressure utilization, with more of an emphasis on blowdown and minimizing exhaust-pumping losses. The later IVC attempts to strike a balance between harnessing the ram effects of the induction 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 for 2-valve engines. 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 for 2-valve engines. 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 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



SC-DynoSim Camshaft Modeling

Camshaft

Cam Name: High Performance Street

Lifters: Roller Hydraulic

Cam Specification	Low Speed Lobes Intake	Low Speed Lobes Exhaust	☐ High Speed Lobes Intake	High Speed Lobes Exhaust
Lift At Valve:	14.02 mm	14.02 mm	#### mm	#### mm
Duration:	274.0	286.0	####	####
Centerline Angle:	106.0	114.0	####	####
True Centerline Angle:	106.0	114.0	####	####
Cam Advanced(+)/Retarded(-):	0.0	0.0	0.0	0.0
Lobe Centerline Angle:	110.0		####	
Valve Overlap:	60.0		####	
Lifter Acceleration Rate:	3.10		3.00	
Activation RPM:			6000 rpm	
Valve Timing Based On:	Seat-To-Seat		Seat-To-Seat	

	IVO	IVC	EVO	EVC	IVO	IVC	EVO	EVC
Simulation Timing (Seat-to-Seat):	31.0	63.0	77.0	29.0	####	####	####	####
Additional Timing (0.050-inch):	9.0	41.0	52.0	4.0	####	####	####	####
True Timing	31.0	63.0	77.0	29.0	####	####	####	####

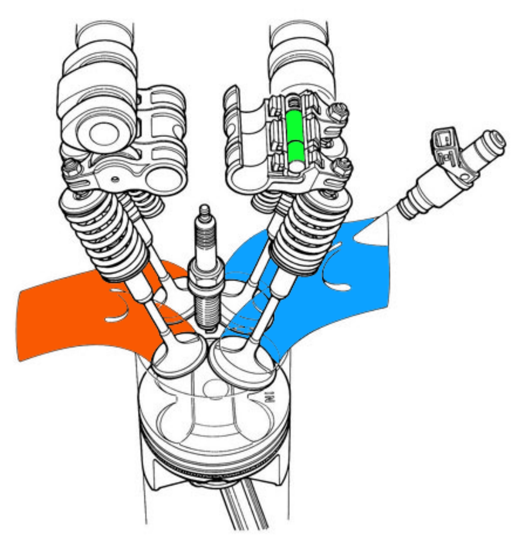
There are hundreds or even thousands of cam profiles and lifter/valvetrain combinations for any typical performance engine. Determining the best cam for any application often required extensive dyno testing. Today, with tools like the SC-DynoSim, you can "zero-in" on the right cam for your engine <u>before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

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 for 2-valve engines. 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 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.

V-V-T (VTEC) Camshaft Modeling



The SC-DynoSim will model variable valve timing (V-V-T) of the type used on Honda (VTEC) and other engines where a discrete low-speed profile is used during low-speed operation then the engine switches to a high-speed profile at a particular engine speed. Honda uses a simple pin (shown in green) driven with oil pressure (timed with an electronic control) that locks the outer two low-speed rockers to the center rocker riding on the high-speed lobe. This allows the engine to maintain excellent driveability and fuel economy at low speeds, yet produce power similar to a "race" engine at higher speeds.

Camshaft Modeling

V-V-T Street Cam—(modeled after the Honda Baseline Factory cam for the B16A, B17A, B18C engines) This profile is designed to simulate a "street" camshaft commonly used in 2- and 4-valve, V-V-T (VTEC) sport-compact engines. This cam uses direct-rocker valve actuation (Overhead Cam) and produces an acceleration rate of 2.41 for the Low-Speed Lobe and 3.39 for the High-Speed Lobe, indicating that valve acceleration for this profile falls in the range of mild to performance rates. Rated valve lift is 0.305-inch (7.75mm) on the Low-Speed Lobes and 0.459/0.416-inch (11.6/10.57mm) for the intake and exhaust on the High-Speed Lobes.

This camshaft uses very mild cam timing on the low-speed lobes, with only 11-degrees overlap. This profile is designed, primarily, to minimize emissions and maximize fuel economy up to the activation rpm of the high-speed lobes (typically 5000-to-5500rpm). The high speed lobe is of moderate performance design, with 50% more lift and a 15% increase in valve durations. Valve overlap is increased to 46-degrees, a sufficient amount to begin harnessing some exhaust scavenging effects. If the high-speed lobe was used below about 4000rpm, the modestly-aggressive overlap would allow exhaust-gas reversion into the induction system at lower engine speeds, affecting idle quality and low-speed torque. The overall characteristics of this cam are smooth idle, good power from 1000 to 7500rpm, and part-throttle good fuel economy.

V-V-T Max Street Cam—(modeled after the Honda Stage-2 Street Performance cam for the B16A and B18C engines) This profile is designed to simulate a high-performance street camshaft for 2- and 4-valve, V-V-T (VTEC) sport-compact engines. This cam uses direct-rocker valve actuation (Overhead Cam) and produces an acceleration rate of 2.93 for the Low-Speed Lobe and 3.84 for the High-Speed Lobe, indicating that valve acceleration for this profile falls in the range of performance rates. Rated valve lift is 0.354-inch (8.99mm) on the Low-Speed Lobes and 0.472/0.457-inch (11.99/11.61mm) for the intake and exhaust on the High-Speed Lobes.

This camshaft uses somewhat more aggressive cam timing on the low-speed lobes, with 29-degrees overlap. This profile will begin to harness exhaust scavenging effects even while the engine runs on the low-speed lobe. The increased overlap allows some exhaust gas reversion into the induction system at lower engine speeds, affecting idle quality and low-speed torque. The high speed lobe is of performance design, with 33% more lift and a 11% increase in valve durations. Valve overlap is increased to 65-degrees, a modestly-aggressive value that takes advantage of free-flowing headers and mufflers (recommended for this cam). The narrow lobe centerline angle (102 degrees) of the high-speed lobes should be widened (with adjustable cam sprockets) for turbocharged applications and even on naturally-aspirated engines with low exhaust restriction. The overall characteristics of this cam are a somewhat rough idle, good power from 2500 to 8500rpm, and moderate part-throttle fuel economy.

V-V-T Hot Street/Race Cam—(modeled after the CompCams 57200 for the B16A, B17A, B18C and B18C5 engines) This profile is designed to simulate a maximum performance street camshaft for 2- and 4-valve, V-V-T (VTEC) sport-compact engines. This cam uses direct-rocker valve actuation (Overhead Cam) and produces an acceleration rate of 2.83 for the Low-Speed Lobe and 2.80 for the High-Speed Lobe, indicating that valve acceleration for this profile falls in the modest range of performance rates (easier on the valvetrain). Rated valve lift is 0.380/0.370-inch (9.65/9.40mm) on the Low-Speed Lobes and 0.500/0.480-inch (12.70/12.19mm) for the intake and exhaust on the High-Speed Lobes.

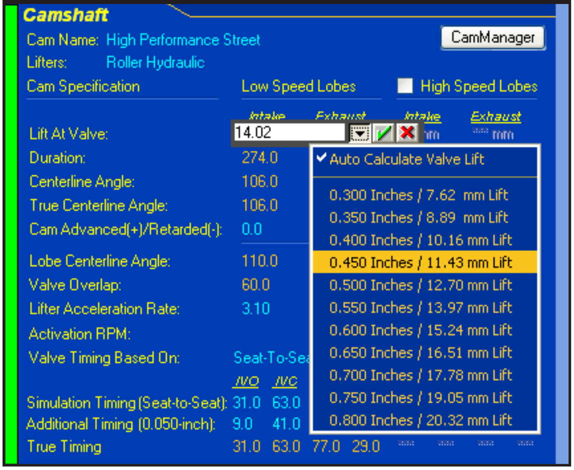
This camshaft uses somewhat relatively mild cam timing on the low-speed lobes, with only 16-degrees overlap. This profile is designed to maintain a good idle and torque at low engine speeds, while the increased duration and lift increase performance over stock profiles. The high speed lobe is of high-performance design, with 31% more lift and a 20% increase in valve durations. Valve overlap is increased to an aggressive 76-degrees that takes advantage of free-flowing headers and mufflers (while not required will significantly improve performance with this cam). The lobe centerline angle (109 degrees) of the high-speed lobes can be widened (with adjustable cam sprockets) for turbocharged applications and even on naturally-aspirated engines with low exhaust restriction. The overall characteristics of this cam are a somewhat good idle and excellent power from 1500 to 9000rpm, with good to moderate part-throttle fuel economy.

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

Valve Lift Menu



Camshaft

Cam Name: High Performance Street

Lifters: Roller Hydraulic

Cam Specification — Low Speed Lobes — ☐ High Speed Lobes

Lift At Valve: 14.02

Duration: 274.0

Centerline Angle: 106.0

True Centerline Angle: 106.0

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

Lobe Centerline Angle: 110.0

Valve Overlap: 60.0

Lifter Acceleration Rate: 3.10

Activation RPM:

Valve Timing Based On: Seat-To-Sea

Simulation Timing (Seat-to-Seat): IVO 31.0 IVC 63.0

Additional Timing (0.050-inch): IVO 9.0 IVC 41.0

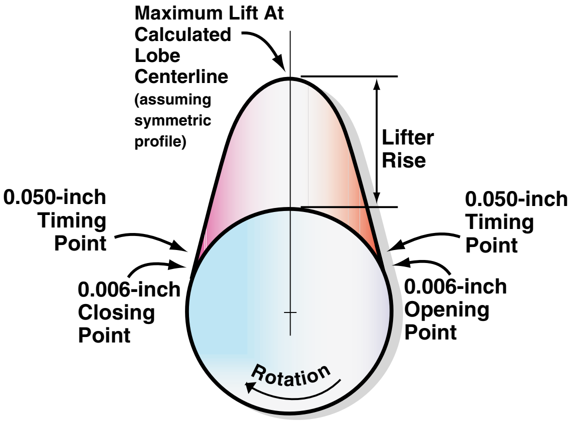
True Timing 31.0 63.0 77.0 29.0

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).

Camshaft Modeling

The SC-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 SC-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



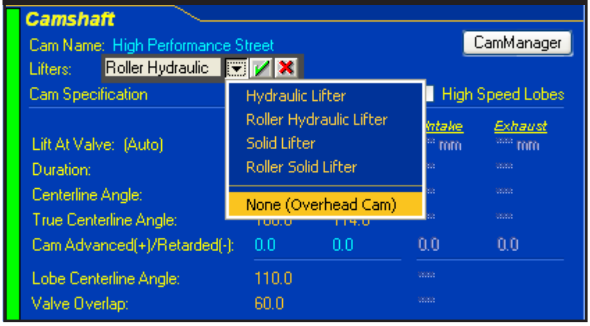
Lobe Profiles Are Calculated From Seat-To-Seat and 0.050-inch Opening and Closing Points, And The Point Of Maximum Lift

was chosen from the **Cam Name** menu or loaded from a CamFile using the **CamManager** (see page 99). At any time, you can manually enter custom valve-lift values from 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 also select any of the predetermined valve lifts listed in the menus, or you can select ***Auto Calculate Valve Lift*** (turned off, by default) that is available as the first choice from any of the **Lift-At-Valve** menus. When *Auto Calculate* is enabled, the SC-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 2-valve in a 4-valve 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 typically represents a "real-world" cam that has specific valve lift values associated with it (ground-in by the manufacturer).* However, you can turn 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.

Camshaft Modeling

Lifter-Type Menu Selections


Camshaft
Cam Name: High Performance Street
Lifters: Roller Hydraulic
Cam Advanced(+)/Retarded(-): 0.0 0.0 0.0 0.0
Lobe Centerline Angle: 110.0
Valve Overlap: 60.0

Lifter type is often associated with the description of a particular camshaft, e.g., Roller Cam 123. The SC-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).

Lifter Menu

The type of lifters used with any particular camshaft are often part of the description of that cam (e.g., a Roller Cam 123, or a Overhead 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 SC-DynoSim based on the ten timing points (five for each lobe, see photo on previous page) published by the cam manufacturer. For more information on lobe profiles and lifter

Lifter-Acceleration Menu Selections


Lobe Centerline Angle: 110.0 107.5
Valve Overlap: 11.0 46.0
Lifter Acceleration Rate: 2.41

The SC-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).

acceleration rates, refer to the next section.

Lifter-Acceleration Menu

As mentioned, the SC-DynoSim uses a unique 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) the SC-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). This technique provides a 500-step granularity for lifter acceleration that accurately models valvetrain acceleration rates generated by cams designed for street to all-out racing 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, Limited Valvetrain Life**

Note-1: The valvetrain acceleration rates for 4-valve engines do not need to be as high as those used in 2-valve engines designed for similar applications. 4-valve engines produce much more low-lift flow (due to the increased curtain area exposed as the valves open), and consequently, do not need to accelerate the valves as rapidly off of the seats.

Note-2: While the new algorithms used in this model have proven to be remarkably 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 each intake lobe and five for each exhaust lobe. Furthermore, the SC-DynoSim develops valve-motion curves that are biased toward symmetric (meaning that the "opening" side of the lobe has a nearly identical shape as the "closing" side). Asymmetric modeling cannot be performed accurately with only five data-input points per lobe, fortunately, performance differences between symmetric and asymmetric valve motion curves are often quite small. In most cases, the predicted ramp rates and valve motions within the SC-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

Camshaft Modeling

The new *SC-CamDataSim™* from ProRacing Sim Software includes over 300 CamFiles and all cam timing information required for the SC-DynoSim to automatically calculate the *Lifter Acceleration* rates. Use the new CamManager™ and Quick Iterator™ with SC-CamDataSim to automatically locate optimum profiles for any engine. SC-CamDataSim and the SC-DynoSim are, simply, the most powerful tools you can use to find the best cams for any application.

SC-CamDataSim™ 300+ CamFiles

As discussed in the previous section, the SC-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 SC-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). 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 SC-DynoSim and the 300+ additional CamFiles included on ***SC-CamDataSim™*** have complete cam specifications that allow the SC-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 SC-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 (if you can't guess at an acceleration rate, use 3.00 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 application 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 SC-DynoSim to automatically calculate this value—keep in mind that you may be increasing potential variabilities in simulated power by ±5% (even a really “bad guess” of Lifter Acceleration rarely affects power more than this).

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 some all-out racing 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.

Selecting The Cam Timing Method

Camshaft

Cam Name: V-V-T Street Cam

Lifters: None (Overhead Cam)

Cam Specification	Low Speed Lobes Intake	Low Speed Lobes Exhaust	☑ High Speed Lobes Intake	High Speed Lobes Exhaust
Lift At Valve:	7.75 mm	7.75 mm	11.66 mm	10.57 mm
Duration:	231.0	231.0	266.0	256.0
Centerline Angle:	109.0	111.0	107.0	108.0
True Centerline Angle:	109.0	111.0	107.0	108.0
Cam Advanced(+)/Retarded(-):	0.0	0.0	0.0	0.0
Lobe Centerline Angle:	110.0		107.5	
Valve Overlap:	11.0		46.0	
Lifter Acceleration Rate:	2.41		3.39	
Activation RPM:			4500 rpm	

Valve Timing Based On: Seat-To-Seat

	IVO	IVC	EVO					EVC
Simulation Timing (Seat-to-Seat):	6.5	44.5	46.5					20.0
Additional Timing (0.050-inch):	-9.5	29.5	31.5	-11.5	12.5	46.5	42.5	6.5
True Timing	6.5	44.5	46.5	4.5	26.0	60.0	56.0	20.0

The SC-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, if necessary, 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

VALVE OPENING/CLOSING AND TIMING-METHOD MENUS

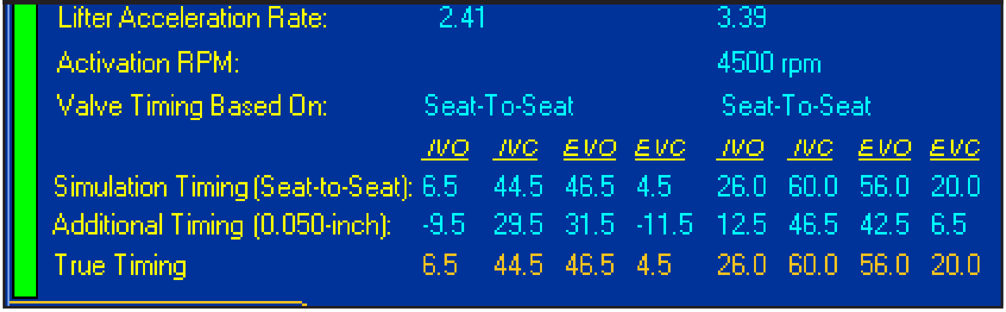
In addition to calculating (or manually entering) the acceleration rate of the lifter, and, therefore, categorizing the ramp rates of the cam profile, the SC-DynoSim simulation must determine the opening and closing points of the intake and exhaust valves in order to accurately predict valve motion at 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 *Simulation Timing* 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 *Simulation Timing* 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 SC-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 Timing Based On:** menus. The notation ***Simulation Timing*** will be associated with either the **Seat-To-Seat** or **0.050-inch timing** groups to indicate the current timing used by the simulation. If you change the *Simulation Timing* method, a warning message will be displayed and the *Simulation Timing* notation will be moved to the alternate event-timing group. Changing the *Simulation Timing* valve-event

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

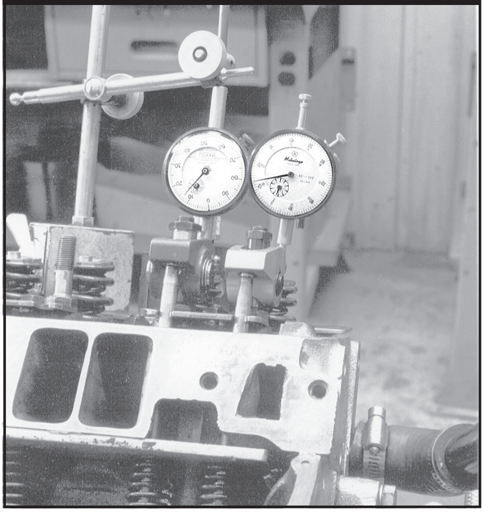


Lifter Acceleration Rate:	2.41				3.39			
Activation RPM:					4500 rpm			
Valve Timing Based On:	Seat-To-Seat				Seat-To-Seat			
	IVO	IVC	EVO	EVC	IVO	IVC	EVO	EVC
Simulation Timing (Seat-to-Seat):	6.5	44.5	46.5	4.5	26.0	60.0	56.0	20.0
Additional Timing (0.050-inch):	-9.5	29.5	31.5	-11.5	12.5	46.5	42.5	6.5
True Timing	6.5	44.5	46.5	4.5	26.0	60.0	56.0	20.0

The SC-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 *Simulation Timing*. If both sets of timing data and the intake- and exhaust-valve lifts have been entered, the SC-DynoSim can automatically calculate the *Lifter Acceleration* rate, as discussed in the previous section.

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 valve rise, 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.

timing affects not only the simulation results, but also the calculated values displayed in the **CAMSHAFT** category: including *True IVO*, *True IVC*, *True EVO*, *True EVC*, *True ICA*, *True ECA*, *Intake Duration*, *Exhaust Duration*, *Intake Centerline (ICA)*, *Exhaust Centerline (ECA)*, *Lobe Center Angle (LCA)*, and *Valve Overlap*.

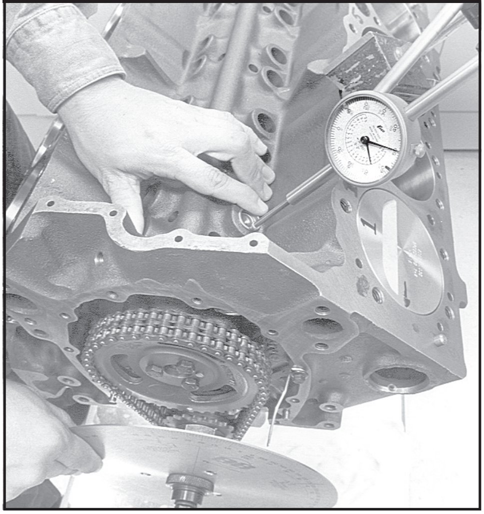
The following sections explain these common camshaft timing methods and gives useful advise on how to improve camshaft simulation accuracy by optimizing profile modeling in the SC-DynoSim.

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 SC-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 tim-***

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 SC-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.

ing specifications as the Simulation Timing for the SC-DynoSim to determine valve opening and closing will produce the most accurate results.
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 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 substantially greater than 0.006-inch valve rise will not produce accurate results in the SC-DynoSim.*

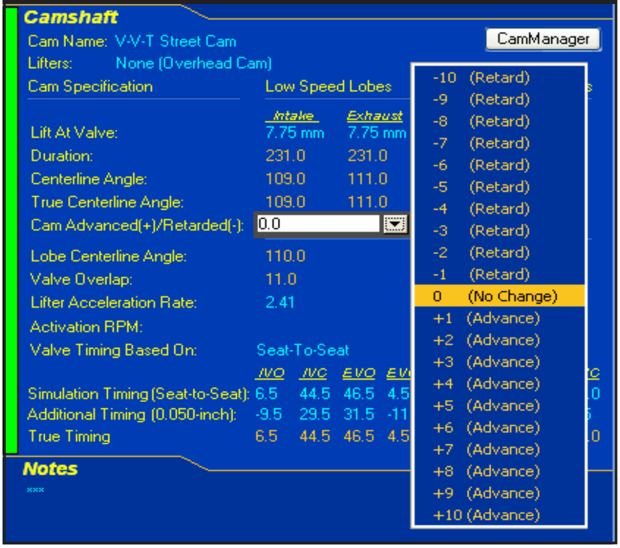
0.050-inch cam timing—This timing method is widely used and standardized by cam manufacturers. 0.050-inch cam timing points are always measured at:

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 follower 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 good 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; 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 ***Simulation Timing*** method, the SC-DynoSim simulation must convert 0.050-timing to seat-to-seat val-

Camshaft Advance/Retard

Advance/Retard Menu



Cam Name: V-V-T Street Cam
Lifters: None (Overhead Cam)

Cam Specification	Low Speed Lobes	
	Intake	Exhaust
Lift At Valve:	7.75 mm	7.75 mm
Duration:	231.0	231.0
Centerline Angle:	109.0	111.0
True Centerline Angle:	109.0	111.0
Cam Advanced(+)/Retarded(-):	0.0	
Lobe Centerline Angle:	110.0	
Valve Overlap:	11.0	
Lifter Acceleration Rate:	2.41	
Activation RPM:		
Valve Timing Based On:	Seat-To-Seat	

	IVO	IVC	EVO	EV
Simulation Timing (Seat-to-Seat):	6.5	44.5	46.5	4.5
Additional Timing (0.050-inch):	-9.5	29.5	31.5	-11
True Timing	6.5	44.5	46.5	4.5

The SC-DynoSim allows direct entry of camshaft advance or retard for each cam (or lobe in the case of DOHC engines). 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.

ues. And unfortunately, this often introduces some error into valve-motion calculations. ***Whenever possible, use Seat-To-Seat timing specifications as the <u>Simulation Timing</u> to obtain the most accurate simulation results.***

CAMSHAFT ADVANCE/RETARD MENU

The SC-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. In the case of OHV or single-cam engines, the *Advance/Retard* function "shifts" all the intake and exhaust lobes the same advanced or retarded value relative to the crankshaft. In DOHC engines, where separate cams are used for the intake and exhaust lobes, an Advance/Retard feature is activated for each cam (one for the intake and one for the exhaust) that can be individually modified.

Why advance or retard a cam? For single-cam engines, 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.

Advancing Or Retarding A Single-Cam Engine

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

Camshaft Advance/Retard

DOHC Adjustable Cam Sprockets

In DOHC engines, like the Honda VTEC, where separate cams are used for the intake and exhaust lobes, each cam may be Advanced or Retarded to fine tune performance. This can be easily accomplished with adjustable cam sprockets, like these from ZEX. Adjustable timing sprockets can also compensate for milled deck and head surfaces that can often result in retarded cam timing

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 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 in a single-camshaft engine 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.

Advancing Or Retarding A DOHC Engine

Tuning DOHC engines with individual intake and exhaust cams greatly simplifies cam tuning. Advancing the intake lobes on an engine with a single cam forces you to advance the exhaust lobes, also. This usually reduces or eliminates any benefits you may have gained by advancing the intake cam alone. But on DOHC engines, this problem is eliminated, and cam tuning by advancing/retarding takes on a whole new significance. That said, cams that are manufactured properly often produce peak power (or torque) when installed “heads-up,” or without any advance or retard. On the other hand, many engine builders have found slight improvements by advancing one cam and retarding the other. This is especially true in turbocharged applications, where advancing the intake cam and retarding the exhaust cam increases the lobe-separation angle, reducing valve overlap, which sometimes improves forced-induction efficiency.

In many real-world dyno tests it is often found that it is impossible to predict which cam you should advance or retard or how much is the right amount. While the SC-DynoSim can give you some guidelines, variances in individual cams make this fine-tuning best done on a real-world dynamometer.

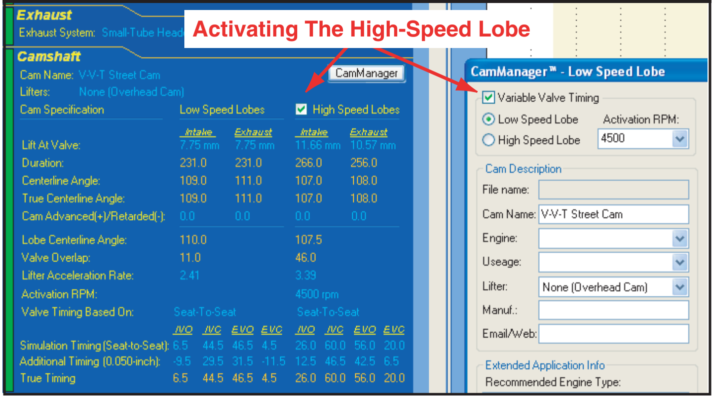
Note: While the SC-DynoSim will let you alter cam timing by up to +/-10-degrees, make sure you keep in mind that changing cam advance or retard on a real engine will alter valve-to-piston clearance. Usually, changing cam timing by less than 4 degrees will not cause interference problems, however, it is always best to check this carefully, especially if you are using a high-performance camshaft. Just starting and idling an engine with piston-to-valve interference can damage valves and valvetrain components.

Variable Valve Timing (V-V-T) Activation

The Variable Valve Timing (V-V-T) model in the SC-DynoSim functions like a VTEC system in Honda engines. At low speeds, the engine operates on the Low-Speed Lobe profiles. Then, at some higher engine speed (usually between 4000 and 6000rpm), the valvetrain switches over to the High-Speed Lobe profiles for all intake and exhaust valves.

Whenever you select any of the V-V-T cams from the *Cam Name* menu, V-V-T modeling and the high-speed lobe will be activated, indicated by a checkmark in the box next to the ***High-Speed-Lobe*** column in the CAMSHAFT category. Also, when

Activating The High-Speed V-V-T Lobe



Exhaust

Exhaust System: Small-Tube Head

Camshaft

Cam Name: V-V-T Street Cam

Lifters: None (Overhead Cam)

Cam Specification	Low Speed Lobes				☑ High Speed Lobes			
	Intake		Exhaust		Intake		Exhaust	
Lift At Valve:	7.75 mm		7.75 mm		11.66 mm		10.57 mm	
Duration:	231.0		231.0		266.0		256.0	
Centerline Angle:	109.0		111.0		107.0		108.0	
True Centerline Angle:	109.0		111.0		107.0		108.0	
Cam Advanced(+)/Retarded(-):	0.0		0.0		0.0		0.0	
Lobe Centerline Angle:	110.0				107.5			
Valve Overlap:	11.0				46.0			
Lifter Acceleration Rate:	2.41				3.39			
Activation RPM:					4500 rpm			
Valve Timing Based On:	Seat-To-Seat				Seat-To-Seat			
	IVO	IVC	EVO	EVC	IVO	IVC	EVO	EVC
Simulation Timing (Seat-to-Seat):	6.5	44.5	46.5	4.5	26.0	60.0	56.0	20.0
Additional Timing (0.050-inch):	-9.5	29.5	31.5	-11.5	12.5	46.5	42.5	6.5
True Timing	6.5	44.5	46.5	4.5	26.0	60.0	56.0	20.0

CamManager™ - Low Speed Lobe

☑ Variable Valve Timing

● Low Speed Lobe

○ High Speed Lobe

Activation RPM: 4500

Cam Description

File name:

Cam Name: V-V-T Street Cam

Engine:

Useage:

Lifter: None (Overhead Cam)

Manuf.:

Email/Web:

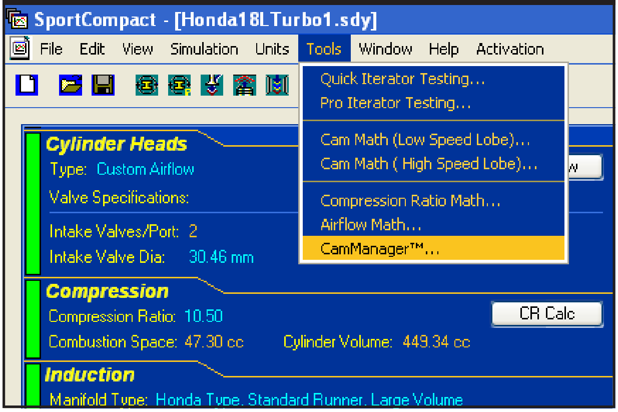
Extended Application Info

Recommended Engine Type:

When any of the V-V-T cams have been selected or a V-V-T CamFile has been loaded in the CamManager™, V-V-T modeling will be activated, indicated by a checkmark next to the *High-Speed-Lobe* column in the CAMSHAFT category and next to the *Variable Valve Timing* field in the CamManager™.

Using The *CamManager™*

Opening The *CamManager™*



Type: Custom Airflow
Valve Specifications:
Intake Valves/Port: 2
Intake Valve Dia: 30.46 mm
Compression Ratio: 10.50
Combustion Space: 47.30 cc
Cylinder Volume: 449.34 cc
Manifold Type: Honda Type, Standard Runner, Large Volume

Open the *CamManager™* from the *Tools* drop-down menu or click on the *Cam Manager* button in the CAMSHAFT category. This powerful tool will help you understand, analyze, create, and modify camshafts for any engine application.

the V-V-T is activated, the box next to the ***Variable Valve Timing*** field in the CamManager™ (discussed next) will show a checkmark.

USING THE CamManager™

The SC-DynoSim incorporates a powerful 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 **.SCM** specifically designed for the SC-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:

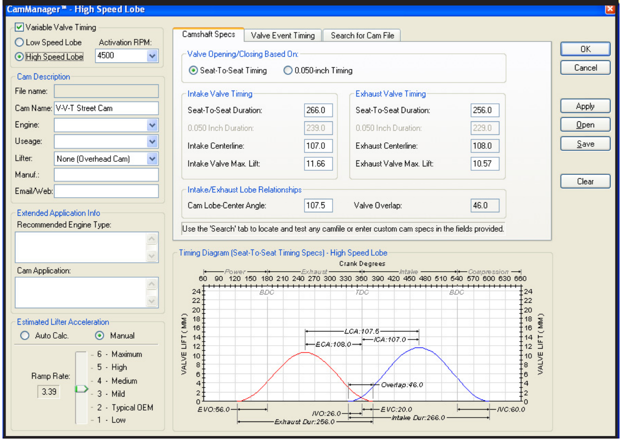
—Loading CamFiles: Open the *CamManager*, click on the ***Open*** button, locate the **CamFile (.SCM)** folder (or one of its subfolders) and select the CamFile you wish to test. Press the ***Apply*** or ***OK*** button to load the CamFile into the **CAMSHAFT** Category and update the simulation with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

—Saving CamFiles: Open the *CamManager*, click on the ***Save*** button, locate the **CamFile (.SCM)** 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 (.SDY) file* when you click on the ***Apply*** or ***OK*** buttons. However, the *CamFile itself will not be updated* unless you ***Save*** and update the CamFile on your hard disk.

—Entering or Modifying "Published" Cam Specifications: Open the

Using The *CamManager™*

The *CamManager™*



CamManager™ - High Speed Lobe

☑ Variable Valve Timing
○ Low Speed Lobe
● High Speed Lobe
Activation RPM: 4500

Cam Description
File name:
Cam Name: V-V-T Street Cam
Engine:
Useage:
Lifter: None (Overhead Cam)
Manuf.:
Email/Web:

Extended Application Info
Recommended Engine Type:
Cam Application:

Estimated Lifter Acceleration
○ Auto Calc.
● Manual
Ramp Rate: 3.39

Valve Opening/Closing Based On:
● Seat-To-Seat Timing
○ 0.050-inch Timing

Intake Valve Timing
Seat-To-Seat Duration: 266.0
0.050 Inch Duration: 239.0
Intake Centerline: 107.0
Intake Valve Max. Lift: 11.66

Exhaust Valve Timing
Seat-To-Seat Duration: 256.0
0.050 Inch Duration: 229.0
Exhaust Centerline: 108.0
Exhaust Valve Max. Lift: 10.57

Intake/Exhaust Lobe Relationships
Cam Lobe-Center Angle: 107.5
Valve Overlap: 46.0

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

The *CamManager™* is a powerful "mini-application" built into the SC-DynoSim. This comprehensive cam-analysis tool offers complete control and visualization of all cam timing specifications. Enter and modify any cam-related information or technical specifications. Select the *Simulation Timing* method. And use the powerful search features to locate a "real-world" camshaft that matches any range of timing values.

CamManager, if necessary, click on the ***Camshaft Specs*** tab (top of screen), chose the *Simulation Timing* 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.

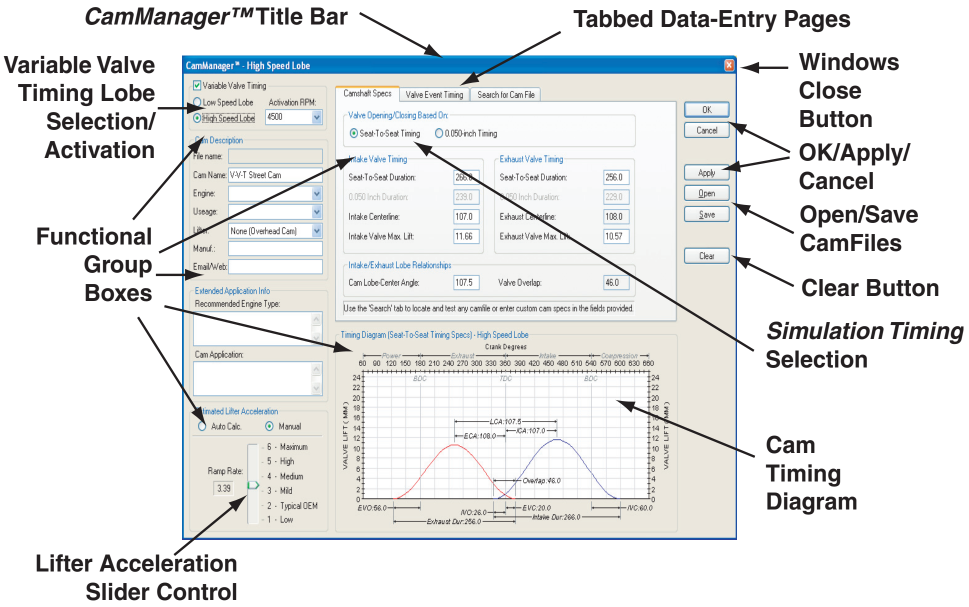
—Entering or Modifying Valve-Timing Events: Open the *CamManager*, if necessary, click on the ***Valve Event Timing*** tab (top of screen), chose the *Simulation Timing* valve timing method by selecting either the ***Seat-To-Seat*** or the ***0.050-inch Timing*** radio button, enter or change any displayed ***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 (.SDY) file* when you click on the ***Apply*** or ***OK*** buttons. However, the *CamFile itself will not be updated* unless you ***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 the ***Apply*** or ***OK*** button to load the new CamFile into the **CAMSHAFT** Category and update the simulation.

The *CamManager™* In Detail

Using The *CamManager™*

The *CamManager™* Features And Functional Groups



CamManager™ - High Speed Lobe

☑ Variable Valve Timing
○ Low Speed Lobe
● High Speed Lobe
Activation RPM: 4500

Cam Description
File name:
Cam Name: V-V-T Street Cam
Engine:
Useage:
Lifter: None (Overhead Cam)
Manuf.:
Email/Web:

Extended Application Info
Recommended Engine Type:
Cam Application:

Estimated Lifter Acceleration
○ Auto Calc. ● Manual
Ramp Rate: 3.39
6 - Maximum
5 - High
4 - Medium
3 - Mild
2 - Typical OEM
1 - Low

Valve Opening/Closing Based On:
● Seat-To-Seat Timing ○ 0.050-inch Timing

Intake Valve Timing
Seat-To-Seat Duration: 266.0
0.050 Inch Duration: 239.0
Intake Centerline: 107.0
Intake Valve Max. Lift: 11.66

Exhaust Valve Timing
Seat-To-Seat Duration: 256.0
0.050 Inch Duration: 229.0
Exhaust Centerline: 108.0
Exhaust Valve Max. Lift: 10.57

Intake/Exhaust Lobe Relationships
Cam Lobe-Center Angle: 107.5
Valve Overlap: 46.0

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

Timing Diagram (Seat-To-Seat Timing Specs) - High Speed Lobe

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 of this tools to make it 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.

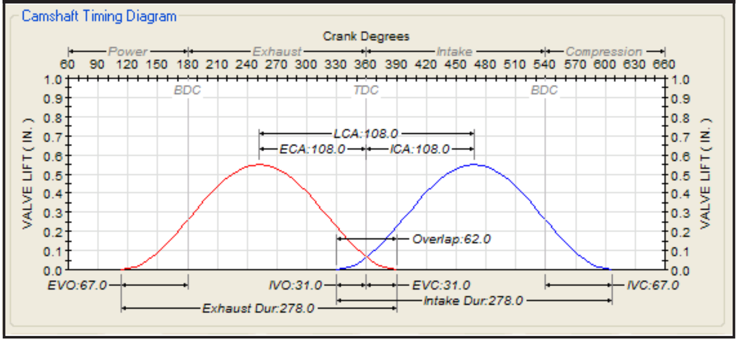
The *CamManager* incorporates a wide range of functionality that has never been available to the performance enthusiast in one integrated package. In fact, the *CamManager* alone consists of more programming code than the entire first version of this engine simulation (DeskTop Dyno released in 1984). Great care was used in the design of this tool 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), you will see the ***Variable Valve Timing*** group in the top-left corner of the dialog box. The ***Cam Description*** group is just below it in the upper-left corner. 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:

Variable Valve Timing Activation/Selection Group (top-left corner)—The Variable Valve Timing (V-V-T) model in the SC-DynoSim functions like a VTEC system in Honda engines. At low speeds, the engine operates on the Low-Speed Lobe profiles. Then, at some higher engine speed (usually between 4000 and 6000rpm), the valvetrain switches over to the High-Speed Lobe profiles. Activate V-V-T by placing a checkmark in the box next to the ***Variable Valve Timing*** field. This group also contains an ***Activation RPM*** field (duplicates the field in the CAMSHAFT category) that allows you to indicate the engine rpm for switch-over to the high-speed lobe profile.

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 dialog)—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 char-

"Twin-Hump" Valve Timing Diagram



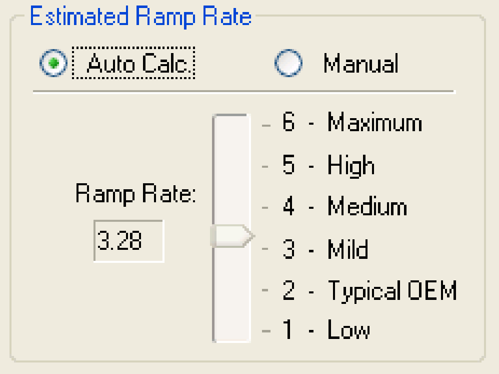
The "Twin-Hump" valve motion diagram in the CamManager is dynamically updated whenever any timing specification is changed, even *Lifter Acceleration* (see text).

acteristics. 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 in dialog)—This graph, often called a 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 dialog)—As discussed earlier, the SC-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 SC-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 SC-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

Estimated Lifter Acceleration



Estimated Ramp Rate

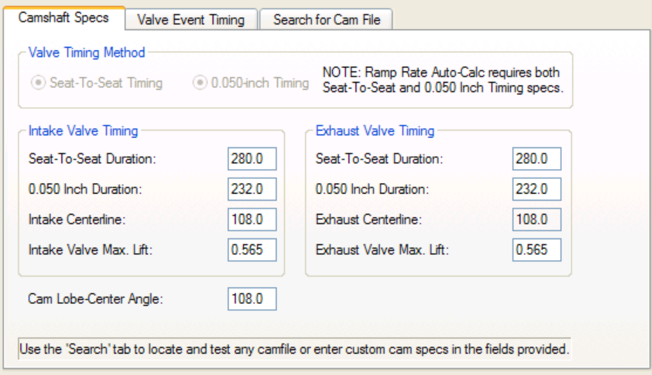
● Auto Calc ○ Manual

Ramp Rate: 3.28

If the SC-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.

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

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

Exhaust Valve Timing

Seat-To-Seat Duration: 280.0
0.050 Inch Duration: 232.0
Exhaust Centerline: 108.0
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.

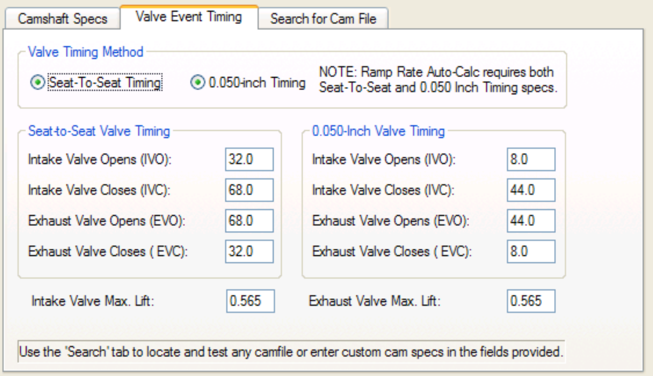
the **Camshaft Timing Diagram**.

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*.

Camshaft Specs* Tabbed Page**—The first tabbed page, displayed by 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 SC-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 SC-DynoSim will calculate ***Lifter Acceleration*** in addition to valve-event timing (***Auto Calc*** must be selected in the *Estimated Lifter Acceleration* group).

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

Intake Valve Opens (IVO): 32.0
Intake Valve Closes (IVC): 68.0
Exhaust Valve Opens (EVO): 68.0
Exhaust Valve Closes (EVC): 32.0

0.050-Inch Valve Timing

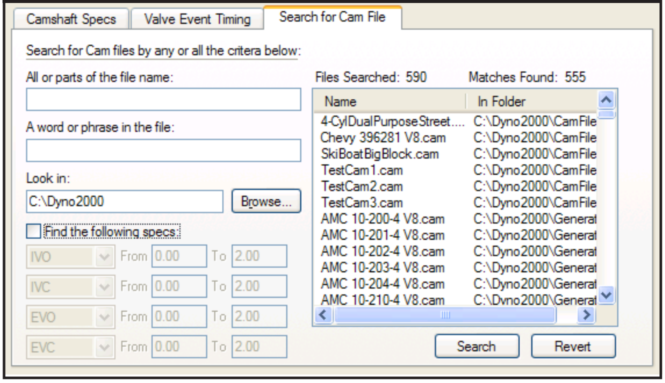
Intake Valve Opens (IVO): 8.0
Intake Valve Closes (IVC): 44.0
Exhaust Valve Opens (EVO): 44.0
Exhaust Valve Closes (EVC): 8.0

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.

Using The *CamManager*™

***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 SC-DynoSim *Iterator*™!

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 SC-DynoSim will calculate the Camshaft Specs (displayed on the 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 SC-DynoSim also will be able to calculate ***Lifter Acceleration*** (***Auto Calc*** must be selected in the *Estimated Lifter Acceleration* group).

Simulation Timing Method Selection—As discussed earlier (see pages 83 to 86), the ***Simulation Timing*** method establishes how the simulation determines valve opening and closing points. You an select the 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 CAMSHAFT 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 ***Simulation 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 ***Simulation Timing*** forces the SC-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 ***Simulation 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 cams designed for a Honda, 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 ***SC-CamDataSim***™ will add more than 300 CamFiles to those supplied with the SC-DynoSim (***SC-CamDataSim*** is an optional data resource CD available from ProRacing Sim, LLC., see page 134 for information on optional program features).

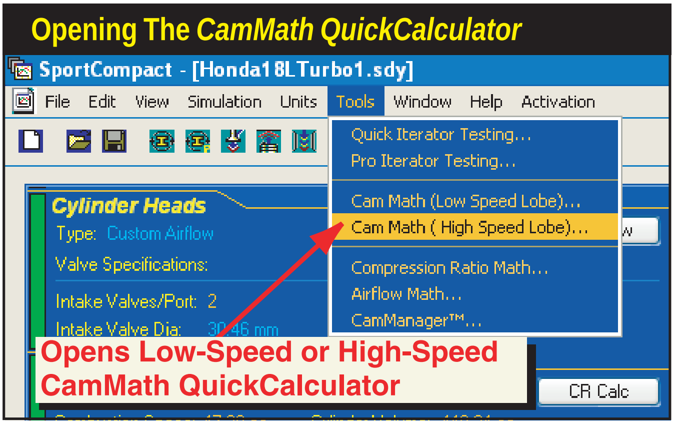
Important Note: If you change any cam specification within the *CamManager* after saving or retrieving CamFiles, the *CamFile* ***data*** *will automatically be saved with the engine (.SDY) file* when you click on the ***Apply*** or ***OK*** buttons. However, the *CamFile itself will not be automatically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

The *CamMath Quick-Calculator* is available from the Tools menu. If a V-V-T cam is currently simulated, you can select between two versions of the QuickCalculator: low-speed and high-speed versions. Use *CamMath QuickCalculator* to easily modify Lobe Center Angles or Duration Values.

Opening The CamMath QuickCalculator



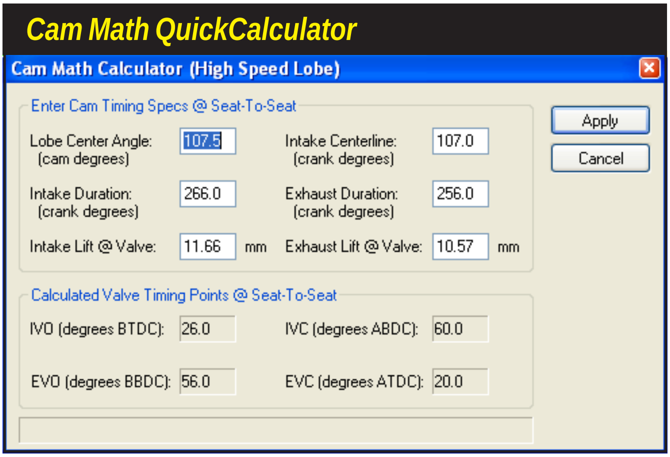
Type: Custom Airflow

Intake Valves/Port: 2

Intake Valve Dia: 30.46 mm

Opens Low-Speed or High-Speed CamMath QuickCalculator

The *CamMath QuickCalculator*™



Cam Math QuickCalculator

Enter Cam Timing Specs @ Seat-To-Seat

Lobe Center Angle: (cam degrees) 107.5

Intake Centerline: (crank degrees) 107.0

Intake Duration: (crank degrees) 266.0

Exhaust Duration: (crank degrees) 256.0

Intake Lift @ Valve: 11.66 mm

Exhaust Lift @ Valve: 10.57 mm

Calculated Valve Timing Points @ Seat-To-Seat

IVO (degrees BTDC): 26.0

IVC (degrees ABDC): 60.0

EVO (degrees BBDC): 56.0

EVC (degrees ATDC): 20.0

The *CamMath Quick-Calculator* (active here for the high-speed lobe of a V-V-T cam) 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.

required for the SC-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 *CamManager*, the simple the ***CamMath QuickCalculator***™ instantly converts the lobe-center angle, intake centerline, and the duration values into IVO, IVC, EVO, and EVC valve events. By clicking the ***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 ***SC-CamDataSim*** from ProRacing Sim Software that provides over 300 read-to-use CamFiles for the SC-DynoSim (see page 92).

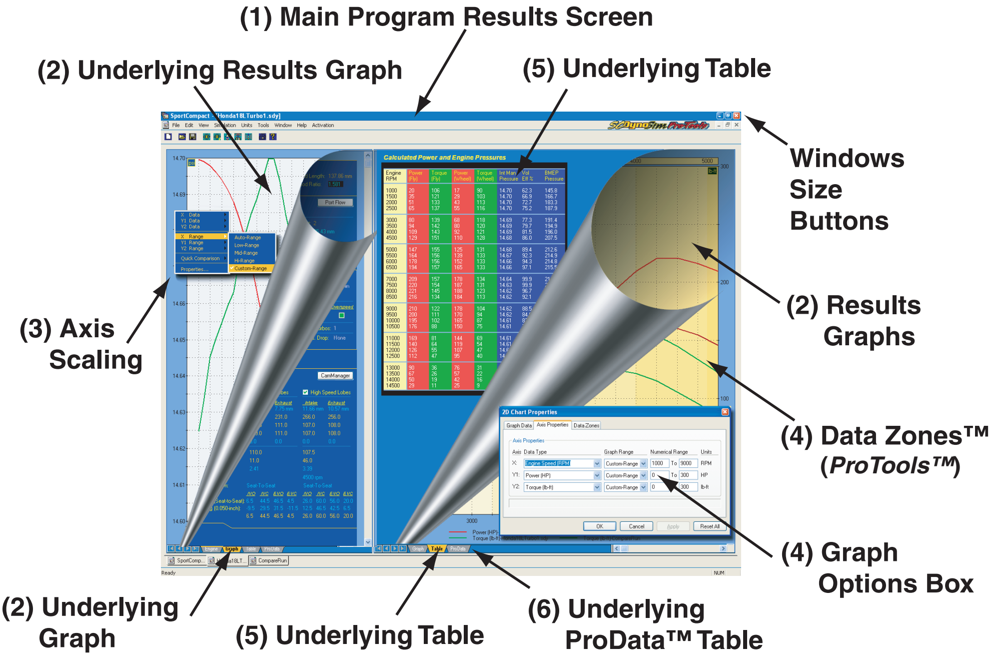
Important Note: The selection of cam timing in the ***CamMath QuickCalculator*** only applies to calculations within the calculator. It does not change the ***Simulation Timing*** method for determining valve opening/closing points used in the simulation. The ***Simulation Timing*** method is selected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

Sport Compact DynoSim
Racing Software

Advanced
Engine
Simulation

SIMULATION RESULTS



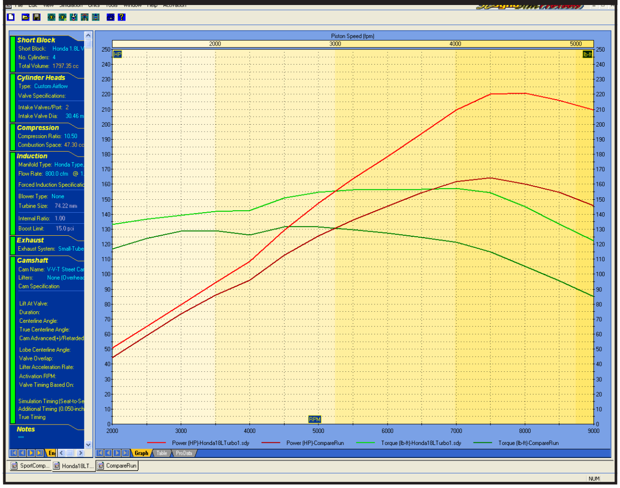
The **Simulation Results** display is composed of several elements that will help you retrieve the most information from any simulation as quickly and easily as possible:

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 SC-DynoSim will graph the following variables: Rpm, Flywheel and Wheel Horsepower and Torque, Intake Manifold Pressure, Volumetric Efficiency, Imep (Indicated Mean

Simulation Results Displays

Moveable Vertical Screen Divider

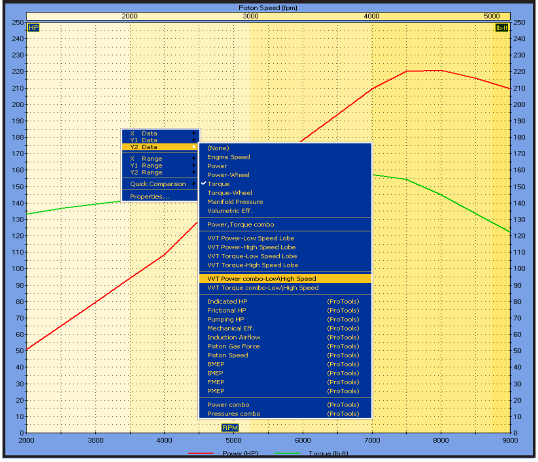


The screen divider can be moved to allow the graph more display area. Drag it all the way to the left screen margin to display graph data "full screen."

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 that

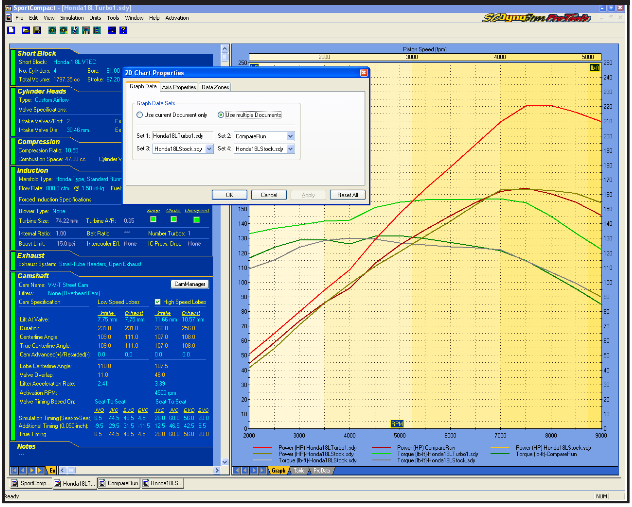
Three-Axis Graphs



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



2D Chart Properties

Graph Data Sets

○ Use current Document only ● Use multiple Documents

Set 1: Honda18LTurbo1.sdy Set 2: CompareRun

Set 3: Honda18LStock.sdy Set 4: Honda18LStock.sdy

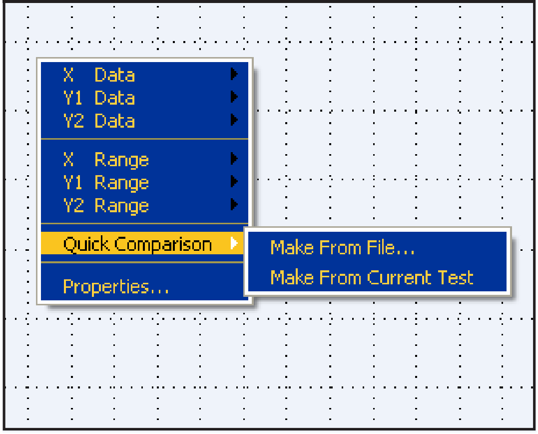
A comparison of three engines was setup using the Properties Box. Up to four “open” engines can be compared on any graph. This graph shows how horsepower (red, dark red, dark yellow) and torque varied for all three test engines.

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

The *Graph Options* menu also contains a ***QuickCompare***™ feature that instantly establishes any engine as a “baseline,” allowing you to quickly see the results of any furthter changes to your current simulation. To establish a “baseline” using the current engine, select ***Quick Comparison, Make From Current Test*** from the *Graph Options* menu (see photo, below). This will “spawn” the current engine to an additional open engine, name the simulation *CompareRun*, then setup a comparison with your current engine on the main graph. Changing any component on the current engine will instantly show any performance differences.

The ***QuickCompare***™ feature also allows you to setup a similar comparison but

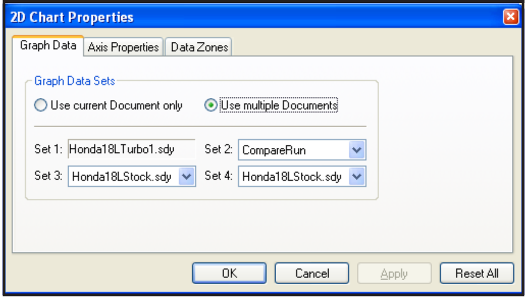
QuickCompare™ Feature



The *Graph Options* menu also contains a *QuickCompare*™ feature that instantly establishes any engine as a “baseline,” allowing you to quickly see the results of any furhter changes to your current simulation.

Simulation Results Displays

Graph Properties—*Graph Data*



○ Use current Document only ● Use multiple Documents

Set 1:	Honda18LTurbo1.sdy	Set 2:	CompareRun
Set 3:	Honda18LStock.sdy	Set 4:	Honda18LStock.sdy

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.

with any saved (.SDY) engine file. Choose the ***Quick Comparison, Make From File*** selection. This will open a copy of the saved engine, name the simulation *CompareRun*, then automaticall setup a comparison on the main graph. Changing any component on the current engine will instantly show any performance differences.

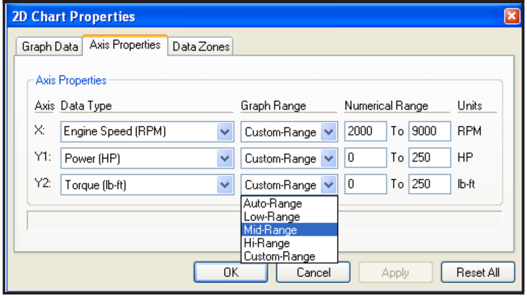
4) Right click on the graph to open the *Graph Options Menu*, then select ***Properties***. This will open a dialog box that has allows three tabbed data pages:

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™*** feature) for the current display. Change the characteristics of the display by modifying any of the graph properties.

Data Zones™—This ***ProTools™***-only feature displays additional data and data-ranges on the graphs (see page 134 for more information on activating optional program features). ***DataZones*** extend the graphic-display and data-analysis

Graph Properties—*Axis Properties*

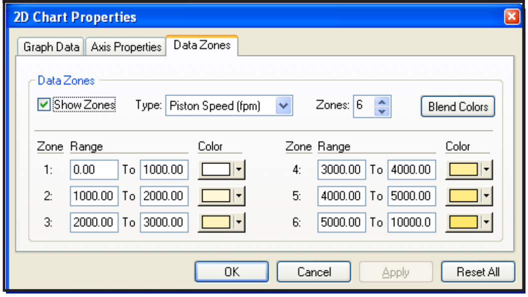


Axis	Data Type	Graph Range	Numerical Range			Units
X:	Engine Speed (RPM)	Custom-Range	2000	To	9000	RPM
Y1:	Power (HP)	Custom-Range	0	To	250	HP
Y2:	Torque (lb-ft)	Custom-Range	0	To	250	lb-ft

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)

Simulation Results Displays

Graph Properties—*Data Zones*



2D Chart Properties

Graph Data | Axis Properties | Data Zones

Data Zones

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

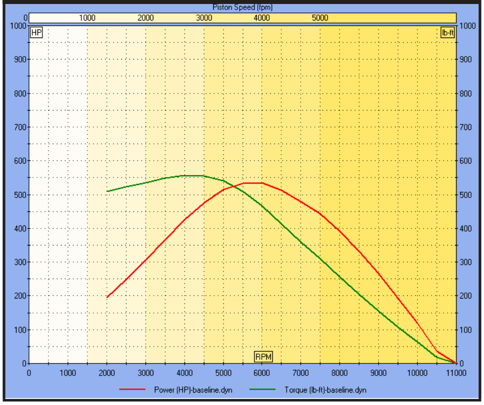
Zone	Range			Color	Zone	Range			Color
1:	0.00	To	1000.00		4:	3000.00	To	4000.00	
2:	1000.00	To	2000.00		5:	4000.00	To	5000.00	
3:	2000.00	To	3000.00		6:	5000.00	To	10000.0	

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

capabilities of the SC-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 Speed* is directly calculated from engine rpm (stroke is held constant), but *Manifold Pressure* cannot be displayed, since it is not <u>*directly calculated*</u> 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 SC-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.

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.

Simulation Results Displays

Table Shows Exact Test Results

SportCompact - [Honda18LTurbo1.sdy]

Calculated Power and Engine Pressures

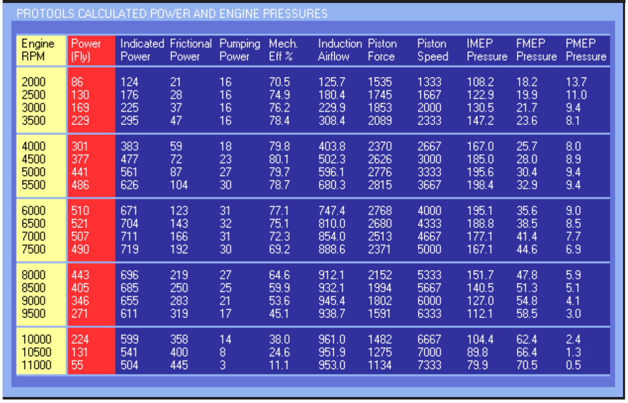
Engine RPM	Power (Fly)	Torque (Fly)	Power (Wheel)	Torque (Wheel)	Int Man Pressure	Vol Eff %	BMEP Pressure
1000	20	106	17	90	14.70	62.3	145.8
1500	35	121	29	103	14.70	66.9	166.7
2000	51	133	43	113	14.70	72.7	183.3
2500	65	137	55	116	14.70	75.2	187.9
3000	80	139	68	118	14.69	77.3	191.4
3500	94	142	80	120	14.69	79.7	194.9
4000	109	143	92	121	14.69	81.5	196.0
4500	129	151	110	128	14.68	86.0	207.5
5000	147	155	125	131	14.68	89.4	212.6
5500	164	156	139	133	14.67	92.3	214.9
6000	178	156	152	133	14.66	94.3	214.8
6500	194	157	165	133	14.66	97.1	215.5
7000	209	157	178	134	14.64	99.9	216.1
7500	220	154	187	131	14.63	99.9	212.1
8000	221	145	188	123	14.62	96.7	199.4
8500	216	134	184	113	14.62	92.1	183.6
9000	210	122	178	104	14.62	88.5	168.3
9500	200	111	170	94	14.62	84.8	152.4
10000	195	102	165	87	14.61	82.9	140.5
10500	176	88	150	75	14.61	78.7	121.0
11000	169	81	144	69	14.61	76.9	111.2
11500	140	64	119	54	14.61	72.5	88.0
12000	126	55	107	47	14.61	69.5	76.0
12500	112	47	95	40	14.61	67.3	64.6
13000	90	36	76	31	14.61	64.5	49.8
13500	67	26	57	22	14.61	61.4	35.8
14000	50	19	42	16	14.61	59.5	25.8
14500	29	11	25	9	14.61	57.2	14.6

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.

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 SC-DynoSim activated (see page 134 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.

Engine-Pressures Table *(ProTools™)*



PROTOOLS CALCULATED POWER AND ENGINE PRESSURES

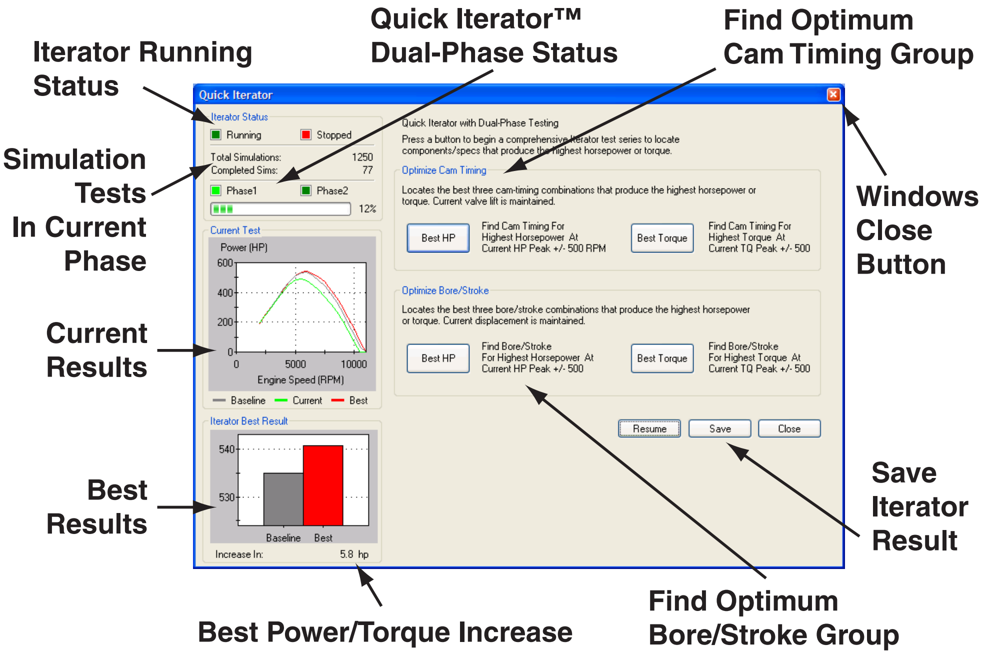
Engine RPM	Power (Fly)	Indicated Power	Frictional Power	Pumping Power	Mech. Eff %	Induction Airflow	Piston Force	Piston Speed	IMEP Pressure	FMEP Pressure	PMEP Pressure
2000	86	124	21	16	70.5	125.7	1535	1333	108.2	18.2	13.7
2500	130	176	28	16	74.9	180.4	1745	1667	122.9	19.9	11.0
3000	169	225	37	16	76.2	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 SC-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.

Sport Compact DynoSim
Racing Software

Advanced
Engine
Simulation

QUICK ITERATOR™



Quick Iterator

Iterator Status

🟩 Running 🟥 Stopped

Total Simulations: 1250
Completed Sims: 77

🟩 Phase1 🟩 Phase2

12%

Current Test

Baseline — Current — Best

Iterator Best Result

Increase In: 5.8 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.

Optimize Cam Timing

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

Optimize Bore/Stroke

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

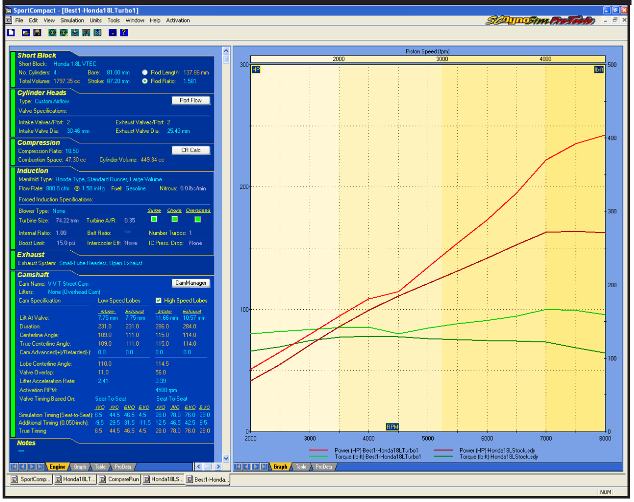
Find Bore/Stroke For Highest Torque At Current TQ Peak +/- 500

With the power and low-cost of SC-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 SC-DynoSim incorporates a completely new version of the *Iterator*: ***The Quick Iterator***™. Now, click on only one button, and the SC-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 combination in the shortest time. The first test phase uses a wider range of values.

Using The *Quick Iterator*™

Quick Iterator™ Spawned Engine



SportCompact - [Best1-Honda18LTurbo1]

Short Block
Short Block: Honda 1.8L VTEC
No. Cylinders: 4 Bore: 81.00 mm ○ Rod Length: 137.86 mm
Total Volume: 1797.35 cc Stroke: 87.20 mm ● Rod Ratio: 1.581

Cylinder Heads
Type: Custom Airflow
Valve Specifications:
Intake Valves/Port: 2 Exhaust Valves/Port: 2
Intake Valve Dia: 30.46 mm Exhaust Valve Dia: 25.43 mm

Compression
Compression Ratio: 10.50
Combustion Space: 47.30 cc Cylinder Volume: 449.34 cc

Induction
Manifold Type: Honda Type, Standard Runner, Large Volume
Flow Rate: 800.0 cfm @ 1.50 inHg Fuel: Gasoline Nitrous: 0.0 lbs/min
Forced Induction Specifications:
Blower Type: None Surge 🟩 Choke 🟩 Overspeed 🟩
Turbine Size: 74.22 mm Turbine A/R: 0.35
Internal Ratio: 1.00 Belt Ratio: *** Number Turbos: 1
Boost Limit: 15.0 psi Intercooler Eff: None IC Press. Drop: None

Exhaust
Exhaust System: Small-Tube Headers, Open Exhaust

Camshaft
Cam Name: V-V-T Street Cam
Lifters: None (Overhead Cam)

Cam Specification	Low Speed Lobes Intake	Low Speed Lobes Exhaust	☑ High Speed Lobes Intake	☑ High Speed Lobes Exhaust
Lift At Valve:	7.75 mm	7.75 mm	11.66 mm	10.57 mm
Duration:	231.0	231.0	286.0	284.0
Centerline Angle:	109.0	111.0	115.0	114.0
True Centerline Angle:	109.0	111.0	115.0	114.0
Cam Advanced(+)/Retarded(-):	0.0	0.0	0.0	0.0

Lobe Centerline Angle: 110.0 (Low Speed), 114.5 (High Speed)
Valve Overlap: 11.0 (Low Speed), 56.0 (High Speed)
Lifter Acceleration Rate: 2.41 (Low Speed), 3.39 (High Speed)
Activation RPM: 4500 rpm
Valve Timing Based On: Seat-To-Seat (Low Speed), Seat-To-Seat (High Speed)

	IVO	IVC	EVO	EVC	IVO	IVC	EVO	EVC
Simulation Timing (Seat-to-Seat):	6.5	44.5	46.5	4.5	28.0	78.0	76.0	28.0
Additional Timing (0.050-inch):	-9.5	29.5	31.5	-11.5	12.5	46.5	42.5	6.5
True Timing	6.5	44.5	46.5	4.5	28.0	78.0	76.0	28.0

Notes
***

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 SC-DynoSim.

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*™

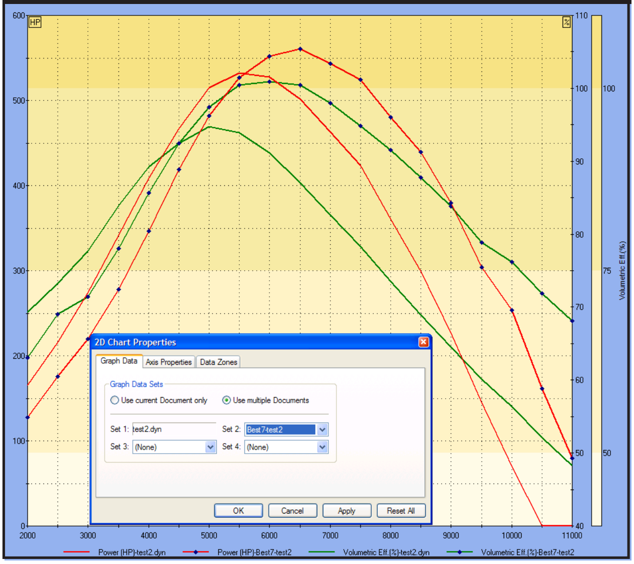
To perform a ***Quick Iterator*** analysis, first select all the components for the baseline engine. Make sure all *Status Boxes* in each Component Category are green, and turn off **Auto Calculate Valve Size** and **Valve Lift**, if necessary. There are two testing groups in the ***Quick Iterator***, 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 within ±500rpm of the current horsepower or torque peak (current displacement will be

Using The *Quick Iterator*™

Comparison With Baseline Engine



2D Chart Properties

Graph Data Sets

○ Use current Document only ● Use multiple Documents

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

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.

maintained).

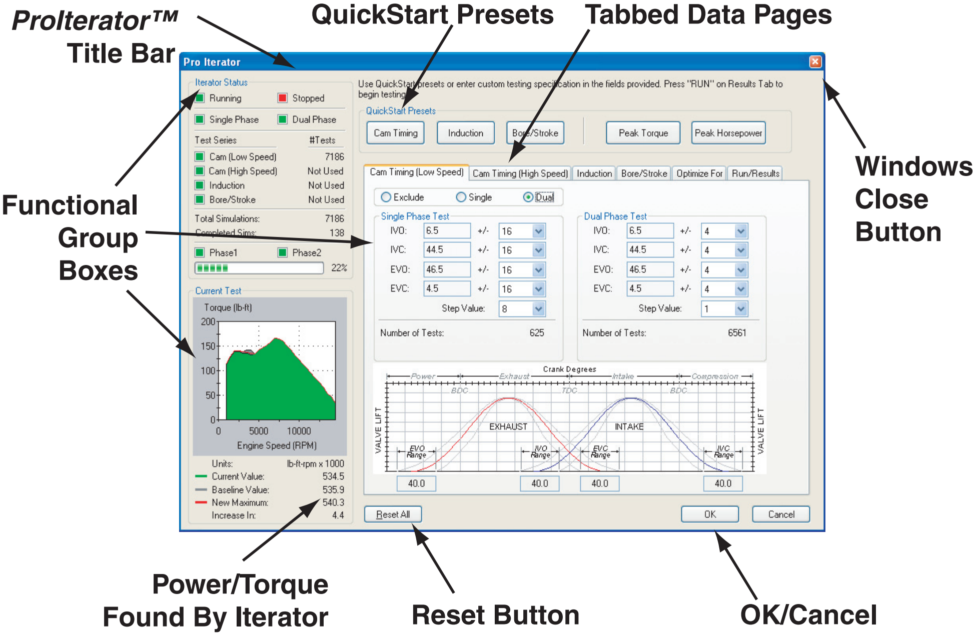
When *Iterative* testing is complete (you can stop testing at any time by pressing the ***Stop*** button; press ***Resume*** to continue testing), the ***Iterator Best Result*** graph will show the improvement in horsepower or torque found with the new component specifications. You can keep the results by clicking ***Save***. In a few seconds, the SC-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 SC-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.

Note: Whenever the *Quick Iterator* is used with ***Variable Valve Timing*** to find the best Horsepower or Torque, tests are only run on the High-Speed Lobe profiles. The low-speed lobes remain fixed. If peak torque is generated by the low-speed cam and you wish to optimize torque using the low-speed profile, build a separate engine—without V-V-T—using low-speed cam data. Then run a *Quick Iterator* test to find the best torque valve timing.

Sport Compact DynoSim
Racing Software
Advanced Engine Simulation

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 (Low Speed)	7186
🟩 Cam (High Speed)	Not Used
🟩 Induction	Not Used
🟩 Bore/Stroke	Not Used

Total Simulations: 7186
Completed Sims: 138
🟩 Phase1 🟩 Phase2 22%

○ Exclude ○ Single ● Dual

Single Phase Test		+/-	
IVO:	6.5	+/-	16
IVC:	44.5	+/-	16
EVO:	46.5	+/-	16
EVC:	4.5	+/-	16
		Step Value:	8
Number of Tests:			625

Dual Phase Test		+/-	
IVO:	6.5	+/-	4
IVC:	44.5	+/-	4
EVO:	46.5	+/-	4
EVC:	4.5	+/-	4
		Step Value:	1
Number of Tests:			6561

EVO Range 40.0 IVO Range 40.0 EVC Range 40.0 IVC Range 40.0

Units: lb-ft-rpm x 1000
Current Value: 534.5
Baseline Value: 535.9
New Maximum: 540.3
Increase In: 4.4

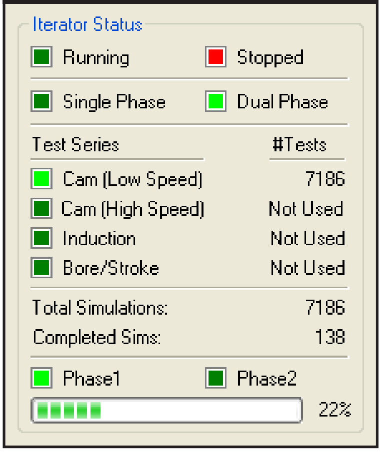
The ***Quick Iterator™*** (pronounced *IT-TER-A-TOR*—discussed in the previous chapter) provides a powerful and easy-to-use tool for anyone to optimize engine components. While this capability will satisfy most enthusiasts, the more serious engine builder needs the ability to perform Iterative tests 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 134 for more information on optional-feature activation).

Using The *ProIterator™*

Open the ***ProIterator™*** by choosing the ***ProIterator™*** selection from the **Tools** menu or by clicking the ***ProIterator™ Icon*** in the **Toolbar.** The main screen consists

Using The *ProIterator™*

ProIterator™ Status Group



Iterator Status

🟩 Running 🟥 Stopped

🟩 Single Phase 🟩 Dual Phase

Test Series	#Tests
🟩 Cam (Low Speed)	7186
🟩 Cam (High Speed)	Not Used
🟩 Induction	Not Used
🟩 Bore/Stroke	Not Used

Total Simulations:	7186
Completed Sims:	138

🟩 Phase1 🟩 Phase2

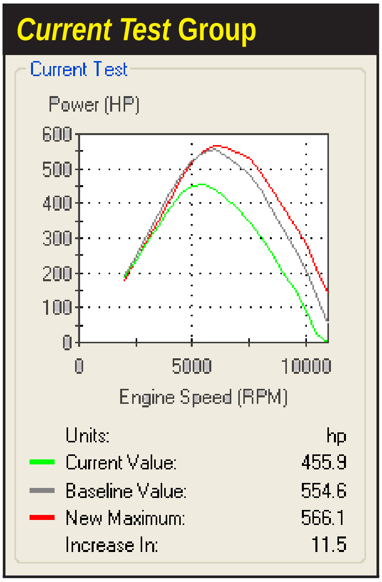
22%

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.

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*** *(for V-V-T, High or Low-Speed Lobes)*, ***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 values for the baseline, current, maximum, and gain-or-loss in power/torque.

Using The *ProIterator™*



***Current Test* Group**

Units: hp

🟩 Current Value: 455.9

▬ Baseline Value: 554.6

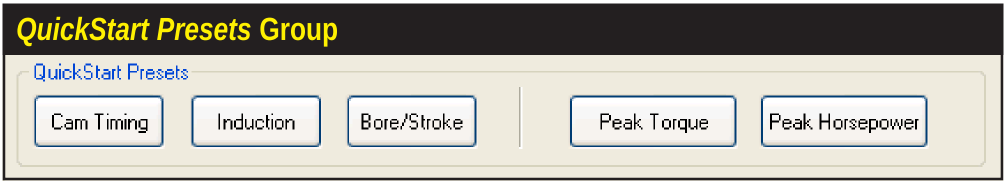
🟥 New Maximum: 566.1

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.

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™***.

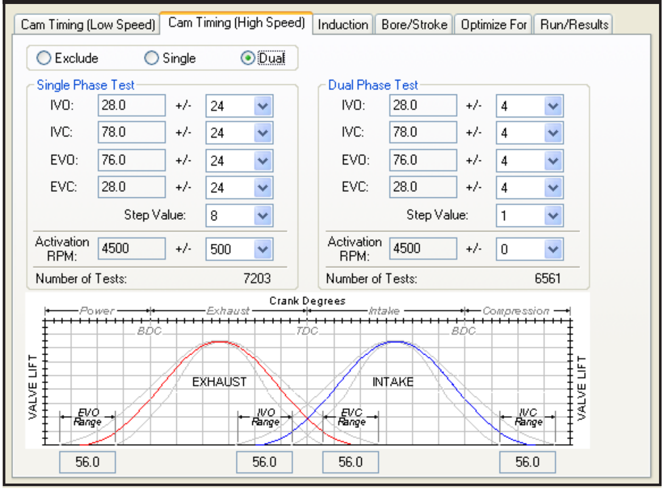


***QuickStart Presets* Group**

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 Pages



○ Exclude ○ Single ● Dual

Single Phase Test
IVO: 28.0 +/- 24
IVC: 78.0 +/- 24
EVO: 76.0 +/- 24
EVC: 28.0 +/- 24
Step Value: 8
Activation RPM: 4500 +/- 500
Number of Tests: 7203

Dual Phase Test
IVO: 28.0 +/- 4
IVC: 78.0 +/- 4
EVO: 76.0 +/- 4
EVC: 28.0 +/- 4
Step Value: 1
Activation RPM: 4500 +/- 0
Number of Tests: 6561

56.0 56.0 56.0 56.0

The *Cam Timing (Low-Speed) or Cam Timing (High-Speed)* tabbed pages establish 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.

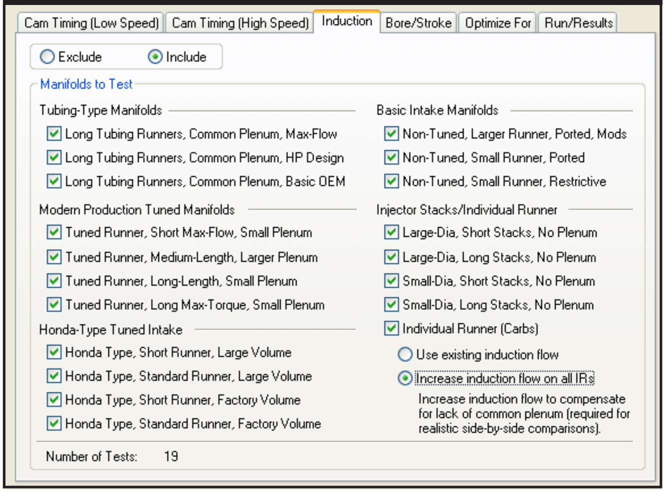
Cam-Timing* Tabbed Page**—The first two tabbed pages and the default display when the ***ProIterator™ is opened, establishes a *Single-* or *Dual-Phase*™ test of cam-timing changes on power or torque output. Also by default, the *Cam-Timing Tabbed Page* is set to ***Exclude*** (perform no cam-timing 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 (of the High-Speed Lobe on V-V-T cams) that will be completed in about 5 minutes on a 1Ghz and faster computer.

Note: When performing Iterative testing on cams with **Variable Valve Timing**, it is much faster to test each lobe profile (low and high speed) separately, then select the best of each test for the final cam. While the *ProIterator* will run “combined” tests of both lobe profiles at once, this usually results in a test series that can take many hours to complete.

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

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 ● Include

Manifolds to Test

Tubing-Type Manifolds
☑ Long Tubing Runners, Common Plenum, Max-Flow
☑ Long Tubing Runners, Common Plenum, HP Design
☑ Long Tubing Runners, Common Plenum, Basic OEM

Modern Production Tuned Manifolds
☑ Tuned Runner, Short Max-Flow, Small Plenum
☑ Tuned Runner, Medium-Length, Larger Plenum
☑ Tuned Runner, Long-Length, Small Plenum
☑ Tuned Runner, Long Max-Torque, Small Plenum

Honda-Type Tuned Intake
☑ Honda Type, Short Runner, Large Volume
☑ Honda Type, Standard Runner, Large Volume
☑ Honda Type, Short Runner, Factory Volume
☑ Honda Type, Standard Runner, Factory Volume

Basic Intake Manifolds
☑ Non-Tuned, Larger Runner, Ported, Mods
☑ Non-Tuned, Small Runner, Ported
☑ Non-Tuned, Small Runner, Restrictive

Injector Stacks/Individual Runner
☑ Large-Dia, Short Stacks, No Plenum
☑ Large-Dia, Long Stacks, No Plenum
☑ Small-Dia, Short Stacks, No Plenum
☑ Small-Dia, Long Stacks, No Plenum
☑ Individual Runner (Carbs)
○ Use existing induction flow
● Increase induction flow on all IRs

Increase induction flow to compensate for lack of common plenum (required for realistic side-by-side comparisons).

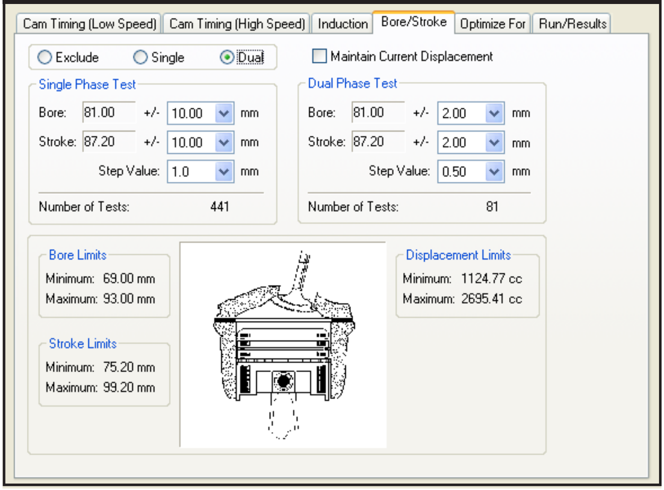
Number of Tests: 19

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 on all IRs* to compensate for the lack of a common plenum in IR systems. If you select the ***Increase Induction Flow*** button, the induction airflow (as specified in the **INDUCTION** category, see page 43) will be modified using the following formula: (number-of-cylinders x air-flow)/2. This formula only will be used when the IR manifold is being simulated. When other non-IR manifolds are tested (manifolds with an interconnecting passage between ports, like a plenum), 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 SC-DynoSim). If you select ***Use Existing Airflow***, the baseline airflow will be used at all times. This typically results in poor performance for the IR systems, 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 (IR and non-IR) 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

Bore/Stroke "Tabbed" Data Page



○ Exclude ○ Single ● Dual

☐ Maintain Current Displacement

Single Phase Test
Bore: 81.00 +/- 10.00 mm
Stroke: 87.20 +/- 10.00 mm
Step Value: 1.0 mm
Number of Tests: 441

Dual Phase Test
Bore: 81.00 +/- 2.00 mm
Stroke: 87.20 +/- 2.00 mm
Step Value: 0.50 mm
Number of Tests: 81

Bore Limits
Minimum: 69.00 mm
Maximum: 93.00 mm

Stroke Limits
Minimum: 75.20 mm
Maximum: 99.20 mm

Displacement Limits
Minimum: 1124.77 cc
Maximum: 2695.41 cc

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).

(described previously). This will establish a 242-test *Dual-Phase* simulation series (completed in about 1 minute on a 1Ghz or faster computer).

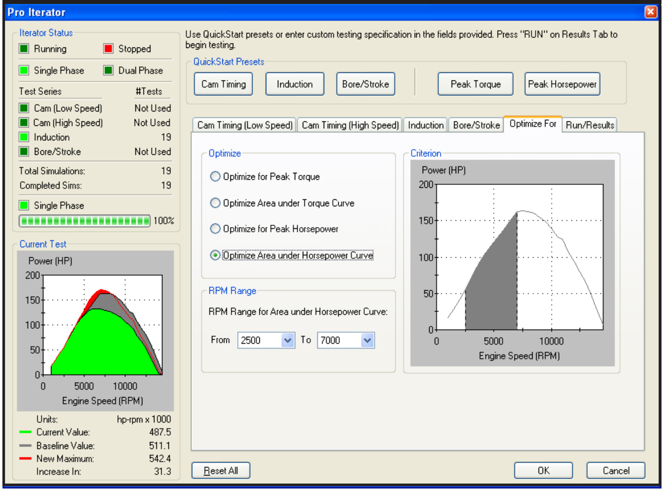
Note: You can chose to *Maintain Current Displacement* or let engine displacement vary throughout Bore/Stroke Iterative testing. By checking the ***Maintain Current Displacement*** box, the ***Stroke*** within both ***Phase-Test*** boxes will switch to ***(Auto)***, indicating that *Stroke* will be allowed to vary as much as required to 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).

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



Test Series	#Tests
Cam (Low Speed)	Not Used
Cam (High Speed)	Not Used
Induction	19
Bore/Stroke	Not Used
Total Simulations:	19
Completed Sims:	19

Single Phase 100%

Units:	hp-rpm x 1000
Current Value:	487.5
Baseline Value:	511.1
New Maximum:	542.4
Increase In:	31.3

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

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 Horsepower Curve:
From 2500 To 7000

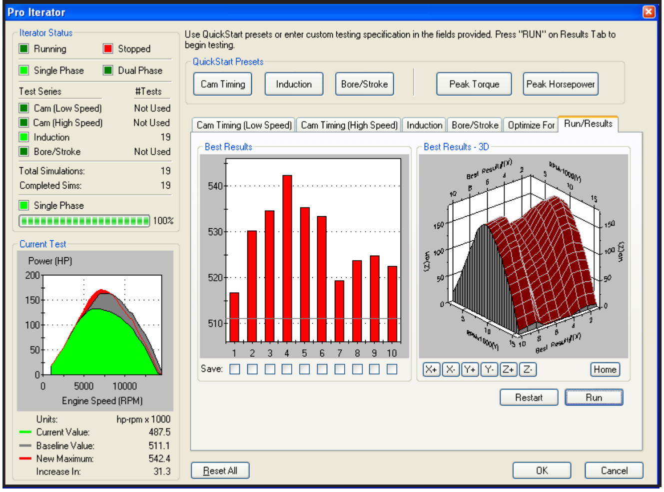
Below the *Optimize* settings box, the ***RPM Range*** choices let you set the lower and upper limits through which the *Iterator* will search for optimum power or torque combinations. When the *Iterator* is searching for peak values, the *RPM Range* will be illustrated as dotted lines on the *Criterion* 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.

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 ***SC-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

Using The *ProIterator*™

RUN/Results “Tabbed” Data Page



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

🟩 Running 🟥 Stopped

🟩 Single Phase 🟩 Dual Phase

Test Series	#Tests
🟩 Cam (Low Speed)	Not Used
🟩 Cam (High Speed)	Not Used
🟩 Induction	19
🟩 Bore/Stroke	Not Used

Total Simulations: 19
Completed Sims: 19

🟩 Single Phase 100%

Save: ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

Units:	hp-rpm x 1000
Current Value:	487.5
Baseline Value:	511.1
New Maximum:	542.4
Increase In:	31.3

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 SC-DynoSim.

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),

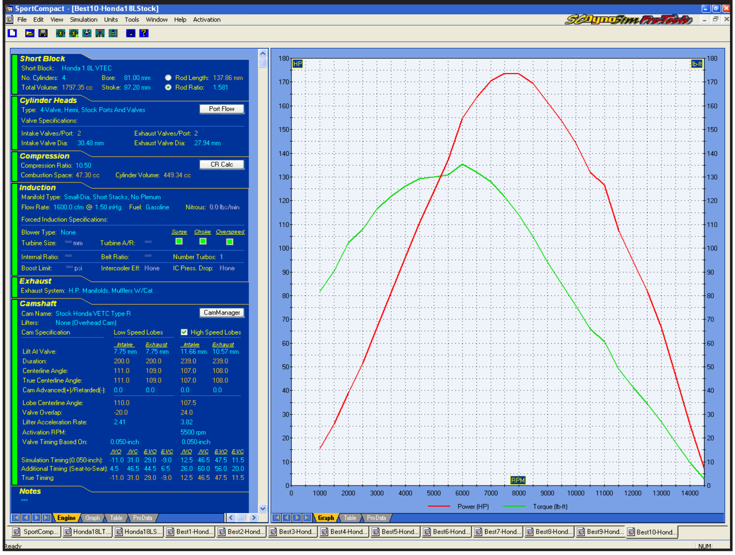
During *Iterative* testing, you can view the number of completed and remaining tests in the ***Iterator Status*** box, as discussed earlier (you can stop testing at any time by pressing the ***Stop*** button; press ***Run*** to continue testing or ***Restart*** to clear current results). When testing 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 SC-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.

Using The *ProIterator*™

Spawned Engines Displayed In Engine Selection Tabs



Short Block

Short Block: Honda 1.8L VTEC
No. Cylinders: 4 Bore: 81.00 mm ○ Rod Length: 137.86 mm
Total Volume: 1797.35 cc Stroke: 87.20 mm ● Rod Ratio: 1.581

Cylinder Heads

Type: 4-Valve, Hemi, Stock Ports And Valves
Valve Specifications:
Intake Valves/Port: 2 Exhaust Valves/Port: 2
Intake Valve Dia: 30.48 mm Exhaust Valve Dia: 27.94 mm

Compression

Compression Ratio: 10.50
Combustion Space: 47.30 cc Cylinder Volume: 449.34 cc

Induction

Manifold Type: Small-Dia, Short Stacks, No Plenum
Flow Rate: 1600.0 cfm @ 1.50 inHg Fuel: Gasoline Nitrous: 0.0 lbs/min
Forced Induction Specifications:
Blower Type: None Surge Choke Overspeed
Turbine Size: **** mm Turbine A/R: **** 🟩 🟩 🟩
Internal Ratio: **** Belt Ratio: **** Number Turbos: 1
Boost Limit: **** psi Intercooler Eff: None IC Press. Drop: None

Exhaust

Exhaust System: H.P. Manifolds, Mufflers W/Cat

Camshaft

Cam Name: Stock Honda VETC Type R
Lifters: None (Overhead Cam)

Cam Specification	Low Speed Lobes		☑ High Speed Lobes	
	Intake	Exhaust	Intake	Exhaust
Lift At Valve:	7.75 mm	7.75 mm	11.66 mm	10.57 mm
Duration:	200.0	200.0	239.0	239.0
Centerline Angle:	111.0	109.0	107.0	108.0
True Centerline Angle:	111.0	109.0	107.0	108.0
Cam Advanced(+)/Retarded(-):	0.0	0.0	0.0	0.0
Lobe Centerline Angle:	110.0		107.5	
Valve Overlap:	-20.0		24.0	
Lifter Acceleration Rate:	2.41		3.82	
Activation RPM:			5500 rpm	
Valve Timing Based On:	0.050-inch		0.050-inch	

	IVO	IVC	EVO	EVC	IVO	IVC	EVO	EVC
Simulation Timing (0.050-inch):	-11.0	31.0	29.0	-9.0	12.5	46.5	47.5	11.5
Additional Timing (Seat-to-Seat):	4.5	46.5	44.5	6.5	26.0	60.0	56.0	20.0
True Timing	-11.0	31.0	29.0	-9.0	12.5	46.5	47.5	11.5

Notes

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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 SC-DynoSim.

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 (.SDY) file. When all parts have been selected, the SC-DynoSim will perform a simulation and display horsepower and torque curves in the right results pane.

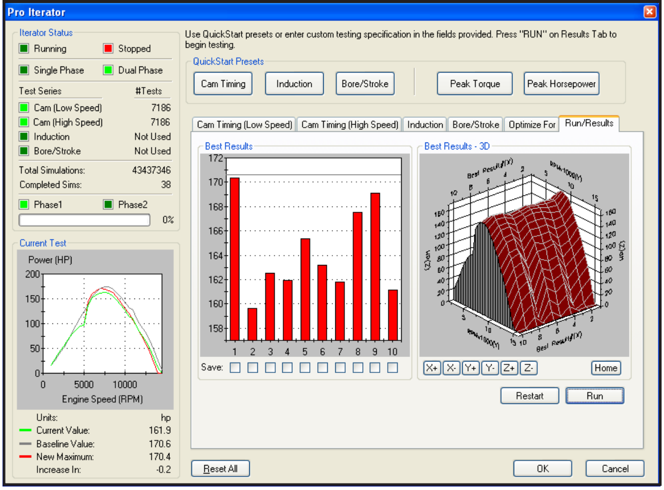
When the baseline engine simulation has been performed, you may conduct an *Iterative* test. Open the *ProIterator*™ by choosing ***ProIterator*™** from the **Tools** menu or by clicking the ***ProIterator*™ *Icon*** in the **Toolbar**. The tabbed data-entry-and-display pages establish a component or 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

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 (Low Speed)	7186
Cam (High Speed)	7186
Induction	Not Used
Bore/Stroke	Not Used

Total Simulations: 43437346
Completed Sims: 38
Phase1 Phase2 0%

Units: hp
Current Value: 161.9
Baseline Value: 170.6
New Maximum: 170.4
Increase In: -0.2

Narrowly-focused or multiple-component tests may require several thousand, or even many millions of 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. 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.

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 SC-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.

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 SC-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 SC-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 SC-DynoSim and regain your desktop during an *Iterator* test.

PRINTING

PRINTING DYNO DATA AND POWER CURVES

The SC-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 SC-DynoSim (see page 134 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.

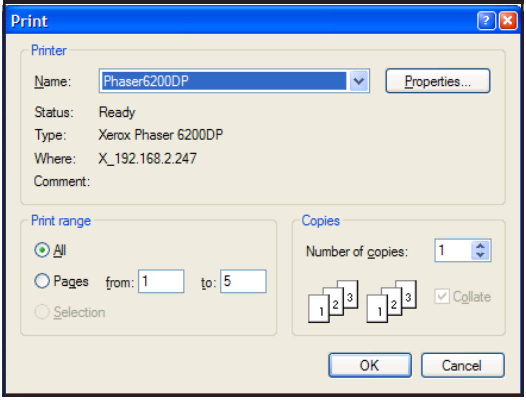
There are three choices in the ***File*** menu (located on the *Main Program Screen*) that will help you setup your printer and print dyno data. The choices are:

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 Preview—Opens the Print Preview Screen that provides an on-screen render-

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.

Print Dialog Box



Print

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

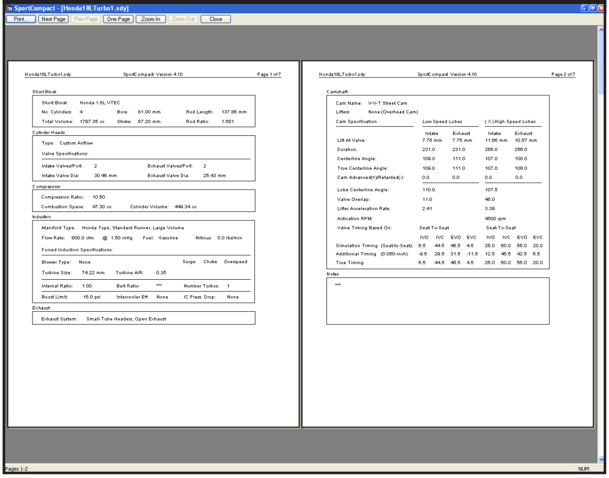
Number of copies: 1

☑ Collate

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.



Honda18LTurbo1.sdy SportCompact Version 4.10 Page 1 of 7

Short Block

Short Block: Honda 1.8L VTEC
No. Cylinders: 4 Bore: 81.00 mm Rod Length: 137.86 mm
Total Volume: 1797.35 cc Stroke: 87.20 mm Rod Ratio: 1.581

Cylinder Heads

Type: Custom Airflow
Valve Specifications:
Intake Valves/Port: 2 Exhaust Valves/Port: 2
Intake Valve Dia: 30.46 mm Exhaust Valve Dia: 25.43 mm

Compression

Compression Ratio: 10.50
Combustion Space: 47.30 cc Cylinder Volume: 449.34 cc

Induction

Manifold Type: Honda Type, Standard Runner, Large Volume
Flow Rate: 800.0 cfm @ 1.50 inHg Fuel: Gasoline Nitrous: 0.0 lbs/min
Forced Induction Specifications:
Blower Type: None Surge Choke Overspeed
Turbine Size: 74.22 mm Turbine A/R: 0.35
Internal Ratio: 1.00 Belt Ratio: *** Number Turbos: 1
Boost Limit: 15.0 psi Intercooler Eff: None IC Press. Drop: None

Exhaust

Exhaust System: Small-Tube Headers, Open Exhaust

Honda18LTurbo1.sdy SportCompact Version 4.10 Page 2 of 7

Camshaft

Cam Name: V-V-T Street Cam
Lifters: None (Overhead Cam)

Cam Specification	Low Speed Lobes				(X) High Speed Lobes			
	Intake		Exhaust		Intake		Exhaust	
Lift At Valve:	7.75 mm		7.75 mm		11.66 mm		10.57 mm	
Duration:	231.0		231.0		266.0		256.0	
Centerline Angle:	109.0		111.0		107.0		108.0	
True Centerline Angle:	109.0		111.0		107.0		108.0	
Cam Advanced(+)/Retarded(-):	0.0		0.0		0.0		0.0	
Lobe Centerline Angle:	110.0				107.5			
Valve Overlap:	11.0				46.0			
Lifter Acceleration Rate:	2.41				3.39			
Activation RPM:					4500 rpm			
Valve Timing Based On:	Seat-To-Seat				Seat-To-Seat			
	IVO	IVC	EVO	EVC	IVO	IVC	EVO	EVC
Simulation Timing (Seat-to-Seat):	6.5	44.5	46.5	4.5	26.0	60.0	56.0	20.0
Additional Timing (0.050-inch):	-9.5	29.5	31.5	-11.5	12.5	46.5	42.5	6.5
True Timing	6.5	44.5	46.5	4.5	26.0	60.0	56.0	20.0

Notes

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ing 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.

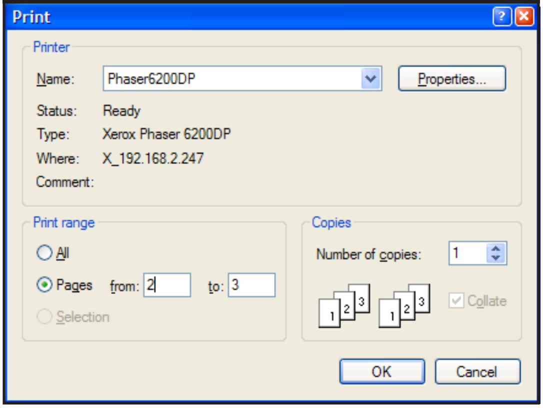
The dyno-test report generated by the SC-DynoSim consists of 5 pages. Here is description of each page:

Page 1—This page prints the first group of 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—This page prints the second group of components selected for the current simulated dyno test, including the Camshaft and Notes categories.

Page 3—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 4—Calculated engine power and pressures are provided in chart form. Values are listed for each 500rpm test point throughout the full test range.

Page 5 (ProTools™)—Comprehensive table of engine power and pressures, including all MEPs, Induction Airflow, Piston Forces, Frictional Losses, Pumping Losses, and more.

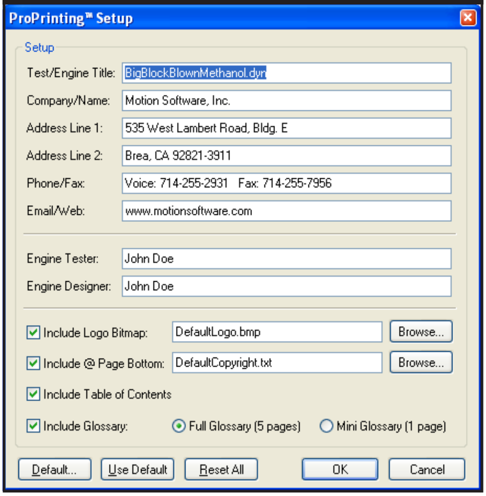
Page 5 (Advanced) or 6 (ProTools™)—The first of two engine-output graphs is reproduced on this page (this is the graph located on the left side of the *Main Program Screen* under the *Component Categories*—select the ***Graph Tab*** at the bottom of the left of the pane to display this graph). Full color printing is supported.

Page 6 (Advanced) or 7 (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 134 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 SC-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 SC-DynoSim, then select *Print Preview* from within your browser.

Pro-Printing™ Setup

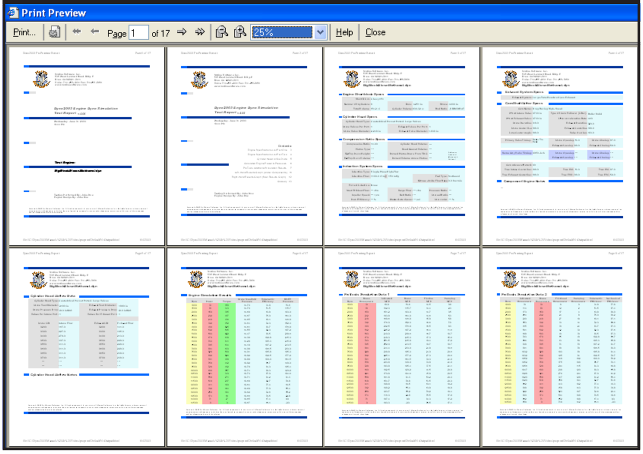


Test/Engine Title: BigBlockBlownMethanol.dyn
Company/Name: Motion Software, Inc.
Address Line 1: 535 West Lambert Road, Bldg. E
Address Line 2: Brea, CA 92821-3911
Phone/Fax: Voice: 714-255-2931 Fax: 714-255-7956
Email/Web: www.motionsoftware.com
Engine Tester: John Doe
Engine Designer: John Doe
☑ Include Logo Bitmap: DefaultLogo.bmp Browse...
☑ Include @ Page Bottom: DefaultCopyright.txt Browse...
☑ 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 _SC-DynoSim/Manuals & Videos/ProPrint_ subdirectoy. You can modify these files to suit your requirements.

ProTools™ Printing Features

Pro-Printing™ Dyno Test Report



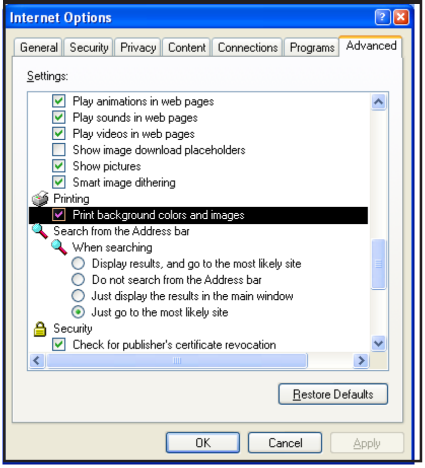
A *ProPrinting*™ report includes "presentation" graphics, a cover page with the name and address of your business (or your personal name and address) and logo, a table of contents, optional text printed at the bottom of each page, optional "full" or "mini" glossaries, and a complete listing of all test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

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 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 SC-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 *SC-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 Setup



Settings:

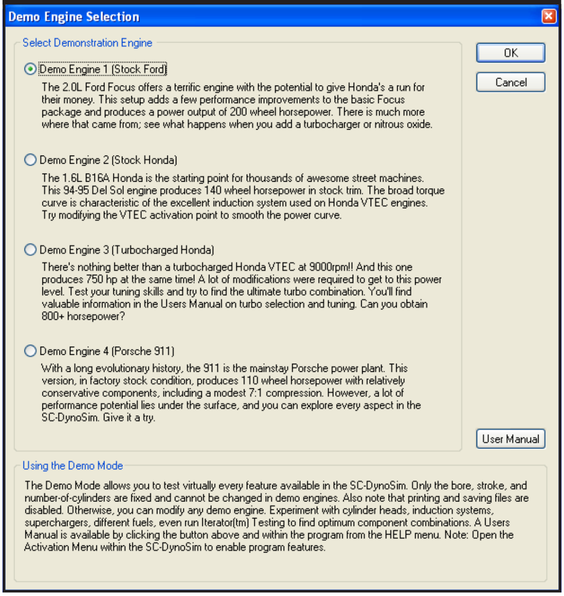
- ☑ Play animations in web pages
- ☑ Play sounds in web pages
- ☑ Play videos in web pages
- ☐ Show image download placeholders
- ☑ Show pictures
- ☑ Smart image dithering
- Printing
  - ☑ Print background colors and images
- Search from the Address bar
  - When searching
    - ○ Display results, and 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

OTHER FEATURES

The SC-DynoSim can start-up and run in four distinct modes: 1) ***Demo***, 2) ***DeskTop SC-Dyno Version***, 3) ***Advanced DynoSim Version***, and 4) ***ProTools™ Activated***.

Demo Mode—If you have downloaded the SC-DynoSim from an Internet site or installed the SC-DynoSim Demo on your system along with other, purchased ProRacing Sim Software simulations, the SC-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 SC-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-Selection Screen* (shown above).

***Demo Mode* Engine-Selection Screen**



● Demo Engine 1 (Stock Ford)

The 2.0L Ford Focus offers a terrific engine with the potential to give Honda's a run for their money. This setup adds a few performance improvements to the basic Focus package and produces a power output of 200 wheel horsepower. There is much more where that came from; see what happens when you add a turbocharger or nitrous oxide.

○ Demo Engine 2 (Stock Honda)

The 1.6L B16A Honda is the starting point for thousands of awesome street machines. This 94-95 Del Sol engine produces 140 wheel horsepower in stock trim. The broad torque curve is characteristic of the excellent induction system used on Honda VTEC engines. Try modifying the VTEC activation point to smooth the power curve.

○ Demo Engine 3 (Turbocharged Honda)

There's nothing better than a turbocharged Honda VTEC at 9000rpm!! And this one produces 750 hp at the same time! A lot of modifications were required to get to this power level. Test your tuning skills and try to find the ultimate turbo combination. You'll find valuable information in the Users Manual on turbo selection and tuning. Can you obtain 800+ horsepower?

○ Demo Engine 4 (Porsche 911)

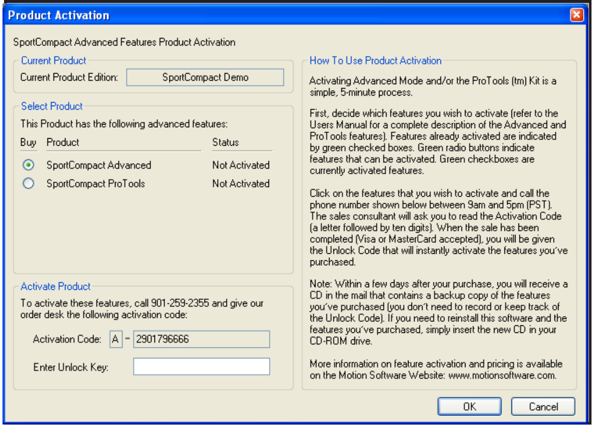
With a long evolutionary history, the 911 is the mainstay Porsche power plant. This version, in factory stock condition, produces 110 wheel horsepower with relatively conservative components, including a modest 7:1 compression. However, a lot of performance potential lies under the surface, and you can explore every aspect in the SC-DynoSim. Give it a try.

The Demo Mode allows you to test virtually every feature available in the SC-DynoSim. 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. Otherwise, you can modify any demo engine. Experiment with cylinder heads, induction systems, superchargers, different fuels, even run Iterator(tm) Testing to find optimum component combinations. A Users Manual is available by clicking the button above and within the program from the HELP menu. Note: Open the Activation Menu within the SC-DynoSim to enable program features.

If you've downloaded the SC-DynoSim from an Internet site or installed the SC-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 SC-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, *DeskTop, Advanced* and *ProTools™*

Activating Features



Product Activation

SportCompact Advanced Features Product Activation

Current Product

Current Product Edition: SportCompact Demo

Select Product

This Product has the following advanced features:

Buy	Product	Status
●	SportCompact Advanced	Not Activated
○	SportCompact ProTools	Not Activated

Activate Product

To activate these features, call 901-259-2355 and give our order desk the following activation code:

Activation Code: A - 2901796666

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 program features 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.

DeskTop Sport-Compact Dyno—(Basic Version Of SC-DynoSim) The ***DeskTop Sport Compact Dyno*** contains features that most enthusiasts will find more than sufficient to allow them to test components and determine optimum combinations for most applications. <u>All essential simulation features are included in the *DeskTop SC-Dyno*</u>. In the DeskTop mode, the user can measure and monitor various engine pressures and efficiencies, including Intake-Manifold Pressure and Volumetric Efficiency, enter custom cylinder-head airflow, model forced-induction systems, and much more. The ***Advanced SC-DynoSim*** and the ***ProTools™*** versions extend the program to allow a more technical and/or detail analysis of engine performance.

Advanced DynoSim Mode—In ***Advanced DynoSim Mode***, you can run multiple simultaneous simulations and perform on-graph comparisons of up to four engines. One-Click QuickCompare™, Variable Valve Timing, the CamManager™, saving and loading Camfiles, running One-Click Iterative Testing™, and an expaned user interface are also included in the Advanced DynoSim mode.

DynoSim With ProTools™ Kit Activated—(Professional Version Of SC-DynoSim) If you are a serious enthusiast, racer, or professional engine builder, you will find the additional tools and features supplied in the ***SC-DynoSim ProTools™ Kit*** a valuable addition to the *Advanced Mode*. 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, and more. Plus the ***ProTools Kit*** includes custom *ProPrinting™*, *ProData™* tables, *GraphZone™* data analysis, plus the *ProIterator™* with the analysis of areas under the curves.

Demo, *DeskTop*, *Advanced* and *ProTools*™

SC-DynoSim Feature Activation

Engine Simulation Program Features	DeskTop SC Dyno	SCDynoSim Advanced	SCDynoSim ProTools™
Dyno-Testing RPM Range	2000 to 8500 rpm	1500 to 11500 rpm	1000 to 14500 rpm
Bore Range Limits	3.00 to 7.00-in	2.50 to 7.00-in	2.00 to 7.00-in
Stroke Range Limits	2.50 to 7.00-in	2.00 to 7.00-in	1.50 to 7.00-in
Alternate Fuels/Nitrous	✓	✓	✓
AirFlow Calculator	✓	✓	✓
CamMath QuickCalculator™	✓	✓	✓
Advanced Compression Rati0 Calculator	✓	✓	✓
Forced-Induction Modeling	✓	✓	✓
Optimized High-Speed Simulation	✓	✓	✓
Custom Cylinder-Head Flow	✓	✓	✓
Multi-Page Dyno Test Reports	✓	✓	✓
DirectClick™ Menus	✓	✓	✓
Real-Time Results Displays	✓	✓	✓
U.S./Metric Units	✓	✓	✓
Test Multiple Engines	✗	✓	✓
On-Graph Comparisons With Up To Four Engines	✗	✓	✓
One-Click QuickCompare™	✗	✓	✓
Cam Manager™	✗	✓	✓
Variable Valve Timing	✗	✓	✓
Import CamData™ Files	✗	✓	✓
One-Click Iterative™ Testing	✗	✓	✓
Extended Color Display	✗	✓	✓
Extended-Data Displays	✗	✗	✓
ProPrinting™ Extended Dyno Reports	✗	✗	✓
ProData™ Tables	✗	✗	✓
Graph DataZones™ Displays	✗	✗	✓
ProIterator™ Advanced Dyno Testing	✗	✗	✓
Analyze Area Under Power And Torque Curves	✗	✗	✓

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

Here is a more infomation about key ***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 of areas under the power and torque curves, and much more. For a complete description of ***ProIterator™*** features, refer to page 119.

DataZones™—Extends the graphic-display and data-analysis capabilities of the SC-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 113.

Additional Simulation Data And Analysis—***ProTools™*** add additional simulated pressures, forces, and other data to the graphs and tables in the SC-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 132.

Activating *Advanced* Or *ProTools*™ Modes

Activating ***Advanced Mode*** or activating the ***ProTools*™** Kit 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 SC-DynoSim, including any or all of the optional features you have activated, simply insert the new CD in your CD-ROM drive.

DYNO FILE (.SDY) COMPATIBILITY

ProRacing Sim Software’s SC-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 DragSim and test the combination in 1/8- or 1/4-mile drag events. And using the new FastLapSim closed-course simulation, you can test any SC-DynoSim engine on virtually any track in any vehicle.

Note: Upon the initial release of the SC-DynoSim (3/1/04), .SDY engine files may not be compatible with existing versions of DragSim and FastLapSim. Update patches for these products will be posted on www.proracingsim.com. To maintain SC-DynoSim engine file compatibility download the latest program updater.

GENERAL SIMULATION ASSUMPTIONS

The SC-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 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 SC-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.

Sport Compact 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 SC-DynoSim. If you don't find an answer to your problem here, send in the **Mail/Fax Tech Support Form** on page 157 *(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 SC-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 SC-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 SC-DynoSim CD. If these operations produce an error message only when using the SC-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 SC-DynoSim CD disk" error message when trying to run the SC-DynoSim. Why?

***Answer*:** Please insert the SC-DynoSim disk in your CD-ROM drive. Occasionally, the SC-DynoSim may need to access the CD. Please keep the SC-DynoSim disk handy while you use ProRacing Sim Software products.

Question: The SC-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 SC-DynoSim.

SCREEN DISPLAY QUESTIONS

Question: Even though I have a 19-inch monitor, I can only see a small portion of the SC-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 SC-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 SC-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 134).

COMPRESSION-RATIO QUESTIONS

Question: The SC-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 <u>entire volume</u> that remains in the cylinder when the piston reaches top dead center. See page 35 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 induction flow that is too large for an engine (for example 4000cfm on a Honda 4-cylinder), why does the power increase without a typically seen “bog” at low speeds?

***Answer*:** The SC-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 carburetors. How can I simulate the airflow?

***Answer*:** The SC-DynoSim will simulate induction airflow from 100 to 4000cfm, rated at either the standard pressure drop of 1.5-inches or 3.0-inches of mercury (a pressure drop of 1 inch of mercury is equivalent to 13.55 inches of water). To simulate two carburetors, simply add the airflow and enter the total cfm value into the INDUCTION category.

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 SC-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 SC-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 SC-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 SC-DynoSim allow for the different acceleration rate cams used with hydraulic, solid, and roller lifters?

***Answer*:** The SC-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 SC-DynoSim does not use lifter-type to determine valve motion (and, subsequently, determine horsepower). See page 80 for more information about valve timing and acceleration modeling.

Question: Can I change rockerarm ratios with the SC-DynoSim?

Answer*:** Yes. Simply use this formula to alter the values you enter in the ***Lift @ Valve fields in the **CAMSHAFT** category (the SC-DynoSim will calculate the new valve motion throughout the lift curve):

$$\textbf{New Lift} = \textbf{Old Lift x} \frac{\textbf{New Ratio}}{\textbf{Old Ratio}}$$

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 an engine that I am building. The IVC occurs at 112 degrees (ABDC). Something goes wrong when I enter the valve events into the SC-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 engine is a classic example of a lack of standards. The OEM 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 SC-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 SC-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 107 for more information on the *CamMath QuickCalculator™*.

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 SC-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 SC-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 ***SC-CamDataSim™*** that contains 300+ cam files you can instantly load and test in the SC-DynoSim. Every CamFile on *SC-CamDataSim™* has BOTH seat-to-seat and 0.050-inch timing specs, allowing the SC-DynoSim to automatically calculate valve acceleration rates.

QUESTIONS ABOUT RUNNING A SIMULATION

Question: The SC-DynoSim displayed an error message "The SC-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: 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 112 for more information about graph scaling and plotting variables.

Sport Compact 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 SC-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

Dyno Testing Notes

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Tech Support Request

Please use this form (or a copy) to obtain technical support for the SC-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 .SDY 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 SC-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 SC-DynoSim (see front of CDROM) ____________________

Please describe the problem you encountered with the **SC-DynoSim:** ______________

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Can you duplicate the problem? ________________________________

Mail/Fax this form to:

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Version SC-DynoSim v4.11.0504

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