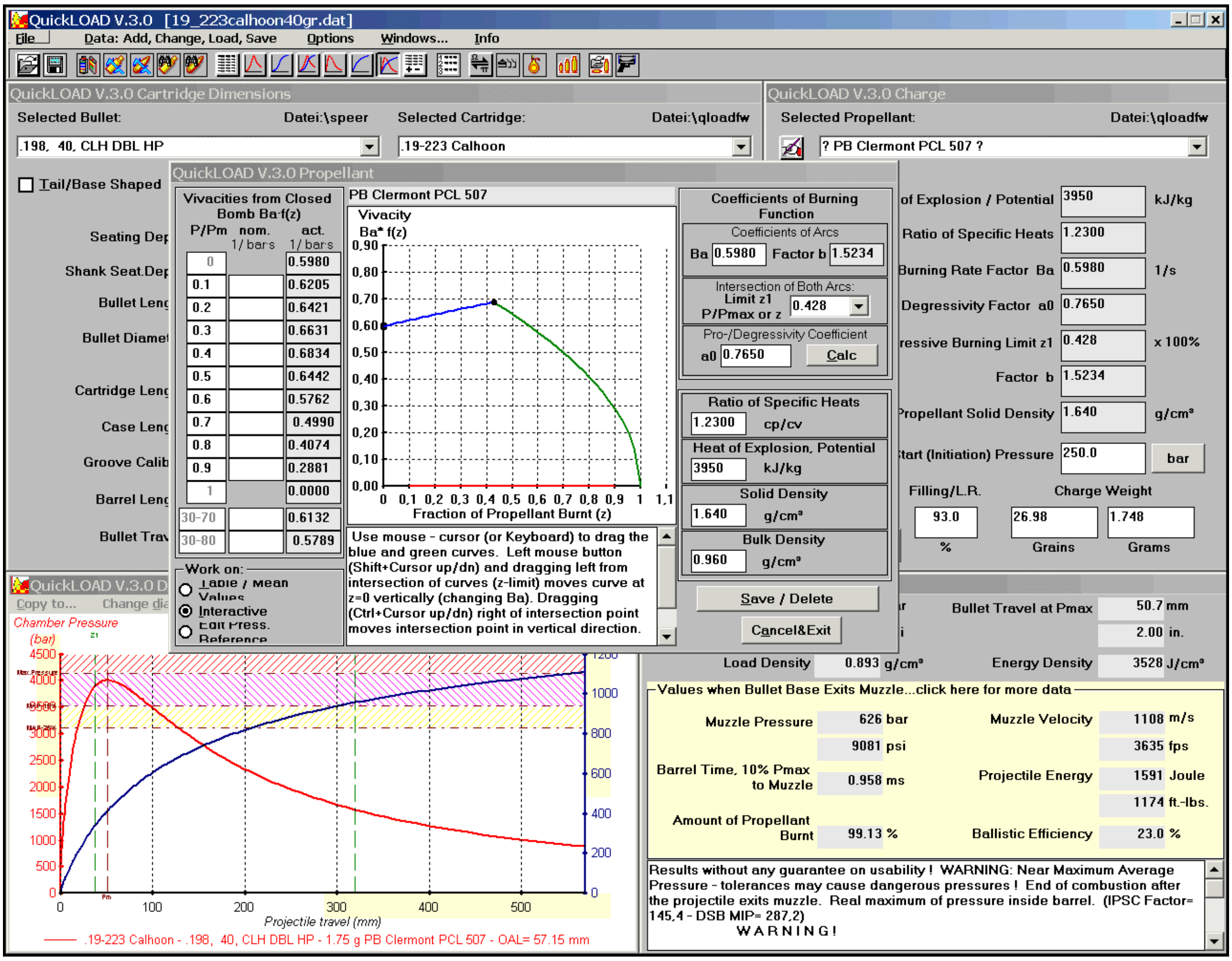
QuickLOAD©



Interior Ballistics Program
for
Ammunition Development
and for
Experienced Handloaders

Calculating Effects of Varying Interior Ballistics System Data for Guns with Normal Barrels

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Disclaimer

Since we have no control over equipment, components or data that might be used with this program, we neither imply nor assume any responsibility for results obtained through such use.
The program and data user assumes the acknowledge of following safe handloading practices. Failure to do so can result in serious personal injury, property damage or death to that individual and bystanders.
Those who use the results of Interior Ballistics Calculations are strongly advised to verify the computed results against loading data available in current handloading manuals. In any case, only data obtained from current loading manuals are valid.
This latter point is especially true when this program calculates any load using a powder charge that is either greater than or less than a corresponding maximum load or minimum load, as published in current handloading manuals. Remember always:

Interior Ballistics programs cannot predict EXACT ballistic results under all conditions.

Besides the obvious effects of loading techniques, component lot variations, shooting conditions and the like, brand-to-brand substitution of primers or bullets and variations in chambering & barrel dimensions often result in significant differences in pressure and other internal ballistic results.

SPECIAL WARNING

Not all guns are suited to fire handloads. In recent years it has become very apparent that there exists a situation regarding some pistols which may not provide complete support to the case when a cartridge is chambered. This warning is not aimed at specific weapons. Furthermore it has become very apparent that there exists a situation regarding modern rifles which may, in case of case-failure, propell the bolt backwards to shooters head, injuring the shooter seriously.

Ask manufacturer of weapon to determine if gun is capable or allowed to fire handloaded ammunition !

The established maximum average pressure for the cartridges used in the above mentioned guns seems to be safe for use in firearms which provide complete support of the case while using flawless factory-new cases. Resizing bulged cases results in weakening the case strength. Failure to fully support the case with cartridges of such intensity may result in bulged cases, ruptured cases, separated case heads or other consequences which may result in damage to the firearm and/or injury or death to the shooter and/or bystanders. If you own such a firearm, we recommend you contact the manufacturer to determine if the case is fully supported and suited to fire handloads.

If your firearm does not provide complete support for the case or is not intended to fire handloads, DO NOT USE *QuickLOAD* loading data to reload your ammunition for this specific firearm. Refrain from using handloads in such guns.

This is the first time we have felt it necessary to place such a restriction on the use of QuickLOAD's data, but the continued safety and welfare of the shooting public compels us to do so.

Advice to Handloaders regarding the Use of Propellants

1. **Never mix propellants of different lots even of the same designation, because the chemical composition has not been matched and from this an unpredictable rate of combustion could result.**
2. **Disintegrated or deteriorating propellants must not be further used or stored, because the rate of combustion has changed considerably and could accidentally lead to self combustion. Deteriorating propellants are recognized as brownish red in color, somewhat acrid fumes.**
3. **Deteriorating propellant particles must not contact good propellant; otherwise the disintegration of the fresh propellant might be expedited through an automatic catalytic reaction !**
4. **Never substitute primers of a proven load against other types until you work up the load from a save level again.**
5. ***Never shoot someone else's handloads*.**
6. **Be aware that 'canister-grade' propellants differ from lot-to-lot.**
7. **Never smoke or use open fire while working with propellants. Avoid electrostatical discharge.**

Program Installation

The software will run and has been tested on IBM-PC compatible computers under the operating systems Microsoft® Windows® 98, ME, NT4.0®SP4, 2000 and XP, versions and releases dated before December 2003.
It is assumed the program will run also under newer releases and versions of Microsoft® Windows®, but it cannot be guaranteed.

Recommended screen resolution is 1024 x 768 and higher.

The installation program will automatically start after inserting the CD into the drive when the autostart feature for your CD-Rom drive is enabled.

To install the software manually run the 'SETUP.EXE' program from the root directory of the CD. In addition, follow the instructions on screen. This setup program will invoke the program installation for *QuickLOAD and QuickTARGET*.

You will be asked for a destination directory where you want to install *QuickLOAD and QuickTARGET*.
If you have already installed Cartridge Designer Program *QuickDESIGN* you will have the opportunity to tell the setup program where to find *QuickDESIGN* files. Setup program will then install necessary settings to *QuickLOAD* enabling you to retrieve data provided by *QuickDESIGN*.

You may uninstall the program by selecting *My Computer* icon, *Control Panel* icon, S*oftware* icon. Search there for *QuickLOAD* entry to uninstall the program. Files you may have created meanwhile which are not known to the uninstaller program cannot be removed and have to be removed manually.

To read this manual you must have the Acrobat® Reader ready installed.
The actual version of Adobe® Acrobat® Reader you will find on ***QuickLOAD*** Setup-CD in directory or folder Adobe\.

Note:
The program is registered to the computer on which it was first installed by saving a unique equipment ID. Changing the motherboard, CPU or significant system's settings may cause a re-installation of the program.

Please save your own load-, bullet-, case- and powder data from time to time to a separate backup medium.

Please do not copy the *QuickLOAD* CD to prevent software piracy. The *QuickLOAD* CD contains a unique identification tag which cannot be copied to identify illegal copies of the CD.

The **DEMO** version of *QuickLOAD/QuickTARGET* cannot save any data. There are only 3 propellants, 3 cartridges and 3 bullets in caliber .308.

Foreword

The idea to code an interior ballistics program arises, when the author as a handloader and student, first got unrestricted access to a Digital Equipment PDP 8 computer about 1969 at Technical University of Darmstadt. Programming language was Focal and the console terminal was a Teletype typewriter. The storage media consists of a paper tape fed into a punched-tape reader and puncher. The first propellant specifications were derived from four military small to medium caliber powder types, gun data were taken from anti-aircraft gun barrels. With these components an interior ballistics model was programmed and verified against laboratory data. By the time program migrates to a DEC PDP11 equipment using RT11 operating system and Fortran programming language. Console terminal was a VT52 and program was stored on magnetic tape now. Finally, in the eighties, I moved the program to an IBM PC.

First version on PC was a DOS-based program. At this time there were data of about fifteen powders within program available and I gave copies to friends working in ammunition test labs who like to use it accompanying their work. After a while a lot of people involved with ammunition making noticed and tested the program there and I received many requests to make the program available to the public.

It was a lot of work to prepare and retrieve all the propellant data, and in late 1995 I released the first Windows' version of the program named *QuickLOAD* including data of 45 propellants. The program became soon a success and was improved over the time until today.

I must credit those companies, especially some powder manufacturers, whose kind consent facilitated incorporating the data herein. The investment in time and money represented by their preparation of data is difficult to imagine. Also, I would like to thank those companies and individuals who facilitated me to acquire used ballistics lab equipment.

Specifically, I would like to thank Mic McPherson, author of various handloading publications, for the numerous tips and ideas to improve the user interface of the program to the needs of handloaders.

And last but not least, I would thank my wife for all the patience she has with me while I am working with and for *QuickLOAD*.

The user should be aware that this program uses only one possible model for interior ballistics calculations. There are numerous different approaches modeled to accomplish this task. Some perform better for specific tasks and some are much more complicated to operate. But all use simplifications and deliver sometimes faulty results or may be not appropriate for the task they are used for.

Never trust blindfolded the results of interior ballistic calculations. Always compare results with safe known data.

You may copy factory data but seldom improve them. Handloaders do not have all the powders a factory has. To get higher performance means to exceed safe pressure limits. That is like leaving the paved way and walk over a glacier without being safeguarded by a rope, not seeing how close you walk to the edge of the next crevasse.

There are two similar safety standards for (civil) ammunition established all over the world, which every handloader should know. In the USA, the **SAAMI** (**S**porting **A**rms and **A**mmunition **M**anufacturer's **I**nstitute, Inc., 555 Danbury Road, Wilton, Connecticut 06897) publishes and sponsors standards approved by ANSI (American National Standards Institute) as *voluntary* industry performance standards for the use by commercial manufacturers. The **C.I.P.** (**C**ommission **I**nternationale **P**ermanente Pour l'Epreuve des Armes à Feu portatives, 45, Rue Fond-des-Tawes, 4000 Liège, Belgium) sets the standards for civil ammunition and weapons for member countries. These standards are *mandatory* (like a law, or forced into local law) in countries having ratified the CIP Standard. By working together, the CIP and SAAMI are working towards the development of international standards.

Maximum standardized pressures are listed in *QuickLOAD's* database; so far the cartridge is governed by CIP or SAAMI.

Hartmut G. Broemel

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QuickLOAD User's guide

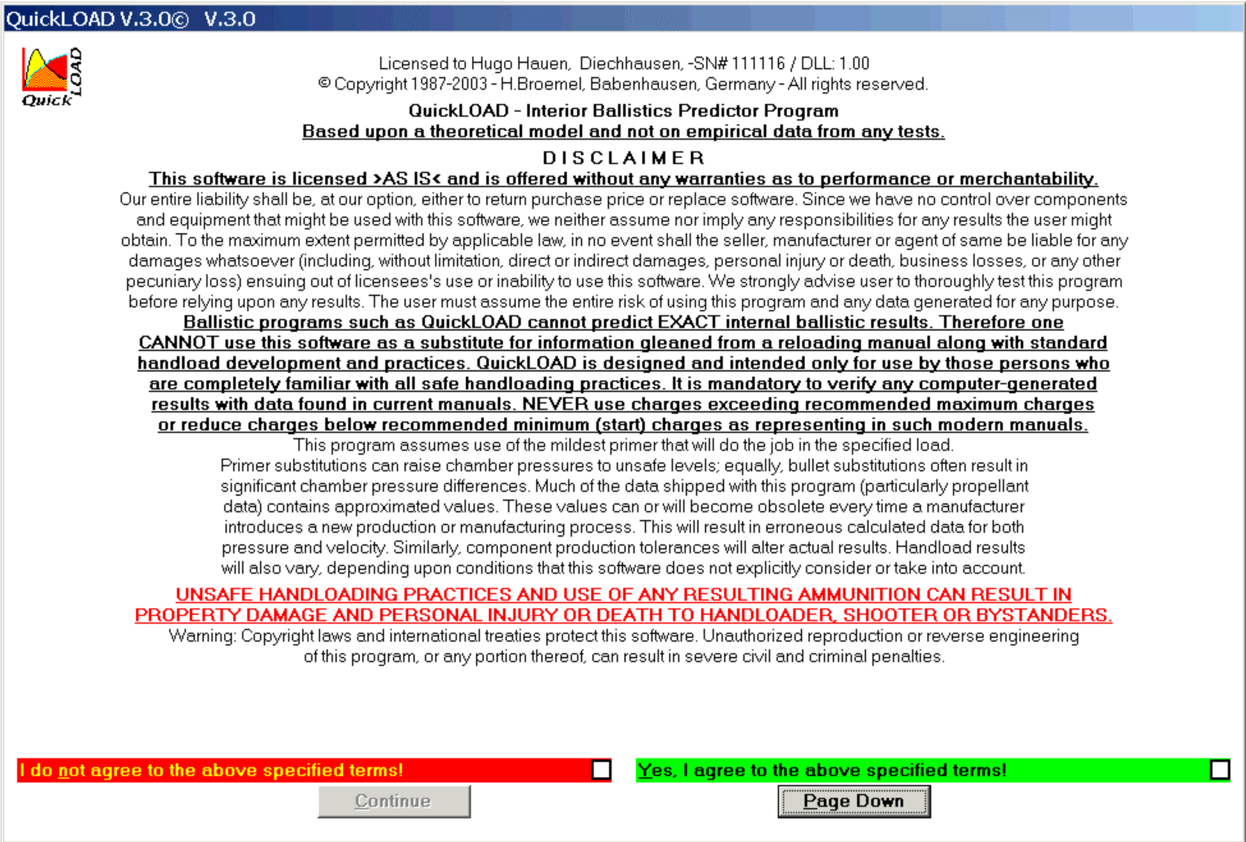
Starting *QuickLOAD*

Run *QuickLOAD* by double-clicking on this program icon on desktop or in startmenu.

QuickLOAD

NOTE: The ongoing addition of new *QuickLOAD* features limits our ability to include pictorial and textual information on every program option.

After a few seconds of loading, a text window with important warnings and notes appears. At the first run of QuickLOAD you must accept the warnings shown on entry screen:



Picture 1: Initial Entry Window containing warnings

Please read and understand this entire message. Then select the appropriate button, according to your decision.
The license agreement and important advice, that you must necessarily read and understand, are located on the opening pages of this manual. Please also refer to *readme.txt* file on CD.

If the program does not start or aborts without error notification, the program code or the code of QLOADFW32.DLL, a file placed in WINDOWS\SYSTEM32 directory, could be corrupted or tampered with by a virus (Checksum failure). Please uninstall program and try to reinstall the program with the installation disk. You may also have to re-install the software when changing motherboard or CPU or by placing harddisk in different computers.

Errors and warnings, during loading of the files QLOADFW.VOL, QLOADFW.PRO, QLOADFW.BUL or QLOADFW.INI mean that the reported file is corrupt or does not exist in the program directory.

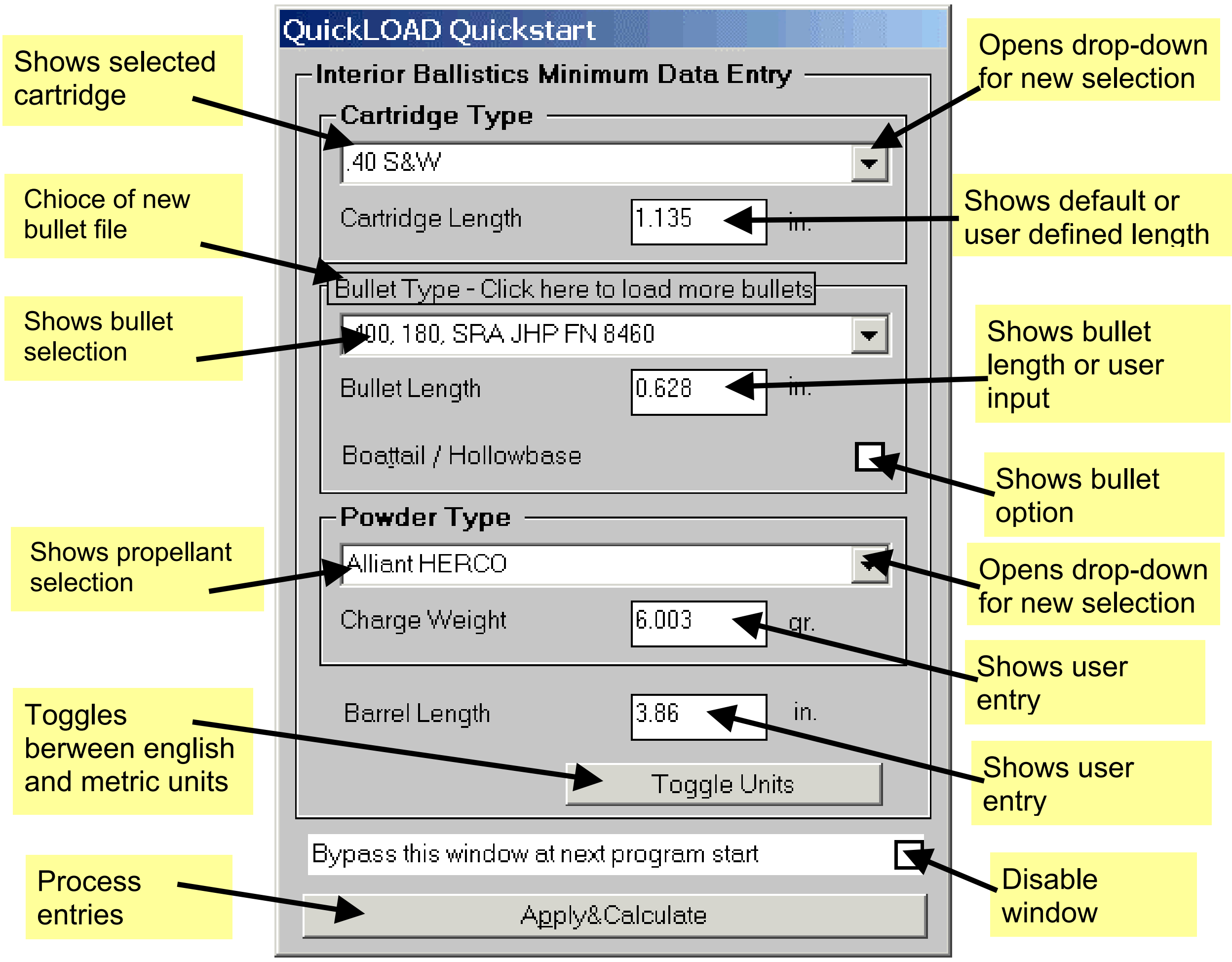
That can occur, e.g. when a text editor program has processed these files and characters have been inserted, deleted or when unidentified characters have been added.
Backup these files frequently, especially when you generate new cartridge, bullet- or propellant records.
The file QLOADFW.INI holds data of the last computation; options set state and important constants that should not be altered. At restart, the user can always continue with those values last used before exiting the prior session.

The structure of these files is explained in APPENDIX.

Upon program opening, the *Quickstart* data entry screen opens. This window allows entry of minimum necessary data for calculations. This screen is only available during initial startup.

The purpose of this window is to simplify use of this program for a first-time user or a computer novice. After running *QuickLOAD* a few times, most users will turn this feature off. It can be re-enabled in the main menu, under *Info...* (see Page 19, Menu Item Info).

Quickstart Data Entry Screen Window



Picture 2: Quickstart Window

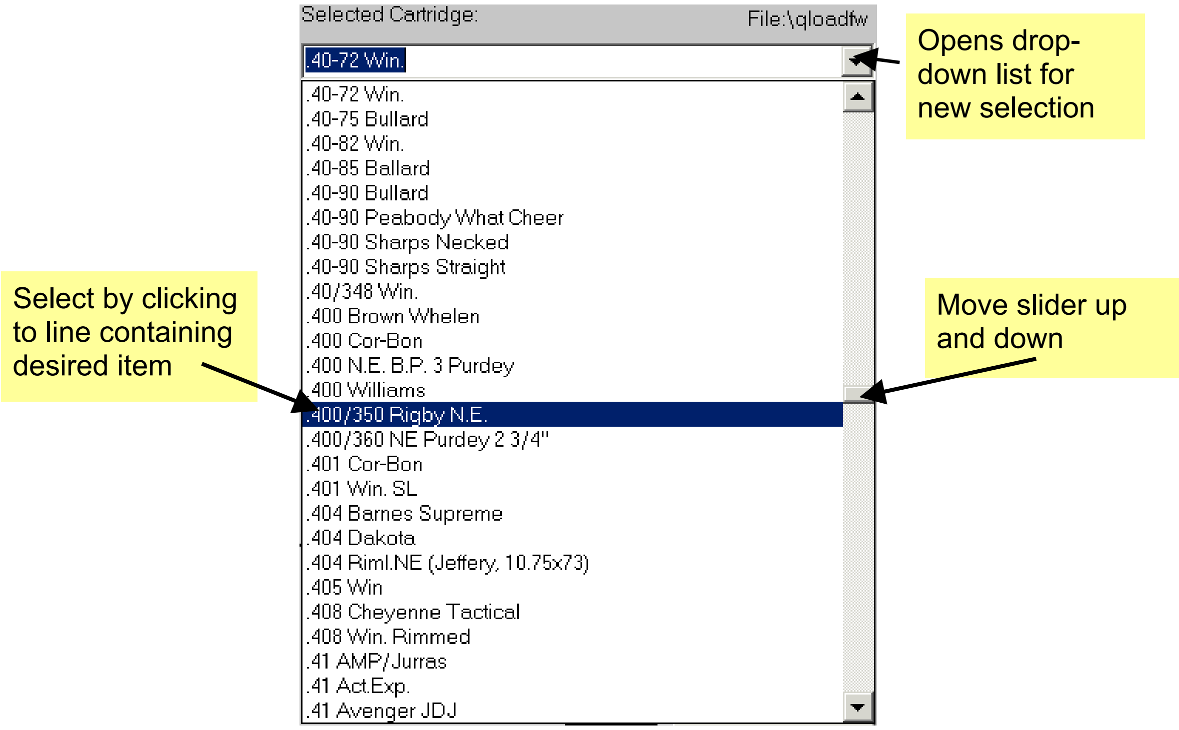
The *Quickstart* data entry window contains data from the last session. The user can accept these values or choose new data. When all data entries are valid, positioning the mouse cursor over the *Apply&Calculate* button and pressing the left mouse button once selects the *Apply&Calculate* button. This transfers that data into the main program windows, which are automatically opened.
The user can also choose to bypass this window at next program start by selecting the check box: *Bypass this window at next program start*.

This window contains three drop-down-windows with slider-bars: *Cartridge type*, *Bullet type* & *Powder type*. Selecting one of the down arrows (at right side of data entry window) opens the associated database. The user can then use the slider to bring the desired item into view in the sub-window. To select the desired item, position the cursor over that item and single-click. *QuickLOAD* automatically places the selected item into the associated data entry window.

After specifying all necessary data, single-click the *Apply&Calculate* button to perform the initial entry into the main *QuickLOAD* window.

Depending upon program settings, one or more new (child) windows will appear. If only one of these windows opens, single-click the *Apply&Calc* button at the lower-right of that window. This will open a second window, single-click the *Apply&Calc* button at the lower-left of that window. This will open two new windows. If two of these windows initially open, single-click the *Apply&Calc* button at the lower-left of the visible window. If four of these windows initially open, proceed as described in the following section.

Drop-Down sub-window with slider bar



Picture 3: Drop-down list field sample

A lot of entry fields are combined function fields allowing direct manual entries or selection of items from a list which may drop-down on command. Example : *Cartridge type* selection field in *Quickstart window* as described before. To open drop-down list select downward pointing arrow at the right corner of entry field. Easy mouse action can be replaced by following **keyboard commands:**

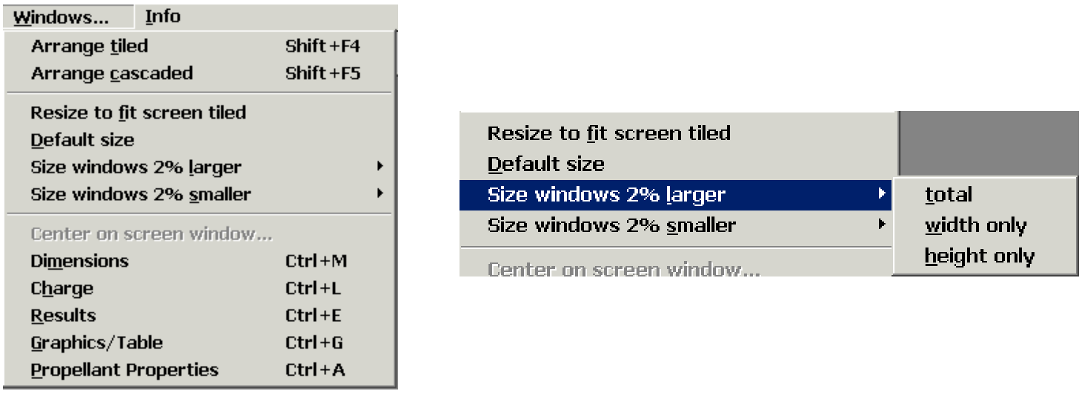
- While blinking cursor is inside field press [ALT-ARROW DOWN] key to open drop down list.
- Use ARROW-DOWN or ARROW-UP keys to scroll selection bar up and down the list.
- Use PAGE-UP or PAGE-DOWN keys to advance one full page up or down.
- Press ENTER key to select highlighted selection.

Note: When blinking cursor is inside field and you press Alt-S key the field toggles from and to "Search Mode". Search mode is indicated by yellow background color. In search mode you may type in any matching characters and the list field drops down and displays the first found match.

Fitting *QuickLOAD* Windows to the Desktop Area

If your computer has an very low resolution monitor that has to run in the 800x600 or lower screen resolution mode, *QuickLOAD* must be run in the *arrange cascaded* windows arrangement mode. In this mode, the *QuickLOAD* child windows are displayed in an overlapping style. Single-clicking on any visible area of any of these windows brings that window to the front. To enable this display mode, single-click the *QuickLOAD* menu item *Windows* (to open the *Windows* menu). Single-click the *arrange cascaded* option.

For most monitors, the alternative display method, *arrange tiled*, is feasible. This option provides superior program usefulness. However, owing to the many variables in monitors and settings, especially the arrangement of the taskbar which may reside anywhere on the screen sides, it is sometimes necessary to adjust the child windows to achieve a proper screen fit.



Picture 4: Menu Windows... to arrange windows

Upon initial entry into the main *QuickLOAD* window, the four child windows might not align and fit properly in the display area. To achieve a proper fit of the *QuickLOAD* child windows (each is fully visible, without any overlapping, and these four windows occupy essentially the entire active viewing area) follow procedure :

1) Single-click the word *Windows* in the menu bar (this opens the *Windows* menu);
2) Single-click the menu option *arrange tiled*.
3) Single-click the menu option *Resize to fit Screen tiled*
4) A message window *Resize Windows* displays, single-click the *Yes* icon;
5) A new message window displays, single-click the *OK* icon;

Under Windows XP with Service Pack 1 QuickLOAD's windows should now properly fit the area of screen leaving the taskbar visible. Under older Versions of Windows operating system you may have to do some additional work.

Even after following this procedure, the child menus might not properly fit the screen. In this case, the windows will be either too small or too large. This depends upon various *QuickLOAD* and Windows Operating System preference settings. *QuickLOAD* provides an additional method to achieve a near perfect screen fit of the four child windows.

If the child windows are initially too large, resulting in overlapping and hidden portions of the *QuickLOAD* windows, follow this procedure:

1) Single-click the word *Windows* in the menu bar
2) Single-click the menu option *Size windows 2% smaller*;
3) A message window *Resize Windows* displays, single-click the *Yes* icon;
4) A new message window displays (specifying that you might have to restart *QuickLOAD* to get the new settings to take effect), single-click the *OK* icon;

If the windows still do not properly fit the monitor, repeat the above steps, as many times as might be necessary.

If the child windows are initially too small, resulting in a display with unused screen area and gaps between the *QuickLOAD* child windows, follow previous procedure with the exception that in *step 2* choose the *Size windows 2% larger* option.

Sizing Font to Correctly Fit *QuickLOAD* Windows

In some instances, the text in the correctly sized windows might be either too large or too small to allow a legible display (see below). *QuickLOAD* window font adjustment is achieved as described here:

1) Single-click the word *Options* in the menu bar;
2) Single-click the *Setup screen font* option;
3) A message window *Resize fonts* displays, single-click the *Yes* icon;
4) The *Font* window displays;
5) Use standard Windows procedures to select font, style and size.

(To choose a font, single-click over any displayed font choice. Use the keyboard arrow keys to move up or down through the list. When the desired font is displayed in the box above the list, single-click the desired font style in the Font style option. Then double-click over the entry box just below the word size. *Note that the list below shows the range of likely font size integer choices. Type in an integer falling within the displayed list. Single-click the OK button. Usually, MS sans serif, regular, 9 or 10 provides good legibility.)*

If not, try again, increase or decrease font size, as necessary, to produce a fully legible display of all child-window data.

If the end result of correctly following these procedures and the above font size adjustment does not produce legible results in windows that properly fit the screen, it is very likely that the screen resolution settings or Font DPI settings in the *Windows Operating System* (or Desktop properties) do not match your monitor. Refer to Windows Operating System help for information on correctly sizing the monitor and setting screen resolution.

QuickLOAD Bubble Help System

QuickLOAD includes a user selectable and interactive *Bubble-help* system named the *ToolTip help* system. When this system is active, positioning the mouse cursor over any data box and pausing one second opens a sub-window containing useful information about the selected box or screen area.

This system is enabled and disabled by a toggle switch under the *Info* menu item. The initial program startup value is *On*. We suggest leaving this system active until you are reasonably familiar with *QuickLOAD*.

After initial program startup (or when* Quickstart *menu is disabled) program execution proceeds as described below.

Important *QuickLOAD* Keyboard Commands

User can access *Main menu* with the < Alt > + < PgUp > key combination.

Holding the < Alt > key down while pressing the key corresponding to the underlined character in a menu begins the desired action.

Activate or jump over opened windows by pressing < Ctrl > + < Tab >; activate or jump over input fields by pressing < Tab >.

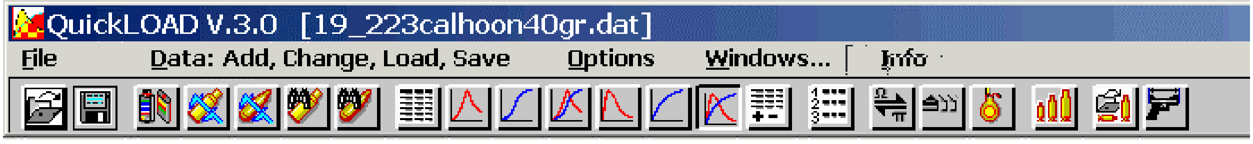
In the input fields, the user can navigate with the arrow keys.

Drop Down fields (e.g. powders) are opened with < Alt > + < arrow down >.

Program exit is initiated by pressing < Alt > + < F4 >.

After starting and loading all necessary files, the Main Menu Bar and the Symbol Toolbar (similar to the following) appear on the screen:

Important *QuickLOAD* Views & Actions



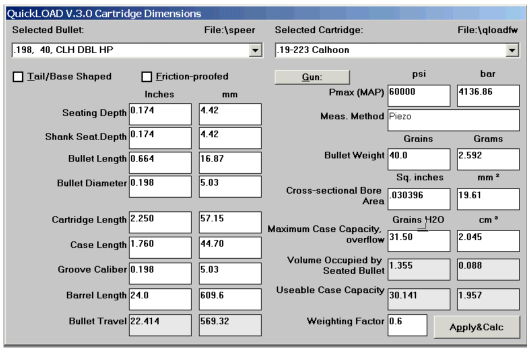
Picture 5: Main Menu Bar & Symbol Toolbar

We address all Main Menu Bar options later in this text.

The Symbol Toolbar provides various shortcut options to oft-used *QuickLOAD* features. Those features are not described separately here. Rather, we indicate under the menu choice discussions when a Symbol shortcut option is available.

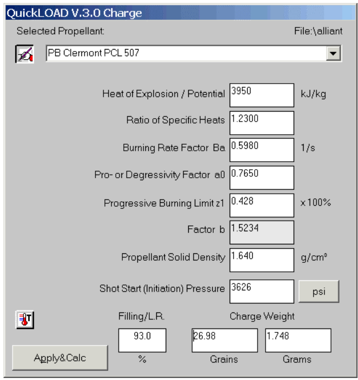
Default *QuickLOAD* Input & Output Windows

QuickLOAD Cartridge Dimensions Window



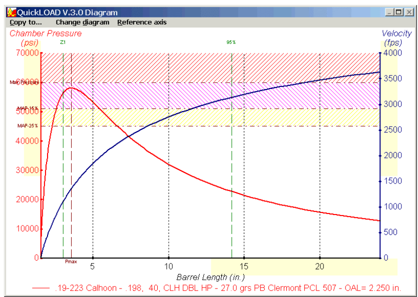
This window is normally located just below the Main Menu Bar and Symbol Toolbar. Tiled window position is upper-left screen corner. This window allows selection and specification of necessary ammunition and gun dimensions.

QuickLOAD Charge Window



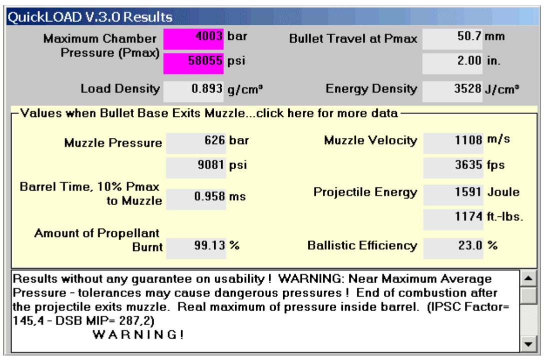
This window is normally located just below the Main Menu Bar and Symbol Toolbar. Tiled window position is upper-right screen corner. This is where powder and charge information is selected and entered.

QuickLOAD Diagram Window



Tiled window position is lower-left screen corner. This is where graphic diagrams (and various other special outputs) are displayed. The standard output graphs also allow data entry – an exciting and useful feature.

QuickLOAD Results Window



Tiled window position is lower-right screen corner. This is where various standard output data is displayed – this screen includes a switch feature, to allow display of more information.

Selecting menu items from *Main menu* bar

The main menu line contains the sub menus: *File; Data, Add, Change, Load, Save; Options; Windows; Info*. Use the mouse cursor and left button to access these functions in the standard Windows method.

Alternatively, to activate these options from the keyboard, press the < Alt > key or, from within other active windows, press < Alt > + < PgUp > keys. To open one of these menus, hold down the < Alt > key and press the key corresponding to the underlined character.

After a menu is opened, simply press the key corresponding to the underlined character on the desired option.

Selecting options in menus

Selecting an option in a *QuickLOAD* menu is achieved by moving the mouse cursor over that option and single-clicking the left mouse button. Selecting a menu option produces one of three results:

A new window opens,

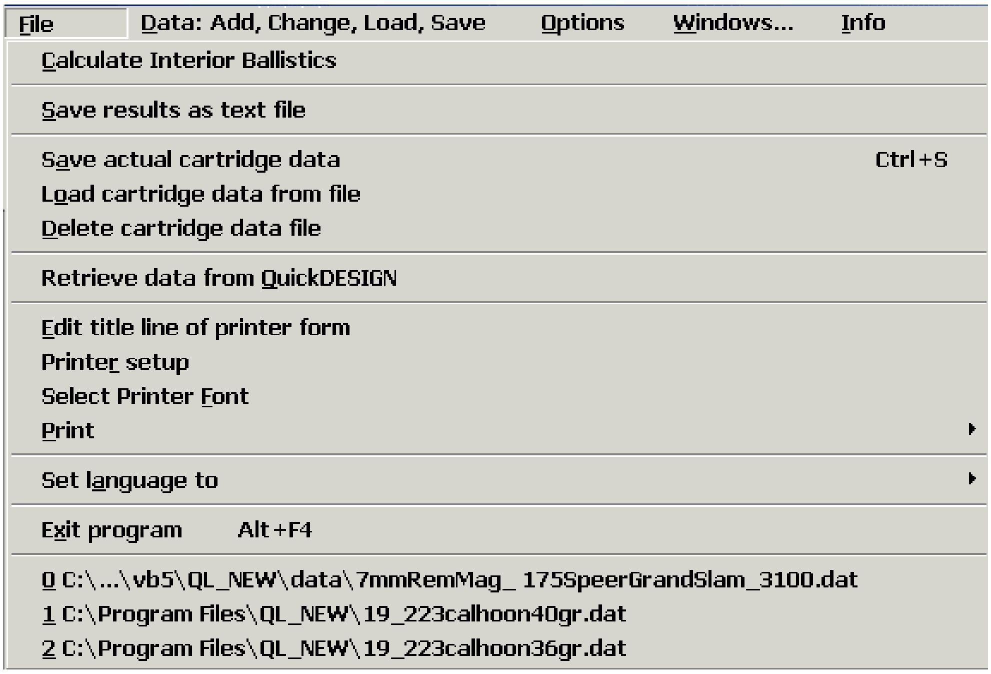
The selected item is either turned *On* or *Off* (depending upon the state of the item before the selection),

A sub-menu opens, providing for selection among new choices.

Each time the user makes any selection in any menu (or sub-menu), the parent menu item automatically closes. To select an additional menu (or sub-menu) choice, the user must reselect the menu (or sub-menu). Note that “toggle switches” either place or clear a check mark (✔) to the left of the selected item (presence of a checkmark signifies that the named option is enabled) or changes the text describing the item (to indicate whether the option is enabled or disabled).

Menus

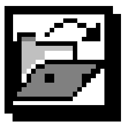
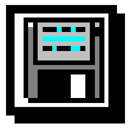
Menu Item File



Picture 6: Menu *File*

The menu *File* provides these options:

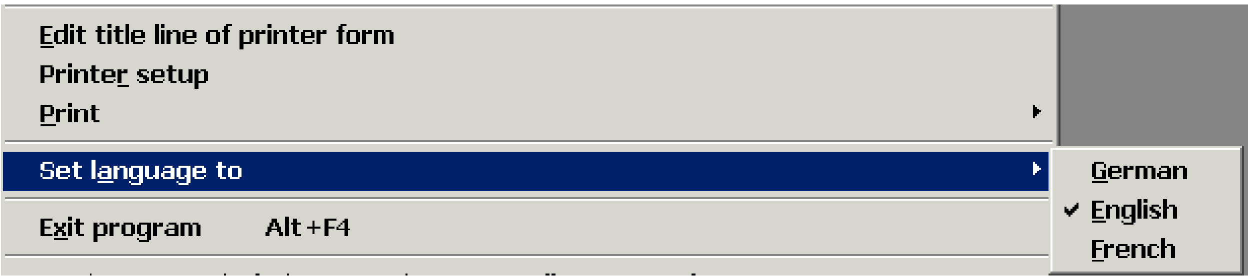
- *Calculate Interior Ballistics:*
  - Activates cartridge dimensions window (not normally needed);
- *Save results as text file:*
  - Stores all inputs and calculated results as an ASCII text file;
- *Save.../Load.../Delete... cartridge data:*
  - Save or retrieve cartridge data set;

    (Also available with these Symbol toolbar icons.*) Open:*  *Save:* 
- *Retrieve data from QuickDESIGN:*
  - If available, fetch actual cartridge design data from *QuickDESIGN* program;

    (Also available with this Symbol toolbar icon.*)* 
- *Edit title line of printer form:*
  - Enter form heading used in printed results;
- *Printer setup:*
  - Opens printer setup dialogue box;
    - select and setup temporary printer for program
- *Select Printer Font:*
  - Select a font of your choice for printig datasheets;
- *Print*:
  - Provides the user the option to print all pertinent data on the active cartridge along with one of the following;
    - The displayed graph, but only one of six standard graphs, no optional graph
    - Time and space graphs,
    - A single-powder, stepwise incremental loading table,
    - A load table listing data for various powders meeting specified requirements.

This print-menu point is disabled when no valid calculations are available. Print color is coupled to screen colors (for color printers). Before printing, the user is asked to add an optional comment line.

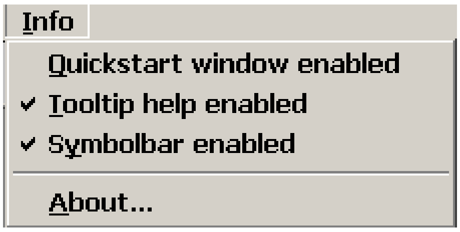
- *Set Language to*:
  - Select one of three languages used in *QuickLOAD's* windows: *English, German or French (French not available yet)*



Selecting a different language causes a re-write of all labels to new language in program's windows and fields. Text in larger text fields or comments is updated to new language after next calculation cycle.

- *Exit program:*
  - Terminate *QuickLOAD* session. Returns operation to Windows;
- *Recent file list::*
  - A file list containing the last nine loading data files used appears in lower portion of the file menu. Loading data can be re-selected by click on recent file selection or using key combination <ALT+ Number of recent file>

Menu Item Info

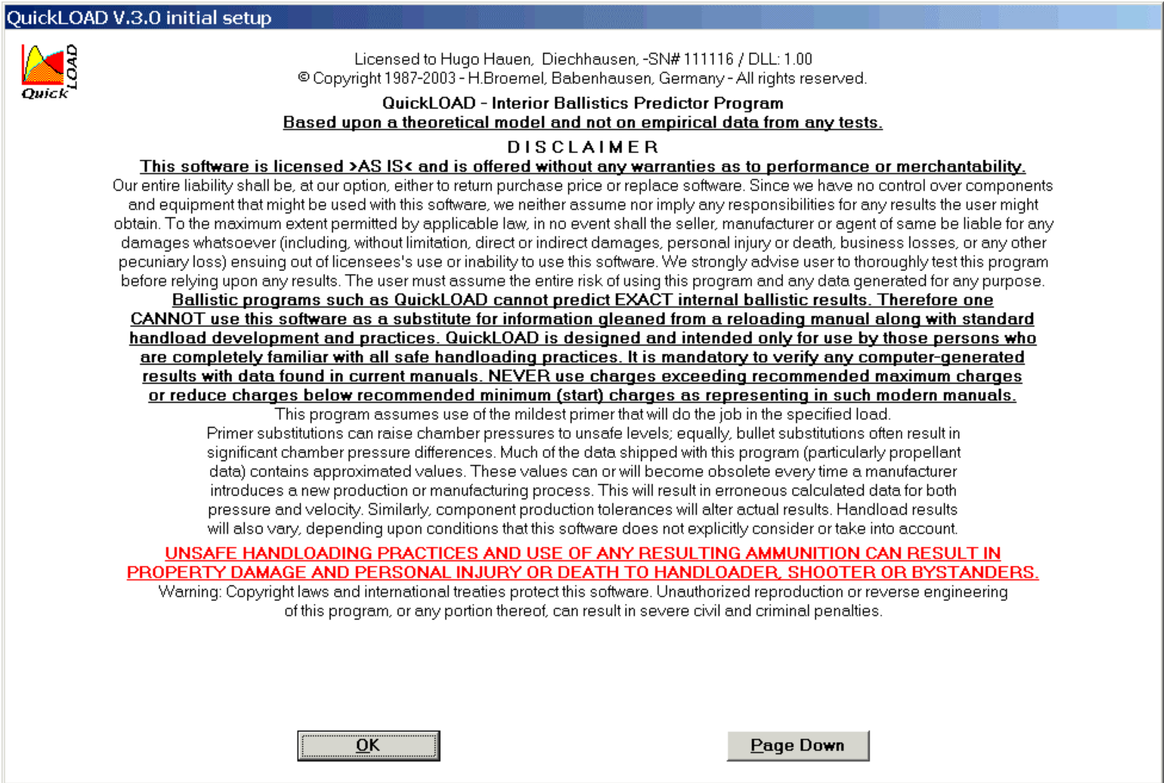


Picture 7: The menu Info

provides these options:

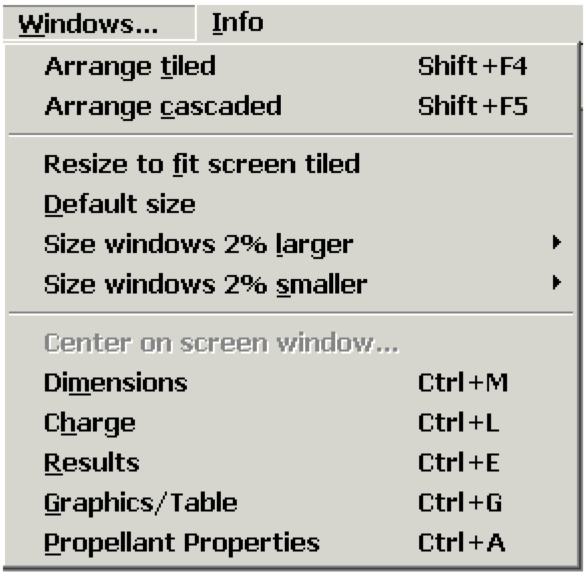
- Toggle switch for *Quickstart* window:
  - Position mouse cursor over selection and single-click left mouse button (shown enabled);
- Toggle switch for *ToolTip* help:
  - Position mouse cursor over selection and single-click left mouse button (shown enabled);
- Toggle switch for *Symbol toolbar*:
  - Position mouse cursor over selection and single-click left mouse button (shown enabled);
- *about...* (repeats *QuickLOAD* startup text window);

about... Window



Picture 8: ..about window

Menu Item Windows



Picture 9: Windows Management

The menu Windows provides these options:

For a detailed discussion on the various QuickLOAD *windows size and position adjusting functions, refer to the text titled,* Sizing & Positioning *QuickLOAD* Windows to Fit Monitor*, found near the opening of this section.*

- *Arrange tiled*: Positions the four active windows at the screen corners; Most useful on full-size monitors – shown selected.)

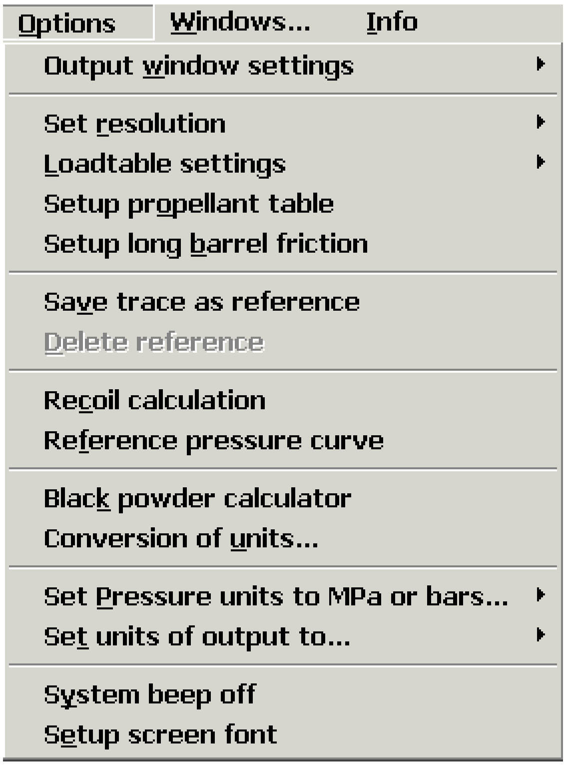
- *Arrange cascaded:* Positions the four active windows in an overlapping mode: (Most useful on smaller monitors and for those with limited visual acuity – shown unselected.)
- *Resize to fit screen:* In some instances, the default window sizes within QuickLOAD might not be correct; (This option provides for an automatic adjustment that usually sizes the windows to properly fit the screen in the tiled mode.)
- *Default size:* Resizes windows to the default size settings;
- *Size Windows 2% larger:* Enlarges windows 2% from the current size; see details below
- *Size Windows 2% smaller:* Reduces windows 2% from the current size;
- *Center on screen:* Provides a means of forcing a window that might have been inadvertently hidden to zoom onto the screen;

Remaining options center the identified window at screen front.

Picture 10: Size Windows 2% options

User can also move arrange adjacent *QuickLOAD* windows or move hidden or partially masked *QuickLOAD* windows. To do this, use the *Windows Operating System* *"Drag"* function: simply position the mouse cursor over the title bar of the desired window, press and hold the left mouse button, then drag the window by moving the mouse.

Menu Item Options



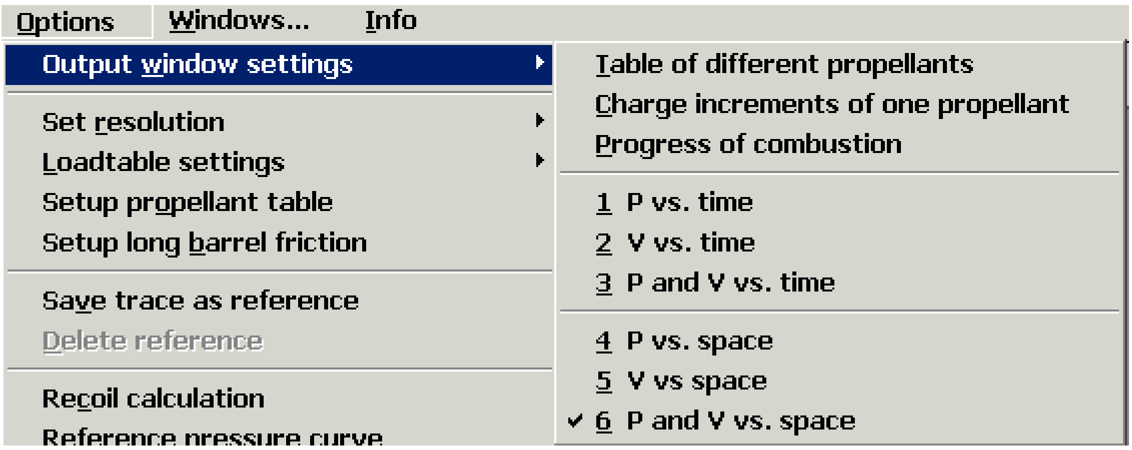
Picture 11: Menu Options

The menu *Options* provides these choices:

- *Output window settings*:
  - Opens sub-sub-menu allowing selection among various graphs or tables for viewing and printing calculation results;

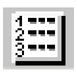
The sub-menu item Options –

Output window settings



Picture 12: Submenu Output Window Settings

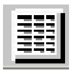
The sub-menu *Options* –
***Output window settings* provides these choices:**



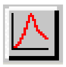
- *Table of different propellants:*
  - Enables generation of a table listing predicted loads and results for various propellants; *(According to user inputs specified in the* Setup propellant table *option – described below. Also available through a* Symbol toolbar icon.*)*

- *Charge increments of one propellant:*
  - Enables generation of a charge table for one propellant according to the user

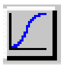
specifications as described below;



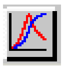
- *Progress of combustion*:
  - Enables production of a tabular output listing based upon the specified load parameters;



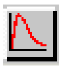
- *P vs. time:*
  - Enables output graph showing pressure versus time;



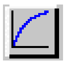
- *V vs. time:*
  - Enables output graph showing velocity versus time;



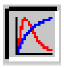
- *P and V vs. time:*
  - Enables output graph showing both pressure and velocity versus time;



- *P vs. space:*
  - Enables output graph showing pressure versus space (bullet travel);



- *V vs. space:*
  - Enables output graph showing velocity versus space (bullet travel);

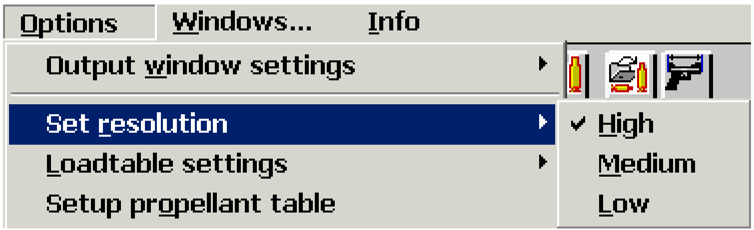


- *P and V vs. space (*shown selected):
  - Enables output graph showing both pressure and velocity versus space (bullet travel).

(Each of the above options is available through shown Symbol toolbar icon.*)*

The sub-menu item *Options -*

Set Resolution



Picture 13: Set resolution of calculations

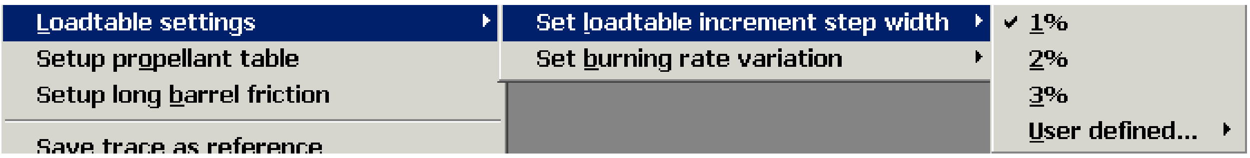
The sub-menu *Options – Set resolution*:

(Interior ballistic calculations use a self adapting step width, the user can change here the initial value. With resolution set low*, time calculations are not supported but calculation results are greatly accelerated. Rarely, there will be a useful (or significant) difference in calculation accuracy between* medium *and* high.*)*

- Set resolution:
  - *high* (shown selected –for fast computers),
  - *medium* (for all normal calculations, default setting),
  - *low* (recommended only for very-slow computers).

The sub-menu item Options –

Loadtable settings



Picture 14: Loadtable settings

The sub-menu *Options – Set Loadtable incremental step width* provides these choices:

- *Set Loadtable incremental load width*:
  - Select step width for a Loadtable showing charges and results using the active powder at the specified incremental load steps;
    - 1%, to produce an incremental Loadtable with charges ranging from 90% to 105% of the specified charge (shown selected),

- 2%, to produce an incremental Loadtable with charges ranging from 80% to 110% of the specified charge, 3%, to produce an incremental Loadtable with charges ranging from 70% to 115% of the specified charge,
- User defined, to allow specification of a Loadtable using increments as low as 0.2%.

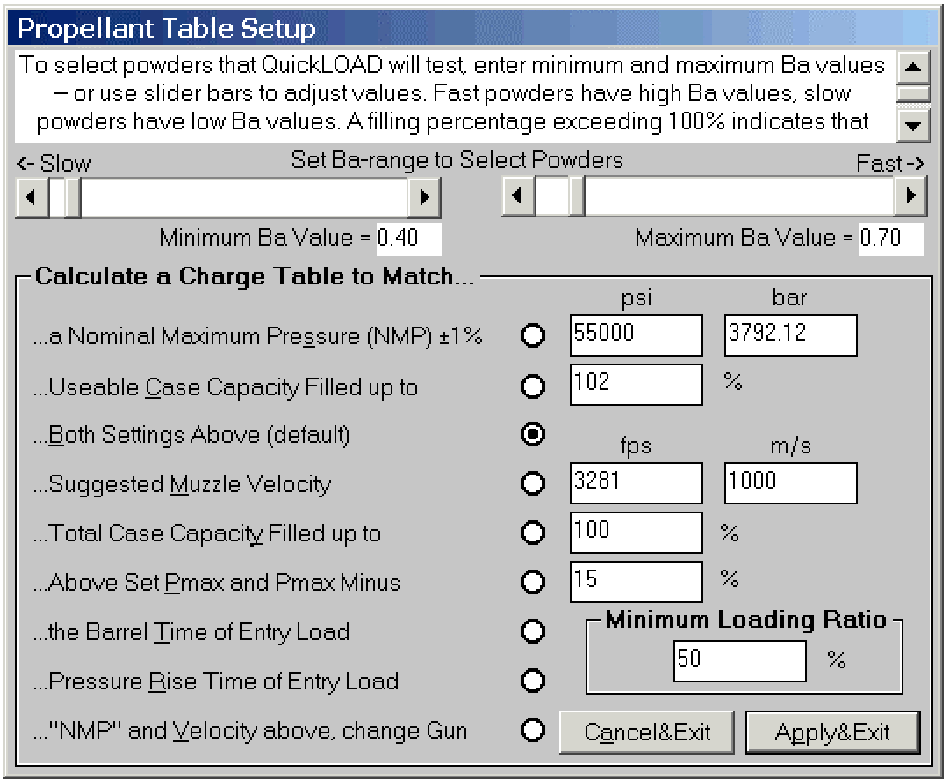
The sub-menu *Options – Set burning rate variation* provides these choices:

❖ *Set burning rate variation*:

➢ Select maximum lot-to-lot variation bandwidth of burning rate of selected powder in percents; the last two lines of Loadtable contains calculation results using your nominal charge but varies burn-rate by selected percentage (increased and reduced). So you can look what happens "if" your powder's properties vary.

The sub-menu item Options –

Propellant table setup



Picture 15: Window Propellant Table Setup

The sub-menu *Options – Propellant table setup*, settings that *QuickLOAD* will use in the creation of a table containing data for one cartridge loaded with different propellants:

❖ *Setup propellant table:*

➢ Slider bars or manual entry in data boxes for *Ba* factor (initial burning rate coefficient);

(A low Ba *factor corresponds to "slow" powders; a high* Ba *factor corresponds to "fast" powders. Adjusting these slider bars limits the resulting calculations to specific classes of powders. The following examples should provide a useful reference:*

Propellant	Ba	*Propellant*	Ba	*Propellant*	Ba
PCL 514	5.93	*Bullseye*	3.63	*Unique*	2.35
H 4227	1.01	*VV N133*	0.75	*H 335*	0.61
IMR 4350	0.46	*Norma MRP*	0.37	*VV 20N29*	0.24

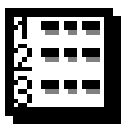
(Note that Ba values have no exact relationship to overall effective burning rate in a cartridge, it is only the rate of outer layer which changes (so called vivacity) when the granule burns down,… Norma MRP is not, in any useful sense, twice as slow as VV N133).

Calculate a Charge Table to Match...

- *… a Nominal Maximum Pressure NMP (+/-1%);*
  - If this is the only goal, select this *radio button* and specify a maximum pressure for calculations: (Default pressure value represents 85% of specified maximum cartridge pressure.)
- *… a Usable Case Capacity Filled up to*;
  - If this is the only goal, select this *radio button* and specify a case filling percentage: *(Percentage of usable case capacity occupied by powder, default setting is always the same as the last-specified value. Some or all of the resulting predictions can fall outside of safe limits).*
- *… Both Settings Above (default)*;
  - Allows limitation of calculations based upon limits of both pressure and powder compression.
- *… Suggested Muzzle Velocity*;
  - If this is the desired result, select this *radio button* and specify a calculation velocity for all powders tested. *(Some or all of the resulting predictions can fall outside of safe limits.)*
- *… Total Case Capacity Filled up to...*;
  - If this is the desired result, select this *radio button* and specify a filling percentage for case without seated bullet for all powders tested. *(Some or all of the resulting predictions can fall outside of safe limits.)*
- *… above Set Pmax and Pmax minus (a second load generating less pressure);*
  - If this is the desired result, select this *radio button* and specify a pressure reduction (percentage below maximum specified pressure).
- *… the Barrel Time of the Entry Load;*
  - Selecting this *radio button* results in calculations for all selected powders giving charges that match the barrel time of the entry load (as specified in the charge window). *(Some or all of the resulting predictions can fall outside of safe limits.)*
- *… the Pressure Rise Time of the Entry Load;*
  - Selecting this *radio button* results in calculations for all selected powders giving charges that match the pressure rise time of the entry load (as specified in the charge window). *(Some or all of the resulting predictions can fall outside of safe limits.)*
- We believe the latter two options might be useful to those interested in developing accuracy loads. For example, if the entry load has been shown to produce particularly good accuracy in a given rifle, other loads generating similar barrel time might also be accurate….
- *… NMP and Velocity above, change Gun;*
  - Selecting this *radio button* results in calculations for all selected powders giving charges that match the pressure and velocity specified above. Case capacity and barrel length will be changed to find a match for selected powder range.

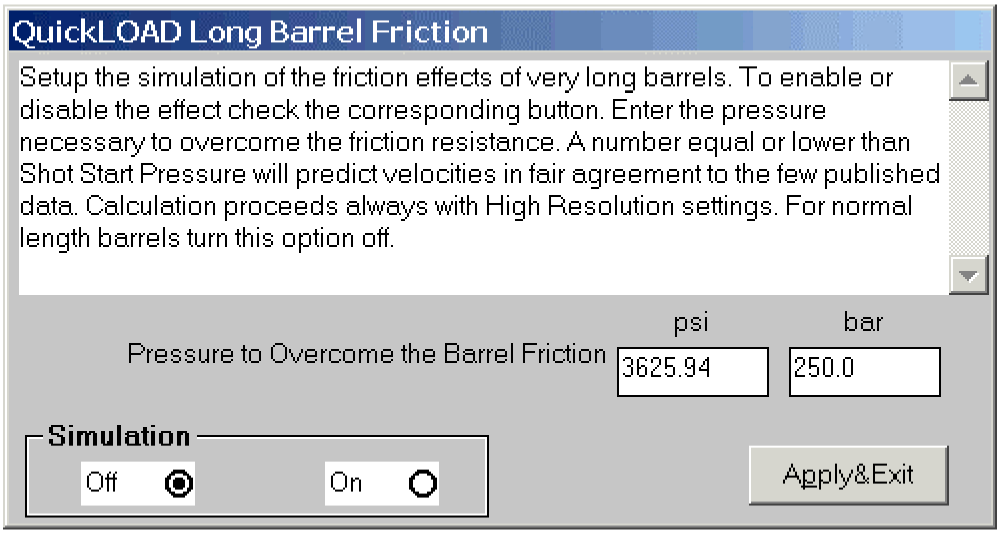
We believe the latter option might be useful to those interested in developing a new cartridge.

- *Select Apply&Exit button;*
  - Automatically begins specified calculation*. (To achieve useful results, the user must specify the desired parameters and actions. A new window, QuickLOAD* checking propellants*, opens at bottom-left screen corner. User can maximize this window, scroll through results – using a slider bar – and print calculated data. This is a one-time operation. At the next recalculation, QuickLOAD closes the QuickLOAD* checking propellants *window and displays the selected graphic output window.)*
- Select *Cancel&Exit* button;
  - Closes window and menu, without taking any action.

(Also available through this Symbol toolbar icon*.)* 

The sub-menu item Options –

Long Barrel Friction



Picture 16: Set Long Barrel Friction

The sub-menu *Options – Long Barrel Friction*:

- ❖ *Setup Long Barrel Friction:*
  - ➢ Specify estimated barrel friction of barrel;
    - ▪ Default pressure is based upon specified *Shot start* pressure – set to 3625-psi in this example,
  - ➢ Select radio button to turn simulation *On* or *Off* – set to *Off* here;
  - ➢ When entries are as desired, select *Apply&Exit* button,
    - ▪ Closes window and menu.

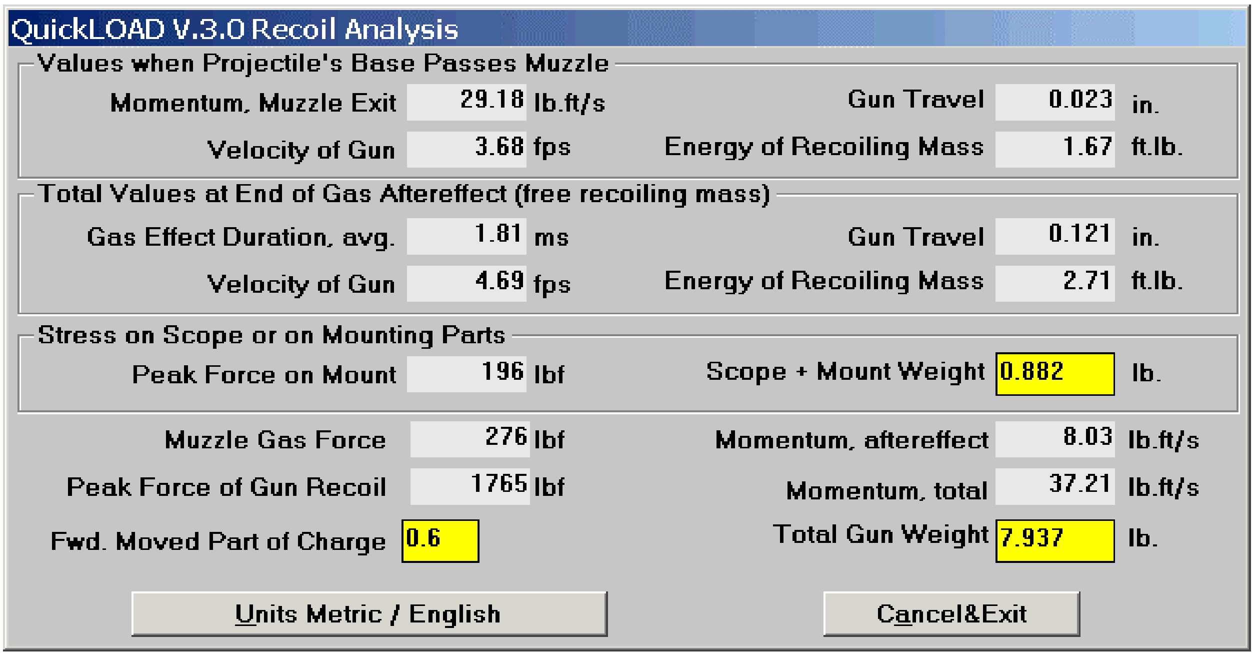
(Simulation stays On *or* Off*, according to specified setting, throughout QuickLOAD session. Simulation is always turned Off at program restart.)*

The sub-menu *Options – Reference:*

- ❖ *Save trace as Reference*:
  - ➢ Retains current calculation in memory;
    - ▪ Upon next calculation, displays new graph together with saved graph – for comparison purposes.
- ❖ *Delete Reference*:
  - ➢ Deletes saved reference graph.

The sub-menu item *Options* –

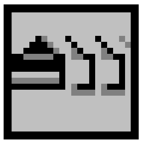
Recoil Analysis



Picture 17: Recoil Window

The sub-menu *Options – Recoil Analysis* (Menu point enabled only after a valid calculation):

(Also available through this Symbol toolbar icon.*)*



***Recoil calculation*:**

- *Input data boxes:*
  - Scope + Mount Weight:
    - Enter actual weight or weight of interest;
  - Total gun weight:
    - Enter actual weight or weight of interest;
  - Forward moved part of charge:
    - Adjust to see effect.

(Changes to aforementioned fields results in automatic recalculation of pertinent data.)

- *Units Metric / English:*
  - Toggles all input and output units.
- Selecting *Cancel&Exit* button closes window.

Results of this recoil calculation are only applicable to realistic relationships of projectile mass and entire whole gun mass (when the gun is significantly heavier than combined mass of projectile and powder).

As gun weight is reduced, results at first err slightly. With continuing reduction in gun mass, error reaches significant level. Finally, all internal ballistic calculation results become useless. For such a system, the inertial reference frame must be changed. This means, a different movement of the masses has to be modeled within the interior ballistic calculation.

QuickLOAD interior ballistic calculations assume a fixed gun with projectile and some amount of charge moving forward. The short recoil of a real gun, while a projectile moves through the barrel, has little calculation effect.

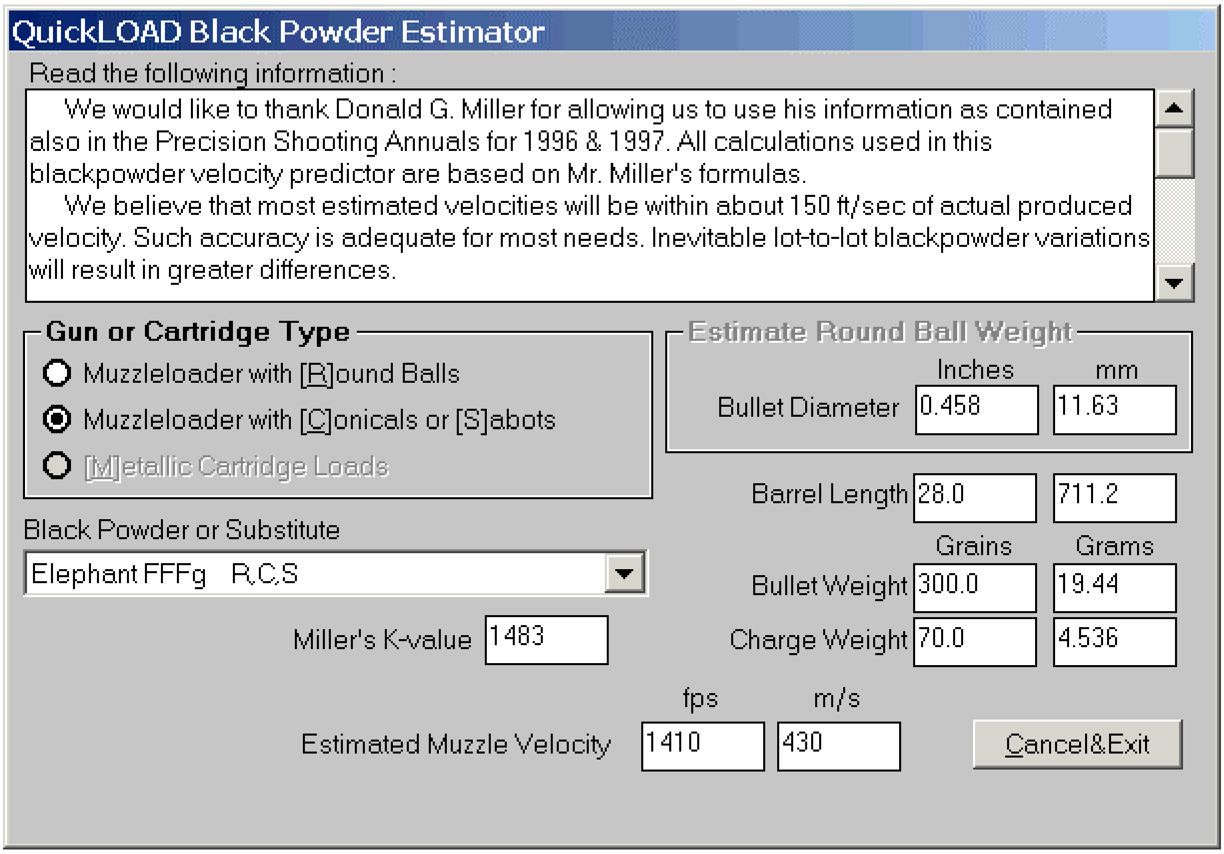
Actual recoil momentum and recoil energy values for a gun, which is pulled tightly against the shooter’s shoulder (the shooter adds mass to the gun) or which uses a muzzle brake (some of the propellant gases are vented tangentially to the bore axis) or some other braking device, are lower than *QuickLOAD* calculated values. These values are valid only for an ideal free-recoiling gun, with the center of gravity along bore axis.

The sub-menu item *Options – Reference pressure Curve*

- *Reference pressure Curve*:
  - Enables reference pressure curve that will display with subsequent calculated curves. This curve must been set up in Powder properties window before you can use it.

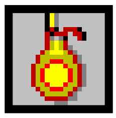
The sub-menu item Options –

Black Powder Estimator



Picture 18: Black Powder Window

(Also available through this Symbol toolbar icon.*)*

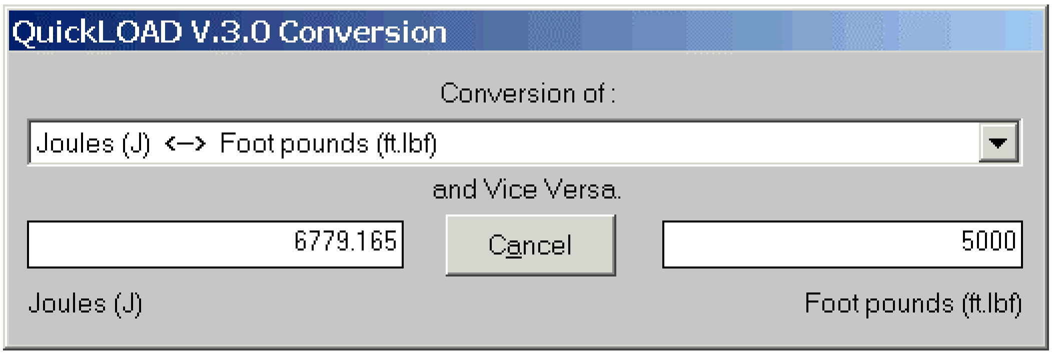


The sub-menu *Options – Black Powder Estimator*:

- Black Powder Calculator: *(Provides rough-estimate calculations for pressure and velocity with loads using blackpowder and blackpowder substitutes.*
  - When the user enters new data in the option window, *Estimate round ball weight*, *QuickLOAD* automatically estimates weight of a pure-lead round ball of the specified diameter;
  - Adjusting charge, bullet weight and powder type results in automatic recalculation;
- *(Note that not all powder type listings provide data for each calculation option listed under* Gun or cartridge type.*)*
  - Selecting *Cancel&Exit* button closes window.

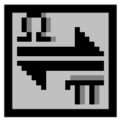
The sub-menu item Options –

Conversion of units



Picture 19: Unit Conversion Calculator

(Also available through this Symbol toolbar icon.*)*



The sub-menu *Options – Conversion of units*:

- Conversion of units:
  - Select units from pull-down menu field;
  - Enter any value in either result field
    - *QuickLOAD* automatically calculates corresponding value.
- *Cancel*:
  - closes window

Other *Option* Menus

- *Set pressure units to MPa or to bars…* :
  - Allows the user to select display and entry metric pressure units; MPa (megapascals) is actual metric "SI Standard" pressure unit for high pressures, bars are obsolete, but still used by CIP.

- *Set units of output to...* :
  - Allows the user to select between Metric & English (SAE) systems;

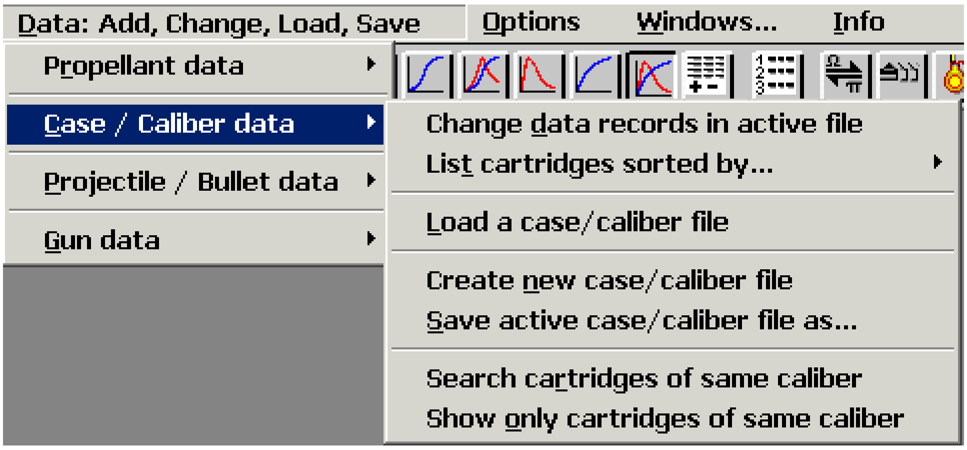
- *System beep on/off* :
  - Toggles default error signal beep *On* and *Off*;

- *Setup screen font* :
  - Allows the user to alter the font used within *QuickLOAD*'s windows, useful when characters are truncated within a window. Appearance may be different after re-starting the program. User must try out to find optimal font. *(This is a basic screen setup operation, described previously in this section.)*

The Menu Data, Add, Change, Load, Save

contains

The sub-menu Data – Case / Caliber data

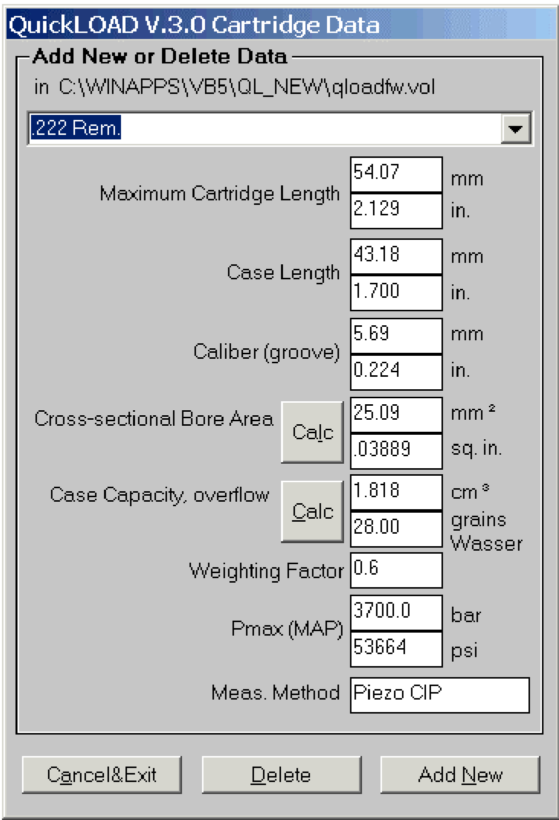


Picture 20: Case /Caliber Data

The sub-menu *Data – Case / Caliber data* provides these options:

- Case / Caliber data:
  - *Change data records in active file;*
    - Invokes a window where the user can create or change a single data record,

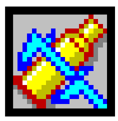
Cartridge data window



Picture 21: Cartridge Data Window

(see Section titled **Case: Change Cartridge Data in Active File** for a complete description of this option.)**:**

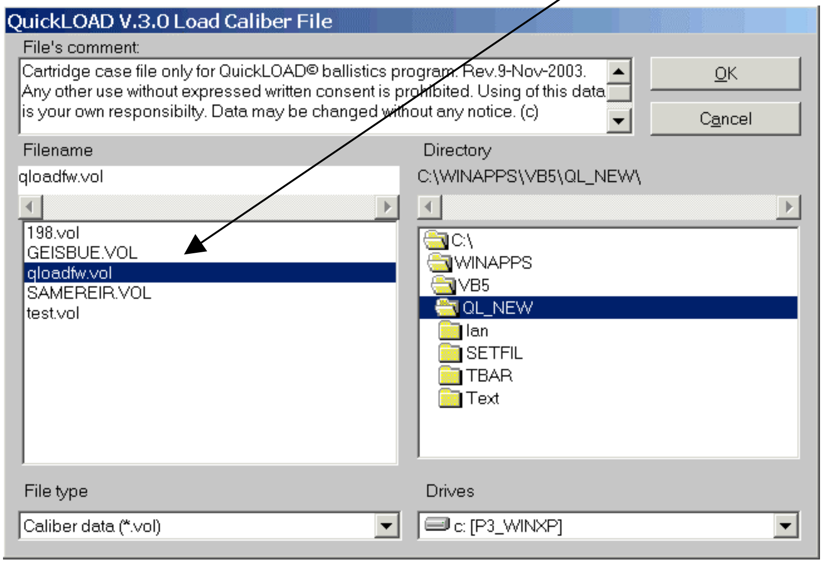
(Also available through this Symbol toolbar icon.*)*



- Case / Caliber data:
  - *Load a case/caliber file;*
    - Opens a file dialogue window to allow loading of a different case/caliber data file,

Load caliber file window

Select file here, then press OK or double click on file name

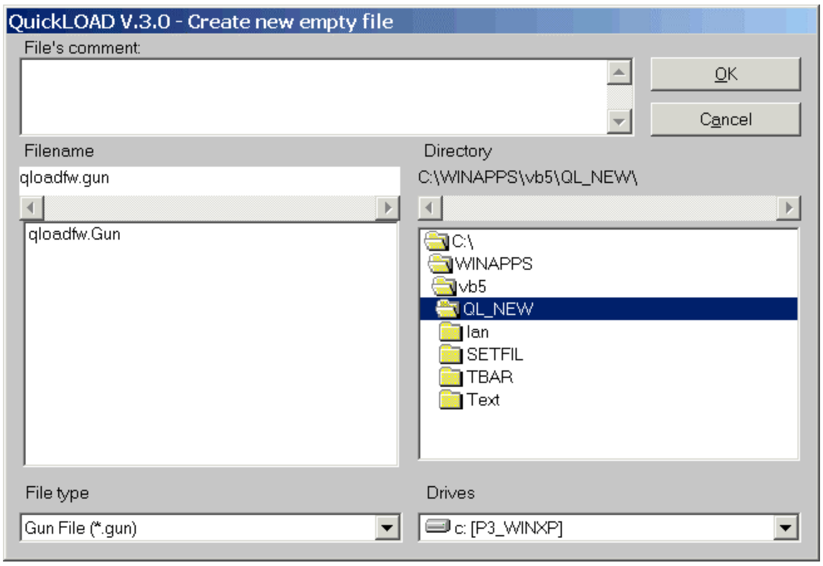


Picture 22: Load Caliber File window

(see Section titled **: Load Cartridge File** for a complete description of this option.)

- Case / Caliber data:
  - *Create new case / caliber file;*
    - Opens a file dialogue window to allow the user to create a new case/caliber data file,

Create new empty file window



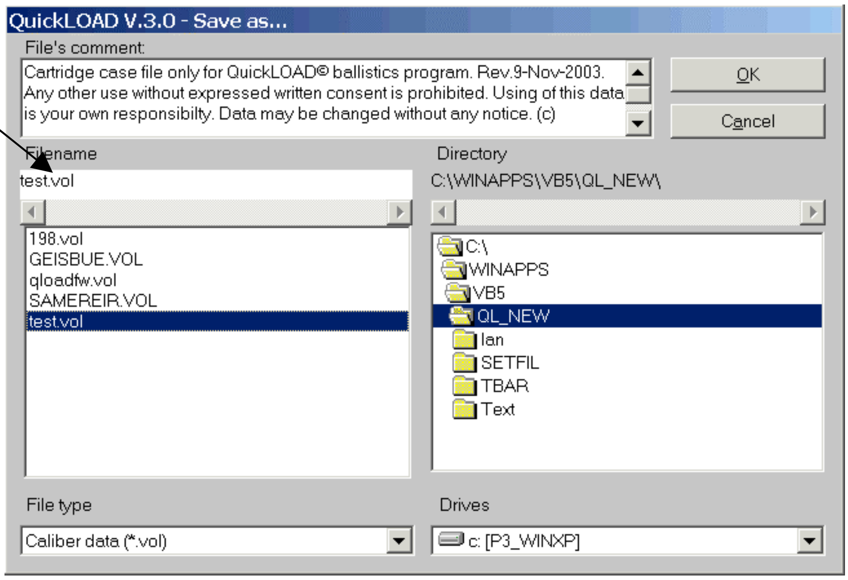
Picture 23: Create new empty file window

(see Section titled **Case: Create New Empty Cartridge File** for a complete description of this option.)

- ❖ Case / Caliber data:
- ❖ *Save active case / caliber file as…;*
- ❖ Opens a file dialogue window to allow the user to rename the active (loaded) powder file,

Case Save as... window

Enter a new file name here, then press OK (remove *Asterisk-character in line if one exists)

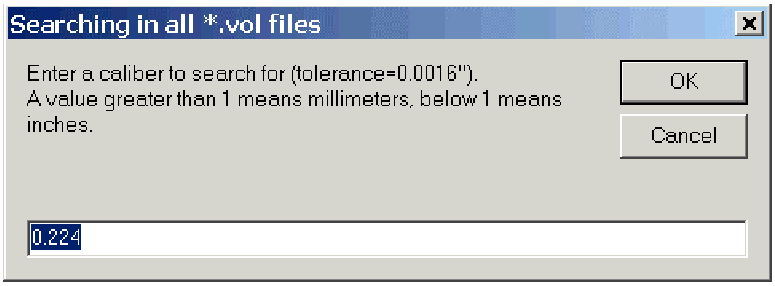


Picture 24: Case Save as... window

(Refer to Section titled **Case: Save Cartridge File as...** for a complete description of this option.)

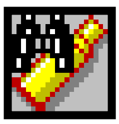
- ❖ Case / Caliber data:
  - ➢ Search cartridges of same caliber;
    - ▪ Opens *Searching in all *.vol file*s window where the user specifies a cartridge caliber for *QuickLOAD* search,

Case caliber selection – Searching in all… window



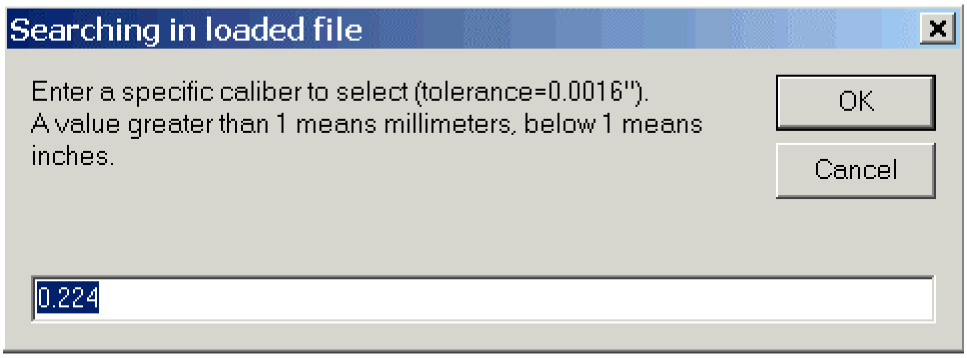
Picture 25: Case caliber selection – searching in all... window

(Refer to Section titled **Case: Caliber Selection – Search all Cartridge Files** for a complete description of this option.):

(Also available through this Symbol toolbar icon.*)* 

- Case / Caliber data:
  - Show only cartridges of same caliber;
    - Opens *Searching in loaded file* window where the user specifies a cartridge caliber for *QuickLOAD* search,

Case caliber selection – Searching in loaded file … window



Picture 26: Searching in loaded file window

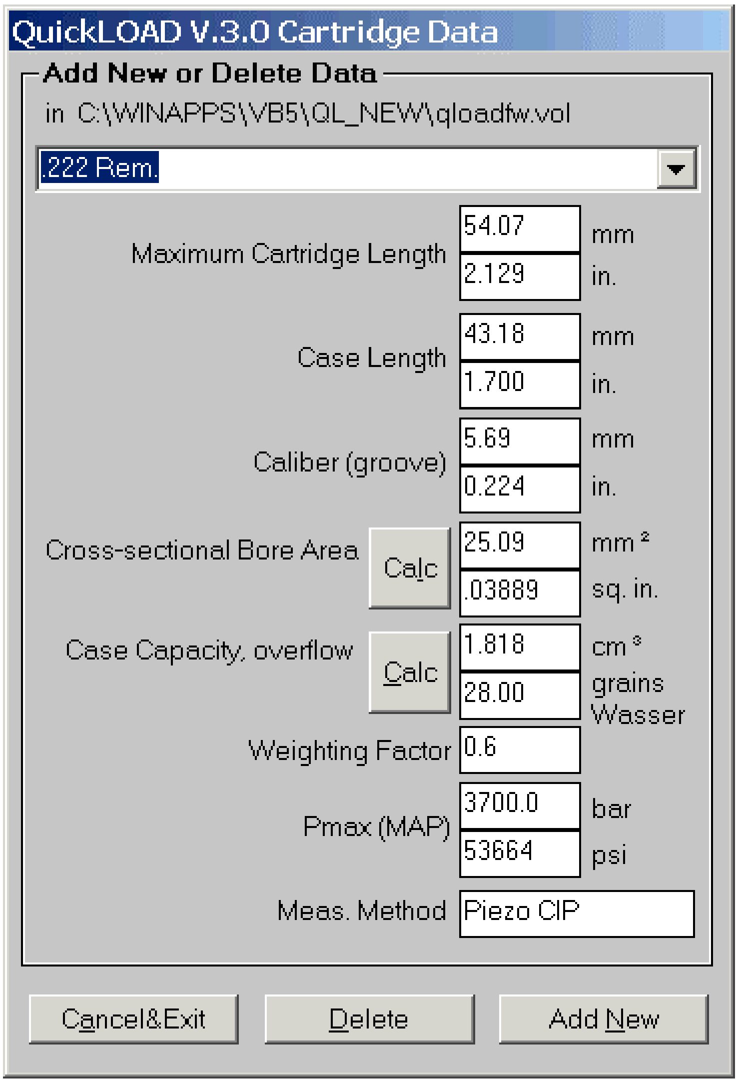
Performing this step selects all cartridges of same bullet caliber (+/- 0.0016 inch). In *Cartridge Dimensions* Window the *Selected Cartridge* box is populated only with this selection of calibers; the File field above this box contains the diameter as a hint to this selection. A checkmark is placed in front of menu option *Show only cartridges of same caliber*. Undo this selection by selecting menu option *Show only cartridges of same caliber* again; then checkmark will be removed.

Change Cartridge Data Record in Active File

Main Menu Selection:

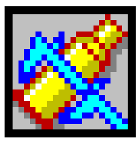
- Data: add, load, change, save:
  - Case / Caliber data;
    - Change data records in active file,

Opens the following window:



Picture 27: Cartridge data window

(Also available through a Symbol toolbar icon.*)*



- Add New or Delete Data:
  - Input, name of cartridge, or select a cartridge

This field should include sufficient information to provide positive cartridge identification. Field must contain 5 ore more characters.

Cartridge name for "inch" designations must begin with a decimal point; name for "mm" designation must begin with a number and should include a space between the number and the mm – 6.5 mm, not 6.5mm. That is because windows sorts all names in the drop-down list. Otherwise the cartridge you look for will be not at the place where you believe to find it.

- Maximum Cartridge Length:
  - Input, nominal cartridge length (mm or inches); shipped values are SAAMI or CIP maximum values. User entry may exceed those values.
- Case length:
  - Input, nominal case length (mm or inches);
- Caliber (groove):
  - Input, nominal groove diameter (mm or inches);
- Cross sectional bore area:
  - Input, if known, in mm^2 or square inches; When this value is not known, calculation is started with *Calc* button left of input field. Opens window, *QuickLOAD* Cartridge data – *Calc* X-section of bore, described below – requires specific knowledge of actual bore dimensions.
- Case capacity, overflow:
  - Input, cm^3 or grains of water; When it is not feasible to accurately determine this volume by weighing, calculation is started with *Calc* button left of input field. Opens window, QuickLOAD Cartridge capacity, described below.
- Weighing Factor:
  - Input, value by experience; Average about 0.5 (0.25 to 0.75 is a good range). Refer to *Bubble help*.
- Max. Avg. Pressure:
  - Optional input, Maximum Average Pressure; *(Based upon* CIP *or* ANSI/SAAMI *specifications or construction of gun – should only be referenced to piezo pressure method.)*
- Meas. Method:
  - Optional input, method for pressure measurement;

Standard text characters. Examples: Piezo, SAAMI psi, ANSI psi, CUP (Copper Crusher), Strain gauges, and CIP bars. Or Mpas.

Adding a new data record:

After specifying all cartridge data, including distinct name, select *Add new*. This adds the cartridge to the active program cartridge file. This action rewrites the file [filename].VOL. Simultaneously the existing file is renamed to [filename].VO$.

Deleting an existing data record:

Use the slider to select a cartridge from the current file list. Select the *Delete* button to initiate removal of that cartridge from the active file. Confirmation of deletion erases selected data record from file [filename].VOL. Simultaneously, existing previous file is renamed to [filename].VO$.

Canceling action:

Selecting the *Cancel* button cancels action and closes window without taking any action.

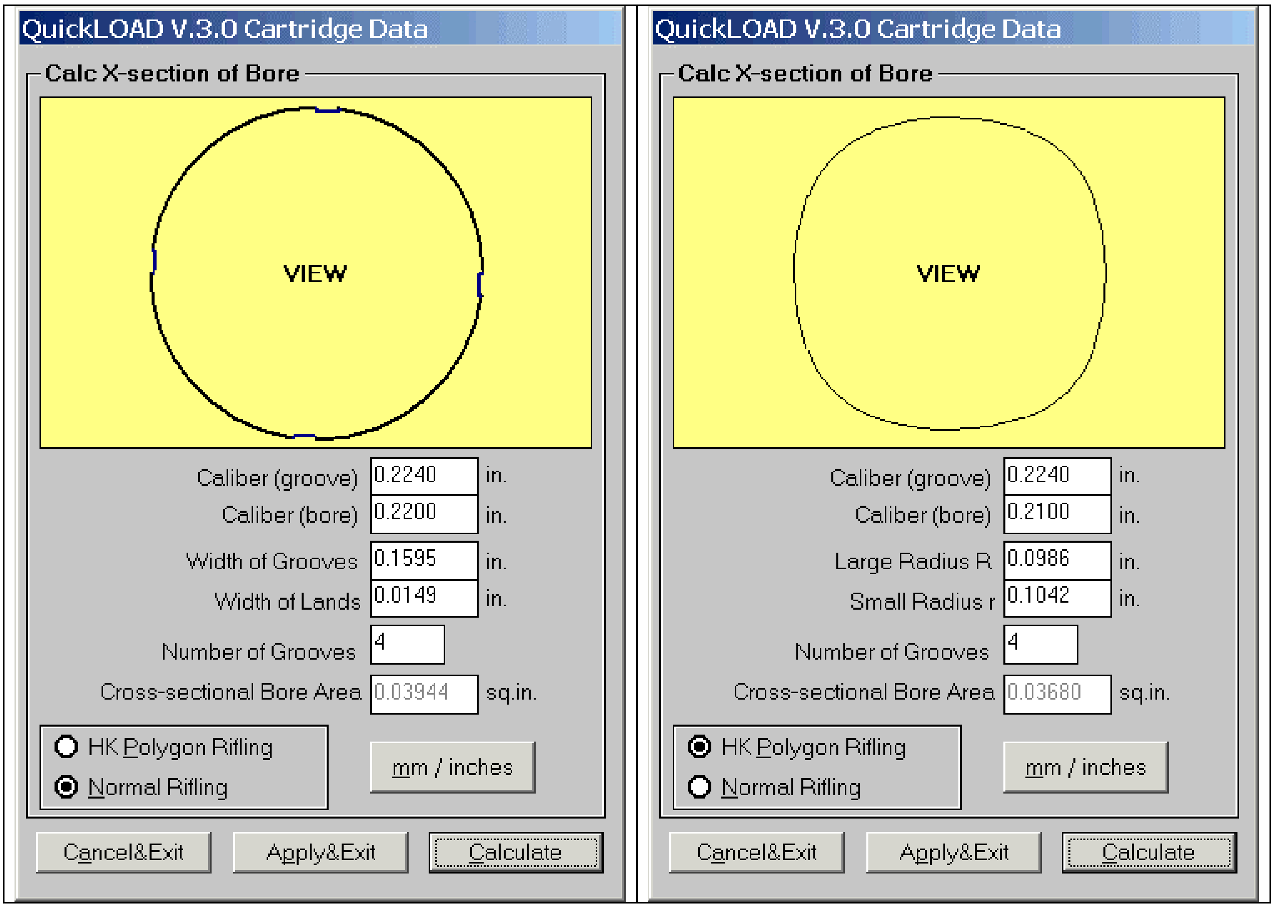
Main Menu Selection:

- Data: add, load, change, save:
  - Case / Caliber data;
    - Change data records in active file,
      - Cross-sectional bore area,

Selecting *Calc* Button opens one of these windows:

Cartridge data – Selecting *Calc* X-section of bore

(Version depends upon selection of rifling type)



Picture 28: Cartridge data – Selecting *Calc* X-section of bore:

(Dimensions can be taken with a caliper at muzzle or by measuring a soft lead bullet that has been used to “slug” the bore.)

- Caliber (groove):
  - Input diameter between opposing grooves (maximum);
- Caliber (bore):
  - Input diameter between opposing lands (minimum diameter);
- Width of groove or Large Radius (R):
  - Input width across groove (or polygon radius – as supplied by barrel maker);

(Note that until a specific value is entered, the groove width is shown as total circumference of bore -- $\pi \times$ diameter – divided by entered number of grooves, leaving zero for land width. Further, data entry into this box automatically enters correct corresponding value into Width of land *box. See note below.)*

- Width of Lands or Small Radius (r):
  - Input width across lands (or polygon radius – as supplied by barrel maker);
- Number of grooves:
  - Input number of grooves;

- Normal rifling:
  - Select for conventional-style rifling – land & groove rifling with approximately square-sided grooves);
- HK polygon rifling:
  - Select for Heckler and Koch (rounded) rifling profile);

- Select *mm / inches* bar to switches between metric and English units:
- Select *Calculate* to calculate cross-sectional bore area (based upon entered data):
- Select *Use data* to close window (transfers calculated value to previous window and returns operation to previous window).
- Select *Cancel* to close window (no transfer of calculated value to previous window).

VIEW shows a picture representing an approximately correct cross-sectional view of the described bore.

Note that for conventional bores, groove width is usually about 60% of total land-groove pair width. Therefore, a reasonable estimate results from multiplying the initial start groove width (100% of total) by 0.6 and entering the result (60% of total) into width of grooves entry box. Data entry into either width box results in automatic filling of corresponding box with a value representing the remaining width that is available, based upon number of grooves selected and bore diameter specified.

For those calibers found in the default database, the default *QuickLOAD* value is derived from ANSI/SAAMI or CIP specifications and is sufficiently accurate for most applications.

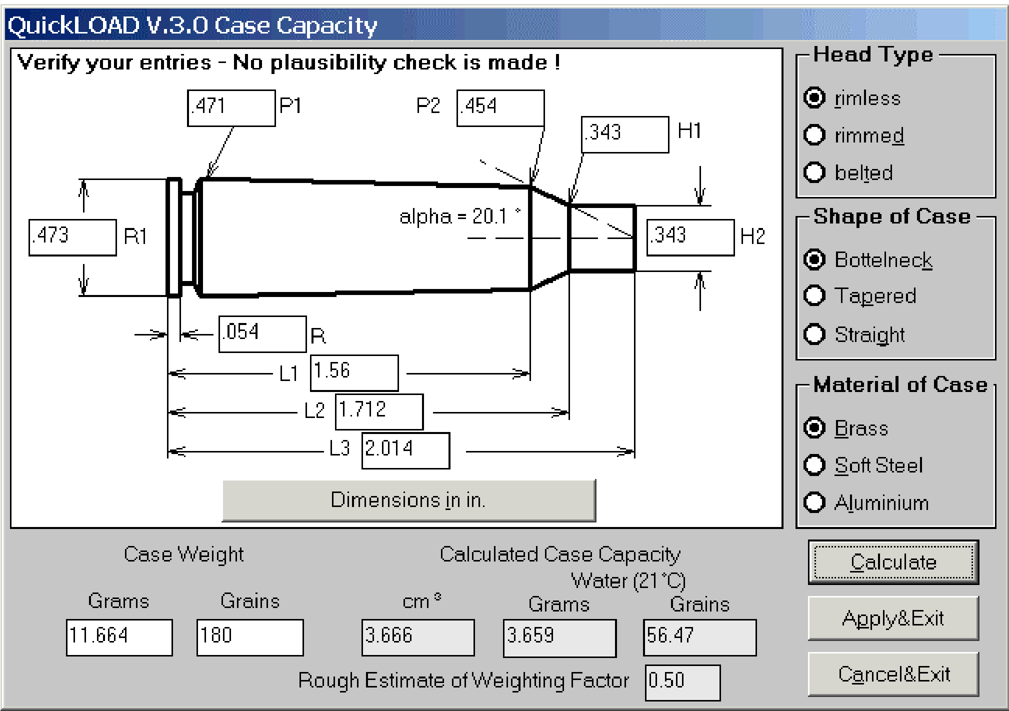
Unless the user has specific data that is very accurate, it is unlikely that the results based upon any “rough estimate” will be as accurate as the default value.

Main Menu Selection:

- Data: add, load, change, save:
  - Case / Caliber data;
    - Change data records in active file,
      - Case capacity, overflow,

Selecting *Calc* Button opens this window:

Cartridge data – Selecting *Calc* Case capacity



Picture 29: Case capacity window

– calculating case volume (designators beside input fields correspond to CIP naming conventions):

- Dimensions in inches / mm:
  - Selection toggles input values – must match entry units;

Head type:

- Rimless;
  - Selection specifies conventional rimless, semi-rimmed and rebated rimmed case types,
- Rimmed;
  - Selection specifies rimmed case type,
- Belted;
  - Selection specifies belted case type.

Shape of case:

- Bottleneck;
  - Selection specifies conventional bottlenecked case type,
- Tapered;
  - Selection specifies tapered case type (example shown),
- Straight;
  - Selection specifies cylindrical case type (such as a typical revolver case).

Material of case:

- Brass;
  - Selection specifies conventional cartridge brass (70% copper, 30% zinc),
- Soft steel;
  - Selection specifies mild steel, as is used in military small-arms to medium calibers case construction,
- Aluminum;
  - Selection specifies that case is made from aluminum, as is used in non-reloadable small-arms and many larger military cartridges.

Dimensions:

- R1:
  - Enter case rim diameter;
- P1:
  - Enter case diameter at web (just in front of rim or rim cut);
- P2 (if applicable):
  - Enter case diameter at front of body (just behind case shoulder);
- R:
  - Enter rim thickness;
- L1 (if applicable):
  - Enter case body length – distance between head and end of case body;
- L2 (if applicable):
  - Enter case body plus case shoulder length – distance between head and base of case neck;
- L3:
  - Enter case length;
- H1 (if applicable):
  - Diameter at base of case neck;
- H2:
  - Diameter at end of case neck;
- Case weight:
  - Weight of empty, unprimed case.
- Calculated case capacity:
  - Output window, provides estimate based upon input data.
- Calculate:
  - Selecting *Calculate* button calculates case capacity (grains of water), based upon data entries.

(All data must be entered very carefully. No plausibility check is performed! Typing errors and wrong input values can lead to absurd case volumes, unpredictable results and potentially dangerous data.)

- *Apply&Exit*:
  - *Selecting Use data* button closes window (transfers calculated value to *QuickLOAD Cartridge volume* window and returns operation to previous window).
- Cancel:
  - Selecting *Cancel* button closes window and returns operation to *QuickLOAD Cartridge volume* window.

For calculations with low-pressure cartridges (most pistol, revolver and black-powder era rifle cartridges) use case dimensions from a resized case. For high-pressure cartridges, use dimensions from a fired case.

For user information only, with bottleneck cases, case shoulder angle (included angle) is calculated. Once these data fields are filled, all dimensions are permanently stored in the cartridge data file.

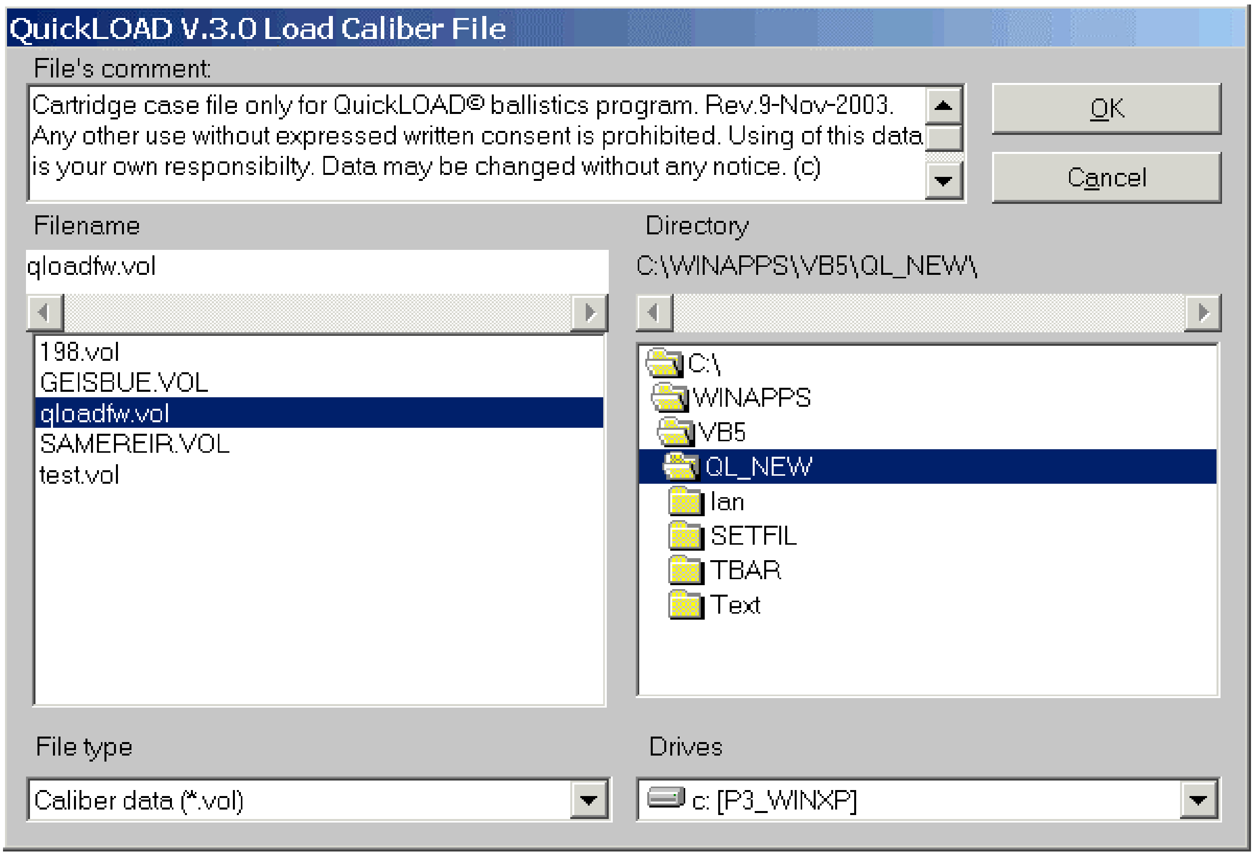
QuickLOAD's Database does not contain dimensions of case diameters and case head section. Only a few samples contain full dimensions as in picture above : the .308 WIN case.

Load a Case/Caliber File

Main Menu Selection:

- Data: add, load, change, save:
  - Case / Caliber data;
    - Load a case/caliber file,

Opens dialogue window to allow loading of a different case/caliber data file:



Picture 30: *Load caliber file* window

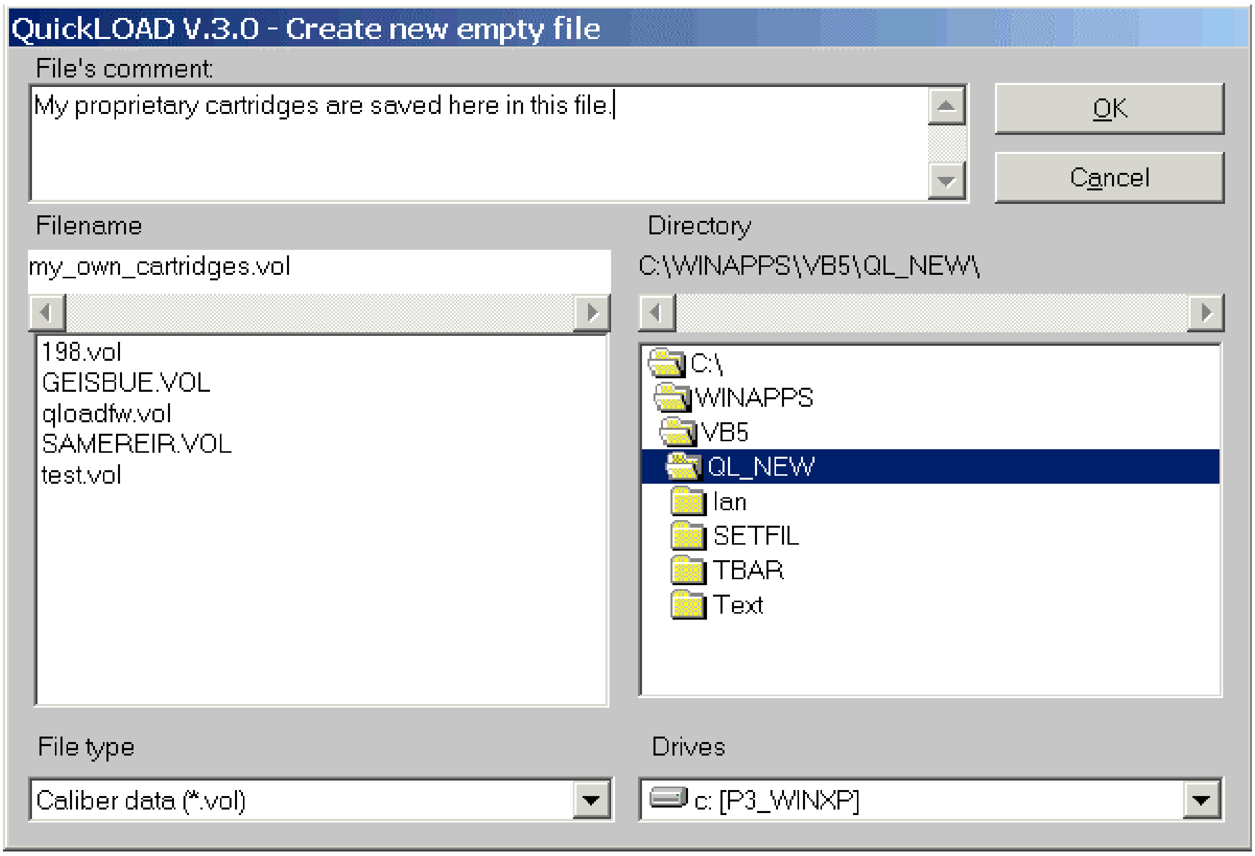
- File's comment:
  - Contains information describing the contents of the file;
- Filename:
  - Contains selected filename and allows direct entry of filename; An asterisk * in filename's text has to be removed (* is a placeholder sign), otherwise an error message displays.
- Directory:
  - Shows currently active files and allows selection of other files and directories;
- Drives:
  - Shows currently selected drive and allows selection of other drives;
- File type:
  - Selects to view only the specified file types;
- OK:
  - Selecting *OK* button results in a search for (under Filename) specified file,
- If search is successful, loads file and closes window,
  - If search fails, error message displays (user must respond).
- Cancel:
  - Selecting *Cancel* button closes window without taking any action.

Create New Empty Cartridge File

Main Menu Selection:

- Data: add, load, change, save:
  - Case / Caliber data;
    - Create new case / caliber file,

Opens dialogue window to allow loading of a different case/caliber data file:



Picture 31: *Create new empty file* window

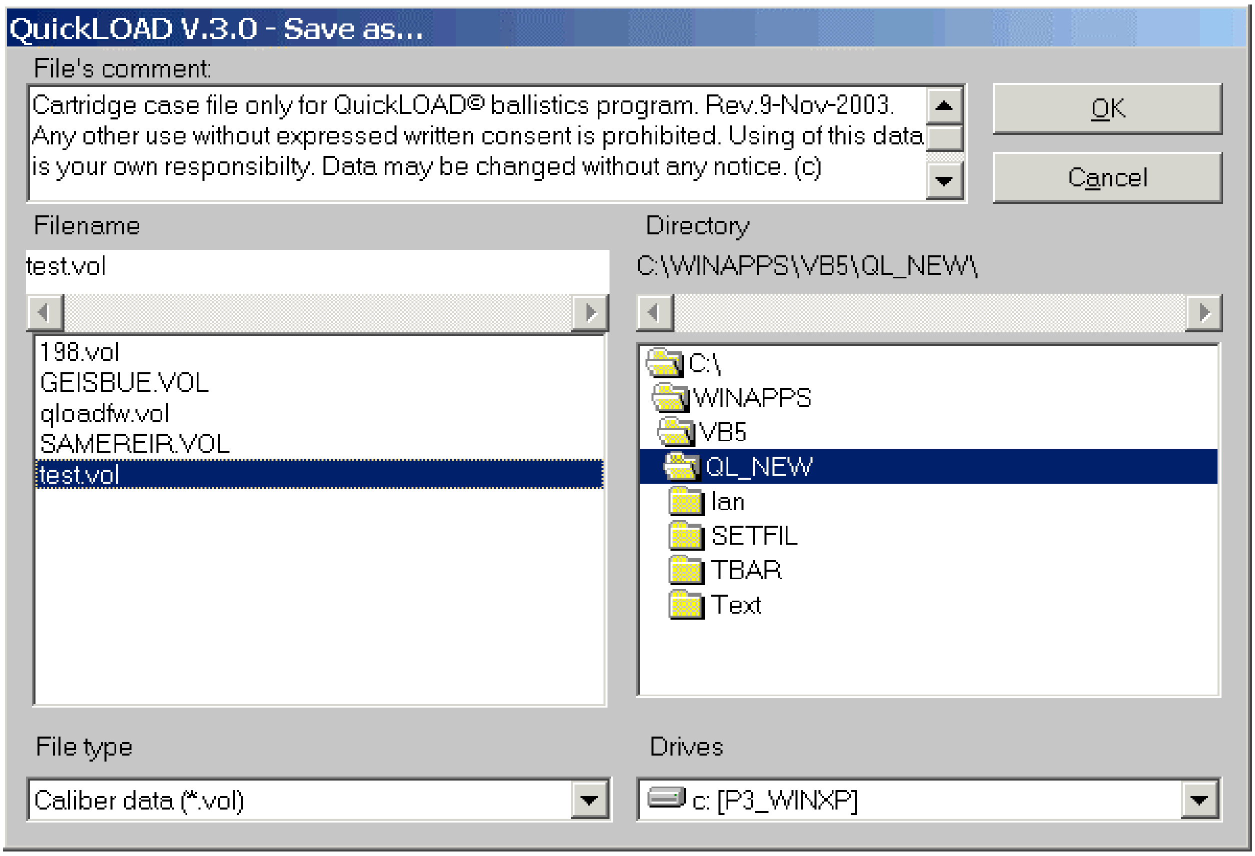
- File's comment:
  - Input sufficient information to uniquely describe new file contents;
- Filename:
  - Input a new filename; Following characters are not allowed in filenames :
    - <u>? * ; : = ' ^ ° > < | \ %</u> ; Filename plus path should not exceed 255 characters.
- Directory:
  - Select folder to save file in; Default: [program files]\quickload\data\calibers
- Drives:
  - Selection of drive to save file on;
- Type:
  - Select file type (extension must be *.VOL* for use as case file);
- OK:
  - Selecting *OK* button creates new file, as specified. If file already exists or file name contains illegal characters a warning is displayed.
- Cancel:
  - Selecting *Cancel* button closes window without taking any further action.

Save Cartridge File as…

Main Menu Selection:

- Data: add, load, change, save:
  - Case / Caliber data;
    - Save active case/caliber file as,

Opens this dialogue window to allow saving the active case file under a new name:



Picture 32: ***Case save as…*** **window**

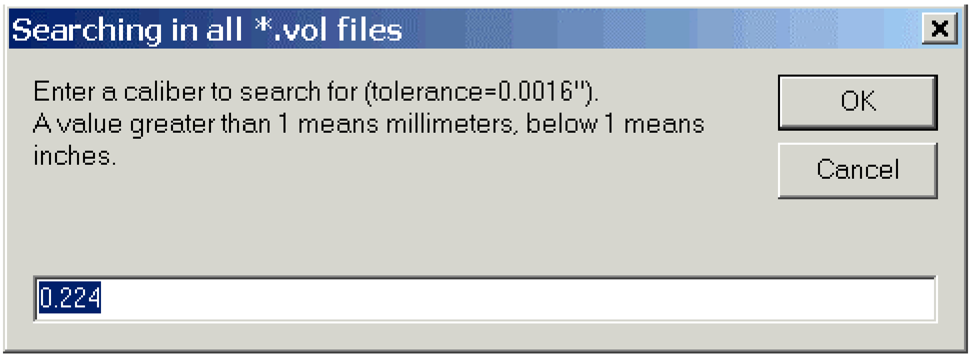
- File's comment:
  - Input sufficient information to uniquely describe duplicate file;
- Filename:
  - Input a new filename; Following characters are not allowed in filenames:
    - **? * ; : = ' ^ ° > < | \ %**
- Directory:
  - Select folder to save file in; Default: [program files]\quickload\data\calibers
- Drives:
  - Selection of drive to save file on;
- Type:
  - Select file type (extension must be .*VOL* for case file);
- OK:
  - Selecting *OK* button saves open file with new name, as specified.
- Cancel:
  - Selecting *Cancel* button closes window without taking any further action.

Caliber Selection – Search all Cartridge Files

Main Menu Selection:

- Data: add, load, change, save:
  - Case / Caliber data;
    - Search cartridges of same caliber,

Opens this window:

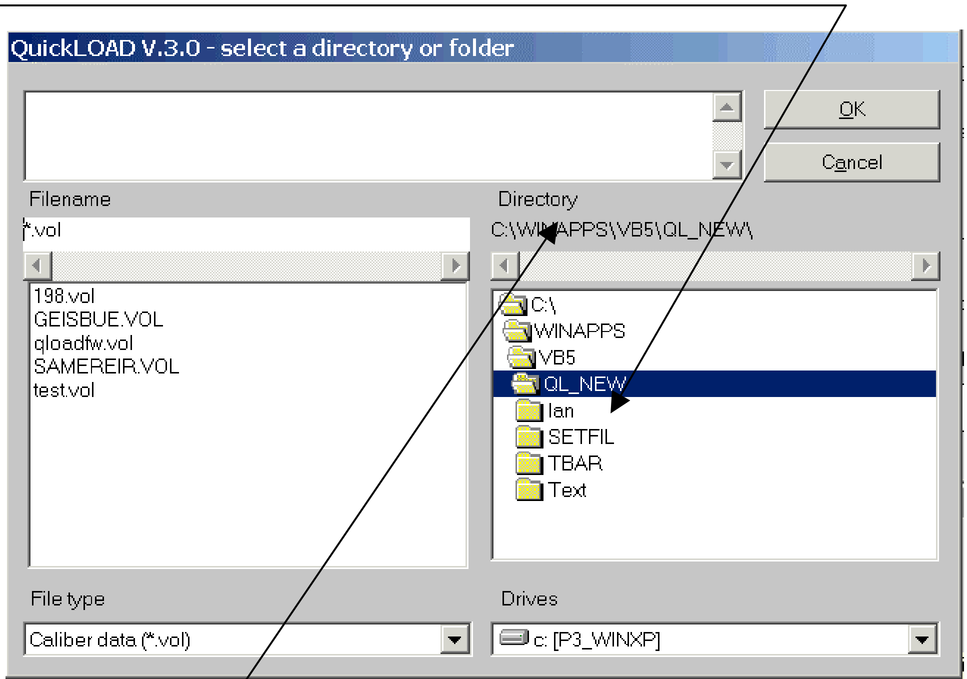


Picture 33: ***Case caliber selection – searching in all...* window**

(Also available through a Symbol toolbar icon.*)*

- Enter desired caliber (as directed in window text):
  - Select *OK* button, *(When invalid data is entered or no match is found, a warning message window opens, user must acknowledge this message. When a match is found QuickLOAD prompts the user to save the file.)*
    - Opens *select a directory or folder...* window.

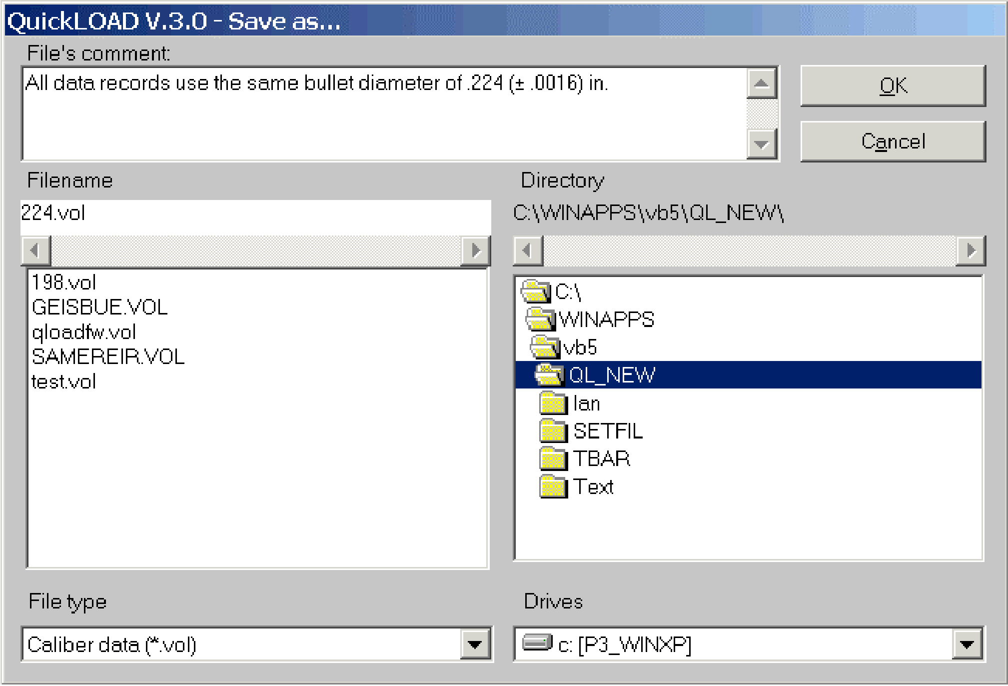
Select a directory where to search for caliber files containing selected caliber.



Picture 34: -select a directory or folder

Default: directory is [program files]\quickload\data\calibers .
After selecting directory (selection is displayed under the word Directory)

- *OK button, opens Save as… window (see next page)*
- *Cancel* – cancels action and closes window.



Picture 35: *Save as...* window

- Enter a descriptive comment:
  - *(Comment text should uniquely describe the file contents).*
- Change the default filename (if desired): Program suggests diameter as file name.
  - (Cartridge files must use the extension *.VOL*. - or omit dot and extension, the program will add appropriate extension)
- Select *OK*:
  - Begins search for entered diameter, displays found calibers in *Cartridge dimensions* window, *Selected Caliber* box, then saves collection in the file (as described and named).
- Select *Cancel*:
  - Begins search for entered diameter, displays found calibers in *Cartridge dimensions* window, Selected Caliber box but does not save collection. Closes window.

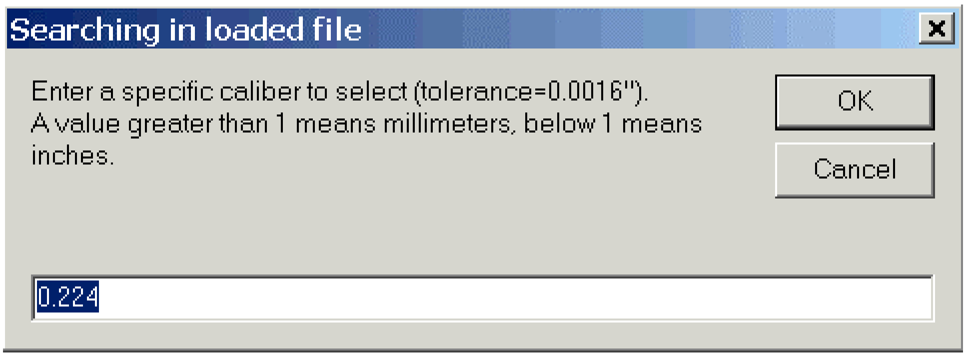
(If user selects *Cancel*, *QuickLOAD* will proceed and will work with the selected data; however, if the user tries to change any cartridge data this window will reopen – you must save the file before making any changes or reload an existing cartridge file.)

Caliber Selection – Search in Loaded Cartridge File

Main Menu Selection:

- Data: add, load, change, save:
  - Case / Caliber data;
    - Show only cartridges of same caliber,

Opens this window:



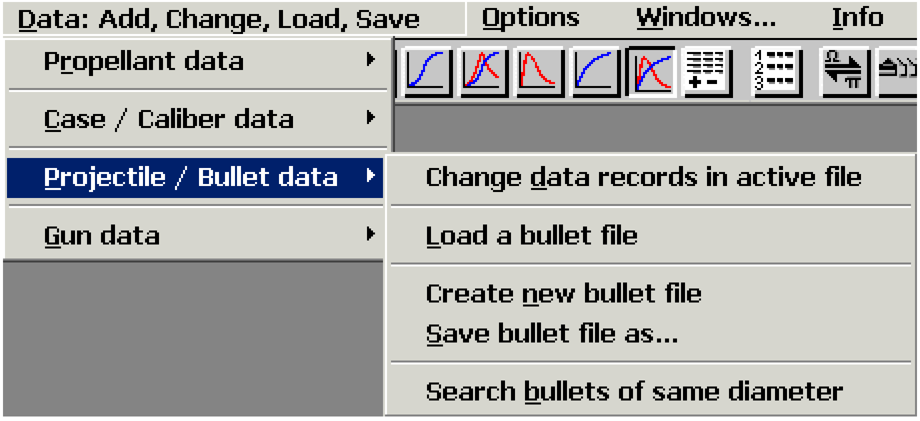
Picture 36: Case caliber selection – Searching in loaded file

- Enter desired caliber (as directed in window text):
- Select *OK* button:

(When invalid data is entered or no match is found, a warning message window opens, user must acknowledge this message.)

When a valid value is entered, *QuickLOAD* searches the active file for matching cartridges. A successful search restricts the *Cartridge dimensions* window to display only those cartridges matching the specified caliber; an unsuccessful search produces the message, “No specimen of “.*XXX*” cal. found,” – displayed in the *Selected cartridge* data box in the *Cartridge dimensions* window.

The sub-menu Data – Projectile / Bullet data

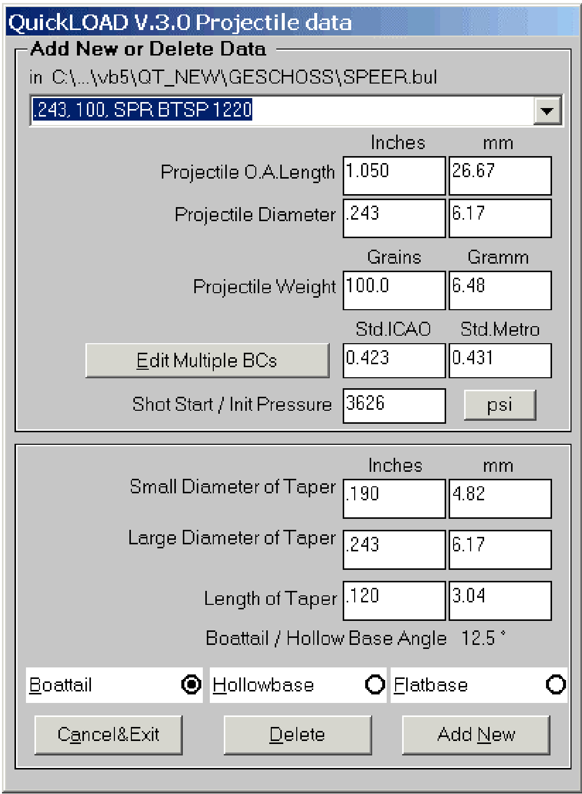


Picture 37: sub-menu *Data – Projectile / Bullet*

The sub-menu *Data – Projectile / Bullet data* provides these options:

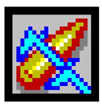
- Projectile / Bullet data:
  - *Change data records in active file;*
    - Invokes a window where the user can create or change a single data record,

Projectile data window



Picture 38: *Projectile data* window

(Refer to Section titled **<u>Projectile: Change Bullet Data in Active File</u>** for a complete description of this option.)**:**

(Also available through this Symbol toolbar icon.*)* 

*Note: all extensions for bullet files must be .**BUL or .BU$***

Load Bullet File

- Projectile / Bullet data:
  - *Load a projectile/bullet file;*
    - Opens a file dialogue window to allow loading of a different projectile/bullet data file,

***Load bullet file* window** (Refer to Section titled **Load Case/Caliber File** for a complete description of this option.)

Create New Empty Bullet File

- Projectile / Bullet data:
  - *Create new empty bullet file;*
    - Opens a file dialogue window to allow the user to create a new bullet data file,

***Create new empty file* window** (Refer to Section titled **Create New Empty Cartridge File** for a complete description of this option.)

Save Bullet File as…

- Projectile / Bullet data:
  - *Save active bullet file as…;*
    - Opens a file dialogue window to allow the user to rename the active (loaded) bullet file.

***Bullet Save as...* window** (Refer to Section titled **Save Cartridge File as…** for a complete description of this option.)

Caliber Selection – Search Bullet of Same Caliber in Files

- Projectile / Bullet data:
  - *Search bullets of same caliber*;
    - Opens *Searching in all *.bul file*s window where the user specifies a bullet diameter for *QuickLOAD* search,

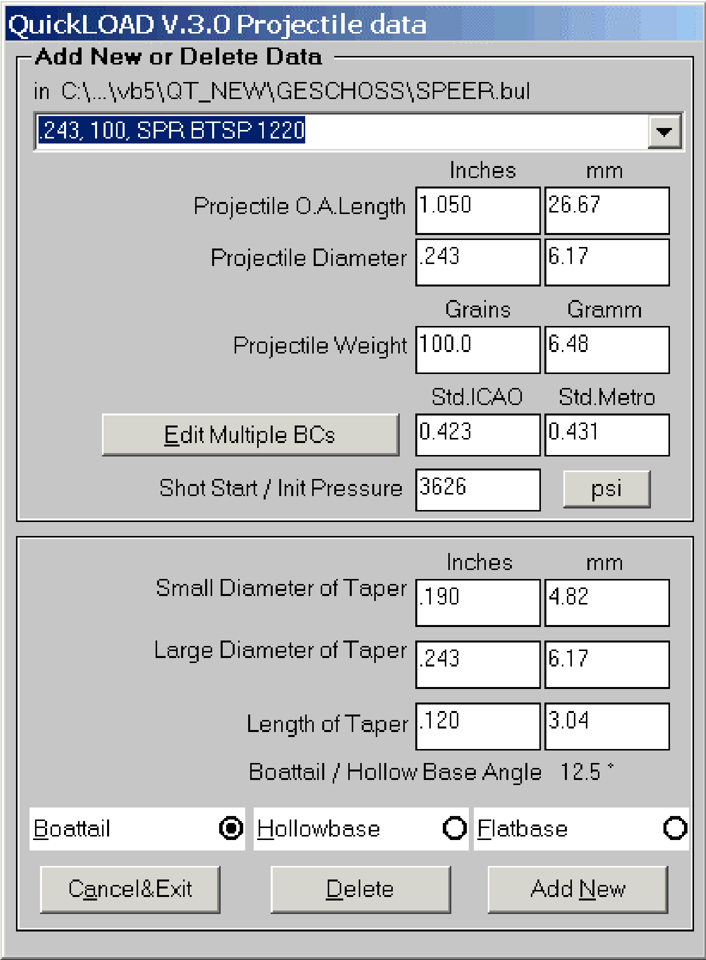
Bullet selection – searching in all…* window** (Refer to Section titled ***Case caliber selection – Searching in all files… **window** for a complete description of this option.)**:**
(Also available through a Symbol toolbar icon*.)*

Change Bullet Data Record in Active File

Main Menu Selection:

- Data: add, load, change, save:
  - Projectile / bullet data;
    - Change data records in active file,

Opens this window:



***Projectile data* window:**

- Add New or Delete Data
  - Input, descriptive name of bullet or select a bullet;

This field should include sufficient information to provide positive bullet identification. This field must contain 5 or more characters; for proper sorting and consistency with pre-established QuickLOAD bullet files, all bullets should be named as follows: bullet diameter in inches (don't forget the leading dot), comma, space, *bullet weight in grains,* comma, space, *Manufacturer(see* Bullet Manufacturer Abbreviations and File Names*) and descriptive information)*

- Projectile length:
  - Input, nominal bullet length (mm or inches);
- Projectile diameter:
  - Input, bullet shank diameter (mm or inches);
- Projectile weight:
  - Input, in grains or grams;
- Projectile BC:
  - Single datum;
    - Input, bullet BC (*Std. ICAO* or *Std. Metro*),
  - Multiple data;
    - Select *Edit multiple BCs* box, *(Opens* Ballistic Coefficients C1 *window, described below.)*

- Shot start / init pressure:
  - Input, pressure needed to drive bullet from case and into rifling – refer to bubble help tool tip for reasonable values;

(Since QuickLOAD includes a separate switch to account for the Shot start pressure *reduction associated with friction-proofing of bullets, we suggest entering the value for a non-friction-proofed version of the bullet here, rather than keeping separate files for each basic bullet…)*

- Small diameter of cone:
  - Optional input, diameter of base of boattail or bottom of hollowbase cavity – if applicable;
- Large diameter of cone:
  - Optional input, diameter of large end of boattail or opening of hollowbase cavity – if applicable;
- Length of cone:
  - Optional input, length (along bullet axis) of boattail section or depth of hollowbase cavity – if applicable;
- Boattail selection box:
  - If bullet design includes a boattail, select this box and fill in the related data;
- Hollowbase selection box:
  - If bullet design includes a boattail, select this box and fill in the related data;
- Flatbase:
  - If bullet is a flatbase design, select this box (clears any data entries in the related data boxes).

Adding a new data record:

After specifying all data bullet, including a distinct name, select the *Add new* button.

This adds the bullet to the active program cartridge file. This action rewrites the file [filename].BUL Simultaneously, the existing file is renamed to [filename].BU$.

Deleting an existing data record:

Use the slider to select a bullet from the current file list. Select the *delete* button to initiate removal of that bullet from the active file. Confirmation of deletion erases selected data record from file [filename].BUL. Simultaneously, existing previous file is renamed to [filename].BU$.

Canceling action:

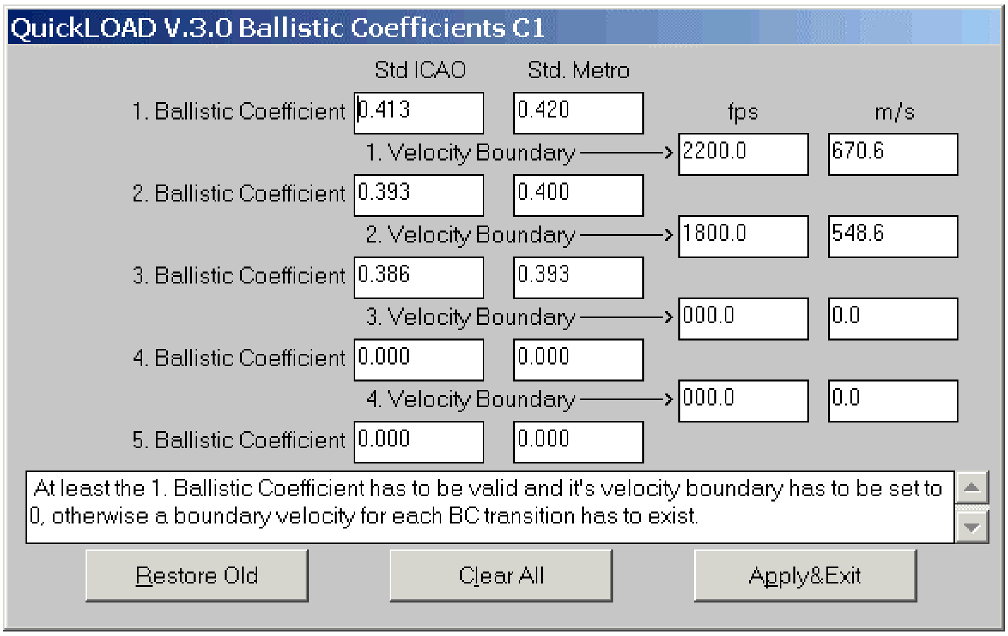
Selecting the *Cancel* button cancels action and closes window without taking any action.

Main Menu Selection:

- Data: add, load, change, save:
  - Projectile / bullet data;
    - Change data records in active file,
    - Edit multiple BCs,

Selecting this button opens this window:

Edit multiple BCs



Picture 39: Multiple Ballistic Coefficients C1 window

Bullet data – Selecting *Edit multiple BCs*:

(Some manufacturers provide multiple, velocity dependent, BC data. The data for this example, the 0.224" Sierra 80-grain Matchking, is found in Sierra's 50th Anniversary Manual.*)*

1. Ballistic Coefficient, as measured at maximum feasible velocities:
   Input data, in either Standard ICAO or standard Metro (depending upon system used to calculate BC data);
   1. Velocity boundary: Input minimum velocity, in either fps or m/s, for above data value;

2. Ballistic Coefficient, as measured within second-fastest velocity range:
   Input data, in either Standard ICAO or standard Metro (depending upon system used to calculate BC data);
   2. Velocity boundary: Input minimum velocity, in either fps or m/s, for above data value;

3. Ballistic Coefficient, as measured within third-fastest velocity range:
   Input data, in either Standard ICAO or standard Metro (depending upon system used to calculate BC data);
   3. Velocity boundary: Input minimum velocity, in either fps or m/s, for above data value;

4. Ballistic Coefficient, as measured within fourth-fastest velocity range:
   Input data, in either Standard ICAO or standard Metro (depending upon system used to calculate BC data);
   4. Velocity boundary: Input minimum velocity, in either fps or m/s, for above data value;

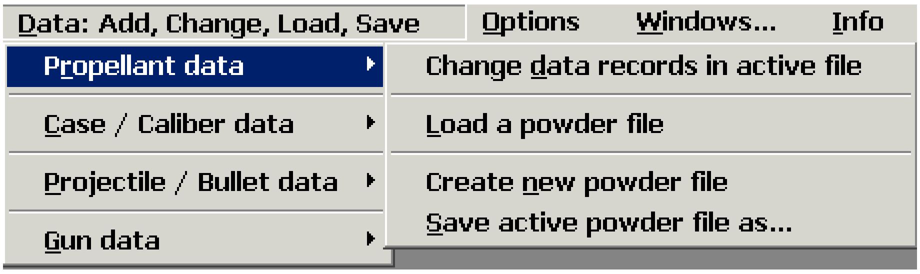
5. Ballistic Coefficient, as measured below fourth-fastest velocity range:
   Input data, in either Standard ICAO or Standard Metro (depending upon system used to calculate BC data);

(Note, refer to the window text box for detailed instructions.)

- *Restore Old:*
  - Selecting *Restore* button clears any entries and returns previous values;
- *Clear All*:
  - Selecting *Clear all* button clears all values, whether user entered or default data;
- *Apply&Exit*:
  - Selecting *Apply&Exit* button closes window and transfers entered data to *Projectile data* window.

(Note, QuickLOAD does not require BC data. However, any bullet used in QuickTARGET must include valid BC data. For this reason, it is usually best to include an estimated BC value with any bullet – specify this by adding a note in bullet name such as, "…est. BC".)

The sub-menu Data – Propellant data

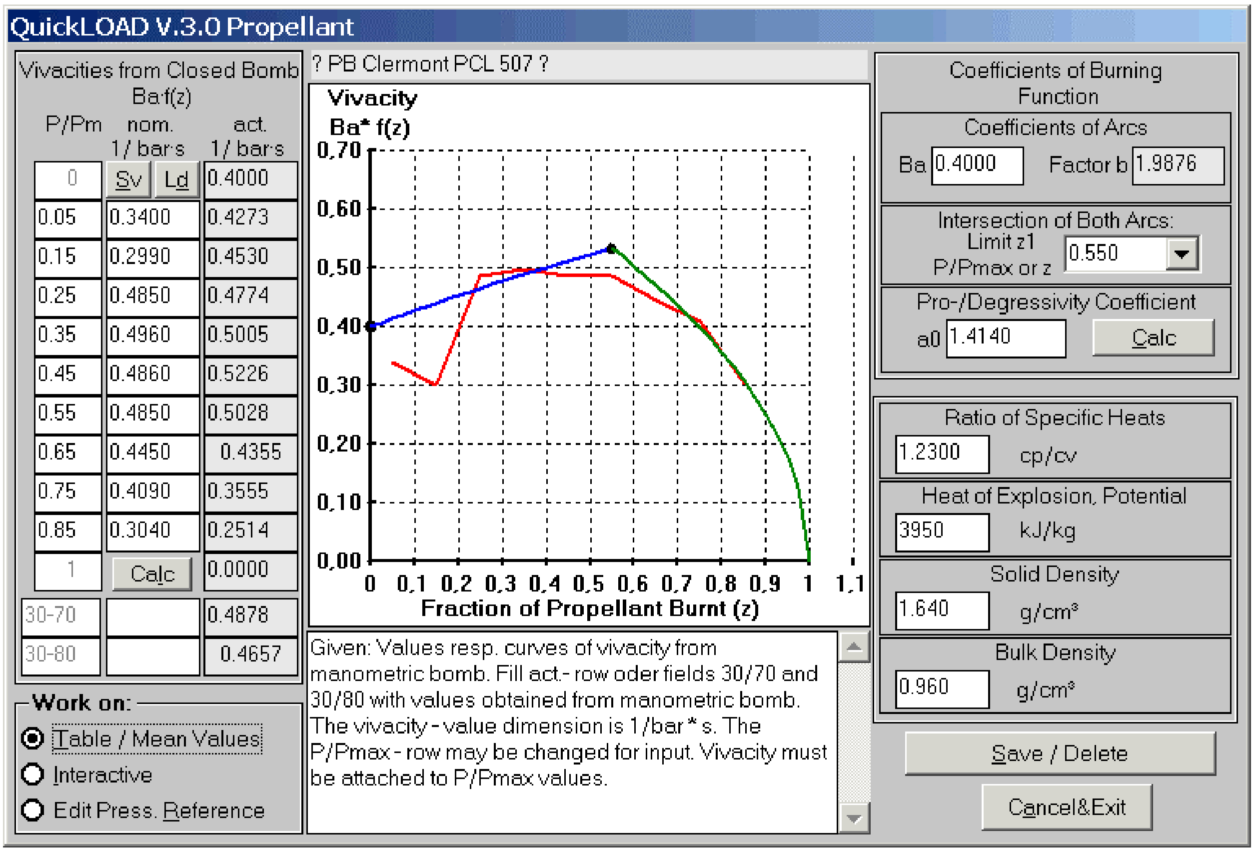


Picture 40: Sub menu Propellant data

The sub-menu *Data – Propellant data* provides these options:

- Propellant data:
  - *Change data records in active file;*
    - Invokes a window where the user can create or change a single data record or temporarily work on powder data,

Propellant data window



Picture 41: Propellant window

Note: all extensions for powder files must be ***.VOL or .VO$***

Load Powder File

- Powder data:
  - *Load a powder file;*
    - Opens a file dialogue window to allow loading of a different powder data file,

Load powder file **window** (Refer to Section titled **Load Case/Caliber File** for a complete description of this option.)

Create New Powder File

- Powder data:
  - *Create new powder file;*
    - Opens a file dialogue window to allow the user to create a new empty powder data file,

Create new powder file **window** (Refer to Section titled **Create New Empty Cartridge File** for a complete description of this option.)

Save active Powder File as…

- Powder data:
  - *Save active powder file as…;*
    - Opens a file dialogue window to allow the user to rename the active (loaded) powder file.

Save active powder file as... **window** (Refer to Section titled **Save Cartridge File as…** for a complete description of this option.)

Change Powder Data Record in Active File

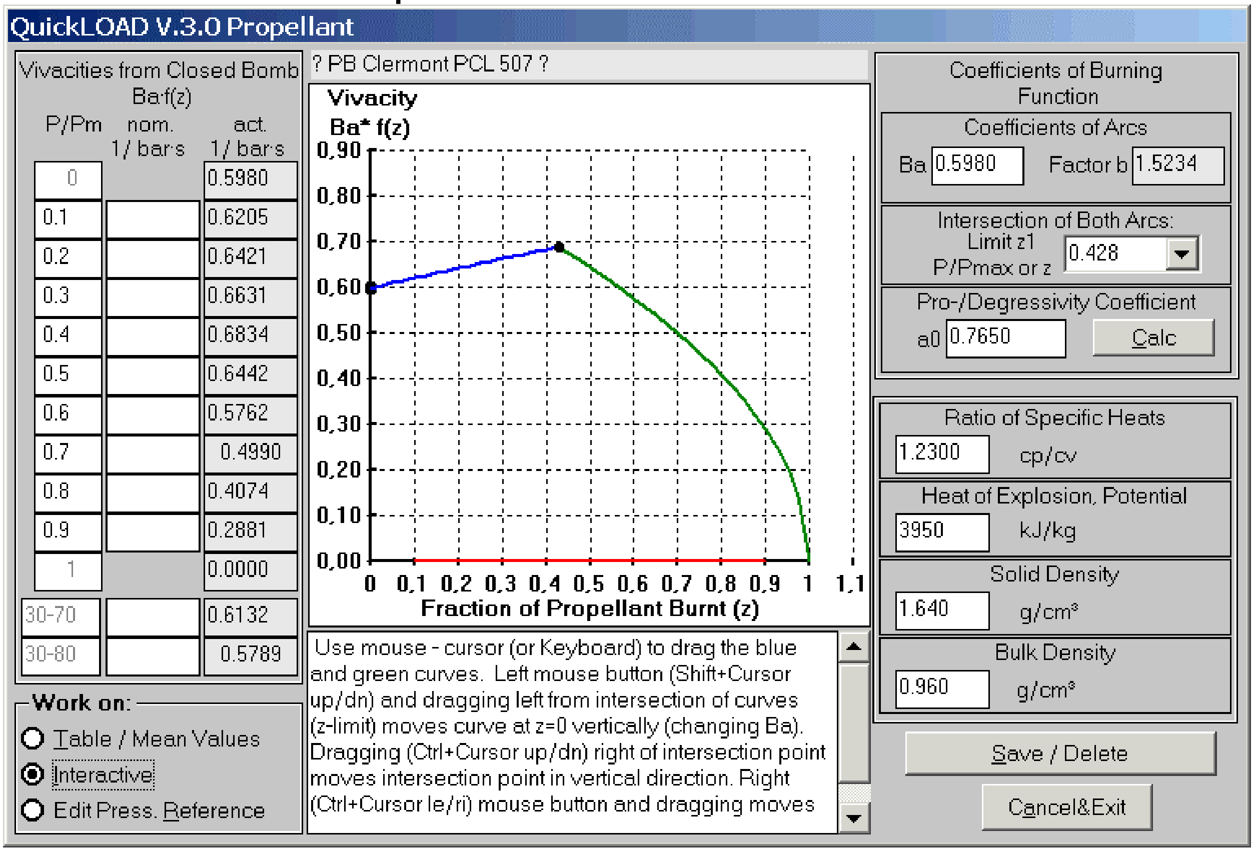
- Interactive Option selected

Main Menu Selection:

- Data: add, load, change, save:
  - Propellant data;
    - Change data records in active file,

Opens following window:

Propellant window – Mode Interactive



Picture 42: *Propellant* window – *Interactive*

(Also available through this Symbol toolbar icon.*)*

This window facilitates generating & adapting burning function data and saving & deleting propellant data:

With *Interactive* button activated, the following manipulations and calculations are allowed:

1) User can either change burning function directly or enter values within *Coefficients of Burning Function frame* to generate new values that correspond to formula [8] (see section, Reflections on Interior Ballistics). After changing any field, activate *Calc* button in this frame. Any new input data entered must fulfill equations in formula [8].
   i) When making changes, only one value should be changed at any time. Activate *Calc* button before making any other change. Doing so calculates new burning function and immediately changes graph to match that function. Results are (temporarily) transferred into window, *QuickLOAD Charge*.

2) User can interactively modify the graph by using the mouse:
   i) Place mouse cursor on the left, **progressive (blue) part of curve**. Press and hold left mouse button. Moving mouse up or down modifies left part of curve accordingly. Burning rate coefficient automatically changes to match new curve. Releasing mouse button (temporarily) transfers new coefficient values into the corresponding fields and into the window, *QuickLOAD Charge*.
   ii) Place mouse cursor to right of intersection point on **degressive (green) side of curve**. Press and hold left mouse button. Move mouse up (or down) to raise (or lower) the intersection point of the curves. Rise of first arc and value of (b) are changed automatically. Releasing mouse button (temporarily) transfers new values of these coefficients to window, *QuickLOAD Charge*.
   iii) Press and hold right mouse button. Moving mouse left or right moves intersection of curves horizontally. Rise of first arc, limit z_1 and value of (b) are automatically changed. Releasing mouse button (temporarily) transfers new values of these coefficients to window, *QuickLOAD Charge*.

3) Upon release of mouse button, when main menu *Options... Reference pressure curve* is activated (under 2 above), mouse movements result in new set of interior ballistics calculations, based upon new powder burning coefficients.
   i) In addition, this brings up window, *QuickLOAD diagram*, which shows both a fixed and a variable pressure curve. This is displayed every time these values are changed. This interactive process can be continued until the settings result in sufficient correspondence between these curves.

(Other propellant properties, barrel length and volumes etc. must, also, be adjusted to achieve congruency).

   ii) Deactivating *Options… Reference pressure curve*, in main menu bar cancels this routine.

Change Powder Data Record in Active File

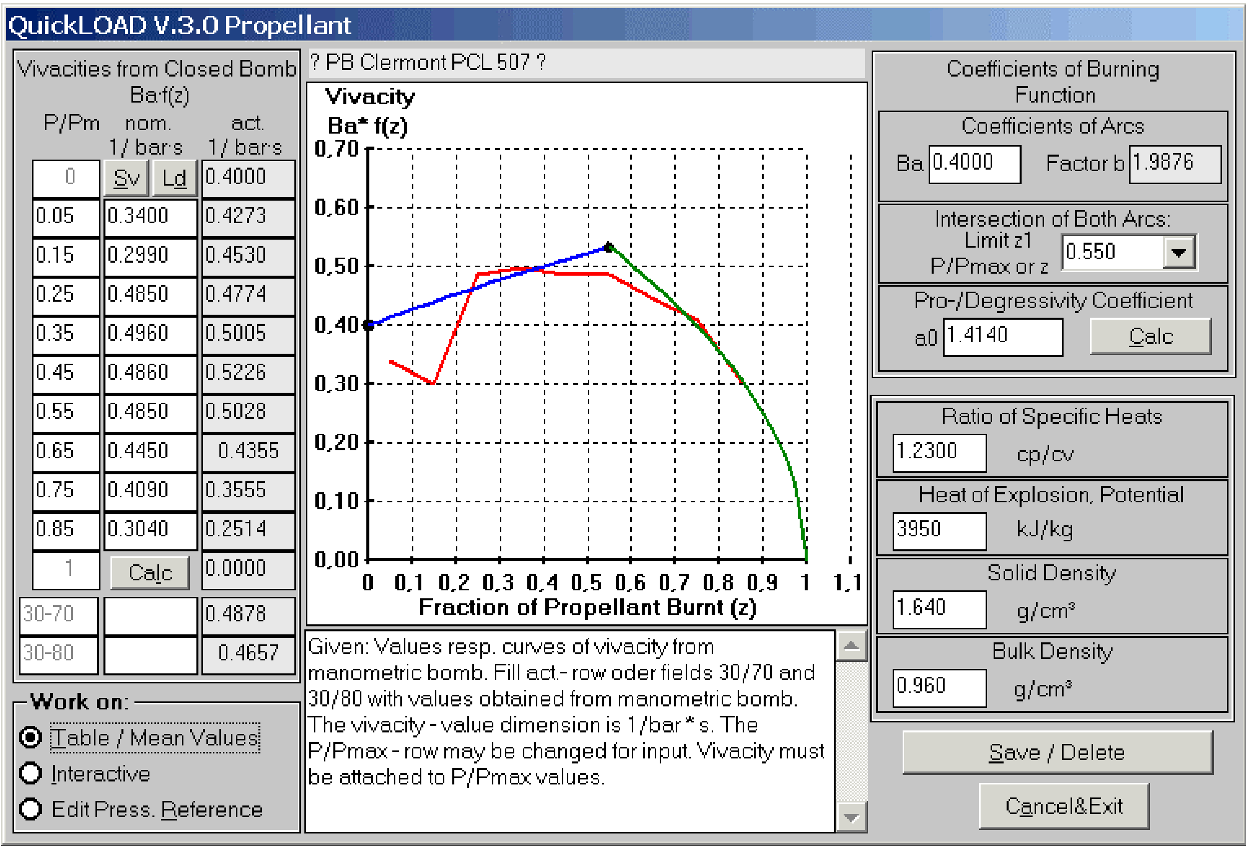
Table / Mean values option selected

Main Menu Selection:

- Data: add, load, change, save:
  - Propellant data;
    - Change data records in active file,

Opens this window:

Propellant window – Mode Table / Mean values
(with sample values from closed vessel, manometric- or closed bomb)



Picture 43: *Propellant* window – Table / Mean values

Activating *Table/Mean values* button facilitates the following manipulations and calculations:

Within table *Vivacities from Closed Bomb*, Vivacity values according to their P/P_{max} values are manually transferred into *nom.* column. All nine lines have to be filled completely (Vivacities are always recorded in bars or MPa, so no psi values are shown). Next, positioning and clicking the mouse cursor marks two P/P_{max} fields. These marked fields are *yellow.*

Inserted data should come from almost progressive portion of burning curve.

After activating *Calc* button below entry table, a initial burning function graph is displayed in red color. This curve crosses both marked function values, shown in column *act.* and in the graph.

This burning function can be further adapted by using the mouse with the procedures described in the previous section (Propellant window – interactive).

Often, only *average* Vivacity values are known. These are usually:

- mean value of vivacity from;
  - $P/P_{max\ 30\text{-}70} = P/P_{max}$ from 0.3 to 0.7,
- mean value of vivacity from;
  - $P/P_{max\ 30\text{-}80} = P/P_{max}$ from 0.3 to 0.8.

User can enter these values into the special fields (other table fields are empty or filled with zeros). Selecting the *Calc* button under the table reveals a red point, through which the curve with $P/P_{max} = 0.8$ passes. In addition, actual values are shown in the respective fields. The burning function can be further adapted using the mouse cursor, as described in the previous section (Propellant window – interactive). In this manner, actual mean values can be compared with nominal mean values.

Change Powder Data Record in Active File

- Edit Press. Reference option selected

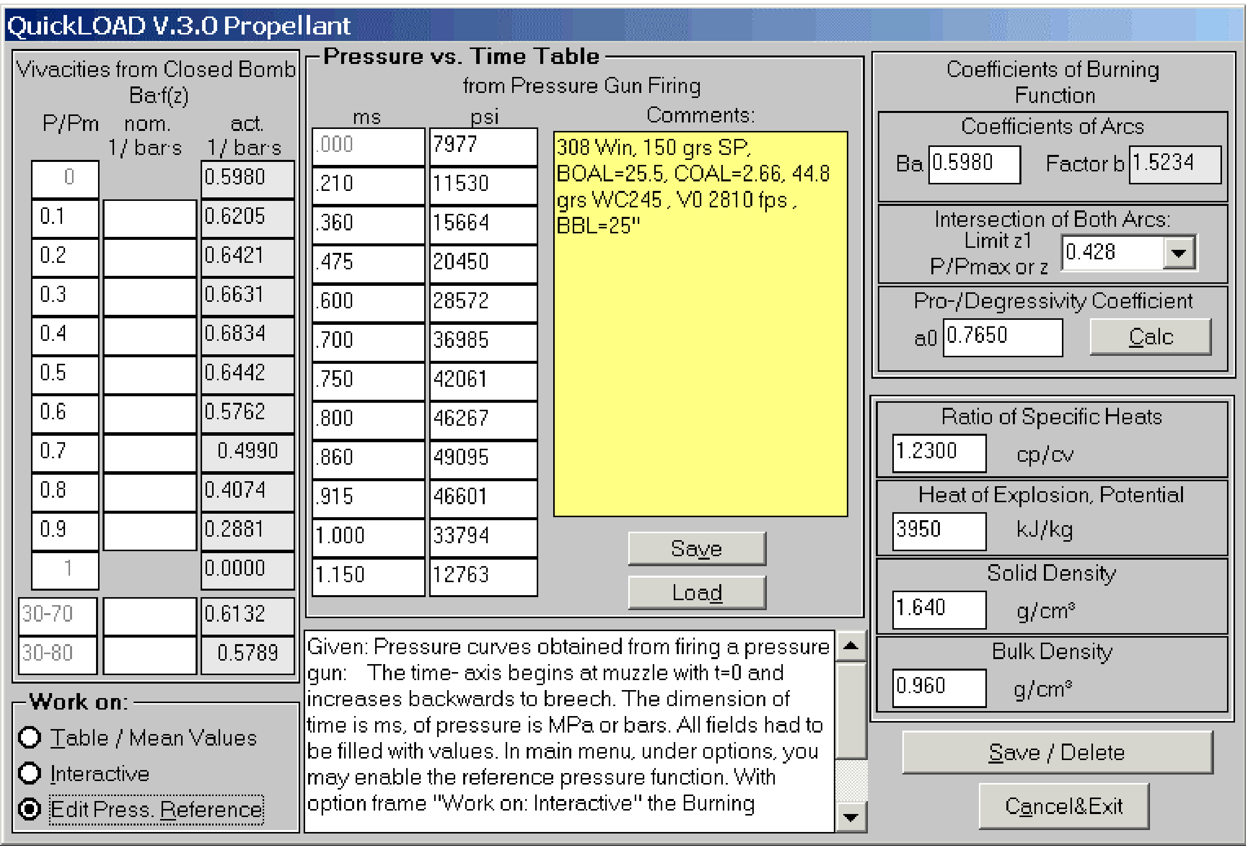
Main Menu Selection:

- Data: add, load, change, save:
  - Propellant data;
    - Change data records in active file,

Opens this window:

Propellant window – Mode Edit press. Reference

(with sample results from pressure gun curve)



Picture 44:*Propellant* window – Edit Press. Reference

Activating *Edit press. Reference* button facilitates the following manipulations and calculations:

From a pressure curve (as a time function), which was generated using a pressure gun equipped with piezoelectric transducer, 12 value pairs are transferred into the *Pressure versus time table.*

Timing begins at muzzle (t = 0). Time (in milliseconds) and corresponding pressure values are then entered backward (as bullet gets closer to the starting location). That is because bullet exit is easier to detect than bullet start.

For best results, choose points where important alterations of pressure exist (maximum pressure, inflection points (curve changing from getting steeper to getting flatter and vice versa), maximum rise rate, etc. Good choices can adequately characterize the curve. All fields must contain values.

In the text field, *Comments,* enter ballistics system data, to allow subsequent curve identification. Activating *Save* button stores the curve and a comment in the QLOADFW.INI file. Choosing *Load* button allows loading of an existing reference data file. Activation of *Reference pressure curve* displays both actual and reference curves.

Attention: The user cannot alter data in the original propellant files named QLOADFW.PRO or ALLPOWDR.PRO!

This safeguard provides additional security against the inadvertent corruption of these critical files. If you want to “play with” altering powder properties and save any theoretical powders or if you have data on a powder not found in the database and want to save that data, you must create a new powder file. This file can be a renamed duplicate of an existing file. For example, QUICKTST.PRO.

Before you save propellant data you should check the input fields at the right side of the window for correct entries:

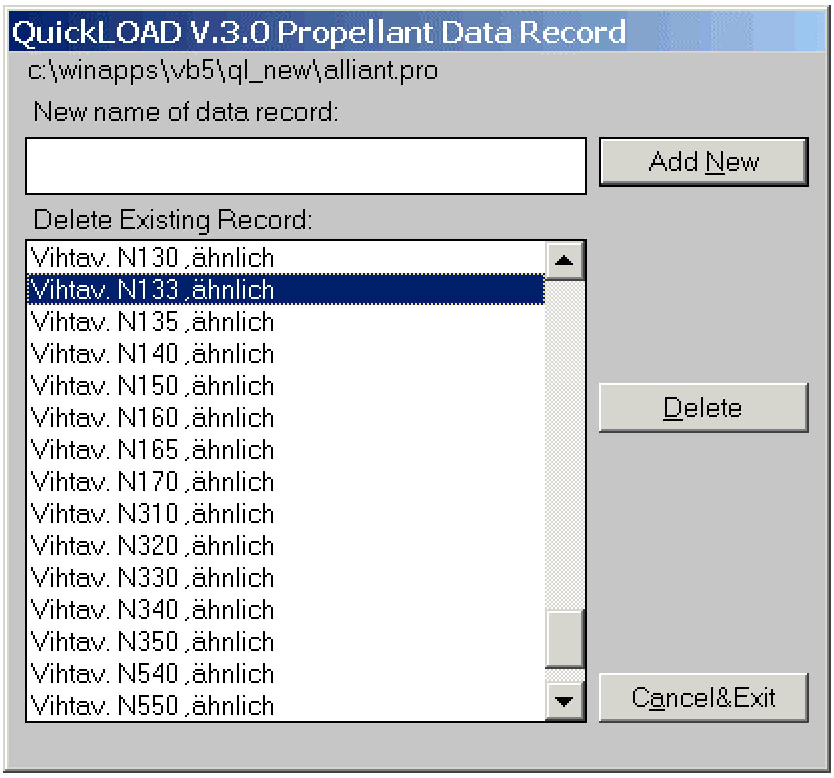
- *B_a:*
  - Burning rate coefficient; It's the value of synthetic vivacity function at the origin of function for z=0.
- *Factor b:*
  - Coefficient, necessary to fit equation [8]; will be calculated by pressing *Calc* button.
- *Limit z1:*
  - Value of intersection of both arcs of function.
- *Pro-/Degressivity Coefficient:*
  - Coefficient a0: defining the slope of first arc of function; zero means neutral or horizontal line, positive values cause rising curve; negative values cause falling curve.
- *Calc button in frame Coefficients of Burnig Function:*
  - Checks entered cvalues and corrects values to match function.

- Ratio of specific heats:
  - adiabatic exponent c_p/c_v; altered and adjusted to match interior ballistics model.
- Heat of Explosion:
  - Caloric energy of powder substance per unit of mass.
- Solid Density:
  - Density of powder substance (not density of granules)
- Bulk Density:
  - also gravimetric density, of granuled powder. Ratio of weight of powder filling a particular volume (under prescibed conditions).

When every entry is properly checked, user may add new powder data record to powder file:

Adding a new data record /deleting a data record:
After specifying all propellant data select *Save / Delete* button.
Selecting this button opens this window:

Propellant Data Record



Picture 45: *Propellant Data Record window*

Adding a new data record
Enter a distinct name into the *New Name Of Data Record* field. Selecting *Add new* button adds the propellant to the active program powder file. This action rewrites the file [filename].PRO. Simultaneously, the existing file is renamed to [filename].PR$.

Note: Other than with saving bullet- or cartridge data, you are not allowed to overwrite powder data with the same designation. This prevents from accidental overwriting. In you want to do so, you have first to delete the old data and then write the new one or save the new one under a slightly modified designation. This safeguard applies for powder files only, because it is more difficult for powder data to recover the lost data than for bullets or cartridges.

Deleting an existing data record:
Use the slider to select a powder from the current file list. Select the *Delete* button to initiate removal of that powder from the active file. Confirmation of deletion erases selected data record from file [filename].PRO. Simultaneously, existing previous file is renamed to [filename].PR$.

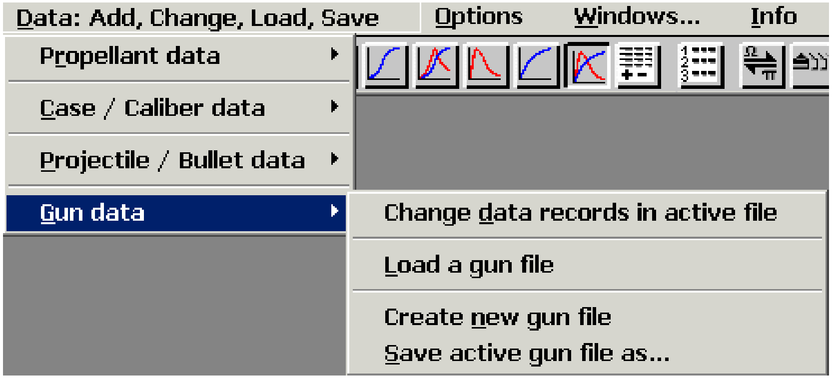
Canceling action:
Selecting the *Cancel* button cancels action and closes *Propellant Data Record* window without taking any action.

Selecting Cancel

Propellant window – All Modes

Canceling action:
Selecting the *Cancel* button closes ***Propellant*** window. All changes made to actual propellant properties <u>are transferred</u> to the *Charge* window and used by the next calculation. The powder name in the *Charge* window gets leading and trailing *question marks*, indicating changed powder data.

The sub-menu Data – Gun Data

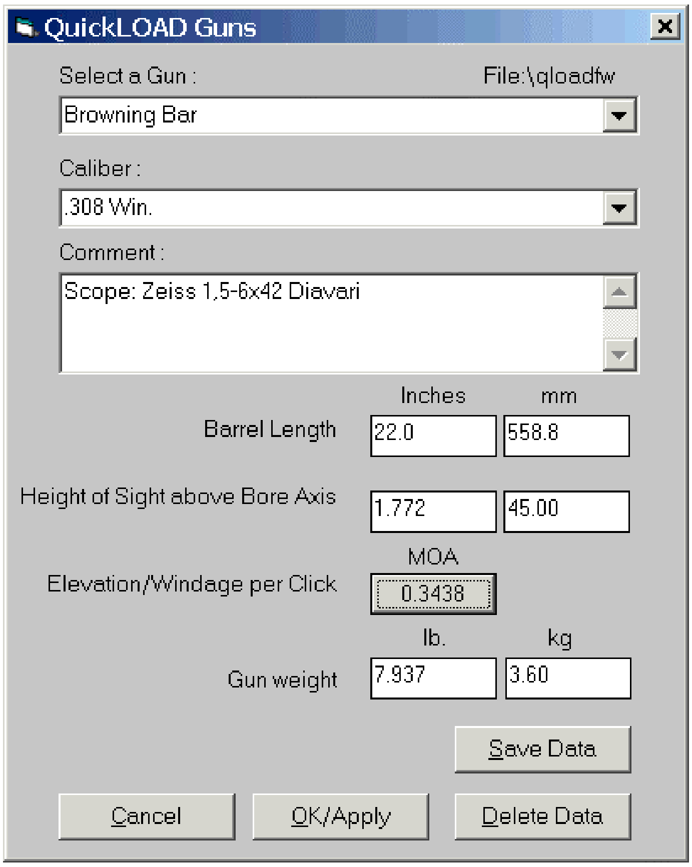


Picture 46: Sub menu Gun Data

The sub-menu *Data – Gun data* provides these options:

- Projectile / Bullet data:
  - *Change data records in active file;*
    - Invokes a window where the user can create or change a single data record
  - *Load a Gun file;*
    - Invokes *the open file* window
  - Save active gun file as;
    - invokes *save as* window, allowing you to save gun database under a new name and/or new location on disk.

The Guns window



Picture 47: Guns window

In this window user may specify his guns dimensions necessary for *QuickLOAD* and *QuickTARGET.* In list field *Select a gun* user may retrieve gun data which is then transferred by *OK/Apply* button to *QuickLOAD's* Dimensions window. Selecting the MOA button opens window to change settings for elevation- and windage correction clicks. See description in *QuickTARGET* manual.

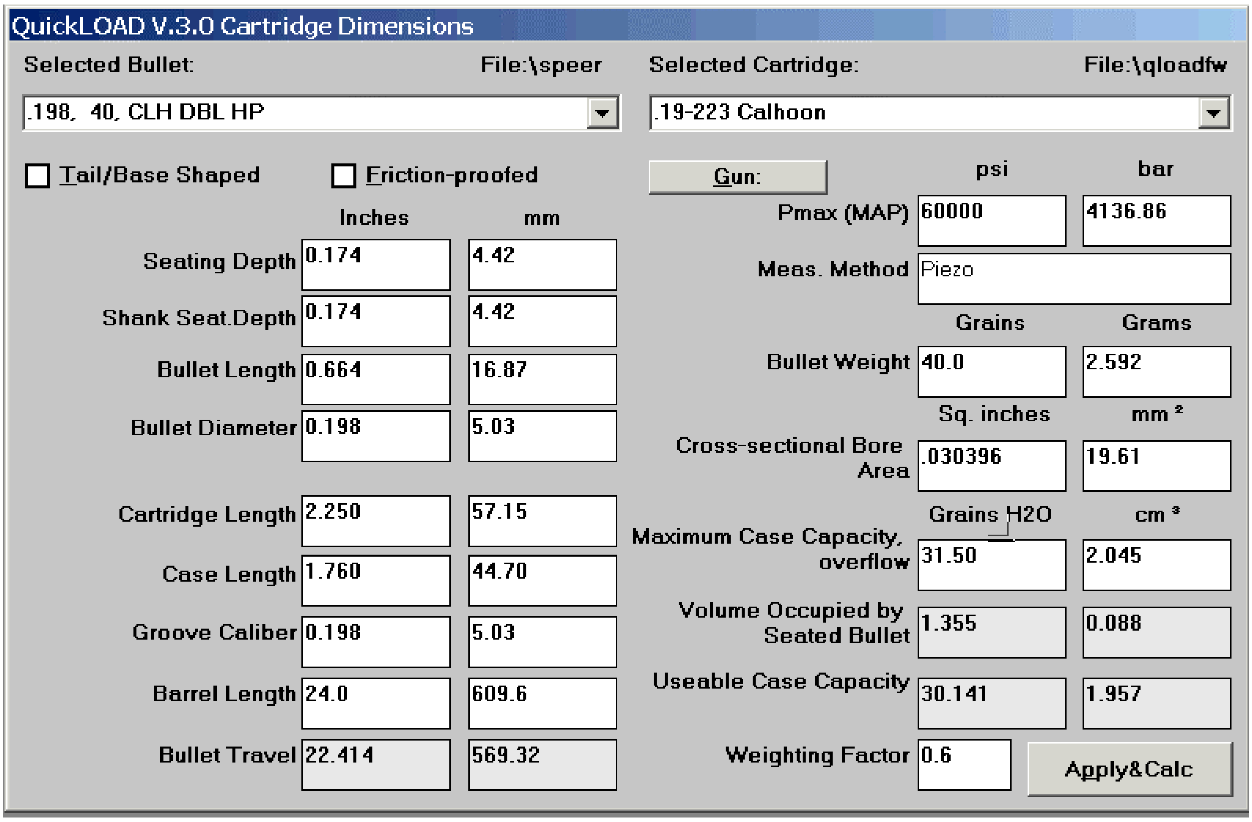
- *Select a gun;*
  - Input or drop-down selection field;
    - When specifying a new gun enter gun's descriptive name.
    - When selecting a gun to work with, drop down list field and select an existing gun.
- *Caliber;*
  - Drop-down selection field of all calibers available in program.
    - When specifying a new gun, drop-down list and select appropriate caliber.
    - When selecting a gun to work with, no action.
- *Comment;*
  - Enter a comment for appropriate for the gun. Information is saved in data record.
- *Barrel length;*
  - Input field;
    - Enter gun's barrel length while specifying new gun.
- *Height of Sight above Bore Axis;*
  - Input field;
    - Enter distance between virtual Line of Sight and Bore Axis measured at muzzle of gun with iron sights or use distance from centerline of scope to firing pin (center fire).
    - Valid only for use within *QuickTARGET*.
- *Elevation/Windage per Click;*
  - Read-only value of units per click or scale mark value of your gun sight's adjustment device.
  - By pressing button, an additional window opens to specify adjustment setting.
    - Valid only for use within *QuickTARGET*. For a detailed description see *QuickTARGET* manual.
- *Gun weight;*
  - Input field;
    - Enter complete gun weight including magazine weight and telescope weight.
    - Used in *QuickLOAD* by recoil calculations.

Buttons:

- *Save data;*
  - Saves above entered data to gun database. Overwriting an existing record needs confirmation.
- *OK/Apply;*
  - Data displayed is transferred to Dimensions window. Gun window is closed.
- *Delete data;*
  - Data record of selected gun will be erased from database.
- *Cancel;*
  - Window is closed; no action performed.

QuickLOAD's Main Working Windows

Cartridge Dimensions Window



Picture 48: Cartridge Dimensions Window

In this input window all essential cartridge data and most bullet data used in *QuickLOAD* calculations are recorded or entered:

In this window, the user can select the cartridge and bullet to use. Doing so fills all data fields with default values that are associated with the cartridge and bullet. However, the user can make temporary changes to most of these fields. Such changes affect calculations but are not permanently reflected in the data files associated with the cartridge and bullet.

Not all text and numerical fields are input fields. Some values, such as *Bullet travel*, *Seating depth*, *Usable case capacity* and *Volume occupied by seated bullet* are calculated by *QuickLOAD*, based upon other values (either manually entered or defaults). Enabled input fields have a white background; other fields have a slightly stippled or gray background (which does not show in this representation).

All numerical fields automatically convert units. Changing *English (SAE)* figures changes data in the *Metric* fields and vice-versa.

The input character for the decimal point is always the keyboard *period*. *QuickLOAD* checks for lower and upper limits on all entries in numerical input fields. A limit violation activates a yellow popup field warning of error and showing suggested (or required) input value limits. However, owing to wide variations in chambering and user goals, it is not possible to guard against all unrealistic data entry values. Therefore, it is possible to calculate results with undesired or unintended values – verify all entries!

Fields in approximate order of screen arrangement:

- ❖ **Selected bullet:**
  - ➢ Bullet name/description *(See above* comment *and note.)*;

This is a "combo list" field. By single-clicking the *down* arrow, the user can select from the available cartridges. All fields corresponding with data record information are immediately updated when a cartridge is chosen;

(User can use any ANSI *character in this field. This field must contain characters. Single-clicking the label to the right of the* Selected cartridge *label invokes a dialogue box for loading a new cartridge file into memory.)*

Note: When cursor is inside this field and you press Alt-S key the field changes from and to "Search Mode". Search mode is indicated by yellow background color. In search mode you may type in any matching characters and the field displays the first found match. The same is true for the Selected Cartridge field.

On left side:

- Seating depth:
  - Input or Output, calculated by *QuickLOAD;*
- Shank Seating depth:
  - Input or Output, calculated by *QuickLOAD; valid with boattail bullets*
- Bullet length:
  - Input, actual length of bullet;

(Default is measurement of hand sample or data provided by QuickLOAD's bullet files, the bullet manufacturer or other source.)

- Bullet diameter:
  - Input, diameter of bullet *(See above comment.)*;
- Cartridge length:
  - Input, actual overall length of cartridge; *(Default is maximum SAAMI, CIP or nominal datum.)*
- Case length:
  - Input, length of empty case; *(Default is case length of an sample case used to measure case capacity .)*
- Groove Caliber:
  - Input of bore groove diameter (bullet diameter); *(Default value, according to CIP, SAAMI or as measured.)*
- Barrel length:
  - Input, measured length from bolt face to muzzle; *(Default is last value entered by the user….)*
- Bullet travel:
  - Output, calculated by *QuickLOAD; way from bullet's base start position to muzzle exit.*

On right side:

- **Selected Cartridge:**
  - Cartridge name;
- Pmax (MAP):
  - Input, *Maximum Average Pressure* in psi, bars or MPa; *[*1 bar = 14.503 psi*].*

NOTE: Database contains, so far available, absolute maximum allowed values according to SAAMI *or* CIP *and depending upon selected input settings. Most values in the shipped database are related to piezoelectric measurement, which delivers normally higher, but true, numbers with rifle calibers than* CUP *– copper crusher method figures at both equal pressures. For safety reasons, in many European countries, it is illegal to use cartridges exceeding CIP maximum pressure values, furthermore it is illegal to use smokeless powder in guns designed for Black Powder.*

- Meas. Method:
  - Measurement system, e.g. *Piezo according to SAAMI or CIP or other*
- Bullet weight:
  - Input in grains or grams *(Default is manufacturer's nominal value.)*;
- Cross-sectional Bore area:
  - Input, bullet base area worked upon by gas force (pressure);

(The shipped database normally contains minimum values according to CIP *or ANSI/*SAAMI *specifications. If no data exists, QuickLOAD estimates this area based upon specified groove diameter.)*

- Maximum case capacity, overflow:
  - Input, grains of water or cm^3.

(The shipped database contains capacities for differing calibers and case makes. These are only first-approximation values – obtain better data by measuring capacity of a fired case, see text below).

It is imperative to accurately determine the average capacity for a given group of cases (brand and lot) because case capacity differs substantially from lot-to-lot and brand-to-brand. This measurement is easily done using a dry, empty fired case (with fired primer in place).

(For published loading data anywhere in magazines we often find case brand information together with bullet, charge and primer data. This is tradition, but it makes no sense at all. Cases are often "outsourced" manufactured, so in truth the manufacturer of one brand may differ, and therefore the tools for drawing cases too).

For most RIFLE CALIBERS and other guns using peak pressures above 30,000 psi (2,000 bars): use a case fired in the specific gun you are working with. Do not resize the case before making the capacity measurement.

For most PISTOL CALIBERS and other guns using peak pressures below 30,000 psi (2,000 bars): use a resized case.

After obtaining the weight of a dry empty case (with used primer in place), fill the case with cold water. Eliminate any air bubbles and bring water even to end of case neck. Reweigh water-filled case. Subtract dry weight from water-filled weight. This gives case capacity in grains of water, which is the standard unit of measure.

QuickLOAD provides another means for estimating case capacity. This option is addressed under Cartridge data, which is described elsewhere (see Page 37Cartridge data – Selecting *Calc* Case capacity).

- Volume occupied by seated bullet:
  - Output, case volume displaced by seated bullet – amount subtracted from Maximum case capacity (overflow);
- Usable case capacity:
  - Output, calculated by *QuickLOAD* based upon various germane input parameters;
- Weighing factor:
  - Input, represents energy losses from friction, heating and gas leakage;

(Default is an estimated value based upon consideration of various cartridge parameters.)

Most data records contain a 0.5. This means that 50% of the propellant mass is considered to move with the bullet. For typical cartridges, this is a good figure with which to work, so long as nothing better is available. Refer to the associated Bubble-help (tool tip) window for more information.

When using so-called solid bullets, like Winchester FailSafe™, MEN-SF™, SFS, Hirtenberger ABC™ or Barnes X™, the user can set this value slightly higher (add 0.05).

With moly-coated bullets (like NECO-Coat™ processed) reduce this value about 0.02.

Note that frictional loss percentage probably varies with jacket materials and barrel materials and bore profiles and this value is not constant along the path of the bullet through the bore. Nevertheless, in the current *QuickLOAD* version, a mean value of friction is assumed.

The marking box:

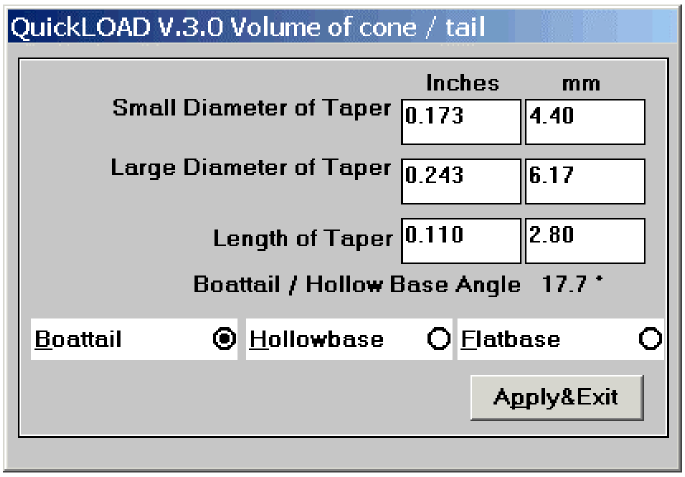
- **Tail/Base shaped:**

Effective combustion chamber volume is calculated by subtracting the volume of that portion of the bullet extending into the case from *Maximum case capacity (overflow)*.

With flat-base bullets, calculation of the area occupied by the bullet requires only bullet diameter and seating depth. With boattail or hollowbase bullets, neglecting base design introduces serious calculation errors.

  - When this box is checked, the window Volume of Cone / Tail is activated, see below.

Volume of cone / tail Window



Picture 49: Volume of cone / tail window

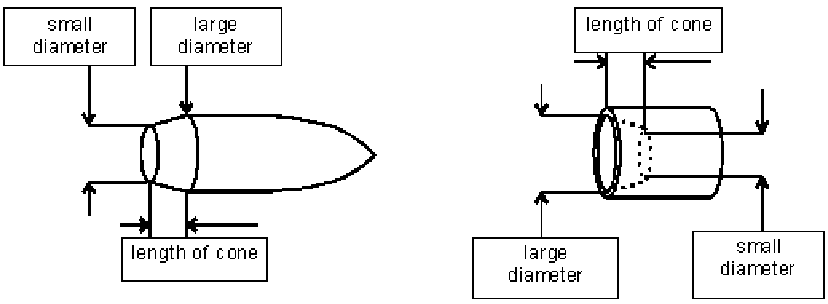
All inputs to define base cone of bullet occur in this window:

- Small diameter of Taper:
  - Required input; *(For boattail bullets, this is the diameter at the juncture of the projectile base and the boattail section. For hollowbase bullets, this is the diameter at the bottom of the hollowbase.)*
- Large diameter of Taper:
  - Required input; *(For boattail bullets, this is the diameter at the fattest position of cone (equals bullet diameter except in stepped or rebated boattail designs). For hollowbase bullets, this is the diameter at the opening in the projectile base.)*
- Length of Taper:
  - Input necessary; *(Length, along axis of bullet between small & large diameter measurement points.)*
- Boattail / Hollow base angle (Output only): Angle to centerline of bullet. Value automatically calculated, based upon the input values; *(Boattail/hollowbase angle is calculated and displayed by QuickLOAD only for user information.)*

- Option button Boattail:
  - Specifies a boattail bullet configuration (requires inputs in the above specified fields);
- Option button Hollowbase:
  - Specifies a hollowbase bullet configuration (requires inputs in the above specified fields);
- Option button Flatbase:
  - Specifies a flat bullet base (clears all data entry fields to zero);

- *Apply&Exit Button:*
  - Values checked, window closed, enters boattail, hollowbase or flatbase data in bullet file.

Measurement points on bullet base



Picture 50: Defining Points on Bullet base

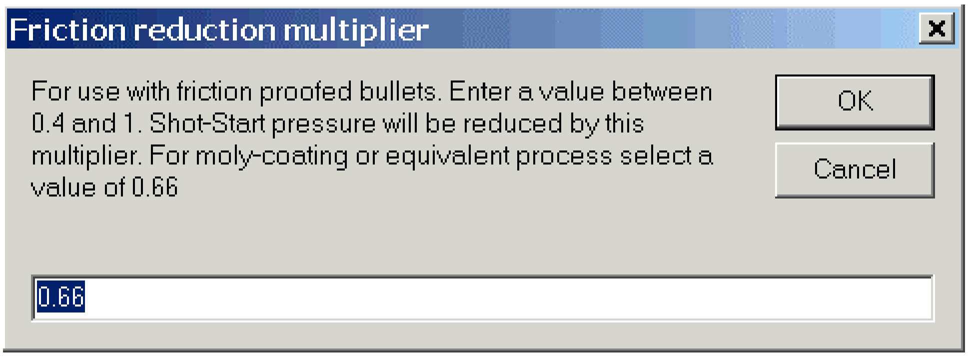
The marking box:

➢ **Friction-proofed:**

- This box allows the user to specify that the selected bullet has been friction-modified in some manner.

Selecting this box opens the following window. The response in that window temporarily alters the default *Shot start* pressure for the selected bullet (discussed later).

Friction reduction multiplier Window



Picture 51: Friction reduction multiplier entry

Inputs to adjust the friction characteristics of the bullet occur here (as described in the window text)

Exit data entry in *QuickLOAD Cartridge dimensions* window by single-clicking (selecting) the *Appily&Calc* button – at lower-right window corner.

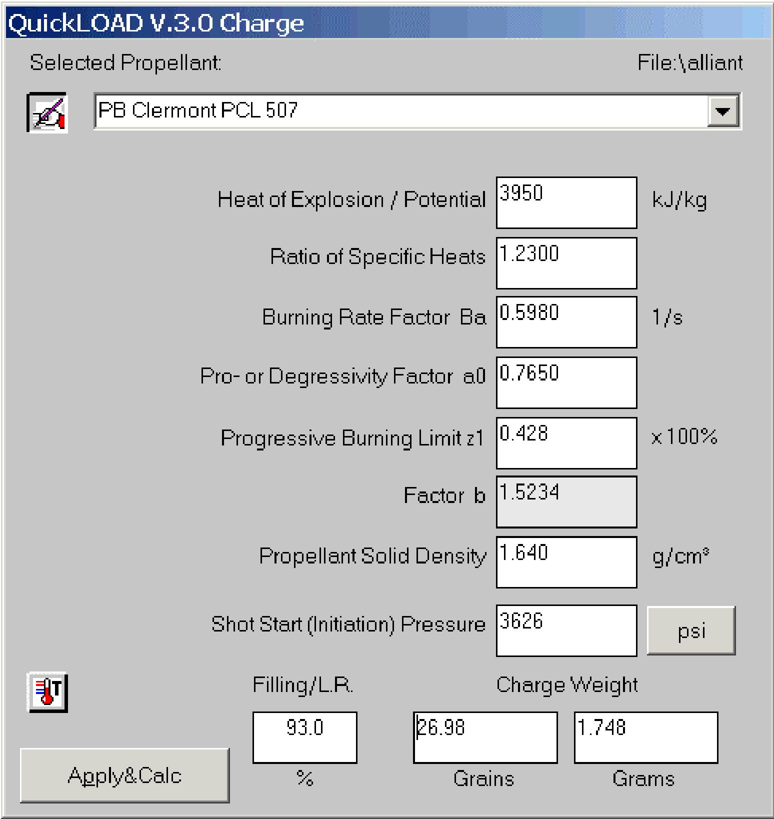
Should any inputs fail a plausibility check, a beep sounds and a warning message displays. The user must acknowledge and correct any errors.

The first window, where a wrong input was located, is activated. After correction, select *OK* button again.

If a complete interior ballistic calculation was already done and the values in all other windows are valid, selecting the *Apply&Calc* button launches a new calculation.

If *QuickLOAD* is not ready to perform calculations (owing to lack of input data), window *QuickLOAD Charge* is activated.

Charge Window (conventional bullet)



Picture 52: Charge window

In this input window all essential propellant and charge data and one bullet datum (Shot start pressure) is recorded or entered:

In this window, the user can select the powder to use for calculations. Doing so fills all data fields with default values that are associated with the specified powder. However, the user can make temporary changes to most of these fields. Such changes affect calculations but are not reflected in the data files associated with the powder.

Before the user can change any powder characteristic values, it is necessary to click the stylized “writing hand” *icon at the left of the powder name field. The Temperature button becomes visible above the Apply&Calc button. This is a toggle-switch function.*

The User can enter charge weight and all required propellant parameters here. All fields, with the exception of *Factor b*, are input fields and must be filled with data. However, most fields are filled with default values when a powder is chosen from the database. The user should not alter these default values without specific information suggesting more accurate data.

Changes made here are temporary, applied only during the active session. To make permanent changes, refer to *Data…* menu choices.

All datum included in the propellant database are partly derived from one propellant lot available on market and are not compared with all production lots that are actually available. Normally, new production lots vary somewhat from the reference lot, which was used in defining these default values.

This unavoidable computational accuracy-limiting situation can result in incorrect results in pressure calculations.

Data for new powder lots must always be corrected and adjusted. Tolerances among propellant production lots (including handloader propellants) are significant. Sometimes a propellant of a slower category burns as rapidly as one from the, supposedly, next-faster category. This unfortunate fact prevents the generation of any permanently valid propellant data for any nominal powder type.

Often, minor deviations can be observed in baseline velocity (V_0) measurements. The sophisticated user can adjust this data by changing burning rate coefficient B_a or ratio of specific heats cp/cv. However, any such adjustment is applicable only to the currently active load.

Input fields:

- **Selected propellant:**
  - Powder name and/or description;

This is a drop-down list field. By selecting the *down* arrow, the user can select from the available powders. All fields corresponding with data record information are immediately updated when a powder is chosen.

- Heat of Explosion:
  - Input of specific Heat of Explosion (Q_{ex}) in kJ/kg or in J/g – depending upon use specified program settings;
- Ratio of specific heats:
  - Input of κ (cp/cv, also called adiabatic exponent) adjusted to system used in *QuickLOAD*;
- Burning rate factor B_a:
  - Input of B_a, mean burning function coefficient, as used in *QuickLOAD;*
- Pro- or Degressivity factor:
  - Input of a_0, characterizes rise or fall of first segment of burning function arc (Formula 8);
- Progressive burning limit z_1:
  - Input of limit value z, valid to extent of first arc segment (Formula 8);
    (Refer to Reflections on Interior Ballistics *section.)*
- Factor b:
  - Output of b, moves second arc segment to desired intersection point with first arc segment (Formula 8);
    (Refer to Reflections on Interior Ballistics *section.)*
- Propellant solid density:
  - Input of solid density (ρ) in g/cm$^{3;}$
- Shot start / Initialization pressure:
  - Start pressure input value, pressure where projectile begins to move from case or engrave rifling;

(Represents force necessary to push bullet from case added to force necessary to engrave bullet into the bore rifling.)

IMPORTANT: A pressure of 2900 psi to 3600 psi (200 - 250 bars) is a practical value for normal soft-point, soft-cored projectiles.

So-called copper solids (without a lead-alloy core) or tungsten hard-cored jacketed bullets require a *Shot start* pressure exceeding 6500 psi (450 bars).

Short pistol bullets can require only 1000-psi (70 bars) hard-cast lead and jacketed soft-core pistol bullets up to 2100 psi (150 bars).

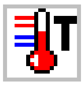
Moly-coated or otherwise friction-proofed bullets can require a reduction of 35% (or more) in the above mentioned values. Example: If your Standard Shot Start Pressure is set to 3600 psi (soft point bullet without moly), set it for 2400 psi (2/3 x 3600) when using moly-coated bullets. See below. (For more information, refer to Bubble-help text.)

- Filling %:
  - Optional input field. Usable space occupied by charge with seated bullet; also named Load Ratio

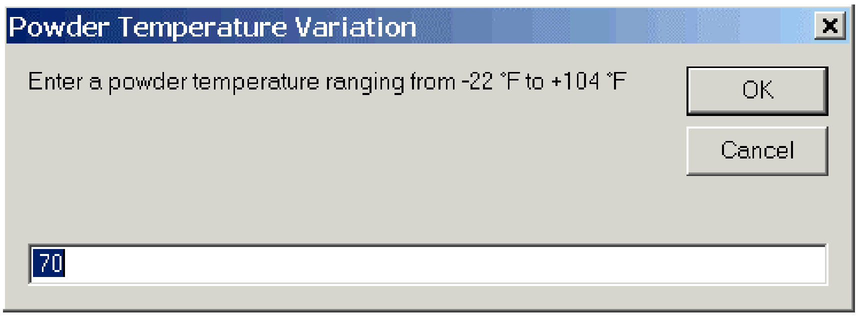
(Any value exceeding 100% usually indicates a charge compressed by the seated bullet.)

- Charge weight:
  - input of propellant mass (charge weight);

(Automatic unit conversion fills unused entry field – user must verify charge weight entry into correct field.)

By selecting *Temperature* button  the

Powder Temperature Variation window

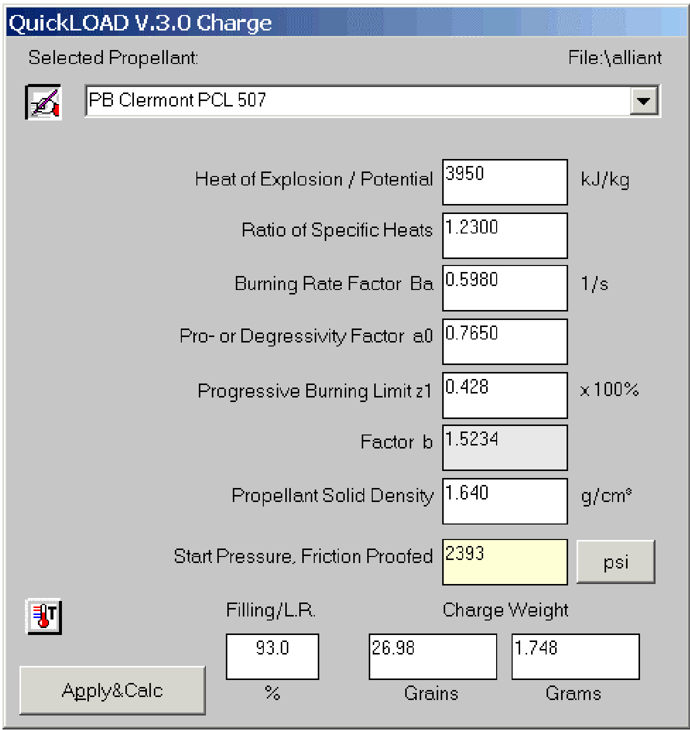


opens:

Picture 53: Powder Temperature Variation window

The user may vary powder temperature at ignition time. Default is 70° F. Changing the temperature means that burning rate and vivacity is corrected according to Yamagas formulas. This produces temporarily usable powder data and this change is not saved to powder's database. **This function is only applicable with single base powders which are not temperature compensated.** To day, most manufacturers take efforts to reduce influence of temperature on burning rate - used formula my not be valid.

Charge Window (friction-proofed bullet)



Picture 54: Charge window - friction proofed bullet

This is the Charge window when the *friction-proofed* box is checked in the *Cartridge Dimensions* window:

Note that the *Shot Start* box specifies that friction-proofed bullet data is already entered. See text in *Start pressure label*. Therefore, make no further *Shot start* pressure reduction.

Exit *QuickLOAD* propellant window by selecting the *Apply&Calc* button.

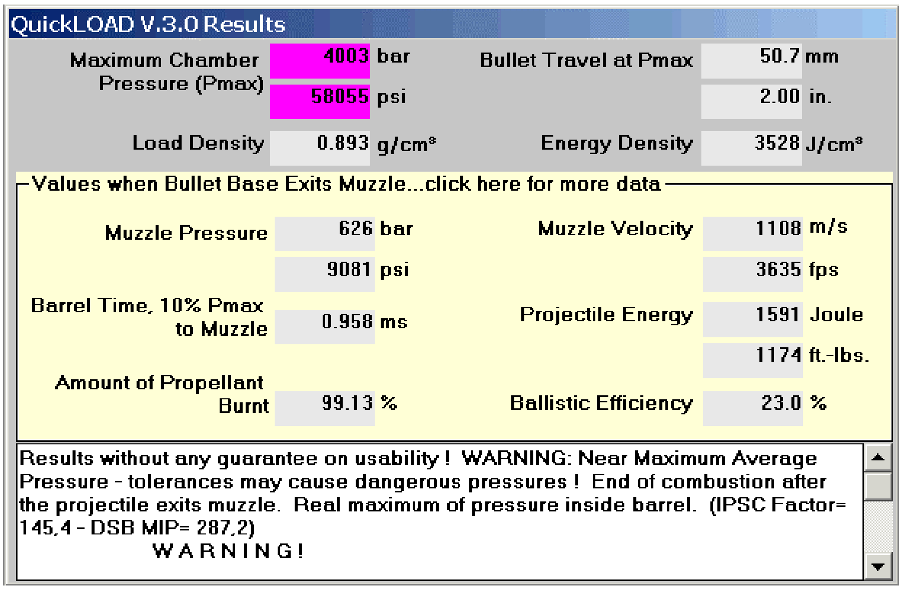
Plausibility errors in input values result in a warning beep and a message box. User must acknowledge (and, typically, make input corrections). After correction, the user must again select *Apply&Calc* button. Selecting *Apply&Exit* button begins new interior ballistics calculation cycle. Window *QuickLOAD* results is activated :

QuickLOAD Results window

During calculation, background color of *Results* window changes. Background appears yellow, during calculation of progressive part; then red, during degressive part; then gray, at end of powder combustion. This function allows observation of progress during long calculations on slow computers.

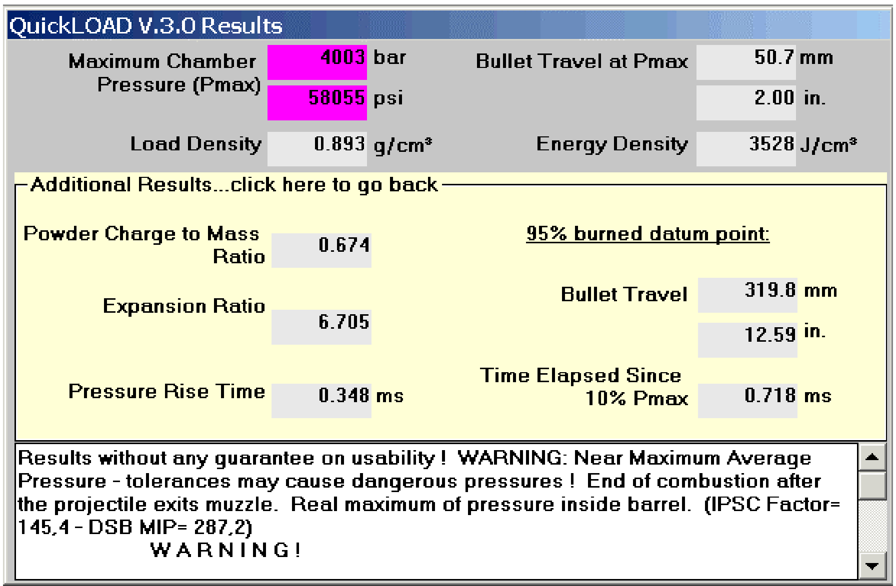
Choosing unrealistic interior ballistics combinations can result in calculations that last several seconds, such situations are always possible. An overflow error can occur and display. In this situation, either lower the calculation resolution (options menu) or alter other input values.

Results Window (initial display)



Picture 55: Results window

Results Window (alternative display)



Results window displays significant interior ballistics computational results:

- Maximum Chamber Pressure (P_{max}):
  - P_{max}, Peak chamber pressure, shown in MPa or bar (depending upon settings) and psi;

Values comparable with conventional piezo transducer data. Do not compare with CUP-, conformal transducer- or strain gauge data. Background color of this field indicates pressure regime of calculated load. Default values use the following color scheme: YELLOW between 75% and 85% of P_{max}; CYAN between 85% and 100% of P_{max}; RED exceeds P_{max} (or no maximum cartridge pressure specified).

(Result of pressure calculation depends strongly upon quality of propellant data. With "weak" *propellant data, the user must expect serious deviations from actual values.)*

- Loading density:
  - Ratio of charge weight (grains) to usable case capacity (grains of water) or grams per cubic centimeters; ***Contrary to common belief, this contains no comparative information about the space occupied by the charge. A Loading Density of "1" does not necessarily mean a totally filled case!*** *For example: A charge with a low Loading Density value may result in a compressed load by using a powder with low bulk density – opposite, a higher Loading Density obtained with high bulk density powder which may not fill the case sufficiently.*
- Bullet movement at P_{max}:
  - Distance projectile base has moved at occurrence of maximum chamber pressure (P_{max});
- Energy density:
  - Ratio of charge energy to useable case capacity (net combustion chamber volume) (J/cm^3);
- Muzzle pressure:
  - Pressure at bullet base when bullet passes muzzle;

(Typically about 15% less than chamber pressure, depending upon load characteristics. For chamber pressure results at each increment of bullet travel, see Progress of combustion *display under options.)*

- Barrel time, 10% P_{max} to muzzle:
  - Time between instant chamber pressure first reaches 10% of P_{max} and the instant bullet base passes muzzle;
- Amount of burned propellant:
  - Percentage of starting charge burned when bullet base passes muzzle;
- Muzzle velocity:
  - Projectile velocity (V_0) at the instant bullet base passes muzzle. (Units, m/s & fps.);
- Projectile energy:
  - Bullet kinetic energy (E_0), without rotational energy, at muzzle exit. Units in Joules & foot pounds;
- Ballistic efficiency:
  - Ratio of bullet energy to theoretical powder charge energy;

(As noted above, a text field for comments is located in the lower part of the window. It displays messages corresponding to these calculations as well as IPSC Factor and German DSB MIP factor).

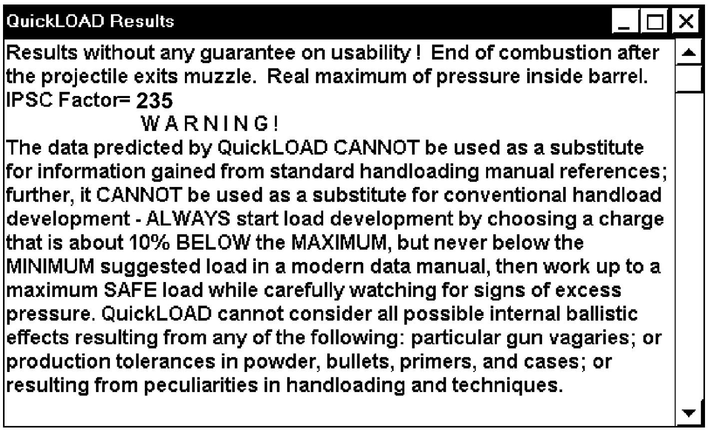
Single-clicking on the message, *Values when bullet base exits muzzle… click here for more data* brings up the following additional values in the center portion of the *Results* window:

- Charge to mass ratio:
  - Charge weight divided by bullet weight;
- Expansion ratio:
  - Total volume of chamber and barrel divided by usable chamber volume (case capacity with a seated bullet);
- Pressure rise time:
  - Time between first occurrence of 10% of P_{max} and maximum chamber pressure;
- Bullet movement at "all-burnt":
  - Distance bullet has moved when 100% of the powder charge has burned; *(An "n.a." in this field signifies that the powder did not finish burning before the bullet exited the muzzle).*
- Time 10% P_{max} to "all-burnt":

- Time between instant that 10% of maximum pressure first occurred and instant that 100% of the powder charge burned; *(An "n.a." in this field signifies that the powder did not finish burning before the bullet exited the muzzle).*

The *Results* text, partially displayed in the above representation of the standard *Results* window, contains important and useful information about the calculated load. To temporarily display this entire message, position the mouse cursor over the visible text and single-click the left mouse button. To view the entire message it is also sometimes necessary to use the scroll function. Moving the cursor from the message cancels this display.

Results Text Window


QuickLOAD Results

Results without any guarantee on usability ! End of combustion after the projectile exits muzzle. Real maximum of pressure inside barrel.
IPSC Factor= 235
WARNING!
The data predicted by QuickLOAD CANNOT be used as a substitute for information gained from standard handloading manual references; further, it CANNOT be used as a substitute for conventional handload development - ALWAYS start load development by choosing a charge that is about 10% BELOW the MAXIMUM, but never below the MINIMUM suggested load in a modern data manual, then work up to a maximum SAFE load while carefully watching for signs of excess pressure. QuickLOAD cannot consider all possible internal ballistic effects resulting from any of the following: particular gun vagaries; or production tolerances in powder, bullets, primers, and cases; or resulting from peculiarities in handloading and techniques.

Picture 56: Results Comments Display

Example text, only applicable to the example calculation:

(This window can contain messages similar to any of the following, along with other important information.)

- End of combustion after bullet exits muzzle:
  - Powder combustion near the end of granule burning is highly variable because the geometry of burned-down granule will split into "slivers" of different shape. Program assumes an evenly burning through all layers of powder granule. When the program indicates that 100% of combustion is reached near the end of the bore, it is likely that some incompletely burned powder will still exist; *(Variations in powder lots and other factors significantly affect this data point.)*
- Real maximum of pressure (P_{max}) inside barrel:
  - A normal, or real, pressure maximum has occurred; Pressure rises to peak and then drops before bullet exits barrel.
- Unreal maximum of pressure when bullet passes muzzle:
  - Barrel length so short that a "real" maximum pressure cannot occur; *(Any such data is highly suspect and such loads cannot be used in a gun with a longer barrel because excessive pressures will occur.)*
- Unreal maximum of pressure at end of combustion cycle:
  - Entire propellant charge converted before a real maximum pressure is reached. *(This calculation result can occur under highly artificial situations.)*

Various *Results* window pressure warnings (not necessarily visible without manipulation of the results text…):

- Peak pressure between 85% and 100% of entered Maximum Average Pressure elicits the following message:
  - *WARNING: Pressure near maximum level - unknown tolerance variations can cause dangerous pressure! Component tolerances could result in excessive loads.*
- When peak pressure exceeds specified Maximum Average Pressure the following message is displayed:
  - *DANGER: Pressure exceeds maximum level! Pressure exceeds given Maximum Average Pressure. Cartridge case or Gun could fail with catastrophic results.*

- When no Maximum Average Pressure is listed, the following message will display and print:
  - *DANGER: Unknown Maximum Average Pressure. Pressure may exceed maximum level! No Maximum Average Pressure value is entered. No reference value exists.*
- After calculations are completed, all results are entered into *QuickLOAD Results* window and into *QuickLOAD table* window or the *QuickLOAD Diagram* window as selected.

Remember, these are not handloading recommendations!

Qu predictions n of all entr sult represents any handloading recommendation! Rather, this data represents a "comparative analysis." This , bullet length or weight and cartridge overall length. These results also give fair comparisons of various cartridges using similar components and loading pressures. Finally, this data provides very useful and accurate information on the results of altering barrel length with any given loading.

Table Window

QuickLOAD V.3.0 Table

Copy to... Toggle units Fonts

```
Cartridge           : .40 S&W
Bullet              : .400, 180, SRA JHP FN 8460
Cartridge O.A.L. L6: 1.135 inch or 28.83 mm
Barrel Length       : 3.9 inch or 98.0 mm
                    : Alliant HERCO ,ähnlich
Charge              : 6.0 grains or 0.39 grams

Estimates of the progress of combustion:
```

NR.:	x(in.)	Z(%)	v(fps)	p(psi)	t (ms)
0	0,00000	1,39	0,0	2176	0,0000
1	0,00002	1,48	0,9	2317	0,0012
2	0,00007	1,59	2,0	2501	0,0042
3	0,00019	1,75	3,5	2739	0,0080
4	0,00044	1,95	5,5	3053	0,0125
5	0,00087	2,22	8,1	3460	0,0177
6	0,00154	2,57	11,4	3978	0,0235
7	0,00255	3,00	15,5	4624	0,0298
8	0,00398	3,55	20,5	5416	0,0364
9	0,00595	4,24	26,7	6380	0,0434
10	0,00857	5,10	34,3	7543	0,0505
11	0,01197	6,16	43,4	8922	0,0578
12	0,01630	7,47	54,3	10540	0,0652
13	0,02170	9,08	67,3	12416	0,0726
14	0,02834	11,05	82,4	14555	0,0800
15	0,03641	13,46	100,1	16965	0,0873
16	0,04482	16,00	117,8	19300	0,0938
17	0,06106	20,14	146,5	22462	0,1040
18	0,07803	24,19	175,2	24969	0,1128
19	0,09601	28,12	203,9	26897	0,1207
20	0,11523	31,95	232,6	28311	0,1281

QuickLOAD V.3.0 Table

Copy to... Toggle units Fonts

32	0,24259	50,10	381,0	29495	0,1627
33	0,27445	53,28	409,7	28870	0,1695
34	0,30939	56,36	438,3	28060	0,1763
35	0,34781	59,34	467,0	27094	0,1834
36	0,39017	62,21	495,7	26002	0,1907
37	0,43698	64,97	524,4	24810	0,1984
38	0,48886	67,63	553,1	23541	0,2064
39	0,54652	70,19	581,8	22218	0,2149
40	0,61078	72,64	610,5	20858	0,2239
41	0,68262	74,98	639,2	19481	0,2334
42	0,76319	77,22	667,9	18101	0,2437
43	0,85385	79,35	696,6	16731	0,2548
44	0,95622	81,38	725,3	15385	0,2668
45	1,07224	83,31	753,9	14072	0,2799
46	1,20425	85,13	782,6	12802	0,2942
47	1,35507	86,84	811,3	11581	0,3099
48	1,52817	88,45	840,0	10416	0,3274
49	1,72776	89,96	868,7	9312	0,3469
50	1,95907	91,36	897,4	8272	0,3687
51	2,22861	92,65	926,1	7300	0,3933
52	2,54455	93,84	954,8	6398	0,4213
53	2,91720	94,92	983,5	5565	0,4534
54	3,12878	95,43	997,8	5175	0,4712
55	3,24171	95,67	1005,0	4986	0,4806
56	3,30008	95,79	1008,6	4894	0,4854
57	3,32976	95,85	1010,4	4848	0,4879
58	3,34472	95,87	1011,3	4825	0,4891
59	3,35223	95,89	1011,7	4813	0,4897
60	3,35270	95,89	1011,7	4813	0,4898
61	3,35294	95,89	1011,8	4812	0,4898

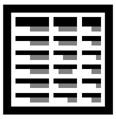
Muzzle

Picture 57: Progress of Combustion table

(This example representation shows two segments of the complete output for a specific calculation.)

Window *QuickLOAD* table is activated from main menu bar under *Options, Output window settings sub-menu, Progress of combustion.*

(This window is also available through this Symbol toolbar icon.*)*



This table lists the results of one interior ballistics calculation cycle. The header of the table contains a short identification of the cartridge. By columns, each line contains:

1. Line and waypoint number,
2. projectile displacement (x),
3. % of charge burnt (z),
4. projectile velocity (v),
5. chamber pressure (p),
6. transition time (t in milliseconds).

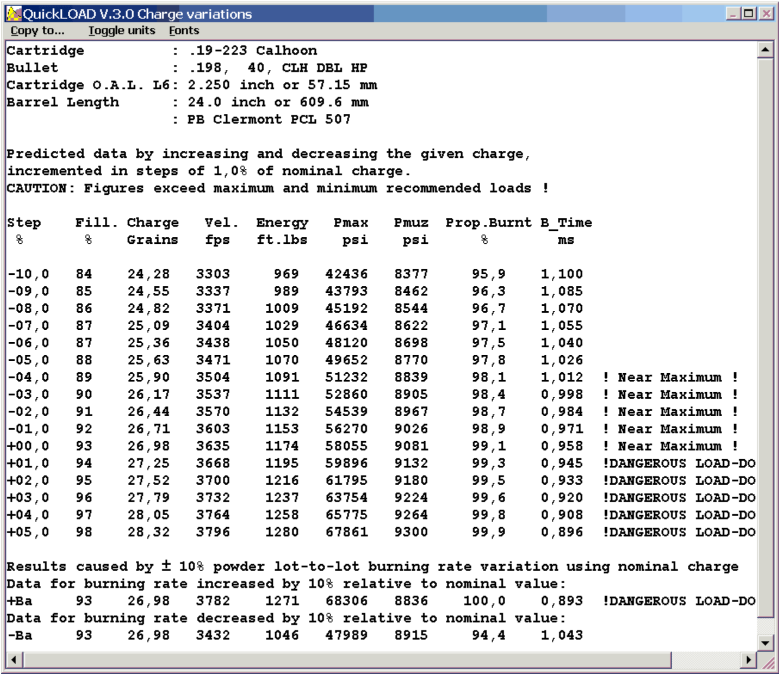
Within *QuickLOAD*, time calculations begin when the bullet base is at the muzzle and proceed backward, to when the bullet base was closer to the breech. A maximum of 950 lines per calculation is possible. At *Resolution... low,* no time values are displayed.

The User may edit the entire text of the table. After starting a new calculation or using the Menu *Toggle units*, all edited text is replaced by default text.

With mouse cursor positioned on window and left mouse button pressed, window contents are selected. Then under menu point *Copy to...* copies data to a file, the clipboard or MS-Excel (when MS-Excel is completely installed; however, we cannot guarantee that this function will operate correctly). With Menu *Toggle Units*, the user can switch between English and Metric units.

If mouse pointer is located within this window and the user presses the right mouse button, font of window can be changed by dialogue. Only fixed-space (monospaced) fonts should be used (e.g. **COURIER NEW**). (Pressing the < Alt > key activates the menu line.)

Charge Variations Window

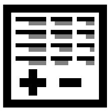


```
QuickLOAD V.3.0 Charge variations
Copy to...   Toggle units   Fonts
Cartridge          : .19-223 Calhoon
Bullet             : .198,  40, CLH DBL HP
Cartridge O.A.L. L6: 2.250 inch or 57.15 mm
Barrel Length      : 24.0 inch or 609.6 mm
                   : PB Clermont PCL 507

Predicted data by increasing and decreasing the given charge,
incremented in steps of 1,0% of nominal charge.
CAUTION: Figures exceed maximum and minimum recommended loads !

Step    Fill. Charge  Vel.  Energy  Pmax    Pmuz  Prop.Burnt B_Time
 %       %    Grains  fps   ft.lbs   psi    psi       %        ms

-10,0   84    24,28   3303    969   42436   8377     95,9    1,100
-09,0   85    24,55   3337    989   43793   8462     96,3    1,085
-08,0   86    24,82   3371   1009   45192   8544     96,7    1,070
-07,0   87    25,09   3404   1029   46634   8622     97,1    1,055
-06,0   87    25,36   3438   1050   48120   8698     97,5    1,040
-05,0   88    25,63   3471   1070   49652   8770     97,8    1,026
-04,0   89    25,90   3504   1091   51232   8839     98,1    1,012   ! Near Maximum !
-03,0   90    26,17   3537   1111   52860   8905     98,4    0,998   ! Near Maximum !
-02,0   91    26,44   3570   1132   54539   8967     98,7    0,984   ! Near Maximum !
-01,0   92    26,71   3603   1153   56270   9026     98,9    0,971   ! Near Maximum !
+00,0   93    26,98   3635   1174   58055   9081     99,1    0,958   ! Near Maximum !
+01,0   94    27,25   3668   1195   59896   9132     99,3    0,945   !DANGEROUS LOAD-DO
+02,0   95    27,52   3700   1216   61795   9180     99,5    0,933   !DANGEROUS LOAD-DO
+03,0   96    27,79   3732   1237   63754   9224     99,6    0,920   !DANGEROUS LOAD-DO
+04,0   97    28,05   3764   1258   65775   9264     99,8    0,908   !DANGEROUS LOAD-DO
+05,0   98    28,32   3796   1280   67861   9300     99,9    0,896   !DANGEROUS LOAD-DO

Results caused by ± 10% powder lot-to-lot burning rate variation using nominal charge
Data for burning rate increased by 10% relative to nominal value:
+Ba     93    26,98   3782   1271   68306   8836    100,0    0,893   !DANGEROUS LOAD-DO
Data for burning rate decreased by 10% relative to nominal value:
-Ba     93    26,98   3432   1046   47989   8915     94,4    1,043
```

Picture 58: Charge Variations Results

QuickLOAD Charge Variations window is displayed by activation from main menu bar under *Options, Output window settings* sub-menu, *Charge increments of one propellant*.

(This window is also available through this Symbol toolbar icon.*)*



To print this table use *File..., Print....* On a color printer, values exceeding specified maximum average pressure (P_{max}) are printed in red.

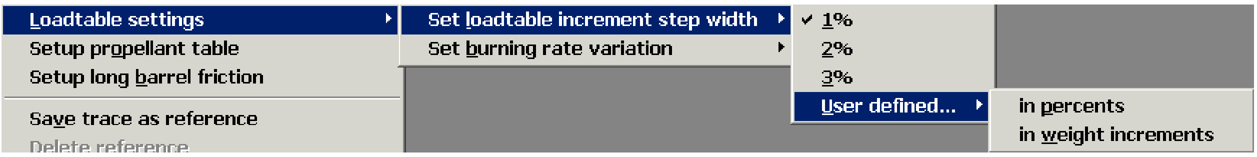
This table shows results of one interior ballistics calculation on one line; each line contains data for a different charge, by columns:

1. Deviation in % of specified charge,
2. Powder filling percentage,
3. Charge weight,
4. Velocity,
5. Energy,
6. P_{max},
7. Muzzle Pressure,
8. Burnt propellant quantity in %,
9. Barrel time in milliseconds.

Data is referenced from entered nominal charge in window *QuickLOAD Charge*.

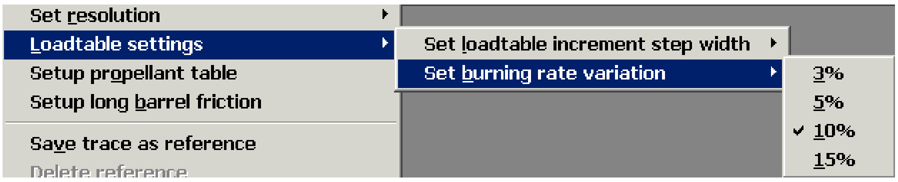
Bottom line of incremental charges usually shows 20% lighter charge (depending upon chosen Loadtable increment). Charge increases in each line by about 2% up to line 16, which then displays a charge that is about 10% heavier than the specified charge (again, depending upon the specified increment).

User can set incremental percentage in *Menu Options, Loadtable step width:*



Picture 59: Set Loadtable increment

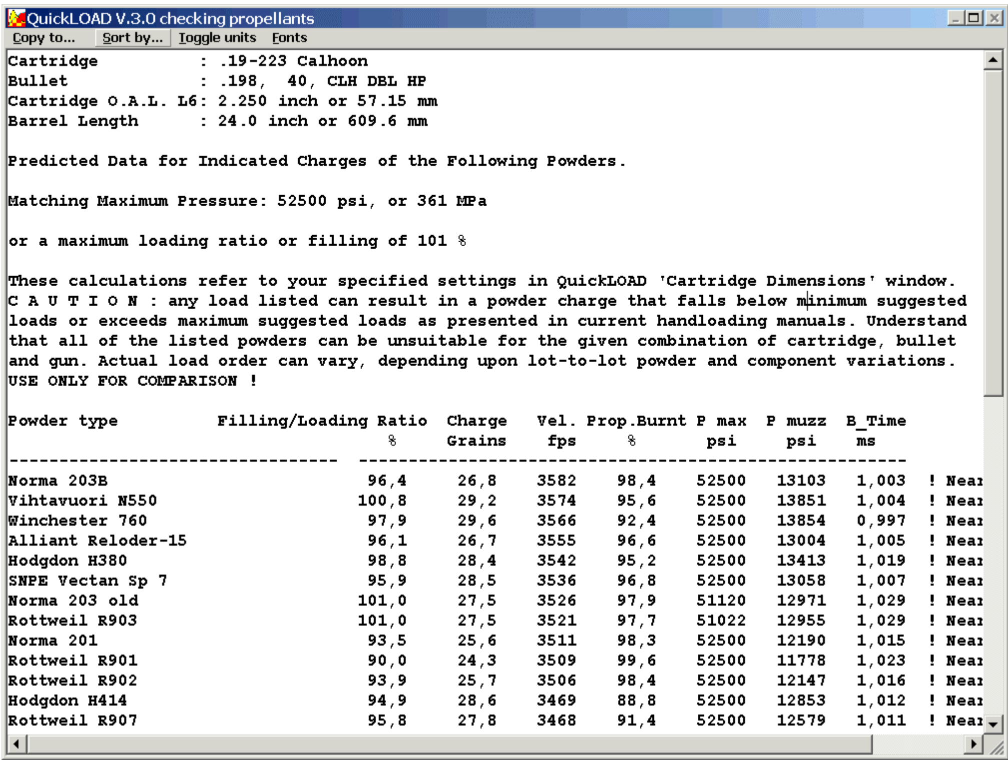
The lower two lines contain calculations at nominal charge weight but the +Ba line contains results for an increased burning rate of powder by 10% while the -Ba line contains results for a by 10% lowered burning rate. The burning rate alteration percentage can be selected by main menu *Options, Loadtable settings, Set burning rate variation* - percentage:



Picture 60: Set burning rate variation

User may edit the text of this window. With mouse cursor and left mouse button select contents of this window. Then, under menu point *Copy to...*, copy table to file, clipboard, printer or MS-Excel.
Positioning mouse pointer within window and pressing right mouse button facilitates window font change (see above).

Checking propellants window



QuickLOAD V.3.0 checking propellants
Copy to... Sort by... Toggle units Fonts

```
Cartridge           : .19-223 Calhoon
Bullet              : .198,  40, CLH DBL HP
Cartridge O.A.L. L6: 2.250 inch or 57.15 mm
Barrel Length       : 24.0 inch or 609.6 mm

Predicted Data for Indicated Charges of the Following Powders.

Matching Maximum Pressure: 52500 psi, or 361 MPa

or a maximum loading ratio or filling of 101 %

These calculations refer to your specified settings in QuickLOAD 'Cartridge Dimensions' window.
C A U T I O N : any load listed can result in a powder charge that falls below minimum suggested
loads or exceeds maximum suggested loads as presented in current handloading manuals. Understand
that all of the listed powders can be unsuitable for the given combination of cartridge, bullet
and gun. Actual load order can vary, depending upon lot-to-lot powder and component variations.
USE ONLY FOR COMPARISON !
```

Powder type	Filling/Loading Ratio %	Charge Grains	Vel. fps	Prop.Burnt %	P max psi	P muzz psi	B_Time ms	
Norma 203B	96,4	26,8	3582	98,4	52500	13103	1,003	! Near
Vihtavuori N550	100,8	29,2	3574	95,6	52500	13851	1,004	! Near
Winchester 760	97,9	29,6	3566	92,4	52500	13854	0,997	! Near
Alliant Reloder-15	96,1	26,7	3555	96,6	52500	13004	1,005	! Near
Hodgdon H380	98,8	28,4	3542	95,2	52500	13413	1,019	! Near
SNPE Vectan Sp 7	95,9	28,5	3536	96,8	52500	13058	1,007	! Near
Norma 203 old	101,0	27,5	3526	97,9	51120	12971	1,029	! Near
Rottweil R903	101,0	27,5	3521	97,7	51022	12955	1,029	! Near
Norma 201	93,5	25,6	3511	98,3	52500	12190	1,015	! Near
Rottweil R901	90,0	24,3	3509	99,6	52500	11778	1,023	! Near
Rottweil R902	93,9	25,7	3506	98,4	52500	12147	1,016	! Near
Hodgdon H414	94,9	28,6	3469	88,8	52500	12853	1,012	! Near
Rottweil R907	95,8	27,8	3468	91,4	52500	12579	1,011	! Near

Picture 61: Propellant table

QuickLOAD Propellant table window is displayed by activation from main menu bar under *Options, Setup Propellant table*.
(This window is also available through this Symbol toolbar icon.*)*

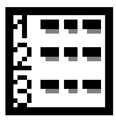
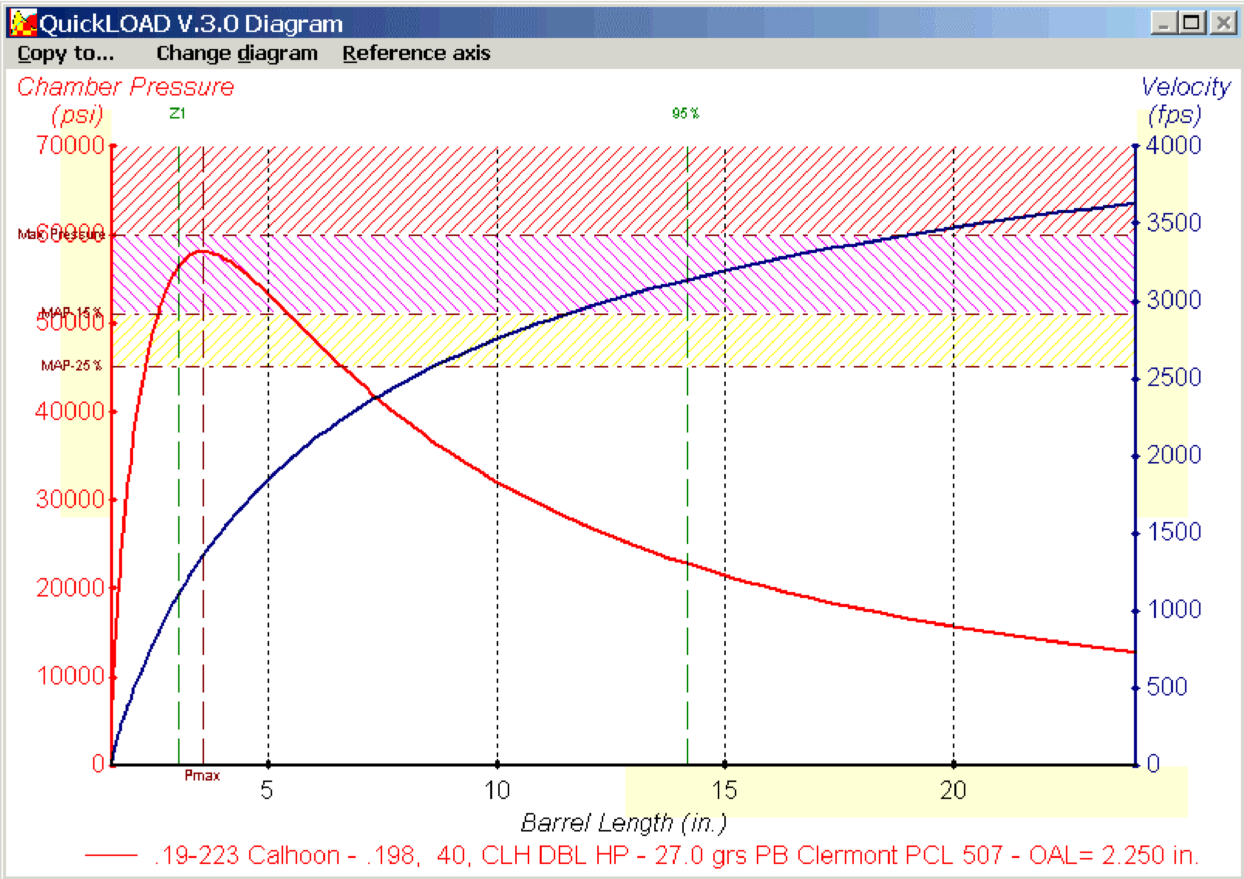


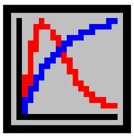
Table contains information about cartridge and one line with results for each powder in selected range. The first column contains the powder's name, the other columns are depend on your settings in Propellant table setup window (see Page 24 Propellant table setup)

Graphic outputs of results

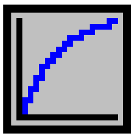


Picture 62: Diagram Velocity and Pressure vs. Barrel length

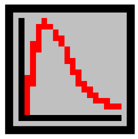
Six standard graphical windows are available by following Symbolbar icons:



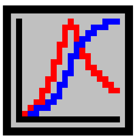
Velocity and Pressure vs. Bullet Travel



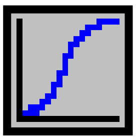
Velocity vs. Bullet Travel



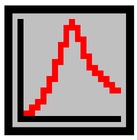
Pressure vs. Bullet Travel



Velocity and Pressure vs. Time

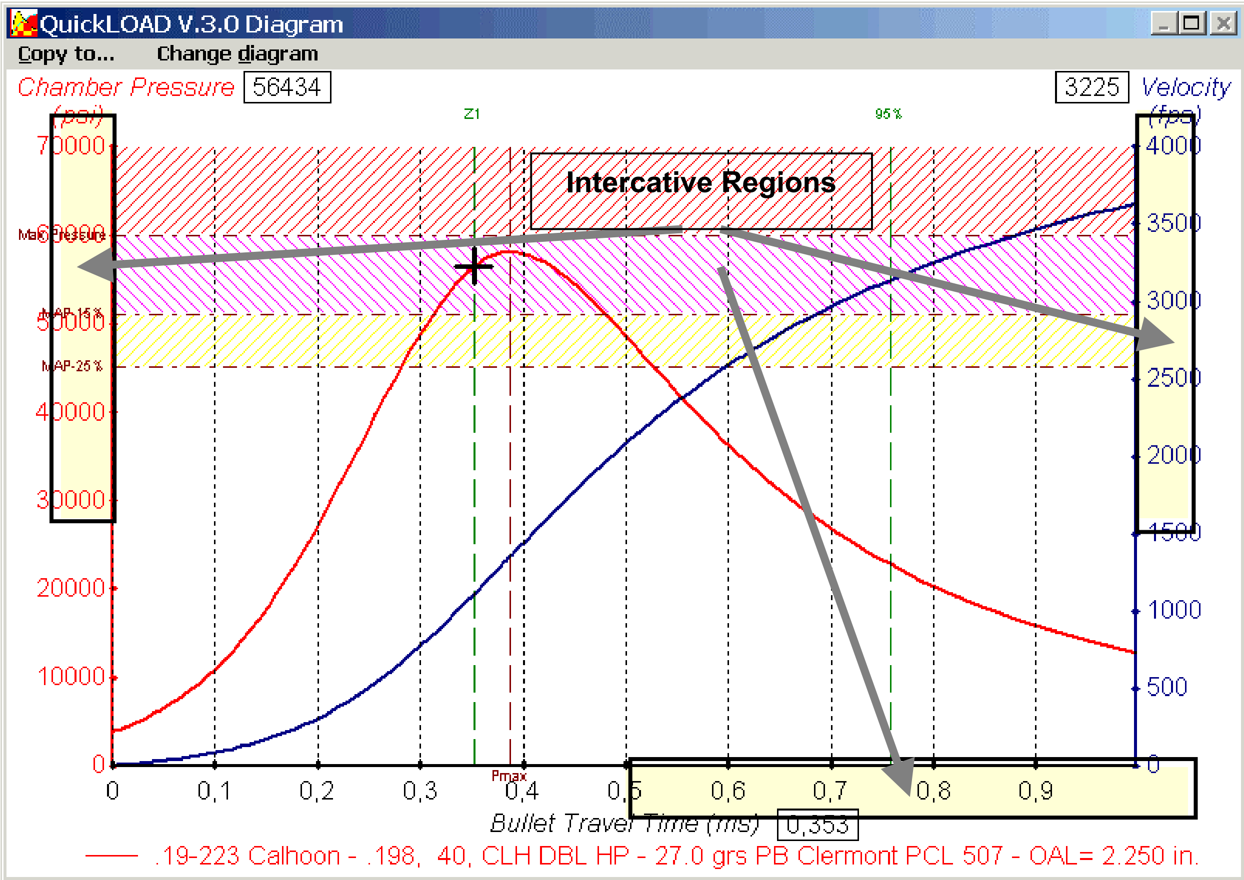


Velocity vs. Time



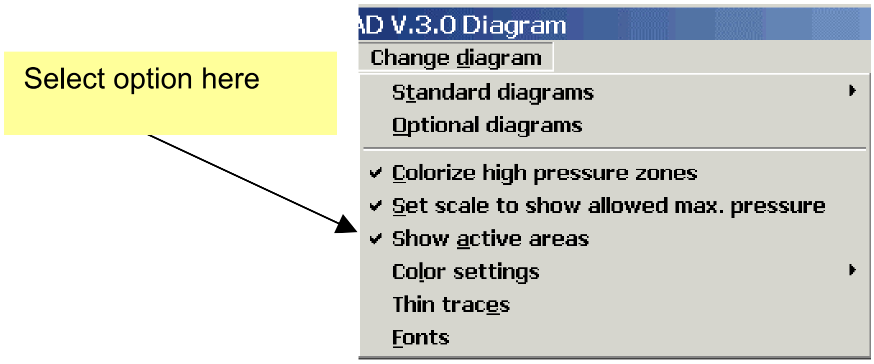
Pressure vs. Time

Automatic Interactive Recalculation



Picture 63: Automatic Recalculation

The six standard graphs provide an "Active Region" feature.
Under menu *Change diagram, Show active areas* the user may toggle the active regions on and off.



Picture 64: Diagram: Menu Change diagram

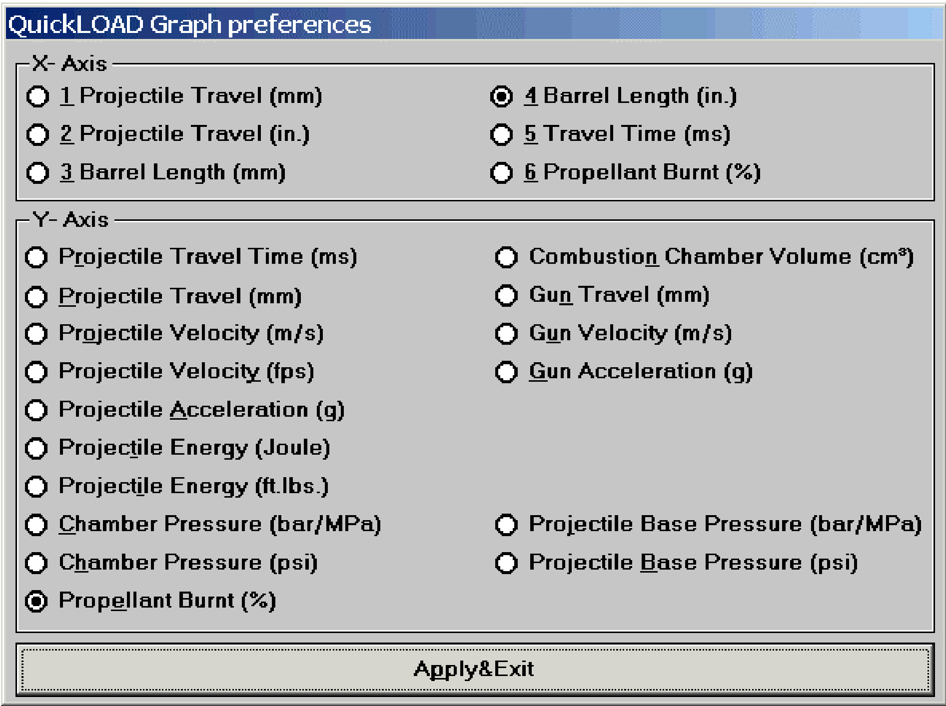
The activated region is marked in light yellow color. When the mouse cursor is over active part of one of three possible axis the cursor changes to an up-arrow indicating being over active area. The corresponding numerical box is highlighted. Always when box is highlighted, single-clicking the mouse recalculates :

- charge to achieve highlighted pressure,
- charge to achieve highlighted muzzle velocity
- charge to achieve highlighted travel time
- barrel length to highlighted length

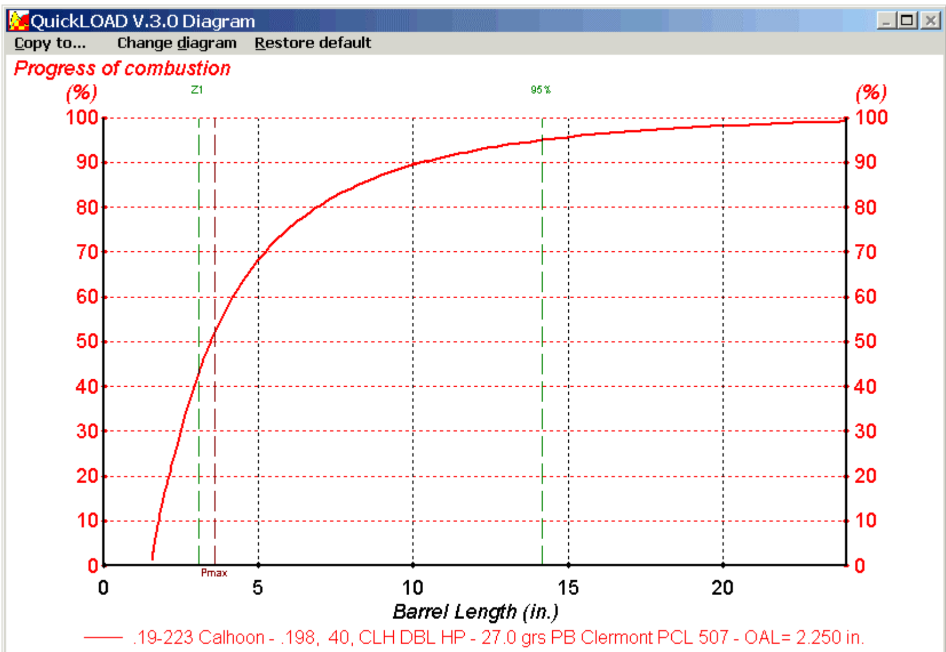
This diagram shows velocity and pressure curves vs. Time axis. The mouse cursor is over the drawing area and looks like a small crosshair. In this picture cursor is located at the point where the green Z1 marking crosses the red pressure curve. The small numeric fields near by the axis' legends reports at anytime values of pressure, velocity time and/or bullet travel.

Additional to six standard graphs you may select up to 64 different graphical displays. Selecting menu *Change diagram, Optional diagrams opens following window:*

Graph preferences



Picture 65: Graph preferences window



Picture 66: Example of an optional graph

Example shows amount of propellant burnt versus bullet's base position in barrel

APPENDIX

QLOADFW.INI

Short explanation of single positions in an example file

[startup]	Keyword
excel_yes=-1	enable Excel automation -1=on, 0=off
schrit= 1	Computational resolution 0,1,2
ldstep= 1	Loadtable steps
metyes= 0	Units –0=english 1=metrisch
tabfon=Courier New	Font name for spreadsheets
tabsiz= 8	Font size for spreadsheet in points
tabbld=-1	Font bold for spreadsheet -1=on
scrfon=MS Sans Serif	Screen font name
scrsiz=8	Screen font size in points
scrbld=-1	Screen font bold, -1=on
scrita=0	Screen font italic, 0=off
volfil=c:\qloadfw\qloadfw.	Cartridge volume file
ibulfil=c:\qloadfw\qloadfw.	Bullet file used by QuickLOAD
ebulfil=c:\qloadfw\qloadfw.	Bullet file used by QuickTARGET
profil=c:\qloadfw\qloadfw.	Powder file
ititle=	Printer title line for QuickLOAD
etitle=	Printer title line for QuickTARGET
labfil=c:\qloadfw\308.dat	Actual loaded lab-file
filcnt= 9	Recent file count (4 to 9)
recent0=c:\qloadfw\308.	Recent lab file
recent1=c:\qloadfw\308.	Recent lab file
recent2=c:\qloadfw\30-379.	Recent lab file
recent3=c:\qloadfw\222.	Recent lab file
[tiphelp]	Keyword
toltip= 0	Tooltips on=-1 off=0
tiptim= .5	Tip duration minimum in sec.
tipwid= 3000	Width of the tip-window
[constants]	
norm_P0=98066.5	Technical pressure p0 in Pascals
dicht_H2=.998	Density of water
dicht_ms=8.65	Density of brass
dicht_fe=7.87	Density of soft steel
dicht_al=2.75	Density of aluminium
pri_font_nam=ARIAL	Printer font name
pri_font_siz=8	Printer font size
pri_graph1page=1	Print all on one page
[exterior]	Keyword
anifil=c:\qloadfw\pr_dog.wmf	Target wmf-file (picture)
tgtfil=c:\qloadfw\nra_c-2.tgt	Target with rings
trjfil=c:\qloadfw\338_200.	Trajectory file for QuickTARGET
filcnt= 4	Recent file count maximum (4 to 9)
recent0=c:\qloadfw\338_200.	Recent Trajectory file
recent1=c:\qloadfw\338_250.	Recent Trajectory file
recent2=c:\qloadfw\222_55.	Recent Trajectory file
recent3=c:\qloadfw\7x64DK~1.	Recent Trajectory file
[metrics]	Keyword
pattyp=.300 WIN MAG	Ammunition identifier
bultyp=Soft Point	Bullet type
[chargedata]	Keyword
pulver=Spherical 4701	Propellant identifier
abkof0=.424	Burning rate coefficient
[referenz]	Keyword
...............Reference data follows	
[recoil]	Keyword
gunmas=3.5	Weight of gun
[user]	Keyword

1=BF3BCAB308F338125AC36BCDBBED5C5D187C3F8BEC22D8518D4AAEB8
2=8C4B8A53667B546D4A706A63629DFBD3FCDBFDF21CB511B51C8031662E

Caution: never change license string under [user].

QLOADFW.VOL

These data files are subject to change without any notice.!

Example:

; This is a test file for case volumes

" 7 [patronen]"

".308 Win. ","57","2.01",".308",".5","47.5","415","Piezo CIP","2.8",_
"1.56","1.712",".054",".473",".471",".454",".343",".343","0","193",_ __"",""

Description:

At the beginning of the file we can place comment lines beginning with a semicolon. The keyword [patronen] is always located in the line before the data lines. This is preceded by a number that correspond to the number of following data lines (in this example 7). If this number is wrong, a faulty reading may occur and an error could follow. Likewise each line must include 21 fields (,"ABC","","", etc.), each in parentheses. Some can be empty. Also, no empty lines are allowed. Decimal points must be represented by a point (.). No parentheses and no commas are allowed within data.

Structure of a data line:

”name of cartridge ”,
”Case volume Grains Water ”,
”Case length L3 in inches ”,
”Groove diameter/caliber in inches”,
”Sebert’s factor”,
”Bore area in mm^3 ”,
”Maximum average pressure in MPa”,
”Method of measurement, body of regulation“,
”Cartridge length L6 inches“,
”Length to shoulder L1 inches“,
”Length to neck L2 inches“,
”Rim thickness R inches“,
”Rim diameter R1 inches“,
”Base diameter P1 inches“
”Shoulder diameter P2 inches“,
”Neck diameter at shoulder H1 inches“,
”Neck diameter at mouth H2 inches“,
”Type code“,
”Case weight in grains“,
“coded case dimensions“,““

The maximum allowable average gas pressure is taken from CIP, ANSI/SAAMI publications, whenever possible. It is important to use pressure values resulting from piezoelectric transducers.

QuickLOAD can represent only such values, which cannot be obtained by or converted from copper crushers data, conformal transducers or strain gauge transducers.

.

QLOADFW.PRO

Example of file:

```
" 5 [pulver]"
"Vihtavuori N150    ","3780"," 1.2560"," 1.560"," 0.4300"," 2.985","0.356","1.790"
"Hodgdon H4198   ","”4000"," 1.2530"," 1.635"," 0.6140"," 0.699","0.736","2.395"
"Alliant UNIQUE    ","4550"," 1.2220"," 1.630"," 2.2335"," 6.000","0.186","1.6123"
"Norma 200           ","4010"," 1.2400"," 1.580"," 0.7052"," 0.197","0.413","1.357"
"IMR 4227             ","3990"," 1.2590"," 1.500"," 0.9310"," 1.790"," .613","2.3279"
```

Description:
For special characters refer to qloadfw.vol section.

Structure of a data line:

" 35 characters name of powder ",
+"Heat of explosion Q_{ex} in J/g",
+"Ratio of spec. heats cp/cv",
+"Solid density in g/cm^{3}",
+"Burning coeff B_a",
+"Progress/degress. factor. a_0",
+"Limit z_1",
+"Factor b",
+“Bulk density”
+Any further necessary empty placeholders ,""

The + signs is used here only because the text will not fit onto one line.
In case of a corrupted file, a backup copy or a renamed backup file *.vo$ or *.pr$ can be used.

QLOADFW.BUL

Bullet file

Example of file:

; This is a comment line beginning with a semicolon
" 108 [bullet] "
".284, 160, Sierra SPBT   ","160","1.258","5.59","7.21","3.68","0","2",_
".284",".447",".447",".462",".464",".452","0","2800","2300","1600",_ "0","0","25"

Description:
For special characters refer to qloadfw.vol section.

Structure of a data line, must contain 21 entrys or placeholders:

”35 characters name of bullet”,
”Bullet weight in grains”,
”Bullet overall length in inches”,
”Boattail/Hollowbase small diameter in mm”,
”Boattail/Hollowbase large diameter in mm”,
”Boattail/Hollowbase length in mm”,
””,
”Tail code “,   1=Hollow base; 2=Boattail
”Bullet diameter in inches“,
”single BC“,
”1.BC“,
”2.BC“,
”3.BC“,
”4.BC“
”5.BC“,
”1.V in fps“,
”2.V in fps“,
”3.V in fps“,
”4.V in fps“,
““,
“Shot-start pressure in MPa“

Bullet Manufacturer Abbreviations and File Names

Abbreviation Manufacturer	*Bullet File Name*
ABW = Alaska Bullet Works	ALASKA.BUL
ASQ = Asquare	ASQUARE.BUL
BAR = Barnes	BARNES.BUL
BER = Berger	BERGER.BUL
Blaser	BLASER.BUL
CLH = Calhoon Bullets	CALHOON.BUL
CBB = Colorado Bonded	COLORADO.BUL
CT = Combined Technology	COMBINED.BUL
DEL = Delsing Speciality Bullets	DELSING.BUL
DKT = DKT (Huntington)	DKT.BUL
FED = Federal	FEDERAL.BUL
FIO = Fiocci	FIOCCI.BUL
Fortek	FORTEK.BUL
GPA = G.P.A. Bullets	GPA.BUL
HWK = Hawk Bullets	HAWK.BUL
HIR = Hirtenberger	HIRTENB.BUL
H&N = Haendler&Natermann	H-NSPORT.BUL
HDY = Hornady	HORNADY.BUL
IMI = IMI Bullets	IMI.BUL
Impala = Impala Bullets	IMPALA.BUL
JLK = JLK Bullets	JLK.BUL
LAP = Lapua	LAPUA.BUL
LRB = Lost River Technologies	LOSTRIVR.BUL
LYM = Lyman	LYMAN.BUL
MEN = Metallwerke Elisenhuette Nassau	MEN.BUL
NOR = Norma	NORMA.BUL
NOS = Nosler	NOSLER.BUL
PMC = PMC Bullets	PMC.BUL
PMP = Pretoria Metal Pressing	PMP.BUL
RCB = RCBS	RCBS.BUL
RBG = Reichenberger Bullets	REICHENB.BUL
REM = Remington	REMINGT.BUL
RWS = Dynamite Nobel Bullets	RWS.BUL
SAK = Sako	SAKO.BUL
SEB = Sellier&Bellot	SEL_BEL.BUL
SHI = Shilen	SHILEN.BUL
SRA = Sierra	SIERRA.BUL
SIF = Sinterfire	SINTERFI.BUL
SPR = Speer	SPEER.BUL
SWF = Swift	SWIFT.BUL
RUA = Swiss (SM, RUAG) Bullets	SWISRUAG.BUL
WIN = Winchester	WINCHES.BUL
WDL = Woodleigh	WOODLEI.BUL

... used in *QuickLOAD* and *QuickTARGET.*

NOTE: Actual file count shipped with program may differ from this list because companies disappeared or new brands emerged meanwhile. Not all bullets contain full dimensions, some bullets contain only BC's. Some manufacturers refuse to submit dimensional data.

Propellant Data in *QuickLOAD*

following powder types have been included in *QuickLOAD:*

Accurate Solo 1000
Accurate Solo 1250
Accurate Solo 4100
Accurate Nitro 150
Accurate No.2
Accurate No.5
Accurate No.7
Accurate No.9
Accurate 1680
Accurate 2230
Accurate 2520
Accurate 2460
Accurate 2700
Accurate 8700
Accurate XMR5744
Accurate XMR2015
Accurate XMR2495
Accurate XMR4064
Accurate XMR4350
Accurate XMR3100

ADI AS 30
ADI AS 50N
ADI AP 70N
ADI AP 90
ADI AP 100
ADI AR 2205
ADI AR 2207
ADI AR 2210
ADI AR 2206
ADI AR 2208
ADI AR 2209
ADI AR 2213
ADI AP 2214
ADI AR 2218

Vihtavuori N310
Vihtavuori N320
Vihtavuori N330
Vihtavuori N340
Vihtavuori N350
Vihtavuori 3N37
Vihtavuori N105
Vihtavuori N110
Vihtavuori N120
Vihtavuori N130
Vihtavuori N133
Vihtavuori N135
Vihtavuori N140
Vihtavuori N150
Vihtavuori N160
Vihtavuori N165
Vihtavuori N170
Vihtavuori N540
Vihtavuori N550
Vihtavuori N560
Vihtavuori 24N41
Vihtavuori 20N29

Alliant BULLSEYE
Alliant RED DOT
Alliant HERCO
Alliant GREEN DOT
Alliant UNIQUE
Alliant BLUE DOT
Alliant Power Pistol
Alliant 2400
Alliant Reloder- 7
Alliant Reloder-10x
Alliant Reloder-12
Alliant Reloder-15
Alliant Reloder-19
Alliant Reloder-22
Alliant Reloder-25

Hodgdon Clays
Hodgdon HP38
Hodgdon Universal
Hodgdon H110
Hodgdon H4227
Hodgdon H4198
Hodgdon Benchmark
Hodgdon H322
Hodgdon H4895
Hodgdon BL-C2
Hodgdon Varget
Hodgdon H335
Hodgdon H380
Hodgdon H414
Hodgdon H4350
Hodgdon H4831(SC)
Hodgdon H1000
Hodgdon H870
Hodgdon H50BMG

IMR 4227
IMR 4198
IMR 3031
IMR 4064
IMR 4895
IMR 4320
IMR 4350
IMR 4831
IMR 7828

Lovex D-032
Lovex S-020
Lovex D-063
Lovex S-060
Lovex D-073
Lovex S-070

Norma R1
Norma R123
Norma 200
Norma 201
Norma 202
Norma 203
Norma 203B
Norma 204
Norma MRP
Norma MRP2

Rottweil R901
Rottweil R902
Rottweil R903
Rottweil R904
Rottweil R905
Rottweil R907
Rottweil R910
Rottweil P801
Rottweil P803
Rottweil P804
Rottweil P805
Rottweil P806
Rottweil J706

PB Clermont PCL 514
PB Clermont PCL 509
PB Clermont PCL 515
PB Clermont PCL 506
PB Clermont PCL 501
PB Clermont PCL 504
PB Clermont PCL 512
PB Clermont PCL 508
PB Clermont PCL 507
PB Clermont PCL 516
PB Clermont PCL 517
PB Clermont PCL 513/520

Ramshot ZIP
Ramshot Silhouette
Ramshot True Blue
Ramshot Enforcer
Ramshot X-Terminator
Ramshot TAC
Ramshot Big Game
Ramshot Magnum (Big Boy)

SF 033 fl (Russian)

SNPE Vectan SP 10
SNPE Vectan SP 9
SNPE Vectan Sp 7
SNPE Vectan SP 11

Somchem S335
Somchem S321
Somchem S341
Somchem S365
Somchem S385
Somchem MP200
Somchem MS200
Somchem S221
Somchem S265

NitroChemie AS 0200
NitroChemie AS 0300

Winchester 231
Winchester WAP
Winchester 540
Winchester 296
Winchester 748
Winchester 760
Winchester WXR

Note: Some powder manufacturers and brand holders are not willing or are unable to support author with data of their propellants.

Cartridges in *QuickLOAD*

.14 Jones
.14 Walker Hornet
.14-221 Walker
.14-222
.17 Ackley Bee
.17 Ackley Hornet
.17 Bumble Bee
.17 Hempalina
.17 Hornady Mag Rimfire
.17 Javalina
.17 K Hornet
.17 Libra
.17 Mach IV
.17 Rem.
.17/218 Bee
.17/22-250 Rem
.17/222
.17/223
.17/224 Weatherby
.17/225 Win
.17/30 Carb.
.19 Calhoon
.19-223 Calhoon
.20-17 Rem. (.20 TNT)
.20-222 Rem.
.20-222 Rem.Mag.
.218 Bee
.219 Don. Wasp
.219 ICL Wolverine
.219 Stingray
.219 Zipper
.22 CHeetah MKII
.22 Harvey Kay-Chuk
.22 Hornet
.22 Hornet (.224)
.22 ICL Gopher
.22 Jet Imp. Ackley
.22 K-Hornet
.22 KSS
.22 Krag Short
.22 Long Rifle, experiment.
.22 Mashburn Bee
.22 Maynard Extra Long
.22 Newton
.22 Nieder Mag
.22 PPC USA
.22 Picra
.22 Rem. Jet Mag.
.22 Savage
.22 Savage Imp. Ackl.
.22 Stark
.22 Waldog
.22 Wasp (303)
.22 Win. Mag. R.F. ,experiment.
.22-15-60 Stevens
.22-250 Ackley Imp.
.22-250 Rem.
.22/06 Easling
.22/243 Win.
.22/284 Win
.22/30-30 Ack Imp
.22/3000 Lovell
.22/303 Sprinter
.22/303 Varmit-R
.22/350 Rem.Mag.
.220 Jaybird
.220 Russian (5,6x39)
.220 Swift
.220 Swift Ack Imp
.220 Weatherby Rocket
.221 Rem Fireball
.222 'K' Imp.
.222 Rem.
.222 Rem. Mag.
.222 Rimmed
.223 Ack Imp
.223 Rem.
.223 Rem. (SAAMI)
.223 WSSM
.224 BOZ
.224 HV
.224 Weath. Mag.
.225 Win.
.226 Barnes QT
.226 JDJ
.228 Ackley Mag.
.228 Hawk
.240 Belt. Riml. Nitr. Exp.
.240 Cobra
.240 Flang. Nitro Exp.
.240 Weath. Mag.
.243 Ack Imp
.243 Rockchucker
.243 WSSM
.243 Win.
.244 Ack Imp
.244 H&H Mag. Belted
.244 Halger Magnum
.244 Rem.
.246 Purdey Flg.
.25 ACP (6.35 Browning)
.25 Ackley Mag.
.25 Gibbs
.25 Hornet
.25 Souper
.25 Souper Imp.
.25-06 Ack Imp.
.25-06 Rem.
.25-20 Win.CF
.25-284
.25-35 Win.
.25/222 Copperhead
.25/284 Win
.250 Ack Imp (250 Savage)
.250 Savage
.256 Mag. Gibbs
.256 Newton
.256 Win. Mag.
.257 Ack Imp (257 Rob)
.257 Arch
.257 Jamison
.257 Roberts
.257 Roberts +P (SAAMI)
.257 Roberts Imp.
.257 Weath. Mag
.260 PICRA
.260 Rem
.264 Jamison
.264 Leroy N.E.
.264 Win. Mag.
.270 Ackley Mag.
.270 Ingram
.270 JDJ
.270 Jamison
.270 Savage
.270 WSM
.270 Weath. Mag.
.270 Win.
.270/257 Roberts
.270/284 Win.
.270/300 Weath. Mag.
.270/308 Win.
.270/338 Win Mag.
.275 Belt. N.E.
.275 Fl. Mag. H&H
.275 H&H Belted.
.275 H.V. Rigby (Rimless)
.277 GS
.280 Ack Imp
.280 Halger
.280 Rem.
.280 Riml. NE. Ross
.284 Jamison
.284 Win.
.297/230 Morris Short
.297/230 Morris long
.297/250 Rook Rifle
.30 Borchard
.30 Carbine
.30 Fl. N.E. Purdey
.30 Gibbs
.30 Herrett
.30 Howell
.30 ICL Grizzly
.30 Luger
.30 Newton
.30 PICRA
.30 R Blaser
.30 Rem.
.30-.284
.30-06 Ack Imp
.30-06 Court Cartry
.30-06 Spring.
.30-30 Ack Imp
.30-30 Wesson
.30-30 Win. (CIP)
.30-30 Win. (SAAMI)
.30-357 AeT
.30-378 Weath. Mag.
.30-40 Krag
.30-40 Wesson
.30-78 Single Shot
.30/224 Weatherby
.30/284 Win.
.30/30 Carb.
.30/338 Win. Mag.
.30/348 Ack Imp
.30/348 Win.
.30/350 Rem Mag.
.30/357 Paxton
.30/378 Arch
.30/444 Marlin (Ackley)
.300 Ack Mag Imp (300 H&H)
.300 Dakota
.300 H.& H. Mag.
.300 ICL Tornado
.300 Jamison
.300 Lapua Mag.
.300 Mashburn Sup.
.300 PMVF (Hollyw.Gun Shop)
.300 Pegasus
.300 Phoenix
.300 Rem SA Ultra Mag
.300 Rem Ultra Mag

.300 Savage
.300 Sherwood
.300 WSM
.300 Weath. Mag.
.300 Whisper
.300 Win. Mag.(@)
.300 Win. Mag.(F)
.300 Win. Mag.(N)
.300 Win. Mag.(R)
.300 Win. Mag.(W)
.300/295 Rook Rifle
.303 British
.303 British (SAAMI)
.303 British Imp. Epps
.303 Magnum Jeffery
.303 Savage
.303 Sporting
.307 Win.
.308 Corbon
.308 Norma Mag.
.308 Win.
.308 x 1.5
.308 x 1.75
.309 JDJ
.310 Cadet Rifle
.318 Riml. N.E. Westl Rich.
.32 ACP (7.65 Browning)
.32 Ballard Extra Long
.32 H&R Magnum
.32 Ideal (M44)
.32 Long Colt
.32 Rem.
.32 S&W (Short)
.32 S&W Long N.P.
.32 S&W Long Wad Cut.
.32 Short Colt
.32 Win. Spec.
.32-20 Win.
.32-30 Rem.
.32-35 Stev. & Maynard
.32-40 Bullard
.32-40 Rem. Hepburn
.32-40 Win.
.32-44 S&W
.320 Long (Revolver)
.320 Short (Revolver)
.33 Belted Riml. BSA
.33 Jeffery Rimmed
.33 Newton
.33 Poacher's Pet
.33 Win.
.33/308 Win.
.330 Dakota
.333 Riml. N.E.
.338 Excalibur
.338 JDJ
.338 Jamison
.338 Lapua Mag.
.338 Rem Ultra Mag
.338 WSM
.338 Water Drop
.338 Win Mag.
.338-06 A-Square
.338-378 Weath. Mag.
.340 Weath. Mag.
.348 Win.
.348 Win. Imp. Ackley
.35 Brown-Whelen
.35 Lever Power Wade
.35 Newton
.35 Rem.
.35 S&W Auto (1913)
.35 Whelen
.35 Win S.L.
.35 Win.
.35-30 Maynard 1865
.35-30 Maynard 1873
.35-30 Maynard 1882
.35-40 Maynard 1882
.35/284 Win.
.35/30-30 Win.
.35/348 Win.
.350 Jamison
.350 Mag. Rigby
.350 Mashburn Short Mag.
.350 Mashburn Super Mag.
.350 Rem. Mag.
.351 Win. SL
.356 TSW
.356 Win.
.357 Auto Magnum
.357 Herrett
.357 Magnum (CIP)
.357 Magnum (SAAMI)
.357 Maximum (CIP)
.357 Maximum (SAAMI)
.357 SIG
.358 Ackley Mag.
.358 Ackley Mag. Imp.
.358 Barnes Supreme
.358 JDJ
.358 Lee Magnum
.358 Norma Mag.
.358 STA
.358 Win.
.360 #2 N.E.
.360 #5 Rook
.360 Dan Wesson
.360 N.E. 2 1/4 in. (9.3x57R 360)
.369 N.E. Purdey
.375 Barnes Supreme
.375 Dakota
.375 Fl. Mag. N.E.
.375 H.& H. Ackley Imp.
.375 H.& H. Mag.
.375 ICL Kodiak
.375 JDJ
.375 JRS
.375 Jamison
.375 Jurras
.375 Rem Ultra Mag
.375 Shannon
.375 Van Horn
.375 Waters Express
.375 Weath. Mag.
.375 Westley Richards
.375 Whelen
.375 Win.
.375/338 Chatfield-Taylor
.375/38-40 Rimless
.376 Steyr
.378 Weath. Mag.
.38 Auto
.38 Ballard Extra Long
.38 Casull
.38 Long Colt
.38 S&W (Colt N.P.) (CIP)
.38 S&W (Colt N.P.) (SAAMI)
.38 S&W +P (Colt N.P.) (SAAMI)
.38 Short Colt
.38 Special (CIP)
.38 Special (SAAMI)
.38 Special +P (SAAMI)
.38 Super Auto (CIP)
.38 Super Auto +P (SAAMI)
.38 Super Comp
.38-35 Stevens
.38-40 Rem. Hepburn
.38-40 Win. CF
.38-45 ACP
.38-45 Bullard
.38-45 Stevens
.38-50 Ballard
.38-50 Maynard 1882
.38-50 Rem.
.38-55 Win.
.38-56 Win.
.38-70 Win.
.38-72 Win.
.38-90 Win. Expr.
.380 Auto (9mm Kurz)
.380 Long Brit.
.380 Short Brit.
.40 S&W
.40 Super
.40 x 2" Winters
.40-110 Win. Express
.40-40 Maynard 1865
.40-40 Maynard 1873
.40-50 Sharps Necked
.40-50 Sharps Straight
.40-60 Marlin
.40-60 Maynard 1882
.40-60 Win.
.40-65 Ballard Everlast.
.40-65 Sharps Straight
.40-65 Win.
.40-70 Ballard
.40-70 Maynard 1882
.40-70 Peabody What Cheer
.40-70 Rem.
.40-70 Sharps Necked
.40-70 Win.
.40-72 Win.
.40-75 Bullard
.40-82 Win.
.40-85 Ballard
.40-90 Bullard
.40-90 Peabody What Cheer
.40-90 Sharps Necked
.40-90 Sharps Straight
.40/348 Win.
.400 Brown Whelen
.400 Cor-Bon
.400 N.E. B.P. 3 Purdey
.400 Williams
.400/350 Rigby N.E.
.400/360 NE Purdey 2 3/4"
.401 Cor-Bon
.401 Win. SL
.404 Barnes Supreme
.404 Dakota
.404 Riml.NE (Jeffery, 10.75x73)
.405 Win
.408 Cheyenne Tactical
.408 Win. Rimmed
.41 AMP/Jurras
.41 Act.Exp.
.41 Avenger JDJ
.41 Long Colt
.41 Rem. Mag. (CIP)
.41 Rem. Mag. (SAAMI)
.41 Short Colt
.41-44 CL (Gaertner)
.411 JDJ
.411 Mag. Bowman

.414 Super Mag.
.416 Barnes Supreme
.416 Dakota
.416 Hoffman
.416 Howell
.416 Jamison
.416 Jurras
.416 R (Chapuis)
.416 Rem. Mag.
.416 Rigby
.416 Taylor
.416 Weath. Mag.
.416/348 Win.
.423 Van Horn
.425 Westl. Richards
.430 JDJ
.44 Auto Mag.
.44 Henry
.44 Rem. Mag. (CIP)
.44 Rem. Mag. (SAAMI)
.44 S&W Russian
.44 S&W Special
.44 Van Houten Super
.44-357 Bain Davis
.44-40 Win. CF
.440 Cor-Bon Mag.
.444 Marlin
.445 Super Mag.
.45 Auto (ACP) (CIP)
.45 Auto (ACP) (SAAMI)
.45 Auto +P (ACP) (SAAMI)
.45 Auto Rim
.45 Blaser
.45 Boxer-Henry Long 1869
.45 Brown
.45 Colt (CIP)
.45 Colt (SAAMI)
.45 Glock Auto Pistol
.45 HP
.45 New South Wales (Mart-Henry)
.45 S&W Schofield
.45 Super (ACP)
.45 Webley
.45 Win. Mag.
.45-100 Rem.
.45-100 Sharps 2.4"
.45-100 Sharps 2.6"
.45-100 Sharps Straight
.45-120 Sharps Straight
.45-125 Win. Express
.45-70 Govt. CIP
.45-70 Govt. SAAMI
.45-75 Sharps Straight
.45-80 Sharpshooter
.45-85 Ward Burton
.45-90 Sharps Straight
.45-90 Win.
.450 Ackley Mag.
.450 Alaskan
.450 Dakota
.450 Fuller
.450 Marlin
.450 Mashburn Mag.
.450 N.E. 3 1/4"
.450 Rigby
.450 SMC
.450 Short
.450 Watts Mag.
.450/400 Mag. N.E. 3 1/4"
.450/400 N. 2 3/8" B.P.
.450/400 N.E. 3"
.454 Casull Magnum

.455 MK I /Colt Eley Enf.
.455 MK II
.458 Jamison
.458 Lott
.458 RCBS
.458 Win.Mag.
.458 x 2" American
.460 G&A Mag.
.460 Jurras
.460 Rowland
.460 Short A-Square
.460 Van Horn
.460 Weath. Mag.
.470 N.E.
.475 #2 Jeffery
.475 #2 N.E. 3 1/2"
.475 Ackley Mag.
.475 Jurras
.475 LTD
.475 Linebaugh
.476 Westl. Richards
.480 Ruger
.495 A-Square
.499 Leitner-Wise
.50 A.E.
.50 A.E. SAAMI
.50 Browning MG (12.7x99)
.50 Russian MG (12.7x108 DK)
.50-110 Win
.50-70 Gov./Musket
.500 A-Square
.500 Jeffery Rimless
.500 Jurras
.500 N.E. 3 1/4"
.500 N.E. 3"
.500 NAI Long Mag.
.500 NAI Short Mag.
.500 S&W Magnum
.500/.416 N.E. 3 1/4"
.500/.465 N.E.
.500/450 #1 Express
.500/450 #2 Musket
.500/450 Magnum BP Express
.505 Barnes Supreme
.505 Mag. Gibbs
.577 N.E. 3"
.577 N.E. 2 3/4"
.577 REWA 577/600
.577 Sld. Snider
.577/450 Sld. Martini Henry
.577/500 #2 N.E.
.577/500 Magnum N.E.
.600 N.E.

4.3 x 45 DAG, experiment.
4.6 mm x 30 HK, experiment.
4.6 x 36 HK, experiment.
4.7 x 45 DAG, experiment.
4.85 mm Brit.Enf., experiment.
5 mm Craig
5 mm Rem. Mag., experiment.
5 mm/223 Rem.
5.45 x 18 Russ.
5.45 x 39 mm (.215 Russ.)
5.6 x 33 Rook
5.6 x 35 R Vierling
5.6 x 50 Mag.
5.6 x 50 R Mag.
5.6 x 52 R
5.6 x 57
5.6 x 57 R

5.6 x 61 R SE v.Hofe
5.6 x 61 SE v.Hofe
5.7 mm Johnson
5.7 mm UCC Voere (equivalent)
5.7 x 28 FN
5.75 Velodog
6 mm Arch
6 mm Arnold
6 mm Atlas
6 mm B.R. Norma
6 mm B.R. Rem
6 mm International
6 mm JDJ #2
6 mm Lee Navy
6 mm Musgrave
6 mm PPC
6 mm PPC USA
6 mm Rem.
6 mm Rem. (SAAMI)
6 mm Shipley Pipsqueak
6 mm T/CU
6 x 29.5 Stahl
6 x 45 (6-223)
6 x 47 (6-222RemMag)
6 x 47 ATZL
6 x 47 SM
6 x 50 R Scheiring
6 x 51 ATZL
6 x 52 R Bretschneider
6 x 57 mm Mauser
6 x 58 R Forster
6 x 58 mm Forster
6 x 61 Shape & Hart
6 x 62 Freres
6 x 62 R Freres
6 x 70 R
6.3 x 53 R Finn.
6.35 Browning
6.5 Gibbs
6.5 JDJ
6.5 mm Bergmann
6.5 mm Gibbs
6.5 mm Rem. Mag.
6.5 mm T/CU
6.5 mm-08
6.5 x 27 R
6.5 x 40 R Sauer
6.5 x 48 R Sauer
6.5 x 50 R
6.5 x 51 R Jap. Arisaka
6.5 x 52 Carcano
6.5 x 52 R
6.5 x 53 R (Dutch) Mannlicher
6.5 x 54 Mann. Schoen.
6.5 x 54 mm Mauser
6.5 x 55 Swedish
6.5 x 57 R
6.5 x 57 mm Mauser
6.5 x 58 R (Sauer)
6.5 x 58 R Krag-Jorg.
6.5 x 58 mm Mauser
6.5 x 61 R Mauser
6.5 x 61 mm Mauser
6.5 x 63 Messner
6.5 x 64 Brenneke
6.5 x 65 RWS
6.5 x 65 R RWS
6.5 x 68
6.5 x 68 R
6.5 x 70 R
6.5-06
6.5-284 Norma

6.53 Scramjet (Lazzeroni)
6.7 x 54 R Russ./Finn.
6.71 Blackbird (Lazzeroni)
6.71 Phantom (Lazzeroni)
7 - 30 Waters
7 mm B.R. Rem.
7 mm Dakota
7 mm Exp. Rem.
7 mm Gibbs
7 mm JDJ
7 mm KM Katzmaier 7mm-338 Lapua
7 mm Mag Fl. H&H
7 mm Nambu
7 mm PPC
7 mm Rem SA Ultra Mag
7 mm Rem Ultra Mag
7 mm Rem. Mag.
7 mm STW
7 mm T/CU
7 mm WSM
7 mm Weath. Mag.
7 mm-08 Rem.
7 x 33 Sako
7 x 39 Giat
7 x 45 Giat
7 x 45 Ingram
7 x 49 Brit. Enfield experim.
7 x 49 GJW
7 x 49 R GJW (aus 5.6x50R)
7 x 50 R
7 x 57 Imp. Ackley
7 x 57 R
7 x 57 mm Mauser
7 x 57 mm Mauser (SAAMI)
7 x 61 S&H (Super)
7 x 64 Brenneke
7 x 65 R Brenneke
7 x 66 SE v.Hofe
7 x 72 R
7 x 75 R SE v.Hofe
7.21 Firehawk (Lazzeroni)
7.21 Tomahawk (Lazzeroni)
7.35 x 52 Carcano
7.5 Ord. Suisse (Swiss Army)
7.5 Swed. Nagant Revolver
7.5 x 53,5 R Rubin
7.5 x 54 mm MAS French
7.5 x 55 GP31 SWISS
7.62 Nagant Russ.
7.62 UKM
7.62 x 25 Tokarev
7.62 x 39 (.308) Russ.
7.62 x 39 (M43) Russ.
7.62 x 45 M52 Czech.
7.62 x 51 mm NATO Mil.
7.62 x 53 R Fin.
7.62 x 54 R Russ.Nagant
7.63 Mannlicher
7.63 Mauser
7.65 Browning
7.65 Long (French)
7.65 Para (.30 Luger)
7.65 x 53 Arg./Belg. Mauser
7.7 mm Japan (Arisaka)
7.82 Patriot (Lazzeroni)
7.82 Warbird (Lazzeroni)
7.82 x 24 Leitner-Wise Sabot
7.92 CETME
7.92 x 33 kurz
7.92 x 61 Norway M17
8 mm -348 Win.
8 mm /300 Win. Mag.
8 mm Gibbs
8 mm Lebel (Revolver)
8 mm Lebel M/93 (8x50R)
8 mm Nambu
8 mm Rast-Gasser
8 mm Rem. Mag.
8 mm Roth-Steyr
8 mm-06
8 x 42 R
8 x 48 R Sauer
8 x 50 R Mannlicher
8 x 51 R Mauser
8 x 51 mm Mauser
8 x 52 R Siam. Mauser
8 x 53 R Murata
8 x 54 Krag-Jorgensen
8 x 56 Mannl.-Schoenauer
8 x 56 R M 89 Port.Krop.
8 x 56 R M30
8 x 56 R M30S
8 x 57 I
8 x 57 IR
8 x 57 IRS
8 x 57 IS (8 mm Mauser CIP)
8 x 57 R 360
8 x 57 mm Mauser (SAAMI)
8 x 58 R (S&S)
8 x 58 RD (Danish Krag)
8 x 59 Breda
8 x 60
8 x 60 R
8 x 60 R Guedes
8 x 60 R Kropatschek M/86
8 x 60 RS
8 x 60 S
8 x 63 Swedish
8 x 64 S
8 x 65 RS
8 x 68 S
8 x 71 Peterlongo
8 x 72 R (Sauer)
8 x 75 RS
8 x 75 S
8.15 x 46 R
8.2 x 53 R Fin.
8.4 mm M 95 S Hung.Mann.
8.5 x 63
8.5 x 63 R
8.59 Titan (Lazzeroni)
9 mm Bergmann-Bayard (long)
9 mm Browning kurz
9 mm Browning long
9 mm FAR
9 mm Luger (Para)
9 mm Makarov
9 mm Mauser
9 mm Steyr
9 mm Super Comp
9 mm Win.Mag.
9 x 18 (Ultra)
9 x 21
9 x 22 MJR
9 x 23 Win.
9 x 24 KC
9 x 25 Super Auto G
9 x 47 R Deutsche Schützen
9 x 56 Mannl.-Schoenauer
9 x 57 Mauser
9 x 57 R Mauser
9 x 85 MEN ,experiment.
9 x 90 HK ,experiment.
9.12 x 77 Lapua ,experiment.
9.3 x 53 R Fin.
9.3 x 53 R Swiss
9.3 x 53 Swiss
9.3 x 57
9.3 x 62
9.3 x 64 Brenneke
9.3 x 65 R
9.3 x 66 Sako
9.3 x 70 Mag. (DWM569)
9.3 x 70 R (360)
9.3 x 72 R (360)
9.3 x 72 R Sauer
9.3 x 74 R
9.3 x 80 R (360)
9.3 x 82 R (360)
9.5 Tornado
9.5 x 47 R Martini
9.5 x 57 Mannl.- Schoenauer
9.5 x 60 R Mauser Turkish
9.5 x 66 SE v. Hofe
9.5 x 73 Miller Greiss
10 mm Auto
10 mm Bren
10 mm IAI Magnum
10.15 x 61 R Jarmann
10.3 x 60 R Swiss
10.3 x 65 R Baenziger
10.4 Ordnance Italy (Glisenti)
10.4 x 38 R Swiss Vetterli M69/81
10.4 x 42 R Vetterli
10.4 x 47 R Vetterli M70 Italy
10.57 Meteor (Lazzeroni)
10.7 x 57 R Krag Petersen
10.75 x 68 (Mauser)
11 x 52 R Beaumont NL
11.15 x 60 R Mauser
11.2 x 60 Mauser/Schueler
11.2 x 72 Schueler
11.43 x 41 Peabody-Martini
12.5 x 70 Schueler
12.7 x 108 Russ. DSHK
12.7 x 70 (.500 Schüler)
14.5 x 114 Russ. KPV
20 mm x 139 Rh202/HS820

Chart of Approximate Burning Rate

Accurate Arms	ADI	Alliant	Bofors	Hodgdon	IMR	ICI	Norma	PRB	Ramshot	Rottweil	SNPE	Somchem	Synthesia	Winchester	Vihtavuori
							FAST **BURNING**								
	AP30N						R1	PCL514							
		Bullseye	PK5	Titewad		Nobel78				P805	Ba10				N310

				Clays										WST	
AA 2 Imp	AS30N	RedDot	PK1	TiteGroup		Nobel80				P801			LovexD032	W231	N320
Solo1000	AP50N	Am. Select	JK6	HP38	700X			PCL509	ZIP	J706	AS		LovexS015	WSL	
		GreenDot		International	PB							MS200		452AA	
	AS50N				SR7625										
			PK4			Nobel82		PCL515		P804	A1	MP200	LovexS011	473AA	N330
No.5	AP70N	Unique	PK3	Universal		Nobel83		PCL506		P803	Ba9			WSF	
	AS70N	Power Pistol		LongShot		NGPP2		PCL501	Silhouette				LovexS012	W540	N340
Solo1250	AP90	Herco		HS6	SR4756	NGSP84		PCL504	True Blue		Sp8			WAP	3N37
No.7	AP100			HS7	800X						A0	S221	LovexD036	W571	N350
		BlueDot	PK6			NGPP1		PCL2595		P806	Sp2			W630	3N38
No.9		2400		H108	SR4759		R123						LovexD037		N105
Solo4100			RP13	H110		Nobel89		PCL512	Enforcer	R910		S265		W296	N110
XMP5744	AR2205		22 Horn.	H4227	IMR4227	RV1					Sp3		LovexS053		
AA1680				Lil'Gun							Ba6		LovexD063	W680	N125
XMR2015	AR2207	Reloder7		H4198	IMR4198		N200		X-Terminato		Tu2000				N120
	BM1	Reloder10X	RP1	H322		Nobel3		PCL508	TAC	R901	Sp10		LovexD075		
AA2230	BM2		RP12	Benchmark	IMR3031							S335	LovexD073L		
AA2460	AR2206	Reloder12	RP2	H335			N201			R902			LovexD073		N130
XMR2495	AR2210			H4895							Tu3000		LovexD073T	W748	
XMR4064			7.62	Varget	IMR4895	Nobel2	N202					S321	LovexD083N		N133
AA2520	AR2208		RP3	BLC(2)	IMR4064			PCL507	Big Game		Sp9	S341	LovexD083		N530
			RP8		IMR4320	Nobel1	N203			R903					N135
		Reloder15	RP11				N203B						LovexS062		N540
				H380				PCL516			Sp11				N140
AA2700			RP7							R907	Tu5000				
		Reloder 21						PCL511			Sp7	S355	LovexS065		N550
				H414		Nobel0			Hunter					W760	N150
XMR4350	AR2209			H4350	IMR4350							S365	LovexS070		
			RP4	H450			N204			R904	Tu7000				N160
		Reloder19											LovexS071		
XMR3100	AR2213				IMR4831							S385		WXR	N560
MAGPRO			RP5	H4831						R905	Tu8000			WMR	
		Reloder22		H570			MRP								N165
			SK		IMR7828		MRP 2							785	
AA8700		Reloder25						PCL517	Magnum						
	AR2214			H1000											N170
	AR2218			Retumbo											
			12.7	H870										W870	
				H5010				PCL513					LovexD100		24N41
	AR2211			H50BMG				PCL9520					LovexD103		20N29

SLOW **BURNING**

Do not use any "burning rate chart" as a guide to reloading. Because there are a lot of factors which determine the combustion of a charge within a cartridge, there exists no comparable "burning rate" for propellants. Propellants have different vivacities and different energy contents as well as other properties which are of importance on combustion. Because of the grid structure used in above chart some powders may not be at their appropriate places.

Reflections on Interior Ballistics

THE FOLLOWING REFLECTIONS ON INTERNAL BALLISTICS REFER TO INTERIOR BALLISTICS OF FIREARMS WITH NORMAL BORES (NO TAPER, CONSTANT TWIST, ETC.). THESE FACETS ARE INTERESTING TO TECHNICALLY INCLINED SHOOTERS AND HANDLOADERS. THE *HANDBOOK ON WEAPONRY*, RHEINMETALL GMBH, DUESSELDORF OR MILITARY BALLISTICS, A BASIC MANUAL, BRASSEY'S , LONDON - WASHINGTON COVERS THIS TOPIC COMPREHENSIVELY. THEREIN ONE FINDS A DESCRIPTION OF ESSENTIAL TOPICS ON INTERIOR BALLISTICS.

The science of firearms interior ballistics includes the propulsion of a projectile along a barrel of a weapon by gas pressure acting on the base of the projectile. In firearms, transmission of kinetic energy to the projectile results from combustion of normally solid chemical propellants into highly energetic gasses.

The purpose of interior ballistics is to describe the propulsive process of a projectile through a bore under specified conditions of both gun and ammunition systems. This results in a theoretical determination of both the resulting projectile velocity and propellant gas pressure. Conversely, it is also possible to calculate system parameters at a given maximum pressure and projectile velocity.

The beginnings of mathematical descriptions of interior ballistics processes date to the early 19th century. Names like Lagrange, Resal, Vieille, Charbonnier and Cranz are often referenced in this context.

In 1908, Charbonnier published a comprehensive volume in the *Encyclopédie Scientifique. Therein, he covered* the interior ballistics problem in an edition titled, *Ballistique Interieur*.

The interior ballistic system can be described by either of two models, hydrodynamic or thermodynamic. Current military interior ballistic modeling development favors the hydrodynamic model.

Progress of the firing process is complex. Complicated thermodynamic and hydrodynamic reactions are linked with the conversion of solid propellant into highly energetic (hot) gases.

Generally, these calculations use approximations. The thermo- and hydrodynamic processes are simplified and the conversion of the propellant is described by empirical formulas.

Nevertheless, for interior ballistic systems, calculated results (based upon theoretical parameters) have been proven to agree sufficiently with measured values.

The thermodynamic solution takes the energy flow, the combustion of propellant and the projectile movement into relationship with one another. The hydrodynamic solution models the behavior of the gaseous mass, propellant granules and the combustion with respect to the geometry of the steady expanding combustion chamber (caused by moving projectile), which is almost represented in programs by mesh of small finite cells.

Although the same combustion model could be used for either method, the hydrodynamic solution requires a disproportionately higher number of calculations.

Additionally, no suitable hydrodynamic model exists for small caliber firearms at this time. Hydrodynamic modeling is complicated by the relatively low gas- and projectile velocities as well as the comparatively large and tightly packed propellant particles relative to bore size.

Comparable results are achieved with either method, by which the hydrodynamic procedure even enables a description of the gas pressure course and the description of the oscillation of the gases up through the barrel. Today mainly hydrodynamic models are used for the interior ballistic optimization of big bore, ultra high velocity guns (V_0 exceeds 5200 fps/ 1600 m/s).

It is not practical for a handloader to supply the necessary data used for the hydrodynamic calculation.

Therefore, the *QuickLOAD* program uses a thermodynamic model of the interior ballistics system because it delivers similarly satisfactory results for handloading purposes.

Components of Interior Ballistic Calculations

QuickLOAD uses the following parameters in calculating interior ballistics values:

- Internal barrel dimensions
- Combustion chamber dimensions, as influenced by case dimensions
- Projectile dimensions
- Propellant charge properties

The barrel consists of either a rifled or smooth tube with the projectile moving forward under the action of the gas pressure toward and out of the muzzle. This section of the barrel, from the base of the seated projectile in the case up to the muzzle, corresponds to the projectile path (or bullet travel).

Physically bore diameter across the path of the projectile is called gun- or barrel "*caliber*".

In rifled barrels, *caliber* is measured across the lands (bore diameter). Groove diameter is sometimes also used to characterize caliber, especially in English-language regions for small arms without driving bands on projectiles. There, caliber is often listed as projectile diameter, which corresponds to groove diameter, e.g. .308 Win, .375 H&H.

The rear part of the barrel consists of a combustion chamber. The interior of the cartridge case forms this chamber. The diameter of this section is normally somewhat larger than bore diameter (with bottlenecked cases). The case head, which is supported by the breechblock (or bolt face), forms the back end of the combustion chamber.

That portion of the barrel between chamber and rifled barrel, which consists of a cylindrical part and a normally slightly tapered part, is given several names: forcing cone, throat or leade.

In cartridge firearms, gas sealing at the rear of the barrel is provided by the cartridge case. With combustible cases or caseless ammo, sealing is achieved by special seal rings, which are located between the breech and chamber.

Normal ammunition consists of case, projectile, propellant and primer.

Propellant, primer and projectile are housed in a case. Insertion of primer and projectile includes a press fit and sometimes crimping or gluing.

Sealing between the projectile and bore results from forcing the (approximately groove diameter) projectile or, in artillery projectiles, a groove fitting driving band into the barrel profile. In addition, in small arms, the bullets main parts, core and/or jacket, are usually unable to support totally the acceleration applied by the propellant gasses. So the bullet obturates (or swells) solidly into the bore, thereby forming a more or less intimate seal.

In rifled barrels, the lands cause a displacement and shaping (swaging) of the projectile or driving band material. (This can also be achieved by means of a polygonal rifling pattern.)

Grooves thus formed on the projectile transmit spin (rotation) to the projectile during its forward movement through the bore.

In small arms, rifling twist along the length of the barrel is normally constant. The number of rifling grooves depends upon barrel make and type. Right-hand twist or left-hand twist is also practicable. Twist rate is characterized in units of bullet travel distance per turn – as in, 1 in 12 (meaning 1 turn in 12- inches).

The imparted spin gyroscopically and dynamically stabilizes the projectile during its atmospheric flight. Spin rate (twist) must be chosen according to projectile's shape, length, center of gravity and muzzle velocity.

For each gun and ammunition combination, a theoretical optimum twist exists. For proper stabilization (accuracy), long projectiles require a higher rotational rate than shorter projectiles.

Annular sealing discs or sabots made of compressible material (either around or behind the projectile) seal smooth bore barrels.

The Process of Firing

In small arms, normally, the firing process is initiated by pulling the trigger of the loaded gun. This allows (or causes) a spring-loaded firing pin to fall. This pin hits the primer cap and ignites the primer pellet. (In electric ignition, heating ignites a primer compound to achieve ignition.)

The primer compound produces a stream of hot particles and gases, which (ideally) should simultaneously ignite the entire surface of every granule in the propellant charge and do so without fracturing any granules. (While such perfectly simultaneous and non-damaging ignition is impossible, the closer the primer flash comes to achieving this goal, the more consistent combustion will be.)

In small arms, delay between firing pin impact and beginning of propellant combustion is less than one millisecond (<0.001-second). In typical cannons this delay is several dozen milliseconds.

Upon ignition, smokeless propellants proceed to burn in a self-sustained reaction (so far no gas leakage occurs). This process converts solid propellant into a large volume of energetic gaseous products. This chemical reaction produces sufficient heat energy to raise propellant gas temperature above 4000°K.

(Conversion products of both blackpowder and nitroguanidine propellants include solid substances. In blackpowder, solid particulates comprise more than 50%, by weight, of the combustion products.)

Hot propellant gases generate high pressure inside the chamber (that section of the barrel between breech and projectile base). This high-pressure gas accelerates the projectile progressively forward until it reaches maximum velocity, normally achieved shortly after bullet base exits muzzle. The flow of gases following the bullet out of the muzzle provides additional acceleration for several calibers distance beyond the muzzle.

Until 100% of the entire charge has combusted the pressure curve form inside the barrel is characterized by the following phenomena:

Coupled to increasing confining pressure, propellant burning rate increases, quite significantly too. This condition accelerates pressure rise. Under the action of this pressure, the projectile absorbs kinetic energy, which is withdrawn from propellant gas energy. Simultaneously with the projectile forward movement, chamber volume (space available to the propellant gases) increases. This results in a decline in pressure, especially in that region near the projectile base.

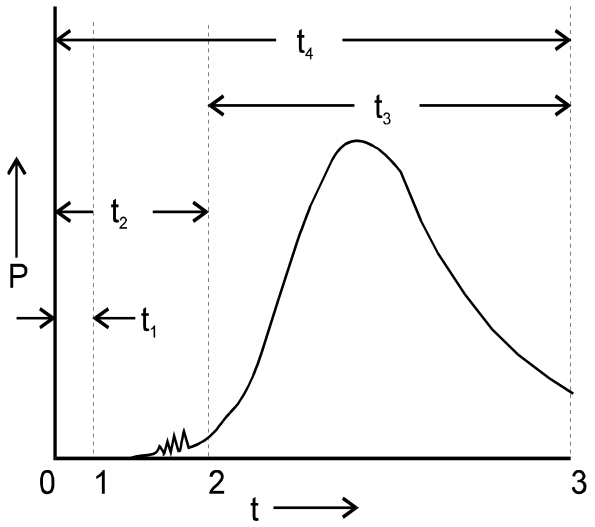
Normally, gas pressure inside the barrel (near the breechblock) and along the projectile path increases smoothly until it reaches a maximum value. It then decreases until the end of propellant conversion (all-burnt) is reached. After propellant combustion (solid-to-gas conversion) is completed, pressure declines continuously in a process called polytrophic expansion.

Note that, when optimizing a cartridge load, through appropriate selection of components (and thereby parameters) combustion preferably ends before the projectile passes the muzzle (achieving more than 95% of burnt propellant will be fair load). This improves energy utilization and somewhat influences the generation and appearance of muzzle flash.

In small arms, projectile propulsion lasts from 1 to 2 milliseconds. Acceleration can exceed 150,000 times the acceleration of gravity on earth! Projectile muzzle velocity can exceed 4000 fps and maximum pressures can significantly exceed 60,000 pounds per square inch (psi).

To gain an exact knowledge of interior ballistics phenomena, it is important to extensively measure every important parameter. Information from theoretical procedures can be very helpful in this quest.

In addition to muzzle velocity measurement, which anyone can now easily do, pressure measurement and measurement of projectile movement inside the barrel play central roles in understanding and predicting internal ballistics. These complex measurements require costly equipment.



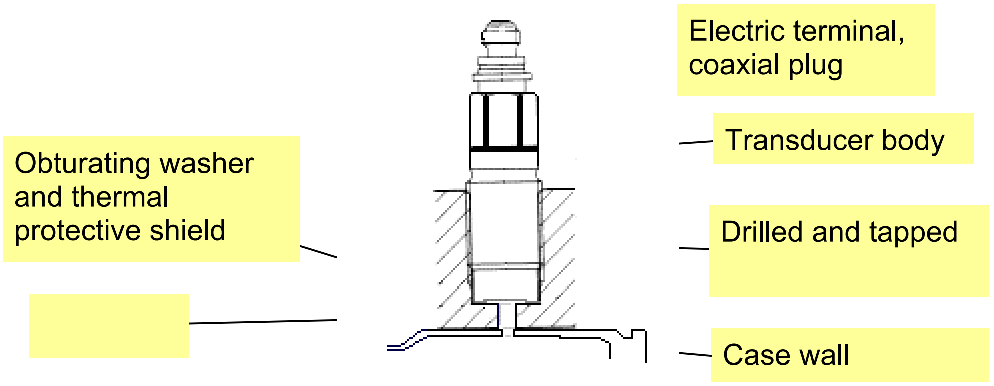
Typical pressure course and definition of time intervals

0 Impact of firing pin on primer
1 Pressure-rise inside primer
1-2 Pressure-start in propellant charge
2 10% of maximum pressure
3 projectile passes muzzle

t1 Primer time
t2 Ignition delay
t3 Transition time
t4 Firing time

Picture 67: Typical Pressure Curve Inside the Combustion Chamber

(as measured inside chamber).



Picture 68: Transducer mounted into Chamber Wall

Piezoelectric transducers are commonly used to measure pressure. A small hole is drilled through especially thick chamber walls of a pressure gun barrel and prepared with threads to accept a screwed -in transducer. Upon firing pressure and corresponding times are recorded into a computer. These pressure and corresponding time values are used to generate a real-time pressure curve.

There are also so called "conformal" piezo-transducers in use. These are mounted on top of a piston, which reaches through a drilled hole in the chamber walls down into the chamber. The surface of piston head reaching into chamber is perfectly reamed to the shape of chamber wall contours. The case wall expands under pressure and applies force to the piston, which is recorded by the transducer. This system is preferred in quality assurance tests of mass production of ammunition, because cases have not to be drilled and characteristics of case walls are known (calibrated into system).

The copper crusher measurement method is generally obsolete for load development; that system is, nevertheless, a very good method for proving purposes especially when pressures expected are totally unknown.

NOTE: The Oehler, Model-43 system uses strain gauges to measure the real-time pressure related curve within the barrel of a gun. This system provides significant useful information and is available to the average shooter.

The Relationships of Energy During Firing

Release of energy by propellant chemical conversion is parsed as follows:

- Energy of linear projectile movement
- Energy of projectile spin
- Energy of recoiling weapon
- Energy to drive (actuate) self-loading mechanism (if applicable)
- Flow energy of propellant gases
- Internal energy of propellant gases
- Energy of gas losses
- Heating and deforming of barrel, projectile and case – through heat transmission and friction
- Work against barrel air column
- Work against release friction of case mouth
- Work to force projectile (or driving band) into rifling

Normally, only a tiny percentage of combustion energy is consumed on projectile spin, gun recoil, actuation energy and barrel air column. Therefore, normally, neglecting these considerations has little calculable effect.

Conversely, because this effect occurs at the beginning of the process, work against case mouth friction and forcing the bullet into the rifling (engravement) are important when calculating interior ballistic data for sporting arms ammunition. Extracting projectile from case requires about 450 psi. Rifling engravement requires approximately 1,400 psi to 4,000 psi for normal soft-point (soft-cored) projectiles; it can be greater than 8,000 psi for so-called "solids" or tungsten-cored projectiles.

Counter-intuitively, very thinly jacketed, soft-cored, projectiles (such as are used in many handgun, varmint, 444 Marlin and 45-70 Springfield loads) sometimes show a higher forcing resistance, compared to projectiles used in more conventional ammo. (This is likely a result of greater obturation deformation, which results from the lower internal strength of such bullets and results in increased bullet-to-bore friction.)

The calculated force necessary to overcome static forcing resistance is higher than is measured during cartridge firing. During actual firing, gases and particles are driven between projectile and bore. This generates a lubricating or „washing“ effect. Furthermore, the barrel stretches under propellant gas pressure: bore cross-sectional area increases (ballistically breathing).

Therefore, it is not feasible to use statically determined values for these forces for general interior ballistic calculations. Also, starting (initial or offset) gas pressure at the forcing cone (leade) is higher with projectiles seated to touch (and seal) the rifling, compared with projectiles seated normally (which have some rotationless forward movement before reaching the rifling).

In addition, where the bullet does not touch the rifling it can be accelerated a short distance before barrel resistance begins. So bullet energy supports forcing the bullet into the rifling.

QuickLOAD accounts for energy losses by use of a weighing factor (also known as *Sebert's factor*) – A portion of the propellant charge is added to the bullet mass. By adding a part of the charge mass to the projectile mass, Sebert's factor accounts for losses from bullet, barrel and ammunition heating, flowing propellant gas kinetic energy and friction – as is often the case in physics, this calculation uses an „effective mass.“

Starting pressure, resulting from forcing resistance and case mouth resistance is generated by the primer and that part of the charge combusted before projectile movement begins. These effects must be included in any interior ballistics calculations. More precise results are possible by the mathematical description of these resistances using special functions. However, the required input values are out of reach to the typical user. Therefore, *QuickLOAD* uses the aforementioned weighing factor and a *Shot start* pressure. These simplifications introduce no significant overall error, but detailed modeling of ignition phase is neglected.

Obviously, that portion of total propellant mass energy that is converted into projectile kinetic energy is of special interest.

Typical small arms and loads convert about 15% to 35% of the energy available in the propellant into projectile kinetic energy. However, for various reasons, projectile energy does not increase precisely according to increases in charge mass.

Theoretically, maximum possible projectile velocity resides near 11,500 fps (3500 m/s). Limiting factors include charge total energy and maximum possible flow speed of propellant gases and their existing molecular weight. However, in the real world of conventional small arms with the allowed maximum average pressures, it is generally not feasible to produce projectile velocities exceeding about 5200 fps (1600 m/s), despite use of relatively lightweight projectiles.

Internal propellant gas energy at the instant the projectile passes the muzzle is calculated from overall barrel volume and muzzle gas pressure distribution inside barrel.

High muzzle pressure suggests thermal inefficiency. This also corresponds to general experience suggesting that shooting precision (accuracy) can be negatively influenced. Furthermore, high muzzle pressures correspond to considerable propellant gas influence upon both strength and type of recoil.

The Distribution of Pressure Inside Barrel

The projectile, gun (by recoil), powder mass and generated propellant gases are all accelerated during the firing process. Because of projectile and powder gas acceleration, chamber pressure normally decreases from breech to projectile base.

Actual pressure at any position in the barrel results from a superposition of propellant gas pressure (resulting from combustion) with pressure oscillations inside that gas column. These oscillations traverse between breech and projectile base. This results in frequent pressure variations. When we talk about these oscillations one must consider that there is normally only a beginning of an oscillation existing. The wave period time is approximately same as the barrel time in small arms, so only one significant wave front may propagate back towards breech, mostly never reaching the breech because bullet has meanwhile exit the barrel. With large cannons several waves may be released causing superimposing of pressures up to dangerous levels.

A small percentage of total propellant energy is changed into gas flow energy.

QuickLOAD initially calculates chamber pressure near the breech, where it is normally measured. Distribution of pressure along the barrel is represented by a weighing factor (effective mass).

The Process of Ignition

Smokeless propellants are self-igniting at a temperature between 300°F to 480°F (150°C to 250°C). Self-ignition (kindling) temperature depends upon heating rate (temperature rise slope). A faster temperature rise increases apparent kindling temperature. Long-term powder- or ammunition storage at elevated temperature decreases kindling temperature.

Initiation of primer combustion results from firing pin impact with percussion primers. This crushes the primer compound between the cup and anvil. Both a minimum firing pin striking energy and striking velocity are required for proper primer action. Priming compounds are shock-sensitive high explosive mixtures consisting of several substances. The resulting ignition stream consists of hot gases and hot particles that pass through one or more flash holes and infiltrate the powder charge. For electric primers initiation of the primer is accomplished by an electrical discharge from the contact button, through the mix, to the external cup. The actual mechanism of electrically igniting the mix has not been determined yet. It seems to be essential that a sufficient amout of calcium silicide plays an important role in electric primers.

Delay from initiation of primer ignition until chamber pressure reaches ~10% of the maximum value (P_{max}) is called ignition delay time. This time depends upon propellant granule ignition resistance and upon composition and volume of priming compound. Propellant surface treatment (deterrent coating) places substances into the outer layers of the powder granule. Deterrents prolong ignition delay, in contrast to untreated propellants (so-called green corn).

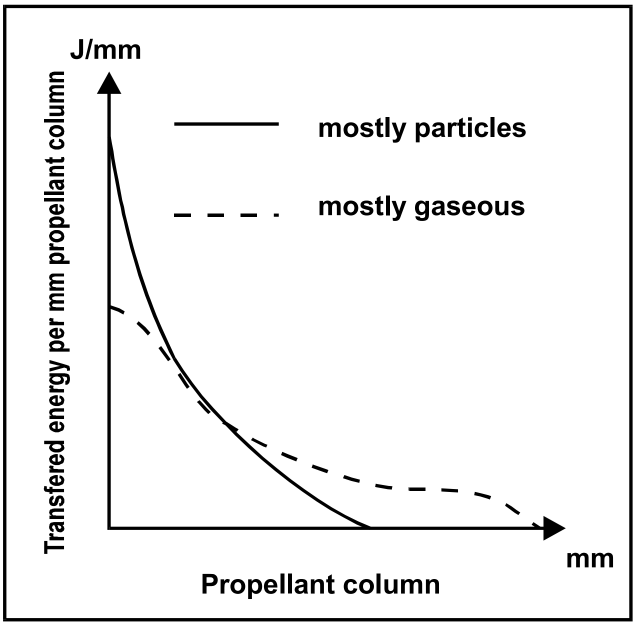
Particle-rich primer compounds cause highly variable ignition delay times. Conversely, gas rich compounds result in more uniform ignition delays. Particle-rich, gas-poor primers cause differential shot-to-shot ignition delay because propellant granules located near the flash hole absorb the incandescent primer particles. These granules, therefore, ignite rapidly. Shot-to-shot uniformity suffers because the number of granules that are „super-ignited“ varies dramatically, depending upon granule packing, orientation and other variables.

The limited gasses of such primers might not carry enough heat into the upper, cold layer of propellant granules. In that case, the primer gases can convert back into the liquid or solid phase without sufficiently heating the powder granule surface to achieve kindling temperature. This can cause hangfires. Further, generally, gases will penetrate deeper into the powder column, compared to particles.

Conversely, relatively gas-rich primers (those generating more gas and less particulate matter) produce a more favorable energy distribution throughout the powder charge. With these primers, a high percentage of the priming energy is transferred to the charge in the form of condensation energy, where the primer gasses directly contact the granules. Condensation of hot gases onto powder granule surfaces provides the fastest and most uniform means of granule heating. Hangfires can cause total system failure with external driven gatling guns who are extracting the living hangfiring round which will explode in breech-feeding mechanism.

For proper ignition we need a primer compound giving a proper balance between particle- and hot gas generation.

The amount of energy transferred to the granules depends upon propellant surface structure. Research demonstrates that the usual graphite propellant glazing has no measurable influence upon ignition energy transfer.



Picture 69: Energy Transfer of Different Primer Compounds.

Uniform propellant ignition requires uniform bullet extraction force (bullet pull). Uniformity of bullet pull can be improved through a consistent bullet-to-case press fit; case mouth crimping into a projectile cannelure; or special handloading techniques.

With a loose projectile-to-case fit, the bullet can release before all powder granules have begun to combust. In this instance, gases can bypass the projectile before it obturates or seals against the forcing cone. If so, pressure will drop. This will cause cooling and condensation of generated gases. This can lead to an irregular and sometimes dangerous combustion. Long, straight cases (and sometimes shotgun loads with improper crimp strength) using low loading densities and relatively slow-burning powders can produce similar effects.

Benchrest shooters avert this potential problem. In their cartridges, the bullet of the chambered round touches the rifling. Bullet-to-rifling engravement force restrains the bullet as ignition begins. Therefore, neither a crimp nor a press fit is required. (Generally, a charge reduction is necessary.)

Usually, propellant ignition is neither precisely uniform nor altogether simultaneous. With any given combination of primer, propellant, charge, case design, etc., a certain primer ignition depth is expected. Granule ignition begins first at the flash hole, then progresses into and through the propellant column. To meet handloader requirements, manufacturers offer primers for special purposes (e.g. Benchrest, Magnum and Pistol).

From the beginning of 1900s to the end of second World War primer mixes contained partly mercury fulminate and/or sodium chlorate causing heavy corrosion in barrels. Current primer mixes do no longer contain corrosive ingredients. Most actual composition consists mainly of lead styphnate, tetracene, barium nitrate, calcium silicide and aluminium- or titan powder. With the upcoming of in-house shooting ranges, so called green-primer mixes emerge, omitting the use of lead and other toxic components in primers. 'Green' primers are currently not available to the public because they work only with certain propellants properly which has to overcome in future developments.

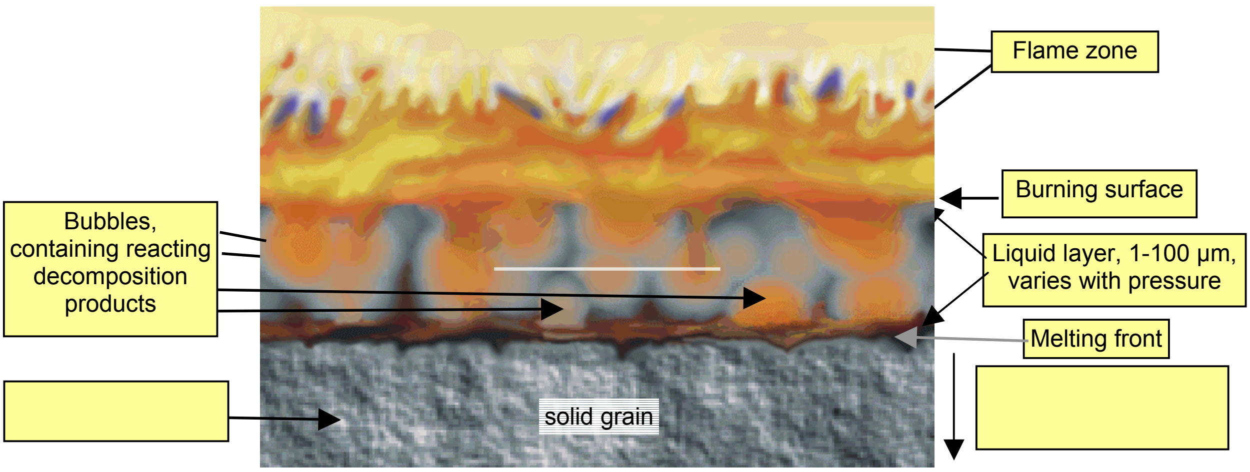
Primers available to handloders are separated into small and large rifle primers, small and large pistol primers and may be classified as normal or 'magnum' primers. There is no information about the difference between normal or magnum types. Some may cause a longer duration of priming stream by change of primimg mix; others simply contain some more priming mix than normal primers. Rifle primers contain more priming compound than pistol primers and the cup material is thicker than that for pistol primers.

There is no evidence that 'magnum' types cause higher pressures than normal primers. It may happen, but the opposite reaction may also be true. As a rule of thumb: use magnum primers with highly deterrent coated propellants and with spherical propellants which are difficult to ignite.

Ignition behavior, ignition delay and primer mix energy are not taken into consideration in *QuickLOAD* calculations. The mildest primer sufficient for the given task is assumed.

Process of Combustion

Transformation of smokeless propellant into hot gases occurs on the overall exposed surface of each ignited granule. Ignition proceeds, uniformly, through each parallel layer of powder substance. The conversion rate through layers near the surface of each granule (so-called linear burning rate), depends mainly upon chemical composition of the powder and pressure in its gaseous phase Propellant.



Picture 70: Burning Surface of Propellant Granule

As a matter of interest, owing to porosity, blackpowder granules with a density less than 1.75 g/cm^3 burns through the entire granule. Denser blackpowder, however, burns in layers. In that instance, burning rate depends upon granule form and size, similar as smokeless powder.

The percentage of powder charge transformed into gas per unit of time depends upon linear burning rate of the propellant and geometric formation of the granule. Various relationships and different pressure dependencies for linear burning rates are provided in literature on that subject.

According to literature, the following relationship (used in *QuickLOAD*) is a fair approximation in a pressure range between about 12,000-psi and about 70,000-psi. At lower gas pressures, users can expect significant deviations between calculation and actual combustion course.

The propellant burning rate is defined by the following relationship:

$$\frac{de}{dt} = \beta \left(\frac{p}{p_0} \right)^{\alpha}$$, (also ***r* = *βp*$^{\alpha}$** Vieille's Law) [Equation 1]

- *de/dt*: linear burning rate per unit of time
- pressure
- *ß* : a powder constant
- p_o : the constant normal pressure (technical)
- For high pressures *α* is set to unity. (p=130 bars - *α* ~0,5; p=1500 bars - *α* ~0,96)

The linear burning rate also depends to some extent on propellant temperature. This explains the influence of propellant temperature on muzzle velocity and gas pressure.

Usually propellants generate higher gas pressure at higher ambient temperatures (an essential consideration with ammunition intended for use in tropical or polar regions). However, certain types of extruded propellants available to the public, contain temperature compensating components in their mixture.

The relationship between amount of propellant that is converted per unit time *dz/dt* and propellant granule geometry is expressed by the equation:

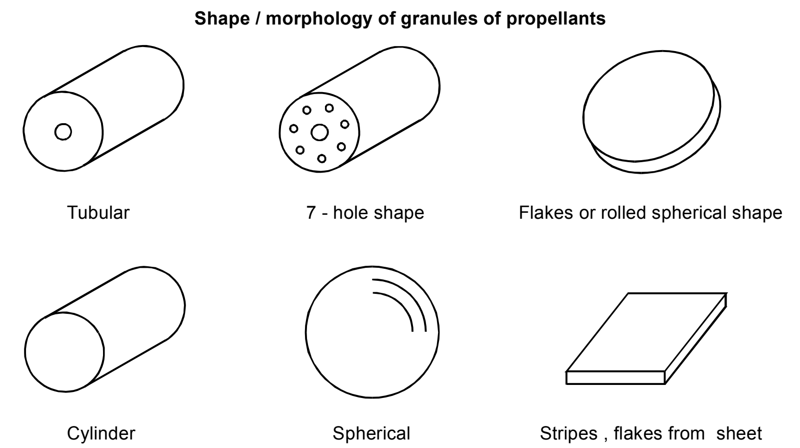
$$\frac{dz}{dt} = \frac{A}{A_a} \times \frac{\rho_c A_a}{m_c} \times \frac{de}{dt}$$ [Equation 2]

- A_a: initial surface of propellant
- A: granule surface at actual time t

The quotient A/A_a is described as form function $\varphi(z)$; to each value of *z,* a surface *A* could be assigned. The possible range varies between 0 (granule has not ignited) and 1 (granule completely burnt).

- m_c: charge mass
- ρ_c: solid density

Geometric granule form and size determines the surface area of the propellant granule. Therefore, propellant granules are produced in many forms.



Picture 71: Examples of Smokeless Propellants, Granule Form.

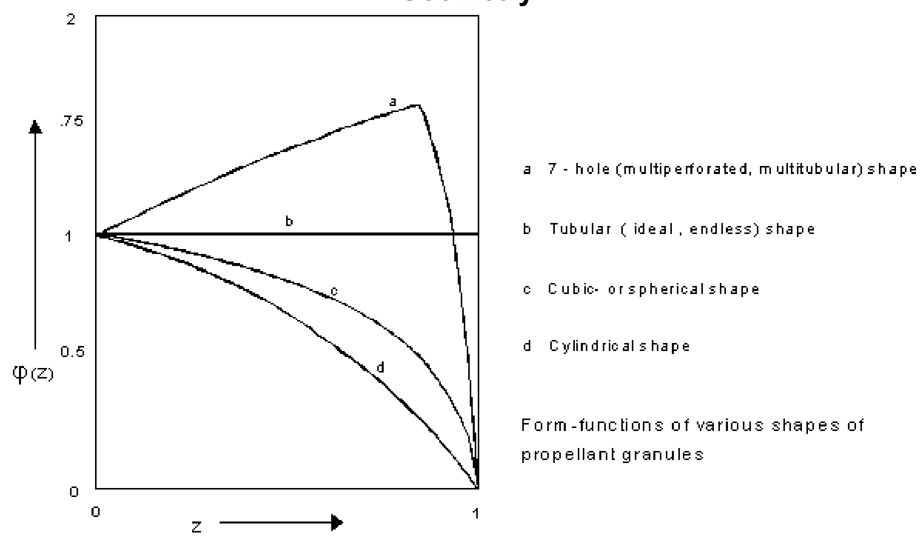
Smokeless propellants are currently produced in tubular, cylindrical, cubic, spherical, flake and strip forms. Cylindrical forms include those with 0, 1, 7 or 19 longitudinal perforations. Also rosette form and slotted cylinders exist.

Each geometric shape could be assigned a specific form function *φ(z).* Currently available canister grade handloader powders include the simpler types of these shapes.

In an early model of smokeless powder burning, Vieille considered the conversion of each, identically shaped powder granule to correspond to its surface alteration during the conversion process: The burning function was dependent upon time, pressure and chemical composition of the mixture.

Charbonnier was the first who used transformation of overall charge mass, which does not always proceed evenly. He thereby extended and improved Vieille's solution because the burning course is additionally dependent upon the momentarily converted portion of a charge and a propellant constant (Formula 2).

Form Function *φ(z)* Burning Course for Powders with Various Types of Powder Granule Geometry



Picture 72: Shapes of Powder's Geometric Form Functions

Picture 72 shows that the ideal tubular (Single-Perforation) granule burns with a constant exposed surface area. This means that burning rate is neutral (*φ(z)* =1).

The decrease of outside surface area is compensated by an increase of inside surface area. In this view, surface area alteration resulting from reaction (burning) at the ends of the tube is neglected, i.e. a tube with infinite length.

Strips and flakes act similarly when strip width and length are significantly greater than its thickness.

Cubic and spherical granules, granules in the form of solid cylinders as well as porous propellants show a strongly degressive form function course (surface area decreases during combustion, powder burns „de- or re-gressively").

This stands in contrast to 7- or 19-perforation granules, where surface area increases until the webs separating into the perforations have burnt. The remaining parts are so called *slivers* - their surface area decreases. However, as Picture 72 shows, these granules burn mostly progressively.

Technical remark: In this context, the term offensive (fast-burning) is often used in opposition to the incorrectly used descriptive term progressive (in the sense of slow-burning). The attribute offensive has nothing to do with the attributes progressive / neutral / regressive (or degressive). Here, the attribute offensive only signifies that granule conversion occurs quickly (or severely). An offensive powder can, nonetheless, also be a progressively-burning powder.

When used with long barrels, progressive propellants tend to achieve higher projectile muzzle velocities at comparatively low maximum gas pressures. Therefore, propellants used in rifle cartridges are normally progressive propellants. Propellants for shotgun cartridges and handgun ammunition show predominantly degressive characteristics.

Through the application of deterrent coatings, a progressive burning characteristic is often achieved in propellant granules having a degressive form factor caused by their shape.

To accomplish this, the granule is treated with suitable inert chemicals. (These chemicals do not form compounds as the propellant burns.) This reduces heat energy (caloric value) of the treated (outer) granule layer. Therefore, the temperature of the produced gases is reduced. This reduces linear burning rate. Therefore, without alteration of surface geometry, initial conversion rate is reduced, compared to subsequent conversion rate.

The manufacturer must consider the physical stability of the treated powder surface; i.e., the applied substances must maintain concentration and chemical composition for many years – these substances must neither vaporize out from nor diffuse further into the powder granule nor chemically react with the granule during storage or combustion.

The mathematical relationship of propellant conversion is derived from equation [1] with [2]:

$$\frac{dz}{dt} = \frac{A}{A_a} \times \frac{\rho_c A_a \beta}{m_c} \times \frac{p}{p_0}$$

Herein with: $$B_a = \frac{\rho_c A_a \beta}{m_c}$$

The burning equation of the propellant is:

$$\frac{dz}{dt} = B_a \varphi(z) \frac{p}{p_0} \quad \text{[Equation 3]}$$

B_a: linear burning coefficient of the propellant as used in *QuickLOAD.* Here α is set to unity. This causes that this relationship is invalid for nitrocellulose propellants during combustion at very low pressures. In that circumstance, combustion shows an exponential dependence upon confining pressure (see Equation1, α). (In that situation, *α* plays a major role, otherwise rocket motors will not function). Also, unfortunately, blackpowder is not correctly represented by these formulas. *QuickLOAD* also uses this relationship as a basic function.

The Components of Smokeless Propellants

Black powder has been in use for thousands of years and is composed by a mixture of potassium nitrate, sulphur and charcoal. It produces, when fired, white smoke and corrosive fouling inside the barrel. It is very sensitive to electrostatic discharge and easily ignited. Meanwhile there exist black powder substitutes, like Pyrodex® or TripleSeven® from Hodgdon or MRBPS from Thiokol Propulsion. These should be a drop-in replacement for original black powder, making it more moisture resistant, lesser risky during manufacture. MRBPS consists of potassium nitrate and potassium perchlorate as oxydizers, phenolphthalein as charcoal replacement and ethyl cellulose as binding agent. Sulfur is not used and the Heat of Explosion equals that of normal black powder.

Propellants that produce *less* smoke than black gunpowder, commonly called smokeless propellants, consist mainly of nitrocellulose (NC). In 1884, *Paul Vieille* invented *poudre B(lanche)*: white powder. He made this product from gelatinized guncotton. In 1888, *Alfred Nobel* invented *Ballistite* powder, combining nitrocellulose (NC) and nitroglycerin (NG).

In 1889, at the request of the British government, *Abel* and *Dewar* invented a smokeless powder using 37% guncotton, 58% nitroglycerin and 5% petroleum jelly. Because this was extruded into spaghetti-like rods (cords), it was called *Cordite*. While otherwise successful, the high nitroglycerin content resulted in rapid and heavy barrel erosion. *Munroe (USA)* developed *Indurite,* a nitrocellulose propellant in 1891.

There are many manufacturing methods for smokeless propellants. The following are just a few examples:

Dry nitrocellulose is an explosive and extremely sensitive to friction, impact and electrostatic discharge. Therefore, for safety reasons, nitrocellulose is normally processed in a moist state.

Nitrocellulose originates through the action of nitric and sulfuric acid on cellulose (cotton, wood cellulose or other similar raw materials). (Nitric acid does the work; sulfuric acid is strongly hygroscopic and, therefore, leaches and isolates water produced by the reaction of the nitric on the cellulose.) This produces a chemical compound of carbon, hydrogen, oxygen and nitrogen that is capable of self-sustained combustion (burning without oxygen from an external source).

Degree of nitration determines energy content. Average nitrocellulose contains about 13% nitrogen (by weight).

Further additive substances that are mixed with the nitrocellulose can increase energy content (the resulting powders are called double- or triple-based powders). Additives include nitroglycerin (high energy) and diglykoldinitrate, which has a lower flame temperature.

Muzzle flash can also be moderated with additives. Muzzle flash is generated and visible even when combustion has completed before the projectile leaves the barrel (all-burnt inside barrel).

The propellant gases, standing under high temperature and pressure, consist of combustible components such as carbon compounds (e.g. carbon monoxide) and hydrogen. If the gas temperature is high enough when gases exit muzzle, the combustible components react with atmospheric oxygen and, therefore burn like a explosion. Muzzle flash hiders distribute the exhausting gases into several jets streams mixed with cool air which reduces the ability to react with the oxygen.

A surface treatment and stabilization against decomposition is applied using substances such as camphor, centralite, dibuthylphthalate (DBP), polymeric deterrents or diphenylamine. Graphite is added as a glazing to reduce the risk of a static electric discharge. Today, more modern anti-static coatings are also used.

In small and medium calibre ammunition, three different propellant types are used almost exclusively: single base propellants, “semi double base” propellants (e.g. spherical powders and extruded propellants; with nitro-glycerine contents between 2% and 15%), and double base propellants (usually containing more than 15% of nitroglycerine or other blasting oils).

Single-Base Propellants

Single-base propellants contain a single energy source: nitrocellulose. Therefore, their specific heat of explosion amounts to approximately 2500-to 4000 kJ/kg, depending upon the nitrogen content of the nitrocellulose and type & degree of surface treatment.

Nitrocellulose is gelatinized with solvents (typically, common ethyl ether and/or ethyl alcohol). This gel is treated with additive stabilizing agents. These prevent decomposition during long-term storage, which could result from the release of nitrosous gases generated by residual nitric acid. Additional additive substances decrease the appearance of muzzle flash and lower the combustion temperature. Some or all of the gel can be dyed to facilitate visual differentiation of otherwise identical appearing powders (double-based examples include Alliant’s Red Dot, Green Dot, etc.).

The plasticized mass is then worked into the desired granule size and shape by any of various means. For example, extrusion through correspondingly shaped dies which generate the familiar tubes, cylinders and other shapes.

The dough must then be dried, whereby the solvent vaporizes. Therein, the granules shrink considerably. Since granule size and geometry are crucial to combustion course, manufacturers must know the amount of shrinkage involved in order to produce correctly sized extrusion and forming tools.

Inert substances are diffused into the surface of each powder granule (adsorption). This decreases the reaction heat energy of the outer layers of the granule. This alters (slows) the initial burning rate and improves chemical consistency. Finally, the granules are glazed with graphite. This minimizes electrostatic charge buildup and enhances blending qualities.

Manufacturing quantity of each propellant batch is relatively small and it is not practical to produce essentially identical batches. Mixing and blending of many production batches provides larger batches (production lots) that are ballistically more similar.

Double-Base Propellants

Here, the energy source consists of two components, usually nitrocellulose with nitroglycerin (NG, trinitroglycerin) or diethyleneglycol dinitrate (DEGDN).

No solvents are required to gelatinize the nitrocellulose in these propellants. Nitrocellulose is washed in water and nitroglycerin is added. The nitroglycerin is adsorbed by the nitrocellulose (adsorption creates an intimate physical mixture at the molecular level). The water is purged and the dough is kneaded in this softened state. (In Germany, during WWII, these propellants are also called P.O.L.-propellants – *Pulver Ohne Lösungsmittel* = Propellants Without Solvents).

Further treatment follows, which is similar to that of single-base propellants. In other processes, double-base propellants are further gelatinized with solvents (e.g. acetone).

By gelatinizing with DEGN instead of nitroglycerin, a so-called cold propellant is produced. This powder has a much lower Heat of Explosion; therefore, lower propellant gas temperature. This considerably decreases barrel erosion. The specific volume of gases is higher than with double-base nitrocellulose/nitroglycerin propellants; therefore, the lower energy content is somewhat compensated. This double-base powder thereby, achieves usable ballistic performance.

The specific heat of explosion of propellants containing nitroglycerin can exceed 5000 kJ/kg. Nevertheless, propellants containing NG are not necessarily more energetic than single-base propellants. This depends upon the nitrogen content of the nitrocellulose used in the particular powder.

Triple-Base Propellants

Addition of a small amount of nitroguanidine to diethyleneglycoldinitrate / nitrocellulose gelatin results in a so-called nitroguanidine propellant (another cold propellant). Nitroguanidine is a crystalline explosive. It does not dissolve into the gelatin but must be pulverized and intimately mixed into the dough.

The propellant generated in this way is called a triple base propellant and is preferred for naval artillery ammunition because nitroguanidine reduces heat-generated barrel erosion. It produces a gray smoke and is not as smokeless as the aforementioned propellants. However, adding 10% to 15% nitroguanidine to the propellant practically eliminates muzzle flash.

LOVA- or IM Propellants

LOVA stands for **LO**w-**V**ulnerability-**A**mmunition, IM for **I**nsensitive **A**mmunition. This special ammunition is (should be, as a goal) relatively insensitive to impact of bullets or jets of shaped charges. In case of accident or fatal impact it should burn and not explode or detonate. Most of them are used in explosive charges and warheads, few are used as propellant.

Generally, LOVA propellants are not based upon nitrocellulose. These propellants are not available for reloading purposes.

The energy source can be nitramines (all *high explosives*) like (Hexogen / RDX, Octogen / HMX and nitroguanidine) or nitramit formulations (ADN=ammonium dinitramite), tongue-twisters like hexanitro-hexa-aza-isowurtzitane (HNIW, sometimes called CL20). Furthermore, a reduced sensitivity RDX (RS-RDX) is under development; which differs from normal RDX only by modification of almost same production process.

In LOVA propellants, the explosives are embedded or cross-linked in polymer compounds so that the explosive attributes are prevented, guaranteeing normal (propellant) combustion. The in matrices cross-linked polymeric substances can actively or passively contribute to combustion. Those energetic binder systems containing both energetic polymers and plasticizers are under development. Active binders are for example: Glycidyl azide polymer (GAP), polyglycidyl nitrate (PGN).

It is also possible to produce "block co-polymers". These are not cross-linked and can be melted (i.e., thermoplastic elastomers, so called TPEs). They are attractive for use in energetic materials because they allow reforming of the propellant during production and utilize the possibility of simple recovery of the energetics at the end of service life.

LOVA-propellant granule shape can correspond to conventional propellants. In certain instances, these propellants can contain also some nitrocellulose.

These propellants are mainly used in the manufacture of caseless and cased ammunition, used in tank cannons, in helicopters guns and in rocket motors.

(HITP = **H**igh **I**gnition **T**emperature **P**ropellants, mainly used with H&K's historical G11 caseless ammunition, belong to this propellant class.)

Ageing of Propellants

The ageing of surface coated single base propellants causes almost no serious problems: The rates of stabilizer depletion and nitrocellulose degradation are very low. The deterrents commonly used for surface coating diffuse very slowly into the single base propellant grains. Therefore, only minor changes in interior ballistic behavior occur even under proper (dry and cool) long time storage conditions. Contrary to this, most deterrents diffuse quickly into double base propellants. The rate of chemical ageing is increased in double base propellants (due to the lower stability of nitroglycerine compared to nitrocellulose), especially if deterrents of small molecular weight were applied (Camphor, DBP). Therefore, it is more difficult to obtain sufficient functional life with surface coated double base propellants for small arms.

Granule's Shape and Manufacturing Process

Spherically shaped propellants are normally double-base propellants. These are easy to meter and dose well, enabling the realization of high loading densities (ballistically Loading Ratios). The degressive burning caused by the spherical shape can be mitigated through suitable surface (deterrent) treatment.

The manufacturing process used to make spherical propellants and rolled flattened spheres can also be used for single-base propellants, but not for triple-base propellants.

All other shapes can be formed out of single-, double- or triple-based propellant substances.

Cylindrical, tubular and other die-formed shapes are produced by extrusion of gelatinized dough, which is cut to the desired length.

Strip and rectangular flake propellants were, in earlier days, rolled and cut, but today those are also extruded and then cut.

There are few processes to make spherical powders. For example, *Primex Technologies*, St. Marks, FL (former OLIN) produces a spherical propellant, which they named *Ball Powder®*. The process was developed by *Olsen*, Western Cartridge Co. in the 1930s. The spherical propellants of *PB Clermont* of Belgium are produced by the same process after aquisition of a license from OLIN in 1952. Some *PB Clermont* propellants are available in USA under the *Ramshot* brand name.

With modifications to original process the unique procedure looks like this:

The raw nitrocellulose is washed with emulsifying additives, stabilizers (e.g. inorganic salts, gelatin) in warm ethyl acetate and the nitrocellulose is partly dissolved to form a viscous doughlike lacquer that is then extruded through a perforated plate with die-face cutting blades into water and continuosly stirred. The resulting suspension consists entirely of tiny spheres of different size. The suspension is slowly heated to distill the solvent. The individual granules thus retain the ball shape as they harden. After cooling, the balls are impregnated with nitroglycerin and dried. The different spheres are separated by sieving the whole batch through sieves of different size of meshes.

The raw material can also incorporate nitroglycerin (NG). If required, the ball shape is flattened to modify exposed surface area. To finish, the granules are surface treated and graphite glazed.

The original patented process was a small volume batch process that produced a spherical globule of limited size and therefore useful only to limited range of calibers. Meanwhile the process has been improved to allow production of larger spheres.

Primex has also developed a process for 'in-case compaction' of spherical powders. This results in an increase of charge up to 25% by deforming the granules shape, but without significantly changing propellant vivacity. That is, because the form function of a undistorted sphere differs not significantly from a distorted sphere wich is pressed to a cube-like shape bei neighbour spheres. Use of very slow- and progressively burning powders and such high-density charges can produce significant ballistic advantage. Other manufacturers use proprietary processes to produce ‘Consolidated Charges’ using extruded powders for increased load density and higher progressivity. Those charges are used in small to medium caliber military rounds and in the civil ‘increased-velocity’ or ‘mini-mag’ factory loads.

We must also mention "cast“ and "baked“ propellants. In these, the raw material consists mostly of soft, wet spherical nitrocellulose. From this dough, propellant bodies (granules) are produced which sometimes exceed 4-inches in diameter. These see primary application in rocket motors.

Modeling the conversion of propellants

The shape functions shown in Picture 72 begin with $\varphi(z)$ =1 for z=0 (begin of combustion). As seen in equation [3], $\varphi(z)$ has to be multiplied with B_a to get approximately the actual burning function $B_a * \varphi(z)$ as a function of z. In principle, the curve looks similar to those shape functions represented in Picture 72, only the scale of the vertical axis (y) is changed. However, that does not correspond to the actual burning course.

Because virtually all propellants are surface treated, the shape of burning function differs considerably from the ideal of the geometrically set course of the shape function.

For the interior ballistics calculation, the following propellant properties are required:

- the burning coefficient(s),
- the shape- or burning function(s),
- the Heat of Explosion and/or the force of the propellant
- the solid density of the propellant
- the covolume
- the ratio of specific heats at constant pressure and volume.

How does one now get the actual burning rate of a propellant and the properties required for the interior ballistics calculation?

Once the desired data is obtained through measurement of projectile velocities and pressure course of different charges (load densities) in an otherwise unaltered arms system (interior ballistic system) it is recalculated with an interior ballistics program.

With an unknown burning function one could estimate only the burning function by experience and correct it if necessary. These data then are valid only for the interior ballistic system upon which the calculations are based and bring very good results in calculating this definite system. With expensive equipment, the projectile base pressure and the projectile movement can be measured inside the barrel, e.g. by active and passive microwave interferometrics and so still more exact values can be obtained.

Historically the specific *Heat of explosion* Q_{ex} of the propellant is defined with assistance of a calorimetric bomb: a small charge of the propellant is ignited in a pressure vessel submerged in water and the temperature increase of the water is measured. From this the Heat of Explosion could be calculated. To day, the chemical composition and the chemical reactions of substances are known and the Heat of Explosion and further thermodynamic parameters will be calculated also with thermochemical methods on a computer.

The measurement of the burning rate is done in the manometric closed pressure vessel. This is a hermetically sealed combustion chamber with screw caps, electric primer and pressure transducer and has a defined volume, burning a definite quantity of propellant.

Here, pressure course and times are measured and recorded. The rise of the pressure is calculated to defined, short and consecutive time intervals and drawn in a curved plot over the relationship of the corresponding pressure to maximum pressure (p/p_{max}).

This results in a curve form which is similar to a shape function. The pressure relationship on the horizontal x-axis P/P_{max} proceeds exactly as the part of burnt powder "z" from 0 to 1. P/P_{max} corresponds to z with homogeneous propellants, e.g. half of the propellant burnt corresponds to a pressure of about half of P_{max} (only in the pressure vessel/bomb).
The estimated start value of this curve represents the *Burning rate function coefficient* B_a**.**

The so found curve represents the ‘dynamic’ *Vivacity* of the propellant. Through a series of measurements, different propellant parameters are easily calculated when only the load densities are changed because, in the pressure vessel (in contrast to the real weapon), the volume does not change and the pressure climbs monotonously until end of combustion.

Therefore, the formulas required for the calculations are simple and the determination of the propellant constants, with the exception of the shape function, is easily made.

With

- the propellant *force* **f**
- the *covolume of gases* η
- the *ratio of specific heats* κ
- the *maximum pressure* $\mathbf{P_n}$
- the *load densities* $\mathbf{L_n}$
- the *volume of chamber* **V**
- the *solid density* of propellant ρ

you obtain with two different loading densities L_{12}

the *force* $$f = \frac{VP_1P_2(L_2 - L_1)}{L_1L_2(P_2 - P_1)}$$, and

the *covolume* $$\eta = \frac{V(P_2L_1 - P_1L_2)}{L_1L_2(P_2 - P_1)}$$ [4,5] , further

the *solid density* $$\rho \approx \frac{1}{\eta}$$ [6] , and

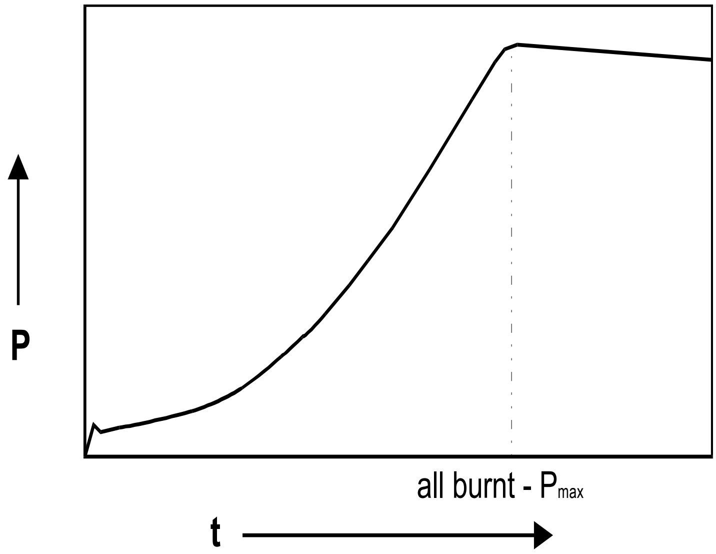
the *Ratio of Specific Heats* $$\kappa = 1 + \frac{f}{Q_{ex}}$$ [7].

(The formula for the solid density is an approximation and is sometimes inaccurate for nitrocellulose propellants at very high load densities. It brings sufficient accuracy at normal load densities and for nitroglycerine propellants).

[6] and [7] is used by the program within the system of the interior ballistic equations.

There are approaches today to calculate burning rate using computational models. The gas-phase process, including convection, reactions, thermal conduction and molecular diffusion is well modeled by computer code. But the condensed phase is not modeled yet because the nature of the chemical and physical processes ongoing there is not sufficiently researched and no detailed information is available.

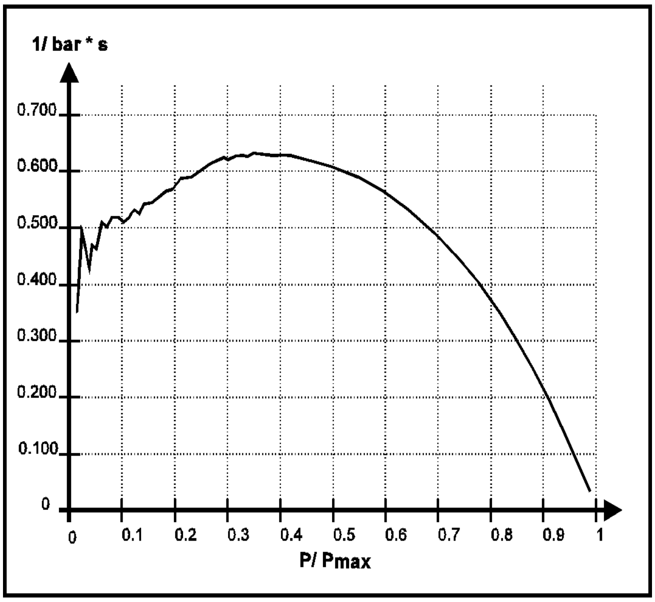
The combustion in the manometric (or closed-) vessel or bomb



Picture 73: Pressure curve from closed bomb

A slow pressure increase, which becomes continuously steeper, is recognizable. After the all-burnt point, the pressure sinks slowly through cooling of the gases. P_{max} at all-burnt point.

Burning course of an actual propellant



Picture 74: Vivacity from closed bomb

From a measurement of the *Vivacity* determined in the pressure vessel vs. the ratio of pressure to max. pressure, corresponding to the burning function of a typical rifle propellant.

Instead of P/P_{max} you can put in z and instead of 1/ bar*s you can put in Ba $\varphi(z)/p_0$. B_a/p_0 can be estimated at z=0 with 0.42.

The curve in Picture 72 fits to no one of those theoretical shape functions shown in Picture 70. It is a highly surface treated propellant, which is also on the market for reloading purposes.

The so obtained shape of the burning course and the different calculated propellant constants can now serve as basis for the input values required for the interior ballistics program. But it must be noted that the conversion in the pressure vessel differs somewhat from the conversion in the weapon.

In the pressure vessel, the pressure rises continuously until it reaches P_{max}, the chamber volume stays constant, the combustion proceeds until the all-burnt point and the hot gases are always heating the same walls.

In the weapon, the pressure ascends and then falls off, the combustion chamber increases its volume constantly and the gases come in contact with new, cold barrel sections. The chemical transposition of the propellant in the weapon therefore differs somewhat from that in the pressure vessel.

The values determined in the weapon, dependent on the energy contents of the propellant, are higher than those obtained through the measurement in the pressure vessel.

So all of the parameters dependent on propellant energy must be modified. Such empirical values must be adjusted by interior ballistics calculation and corrected to real firing measurements.

The burning course shown in Picture 72 had to be described and approximated by a mathematical function, so that a calculation can be performed in an interior ballistics calculation procedure.

The program *QuickLOAD* uses here a two part composite shape function, providing that the burning is characterized as partly progressive and partly degressive.

With this the burning function of almost all current propellants can be simulated, in that all geometrical shape functions are included or could be approximated.

The burning function used in *QuickLOAD* is similar to the following equations:

1st Part $$\varphi(z) = (1 + a_0 z)^n \ldots 0 \le z \le z_1$$ and

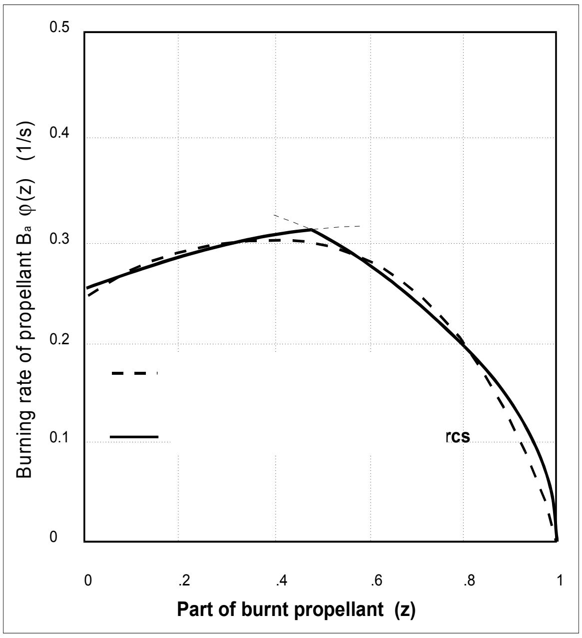
2nd Part $$\varphi(z) = b \bullet (1 + a_1 z)^m \ldots z_1 \le z \le 1 \quad . \qquad [8]$$

The intersection of both parts is determined when both functions deliver the same value for z= z1.

This function also allows a simulation of purely progressive, purely degressive or neutral burning powders.

- For a = 0 a neutral burning is described.
- For a > 0 a progressive burning is described.
- For a < 0 a degressive burning is described.

Example of an approximation of a burning function



Picture 75: Approximated vivacity

Measured burning function (dashed) and approximated burning function (solid), simulated by two parabolic arcs, intersecting at z_1 =0.48.

The interior ballistic formalism included in *QuickLOAD* allows a composition of the burning (shape) function with any number of sub functions, which enables the still more exact simulation of the burning course for testing purposes.
For ease and convenience in handling for the user, the function with 2 arcs was chosen and implemented. Future spherical propellants with intensive surface treatment may require a higher resulotion of the burning function.

With help of the equations for the combustion of propellant, the movement equations of the projectile and the energy equations of the interior ballistics system, a solution of the interior ballistics problem was worked out and implemented in *QuickLOAD*.

Comparisons with scientific publications and with measurements have shown that with this model of shape function (and so the burning function), it is possible to obtain good results which correspond very closely with reality.

However, one may not expect exact correlation with published load charts because often a great deal of their underlying parameters are unknown and vague, and sometimes not published.
The burning course of some fewer propellants (pistol- or shotgun types) who burn extremely degressively is simulated only roughly. Some few (very long, straight wall) cartridges show a higher calculated efficiency than in reality. It is assumed that here the ignition process of the charge closest to the projectile is somewhat delayed or sometimes non-existend.

A strictly exact calculation procedure for Interior Ballistics does not exist and will probably never be in the future. It should be borne in mind that the model used does not have to be perfect to be useful; sometimes it would be enormously helpful to have even semi-quantitatively correct theorethical guidance in interior ballistics work.

The program *QuickLOAD* includes tools and procedures allowing very easy adaptation of the burning function to measured curves and single measurements.

The description of further necessary details of the interior ballistics system is described in the explanation of the user interface to the program and its functions.

Good Advice:

1. **Never mix propellants of different lots even of the same designation, because the chemical composition has not been matched and from this an unpredictable rate of combustion could result.**

2. **Disintegrated or deteriorating propellants must not be further used or stored, because the rate of combustion has changed considerably and could accidentally lead to self combustion. Deteriorating propellants are recognized as brownish red in color, somewhat acrid fumes.**

3. **Deteriorating propellant particles must not contact good propellant; otherwise the disintegration of the fresh propellant might be expedited through an automatic catalytic reaction !**

4. **Never substitute primers of a proven load against other types until you work up the load from a save level again.**

5. **Never shoot someone else's handloads.**

6. **Be careful. Always assume that two lots of propellants are different ! There are propellants known for differences even within the same lot.**

An Army/NASA test report published at Munitions Technology Symposium IV, 1997 in Reno, NV, shows among other results, following (author cites a sentence in abbreviated form):

> *"The results of the evaluation of two batches of propellant)* ... exhibited considerable performance differences. Propellant Lot #X was much less sensitive to ignition than was Lot #Y in all test parameters: (1) ignition time was 25% longer, (2) time to peak pressure was 17% longer, (3) peak pressure was 11% lower, and (4) ignitability was 30% lower."*
>
>)* same type of propellant, types and numbers made anonymous. You should know that this was not a so called '*canister grade*' propellant (remark by author).

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