Glass Manager

Optical Design Software

Optical glass database

A product of

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Summary

Glass Manager is the optical glass database program within the WinLens suite from Qioptiq.

The main aim of Glass Manager is to help an optical designer compare and select the 'best' optical glasses.

Glass Manager contains nearly 2000 glasses from the main manufacturers, both current and obsolete. For each material it contains optical [index & transmission], chemical, thermal and mechanical data.

Glass Manager has all the standard tables and graphs that you would expect in the large paper catalogue, but goes far beyond these in many ways:

- powerful search & sort facilities
- clone and/or lock graphs and tables for quick comparison
- custom waveband selection [user or key spectral/laser lines]
- custom glass maps [select axes from a wide range of properties]
- custom colour coding of glasses on the glass maps
- history logs for rapid access to ‘old’ searches, colour codes & custom plots
- direct comparison of up to 4 glasses on same graph
- zoomable graphs & plots

Furthermore you may also add your own materials using the Material Editor utility.

In short, Glass Manager is a standalone program that will benefit any optical designer, and compliment any optical design software.

This manual is divided into three main sections:

- Section 1. Installation notes and a brief introduction to the main concepts involved in the Glass Manager.
- Section 2. The main manual; it provides detailed notes on all the features to be found. It follows the menu structure in Glass Manager.
- Section 3. A sample session with Glass Manager. This works through much of what you can do with Glass Manager.

We suggest that once you have installed the program, you follow through section 3, the sample session.

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The manual

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Section 1
Introduction

1. Introduction to Glass Manager

Glass Manager is an optical glasses database program written specifically for lens designers. It contains key data on many hundreds of glasses [current & obsolete] from the key manufacturers - CDGM [Chengdu], Corning, Hoya, Hikari, Ohara, Pilkington, Schott & Sumita. This data includes:

- Refractive index
- Transmittance
- Relative partial dispersion
- Chemical properties
- Mechanical properties
- Thermal properties

Glass Manager is designed to make it easy for you to find & compare materials for your projects.

With Glass Manager you can find groups of glasses with specified properties, view their behaviour in graphs and tables and even analyse pairs of glasses for use as achromatic doublets.

Data Display. glass data can be shown in many ways:

- Tables for various properties of one glass
- Spreadsheets to display the properties of a selected set of glasses.
- Graphs for the optical properties of one glass
- Plots for optical properties for a selected group of glasses
- Custom Plot - select from a wide range of properties
- Colour code glasses in plots in many ways [category, maker or property]
- Standard or user selected wavelengths for those plots
- Comprehensive glass finder facility to select glasses from the database
- Doublet making facilities
- Obsolete glass list plus nearest available glass finder
- Glass Data sheet printout, Doublet printout

Simple Interface. The tables and plots in Glass Manager have been designed to resemble those in the large glass catalogs. You can have as many tables and graphs visible as you need, sized and arranged as you want, and accessed via a one level deep menu.

Powerful search tools. [chapter 7] There are various tools for finding sets of glasses, single glasses and alternatives to specific glasses.

Clone and Lock. [chapter 3.4] You can clone - make multiple copies - of tables and graphs. These can then be 'locked' to a specific glass for ease of comparison [new in 2010].

History Logs. [chapter 11] Lists of recent searches, colour codings and individual glasses - click to rapidly re-select. Great for speedy comparison

Custom Wavebands. [chapter 1] You may define the current waveband used in the Plots - such as n-V. These will show the correct data for that waveband. You can specify the waveband manually or from accurate tables of spectral and laser lines.

Colour Coding. [chapter 6.3] glasses in the plots can be colour coded by type, maker or a selected property - thus adding a 'third dimension' to the displayed information

Melt Glass Modeller: [chapter 5.11] Predict the change in refractive index over the entire waveband from 2 index values of the melt data.

Zoom in Graphs. You may zoom into and out of all graphs. Simply click down the left mouse button at one corner of the area of interest and drag the cursor to the other corner, then release the mouse button.

2. Getting started

The Glass Manager program is very easy to install and run, provided of course that your machine has the necessary capabilities.

2.1 System Requirements

Glass Manager will run on PC's with Win XP, 7 or Vista. It will probably run on earlier operating systems too.

Any machine capable of running one of the named operating systems without problem should also run Glass Manager without problem.

2.2 Installation

You will have either downloaded the installation zip file from www.winlens.de or been sent a CD with it.

Inside the zip file, you will find an executable
GlassManagerTD_Installer.exe

Extract this executable onto your PC, and double click to start the installation process.

By default Glass Manager will be installed in folder:
C:\Program Files\Qioptiq\GlassManagerTD
You can change this if so desired.

The installation process is very straightforward - there are no further options.

2.3 License file

Once Glass Manager is installed, you must then place a copy of the encrypted license file, LINOS_3D.LIC in the same folder as the program.

This license file is specific to you and will be send upon purchase of a license file for the WinLens suite.

If you do not do this Glass Manager will refuse to start!

2.4 Running Glass Manager

The first time that you run Glass Manager you will be required to enter the details held within the license file - to confirm that you are the legitimate owner of the software.

These will be included in the email sent with the license file.

Your name and company will then appear in your version of Glass Manager.

3. Using the Program: Key Concepts

This chapter provides a brief introduction to the Glass Manager layout and the key concepts which you must understand.

3.1 Layout

Glass Manager is a single program with a menu, header bar, toolbar, sidebar [notes] and footerbar.

The header bar has been designed to resemble the information displayed for a glass in the large paper catalogs. It shows the data for the 'current glass'

At the right hand end of the header bar are 3 check boxes. These enable you to 'tag' glasses for quick comparison in the graphs- see section... [chapter 10]

You can access all the facilities in Glass Manager via the menus - these are just one level deep, so there is no complex structure to remember.

However it is quicker to use the icons in the toolbar.

The toolbar contains icons to load graphs,tables etc.

Icons	Purpose	Chapter
	Tables showing data for a single glass	5.1
	Tables showing data for all selected glasses	5.8
	Alternate glass finder Melt modeller Glass comparison table	5.9 5.11 5.12
	Graphs showing index or transmission data for a single glass	6.1
	Plots showing data for all selected glasses	6.2
	Doublet focal length plot	6.4
	Search Tools	7
	Doublet Maker Waveband selector History Logs [F9] Print	8 1 11

3.2 The 'Current' Glass

The glass named in the header bar is known as the current glass. Most of the tables and about half of the graphs show a property(s) of the current glass. As you change the current glass, so these are updated automatically.

There are many possible ways to alter the current glass:

- By using the Find Glass dialog [CTRL+F] [section 7.1]
- by clicking on a graph showing the selected glasses (below). The nearest glass to the cursor becomes the current glass.
- by clicking on row in the spreadsheet showing the selected glasses.
- Clicking on a 'recent' glass in the history log [F9]
- by a VCR control on the footer bar
- by selecting a glass name from a list on left of the footer bar.

3.3 The Glass Selection

From the entire database it is possible to select a subset of the glasses (press key F2 to get the Search dialog - discussed in chapter 7.2). This subset is known as the 'selected glasses'. The current glass is always one of the selected glasses. Initially, all glasses in the database are selected.

If you have one or more of the plots, N_d:V_d (shown here), P_{Cs}:V_d, P_{dC}:V_d, P_{Fd}:V_d,P_{gF}:V_d or N_d:density or the Custom plot visible, you will see the selected glasses represented on these plots by a scattering of single points.

On such plots the current glass is highlighted by a small red flashing cross.

3.4 Clone & Lock

You may make additional copies of any table or graph that's dedicated to a single glass. Simply right click on the window of interest and select 'clone' from the popup menu. You can make as many clones as you want.

You can then lock any of the windows to display data from a specific glass - again right click on the graph and select 'Always display glass….' Option from the menu. The Find Glass dialog will appear [chapter 7.1] and you can easily choose the appropriate glass.

Using these features it is simple to compare two or more glasses directly, especially for data in tables where several decimal places may be of import.

3.5 Graph features

All graphs are zoomable: To zoom into a graph simply select the area that you wish to view more closely by clicking and dragging with the mouse pointer. To restore the full plot, press the resize button.

As the mouse pointer is moved over a graph relating to the current glass (e.g. refractive index v wavelength), a

full cursor is shown moving along the curve. On the footer bar, the x & y values are also constantly updated.

As the mouse moves over a plot of the selected glasses, there is NO cursor. However the footer bar reports the x & y co-ordinates of the pointer, along with the name of the glass nearest the pointer.

3.6 Doublets

With Glass Manager you can assess pairs of glasses for use as achromatic doublets. One half of the doublet will always be the current glass. The other half will be one of the selected glasses.

There are two ways to create doublets:

- Click with the RIGHT hand mouse button on a graph showing the selected glasses. You will be asked to enter the required power of the doublet. Glass Manager will then analyse the thin lens system made up of the current glass, and the glass nearest the mouse pointer (when you clicked the graph). On subsequent clicks you will not need to enter a power.
- Select the doublet maker option [F3] for a more systematic approach [chapter 8]. A dialog box will appear. Enter the doublet power and select a sort order. Glass Manager will then make doublet combinations between the current glass and all other glasses in the selection. The sorted results will displayed in a spreadsheet. You may resort the results if desired. If you want to analyse one special combination further, simply click on the row containing that glass. Press EXIT to return to the main program.

In either case, Glass Manager will:

- Indicate the 'second' glass on plots of the selected glasses by a small green flashing cross hair.
- Show the name & code of the 'other' glass at the right of the header bar.
- Display the power of the doublet underneath. This may be edited.
- Add a further pull down list to the footer bar. This also contains the names of the selected glasses, but is linked to the 'second' glass. If you used the doublet maker, then these glasses will be listed in that sort

order. As you click on a glass in the list, so the 'second' glass is altered.
- Enable the doublet focal length plot and doublet printout options.

To cancel the doublet analysis mode, simply enter a power of zero into the text box on the header bar.

By default, a doublet is analysed with respect to the d (587.6nm) wavelength, and corrected at the C (656.3nm) and the F(486.1nm) wavelengths.

These defaults can be changed by pressing F4. For example, you could design a doublet for 900nm, and correct it at 800 & 1000nm. These also apply to the plots of selected glasses.

Hint: to reduce the residual (secondary) chromatic aberration, you will need to select glasses with different V Values, but similar $P_{x,y}$'s. Therefore the plots P_{Cs}:V_d, P_{dC}:V_d or P_{gF}:V_d may be very useful. But also note that glass pairs which have reduced secondary spectrum tend to be exotic.

Section 2
The Manual

Menu by menu review of the main Glass Manager menu items:

- File chapter 4
- Tables chapter 5
- Graphs chapter 6
- Search chapter 7 [F2] or [CTRL + F]
- Doublets chapter 8 [F3]
- Waveband chapter 1 [F4]

Plus notes on

- Tagged glasses chapter 10
- History logs chapter 11 [F9]

4. File Menu

As Glass Manager neither imports nor exports data, this menu is short.

NB you can add glasses to the database using the Material Editor Utility

4.1 Print Current Glass

Select this option to obtain a data sheet for the current glass.

Note that the refractive indices (apart from those in the header) have been calculated from the dispersion constants.

Note also that the internal transmittances have been calculated from the equivalent absorption coefficients.

4.2 Print Selected Glasses

Select this option to generate data sheets (as above) for all the selected glasses. Be careful when using this option, as you could easily generate several hundreds of datasheets.

4.3 Print Doublet Data

If a doublet has been created, then this will give a printout of the two glasses, their names, suppliers & powers along with the plot of focal length against wavelength.

4.4 Screen Dump

Select this option to generate a screen dump of the entire program. The quality of the dump will depend on your printer.

NB You may also generate screen dumps for individual graphs/tables, by clicking with the right hand mouse button on the graph or table.

For the selected glasses plots you should click on the area round the graph rather than on the graph itself, as that would start the doublet creation mechanism.

4.5 Printer Setup

Select this option to access the standard Windows printer setup dialog. With this you may choose the printer, paper orientation etc. Options displayed will depend on the current printer driver. Some, such as print to file, are not supported by Glass Manager.

4.6 Exit

Terminates the program. The following items are kept until the next launch of Glass Manager

- Waveband chapter 1 [F4]
- Tagged glasses chapter 10
- History logs chapter 11 [F9]

The program also remmebers the last locations of the graphs and tables but does not reload them automatically.

5. Tables

Hint: Clone and Lock
Right click a table, and select ***'Clone'*** to make an extra copy of a table.

Right click and select ***'Always display...'*** to force table to display a chosen glass.

These are great for comparing glasses directly.

The Glass Manager contains a variety of tables which may be selected by the user.

Most of the tables show data only for the current glass, and are therefore updated as you change the current glass.

5.1 Refractive Index Table

This table shows the refractive indices for the current glass at specified wavelengths from 250 to 2500nm. These indices are calculated from the dispersion coefficients.

Also shown are the actual indices at the d and e wavelengths, and the difference between the actual and calculated data. This provides a check on the accuracy of the stored dispersion constants.

Note that some manufacturers use the Schott formula with coefficients which give accurate results in the region 365 to 1014nm, whilst Schott Glaswerke now uses the Sellmeier formula which provides extended accuracy between 250 to 2500nm.

If the old Schott formula is being used, then the displayed indices in the 1014-2500nm and 250-365nm regions are extrapolated and must be treated with caution.

Data is not given for the current glass below its UV cut-off.

5.2 Index related data for current glass

This table shows the refractive indicies for the selected waveband, along with the dispersions, V value, partial dispersions and relative partial dispersions - all calculated for the chosen waveband.

Note that if a non-standard waveband is used [not dCF, or eF'G'] then the descriptive labels will be appropriate.

5.3 Dispersion Constants Table

This table shows the dispersion coefficients stored for the current glass. Note that these are used to calculate the refractive indices shown in the refractive index table and graphs.

Most manufacturers give the dispersion constants for the Schott formula [6 coefficients] which have been fitted to measured data in the 365 to 1014nm band. Schott Glaswerke now use a three term Sellmeier formula [6 coefficients], which offers similar accuracy over an extended waveband (typically 250 to 2500nm).

The table also shows the type of the polynomial used to represent the index function and the general region of validity for that polynomial.

5.4 Relative Partial Dispersion Table

This table shows some relative partial dispersions, $P_{x,y}$, for the current glass. It is split into two halves:

- The top part shows $P_{x,y}$ and $dP_{x,y}$ for wavelength pairs (x,y)

  $P_{x,y} = (n_x - n_y)/(n_F - n_C)$

  $dP_{x,y}$ is the difference of $P_{x,y}$ from the 'normal' glass line
- Bottom part shows $P'_{x,y}$ for the same wavelength pairs.

  $P'_{x,y} = (n_x - n_y)/(n_{F'} - n_{C'})$

All the data is calculated from the dispersion polynomial for the glass, except for the values P_{Cs}, P_{dC} & P_{gF} which are stored in the database.

5.5 Transmittance Table

This table shows the internal transmittance, t_i, at specified wavelengths for blocks of the current glass which are 5 and 25 mm thick, where:

$$t_i(\lambda) = e^{-\alpha(\lambda).t}$$

$a(\lambda)$ is the absorption coefficient for that glass and t is the glass thickness.

Since the different manufacturers provide data for different thicknesses and wavelengths, the equivalent absorption coefficient has been calculated beforehand and stored in the database. The transmittances are then recalculated from the absorption coefficients.

5.6 Temp. Coefficients of Ref Index Table

This table shows the temperature coefficients of refractive index for the current glass.

The refractive index of a glass varies with the temperature. This variation depends on both the temperature range and the wavelength under consideration.

Unfortunately, there is little common ground between the manufacturers as to which wavelengths to use. Therefore the form of this table will vary from supplier to supplier.

In essence, the columns show data for a specific wavelength (generally specified by one of the standard letters [whose value will be see in the refractive index table]). The rows show the data for a specific temperature regime.

5.7 Other Properties (Chem / Mech / Thermal) Table

When selecting a glass, many other properties besides its refractive index and transmittance should be considered, for example, cost, handling and density may all be significant.

This table shows a large number of these properties for the current glass. These have been grouped into four categories, separated by a blank row in the spreadsheet:

Thermal	Linear Coeff of Thermal Expansion -30C-+70C [$A_{-30/70}$] Linear Coeff of Thermal Expansion -20C-+300C [$A_{20/300}$] Transformation Temperature [Tg] Softening Point [$T_{10}^{7.6}$] Upper Annealing Point [$T_{10}^{13.0}$] Specific Heat capacity [Cp] Thermal Conductivity [l]
Mechanical	Density, Youngs Modulus, Poissons Ratio, Torsion Knoop Hardness
Chemical	Climatic Resistance [CR] Stain Resistance [FR] Acid Resistance [SR] Alkali Resistance [AR] Phosphate Resistance [PR]
Miscellaneous	Color Code Bubble 'Price' Availability

[Some manufacturers do not provide all this data, either at all or only for certain glasses.]

5.8 Selected Glasses Table

Not clonable

This is a customisable read only spread sheet, which shows data for the selected set of glasses. These glasses are ordered in the way specified by the search facility [chapter 7.2].

The table is only updated when you run the search facility and change or reorder the selected set of glasses.

The glass name, glass code and supplier are always shown at the left hand side of the table.

You can customise the table by checking one or more of the option boxes at the bottom of the window. Thus you can elect to see partial transmission data and/or chemical and/or mechanical etc. properties.

Dispersion	n_F-n_C, P_{Cs}, P_{dC}, P_{gF}
Chemical	Climatic Resistance [CR] Stain Resistance [FR] Acid Resistance [SR] Alkali Resistance [AR] Phosphate Resistance [PR]
Mechanical	Density, Youngs Modulus, Poissons Ratio, Torsion Knoop Hardness
Thermal	Linear Coeff of Thermal Expansion -30C-+70C [$A_{-30/70}$] Linear Coeff of Thermal Expansion -20C-+300C [$A_{20/300}$] Transformation Temperature [Tg] Softening Point [$T_{10}^{7.6}$] Upper Annealing Point [$T_{10}^{13.0}$] Specific Heat capacity [Cp] Thermal Conductivity [l]
Other	Color Code Bubble 'Price' Availability
T5mm	Transmission of a 5 mm thick block of glass
T25mm	Transmission of a 25 mm thick block of glass

The last two do not take into account reflection losses. The values are given at 250, 300, 350, 400, 500, 700 & 1060 nm.

5.9 Calculator

Not clonable

This is a simple interactive form which shows:

- refractive index
- refractive index (first differential wrt wavelength)
- refractive index (second differential wrt wavelength)
- reflection loss
- internal transmission
- total transmission (combined absorption & reflection loss)

for the current glass at a specified wavelength and thickness.

You may alter both wavelength (in nm) and glass thickness (in mm). On entering the new value(s) the display will be updated accordingly.

When the current glass is altered, the results will be recalculated for the wavelength and thickness specified.

The reflection loss is calculated for a double sided plate made of the current glass and immersed in air. The effects of multiple reflections have been included.

5.10 Obsolete glasses

Not clonable

In recent years some of the key glass manufacturers have rationalised their glass lists. Many old glass types are no longer available (unless large quantities are required).

Alternative glass finder
As of version 2.3 [Aug 2010] you can now find alternatives for any glass - not just obsoletes.

Select 'all glasses' from the drop-down list at mid bottom of the form,

The Glass Manager maintains a table of nearly 1000 obsolete glasses. You can simply browse through this list or get the program to find the 'nearest' equivalent available glasses.

This form is divided into several sections (initially not all being visible):
1: Spreadsheet showing the obsolete glasses (name, supplier, refractive index, V value & density) [top left of form]

2: Option buttons. Check on of these to control in what order the obsolete glasses are displayed [bottom of form]

3: Header showing data for one of the selected glasses. To change this glass click on the spreadsheet. This glass in the row you clicked will appear in the header.

4: Spreadsheet showing 'nearest' available glasses to the obsolete glass specified in the header. This appears when you click the 'Find nearest available glasses' button at the bottom of the form. The glasses are displayed in order of 'closeness' to the selected glass. [top right of form]

5: Options section - you can:

- choose number of nearest glasses displayed (1 to 9)
- alter the weighting between refractive index & V value in the programs definition of 'closeness' of glasses. If the slider bar is moved to the left, then refractive index becomes more important, whilst if moved to the right, then V value becomes more significant. If the slider is at either extreme, then the other factor is completely ignored. [middle right of form]

NB use of this table does not alter the current glass or the selected set of glasses in the main program.

5.11 Melt data modeller

Not clonable

Glasses are created in batches called melts. The index data of a melt will vary slightly from the catalogue values. In some cases this can be significant. It is therefore of use to model the impact of a melt.

This table predicts the refractive indices of a melt of one the catalog glasses. You must either supply:

- two refractive indices (at specified wavelengths)
- one index and V Value at the current standard wavelengths

On changing any of these, Glass Manager will predict the indices of the melt using a well tried model[1]. These indices are calculated and displayed for a closely spaced set of wavelengths over the waveband defined by region of validity of the equations defining the normal glasses. Both catalog and melt data will be given (on screen and as a printout).

---

[1] It has been found [Juan Rayces] that a melt will tend to lie on a line on a PV plot (relative partial dispersion v V Value), through the catalog data, where that line is parallel to the normal glass line. By using this model it is possible to determine the melt indices at many wavelengths, from a knowledge of the catalog data and from just two refractive indices of the melt.

Alternative use: modeling old glasses in patents
In most lens design patents, the glasses are not specified by name, but simply by n & V values. Often this may be matched exactly to currently available glasses. However many older patents used glasses from manufacturers who no longer exist. The designer may have an idea what type of glass was used, but no exact index data at other wavelengths.

By using this 'melt' method the designer can still obtain some reasonable data for the old glass. Select an existing glass of a similar chemical composition and then enter the N & V values for the old glass. The resultant 'melt' data may be taken then as a possible set of indices for the old glass.

5.11.1 True melt glasses

using the melt modeller does NOT impact on any of the data in Glass Manager or change any of the graphs & tables.

However, using the separate Material Editor utility, it is easy to create a true melt glass which will be listed in the database, will appear in the graphs & tables etc and can be used in WinLens.

For such a glass you will need the manufacturers melt certificate. Generally you will need the refractive index at several wavelengths, but for Schott glasses you can supply the differences in the format they supply.

5.12 Glass comparison table

Not clonable

In recent years the main manufacturers have made available ranges of eco-friendly glasses - many of which are replacements for the old glasses which contained lead or arsenic etc.

This table enables you to compare any of the following options:

1. any eco glass with its non-eco equivalent [if any]
2. any non-eco glass with its eco equivalent[if any]
3. any two named glasses

[select your prefered option from bottemmost left list]

To choose the glass[s], simply click on the list[s] of visible glass names at the left hand side. Glass Manager will automatically find and display the performance data for the glass[s] in the tables on the right hand side.

The form contains a number of 2 row spreadsheets that display the various properties [index, transmission, chemical, mechanical, thermal and miscallaneous properties]. In this way you can get a overview in onc glance.

NB if you choose selections 1) or 2), then Glass Manager will automatically define the required equivalent name. Thus if you choose eco glass N-BK7 [Schott], Glass Manager will display the properties for N-BK7 and BK7

NB you may choose how the glass name lists are sorted.

6. Graphs

Hint: Clone and Lock
Right click a graph, and select ***'Clone'*** to make an extra copy of that graph.

Right click and select ***'Always display...'*** to force a graph to display a chosen glass.

These are great for comparing glasses directly.

There are three sets of graphical displays:

- **Graphs**: those showing data for the current glass. These will show the variation of some property of the current glass against wavelength.
- **Plots**: those showing data for the current glass selection. These are typically found at the back of the glass manufacturers glass catalogues, except that instead of showing all glasses produced by one manufacturer, these will show the glasses selected via the Search facility (F2) from the database.
- **Doublet Graph**. A graph showing the chromatic aberration of a doublet.

All graphs/plots can be zoomed. Simply select the area of interest on the graph with the mouse pointer (Press down the left hand mouse button at one corner of the rectangle, drag the mouse pointer to the opposite corner and release the button). The selected area will then fill the plot. To return to default setting, simply click the 'resize button' which is at the bottom left of the graph.

There are some useful hot keys:

Hot Key	Function
F6	Large/small glass points on the plots
F7	Thick/thin lines on the graphs
Shift + F6	Glass names on plots
Shift + F7	Glass name options
F8	Plot colouring options

6.1 Graphs for the current glass

These show either graphs of the refractive index (or differentials) or transmission against wavelength.

Note that as you move the mouse pointer over the graph a cursor is 'pulled' along the curve. The x and y values are shown on the bar at the bottom of the screen.

If you have 'tagged' any glasses, their curves will also be shown in different colours.

Useful 'Hot keys'
F7: Thick or thin curves

6.1.1 Refractive Index Graph

This graph shows the variation of refractive index (vertical axis) with wavelength.

By default, this graph is scaled vertically from a refractive index of 1.3 to a maximum of 2.1. This does not change as the current glass is altered.

However the autoscale option (top right), fits rescales the vertical axis each time the current glass is altered, to give the clearest possible display.

6.1.2 Refractive Index Graph (first differential)

This graph shows the variation of the first differential of refractive index (vertical axis) with wavelength.

The first differential is calculated using an exact expression, and not by finite differences.

The autoscale option, as described for the refractive index graph is available.

6.1.3 Refractive Index Graph (second differential)

This graph shows the variation of the second differential of refractive index (vertical axis) with wavelength.

The second differential is calculated using an exact expression, and not by finite differences

The autoscale option, as described for the refractive index graph is available.

6.1.4 Internal Transmittance Graph

This graph shows the internal transmittance, t_i, (vertical axis) of a block of the current glass against wavelength.

$$t_i(\lambda) = e^{-\alpha(\lambda).t}$$

where a(λ) is the absorption coefficient for that glass and t is the glass thickness.

You can specify the thickness of the glass by typing in ue into the text box at the top right of the graph.

6.1.5 Total Transmittance Graph

This graph shows the total transmittance, t_t, (i.e. includes multiple reflection losses) (vertical axis) of a block of the current glass against wavelength.

$$t_i(\lambda) = R(\lambda).e^{-\alpha(\lambda).t}$$

where a(λ) is the absorption coefficient for that glass, t is the glass thickness and R(λ) is the overall reflection loss

The multiple reflection loss for a plane parallel plate of index n immersed in air, with normally incident light at wavelength l, R(λ), is given by:

$$R(\lambda) = 1 - \frac{2n(\lambda)}{n^2(\lambda)+1}$$

You can specify the thickness of the glass by typing in a value into the text box at the top right of the graph.

6.2 Plots for the Selected Glasses

Useful 'Hot keys'
F6: large glass points

Shift+F6: glass names on plot

Shift+F7: glass name options

F8: colour code options [see chapter 6.3]

The following plots are similar to those found at the back of the glass manufacturers catalogues, except that they show the currently selected set of glasses, rather than all glasses in the database.

- N_d:V_d
- P_{Cs}:V_d, P_{dC}:V_d, P_{gF}:V_d
- N_d:density
- Custom Plot [user can select both axes from a wide range of parameters]

Generally these plots show refractive index related properties of the glasses. By convention, these properties are shown for a sequence of standard wavelengths (s - 852nm, C - 656nm, d - 587nm, F - 486nm & g - 435nm) spread over the spectrum. These are particularly appropriate for visual instruments.

However is possible to alter the default wavelengths [chapter 9], in which case the scales and glass positions in these graph will almost certainly change.

You will see a blinking red cursor on each of these plots. The center of the cursor lies at the position of the current glass. (Obviously if you have zoomed in on a specific area of the graph, it is possible that the square will not be visible). Click on one of these graphs with the left hand mouse button and the current glass indicator will move to the nearest glass. (All other graphs, tables etc. will be updated appropriately)

As the mouse pointer is moved about over one of these plots, the current position of the pointer on the graph will be displayed on the bottom bar. You will also see the name of the glass nearest to the pointer. (In general, this is NOT the current glass)

6.2.1 Doublets and the Plots

[***full notes in chapter 8***] If you click with the **right hand mouse** on one of these graphs, then you may create a doublet. The program will ask you to specify a power for the doublet. On entering a non zero value, the program will take the current glass and the glass nearest the mouse pointer and find the appropriate values. The other glass will be indicated by a flashing green square.

If you click again with the right hand mouse button, then the other glass will alter to that nearest the mouse pointer.

6.2.2 n_d : V_d Graph

Not clonable

This graph shows the position of each glass in the selected set in a plot of refractive index (vertical axis) against V Value.

Note. By default these are n_d & V_d, but as stated above, these may be changed, in which case the scales may be changed by clicking on the command button labelled 'scale' now visible.

Also on this graph, there is a series of lines showing the standard Schott subdivisions for the n_d : V_d plot. These do not alter their position. [these only appear if you are using the standard waveband]

There is also a drop down list at bottom left of the plot. You may choose to display the data in any of the formats:

- n: V
- 1/n: V
- n: 1/V
- 1/n: 1/V
- n: dispersion

6.2.3 P_{Cs} : V_d Graph

Not clonable

This graph shows the position of each glass in the selected set in a plot of partial relative dispersion P_{xy} (vertical axis) against the V Value.

This graph shows a P_{xy} which is orientated toward the IR. By default the $P_{C,s}$ & V_d values are shown. (see note beside section 6.2.1)

The 'normal' glass line is shown by a thick grey line across the graph (as also seen in the next two graphs).

6.2.4 P_{dC} : V_d Graph

Not clonable

This graph shows the position of each glass in the selected set in another plot of partial relative dispersion P_{xy} (vertical axis) against the V Value.

This graph shows a P_{xy} which is orientated accross the visible. By default the $P_{d,C}$ & V_d values are shown.

6.2.5 P_{Fd} : V_d Graph

Not clonable

This graph shows the position of each glass in the selected set in another plot of partial relative dispersion P_{xy} (vertical axis) against the V Value.

This graph shows a P_{xy} which is orientated accross the visible. By default the $P_{F,d}$ & V_d values are shown

6.2.6 P_{gF} : V_d Graph

Not clonable

This graph shows the position of each glass in the selected set in a plot of partial relative dispersion (vertical axis) against the V Value.

This graph shows a P_{xy} which is orientated toward the UV. By default the $P_{g,F}$ & V_d values are shown.

6.2.7 n_d : density Graph

Not clonable

This graph shows the position of each glass in the selected set, in a plot of refractive index (vertical axis) at the d [587.6nm] wavelength against density [gm/cc]. [Density means specific gravity]

Naturally, if the default wavelengths are changed, only the refractive indices are altered.

6.2.8 Custom Plot

Not clonable

This graph shows the position of each glass in the selected set, where **both axes** can be defined by the user from a wide range of properties.

Note the printer icon [mid left]- this will generate a high quality printout that uses the full resolution of your printer.

To select the graph axes, click on the 'options' button at bottom left of the graph. Glass Manager will load a simple dialog wherein you can select from a wide range of properties. Including transmissions at certain wavelengths [for a specific thickness]

Glass Manager has sensible default ranges for the different parameters, but you can change the scales with the scale button [top left].

6.3 Custom Colours for the Plots

You may define a customs colour scheme for glass plots - adding extra information to the display. Press Function Key F8.

This will load the dialog shown here.

In this dialog you can select to code for:

- Type [eco, recommended, available?, obsolote etc]
- Maker
- Property - shown above.

In each case you will see coloured panels for the options. Simply click a panel to view a colour picker.

For the 'properties' option, you may choose from a whole range of options - optical, chemical, thermal and mechanical.

Typically properties have a whole range of values. So, for these, you actually setup a colour gradient, by selecting colours for the two end points. You specify the values for the end points in 2 text boxes. You may also define 'blanket' colours for any glass which has a value above or below the range; so for transmission, one nice scheme might be:

- Above 98% - light blue
- 98% [upper limit] - green
- 45% [lower limit] - red
- Below 45% - black

This colour scheme will apply to all plots. You can recall previous schemes in the history logs [chapter 11] - F9

NB using large 'points', F6, enhances the visibility of the colour coding in the plots.

6.4 Doublet Chromatic Aberration Graph

Not clonable

Once you have created a doublet pair [chapter 8], you may select this graph. It shows a plot of wavelength (vertical axis) against variation in focal length, for the doublet.

By default, the doublet power is specified for the d-wavelength (mid) and corrected at the C (long) and F(short wavelengths)

If any of these wavelengths are altered (see section 1), then the powers are calculated for the new wavelengths.

The focal lengths are calculated for many points over the waveband and then normalised against the focal length at the mid wavelength.

You will see three vertical lines:

- green: passing through the 'mid' wavelength
- red/blue: passing through the 'long' & 'short' lines (for achromats these have been made identical and the red line will lie under the blue line).

The form caption shows the glasses and the power.

Underneath the graph you will see the resultant powers of the individual glasses. You will also see a measure of the secondary spectrum (the 'distance' between the mid

and long, short lines). For achromats the smaller this value is, the better the residual chromatic aberration of the doublet

Glass pairs with reduced secondary spectrum have similar P_{xy} values (i.e. lie on approximately horizontal lines on the P_{xy} graphs). Unfortunately, such glass pairs tend to have undesirable properties such as large individual powers or poor handling characteristics in one or both glasses.

Sometimes your glass selection will result in the doublet having the same focal length at three wavelengths. Such systems are called apochromatic - the example above looks as if it such a case.

6.4.1 Doublet focal length plot scales

Click on the command button labelled 'scale' on the top left of this form. A form will appear which will enable you to change maximum & minimum values for the wavelength & focal length axes.

7. Search Tools

There are two main search tools in Glass Manager:

- Find Glass dialog [CTRL+F]- to locate a single glass as the new 'current' glass
- Search dialog [F2] - to select the range of glasses. Once selected these are those displayed in the glass plots etc. The current glass will come from this set.

7.1 Find Glass Dialog - CTRL + F

The Find Glass dialog is an easy to use tool for locating a single glass, by name or by some other properties.

Mainly used to select the new current glass, you will also see it when 'locking' a graph or table to display a specific glass [chapter 3.4]

On first use you will see

- text box to type in your chosen glass name
- list - this will contain glasses whose name matches the letters you type into the box
- most recent glass list - click to select
- checkboxes to select type of glasses allowed

There is a neat 'type-ahead' facility. As you start typing in the first letters of a glass name, you will see a list of all matching glasses - simply click to select.

You can change the search using this drop down list of inequalities, such as 'greater than' [>], 'less than' [<], or even specify a range [><].

If you use a range then separate the upper and lower limit values by a colon, e.g. '1.5 : 1.6'

In fact, going back to the equality search [=], you can enter multiple values each separated by a colon

Of course, you may be more interested in finding a glass with other properties, such as a specific index, rather than a specific glass name.

Simple - click on the nd option in this list and then start typing in the desired refractive index. This time you will see an list of glasses whose index matches your criterion.

As you type in the first text box, so another will appear - in which you can create a second search condition.

You can enter up to 3 search requirements in these boxes - all of which help pin down the glass you want.

So - to summarise, with this FindGlass dialog you can select a single glass. This may be:

- one of the most recently visited glasses [left hand list]
- the result of a deliberate search entered into the text boxes [right hand list]

In either case - simple click the appropriate list to choose the glass you want.

FindGlass remembers your last search criterion so you will see the same search results on re-loading.

7.2 Search Dialog - F2

The glass finder dialog box will allow you to make a selection of glasses with a given set of properties from the database and then sort them into a specific order.

This selection will then appear in the plots and tables showing data for multiple glasses.

The selection criteria are specified by entering values into text boxes or making selections on check boxes on the left hand side of the dialog. The sort order is defined by check boxes on the right hand side of the dialog.

Because there are a great many possible select criteria, these have been grouped into sets under different headings and placed on different tabs on the left hand side of the dialog.

On pressing the 'search' command button at the bottom left hand of the form, the Glass Manager will review each tab and form a combined query. The database is then searched for all glasses which meet these criteria, and sorted. All appropriate graphs are updated, and the current glass is set to the first glass in the selection.

On recalling Search by using F2 again, the last query will still be displayed, so that you can further refine it if necessary (if there are no solutions then the previous query will be retained).

NB You can recall previous searches using the History Log [as described in chapter 11]

7.2.1 Search criteria: General properties (1 & 2)

These two almost identical 'pages' in the glass finder dialog allow you to select glasses by name[2], glass code and/or the equivalent Schott name. Simply enter the desired value into the text box under the appropriate label.

You can also require that the refractive index, n_d, and the V Value, V_d, lie between certain limits. Enter the desired limits into the boxes under the appropriate labels.

You may specify a supplier(s), by checking one or more of their names. A few 'generic' materials such as CaF_2 have been included in the database. These are described as 'specials'

NOTE 1. The reason for having two almost identical 'general' pages is to allow you to specify two quite different groups of glasses simultaneously. This is very useful when creating doublets. For example, you could select all glasses whose equivalent Schott names are either BK* or SF*.

NOTE 2. The only difference between these two pages is that the second can be 'isolated' from the restrictions imposed by any other page. So if you want to compare a known 'exotic' glass with a range of cheaper, easier to handle alternatives; simply enter the exotic name in the second page and check the isolate option in the lower right of that page. Then no matter what restrictions you place on the chemical or other properties, that glass will be selected.

Alternatively, if you want one part of a doublet to be an known 'exotic' glass and the other part to be something common, use this option.

---

[2]Wild cards can be used in the glass name, code and Schott name: i.e. specifying a glass name 'B*' will give all glasses beginning with B, while specifying a glass code '5??6??' will give all glasses whose refractive index nd, lies between 1.500 to 1.599 and whose V Value is from 60.0 to 69.9.

7.2.2 Search criteria: Relative Partial Dispersions

This 'page' in the glass finder dialog box enables you to select glasses whose relative partial dispersions, P_{xy}, lies within certain limits and/or that the absolute difference of P_{xy} from the normal line lies within certain limits.

The former will constrain the solution set to lie between two horizontal bands on the relevant P_{xy} graph, while the latter will select glasses inside (or outside) two lines parralel to the normal glass line.

7.2.3 Search criteria: Transmittance

This 'page' in the glass finder dialog box enables you to specify limits for the internal transmittance of glasses, at various points in the spectrum.(300, 350, 400, 500, 700 and/or 1060nm). The required transmission limits should lie between 0 and 1.

You may specify the thickness of the glass for which these transmissions are to be achieved.

Alternatively you may limit the color code of the glass. by entering required numbers in the text boxes.

7.2.4 Search criteria: Chemical

This 'page' in the glass finder dialog box enables you to select glasses with the required handling characteristics.

- Climatic Resistance [CR]
- Stain Resistance [FR],
- Acid Resistance [SR]
- Alkali Resistance [AR],
- Phosphate Resistance [PR]

Note; for some of these characteristics suppliers use the same test, but not in all. Therefore be cautious about comparisons between different suppliers.

As with other search criteria 'pages' , you may include/exclude 'null'[3] fields

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[3]For various reasons the different glass manufacturers do not always provide the same data. Therefore for some glasses some fields will be null or undefined, i.e. the value is not known. You may choose to exclude such glasses (the default) from the solution set for a given 'page' of criteria or include them. by checking the appropriate box

7.2.5 Search criteria: Mechanical

This 'page' in the glass finder dialog box enables you to control the mechanical characteristics of the selected glasses. You can specify limiting values for:

- Density
- Young's Modulus
- Poisson's Ration
- Torsion
- Knoop hardness

7.2.6 Search criteria: Thermal

This 'page' in the glass finder dialog box enables you to specify limiting values for various thermal properties of the glasses:

- Linear Coefficient of Thermal Expansion -30C-+70C [$A_{-30/70}$]
- Linear Coefficient of Thermal Expansion -20C-+300C [$A_{20/300}$]
- Transformation Temperature [Tg]
- Softening Point [$T_{10}^{7.6}$]
- Upper Annealing Point [$T_{10}^{13.0}$]
- Specific Heat capacity [Cp]
- Thermal Conductivity [l]

7.2.7 Search criteria: Others

This 'page' in the glass finder dialog box enables you to specify a variety of glass characteristics that do not fit under the previous categories.

- Bubble Class
- Price [relative to some key glass]
- Availability

Be wary of direct price comparisons between glasses from different manufacturers!

7.2.8 Sort Capability.

As well as defining the selection criteria, you can determine the order in which the glasses will be available. For example, you can order the glasses by the refractive index or density.

You may have multiple sort criteria. This is only useful if the main sort criteria has only a few possible values (e.g. Climate resistance CR has values 1,2,3 & 4). The secondary sort criteria will then order the glasses within each category resulting from the first criteria.

To select the sort criteria, simply check one of the options in the right hand side of the dialog box. You will see the name appear below. On checking another this will appear below the first. The sort order is specified from the top down.

- **Glass Name**: alphabetical order of the glasses
- **Nd**: order of glasses by refractive index at d wavelength, lowest first.
- **Vd**: order of glasses by V Value, lowest first.
- **Schott Name**: alphabetical order of the glasses by the equivalent Schott name
- **Density**: order of glasses by density, lightest first
- **Tg**: order of glasses by the transformation temperature, lowest first
- **Knoop**: order the glasses in order of hardness, softest first.
- **CR**: order glasses by climatic resistance, best first.
- **FR**: order glasses by stain resistance, best first.
- **SR**: order glasses by acid resistance, best first.
- **AR**: order glasses by alkali resistance, best first.
- **Price**: order glasses by relative cost/unit volume, cheapest first.
- **Avail**: order glasses by availability, most readily in stock first.

Once the search criteria and sort order have been specified, the program will then search through the glass database to find the required glasses.

8. Doublet Maker - F3

One of the commonest problems for the optical designer is the selection of suitable glass combinations for the control of chromatic aberrations.

Obviously a full optimisation program will be required for glass selection in complex lenses - but Glass Manager is very helpful in assessing alternatives.

Glass Manager also has a facility to allow you the assess thin lens doublets - a pre design if you like.

The Doublet Maker dialog will assess all the doublets created by combining the current glass (always one part of the doublet) with the rest of the glasses in the selected set, one at a time. The results of the analysis are then sorted according to criteria that you have chosen.

The Doublet Maker dialog consists of 5 basic areas :

1) **Brief description of the two glasses in the doublet**. If a doublet has not been defined yet, then the data for a second glass will not be shown.
2) **Doublet specification**. **[THIS MUST BE DEFINED]**
   For an achromat [default] **only** the power (1/required focal length) is needed.

For a pseudo glass[4] check the bottom option box, enter the power **and** a non zero V value.

3) **Sort criteria**. You may select from 0 to 3 of these options to determine in what order the results of the doublet analysis will be displayed. The options are discussed in more detail below. As you check/uncheck options so the sort criteria are displayed in the three panels beneath. Note that the primary sort criteria is always shown on the left.
4) **Command Buttons**. These cause the Glass Manager to run the calculations, resort them if you change criteria and leave the doublet maker.
5) **Customisable spreadsheet.** This displays the results of the calculations and sort procedure. The data is displayed in the order that the sort criteria require. It will always display the glass name, code & supplier at the left hand side. Next to these will be a column(s) displaying the sort criteria value(s) for that glass. Finally, if you have checked one or more of the option buttons directly below the spreadsheet, you will see extra columns in the spreadsheet for that data.

By default the doublet is designed at the d wavelength and corrected at the C & F wavelengths, but these defaults may be changed - see chapter 1.

Initially, the topmost glass in the spreadsheet is the second glass in the doublet. You will see its name etc. underneath that of the current glass, on the top left hand side of the dialog.

If you click on a specific row in the spreadsheet, then glass named in that row will become the second glass in the doublet.

You can rerun this as often as you want, changing initial conditions or sort criteria, until you find a suitable combination(s) of glasses

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[4]In some situations, your thin lens pre-design will not require an achromatic doublet, but a glass with a specific power and finite V-Value. If such a glass is not actually available, then you may create a 'pseudo' glass with those specific properties from two real glasses.

8.1 Doublet Maker Sort Options

Description of the options available for sorting doublet glasses.

- **Glass Name**: alphabetical order of the glasses
- **Nd**: order of glasses by refractive index at d wavelength, lowest first.
- **Vd**: order of glasses by V Value, lowest first.
- **Schott Name**: alphabetical order of the glasses by the equivalent Schott name
- **|Ka|**: power of the current glass, from most negative to most positive.
- **|Kb|**: power of the other glass, from most negative to most positive.
- **|Ka|+|Kb|**: sum of the absolute powers of both glasses, lowest first.

Note: the more powerful a lens is, the steeper the curves required on the finished component. This tends to go with increased aberrations and cost of fabrication.

- **Petsval**: Petsval sum; a measure of the field curvature of an optical system.
- **dF_s**: Measure of chromatic aberration between the very long and the mid (design) wavelength
- **dF_C**: Measure of chromatic aberration between the long and the mid (design) wavelength
- **dF_F**: Measure of chromatic aberration between the short and the mid (design) wavelength
- **dF_g**: Measure of chromatic aberration between the very short and the mid (design) wavelength

Note: chromatic aberration is given as difference between normalised focal lengths at the wavelengths in question

Note: if you have changed the default wavelengths [F4] then these four option titles will have also changed to match.

- **Density**: order of glasses by density, lightest first
- **Tg**: order of glasses by the transformation temperature, lowest first
- **Knoop**: order the glasses in order of hardness, softest first.
- **CR**: order glasses by climatic resistance, best first.
- **FR**: order glasses by stain resistance, best first.
- **SR**: order glasses by acid resistance, best first.
- **AR**: order glasses by alkali resistance, best first.
- **Price**: order glasses by relative cost per unit volume, cheapest first.
- **Avail**: order glasses by availability, most readily in stock first.

Note that for some glasses, the selected sort fields may be undefined, e.g. not all glasses have an equivalent Schott name. In such cases, these glasses will appear at the top of the list, with either a zero value or a blank in that field.

8.2 Changes to interface after creating a doublet

On returning to the main program, you will see several modest changes to the initial interface. These changes are designed to help you handle doublets.

The second glass in the doublet will be indicated by a flashing green square in the group graphs.

Another drop down list will appear in the footer bar at the right of the VCR controls.

This list will show the selected glasses for the second in the order specified by the Doublet Maker. The current second glass will be shown when the list is 'closed'. Alternatively you can use the spin buttons beside the list to move up and down.

The status bar will also be modified. At the right hand side, there will be displayed the name of the 'other' glass and its code. Beneath this you will see the power of the doublet. The power may be edited.

The graph showing the chromatic aberration of the doublet is now available (section 6.4), and can be also printed out (section 4.2). This graph will update as you change either glass in the doublet.

8.3 Changing glasses in a doublet

Having created a doublet, you may wish to change either or both of its component glasses.

To alter the current glass, use any of the 'normal' methods:

- Use FindGlass Dialog [CTRL+F]

- Click with the LEFT mouse button on a plot, next to a new glass.
- Click on a glass name in the left hand list in the footer bar.
- Click on the VCR control.

To alter the 'Other' glass either:
- Click with the RIGHT mouse button on a group graph, next to a new glass.
- Click on a glass name in the right hand list in the footer bar.
- Click on the spin button next to that list
- Reload the Doublet Maker, click in the spreadsheet on another name and exit.

8.4 Terminate doublet

Once a doublet has been created you can either:
- From the header bar set the doublet power to 0
- In the doublet maker, set the power to zero and exit the doublet maker.

Changes made to the programs interface to handle doublets will then disappear.

9. Wavelengths - F4

In the paper versions of glass catalogs, the plots of optical properties, such as n_d:V_d, are presented for the standard wavelengths (d,C & F), Naturally, such plots are available in Glass Manager, as discussed in section 6.2.

However if you ares not working at the standard visible waveband then such plots are incorrect and may be misleading.

Glass Manager easily overcomes this problem, by allowing you to alter the 'standard' wavelengths. The plots will update as appropriate.

In Glass Manager there are five such wavelengths associated with plots of selected glasses and also the design & analysis of doublets[5]. The table below shows the wavelengths, their **default** values and the related plots.

Wavelength	Default Values		Related Plots
Very long	s	852.1nm	P_{Cs}:V_d doublet, custom
Long	C	656.3nm	n_d:V_d, P_{Cs}:V_d, P_{dC}:V_d, P_{gF}:V_d doublet, custom
Mid (principle)	d	587.6nm	n_d:V_d P_{dC}:V_d n_d:density doublet, custom
Short	F	486.1nm	n_d:V_d, P_{Cs}:V_d, P_{dC}:V_d, P_{gF}:V_d doublet, custom
Very short	g	435.8nm	P_{gF}:V_d doublet, custom

If one or more of these defaults values is altered, then the related plots are also altered to match. For example, if the plot of n_d:V_d is visible and the Long, Mid & Short

[5]Achromats are designed for the mid wavelength, and corrected (i.e. have same focal length) at the long and short wavelengths. However in the doublet maker facility, the chromatic aberration between the mid & very long and mid & very short wavelengths is also analysed.

wavelengths are changed to 900, 800 & 700nm respectively, Glass Manager will update that plot to n_{800}:V_{user} [$V_{user} = n_{800}-1/(n_{700}-n_{900})$].

To alter the wavelengths press F4. A dialog box will appear with the current values indicated by cursors on a scale (somewhere between 250 & 2500nm). The precise values are shown in text boxes at the right of the dialog box.

The wavelengths may be altered by:

- typing values directly into the text box
- 'dragging' the cursors by the small boxes on their right hand ends
- clicking the spin buttons beside the values [1nm resolution]
- clicking the icons at the right of the text boxes - this will launch a list of accurate standard spectral and laser lines [shown below]. Simply click to select.

You will not be able to make the cursors 'cross over' each other.

Pressing the default key will reset the dialog to the values tabulated above. Pressing the OK button will close this dialog and cause Glass Manager to redisplay any of the plots named above which were already visible. It is quite likely that the scales will be altered.

Changes made to the standard wavelengths only effect the plots for selected glasses and doublet design & analysis graph.

n-V [1000-1400nm]

n-V [1400-1800nm]

As we can see this does indeed make a considerable impact on the form of the n-V plot and therefore on the appropriate choice of glasses!

You can store your custom wavebands for later reuse by clicking the icon at bottom right. You can assign a name to the waveband.

Your wave bands will then appear in the dropdown list under the standard dCF & eC'F' options.

Finally, changes made to the standard wavelength do not effect the header bar, tables, graphs for the current glass or the search facility. Thus if the mid wavelength is altered to 1014nm, then the header bar still shows the refractive index at the d [587.6nm] wavelength.

The sole exception to this rule is the 'Index related data for the current glass' table, section 5.2, which shows n,V, dispersion & relative partial dispersions for the current waveband.

10. Tagged Glasses

Sometimes it is very useful to 'overlay' curves, such as refractive index or transmission, for a small number of glasses.

You can tag up to 3 glasses, using the panel at the top right of Glass Manager.

Simply 'check' one of the tick boxes to tag the current glass. The name of the current glass will appear, along with the name of its maker and a colour code box. Until that option is unchecked, that specific glass is tagged, even if you alter the current glass or run a search.

When a glass is tagged you will also see colour coded curves for that glass in the graphs, along with the curve for the current glass and any other tagged glass.

In the plots showing the selected glasses (such as N_d: V_d), you will see dots of the same colour indicating the position of the tagged glasses.

NB tagging is quite different from 'cloning' a graph. Cloning a graph makes an independent copy. You can then you can then lock either copy to a specific glass

To clone and/or lock - simply right click the graph of interest and select the option from the popup menu - this is fully discussed in Chapter 3.4 and demonstrated in the example at the end of the manual.

11. History Logs - F9

There are lots of nice features in Glass Manager, such as the Search dialog, Find Glass tool and Colour coding for plots. Unfortunately, it may take a while to set up different searches or colour codes, so if you wish to setup an earlier situation or recall a recent glass it can take longer that you might like.

However, this is now no longer a problem. Glass Manager retains logs of:

- Colour Codes [chapter 6.3]
- Search Logs [chapter 7.2]
- Recent Glasses

These logs are displayed in a simple table, which is loaded via the:

- F9 hot key
- History Logs icon in the toolbar
- History logs option in the View menu

To recall an item, all you need to do is click the option. In this way it is very easy to switch rapidly from one option to another

The form is not modal, you you can interact with other windows while this is open.

If you right click on an item then you will see a small popup dialog with a couple of log management options [delete item & clear log]

Section 3
Guided Tour

12. Glass Manager Tour - a quick tutorial.

When you start GlassManager for the first time you will see something like this:

Initial screen

The toolbar & sidebar can be hidden [View menu]. The side bar just contains introductory notes so you might want to read these and then hide it.

The Current Glass

The header shows the name and basic details of the '**current glass**'. Many graphs and tables relate to this glass, and are updated when you alter the current glass.

If you click the VCR control on the footer bar, then you can change the current glass. Note how the header bar updates instantly, showing the name etc. of the new 'current glass'. Try this a couple of times.

Using the VCR control you can work through the database systematically. Of course this is not good for finding a specific glass right in the middle of a set of thousands of items!

Alternatively, try selecting a glass name from the pull down list beside the VCR control. This method is ok if you know the name of the glass that is of interest to you, but is still cumbersome!

We will show some much more interesting/useful methods of changing the current glass in a while…

Plots and Graphs

Glass Manager has many graphs displaying various properties of one or more glasses. Pull down the **'Graph'** menu and select the **'nd:Vd'** option. Glass Manager will display a movable resizable child form containing a graph of refractive index against V Value. This is the standard plot found at the back of all glass catalogues.

Note that each glass in the database is represented by a little dot [later on you will see how to display a subset of the database].

Hit the F6 key several times to toggle between large and small dots.

Hit the Shift+F6 keys to toggle the glass names on and off. Initially thare are so many that the names just cover each other up in a mess.

A little flashing red cursor will be seen on the graph. This shows the position of the 'current' glass. Try changing the current glass again with the VCR and glass list methods. Note how the position of this cursor changes.

Now move the mouse pointer over the graph and look at the footer bar. Note:

- the 'position' of the mouse pointer
- the name of the glass 'nearest' the pointer

Both these are updated as you move the cursor.

Change 'current glass'
click on the n:V plot - at the location of the glass of interest

Click on the graph with the left hand mouse button. You will see the red cursor move to the glass nearest the pointer. Note that the header has changed. This is another way of altering the current glass. You can use this on any of the plots which display many glasses simultaneously [n_d : V_d, P_{Cs}:V_d, P_{dC}:V_d, P_{gF}:V_d or n_d : density].

All graphs can be zoomed. Select an area of interest by click-and-dragging with the mouse pointer. That area will expand to fill the available area. You can zoom in again or return to the default plot by clicking on the 'resize' button at the bottom left of the plot.

Multiple graphs

You may have several graphs visible simultaneously, which may be placed about the screen as you desire.

From the '**Graph**' menu select the **'Refractive index'** option. Glass Manager will load another resizable, movable child form containing a graph showing the refractive index curve[6] for the current glass only. If the current glass is changed then the graph is updated automatically.

Now move the mouse pointer over this graph. Note that a full plot cross hair appears, which runs along the curve as the mouse is moved back and forth. This time the footer bar displays the coordinates of the center of the cross hair.

Naturally, no glass name is shown in the footer.

By moving the cursor to a desired wavelength, you can read off the refractive index at that point. However, because of the finite resolution of the screen you may not be able to select the exact wavelength required (which is where the calculator, described below, is helpful).

---

[6]If you have tagged one or more glasses, then you will also see their curves overlayed on the graph. However the cursor will always move along the current graph curve, and data displayed in the footer bar will refer to the current glass.

The Calculator

To obtain values at exact wavelengths use the calculator. From the **'Table'** menu select the **'Calculator'** option.

Glass Manager will display the form shown here.

At the top you can enter a specific wavelength and glass thickness.

Underneath, in the results frame, the program will display:

- refractive index for that wavelength
- refractive index - firstdifferential
- refractive index - second differential
- internal transmission
- total transmission
- reflection losses (for a uncoated slab of the current glass)

Note that as you change the current glass, so the results are automatically updated.

Try changing the wavelength to 800nm and the glass thickness to 100mm. Then try other values.

Note that any changes made in the calculator have NO impact on any other table or graph in this program.

Most tables, however, are not interactive, merely showing data. A typical example is the table of refractive indices, described on the following page.

At this point you might want to close any graphs, plots etc that you have open - of course, leaving Glass Manager itself running - to unclutter the workspace.

Tables

From the '**Table**' menu select the '**Refractive Index**' option.

Glass Manager will display a child form. In this form you will see a spread sheet containing the values of the refractive index, for the current glass, at a set of standard wavelengths.

ADC1 Hoya - Refractive indices

	WaveLen (nm)	Index-calc	Index-real	error
n1060.0	1060.0	1.608404	Extrapolated	
nt	1013.98	1.609030		
ns	852.11	1.611697		
nA'	768.1943	1.613551		
nr	706.5188	1.615263		
nC	656.2725	1.616976		
nC'	643.8469	1.617456		
n632.8	632.8	1.617905		
nD	589.2938	1.619911		
nd	587.5618	1.620000	1.620000	0.000000
ne	546.074	1.622377	1.622380	-0.000003
nF	486.1327	1.626945		
nF'	479.9914	1.627514		
ng	435.8343	1.632379		
nh	404.6561	1.636893		
ni	365.0146	1.644603		
n334.1	334.1478	1.652948	Extrapolated	
n312.6	312.5663			
n296.7	296.7278			
n280.4	280.4			
n248.3	248.3			

These values have been calculated from the stored dispersion constants.

However in the fourth column from left, Glass Manager displays the measured indices for the n & e wavelengths. These can be compared with the calculated results as a check [we have run more extensive checks on the standard glasses when setting up the database].

Clone and Lock

One of the key functions of Glass Manager is to help you compare glasses. You could do this by switching current glass - but this can be a bit laboured [even with the FindGlass dialog].

Instead we will show you how to make multiple copies of a table and then force it to display a specific glass.

Right click on the nd:Vd table and select 'Clone this table' from the popup menu.

Glass Manager will create an independent copy of the table. You can move this round the workspace at you pleasure.

At present both copies of the table are displaying the current glass - which is nice but not very useful.

ADC1 Hoya - Refractive indices

	WaveLen (nm)	Index-calc
n1060.0	1060.0	1.608404
nt	1013.98	1.609030
ns	852.11	1.611697
nA'	768.1943	1.613551
nr	706.5188	1.615263
nC	656.2725	1.616976
nC'	643.8469	1.617456
n632.8	632.8	1.617905
nD	589.2938	1.619911
nd	587.5618	1.620000
ne	546.074	1.622377
nF	486.1327	1.626945
nF'	479.9914	1.627514
ng	435.8343	1.632379
nh	404.6561	1.636893
ni	365.0146	1.644603
n334.1	334.1478	1.652948
n312.6	312.5663	
n296.7	296.7278	
n280.4	280.4	
n248.3	248.3	

ADC1 Hoya - Refractive indices

	WaveLen (nm)	Index-calc	Index-real	error
n2325.4	2325.42	1.594513	Extrapolated	
n1970.1	1970.09	1.598629	Extrapolated	
n1529.6	1529.582	1.603229	Extrapolated	
n1060.0	1060.0	1.608404	Extrapolated	
nt	1013.98	1.609030		
ns	852.11	1.611697		
nA'	768.1943	1.613551		
nr	706.5188	1.615263		
nC	656.2725	1.616976		
nC'	643.8469	1.617456		
n632.8	632.8	1.617905		
nD	589.2938	1.619911		
nd	587.5618	1.620000	1.620000	0.000000
ne	546.074	1.622377	1.622380	-0.000003
nF	486.1327	1.626945		
nF'	479.9914	1.627514		
ng	435.8343	1.632379		
nh	404.6561	1.636893		
ni	365.0146	1.644603		
n334.1	334.1478	1.652948	Extrapolated	
n312.6	312.5663			
n296.7	296.7278			
n280.4	280.4			

Right click one of the tables again - this time selecting the 'Always display glass...' menu option.

Glass Manager will display the FindGlass dialog. Simply click on any glass in the 'glasses inspected earlier' list. Make sure that your choice is NOT the same as the current glass.

You will now see that the glass data in the chosen table is that of the selected glass.

If a table is locked to a specific glass then the glass name is preceded by a * in the title bar of the form.

ADC1 Hoya - Refractive indices

	WaveLen (nm)	Index-calc	
n2325.4	2325.42	1.594513	E:
n1970.1	1970.09	1.598629	E:
n1529.6	1529.582	1.603229	E:
n1060.0	1060.0	1.608404	E:
nt	1013.98	1.609030	
ns	852.11	1.611697	
nA'	768.1943	1.613551	
nr	706.5188	1.615263	
nC	656.2725	1.616976	
nC'	643.8469	1.617456	
n632.8	632.8	1.617905	
nD	589.2938	1.619911	
nd	587.5618	1.620000	1.
ne	546.074	1.622377	1.
nF	486.1327	1.626945	
nF'	479.9914	1.627514	
ng	435.8343	1.632379	
nh	404.6561	1.636893	
ni	365.0146	1.644603	
n334.1	334.1478	1.652948	E:
n312.6	312.5663		
n296.7	296.7278		
n280.4	280.4		
n248.3	248.3		

*APL1 Ohara - Refractive indices

	WaveLen (nm)	Index-calc	Index-real	error
n2325.4	2325.42	1.491836	Extrapolated	
n1970.1	1970.09	1.497012	Extrapolated	
n1529.6	1529.582	1.502528	Extrapolated	
n1060.0	1060.0	1.507931		
nt	1013.98	1.508508		
ns	852.11	1.510817		
nA'	768.1943	1.512323		
nr	706.5188	1.513668		
nC	656.2725	1.514988		
nC'	643.8469	1.515355		
n632.8	632.8	1.515696		
nD	589.2938	1.517210		
nd	587.5618	1.517277	1.517280	-0.000003
ne	546.074	1.519053	1.519050	0.000003
nF	486.1327	1.522424		
nF'	479.9914	1.522841		
ng	435.8343	1.526382		
nh	404.6561	1.529635		
ni	365.0146	1.535147		
n334.1	334.1478	1.541132		
n312.6	312.5663	1.546784		
n296.7	296.7278	1.552165	Extrapolated	
n280.4	280.4	1.559434	Extrapolated	

Now you can directly compare the data for these two glasses. You are not limited to two glasses - try cloning and locking to a third glass. In fact you are only really limited by the screen real estate you have.

Cloning and locking applies to all tables and graphs that show data for a single glass. Plots & tables which show data for the current selection cannot be cloned.

Note - FindGlass is actually much more powerful - as shown in chapter 7.1. You can play around with FindGlass trying out using the various search tools.

Search & Sort - F2

So far the example has concentrated on various means of displaying data. Now it is time to see how the program can help you select glasses from the many hundreds of possibilities.

To access the search facility you can either press F2 or select the '**Search DataBase**' option from the **'Search'** menu. Glass Manager will then display a dialog form.

The search criteria are specified in a series of tabbed pages held in a frame on the left hand side. To look at the different options available click on the tabs at the top of each page.

The sort criteria are specified in the frame on the right hand side of the dialog.

First of all we will search for all glasses with Refractive Index between 1.6 & 1.7 and V Value between 30 & 40

- Do the following:
- Look at the search frame and make sure that the tab titled **'General - 1'** is active (highlighted) by clicking on it.
- In the sub frame titled **'nd'** [refractive index at d wavelength] enter 1.6 in the box next the word 'from' and 1.7 in the box next the word 'to'.
- In the sub frame **'Vd'** enter 30 and 40 in the same cells.
- Name[7] the search 'n1.6-1.7 V30-40' in the 'Search name' text box at bottom left
- Click the button **'Search'** at the bottom left.

[7] This name will appear in the history log [chapter 11] from where this specific search can be easily recalled.

Glass Manager will find all glasses which meet this criteria. The search dialog will disappear and the graphs will be updated.

In particular note:

- plots such as n_d : V_d will display only the selected set of glasses.
- the current glass is always one of the selected set.
- initially the current glass is the first glass in the selected set.

Now lets find a different set of glasses. Press F2. The search dialog will reappear. Note that the search criteria previously specified are still in place.

- Clear the old criteria by clicking the **'Clear'** button.
- In the page **'General - 1'**, in the sub frame labeled **'Name'** enter 'B*'
- Check the **'Hoya'** & **'Sumita'** check boxes
- Name the search 'B* for HS' [or something similar]
- Click on the **Search** button.

Glass Manager will now find those glasses which are:

- produced by the chosen manufacturer s.
- have names begining with B (such as BK7, BK10)

Note the use of the wild card symbol '*'.

NB You can also

use the other standard wild card symbol '?' to allow one variable character in the search pattern.

Press F2 again.

- Do NOT clear the search pattern, but click on the tab '**General - 2**'. Note how this page is almost identical in layout to tab '**General - 1**'
- Enter 'SF*' in the sub frame labelled '**Equivalent Schott Name**'[8]
- Then click on the tab labelled '**Mechanical**'.
- Set the density to lie between 3 and 5
- Name the search 'B* for HS, SF*, p3-5'
- Click the **Search** button

Glass Manager will find those glasses whose:

[(name begins BK* and is from Hoya/Sumita)]
OR
[whose equivalent Schott name begins with SF***]**
AND
whose density lies between 2 & 4 gm/cc.

Note that by using the tabs '**General - 2**' and '**General - 1**' you can select glasses from two quite different areas on the 'n_d:V_d' plot[9]. This can be useful when creating doublets.

---

[8]Equivalent Schott Name. Each glass manufacturer has their own naming system. However often a glass will be almost identical in its properties to a Schott glass, e.g. NbF 2 from Hoya is similar to LaFN24 from Schott. In such cases the manufacturers also give their glass the Schott name. This can be very useful when comparing equivalent glasses from different sources.

[9]Criteria specified in these two tabs are linked by a logical OR. The criteria specified by any other tab are linked by logical ANDs.

The only difference between the '**General - 1**' and '**General - 2**' page is that you can 'isolate' the latter from the other pages, i.e. you can specify glass on this page which ignore[10] the restrictions imposed by all the other pages.

By default, page "**General - 2**' shares the conditions imposed by other pages, and you have to actively choose to enable the isolation.

As you can see, you can build up quite complex searches, and it would be a shame to keep on rebuilding them. You can actually Save searches to disk and reload them [using the 'Save Search' & 'Load Search' buttons]

History Log

Alternatively, you can recall up the most recent searches using the history log. Press F9 and the log will appear. This contains Colour Codes, Searches and the most recent 'current' glasses.

Simply click on the item of interest to recall it. Try out recalling the different searches.

[10]This could be useful when trying to find a cheap or easy to handle equivalent to and expensive or difficult to handle glass. Enter the difficult glass in General - 2 and check the 'yes' option in the lower left of this page. The difficult glass will then be found no matter what other restrictions you have specified. This may also be usefull when creating doublets if one glass is predetermined.

Current Glass Revisited

So far we have touched on 3 ways of changing the current glass:

- Use the Video controls in the footer bar
- Select from the dropdown list in the footer bar
- Click on one of the glass plots [near a glass]

There are other ways. Load the 'current glasses' table - this is a spreadsheet showing all the glasses in the current selection. Simply then click on a glass of interest.

There is final most effective way using the Find Glass dialog. We have already used this when locking a table - but now we will use it to find a glass with the following properties:

- Refractive index between 1.55 & 1.6
- ECO friendly
- Wavelength cutoff of less then 310nm
- Made by Sumita

First of all, use the history log and click the 'All Glasses' Search - Glass Manager will again display all glasses in the database.

Either click the Find Glass Icon in the toolbar [or footer bar] or press CTRL+F keys together.

Initially you will see something like this.

Make sure that the checkboxes ringed in red are all checked

You will now start defining the refractive index condition in the region ringed in blue.

This time we are going to ignore the most recent glasses list at bottom right!

Drop down the condition list at the bottom left of the text box and select the range '><' option

Drop down the search type list beside it and select the 'refractive index' option

When defining a range [><], you must enter the lower and then the upper value, separated by a colon.

NB If using the equality, you can enter many values all seperated by colons, e.g. a:b:n would be fine for a glass name search.

Enter 1.55 : 1.6 into the text box

Immediately you will see a list of many glasses - these are all matches to your constraint.

Note that a second constraint area has appeared under the first.

We just want ECO friendly glasses, so clear the Recommended, Available? And obsolete checkboxes under the list.

The possible glasses significantly decrease in number.

In the second constraint area set

- the condition to '<='
- the search type to 'wave min'
- the text box value to '310'

this roughly halves the solutions.

In the third constraint area set

- the condition to '='
- the search type to 'Maker'
- the text box value to 'su'

You will now see a few sumita glasses in the list. Click one and that will become the current glass!

To clear a constraint simply remove all text from the text box.

As you can see, the Find Glass dialog is very powerful indeed, and very efficient in finding a specific glass.

Doublets

Selection of glasses for correction of chromatic aberration is a interesting task. Glass Manager has been designed to provide active help to the designer.

We will prepare to look at doublets by getting the 'preferred' Schott glasses and ordering the glasses by climatic resistance.

- Press F2 again, to load the Search dialog.
- Press the **Clear** button.
- Select the '**General - 1**' tab and check the **Schott** option button.
- Select the '**Others**' tab and check the '**Preferred**' check box.
- In the Sort frame, click on the check box labelled CR (climatic resistance). When the program comes to find the glasses, it will order them according to their CR grade (lowest first).
- Press the '**Search**' button.

Use the Find Glass dialog to make N-BK7 the current glass.

You will need to clear the other constraints first.

- Set condition to '='
- Set search to 'Glass name'
- Enter value of

Then make sure that the n_d : V_d plot is visible and at the default zoom, then make N-BK7 the current glass . Note the red cursor in the lower left of the plot. The current glass is always one half of the doublet.

Now click with the **right hand** mouse button near a glass in the upper right of the plot. This will be the initial selection for the 'other' glass in the doublet. As with the current glass, the other glass is always one of the selected set of glasses.

You will be asked to specify the power (1/focal length) of the doublet. Enter a value e.g. 10.

Glass Manager will now 'create' the doublet and also make some modifications to the user interface:

- Green cursor in the n_d:V_d plot over the position of the other glass. If other plots [i.e. P_{Cs}:V_d, P_{dC}:V_d, P_{gF}:V_d or n_d:density] showing the selected set of glasses are visible, then a similar cursor will be seen in those.
- Header Bar: at the right hand side you will see both the name of the 'other' glass along with its code and also the power of the doublet. The power can be altered here. If you enter zero, then the doublet is 'destroyed' and the Glass Manager interface reverts to normal.
- Footer Bar: at the right of the VCR control another list containing the selected glasses appears. However it is linked to the 'other' glass.

- Graph showing the chromatic aberration of the doublet is now enabled.

Pull down the **'Graph'** menu and select the **'Doublet Chromatic Aberration'** option. Glass Manager will display a graph showing normalised focal length (horizontal) against wavelength.

The curve showing the chromatic aberration is updated whenever you alter either glass.

Underneath the plot you will see the powers of the individual components Generally, the larger the individual powers of the component glasses, the worse the general performance is and the harder it is to make.

You will also the residual or secondary spectrum (difference of normalised focal lengths at the d & C[11] wavelengths). For most combinations of glasses this will have a value of about 0.00050. Try changing either current glass or other glass by clicking with left or right hand mouse buttons on the n_d:V_d plot, or by using the pull down lists or the VCR controls.

---

[11]By default, the doublets are designed at the d (587nm) wavelength and corrected at the C (656nm) and F (486nm) wavelengths, i.e. has the same focal length at those two values.

However, in Glass Manager you are not limited to those values. To alter the defaults press the F4 key.

It is possible, however, to reduce this by careful glass choice. Theoretical analysis shows that for a glass combination to have reduced secondary spectrum, both glasses must have a similar relative partial dispersion, P_{xy}. At the same time it is desirable to have a large a V Value difference as possible as this reduces the component powers.

Pull down the **'Graph'** menu and select the **'P_{Cs}:V_d'** option. You will see a plot of V Value (horizontal) against relative partial dispersion. Note how most of the glasses lie clustered along a straight line (known as the normal line); thus making it difficult to get two glasses with similar P_{xy} but very different V.

However a few glasses lie well off this curve, and can be used to give highly colour corrected systems with good performance.

Select N-FK51a (the glass farthest away from the normal line) for the current glass, and N-SK5 for the other glass (use the second glass list in the footer bar).

Note:

- The dramatically reduced level of chromatic aberration in the visible and infra red. (d-C =0.00003).
- Both glasses have a similar relative partial dispersion. Try different glasses for the 'other' glass.

Unfortunately glasses such as N-FK51a, which give good chromatic correction, tend to be expensive and/or difficult to handle.

Doublet Maker Facility F3

Glass Manager has a more systematic method available for evaluating doublet pairs. Make BK7 the current glass (Hint: use the glass list).

Press F3. Glass Manager will launch the Doublet Maker dialog (shown here). Then press the **'Search'** button at the lower left of the dialog. Glass Manager will then work through the selected set of glasses. For each it will make a doublet with the current glass and store the component powers etc. When it has finished the results are displayed in the spreadsheet on the right hand side of the dialog.

By default, the results are displayed in the order of the selected glasses. However you may choose to specify a sort criterion. This could be optical (e.g. powers of the components, petzval sum, or residual chromatic aberration) or related to different characteristics of the 'other' glass (e.g. density, climatic resistance, price etc.).

In this example, we will aim to find those glass combinations with smallest secondary spectrum, so check the df_C check box [middle row, third from left]. This gives the residual chromatic aberration between the doublet focal lengths at the d & F wavelengths. Then press **'Search'**.

When the results are displayed, click on any of the rows, and note how the glass name in that row appears in the doublet description at the left hand side of the dialog. When you return to the main program, this will be the doublet analysed in the chromatic aberration graph etc.

That concludes the brief tour through the main facilities of the Glass Manager program.

13. Qioptiq LICENSE AGREEMENT

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