A Brief History of Windows
Guide to Sympathetic Replacement Design
A BPF Windows Group Guide
Introduction

This guide is not aimed at restricting or criticising window styles but is designed to give advice on what most people consider to be aesthetically pleasing. Of course, beauty is in the eye of the beholder and the final arbiter is you, i.e. do you like it or not? The relatively recent introduction of the double glazed replacement window has led to an ability to change not just the performance but the character of a building. In listed buildings and in conservation areas with an Article IV direction, it is not permitted to replace windows without the approval of the local planning authority. For these instances refer to the BPF publication Replacement Windows and Planning Law (available from the BPF Windows Group Bookshop at http://www.bpfwindowsgroup.com/bookshop.cfm). If in doubt, it is always wise to check with the local council planning department.

This guide will give an historical perspective on how windows came to be as they are today - this will range from early church architecture through to modern housing. The principles of what is generally perceived to be good design will be explored and related back to the historic examples; it will give examples of replacement windows that are sympathetic to the original character of the building and some that are less so; and it will give guidance on compliance with Building Regulations.
An historical perspective.

What is a window? Simply, it’s a hole in a wall to let light in (or an arrow out!). The drawback with just a hole is that it does not just let light in, it lets heat out, lets the weather in and may let unwanted visitors in. Early “windows” in the Bronze and Iron Ages countered these downsides by using wooden shutters and even scraped and stretched animal hides (similar to drum skins) which were dipped in oils to make them translucent and waterproof. The invention of glass took things a step further by providing a cover for windows which lets in light at the same time as keeping the elements out.

The use of glass for architectural purposes began at the end of the first century AD when the Romans discovered that adding manganese oxide to the mixture made clear glass, albeit with poor optics. This glass was only used in the most important buildings. The pane production method, which was basically casting, remained largely unchanged until the eleventh century, when two techniques were developed. Both of these involved blowing a ball of molten glass into a bubble. The bubble was then either, pierced and spun into a disc, or the bubble was swung to form a cylinder, which was then slit and laid out flat. The panes were then cut from the parts of the plate with the best thickness and clarity.
At the end of the seventeenth century the French developed a method of producing larger plates of higher clarity. This was achieved by pouring the molten glass onto a special table. The glass was then rolled flat and the surfaces ground with fine abrasive powder. It was not until the nineteenth century that glass production became mechanised and mass production began. The early twentieth century saw a number of advances in plate production. Two methods for continuous plate production were invented in Belgium around the time of the First World War. These involved drawing ribbons of molten glass from tanks. The later version then drew the ribbon through rollers to obtain a consistent thickness and finish. Further drawing processes were developed in America between the First and Second World Wars, but the next major leap was the invention of the float process in Britain in the 1950s. This is whereby molten glass is poured across the surface bath of molten tin. The glass spreads and flattens before being drawn off in a continuous ribbon. The process is able to produce very large panes of extremely good quality and remains largely unchanged to the present day.

The development of window glass production methods to produce larger, flatter pieces with better clarity has had an enormous influence on the design of windows through history. It is the limitation of the size of a windowpane that gives us leaded lights and astragal bars. It is curious that some modern, expensive, glass effects are actually recreations of what would have been seen as faults, or even waste, in old glass.
Early glass production techniques of casting, blowing and spinning were such that only small panes of consistent thickness and clarity could be produced. These then had to be joined together with lead strips to produce a reasonable area. As glass production technology developed, larger panes could be produced which gave rise to the window designs of the age using the maximum size of pane to give the clearest view.

The Romans in England 43 to 409 AD used small pieces of glass in windows.

The Dark Ages from 410 – 1065 AD do not provide much evidence of windows but there are Saxon churches from the period which utilised early glass technology.

1066 to 1215 AD was the Norman period, which used glass in churches and some fortified buildings, castles, etc.

1216-1398 AD, the High Middle Ages, saw the introduction of Gothic and early English church architecture with much larger windows openings comprising smaller leaded panes.
1399 – 1484 AD, the Late Middle Ages, introduced Perpendicular Gothic and the Baroque styles, both highly decorative and intricate styles. They are distinctive from earlier windows in the form of the arches at the top. Early gothic arches were ‘two centred’ tall arches whereas the later perpendicular form has a low ‘four centred’ arch.

1485 – 1602 AD, the Tudor Period, saw the extension of substantial building from the ecclesiastical/royal/military areas towards domestic buildings, examples of which still exist.

1603 – 1713, the Stuart Period, showed little architectural development and instead concentrated mainly on war. The Great Fire of London in 1666 necessitated large scale re-building and introduced the neo-Classical style, with for instance, Christopher Wren (St. Paul’s Cathedral).
In the Georgian Period from 1714 – 1836 AD. The neo Classical styles were continued. Larger clear panes in a timber lattice (astragals) were used.

Victorian windows, from 1837-1901 AD, used even bigger panes and fewer astragals.

During both the Georgian and Victorian periods, dramatic increases in the numbers of domestic dwellings with windows occurred.

One of the predominant styles of the early 20th Century was Art Deco which frequently utilised metal-framed windows with minimalist designs and some highly experimental forms, including curved glass and nautical engineering styling.
Modern float glass manufacturing techniques enable the production of very large sheets with very good optical clarity and a massive proliferation of styles. Building down to a price rather than up to a standard post-Second World War lead to little of architectural merit in fenestration. Replacement of these windows gives an opportunity to install styles of windows which are more sympathetic to the style of the building and more in line with general aesthetic tastes.

Generally, window designs have either openings in the wall which are taller than they are wide or the window is divided up into sections which are taller than they are wide. This is a recognised aesthetic principle which goes back into classical times with a ratio of height to width of 1.618:1, (Φ or phi) or greater. Interestingly, it is the same as 1:0.618

The method of operating opening windows also determined the appearance and size. Early opening windows were side hung casements and the risk of distortion and the lack accuracy of the hinges limited the size of the opening light. Later windows were vertically sliding sashes which, because they supported the sashes on both sides, could be made larger without fear of distortion.

Replacement windows that follow the phi principle tend to be more amenable to the human eye. Symmetry is also important. Those windows which don't follow this ratio or are not symmetrical tend to be less pleasing.
Buildings and windows are generally designed as a whole and sympathetic replacement is necessary to maintain the overall appearance.

Modern windows can replicate these styles and can produce many more styles of their own. Modern windows are designed for aesthetic and regulatory compliance reasons rather than for limitations of material or processes.
The development of PVC-U systems

PVC-U systems were introduced into the UK from Germany in the late 70s to early 80s and became extremely popular during the 80s. The German profiles were designed for tilt/turn windows and tended to be bulkier than the timber profiles of the casement windows they replaced. However, as the market developed, slimmer profiles specifically for UK style windows were produced which closely emulated existing windows and gave improved performance.
In recent years advances in extrusion technology has enabled even closer matching of windows with shaped and sculpted beads, horns on sliding sashes, etc. In addition, special foils can be laminated on to the surfaces of profiles to give a range of colours and finishes. Long-lasting surface coatings have also been developed to give a wide range of colours.
Building Regulations

Since 2002, Building Regulations have been applied to replacement windows specifying a minimum thermal performance, the use of safety glass and the dwelling must be made no worse with respect to compliance with other parts of the Regulations, e.g. escape in case of fire, ventilation, etc. Normally, Building Regulations are overseen by Local Authorities. However, for the replacement of windows in England and Wales, the Government arranged for a self-assessment scheme to be set up called FENSA (www.fensa.co.uk) as an alternative to the usual process. All replacement window installations must be covered by either FENSA certificates or by Local Authority Building Control. Because of recent practices in replacing sliding sash windows, FENSA have a range of guidance notes to assist compliance with Building Regulations in this particular case.

When replacing vertical sliding windows it is important that the compliance to Approved Documents F (Ventilation), N (Safety) and B (Fire Egress) is either maintained, or that the replacement windows are not worse than those being removed.

Generally speaking, replacing a sliding sash window with a top hung over fixed or a fixed over top hung does not comply with Building Regulations, whereas a top hung over a top hung may do so. Further information is available from www.fensa.co.uk.

Examples of different styles of replacement windows
These replacement windows have been installed into original openings and mirror the proportions and appearance of the original sliding sash windows.

This bow window replaced windows similar to that on the left. The central stone mullion was removed, increasing the risk of structural damage and the stone lintel is clad with flashing. Most would find this unsympathetic. Interestingly, the proportions of each of the panes follows the phi proportion principle.

The window on the left replaced one that was identical to the one on the right – a pivot next to a fixed light. Note the proportion of each light on the new window.

This replacement does not follow the proportion principle and is not symmetrical. Most people would find this less pleasing than the replacement window shown on the photograph on the left.
The character of this building depends heavily on the shape and style of the windows.

This replacement is sympathetic to the original in the photograph on the left.

Building Regulation compliant windows replacing sliding sashes while remaining sympathetic to original style.

Individual panes follow the proportion principle but the whole is not sympathetic to the original sliding sash.
This replacement utilises both leaded-light effect and faux Georgian bars to replace what was almost certainly Victorian sliding sash windows. The result is confused and un-sympathetic.

One of the early PVC-U sliding sash windows installed in the early 80s.

These windows in a new building follow the Φ ratio reasonably closely.

These windows generally do not follow the Φ ratio and most people find them less pleasing than those on the left.
The windows on the left utilise a transom in a tilt/turn window to simulate a sliding sash whilst the windows on the right are real sliding sashes. Both are PVC-U.

A closer view of a tilt/turn with a transom to simulate a sliding sash.
Late 50s semis. The house on the left has almost matched the phi principle whilst the one on the right with the addition of an extra mullion is an even closer match.

It is not difficult to design new or replacement windows which are attractive and complementary to the appearance of the whole building. The following diagrams attempt to illustrate this point.
<table>
<thead>
<tr>
<th>Typical casement window style normally seen in the 1950s which adheres well to the phi principle. Ideally should be replaced with as close a copy as possible</th>
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<tbody>
<tr>
<td>A common replacement with no close relationship to the phi principle which most people would find unattractive.</td>
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<tr>
<td>Another common replacement style which has one element which complies with the phi principle but is again less pleasing than the original.</td>
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<tr>
<td>A relatively complex design from both an appearance and a manufacturing point of view, but still not fully compliant with the phi principle.</td>
</tr>
<tr>
<td>The most attractive and phi principle compliant design alternative to the original, yet no more complex than the one above.</td>
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As often said and as stated in our introduction “beauty is in the eye of the beholder” and no one can say whether an individual's choice of style is right or wrong. However, hopefully the information in this guide has demonstrated that by avoiding a few obvious pitfalls, and by following some well-researched principles of proportion, it is possible to satisfy the eye of most people.

The British Plastics Federation Windows Group has a wide range of standards and codes of practice to assist all those involved in PVC-U windows and doors. More information is available from [www.bpfwindowsgroup.com](http://www.bpfwindowsgroup.com)

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