BOWMONK

TINT TESTA

TRAINING AND OPERATORS MANUAL

What Is Light?

Light is made up of pulses of radiated energy from the sun. The frequency that these pulses occur, (the distance in which the wave is repeated), is known as the wavelength. Only part of all radiated light energy comprises visible light. The shorter wavelengths of light are known as the Ultraviolet Spectrum which is invisible to the human eye, being within the wavelengths up to 380 nm. This is responsible for producing the effects commonly known as sunburn and after prolonged exposure can result in such harmful effects as skin cancer.

Visible light to humans has a wavelength of between 380 and 770 nm and is responsible for the reflected light from objects producing colours visible to the eye.

Infrared light is made up of wavelengths above 770 nm and is responsible for approximately half of the heat energy transmitted through glass but again falls outside the visible spectrum. Basically the slower the molecules vibrate then the longer the wavelength. As a solid object is heated, the molecules, which make up that object, start to move. As this movement increases energy is given off in the form of radiated heat.

There is no visible light emitted from the object as this would fall within the Infrared, non-visible spectrum. As this frequency increases the objects radiated energy moves at a speed and frequency whereby light is given off and it appears to glow red. If the object is heated further the frequency again increases and the light changes from red through orange and yellow to ultimately white light.

Light travels only in straight lines and is either reflected off objects, passes through them or is absorbed by them. A white object reflects most of the light falling on it and absorbs very little, with the result that it feels cooler to the touch than surrounding darker objects. However a black object absorbs most of the light and heat, with the result that there is an increase in temperature and it feels hot to the touch, when compared to a white object directly along side of it.

What is Glass?

The major ingredient for glass making is silica, in the form of sand. Only sand of the highest purity can be used to make glass. If the sand contains a trace of iron, for instance, the glass made with it will have a greenish colour. Even for ordinary window glass, sand must be better than 99 percent pure silica. Silica alone can be melted to form glass at a temperature of approximately 1980 °C. The resulting glass is called fused silica, or fused quartz.

Most glass is made of a mixture of silica with other ingredients, such as fluxes and stabilisers. Silica mixed with a flux melts at a lower temperature, whilst stabilisers increase the strength of the glass. The mixture of silica with the flux Sodium Carbonate produces Sodium Silicate, called water glass because it dissolves in water. If lime (Calcium Carbonate) is added to Sodium Silicate as a stabiliser, the result is a glass of greater durability that does not dissolve in water. Called soda-lime-silica glass, it is the type used to make windows and bottles.

Why have tinted glass?

As we have seen above in its purest form glass is virtually clear. As such most of the radiated visible and infrared light from the sun passes through it, as does a fairly high proportion of the

Ultraviolet light. However with very small amounts of impurities added to the original molten silica, mainly in the form of metals, the glass takes on a coloured tint and certain other properties. (Lead crystal glass appears visually very clear to grey in colour and is somewhat brittle but lends itself to use in very fine glassware, light bulbs and fluorescent tubes etc.).

Normal plain float glass has a rather greenish tint when viewed from the edge. This is due to an Iron Oxide content of about 0.1% and a mixture of Ferric and Ferrous Ions of 20%. Such glass of about 4 mm. thickness, (Standard thickness Automotive Glass), allows approximately 90% of light in the visible spectrum to pass through it. There is a loss of about 4% at each surface due to reflection / refraction with a further 2% being absorbed into the glass, mainly by impurities such as iron. Approximately 80% of the Infrared light passes through, whilst most of the Ultraviolet light is absorbed by the iron content.

Glass which allows light in the lower wavelengths to be transmitted through has a blue appearance, whilst glass which allows the longer wavelengths to be transmitted through it is red.

Decreasing the Ferrous state of the glass turns it more yellow in appearance, whilst increasing the Ferrous content turns the glass bluer. Because Iron absorbs both Ultraviolet and Infrared well it is the most commonly used tinting agent in high performance glass. This is used where the highest possible value of the visible spectrum of light is required to be transmitted through the glass whilst reducing the Ultraviolet and Infrared transmissions.

The major manufacturer of glass in the U.K. is Pilkington Glass of St. Helens. They hold the trade names of, "Float Glass" for normal flat colourless glass and "Sundym" for tinted glass. Depending on the amount of tinting then the "Sundym" mark is further denoted by a number. The following table showing the comparative properties of "Float" and "Sundym" glasses is shown below.

Glass Type	% Ultraviolet transmission	% Visible light transmission	Glass colour
Clear Float	58%	90%	Clear
Sundym 478	27%	78%	Green
Sundym 471	18%	71%	Green

As can be seen from the table much of the harmful ultraviolet light and heat transmitting Infrared light can be filtered out but as a result there is also a significant loss of visible light transmission.

Modern Automotive Glass

Because of requirements placed on manufacturers by vehicle owners glass fitted to modern vehicles has altered significantly over the last few years. All glass fitted to motor vehicles as from 1 January 1959 must be safety glass. There are basically two types used in motor vehicles, toughened glass or laminated Glass

Toughened Glass

Toughened glass is specially heat treated so that when broken it shatters into very small fragments without sharp shards, thereby reducing injuries. The windscreen is treated in specific areas to set up stresses in the glass, which cause the glass to shatter in a pre-defined manner. The stresses in the glass can sometimes be seen in the glass in certain light conditions or when viewed through a polarising light filter, such as some sunglasses. This type of glass is now primarily used on side and rear windows but has been used for some time on the windscreens of some vehicles.

Laminated Glass

Laminated glass is essentially two pieces of annealed glass stuck to each other with a plastics interlayer in between. The plastics interlayer prevents objects shattering and penetrating the glass, as the glass is not stressed in the same way as toughened glass it stays more intact. This type of glass is more resistant to stone chips and even penetration into the vehicle during impacts, especially with pedestrians, thereby reducing the possibility of injury to vehicle occupants and pedestrians.

The plastic film is so thin and optically clear that there is little difference in transparency between toughened and laminated glass of the same thickness, although because of two extra surfaces at the plastic membrane there is a slight difference.

All new cars and car-derived vans sold in the U.K. must now be fitted with laminated glass windscreens, whilst LGV's and PCV's may still have toughened screens. However in certain other countries, notably the United States all vehicles must have laminated windscreens.

Modern trends

There has been a dramatic increase in the number of vehicles fitted with air conditioning and also an increased awareness of the dangers of over exposure to the harmful rays of the sun. Also the suns rays have a damaging effect on the fabrics used for the seat coverings and other areas of vehicles, resulting in the fading of colours and even some decomposition of the fabric itself.

As the area of glass used in vehicles has increased, so has the use of tints, in an effort to try and reduce the energy used by Air Conditioning Units and also improve passenger comfort as well as reducing the effects of the suns rays on fabrics. This is achieved by blocking off or absorbing some of the suns energy.

Increased ultraviolet light absorption by automotive glass is achieved by the addition of other pure or derived earth group elements in addition to those that we have seen above in the Pilkingtons Sundym range.

Libbey Owens Ford manufactured a glass under the trade name EZ - Kool which had Cerium and Titania added to it. However many of these additives are very expensive, which adds considerably to the cost of producing the glass. Sometimes other elements or combinations are used which also alter the visible appearance of the glass giving it a blue, green, grey or red tint. The following table provides some information as to the other additives and their effect on the colour of the glass.

Additive	Colour of tint
Chromium	Yellow /Green
Cobalt	Blue
Copper	Blue
Erbium	Pink
Europium	Orange Red
Holmium	Yellow
Manganese	Colourless / Purple
Neodymium	Blue / Red
Nickel	Yellow / Grey
Praseodymium	Green
Samarium	Orange
Selenium	Pink / Red / Brown / Colourless
Thulium	Deep Blue
Vanadium	Yellow / Green

Motor vehicle manufacturers do not normally manufacture glass for their vehicles themselves but buy it in from specialist manufacturers, who may combine the glass manufacture with the window manufacture process. However some of these specialists in turn buy glass sheet from major glass manufacturers, specifying what properties they require of the glass in terms of tint and transmission properties. They then cut and mould it to the desired shape and curvature before heat treating it to toughen it or laminate the glass together with the plastic film insert.

It must be appreciated that the use of tints does prevent or restrict certain specific light frequencies passing through the glass. Therefore a blue / grey tint will stop more red light than a red tint would.

Whilst this may be desirable during hot sunny weather where a lot of Infrared heat is also cut out, it is not however desirable where the only available light is towards the Red / Infrared region of the visible light spectrum, as in the case of night time, where overhead Sodium street lights are the only source of light. These lights only emit light in the yellow - red portion of the visible light spectrum.

During night time driving light levels, even in built up areas can be extremely low when compared to normal daylight conditions and almost completely made up from the Sodium street lights. There is also a problem with light only from this narrow band of the spectrum, in that it becomes increasingly difficult to differentiate between shapes and objects because the contrast is greatly reduced.

Therefore an excessively tinted window with a 5% visible light transmission value, primarily in the blue / grey spectrum, will allow only 1 - 2% of normal daytime light levels to the driver's eye. At this sort of light level it would be unlikely that the driver would be able to see and identify a pedestrian in the roadway in front of his vehicle until they were picked out in the vehicle headlights, (white light and fuller spectrum) possibly when it was too late to avoid a collision.

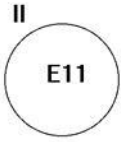
Information that can be found on glass

Manufacturer

Most manufacturers of the actual window mark the glass with their own corporate name or logo and not that of the actual glass manufacturer. They may well source the glass from several suppliers. Some examples of this corporate marking are, Blindex, HW Automotive, Sekurit, Sicursiv, Splintex, and Triplex. Some of these may also have the vehicle manufacturer's logo alongside their own.

Country of Origin

All European manufactured glass will bear the E marking of the country in which it was made. This takes the form of a circle with the capital E followed by a number or in certain cases letters.



In addition there may also be a mark in the form of II or I to the top left or top centre of a circle. The I denotes that the glass is toughened and II is a laminated glass windscreen. As such each has a minimum light transmission value of at least 75%. An example of one such mark is shown overleaf. If there is a figure V outside the circle in place of the I or II then the glass is other than a windscreen and has an original value of less than 70%.

E1	Germany	E2	France	E3	Italy
E4	Netherlands	E5	Sweden	E6	Belgium
E7	Hungary	E8	Czech Republic	E9	Spain
E10	Yugoslavia	E11	United Kingdom	E12	Austria
E13	Luxembourg	E14	Switzerland	E16	Norway
E17	Finland	E18	Denmark	E19	Romania
E20	Poland	E21	Portugal	E22	Russian Federation
E23	Greece	E26	Slovenia	EIRL	Eire

American DOT Number

This takes the form of a series of letters and numbers always proceeded by DOT. Part of the code contains the 2 letters AS followed by a number to denote the degree of tint in the glass.

AS1 denotes a light transmission value through the glass of greater than 70% and the glass has a mechanical performance suitable for all locations in a vehicle, (including windscreens).

AS2 denotes the glass has a light transmission value greater than 70% but cannot be used for a windscreen.

AS3 then the transmission is less than 70% with no lower value being denoted.

Glass may additionally be marked with the percentage light transmission value given as a minimum figure, (Min 70%).

Other Data

There is much more data contained within the code letters on vehicle windows, much of this is specific to each manufacturer and should be verified with them if required.

You should note all details when carrying out an examination

After Market Tinting

There has become an increasing trend for people to modify their vehicles by having the windows tinted by certain after market products.

There are basically two types of tint: Sticky plastic film fitted to the inside of the windows and aerosol spray applied to the inner surface of windows.

The plastic tints which are by far the most prevalent can be coloured similarly to normal glass tints from blue / grey, through to red. Also it is possible to obtain tint film, which acts as a one-way mirror where it is impossible to see into the vehicle at all from more than a few centimetres away. These tints however greatly reduce the light transmission qualities of the glass, sometimes reducing this to as low as 6%. This form of tint tends to be evenly distributed throughout the application.

One large manufacturer of this type of tint is Solar Gard [http://www.solargard.com]. They market plastic tint film, which is distributed worldwide and are arguably the largest exporter of tints to the U.K. under various names. Their tints are designed for several purposes and each is specific for that purpose.

Commercial Flat Glass Film is designed for the fitment to buildings to reduce the transmission of most Ultra Violet Light.

Decorative Film, "Decogard," is designed to enhance the appearance of glass and to allow corporate names etc. to be placed in prominent window locations or to provide privacy within windowed areas etc.

Security Film marketed as "ArmorGARD" is designed to provide maximum safety and security. The strong film is fitted to one side of a window so as to prevent easy forced entry into premises via windowed areas, as in Jewellers, Banks, Building Societies and other high-risk premises.

Automotive Film Products are again plastic tints designed to reduce harmful light transmissions into vehicles. Like conventionally tinted automotive glass, these films are made up by adding metals in very small quantities to the plastic film.

All plastic tint films operate by reflecting some light back through the glass and also by absorbing some of the light into the film. These are known as the Reflectance and Absorption Values with different tints providing different values for each. The actual light allowed through the film is known as the Transmittance or Transmission Value.

Basically, the darker the tint, the lower the light Transmittance / Transmission Value and the higher the Absorption Value. However the Reflectance Value can vary somewhat independently of these other values. Because some tints are far better at absorbing Ultra Violet and Infra Red light than just the Visible Light Spectrum then differing values will be quoted for Solar and Visible Light values.

The important figures for enforcement purposes are within the Visible light Spectrum only.

Spray tints are far less even as they are sprayed on by hand, often resulting in wild variations in density and a patchy appearance. Depending on how many coats are applied the light transmission level of the glass can again be reduced to extremely low levels.

Replacement Plastic Glazing

Modern plastics such as Perspex and Oroglass can have a very deep tint, usually in the grey / blue spectrum. Whilst they will comply with the safety requirements of vehicle glazing if fitted to the rear of the "B" Post they do not conform to the fitment regulations elsewhere, nor can they conform to the light transmission requirements.

Legal Requirements

This text is an abstract taken from the UK regulations in force when the manual was produced. Users of the equipment should ensure that they are familiar with current legislation and case law relevant to the subject.

The requirements for vehicle windows and windscreens are contained within two different sets of legislation. Vehicles used in the United Kingdom must comply with EEC Directives in addition to our own Road Vehicles (Construction and Use) Regulations 1986, specifically Regulations 30, 31 and 32.

N.B. Prior to November 2003 there was some confusion surrounding the interpretation of the Construction and Use Regulations. However in November 2003 VOSA, (Vehicle & Operator Services Agency formerly the Vehicle Inspectorate), issued guidance which clarified the regulations and how they were to be applied.

Regulation 30

Requires the driver of a motor vehicle to have a full view of the road and traffic ahead, whilst controlling the vehicle **and** that all glass or other transparent material fitted to the motor vehicle be maintained in such a condition that it does not obscure the vision of the driver whilst the vehicle is driven on a road.

Note 1: The covering of windows with tinting film or tinting spray, could result in the driver being unable to see through it correctly, thereby constituting an offence contrary to this Regulation.

Note 2: This Regulation could be open to interpretation and argument as to at exactly what level of tinting the vision became obscured. Depending on the specific circumstances it could be argued that vision is not impaired even with a light transmission level as low as 20%.

Regulation 31

Specifies that glass fitted to motor vehicles shall be safety glass. This must be either laminated glass or toughened safety glass but could also be of Perspex or other plastic material, which does not fracture into dangerous pieces. **(However plastics can only be used behind the "B" Pillar of a vehicle).**

Regulation 32

Also requires windows to be of safety glass but 32 (10) also specifies certain minimum light transmission values.

For motor vehicles first used before 1 April 1985 all windows must allow 70% of light to be transmitted through. **(See notes a - c)**.

For motor vehicles first used after 1 April 1985 then Windscreens / Windshields must allow 75% of light through and all other windows 70%. **(See notes a - c)**.

This does not apply to:-

a. Any part of the Windscreen / Windshield which is outside the vision reference zone, as described in British Standard Specifications 857, BS AU 178 and ECE Regulation 43. (e.g. Deep strip tinting across the top edge of a windscreen).

One test should be carried out in each of the areas A, B and C. However this is not the requisite area as laid out in the ECE and BS AU Specifications, it is merely a guide.

b. Windows through which the driver when in the drivers seat is unable at any time to see any part of the road on which a vehicle is waiting or proceeding, (rear or any side windows behind the driver).

c. Windows in a motor ambulance which are not wholly or partly in front of or on either side of any part of the drivers seat; or windows in a bus behind a driver or facing rearwards.

Note 3: The recent notice issued by VOSA now clearly states that Regulation 32 applies to the above windows and includes any film attached thereto. A copy of the clarification to the regulations is shown below, together with a VOSA press release on the subject together with a copy of their Guidelines.

Regulation 32(10) of the Road Vehicles (Construction and Use) Regulations 1986 prescribes levels of light transmission for windscreens and other windows. The intent of the Regulation is to ensure that drivers have a clear view of the road, other traffic and pedestrians so as to enable them to drive safely.

Detail

In order to have any real meaning it should be obvious that the Regulation applies to the whole of the substance through which light is transmitted - including both the glass and any other substance, including, for example, 'film', 'tint', or 'any other substance applied to the windows'. (It is, incidentally, also clear that the light transmittance requirements apply irrespective of whether the incident light is passing either one way, or the other.)

The Secretary of State for Transport, in exercise of the powers conferred by section 41(1), (2) and (5) of the Road Traffic Act 1981, and of all other powers enabling him in that behalf, and after consultation with representative organisations in accordance with section 195(2) of that Act, hereby makes the following Regulations: -

Citation and commencement

1. These Regulations may be cited as the Road Vehicles (Construction and Use) (Amendment) (No.) Regulations 2003 and shall come into force on 2003.

Preliminary

2. The Road Vehicles (Construction and Use) Regulations 1986 shall be further amended in accordance with the following provisions of these Regulations.
Amendments to regulation 32 (windscreens and other windows)

3. In regulation 32(10), after "a vehicle of a class specified in column 2 of that Table" insert " including any tint, film, other substance or material applied to the aforementioned glass or glazing or forming part of the windscreens or other windows".

Explanatory note

(This note is not part of the Regulations)
These Regulations amend the Road Vehicles (Construction and Use) Regulations 1986 (the "1986 Regulations") in the following way.

Regulation 3 amends regulation 32(10) of the 1986 Regulations by the insertion of wording about any tint, film, other substance or material applied to specified glass or glazing or forming part of windscreens or other windows.

By including a specific reference to such items this ensures that the visual transmission requirements for light apply where any tint, film, other substance or material has been applied to specified glass or glazing as well as where such items form part of windscreens or other windows.

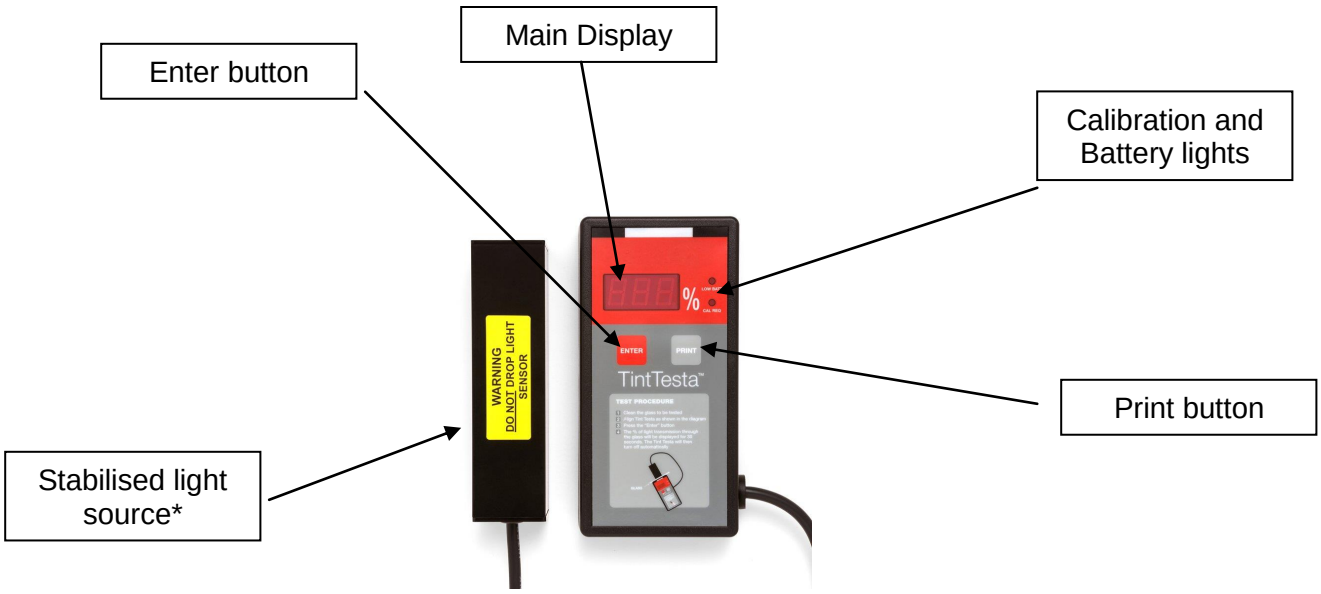
TINT TESTA
Window Tint Meter Operation

<u>This instrument must only be used by trained and authorised personnel</u>

This is an instrument designed specifically for the direct measurement of percentage light transmission through transparent mediums. The complete unit comprises only two components connected by a cable with a total weight of 0.8 Kg. The instrument operates within the temperature range of 0 to + 40 º C.

The two units are the combined hand held readout unit and stabilised power source with optical detector, which has a Photoptic response closely matching that of the human eye. The second component is a stabilised light source with a 25mm diameter filter to provide a white light source at a frequency within the human visual range, mounted within 38 x 38 x 140mm housing.

***N.B. this component is non serviceable.**



The sensor for the light transmission and is the infra red printer link test are located on the top edge of the combination unit. Printing can be via a PC using a cable (not supplied) and Hyperterminal via the port on the right hand side of the machine.

The instrument is checked and calibrated against accurately measured reference glasses, which conform to UKAS scientific standards. A certificate containing all required details is provided with each instrument. A label containing details of the instrument and calibration date is located on the rear of the instrument body.

The instrument should require no alteration to its calibration between set calibration intervals by the factory. The accuracy of the instrument should be checked before and after each set of tests is carried out by using the reference glass supplied and following the procedures contained within this operating manual,

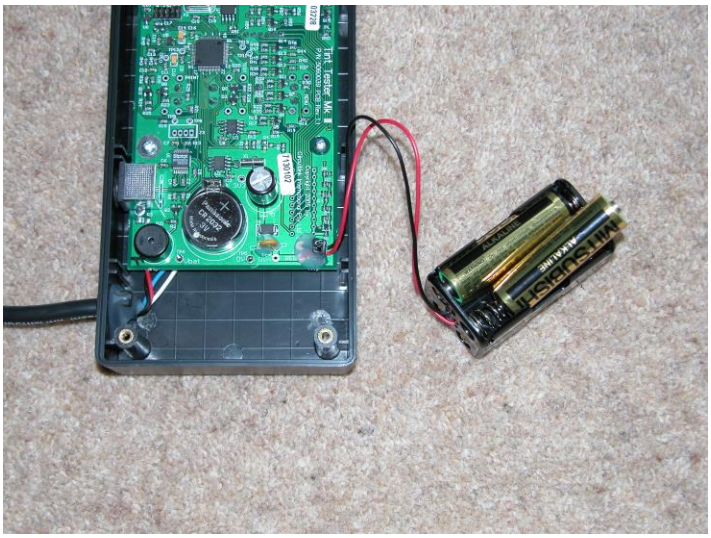
Should the instrument fail to record the required accuracy during these calibration checks, then the batteries within the instrument may require changing. This procedure should only be carried out by competent authorised staff and a record of when this was carried out and by whom should be made and retained.

CHANGING THE BATTERIES

The Tint Testa is powered by four AAA 1.5 volt Alkaline batteries contained within the main body of the instrument. If the instrument displays the Low Batt warning, or fails to turn on or continuously shows a zero figure in the display, then the batteries need replacing.

Remove the back from the main combination unit by removing the four screws and carefully lifting the cover from the main body.

Carefully lift out the battery holder then remove each battery in turn by gently lifting at the + end. Discard the old batteries then fit new ones. Always replace all four batteries.



We recommend that to ensure reliable consistent results, good quality batteries such as Energiser, Duracell or similar are used.

Replace the battery holder in the main body of the instrument. Ensure that it is located between the circuit board and the bottom of the case and between the two screw thread posts. Make sure the battery holder wires are within the casing before replacing the back.

Do not over tighten the retaining screws

Carry out a calibration check before further use

The battery fitted to the circuit board is used by the instrument to retain the date and time. This should last for several years but if you intend to change it, ensure the instrument is switched on when you do so. If the instrument is not powered up when this battery is changed, time and date will need to be reset by Bowmonk Service.

TINT TESTA GLASS CHECK PROCEDURE

If necessary the material being tested should be cleaned using a suitable proprietary glass cleaner and thoroughly dried using lint free cloth.

All details printed or etched into the window should be obtained and entered on the test results form in the appropriate space. Data obtained during the tests should be checked against the information contained within the training document.

Any non-standard glazing / tint medium should be identified whenever possible and noted on the results form, with as full a description as possible.

Calibration checks **must** be carried out immediately before and after each series of tests.

Calibration checks

A manufacturer's calibration is due on the date shown on the sticker affixed to the rear of the device. The Cal Req light will start to flash when there are 28 days before the calibration is due or when the number of tests carried out approaches the preset level. If out of calibration, the instrument will still operate, but the Cal Req LED will flash and 'calibration EXPIRED' will be shown on a printout.

The operator needs to check the calibration before and after the instrument is used.

Switch on the Tint Testa by pressing and holding the [Enter] button. If you just press the button, the instrument will not power up. A small red dot will appear in the lower right corner of the display, the display components will then flash and 0 will be displayed. Now the device is ready for use.

The instrument will automatically switch off after 30 seconds of inactivity. This is signified by a beep and the display goes off. If this occurs while you are carrying out a series of test, just switch the instrument back on and continue with the tests.

To take a reading, either press [Enter] and release or press [Enter] and hold until a reading appears.

Check 1: Take a reading without aligning the light source. Take this opportunity to make sure the light source is functioning. The device must show a reading of 0.

Check 2: Now place the stabilised light source against the end of the main instrument / readout unit and over the top of the light sensor. Ensure that both components are aligned correctly and take a reading. 100 should be displayed (+/- 3%). There is a white line on the top of the front panel of the combination box which should be used to align the two components. If they are not aligned correctly, the value displayed will be lower than the actual value.

Check 3: Measure the Calibration Reference Glass provided with the device. Record the result on the appropriate form. The reading should be no more than +/- 3 from the value on the reference glass.

Providing these checks are satisfactory the Tint Testa is ready for use.

TESTING THE VEHICLE

Three tests should be carried out on each area of glass to be examined. It is possible that some methods of tinting may produce uneven levels of tint in certain small areas.

The tests should be carried out over the whole area of the window and it is suggested to test at the top left, centre and bottom right locations of each window.

However on windscreens the tests should be carried out in each of the defined areas "A" "B" and "C" along the horizontal centre line as shown earlier in the manual.

Ensure that the detector is positioned width ways across any curvature to minimise the air gap between the detector and the glass.

You must place the light source on the outside of the glass being tested

Wherever possible the tests should be carried out away from strong direct sunlight or other direct artificial light such as spotlights / headlights etc. If this is not practicable then background light levels should be obtained and the test results adjusted accordingly. The Tint Testa is **not** suitable for this task.

After the completion of the tests, the calibration checks should be carried out again.

If the final calibration results fall outside the required values then the whole calibration and test procedure must be repeated.

(If the checks are still outside the range after three calibration attempts, please refer to Bowmonk Technical Support)

USING THE INFRA RED PRINTER

Please note: The printer shown here is an optional extra

With the test results on the screen, Press the Print button and the display will show a message indicating the data is being sent. You can only print the details while the reading is displayed.

The test data will be printed with the time and date of the test, the result, calibration details, instrument serial number and the facility to write the Inspectors name and a signature.

TERMINOLOGY

mm	millimetre	0.001 metre
nm	nanometre	0.000000001 metre one billionth of a metre
mil	US term	approx 0.0001 metre

Absorptance

The ratio of the radiation absorbed by a surface to the total energy falling on that surface described as a percentage

Reflectance

The ratio of the light that radiates onto a surface to the amount that is reflected back

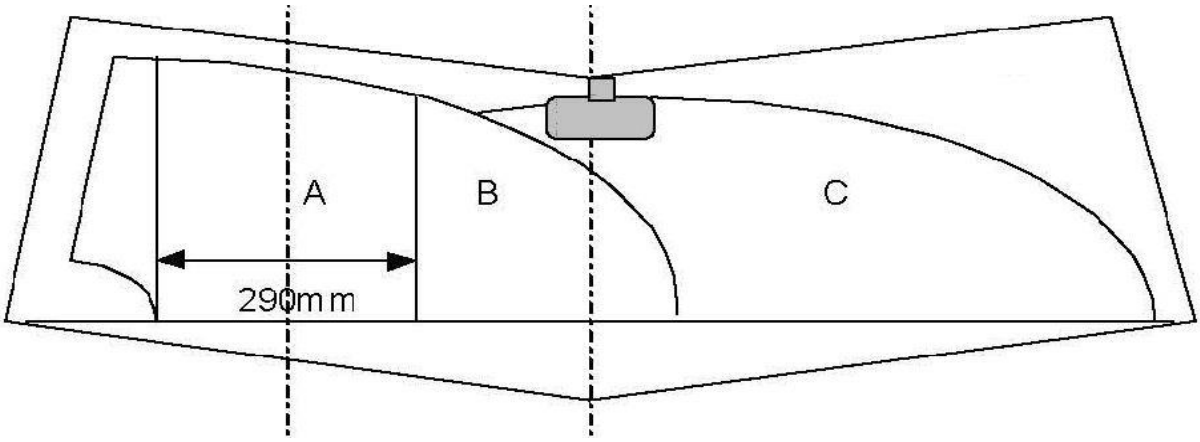
Transmittance

The ability of the glass to pass light and/or heat, usually expressed in percentages (visible transmittance, thermal transmittance, etc.)

°C Temperature measurement in degrees Celsius.

°K Temperature measurement in degrees Kelvin. (0 °K = - 273 °C) known as absolute zero, the lowest theoretical temperature possible, however a temperature change of 1°K = 1°C

Diagram showing areas recommended for testing



Centre line of steering wheel