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TI TECHNICAL INFORMATION

TI 15/19: Optical properties under long-term high temperature exposure of ELPECAST® casting compounds of the series Wepuran VT 3402 KK and Wepesil VT 3602 KK

Owing to their extremely high transparency the casting compounds of the series **Wepuran VT 3402 KK** and **Wepesil VT 3602 KK** are used in lighting electronics/LED technology especially for applications where very high demands are placed on optical properties.

In this Technical Information you will find extensive data on the transmission and colorimetry of the individual casting compounds at various temperatures and over different time periods. Please consider the recommendations / selection criteria given in the Technical Report "Casting compounds of the Wepuran VT 3402 KK series" which will facilitate your selection of a casting compound from this series suitable for your specific application.

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Although anything but desirable when used with LEDs: All common casting materials, as a result of oxidative processes, tend to yellow under exposure to oxygen, whereby temperature, time and resin basis have a major influence on the degree of yellowing and degradation.

Featuring a temperature range of up to 200 °C [392 °F], the silicone casting compound **Wepesil VT 3602 KK** displays only minimal yellowing even under permanent exposure to high temperature.

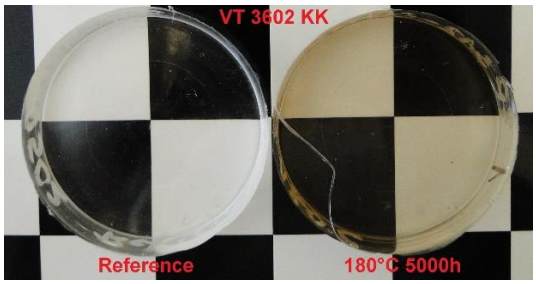


Fig. 1: Casting compound Wepesil VT 3602 KK
left: Reference; right: Minimal yellowing after long-term exposure to high temperature

Based on polyurethane resin, the casting compounds of the series **Wepuran VT 3402 KK** that are generally used at a temperature range of up to 90 °C [194 °F] display a yellowing effect depending on the exposure time and temperature; nevertheless, depending on the wavelength high degrees of transmission are reached.

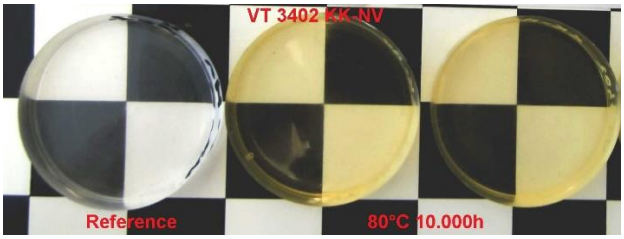


Fig. 2: Casting compound Wepuran VT 3402 KK-NV
left: Reference; right: Yellowing after long-term exposure to high temperature

Fig. 3: Casting compound Wepuran VT 3402 KK-ALU
left: Reference; right: extreme yellowing after long-term exposure to high temperature exceeding the temperature range specified

Although the yellowing/discolouring of a product has no general effect on the insulation properties it is decisive factor when selecting a suitable clear casting material for LEDs.

For this reason, we have performed extensive trials on yellowing effects for the casting compounds of the series **Wepuran VT 3402 KK-NV** and **Wepesil VT 3602 KK.**

One must surely decide for each individual application which degree of yellowing is acceptable, considering that the extent of yellowing will depend on a large number of influences in final use.

Nevertheless, it is possible to carry out measurings in view of selecting the appropriate casting material that permit an initial basic evaluation of the yellowing behaviour. In terms of colour, the human eye is a powerful and sensitive measuring instrument; however, as it can be betrayed, it will not provide reproducible results. Here colorimetric studies provide more reliable and objective measuring results.

Colorimetry

The Report 166 „Conformal coatings, solder resists and casting compounds – optical requirements and performance in LED applications“ published by Peters describes „Measuring colours – colorimetry“ as follows:

„In order to describe a colour or a difference in colour from a quantitative point of view, one can illuminate the surface to be measured by means of a defined light source and measure the light that has been remitted […] To characterise a colour through values, the so-called CIE Lab System (to be precise, the L*-, a*-, b* system of CIE – Commission internationale de l'éclairage, International Commission on Lumination) is commonly referred to. This Lab System is based on the transformation of the primarily calculated colour values X, Y, Z to the coordinates L* (brightness), a* (red-green-value), and b* (yellow-blue-value). […]

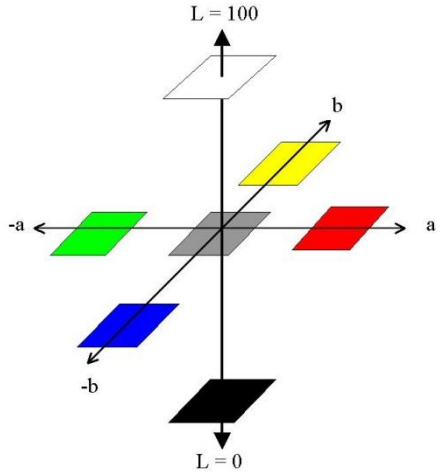


Fig. 4: Scheme of the CIE-L*a*b* system and its colour coordinates

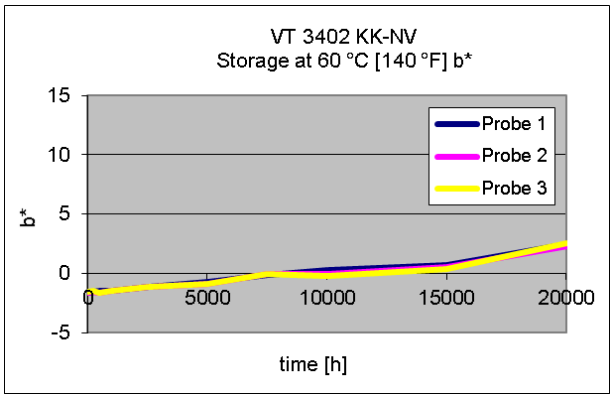
As the major benefit, the CIE lab system is suitable for determining colour distances. The value defining a colour distance i.e. the similarity or identity of colours, is ΔE*, which is calculated as a spacial Pythagoras from the three values $L_1^* – L_2^*$, $a_1^* – a_2^*$ and $b_1^* – b_2^*$:

$$\Delta E^* = \sqrt{(L_1^* – L_2^*)^2 + (a_1^* – a_2^*)^2 + (b_1^* – b_2^*)^2}$$ […]“

Theoretically, a yellowing of clear casting compounds could only be detected through a change of the b* axis. Here it is clearly noticeable indeed, but measurings have shown that the other axes are also affected.

Colorimetric analysis of a long-term temperature storage of Wepuran VT 3402 KK-NV

Please find below a list of measuring results after long-term storage at dry heat (60 °C [140 °F], 80 °C [176 °F] and 100 °C [212 °F]) of the casting compound **Wepuran VT 3402 KK-NV**. The samples (probes) were applied on white stone tiles in a layer thickness of 200 µm and analysed in regular intervals from a colorimetric point of view. In the diagrams below you will find the behaviour of the b* values and the ΔE* values at these three temperatures.



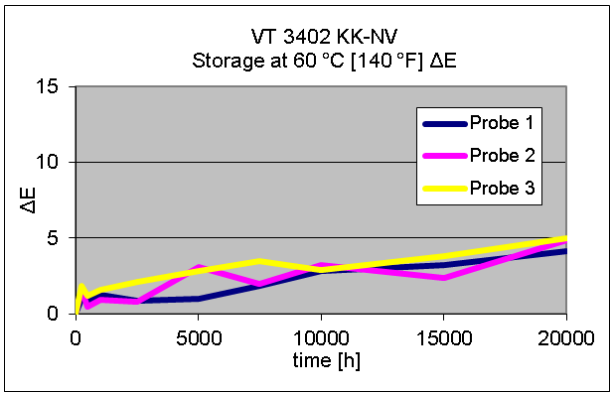
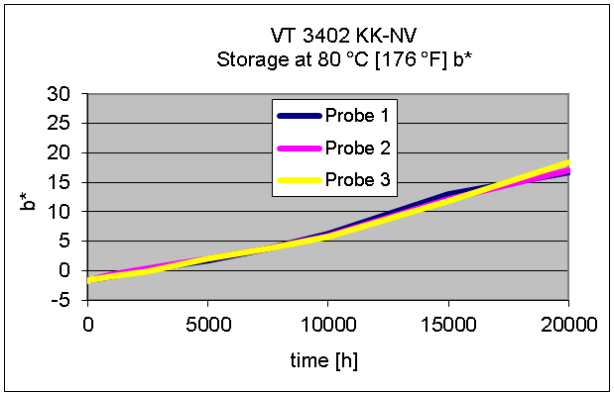


Fig. 5: Colorimetric evaluation VT 3402 KK-NV - Long-term storage at 60 °C [140 °F]



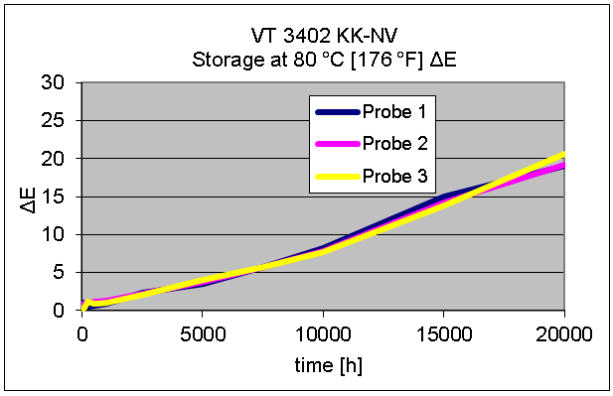
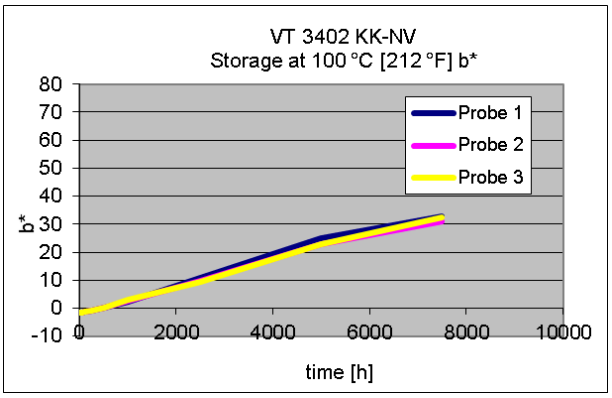


Fig. 6: Colorimetric evaluation VT 3402 KK-NV - Long-term storage at 80 °C [176 °F]



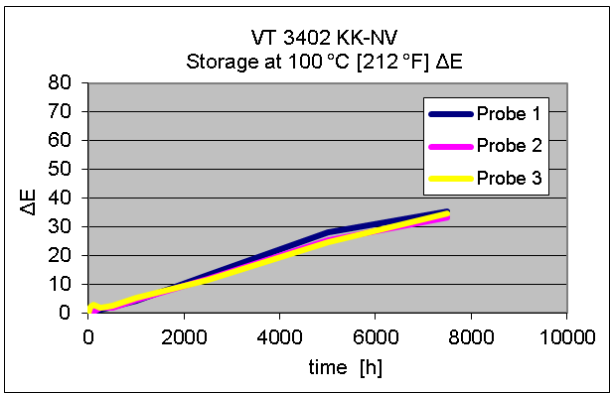


Fig. 7: Colorimetric evaluation VT 3402 KK-NV - Long-term storage at 100 °C [212 °F]

The diagrams above clearly exhibit the influence of temperature on yellowing. This effect is not linear but rather exponential (please note the clearly different axis divisions in some cases).

Example: After exposure to 60 °C [140 °F] a yellowing ΔE* of 5 is reached after as many as 20 000 hours while this same level is already produced after approx. 6000 at 80 °C [176 °F], and after approx. 1000 hours at 100 °C [212 °F].

What does the yellowing effect of a clear casting compound mean?
As a result of the yellowing effect, the short-wave rays of an embedded LED are “blocked” and the entire light spectrum is shifted to yellowish. Moreover, the light output will drop. Such blocking properties can be depicted through transmission measurings of the casting compound.

Transmission measurings

The measurement range of below results consisted of the spectrum from 300 nm to 1000 nm. The range between 380 nm and 780 nm is visible to the eye while any changes outside of this range cannot be perceived by the eye.

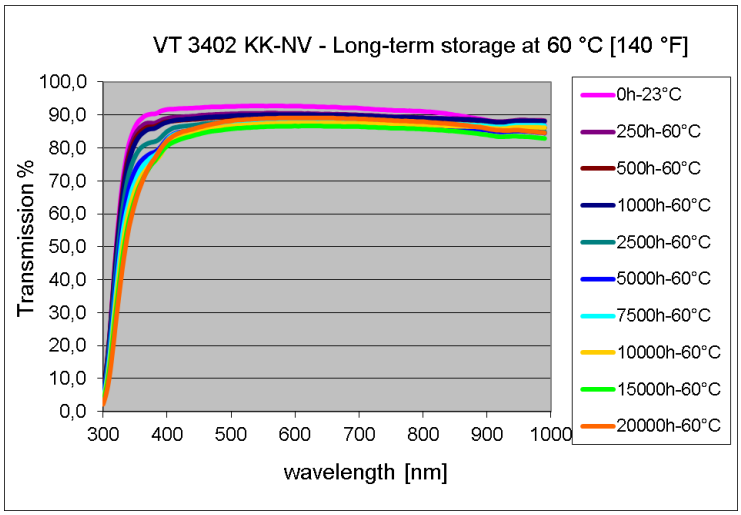


Fig. 8: Transmission VT 3402 KK-NV - Long-term storage at 60 °C [140 °F]

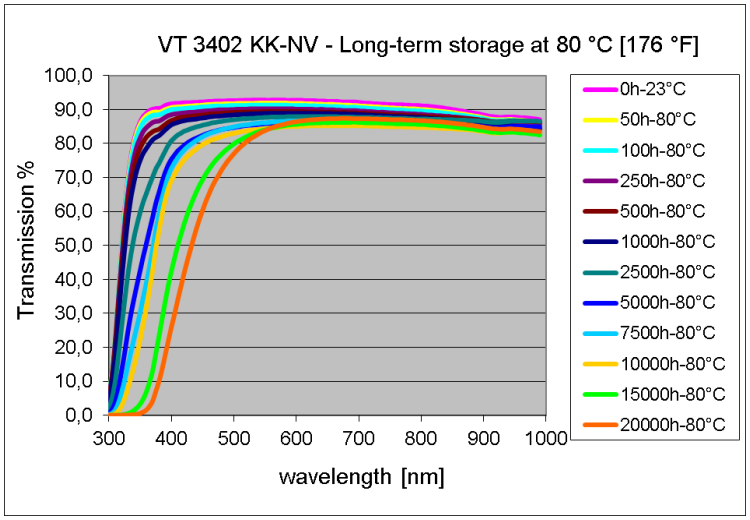


Fig. 9: Transmission VT 3402 KK-NV - Long-term storage at 80 °C [176 °F]

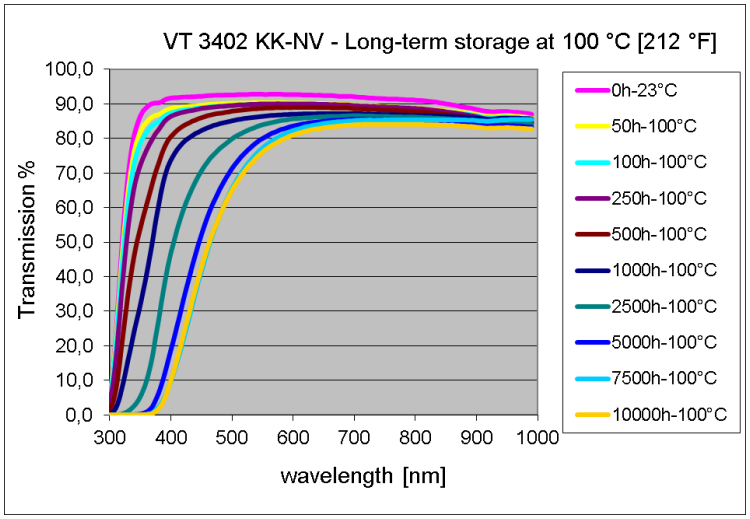


Fig. 10: Transmission VT 3402 KK-NV Long-term storage at 100 °C [212 °F]

For transmission measurings, almost the same as to colorimetric evaluations applies: The higher the temperature, the more distinctive are the changes in the transmission curves. The displacements even have an effect in the visible wavelength range (clearly noticeable in the diagram on storage at 100 °C [212 °F]).

For the measurings described above, the samples (probes) were applied on glass with a layer thickness of 1.5 mm and then stored; the measurings were taken through the probe and the glass.

Transmission in case of casting compounds with UV protection

Casting compounds designed to protect the base material from UV loading contain an additive for UV protection that prevents UVA radiation from penetrating the compound and thus from damaging the basis.

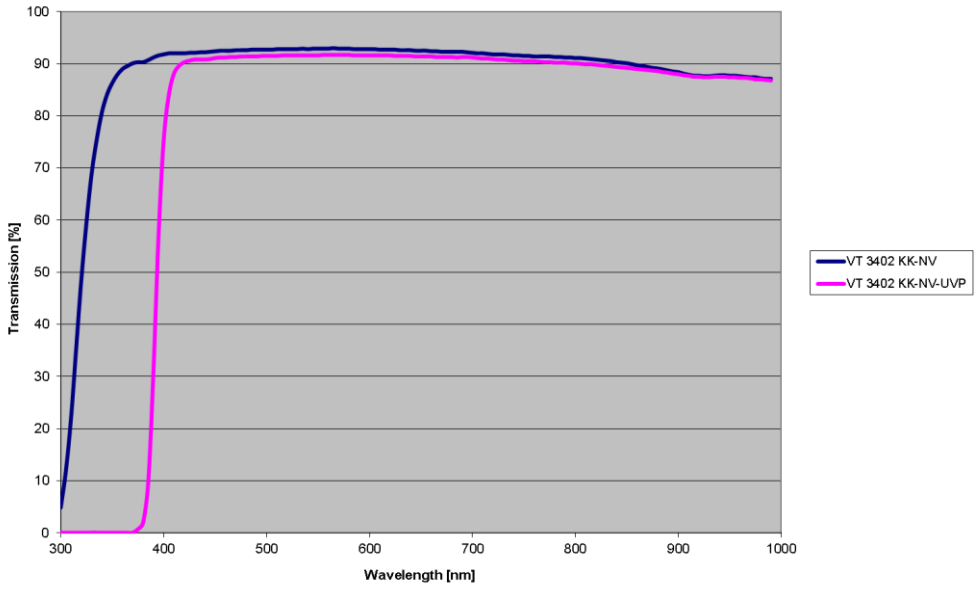
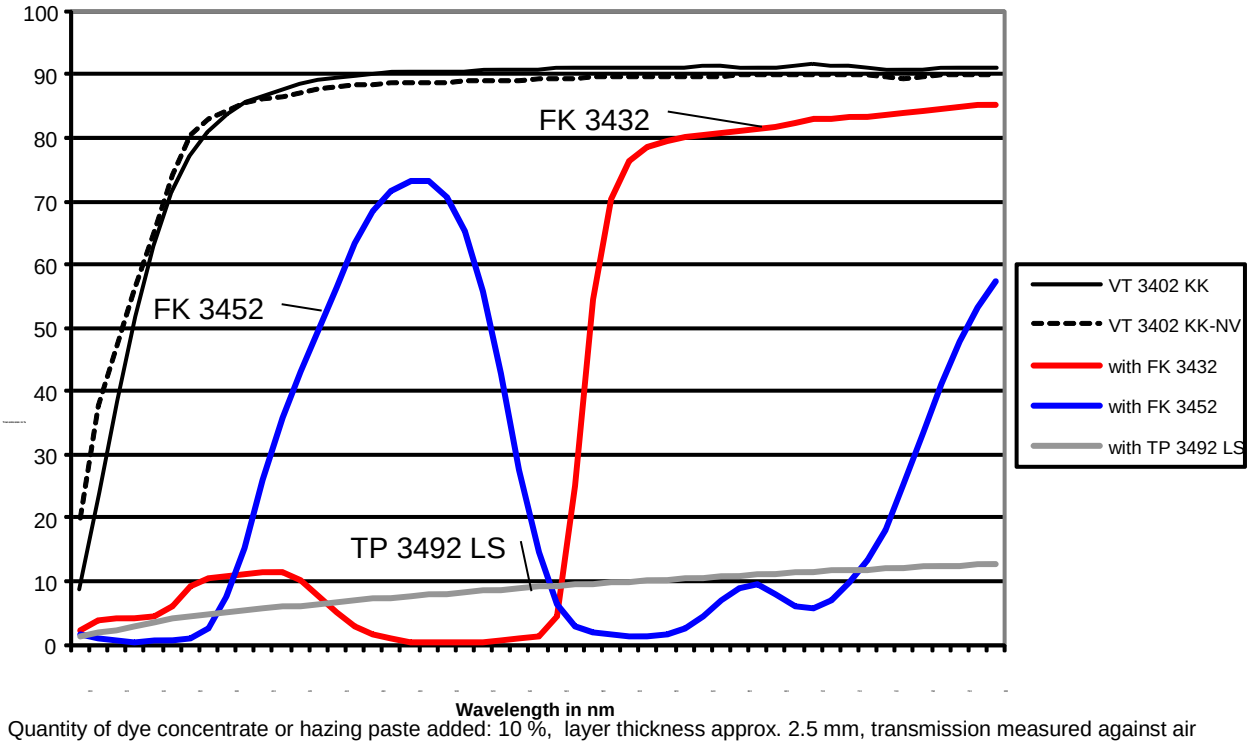


Fig. 11: Comparison of transmission curves: VT 3402 KK-NV-UVP with UV protection reveal no distinct transmission up to approx. 400 µm – UVA radiation is blocked to protect the substrate

Transmission when dye concentrates or hazing paste are used

When a dye concentrate or a hazing paste is added transmission will change (see fig. 12) while the physical and electrical properties remain unchanged.

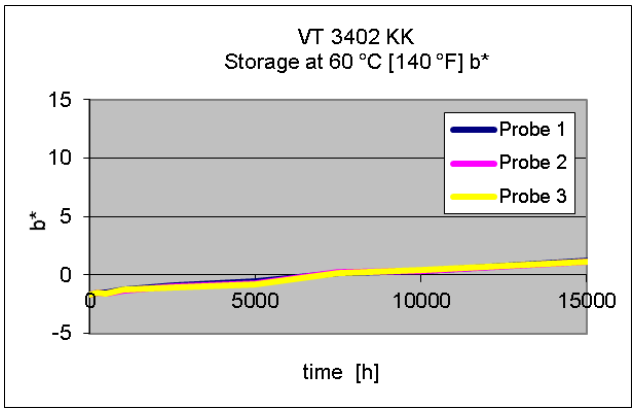


Quantity of dye concentrate or hazing paste added: 10 %, layer thickness approx. 2.5 mm, transmission measured against air

Fig. 12: Transmission of dye concentrates and hazing paste compared to VT 3402 KK and VT 3402 KK-NV

Appendix: Colorimetric evaluation and transmission curves

Wepuran VT 3402 KK



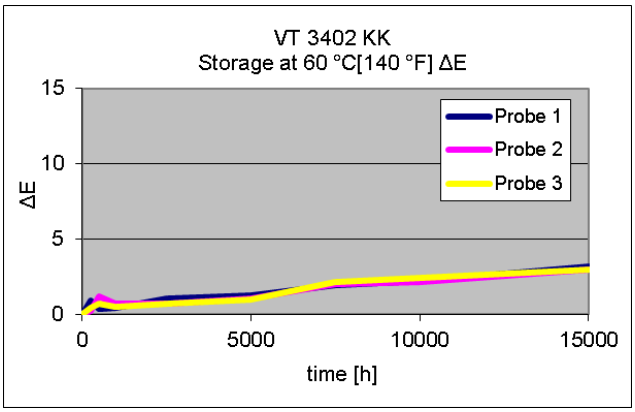
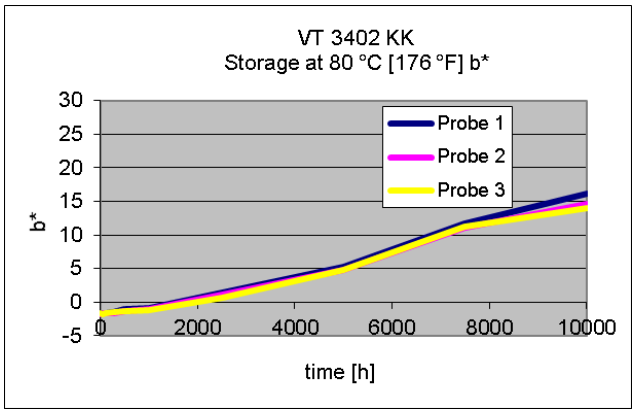


Fig. 13: Colorimetric evaluation VT 3402 KK - Long-term storage at 60 °C [140 °F]



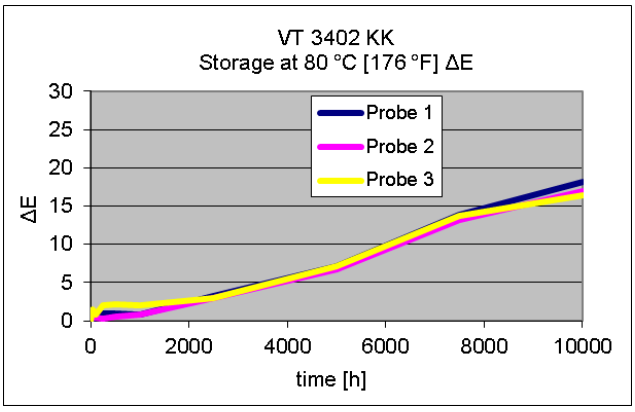
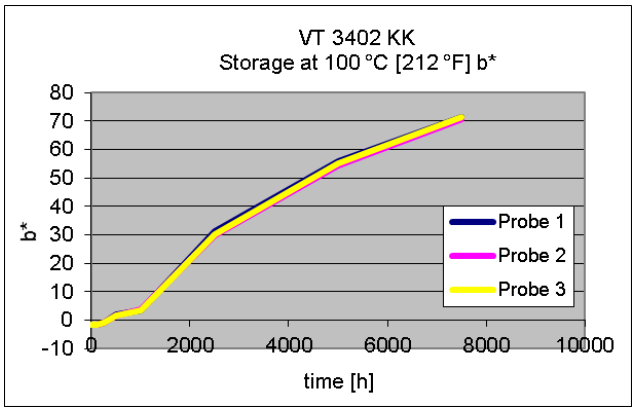


Fig. 14: Colorimetric evaluation VT 3402 KK Long-term storage at 80 °C [176 °F]



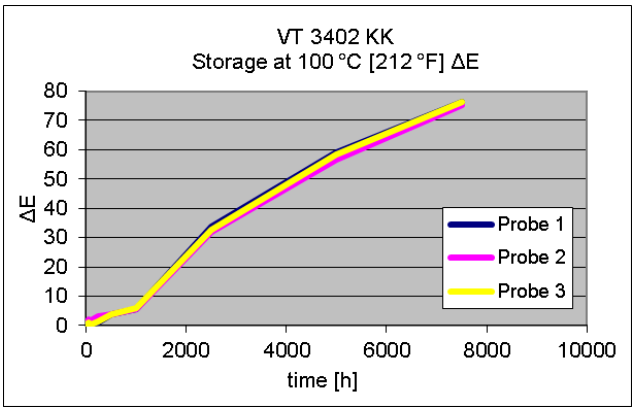


Fig. 15: Colorimetric evaluation VT 3402 KK Long-term storage at 100 °C [212 °F]

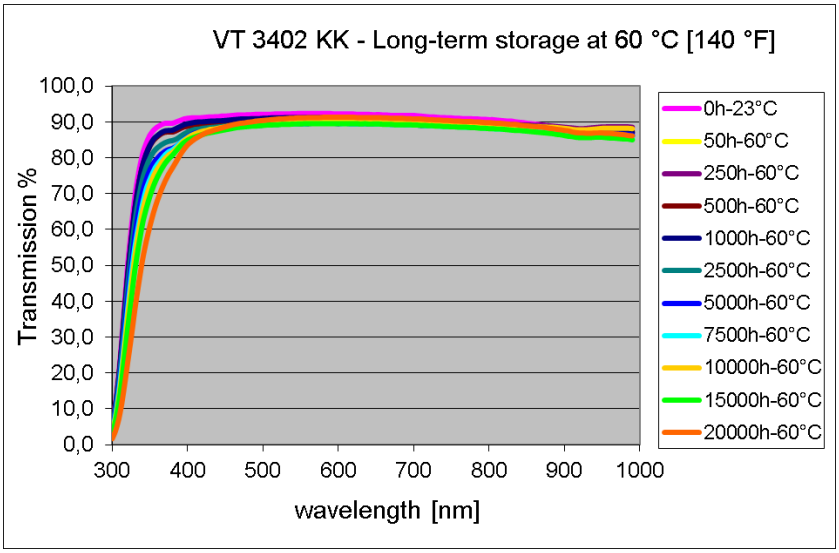


Fig. 16: Transmission VT 3402 KK - Long-term storage at 60 °C [140 °F]

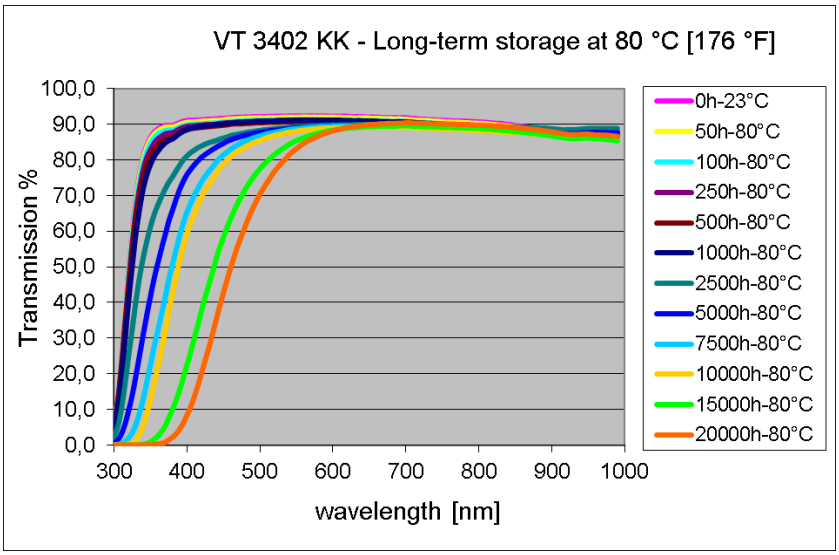


Fig. 17: Transmission VT 3402 KK - Long-term storage at 80 °C [176 °F]

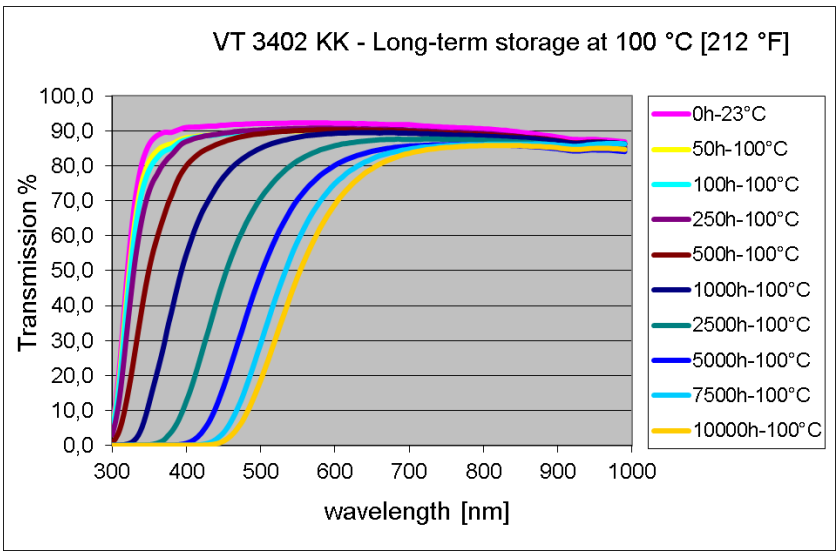
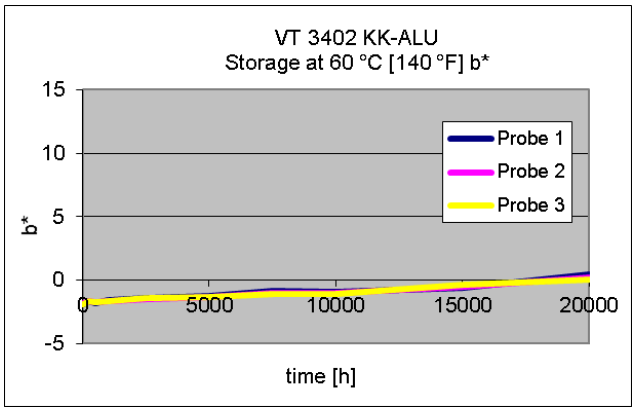


Fig. 18: Transmission VT 3402 KK - Long-term storage at 100 °C [212 °F]

Wepuran VT 3402 KK-ALU



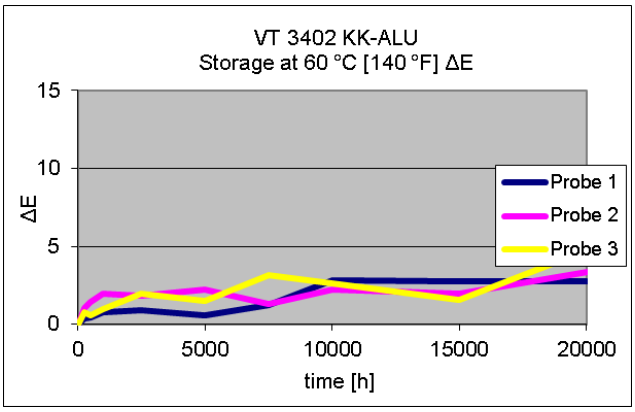
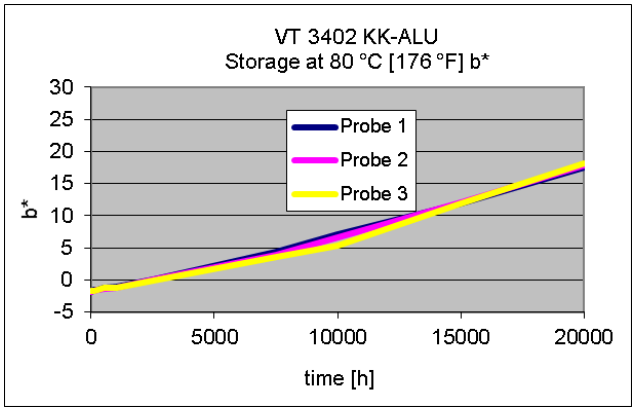


Fig. 19: Colorimetric evaluation VT 3402 KK-ALU - Long-term storage at 60 °C [140 °F]



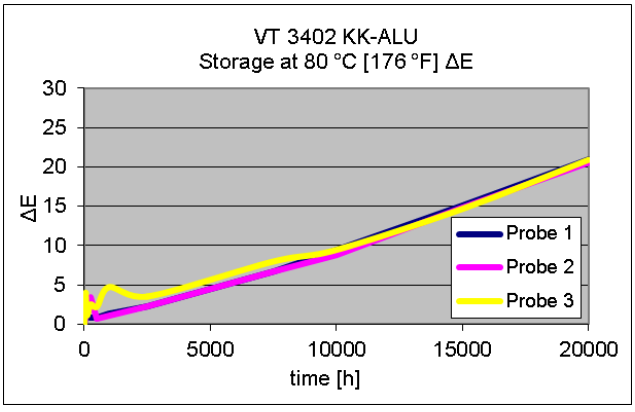
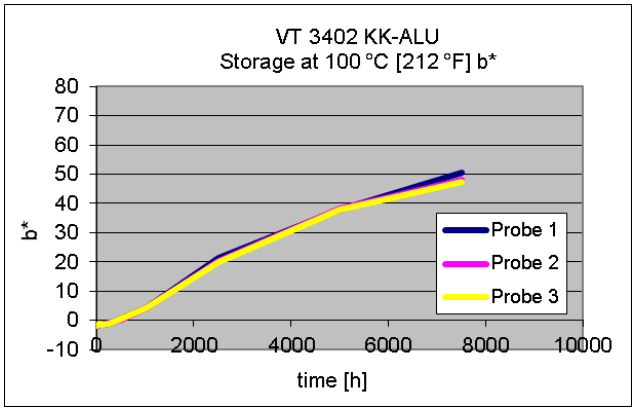


Fig. 20: Colorimetric evaluation VT 3402 KK-ALU - Long-term storage at 80 °C [176 °F]



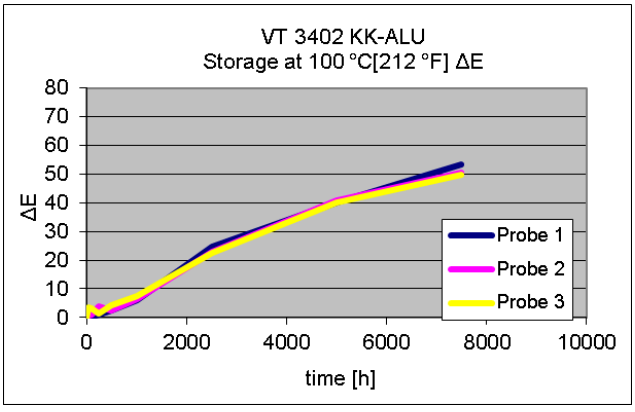


Fig. 21: Colorimetric evaluation VT 3402 KK-ALU - Long-term storage at 100 °C [212 °F]

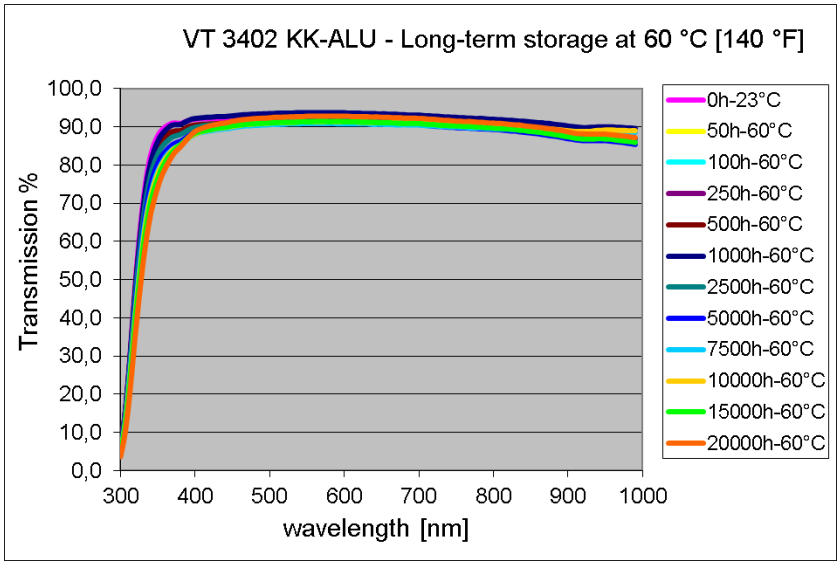


Fig. 22: Transmission VT 3402 KK-ALU - Long-term storage at 60 °C [140 °F]

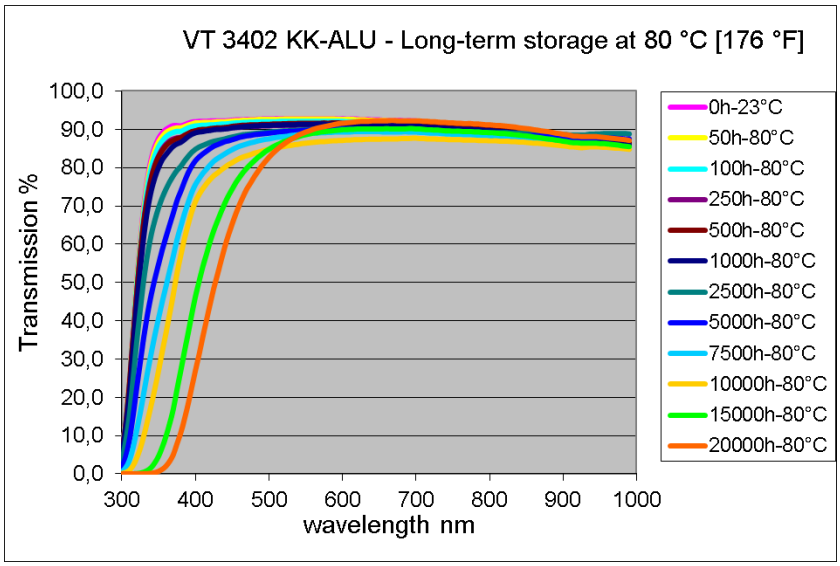


Fig. 23: Transmission VT 3402 KK-ALU - Long-term storage at 80 °C [176 °F]

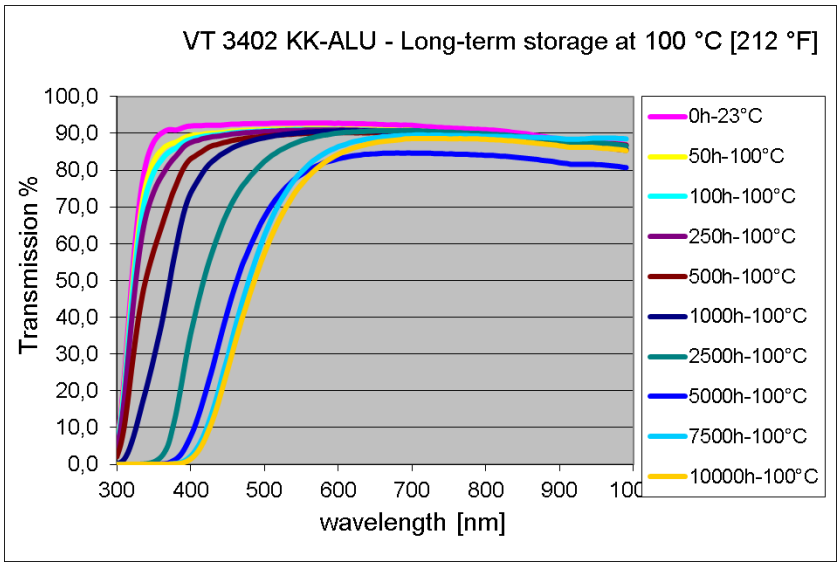
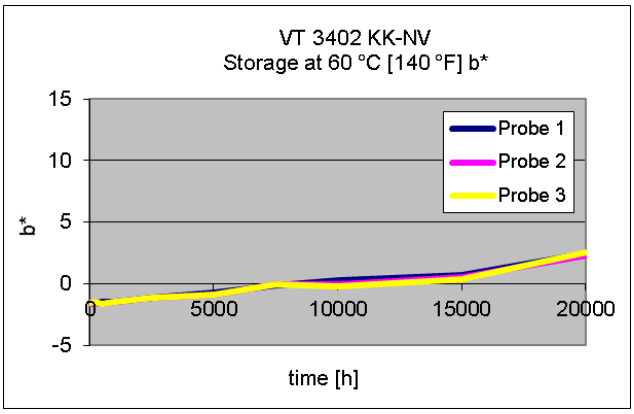


Fig. 24: Transmission VT 3402 KK-ALU - Long-term storage at 100 °C [212 °F]

Wepuran VT 3402 KK-NV / VT 3402 KK-NV-LT



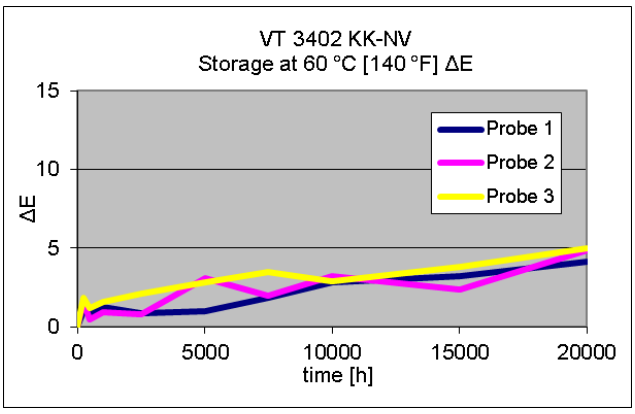
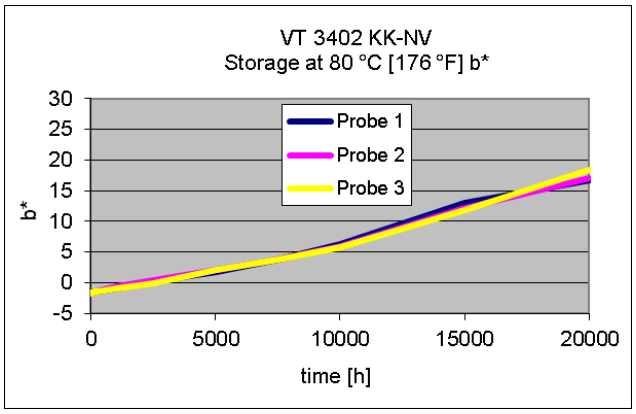


Fig. 25: Colorimetric evaluation VT 3402 KK-NV / VT 3402 KK-NV-LT - Long-term storage at 60 °C [140 °F]



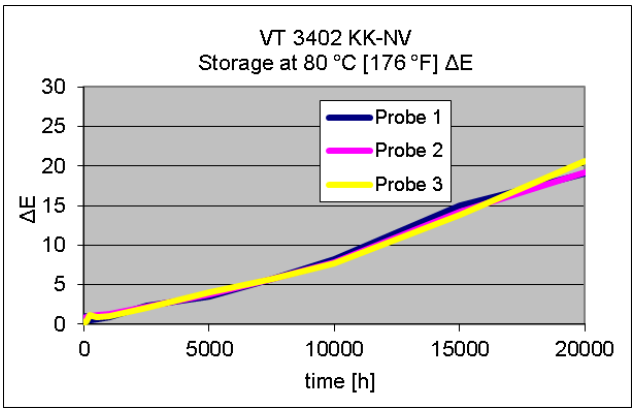
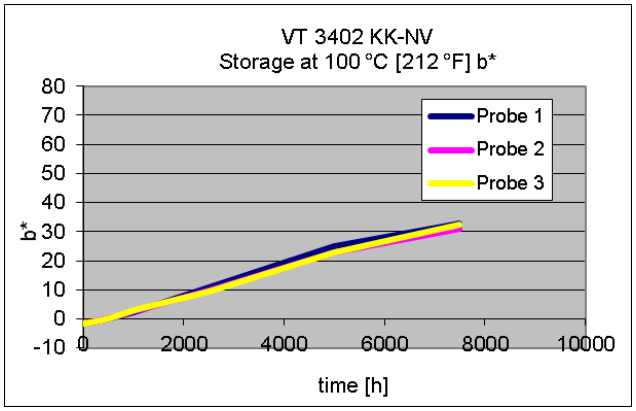


Fig. 26: Colorimetric evaluation VT 3402 KK-NV / VT 3402 KK-NV-LT - Long-term storage at 80 °C [176 °F]



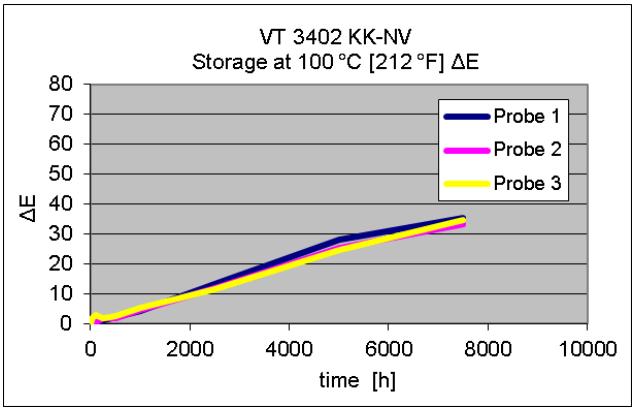


Fig. 27: Colorimetric evaluation VT 3402 KK-NV / VT 3402 KK-NV-LT - Long-term storage at 100 °C [176 °F]

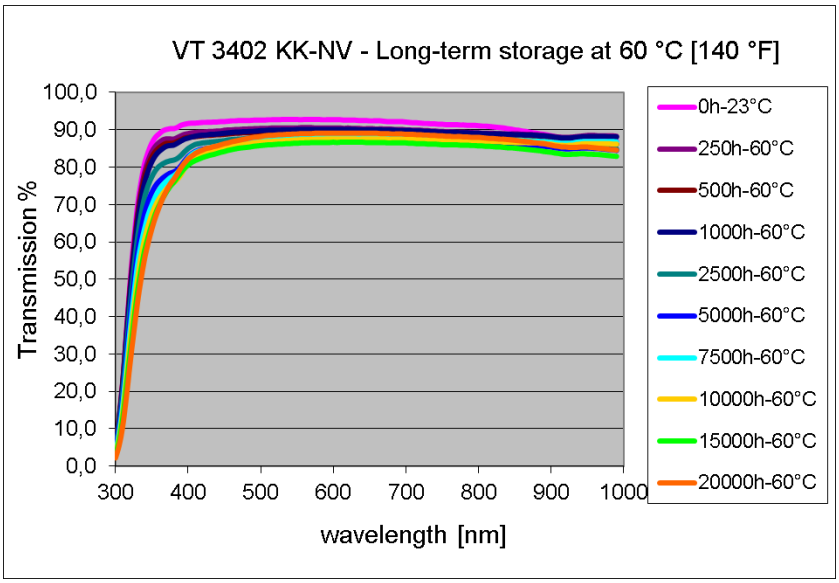


Fig. 28: Transmission VT 3402 KK-NV / VT 3402 KK-NV-LT - Long-term storage at 60 °C [140 °F]

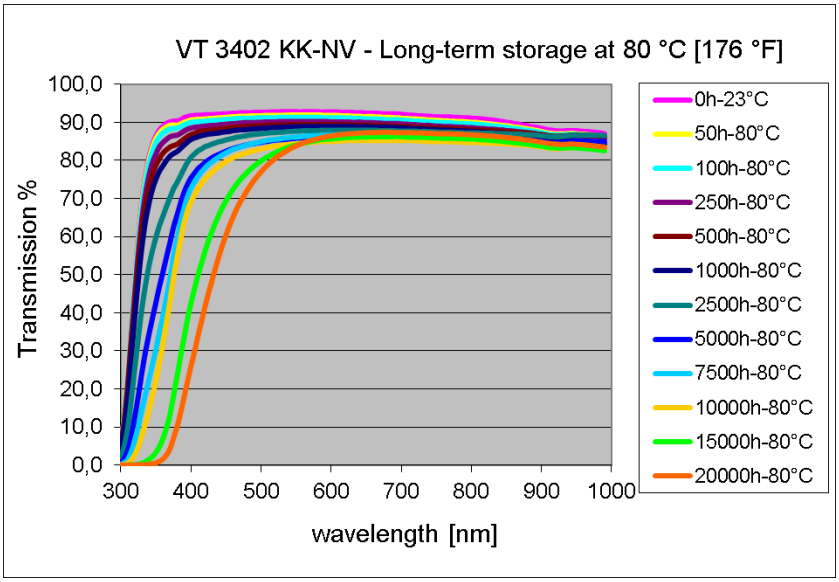


Fig. 29: Transmission VT 3402 KK-NV / VT 3402 KK-NV-LT - Long-term storage at 80 °C [176 °F]

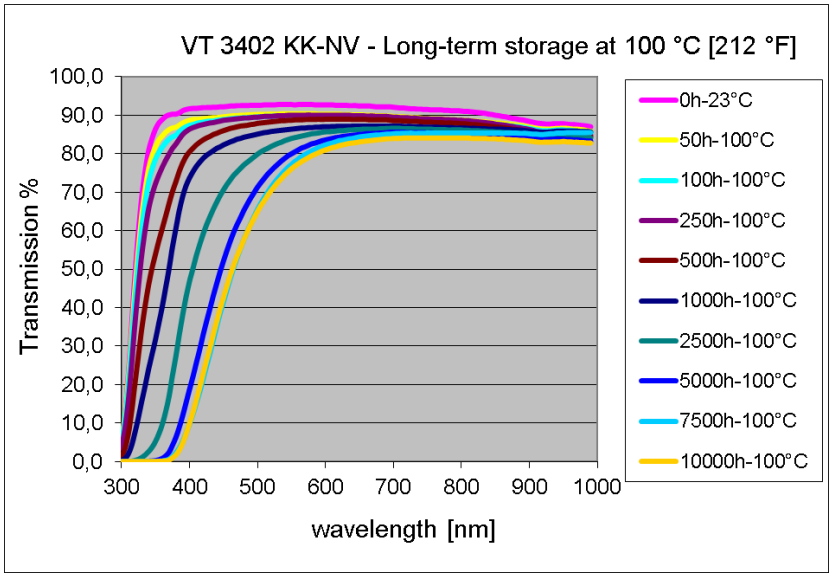
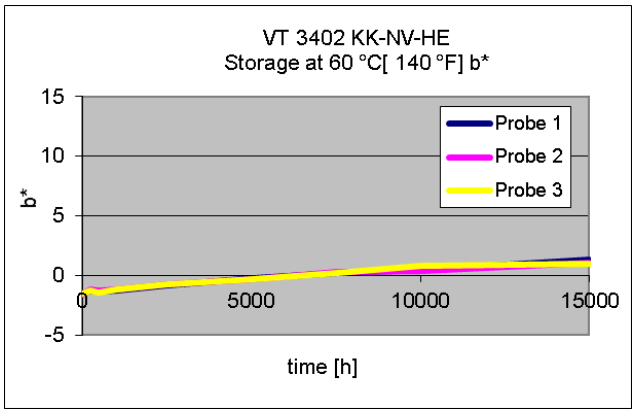


Fig. 30: Transmission VT 3402 KK-NV / VT 3402 KK-NV-LT - Long-term storage at 100 °C [212°F]

Wepuran VT 3402 KK-NV-HE



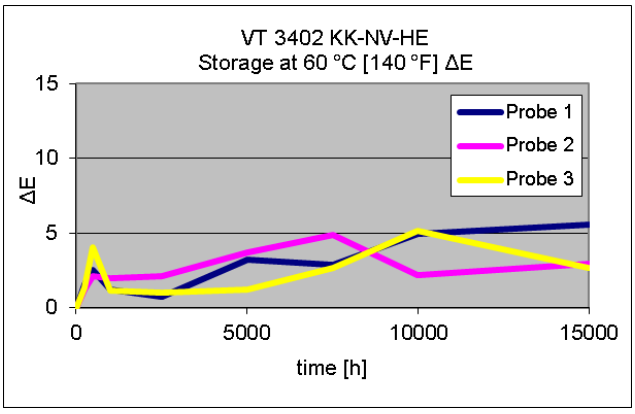
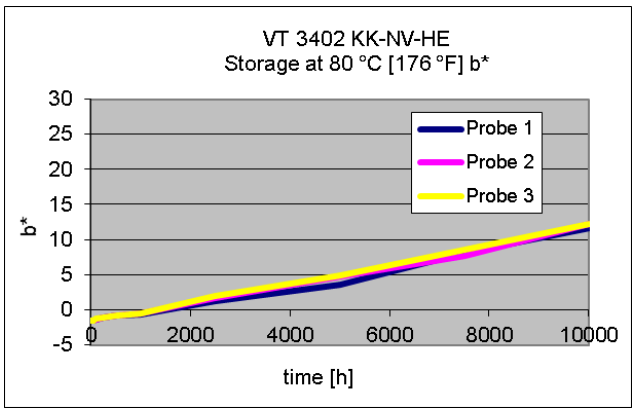


Fig. 31: Colorimetric evaluation VT 3402 KK-NV-HE - Long-term storage at 60 °C [140 °F]



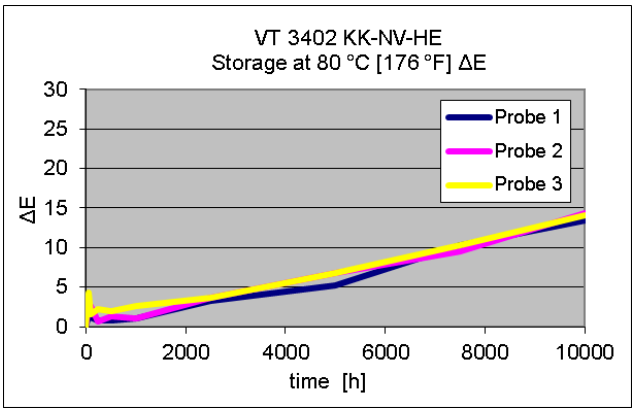
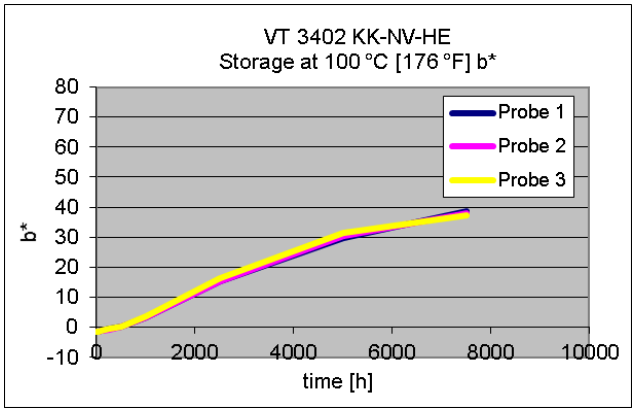


Fig. 32: Colorimetric evaluation VT 3402 KK-NV-HE - Long-term storage at 80 °C [176 °F]



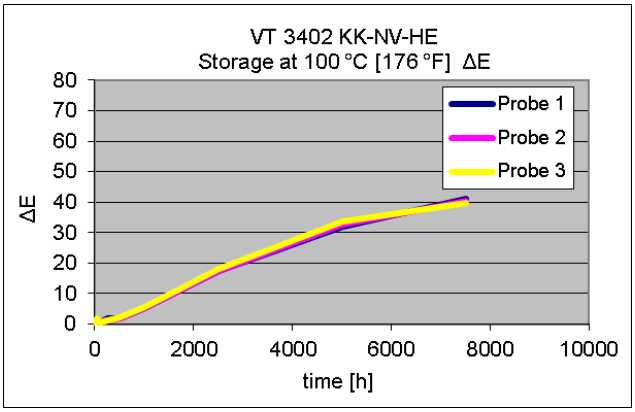


Fig. 33: Colorimetric evaluation VT 3402 KK-NV-HE - Long-term storage at 100 °C [212 °F]

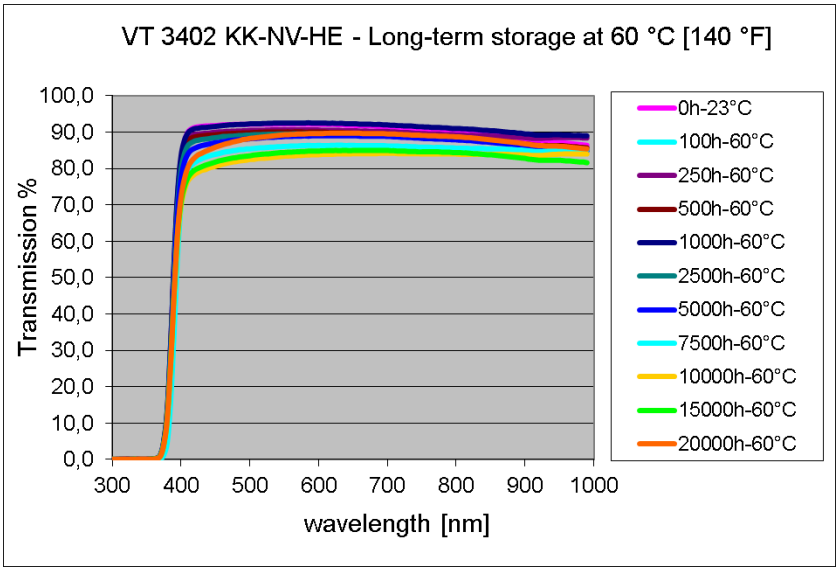


Fig. 34: Transmission VT 3402 KK-NV-HE - Long-term storage at 60 °C [140 °F]

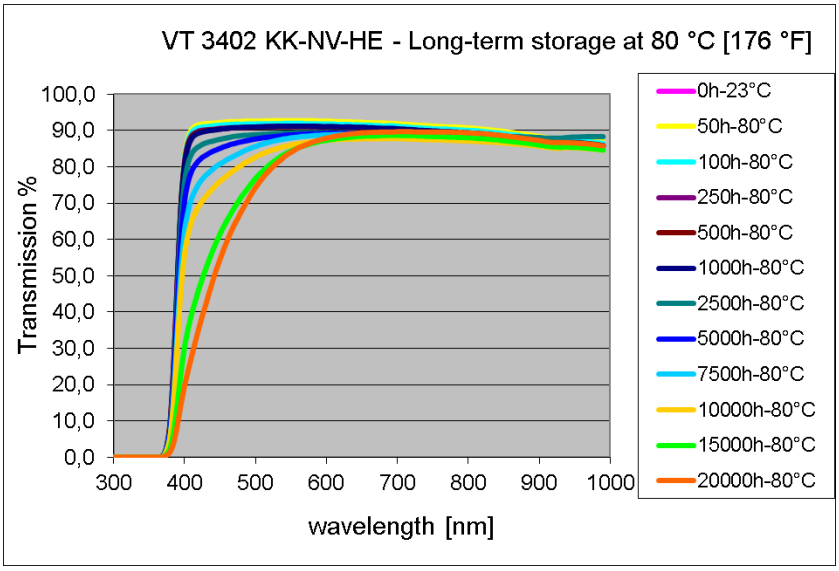


Fig. 35: Transmission VT 3402 KK-NV-HE - Long-term storage at 80 °C [176 °F]

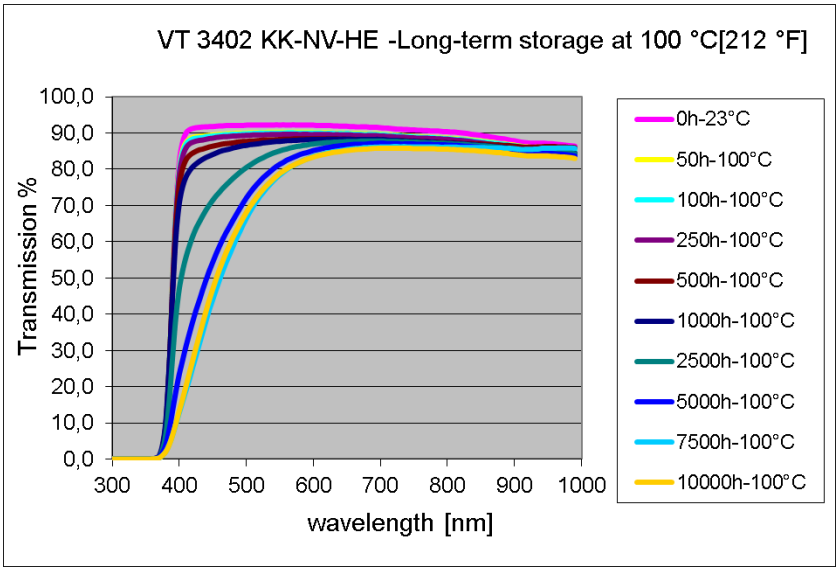
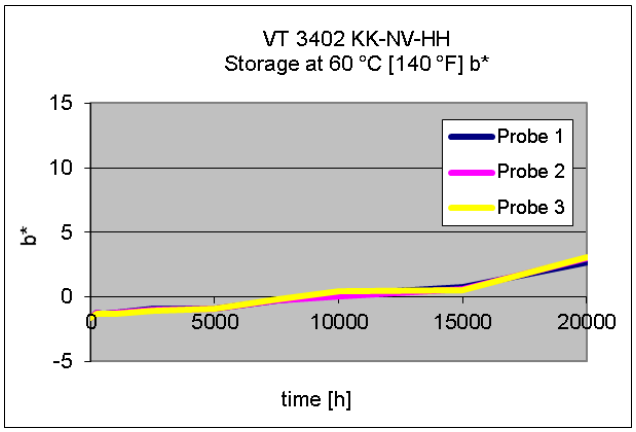


Fig. 36: Transmission VT 3402 KK-NV-HE - Long-term storage at 100 °C [212 °F]

Wepuran VT 3402 KK-NV-HH



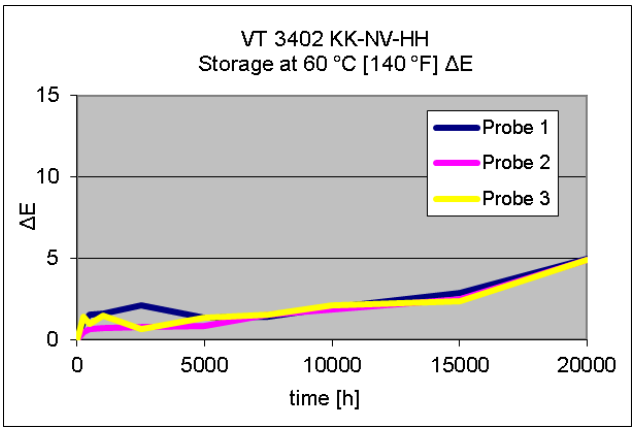
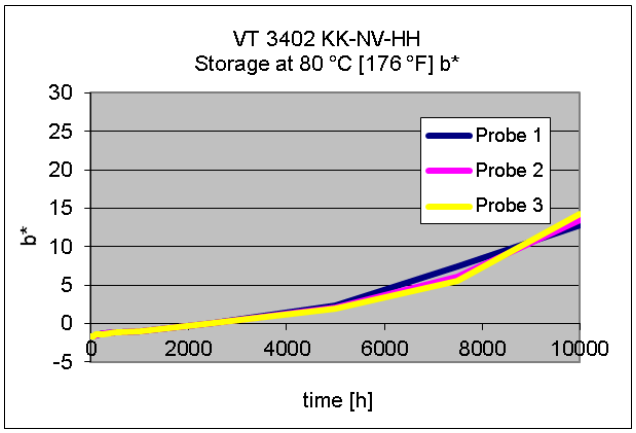


Fig. 37: Colorimetric evaluation VT 3402 KK-NV-HH - Long-term storage at 60 °[140 °F]



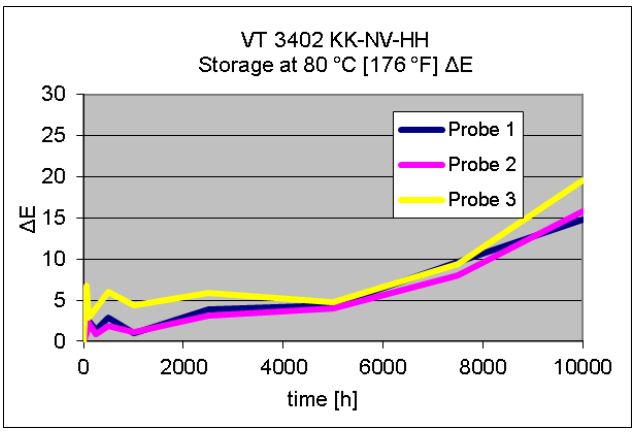
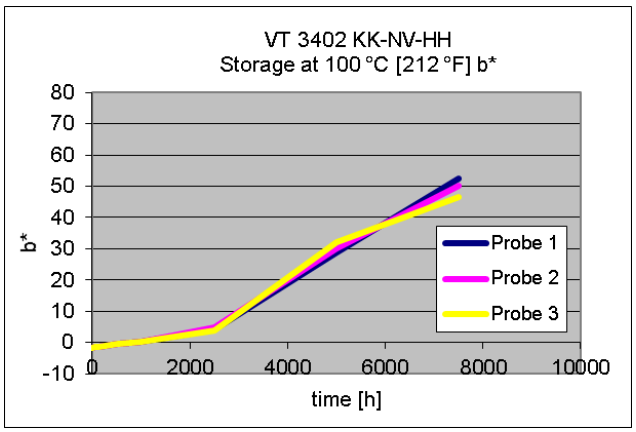


Fig. 38: Colorimetric evaluation VT 3402 KK-NV-HH - Long-term storage at 80 °C [176 °F]



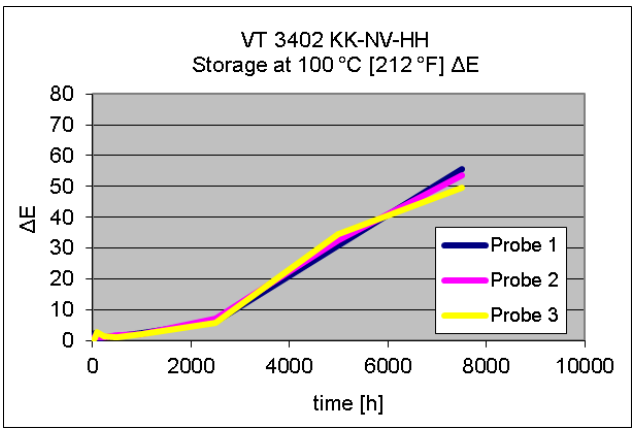


Fig. 39: Colorimetric evaluation VT 3402 KK-NV-HH - Long-term storage at 100 °C [212 °F]

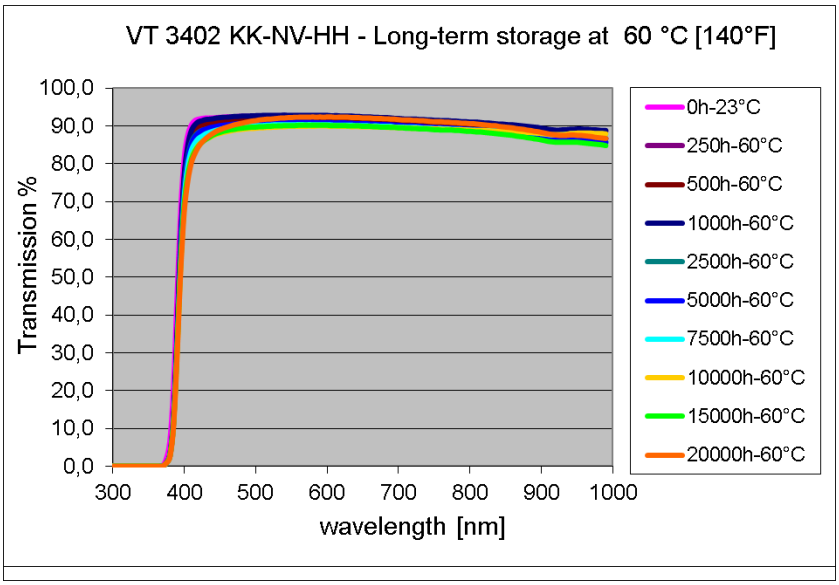


Fig. 40: Transmission VT 3402 KK-NV-HH - Long-term storage at 60 °C [140 °F]

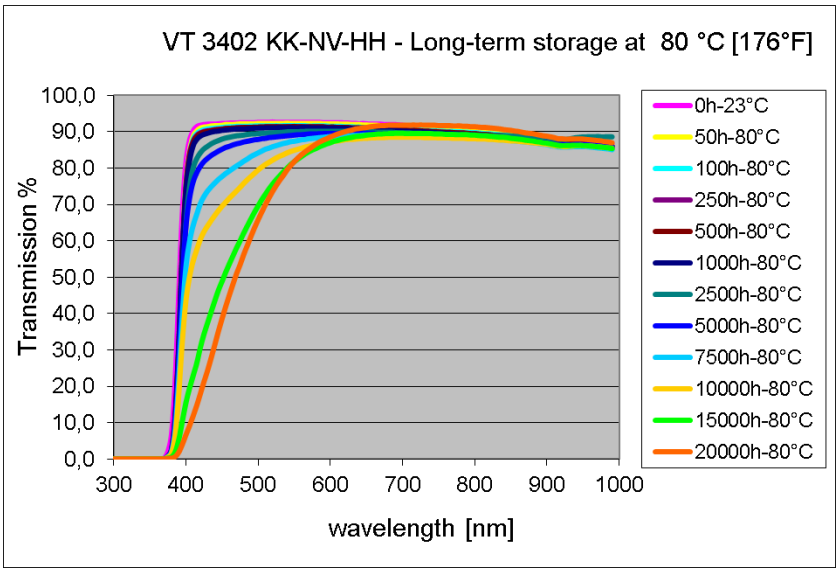


Fig. 41: Transmission VT 3402 KK-NV-HH - Long-term storage at 80 °C [176 °F]

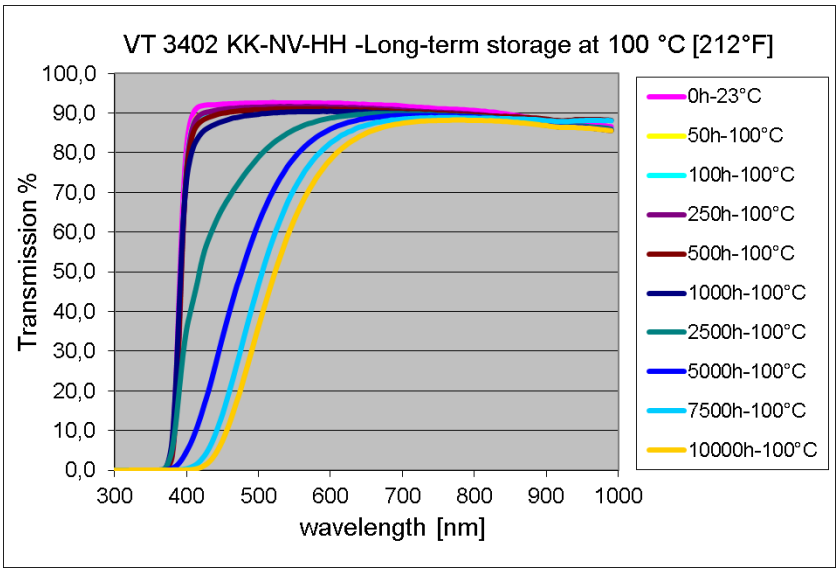
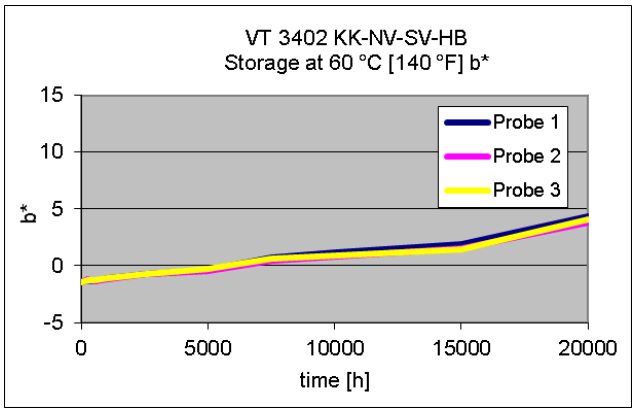


Fig. 42: Transmission VT 3402 KK-NV-HH - Long-term storage at 100 °C [212 °F]

Wepuran VT 3402 KK-NV-SV-HB



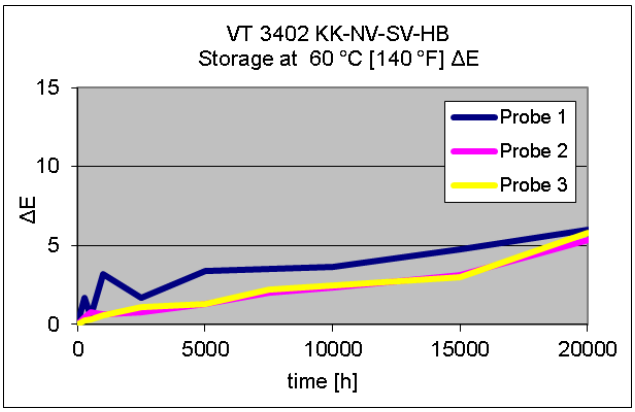
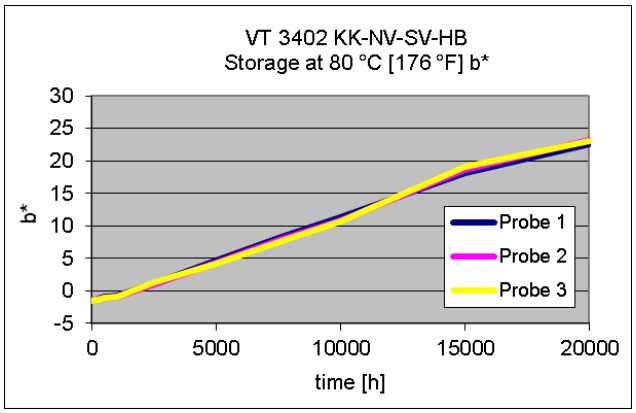


Fig. 43: Colorimetric evaluation VT 3402 KK-NV-SV-HB - Long-term storage at 60 °C [140 °F]



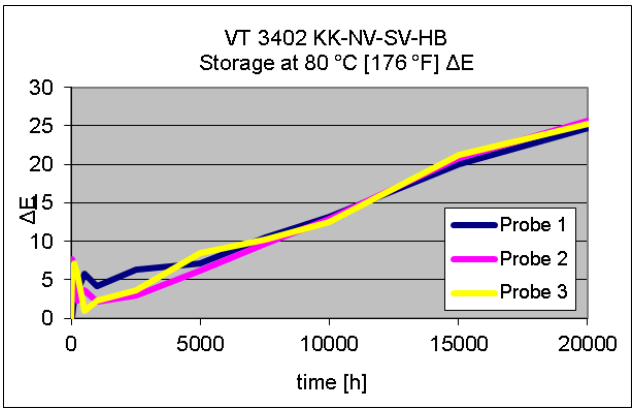
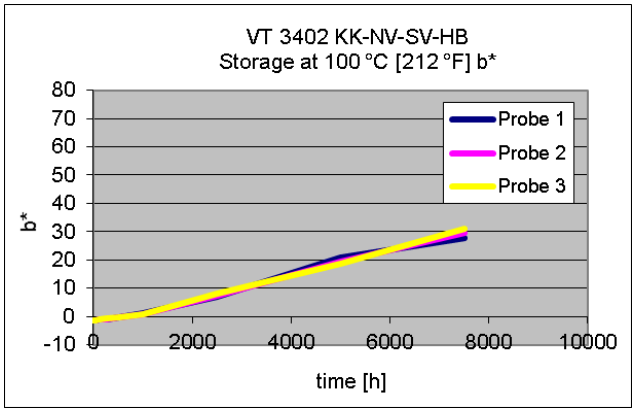


Fig. 44: Colorimetric evaluation VT 3402 KK-NV-SV-HB - Long-term storage at 80 °C [176 °C]



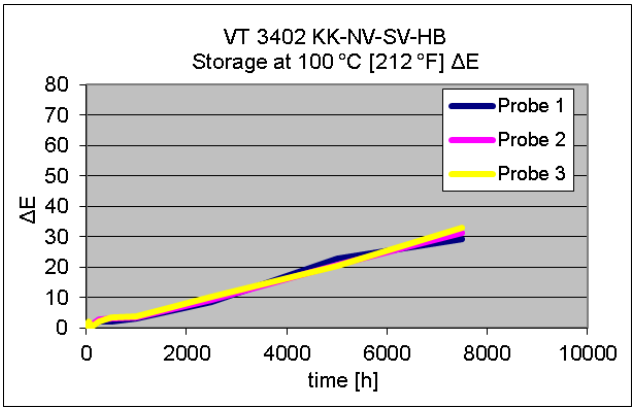


Fig. 45: Colorimetric evaluation VT 3402 KK-NV-SV-HB - Long-term storage at 100 °C [212 °F]

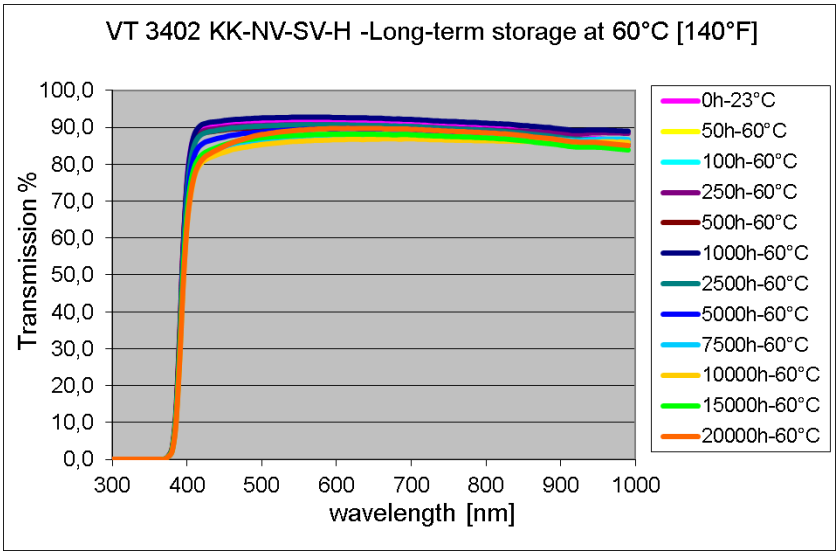


Fig. 46: Transmission VT 3402 KK-NV-SV-HB - Long-term storage at 60 °C [140 °F]

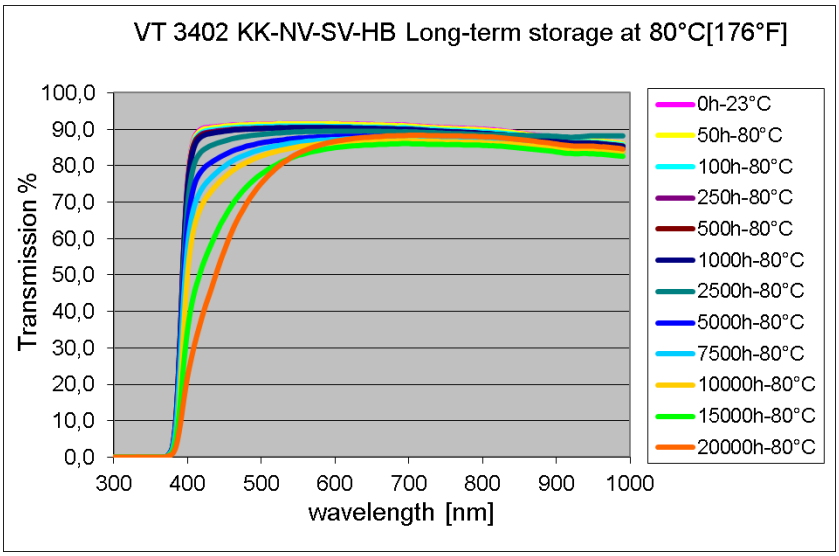


Fig. 47: Transmission VT 3402 KK-NV-SV-HB - Long-term storage at 80 °C [176 °F]

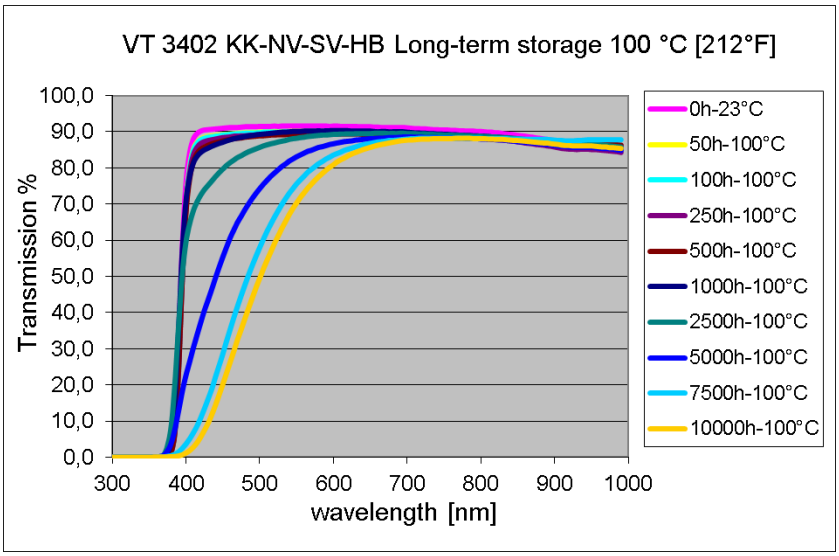
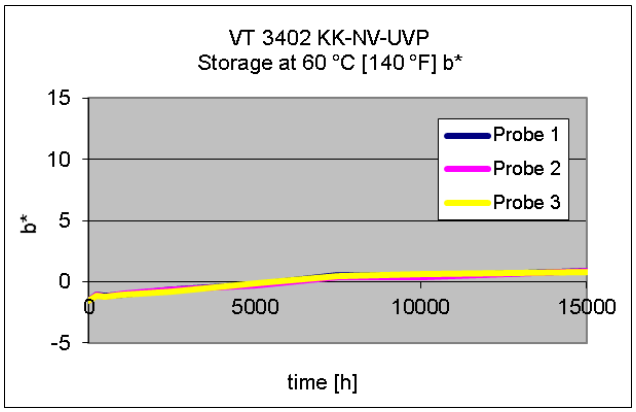


Fig. 48: Transmission VT 3402 KK-NV-SV-HB - Long-term storage at 100 °C [212 °C]

Wepuran VT 3402 KK-NV-UVP



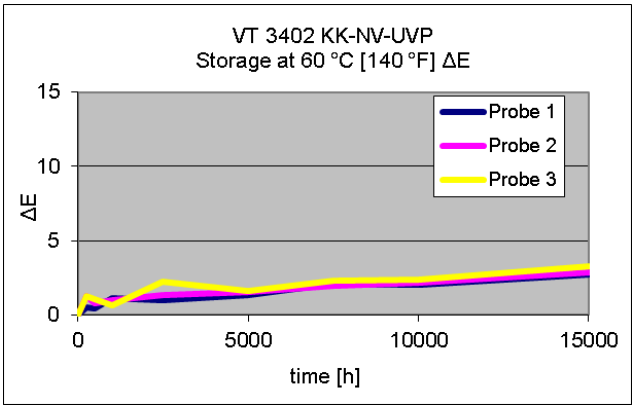
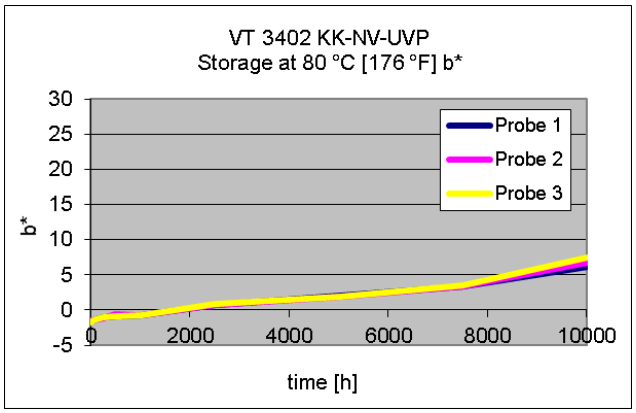


Fig. 49: Colorimetric evaluation VT 3402 KK-NV-UVP - Long-term storage at 60 °C [140 °F]



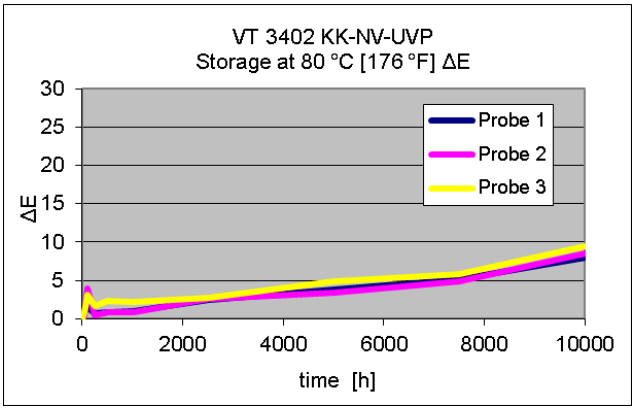
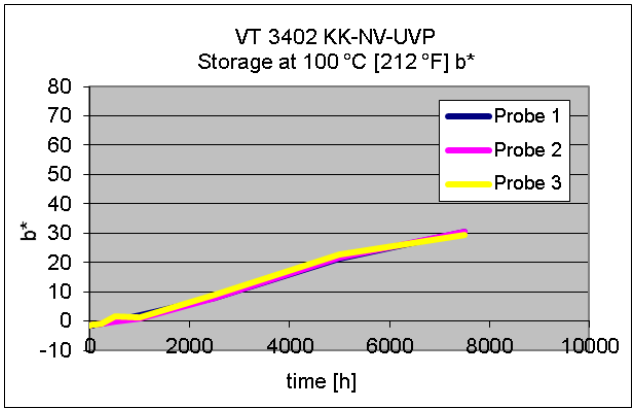


Fig. 50: Colorimetric evaluation VT 3402 KK-NV-UVP - Long-term storage at 80 °C [176 °F]



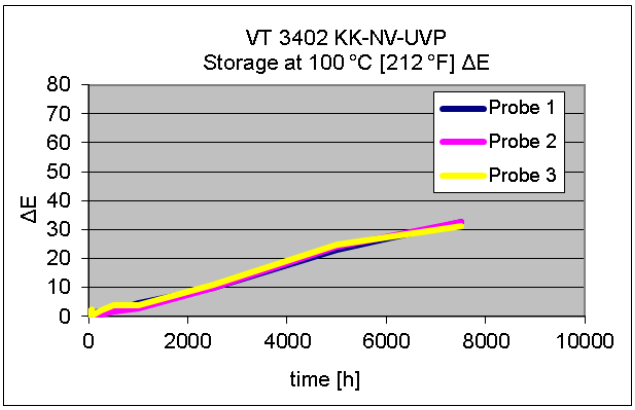


Fig. 51: Colorimetric evaluation VT 3402 KK-NV-UVP - Long-term storage at 100 °C [212 °F]

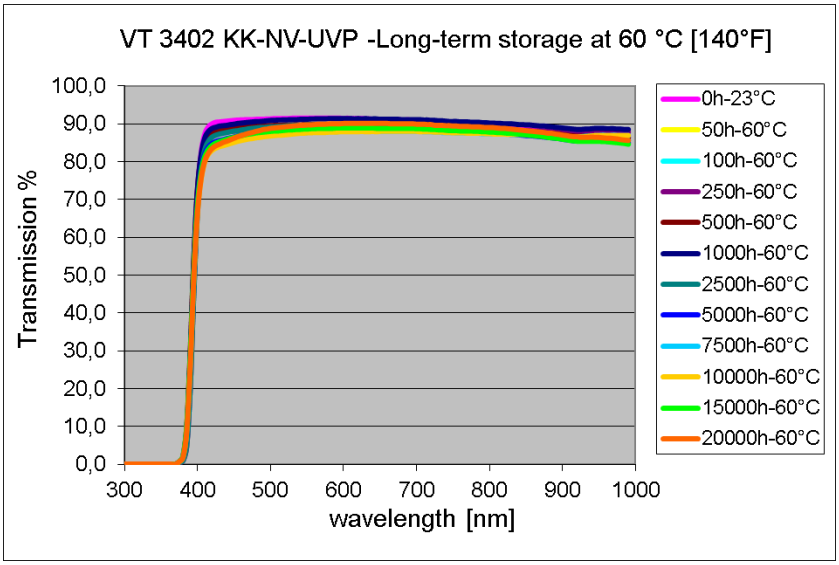


Fig. 52: Transmission VT 3402 KK-NV-UVP - Long-term storage at 60 °C [140 °F]

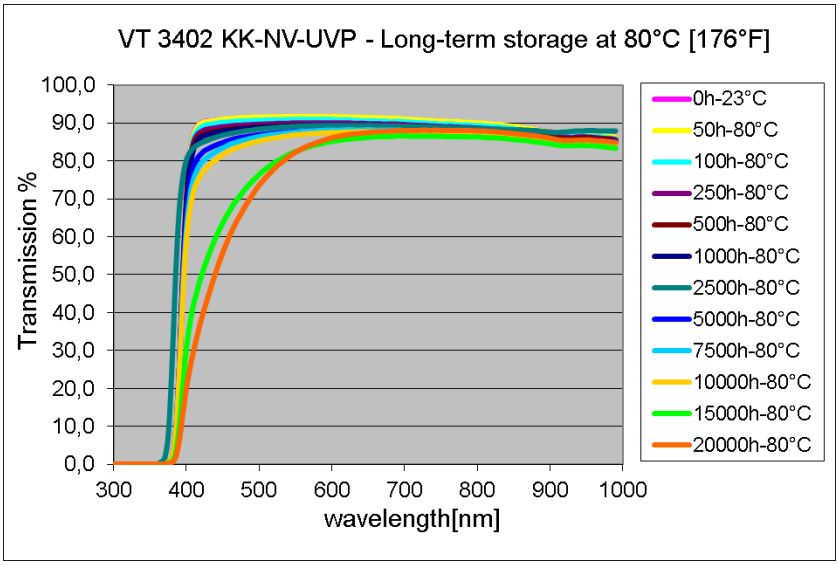


Fig. 53: Transmission VT 3402 KK-NV-UVP - Long-term storage at 80 °C [176 °F]

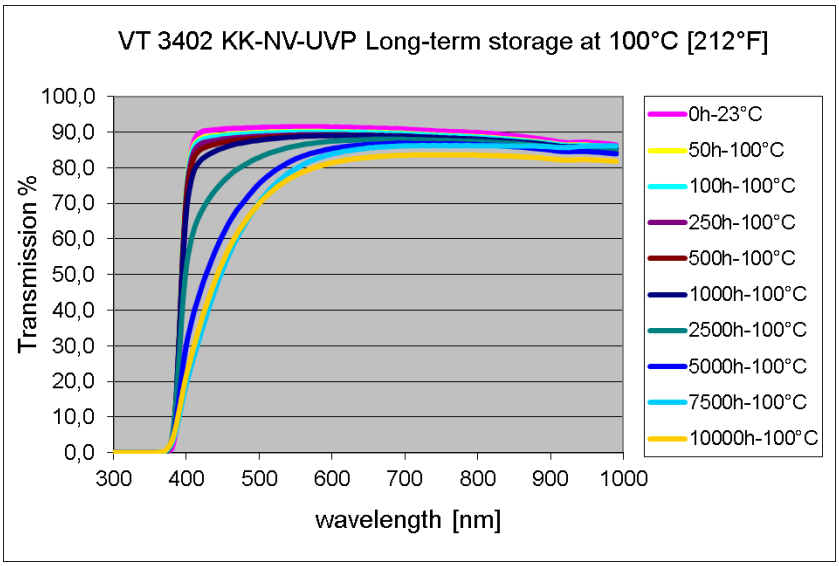
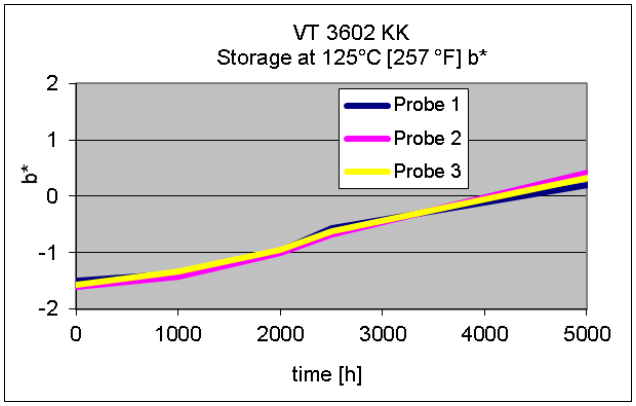


Fig. 54: Transmission VT 3402 KK-NV-UVP - Long-term storage at 100 °C [212 °F]

Wepesil VT 3602 KK



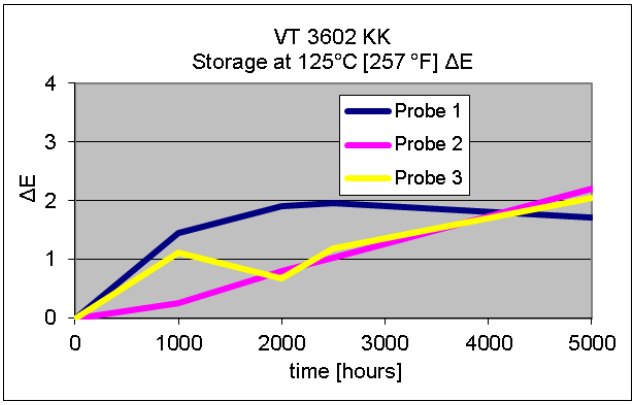
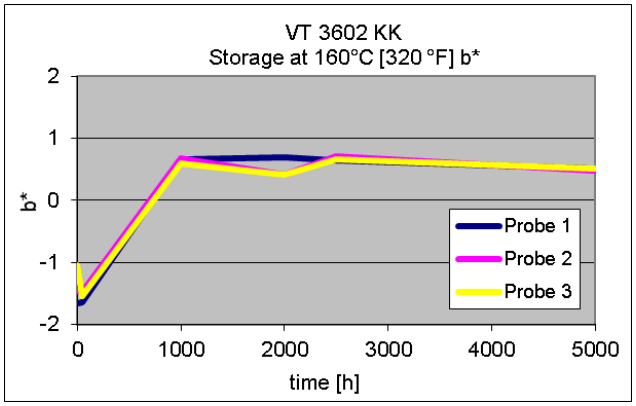


Fig. 55: Colorimetric evaluation VT 3602 KK - Long-term storage at 125 °C [257 °F]



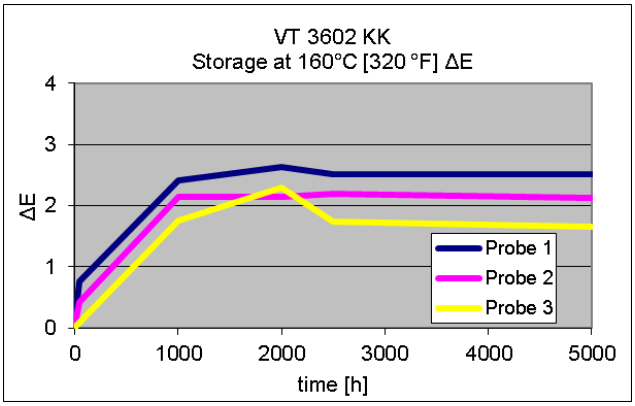
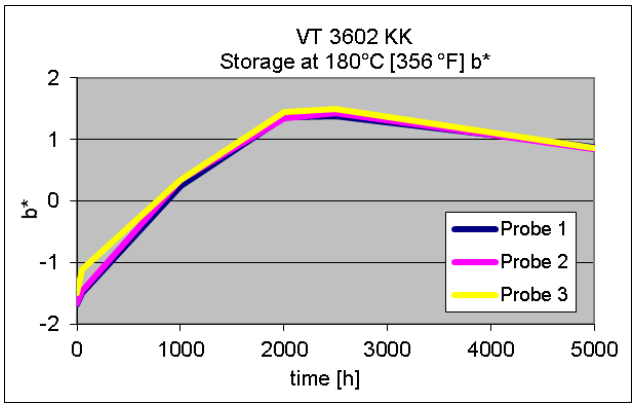


Fig. 56: Colorimetric evaluation VT 3602 KK - Long-term storage at 160 °C [320 °F]



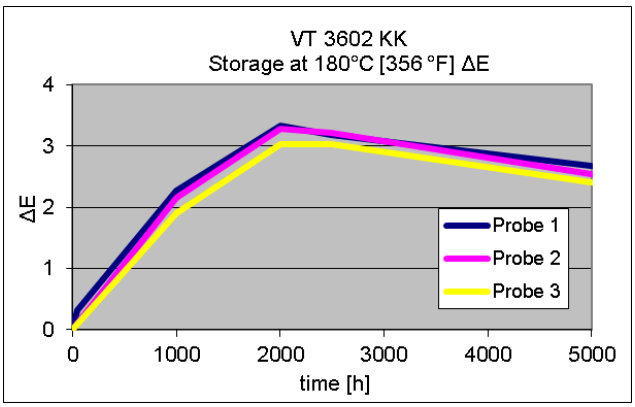


Fig. 57: Colorimetric evaluation VT 3602 KK - Long-term storage at 180 °C [356 °F]

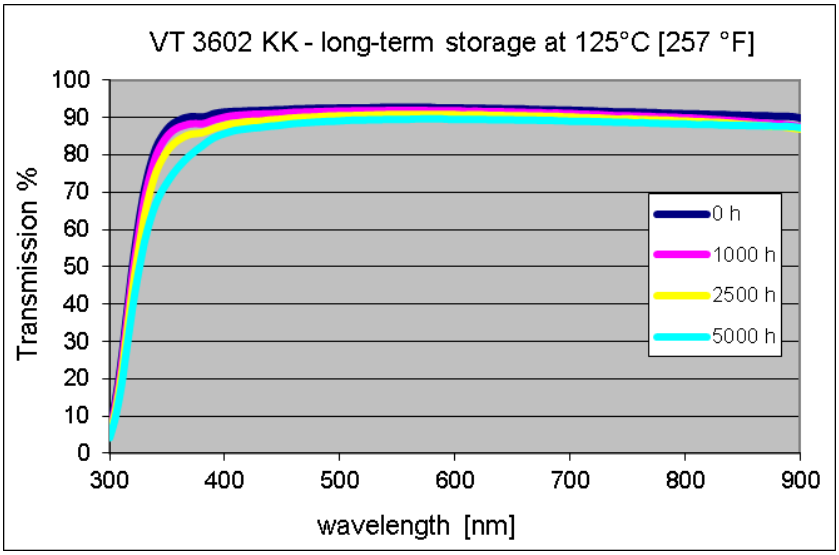


Fig. 58: Transmission VT 3602 KK -Long-term storage at 125 °C [257 °F]

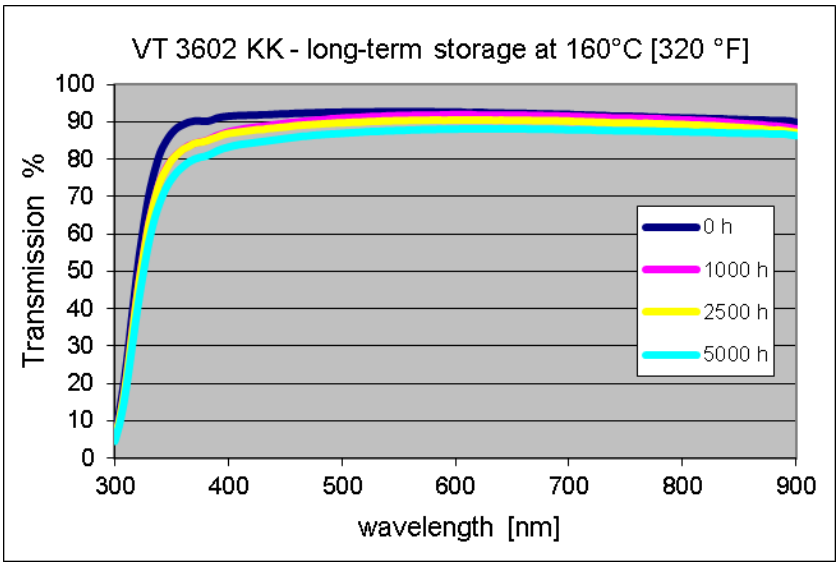


Fig. 59: Transmission VT 3602 KK - Long-term storage at 160 °C [320 °F]

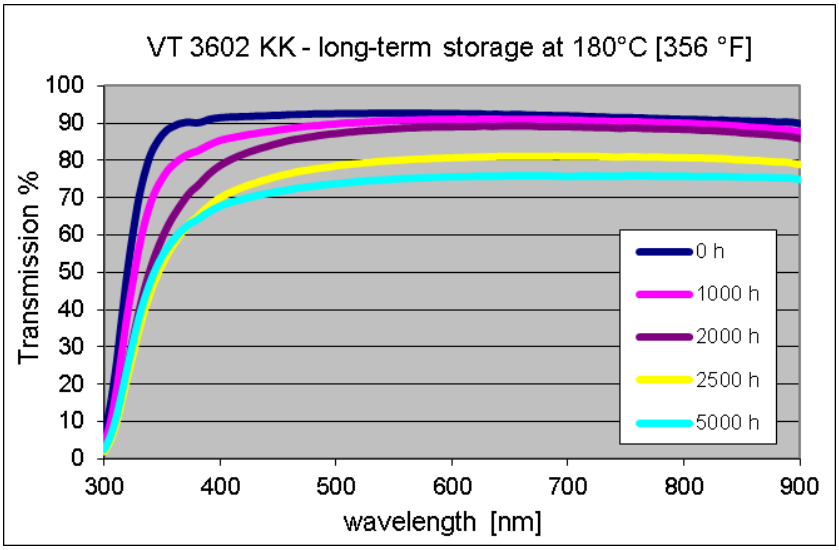


Fig. 60: Transmission VT 3602 KK - Long-term storage at 180 °C [356 °F]

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