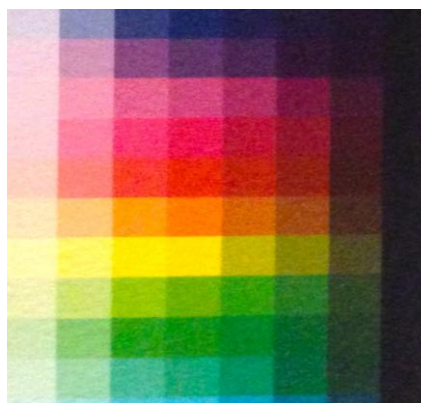


The fading of IRIS prints

A Study in Fading IRIS Prints, reaction and solution.



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Uppsats för avläggande av filosofie kandidatexamen i

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The Fading of IRIS Prints

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ABSTRACT

During early 1990's the inkjet IRIS printing technique was one of the first digital printing techniques used by artists for fine art printing. The technique was initially developed in the mid 1980's, to do pre proof printing. It soon became clear that, though the technique had many aesthetic qualities, it also had poor qualities when it came to stability. It lacked light fastness and was very sensitive to high relative humidity levels (RH) and changes in RH. Research and testing of digital printing techniques have always been done, but for the most part, only to develop new, qualitative and cost effective techniques for the industry.

Poor lightning policies can have immense impact on all art prone to fading. The IRIS prints have shown to fade more than other digital printing techniques and since the printers are no longer in common use, all IRIS prints can be viewed as originals. Many IRIS prints are also printed on different fine art paper and with different ink-sets i.e. all IRIS prints are different.

This thesis will conduct MFT (micro fading testing) of IRIS prints and inkjet model materials. Some results pointed to the fading of a newly produced print to a higher extent than when solvents had evaporated several days later. The results of the conducted tests show that all IRIS prints will fade but to a different extent, due to different qualities of the prints. This study can be used to shed some light on what an IRIS print actually requires when it comes to preventive conservation.

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Martin later became a frequent lecturer during the following years, and when it was time to apply for my internship there was no question where I wanted to go. So Martin, thank you, for many inspirational lectures and for introducing me to the much complex world of preservation of digital prints. You are a great teacher and person, and I have the utmost respect for you.

Thank you to the institute in conservation at the University of Gothenburg. The immense inspiration that I have been given by my fellow students and lecturers have been the fuel to my continually growing interest and dedication to the conservation field. I would especially like to thank the four friends studying paper conservation with me. These three years would not have been the same without you, so thank you Anna, Jenna, Lotta and Fanny.

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Table of contents

1 Introduction	12
1.1 Background.....	12
1.2 Presentation of Context.....	12
1.3 Definition of Problem.....	13
1.4 Issues	13
1.5 Purpose and Aim	13
1.6 Restrictions.....	13
2 The IRIS prints.....	14
2.1 Printing history.....	14
2.2 IRIS printing technique	15
2.3 Nash Editions and artists	16
3 Fading.....	18
3.1 Probable fading causes.....	18
3.2 Simultaneous contrast.....	18
3.3 Ethical issues	19
3.4 Previous studies in the field.....	19
4 Methods and Materials	22
4.1 The MFT Method.....	22
4.2 Tests.....	23
4.3 Materials.....	24
4.3.1 The model materials.....	24
4.3.2 The IRIS reference	25
4.3.3 The original	27
5 Results.....	28
5.1 The model material	28
5.2 The IRIS reference	30
5.3 The Original	31
6 Discussion	34
7 Conclusion.....	35
8 Summary	36
9 Sammanfattning (Summary in Swedish).....	37
References.....	39
Printed:	39

Online:	39
Images:	41
Appendix	42

1 Introduction

1.1 Background

The bachelor conservation program at the University of Gothenburg includes a semester of internship. During a part of this internship I spent approximately seven weeks at the Hasselblad foundation. Their collection contains about 3000 different photographic objects produced in various techniques. Since the Hasselblad Foundation was founded in 1979 their collection has grown considerably. The contemporary photographs collected recent years are for the most part produced by digital printing techniques.

During my internship I got the opportunity to go through more than 75% of their registered collection. Viewing each of the photographs in the storage, bettering some of the placements, mounting and following up with complementary information in their database.

At one point I came across an IRIS print from 1996 by photographer Ritva Kovalainen. During a lecture on digital printing that I attended, the many difficulties of preserving these prints and how sensitive the prints are were discussed. When Kovalainen's print was viewed there seemed to be a difference from the reference image in the database. The Hasselblad conservator Cecilia Sandblom agreed that it seemed as if the colour had faded. Sandblom stated that the print probably hadn't been displayed.

This finding made me want to look closer into the IRIS prints and the fading that might lead to the IRIS prints being excluded for display in recent decades.

1.2 Presentation of Context

During the mid 1980s a new dye-based, continuous-flow, ink-jet printing technique (IRIS prints) was developed primarily for use as a preprint proof process to be used before the material went to press. For instance, it was used as a prepress model for magazines and labels for commercial products (Nash Editions. 2011.p. *About us*). IRIS prints were further developed and refined to be used in fine art printing from the early 1990's (Jürgens. M 2009. p.72). The visual appearance of the print on porous fine art paper became very popular during the 1990's and many objects produced by this process can be found in museum collections throughout the world.

Because the IRIS printing technique was first developed to produce materials with a very short intended lifetime, i.e. pre-print proofs, only the colour rendering properties, and not the long-term stability and light fastness, of the liquid dye-based inks of early IRIS prints was considered. However, it was the colour rendering properties of the technique, which made the printing process so attractive to artists (Wilhelm H. 2007.p. 119).

IRIS prints from the 1990's have been found to be very sensitive to humidity and water, however, prints that have been kept in relatively optimum RH-levels have still shown a loss in colour indicating that another degradation process is active. Display related damage, i.e. colour change, indicates that IRIS prints are also likely sensitive to light.

There are two key factors to be kept in mind with regard to this observed colour change of IRIS prints in museum collections. In addition to the inherent light fastness of the inks used in the printing processes, the display lighting policies, light dose (Lux hours/year) and spectral power distribution (i.e. UV content which is dependent upon light source and filtering), are often unknown from the display period, and the past lighting and display policies might not be compliant with current standards and recommendations.

1.3 Definition of Problem

Previous studies show that IRIS prints are very light sensitive, and display of IRIS prints will result in damage (defined as colour change). Can a display lighting policy be developed to minimize the risk to the objects while still allowing access through display?

1.4 Issues

There are several questions that can be raised.

Which ink is most light sensitive? Are inks in admixture more light sensitive than single dyes? Is it the dyes in the inks, that is directly degrading, or might it be some other additives reacting with the dyes in the ink?

What is the colour change process? What is the shape of the curve resulting from the colour change function? Does the colour change occur only during light exposure, after exposure or a combination of the two? Is the colour change reaction dependent on light only (photolysis or excited state decomposition) or is a reduction/oxidative reaction occurring?

1.5 Purpose and Aim

This thesis will examine factors relating to the light fastness and colour change of IRIS prints from the 1990's. The results will hopefully be the basis for a preventive solution to the problem of keeping and displaying IRIS prints in the future.

1.6 Restrictions

There are many factors that can influence light fastness and colour change. Differences and changes in ink formulations used for IRIS prints will not be addressed. Rather a micro-fading testing method will be developed and validated to directly assess the light fastness of IRIS prints in a gallery/museum setting. The paper on which the IRIS prints are printed will be viewed and discussed, only with regard to the information given from the paper manufacturer, but there will not be any further studies made concerning the paper due to the restriction in time for this thesis.

2 The IRIS Prints

2.1 Printing History

In Richard Benson's *The Printed Picture* the author touches upon most of the different printing techniques e.g. reliefs, intaglio and early photography. The author presents a near chronological view of printing. The change of use from handmade prints to digital prints both in technique and material is described as a revolution. (Benson. R 2008. p.272-296). As with all newly developed techniques it takes time to master and refine a process and the materials used for it. It is evident that the time of development of the IRIS prints is linked to the quality of the prints. Since the IRIS print was developed in the early years of digital printing, it is easy to see why there would be some problems. All new printing techniques since the digital revolution have clearly been developed to be better in quality than previous digital techniques. The industry has grown and all companies producing printers and inks use different formulas for the inks.

The printing history can be viewed in two aspects. The first is the history of industrial printing. The other is that of personal printing. The first printers were made only for printing information or text with regard to work made on the computers.

The first prints were dot matrix line prints and Direct Thermal prints. The dot matrix was first used in 1954 and has almost stopped in production as of today. The direct thermal prints is the technique that is still used for receipts at supermarkets etc.

In 1977 the "Drop on Demand" (DOD) liquid inkjet technique was developed. The DOD technique has been altered and made into different printers, all with DOD technology. The printers varied in usage of ink with pigments, some with dyes and some with thermal systems.

In the 1980's the "Continuous inkjet" (CIJ) printer was made. The two categories of CIJ printing are binary deflection and multiple deflection. The IRIS print is a subcategory of the binary deflection technique (Sheppard. R 2008. p. 26).

Dry toner electrophotography has been used since 1959. It is also called a laser copy or Xerox. Dry toner particles are transferred to the media when a photoreceptor is discharged by exposure to light. The Xerox technique is still used today, and can be used with cellulose acetate film to replicate the photographic paper used for original silver gelatine developed photographs.

Many subcategories exist, some are less used techniques, but they will not be explained further in this thesis due to the fact that they are not in any way relating to the IRIS printing process.

As mentioned earlier the usage of digital printing can be narrowed down to two categories: industrial and private. The industrial usage has always been the primary. Subsequently, private usage was made possible only when the economical aspect with regard to production of printers was made more efficient. Printers for personal use have been made cheaper both in

terms of the production of the printers and the inks and media, though the printers are sold at a loss, the profit is gained by the ink being sold at a higher price. The high quantity usage of office printers have paved the way for printers made at a reasonable cost. Printers for private use were developed when the demand for private photography-prints increased.

Wilhelm Imaging Research, Inc. has conducted various studies concerning digital printing and digital printed photography, mostly regarding the preservation of the objects. Wilhelm's research has been used as a basis for many later studies. In an article published by the Society of Imaging Science and Technology (Wilhelm. H 2006), there is a review of the history of digital printing written by Wilhelm, starting at the first usage of the IRIS printer for fine art printing. The article later shows results from tests made on various digital prints up to 2006, showing what time they might be expected to last. The article emphasises the fact that the life expectancy of the later prints are much higher than the earlier.

2.2 IRIS Printing Technique

IRIS Graphics Inc. was the company producing the first IRIS printer. The company produced many different models with model 3047 being the most used IRIS printer during the 1990's (Jürgens. M. 2009 p. 72). Some of the models allow a larger format for the printing process. The large format and high cost of the printers limited their application for personal use.

During the 1990's the IRIS Graphics company was purchased by Scitex and later by companies as Kodak. The fine art printing started in 1991 and subsequently underwent many changes in the technique before the printing process fell out of common use after 2005 (Jürgens. M. 2009. p.190).

The technique is highly represented in photographic artwork, in a smaller scale in art and reproduction of art.

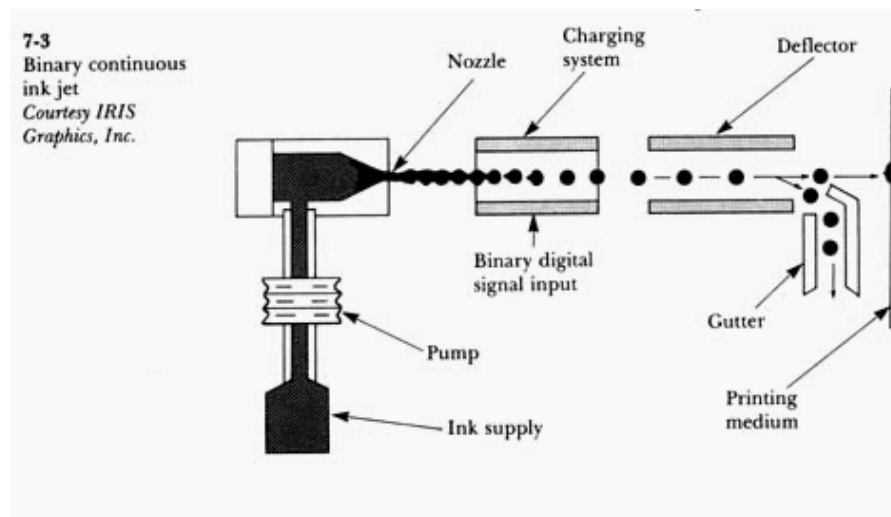


Figure 1 A schematic of an IRIS printer head.

IRIS printers employ a binary deflection system, which means that a deflection plate intercepts some of the drops. These droplets are recycled in a gutter and passed back to the nozzle. IRIS printers also have a drum where the paper media is placed. The drum can be set on various speeds so that the control of the placements of drops can vary, and the effect of

this can be seen in shadowing and highlights in the prints. With this technique it is possible to achieve a very high resolution. Drops from the IRIS printer can vary in sizes and density, which gives it what the industry calls a “continuous tone” (Jurgens.M.2009. p.75). During printing the nozzles, arranged by colour, start by printing the cyan, then sequentially the magenta, yellow and finally the black inks.

The inks used for the IRIS printer was primarily produced with a short intended lifetime since the prints initial use was as pre-print proofs. The inks where similar to earlier DOD printing aqueous inks (Jürgens. M. 2009. p 76.) The components in the inks are water, dye and humectant. The humectant is reported to be glycerine (Iris Graphics 1997). The colours are based on the CMYK system.

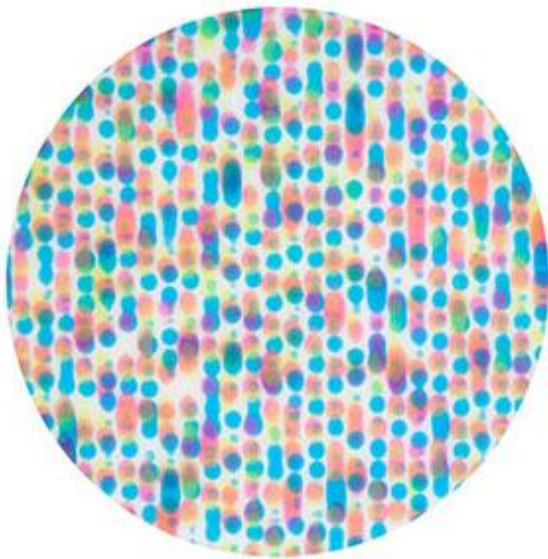


Figure 2 Magnification of the dots on a dye based inkjet print. Picture taken from the Image Permanence Institute, Graphics atlas.

The fine art papers on which the IRIS is printed have often been an uncoated and sized high quality paper. (Jürgens. M.2009 p. 190). Many well-known companies have produced fine art printing papers, many made specially for IRIS prints. Arches, Fabriano and Sommerset have all been used for these prints. The formats can vary, but with the largest possible print size being 89 × 120 cm.

Though it is a digital technique, IRIS prints have a hand-made feel. This is on account of the spreading of the ink on the fine art paper making the print similar to handmade watercolour art. The IRIS prints are unique in the sense that when printed on very fibrous or porous fine art paper, the dots are hard to see without magnification. If printed on uncoated paper the dots may be hard to distinguish in the shadows (Jürgens. M.2009 p.191). Due to wicking of the aqueous ink on uncoated paper the effect of the printed image becomes very matte.

2.3 Nash Editions and Artists

The Nash Editions printing studio was at the forefront of the digital printing production at the American west coast in the 1990's. IRIS prints from Nash Editions became very popular during the 1990's. Nash editions tried out new inks that they had specially manufactured for

the 3047 IRIS printer model (Jürgens. M. 2009 p. 76). Later ink formulations, finally produced an ink-set not as sensitive to light and humidity than previous inks.

Benson's book about Nash Editions (Benson. R. 2007. p. 132) mentions some famous photographers and artists, e.g. David Hockney, that used the IRIS printing technique and the art that it resulted in their collaboration with Nash Editions. The many illustrations in the book give an insight into how they worked and how the prints came to be.

Benson puts emphasis on this collaboration and how it raises value of the art and its provenance. The more valuable the art is considered to be, the more resources stakeholders will devote to preserving the art.

Nash Editions are perhaps the most famous print studio that has been employing the IRIS printing since the early 1990s. They have collaborated with numerous well-known artists and photographers to produce high value prints that are in collections worldwide.

3 Fading

3.1 Probable Fading Causes

Fading of art on paper can vary when it comes to the initial causes of the fading. Paper can undergo both oxidation and hydrolysis, which generate various problems in the papers longevity and structure. The rate and pathway of the degradation is linked to many environmental factors including: light, humidity, pollution of the air etc. as well as to the inherent material properties of the paper. Paper degradation can lead to observable changes in the paper properties becoming discoloured, brittle or distorted.

With regard to colour change of prints and other works on paper, the observed colour change is in relation to the degradation of the paper as well as the degradation of the ink itself, therefor the causes of the fading varies between samples even if preserved in the same environment.

3.2 Simultaneous Contrast

How the beholder perceives the colour of the artwork is a point of view that should not be excluded. The tests and analysis that this thesis has undertaken show that all colours undergo change during exposure to light. It might also prove that one colour in particular is more prone to change (Sisefsky. J. 1995. p.56). If so, then the case of simultaneous contrast must be taken into consideration.

Simultaneous contrast can be explained by how we perceive a colour difference due to a change in nearby colours e.g. if only the yellow colour changes, we might as a result perceive the nearby blue as changed even if it's not. These perceived changes in the nearby colour is only in contrast to the faded colour, not in an actual physical fading of the nearby colour (Itten. J. 2009. p 52).

The way in which we perceive colour is also dependent on what light the object is viewed in. Light sources with different colour temperatures, daylight, cold LED, warm halogen etc. reflect from the image that we see in different ways i.e. the colours will be perceived differently in different light. When it comes to lighting, in regards to display policies it is not only the light least harmful to the object that should be considered, but also the light that displays the prints in the most correct way.

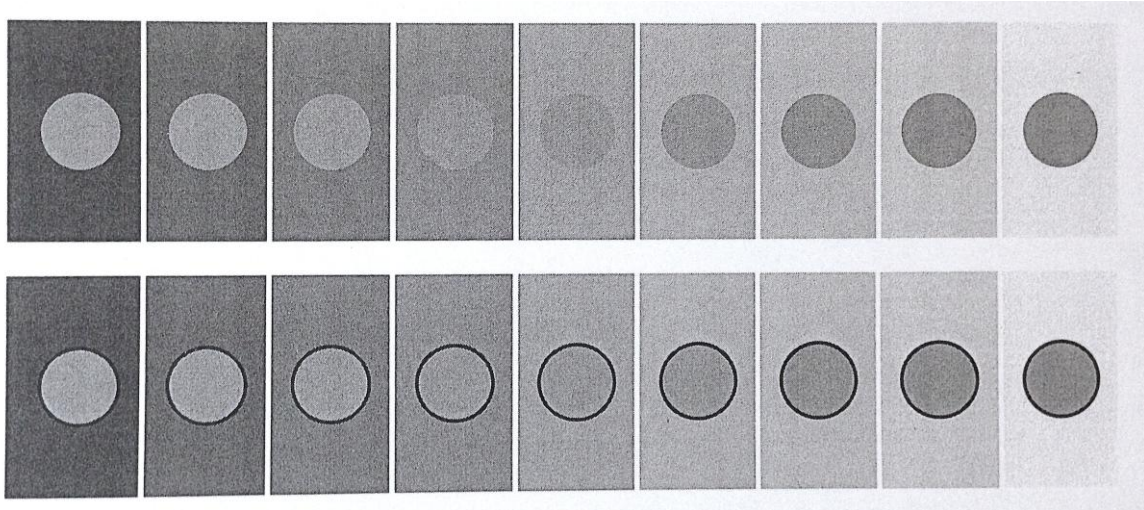


Figure 3 Simultaneous contrast, image taken from Sisefsky, J. (1995).

When a colour is in contrast to a background colour, it can be perceived differently than when it is displayed in contrast to another colour. As seen in figure 3 the dots on the right seem to be in a lighter shade of grey than on the left. In fact the dots are all in the same shade of grey. The eye only perceives the dots as being darker when presented on a lighter background. This is true also with complementary colours. The simultaneous contrast must therefore not be disregarded in discussing fading, especially if one colour is fading more than the others.

3.3 Ethical Issues

For an object to be qualified for preservation or conservation there must be stakeholders involved to lobby the value of the object. It is more common that objects of either high economic value or high cultural value get the attention needed. If an object is a modern work of art, the object might not be considered as important to be preserved, due only to the lack of historic value; this is often the case with digital prints which can be seen to be mass produced and therefore reproducible. The problem with this argument is that many early digital prints should rather be seen as unique originals.

Despite their, once, mass producible nature, due to the rapid development in print techniques and changes in ink formulation and decommissioning of early generation IRIS printers, it is now extremely difficult, if not impossible, to exactly reproduce early IRIS prints. As a result those in existence in collections today can justifiably be viewed as originals.

Many museums have IRIS prints in their collections, but the means to preserve and store them in an effective manner varies a lot. Many museums might have a low budget for conservation and preservation. If studies show that the IRIS prints fade to a point where they need to be excluded when it comes to display, then they will need preservation today or there might not be any good quality IRIS prints left in a few years.

3.4 Previous Studies in the Field.

Research regarding IRIS, and other digital prints, tends to fall into one of two categories: industry-driven research into technique and materials development and conservation focused research.

The vast bulk of the research concerning digital printing is conducted by the industry that constructs new printers. This industry strives to simultaneously better the quality of printing techniques as well as to reduce their costs. This is why it can be difficult to conduct/reconstruct some earlier printing techniques today as materials and technology are rapidly changing due to further development within the industry. Further complicating digital print technique reconstruction is the fact that the exact ink formulations are often proprietary knowledge and trade secrets and third party ink formulations are not equivalent to the original formulations.

Conservation related research focuses mostly on preventive conservation areas, like determining the response of the prints to environmental factors, and there is little published research on the development of applied treatments. The Image Permanence Institute (IPI) in Rochester, New York, is recognized as a leader "in the development and deployment of sustainable practices for the preservation of images and cultural property" (Image Permanence Institute, 2014). The IPI's Digital Print Preservation Project (DP3) is the most significant body of research relating to the topic of the preservation of digital prints.

Conservation studies focusing on the response of prints to environmental factors have fed back into the printing industry serving to advance the field in making higher quality print techniques but also to develop guidelines to lightning in museums (www.getty.edu).

With regard to the development of applied conservation treatments, there are mostly some standards that show the complex problems in displaying and conserving the prints. There have been few studies that look closer into how to prevent the fading of IRIS prints without banning display completely.

Wilhelm Imaging Research, Inc. is a company that conducts independent research on the stability and preservation of digital colour photographs (Wilhelm, H 2006). Among other research they carry out tests on large format inkjet printers. They also have a consulting service for museums with collections containing art on paper. The founder of the company has done consulting for museums like Museum of Modern Art in New York. The company also does consulting for various archives and institutes with storage facilities like Corbis, trying to achieve a long-term solution for storage of highly sensitive photographic material.

Looking closer into some articles that WIP has published it is clear that their knowledge of the permanence of prints and other photographic media is great. Particularly one article is the most specific and most concordant article found on the topic of light fastness in IRIS prints (Wilhelm, H. 2006). It explains what kinds of analysis have been made and the results are presented in reference to printer, ink and paper. The focus is on the light fastness both in relation to light sensitivity and temperature. Eight different prints from the IRIS Graphics 3047 model have been analysed, they have a different production time, different inks and media. This article and this study are highly relevant to the thesis and the analysis. The largest difference between the tests carried out in the article will be that the material today is eight years older. This is of course depending on usage of materials most similar to the tested materials in this article. The results from WIP's study will be viewed when the results from the tests carried out in this study are collected and viewed. Hopefully the results from both

studies will give an elucidation on what happens to different IRIS prints when subjected to light.

4 Methods and Materials

4.1 The MFT Method

Digital printing techniques with their constant development pose a particular problem in making precise statements about their light fastness as a category. Even within a single technique, such as IRIS printing, there can be a significance variance in ink formulations with regard to time. As early IRIS prints are now effectively de facto unique originals, accuracy in the assessment of a single object rather than precision with regard an ever-changing class of objects is preferable. Ideally it would be better to be able to directly evaluate the light fastness of an object.

The Micro fading tester (MFT) has been developed for such applications, and a MFT will be the primary experimental method used of this study. A MFT is an instrument to conduct accelerated light ageing on a small part (typically a spot 0.25 to 0.6 mm in diameter) on an object. Despite the fact that spots on an object are directly tested, the technique is considered to be non-destructive or micro-destructive. See Figure 4 for a schematic of a MFT. During MFT analysis, output from a high intensity light source is focused onto a sub-millimetre spot and the reflectance spectra, from which colour data can be derived, is recorded in real time. The small spot size, and real time nature of the method are the key features. Small spot sizes allow for objects to be directly tested without producing naked-eye observable spots. Real time analysis allows for higher time resolution data to be collected thereby allowing for better prediction and modelling of colour change behaviour, thereby allowing for the experiment to be halted before any perceivable colour change is induced in the object (A. Lerwill ,J. H. Townsend, H. Liang , S. Hackney, J. Thomas; 2008).

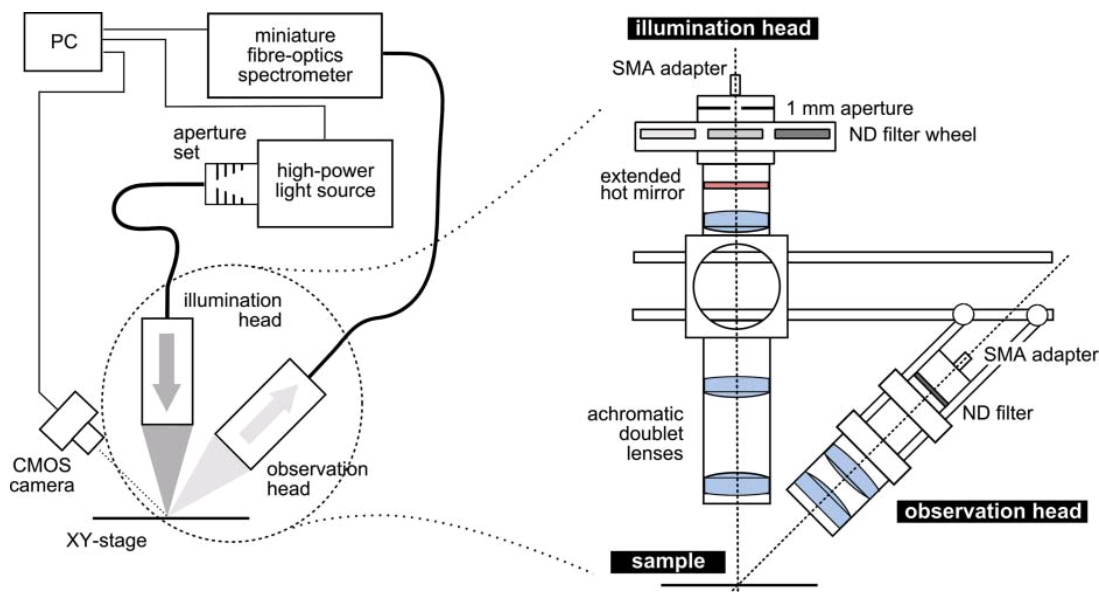


Figure 4A MFT for the direct assessment of colour change behaviour of heritage objects. Image taken from *Light ageing with simultaneous colorimetry via fibre optics reflection spectrometry* with author's permission.

While IRIS printing is a continuous flow ink jet process, some areas of localised ink concentration due to droplet deposition might be apparent on the object. If these are on the same order of magnitude as the MFT measurement spot then they can influence the MFT measurements therefore care must be taken to select appropriate measurement points on the object (T. Łojewski, J. Thomas, R. Gołąb, J. Kawałko, J. Łojewska. 2011).

The materials used for method development and validation will be expendable model materials which, if they are not newly produced IRIS prints, will replicate the key factors of IRIS prints: dye based ink systems and uncoated artist paper.

There will be one test made on material from an IRIS printer model 3047, printed in 2007. A final test will be made on an IRIS original print from 1996 by photographer Ritva Kovalainen. This original is a part of the Hasselblad foundation collection.

4.2 Tests

During a weeklong period of testing, MFT analyses on another ink-jet technique were carried out. The operation of the MFT and the software needed to be practiced to ensure that the result would be accurate when applied to the original IRIS print. The light source and its intensity were closely monitored during all the tests to see if there were any changes in the light source. Measurements of intensity in lux and w/m^2 were taken before testing started, and subsequently after of each day of testing. Four different papers were used for this primary test so that eventual differences in paper might be considered when it comes to differences in fading of the same technique. All of the prints were made only hours before the first test. The last test was carried out approximately a week after. Before every spot analysis a close up picture was taken, then after the 10 minutes of spectroscopy, a new picture was taken of the same spot.

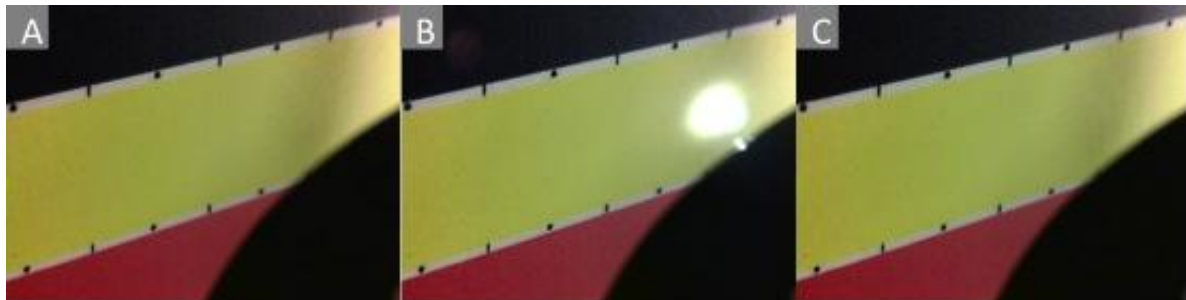


Figure 5 A, the measured spot before MFT analysis. B, the measured spot illuminated during MFT analysis. C, the measured spot after MFT analysis

The software called Waves is a program developed by RGB Laser Systems. This software was used both to control the spectrometer and for data analysis. It registers the spectra taken by the spectrometer. Using Waves the reflectance spectra is converted to coordinates in colour space, in this case CIE Lab colour system. From the Lab coordinates it is possible to calculate the difference in the CIE L^* , a^* and b^* values between any two points in the colour space, and from these calculate the difference in colour expressed as CIE ΔE_{00} .

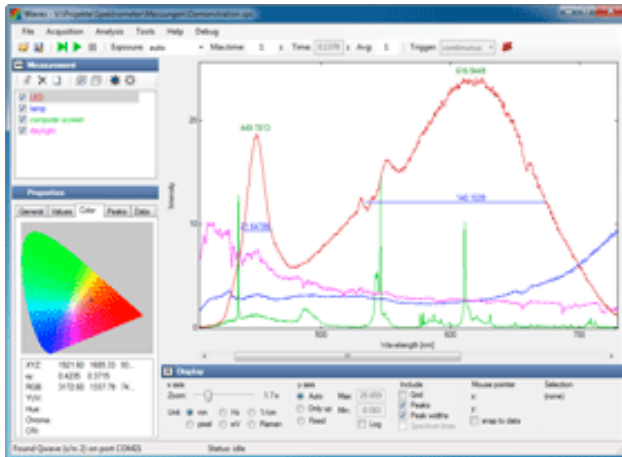
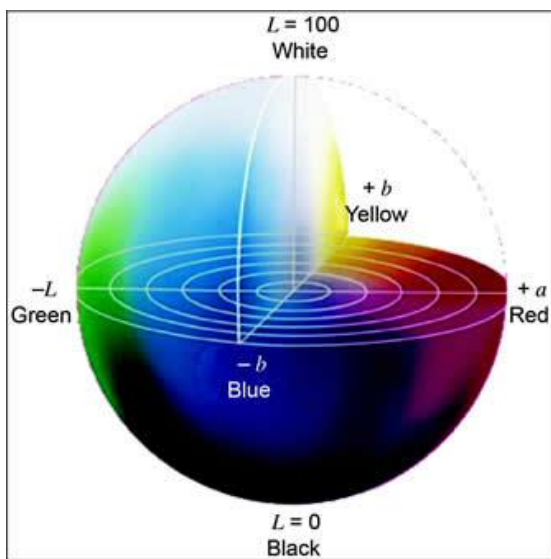


Figure 6 A screen shot showing the software Waves used for collecting data during spectroscopy.



Within the CIE Lab colour space. The L parameter reflects the lightness and darkness, the higher the value the more white/light and the lower the value the more black/darkness there is. The a parameter is defines the red-green axis in the colour space. If there is a positive a value the colour is more red, and if the values are negative the colour is more green. The b parameter defines the yellow-blue axis in the colour space. A positive b value is represents a colour that is more yellow and a negative b value represents a colour that is more blue (Hunterlab. 2014).

Figure 7 A graphical representation of the CIE Lab colour space courtesy of Hunter Lab.

4.3 Materials

4.3.1 The model materials

To be able to verify the method, tests on model materials were necessary. The model materials chosen are different in paper quality and raw pulp material. They also differ in surface texture to evaluate the effect of this parameter on MFT measurements. Some papers have been hard to find information about concerning the pulp and possible inherent materials e.g. optical brighteners. Some paper mills wishes to keep some of their production classified. Due to this there can only be a hypothetical discussion as to what actually might affect the fading of the papers with unknown inherent pulp material.

The papers used for initial tests with the MFT are as follows:

Conqueror connoisseur

100% cotton

pH measurements show that Conqueror connoisseur is neutral to slightly alkaline

Svenskt arkiv

Cotton and a smaller part chemical pulp. Inherent in the paper are calcium carbonate and titanium dioxide.

pH measurements show that Svenskt arkiv is neutral to slightly alkaline which correlates with the information given about the pulp being neutral.

Mohawk (matt white)

Made out of sulphite pulp said to be acid free.

pH measurements show that the Mohawk paper is highly alkaline. The Mohawk paper is visually very bright and has a cold white colour. There is a good chance that optical brighteners have been used but the Mohawk mill does not give out information about additives.

The prints were printed with a Canon mg 3100 ink-jet printer.

Newer models of printers like the Canon 3100 claim to be good in terms of less fading. The inks used today have been modified for over a decade since the first IRIS printer came in use.

4.3.2 The IRIS reference

A printed reference collection can be ordered from various museum and research institutes. These reference materials can advantageously be used as identification references for anyone working with digitally printed art. The IRIS reference used in this study is a part of a larger collection of references like the ones previously mentioned. The IRIS reference print was printed in 2007, on an IRIS printer model 3047. It is printed on a *Somerset Radiant White*, 330g/m² (gsm), 100% cotton. The paper is a sized/coated fine art paper. The ink used for this print was *American Ink Jet Pinnacle Gold*, which is a liquid CMYK dye based ink. The IRIS reference material will be used as a case study for the IRIS prints. There is a saturation scale in the reference print, from 0-100% saturation, printed with CMYK colours. This saturation scale is where the MFT tests will be carried out.



Digital Process Identification Target Version 2006
 Contemporary Photography: Digital Prints
 A Collaborative Workshop in Photograph Conservation
 Sponsored by the Andrew W. Mellon Foundation

Figure 8 Reference IRIS print.

References like these are also advantageously used for analysis of IRIS prints and other digital prints. The many fragile digital prints that should be tested for permanence can benefit from the analysis and testing being carried out on reference material instead. These prints are also an asset, considering that the reference material might be the only prints with pure, non-mixed colours. As seen in the lower right corner of the image pure colours and colours shaded and mixed.

4.3.3 The Original

The photographer Ritva Kovalainen born in 1959 studied Master of Arts at the University of Art and Design in Helsinki. Her work has been displayed at numerous exhibitions and is represented in several Scandinavian museum collections. Kovalainen currently resides in Finland and her work is presented in several books (Kovalainen Ritva. 2014).

The Kovalainen original IRIS print from the Hasselblad Foundation is printed on a Fabriano uncoated fine art paper. The paper shows no visual signs of degradation. There are no yellow parts or foxing, and no signs of other damage to the paper. The paper seems to be well preserved apart from the apparent fading of the print. A previous discussion with conservator Cecilia Sandblom at the Hasselblad Foundation is the basis for why this print was chosen for analysis. An image in the Hasselblad database, taken several years ago, indicated that the print had lost some of its continuous tone and the shadows/highlights had faded.



Figure 9. The Original Ritva Kovalainen, image taken January 2014 at the Hasselblad Foundation, used with permission.

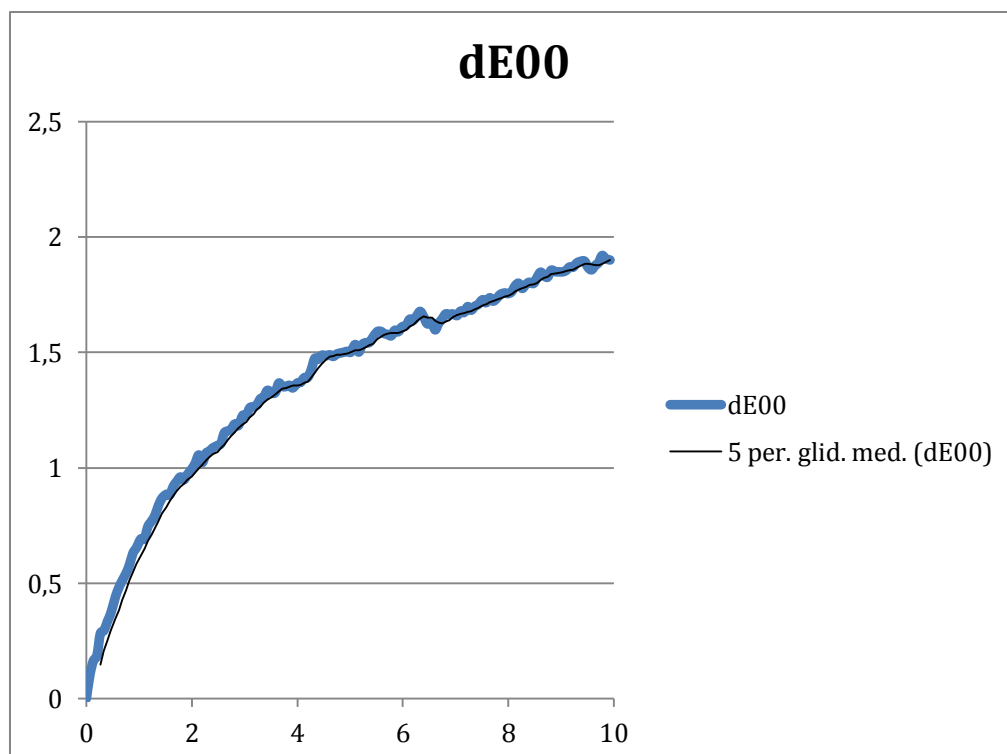
5 Results

The overall results gave more answers than expected. Factors that previously had not been expected became key-factors. The model material was produced only hours before the first MFT analysis. This contributed to the finding that any inkjet technique would be the most light sensitive when it is first produced. This is due to the fact that inks used for any inkjet technique need solvents and until these have evaporated they can facilitate the fading of colours, through the solvation and transport of reactants during photo-redox fading reactions. The case of solvent evaporation is a good example how other components of an ink formulation can affect the fading rate of a dye.

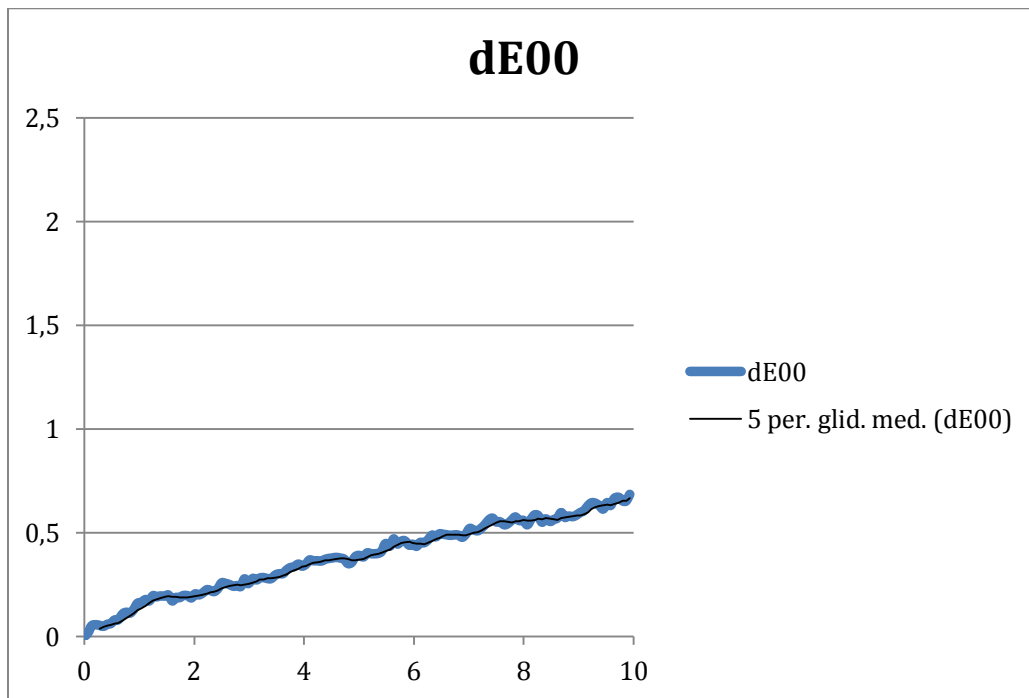
5.1 The Model Material

Some of the inherent components, and the evaporation of these, seems to be the reason for the fading to be higher during the first 24 hours after production. Below are two plots of the observed colour change, expressed as ΔE_{00} of the cyan dye on the Mohawk paper. On day 1 the dye faded nearly $2 \Delta E_{00}$, but on day 3, when given an identical dose of light the response was ca. $0.5 \Delta E_{00}$, a 4-fold decrease in light sensitivity. Moreover, the shape of the fading curve becomes more linear and typical of a light fast material.

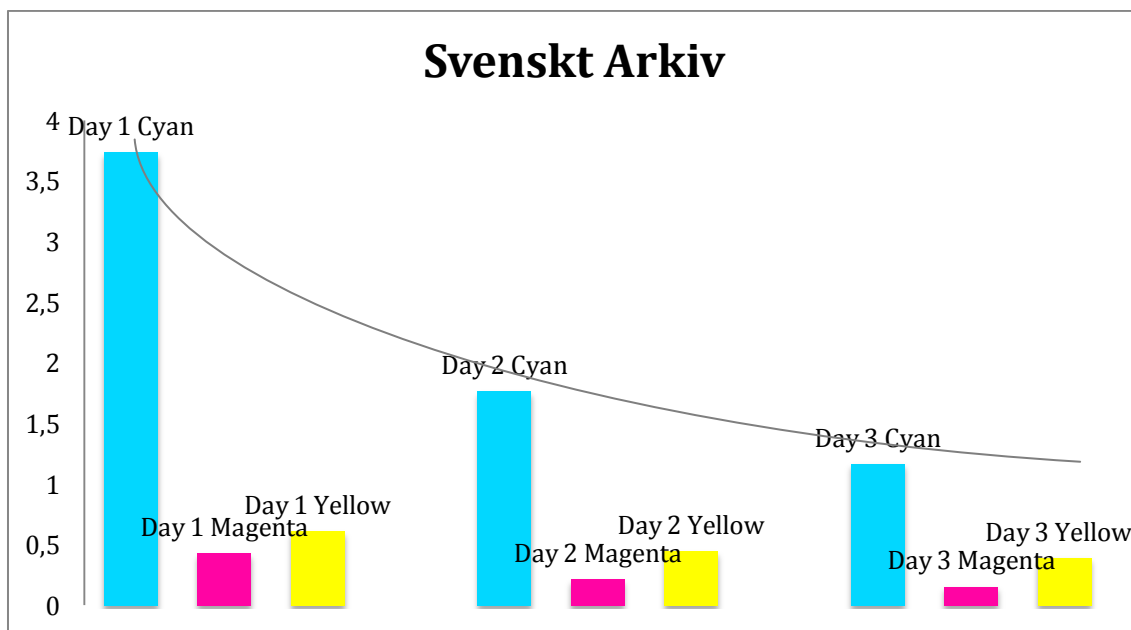
Graph 1 Mohawk Cyan day 1



Graph 2 Mohawk Cyan day 3



Graph 3 Bar graph of the final ΔE_{00} for all inks printed on Svenskt Arkiv paper. The observed decline in fading rate with drying time is readily apparent.

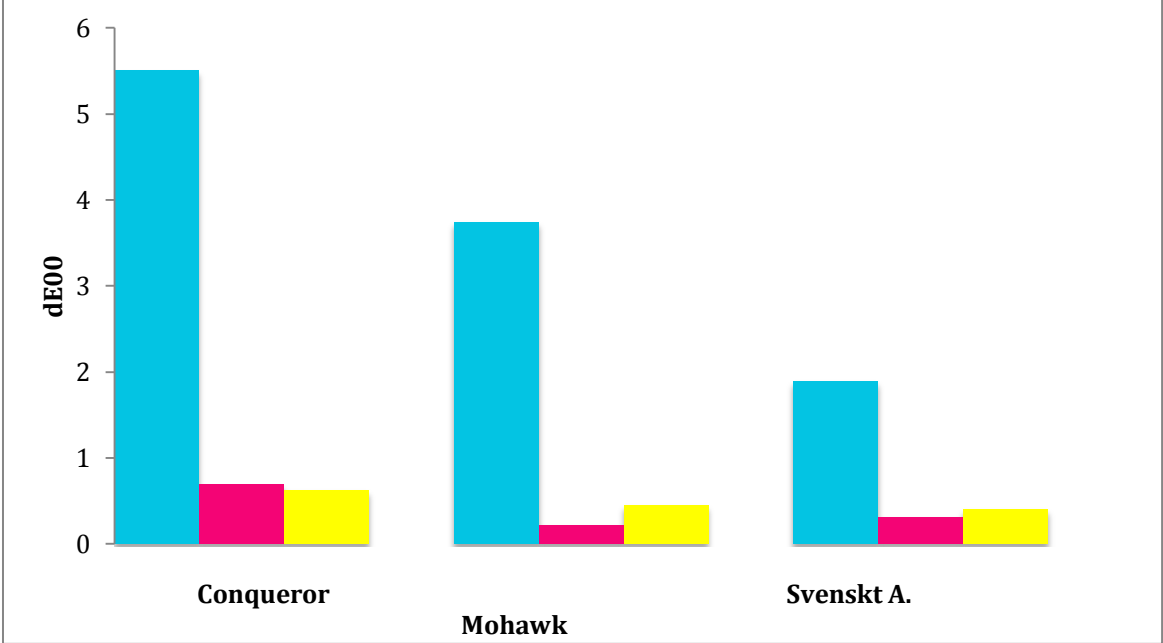


The decline in fading rate was observed for all inks on all paper types. In graph 3 we can see that the cyan dye is the most light sensitive and also the colorant whose fading rate is most strongly dependent on allowed 'drying time'.

Another factor to the difference in fading of the prints is the quality of the paper. The different paper quality of the materials used for MFT analysis during the first day showed that there is

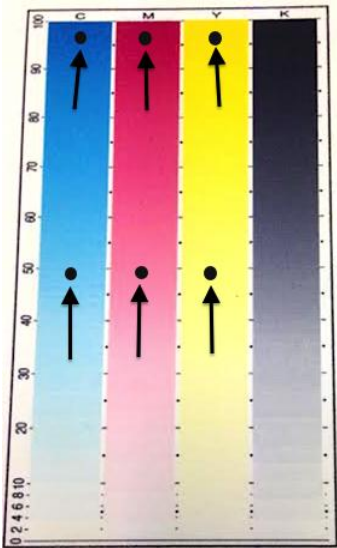
difference in fading extent between different papers. Several factors including: pH, coatings/sizing, fibre furnish etc. could be contributing to these observed differences.

Graph 4 Colour change as expressed by ΔE_{00} for all inks on three different papers after administration of identical light doses. All samples were printed on the same day and all measurements were conducted within 24 hours of print production.



All of the model materials were produced and tested on the same day, and were given nearly identical light doses, thus the observed differences in colour change must be attributable to differences in the paper support.

5.2 The IRIS Reference

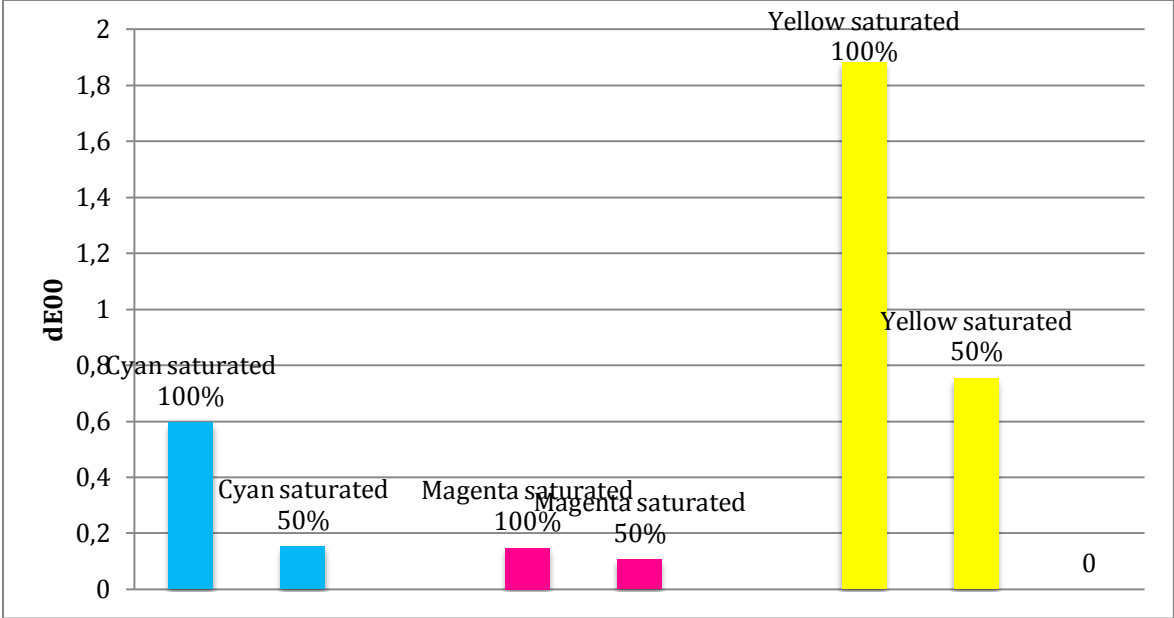


An IRIS reference print was tested for two reasons: first to determine if the dyes used in IRIS prints behave differently than those used in the Canon MG 3100 and second to determine the effect of print saturation on fading rate. This was facilitated by the fact that the print had a saturation scale that gave the opportunity to do analysis of pure CMYK colours.

Figure 10 Image of the points tested on the IRIS reference print

The analysis of the IRIS reference revealed that there are significant differences between the 100% and 50% saturation levels but also between the different colours. It clearly shows that the yellow colour is most prone to fading and that the magenta most likely will be the colour that is more preserved after time of light exposure.

Graph 5. Measurements of the IRIS reference on different saturation.



5.3 The Original

During the IRIS printing process the varying density in droplets during printing (see chapter 2.2) leads to a high variation of saturation. It is near impossible to find traces of a single droplet from a pure colour of ink. This of course is what makes the visual effect of the IRIS print so interesting, and at the same time it makes analysis of the ink in an original quite complex. Microscopic analysis of the print revealed extensive colour mixing with no ‘single-colour’ areas. As the experiments on the reference IRIS print indicated that colour saturation positively correlated to increased fading rate, three measurement points were selected which represented three saturation factors and different hue on the print.

The first measurement point is in the lower right corner of the print where the saturation is relatively high and in a blue hue (see figure 11).

The second spot is in the middle of the right hand edge. This spot was chosen particularly to see how a spot with more shading and saturation reacts to fading. It is a darker spot where the black, which is the last colour to be printed, sits on top of the other coloured droplets.

The last spot is in the middle of the top edge. In this part of the print there is lower saturation and no black ink used.

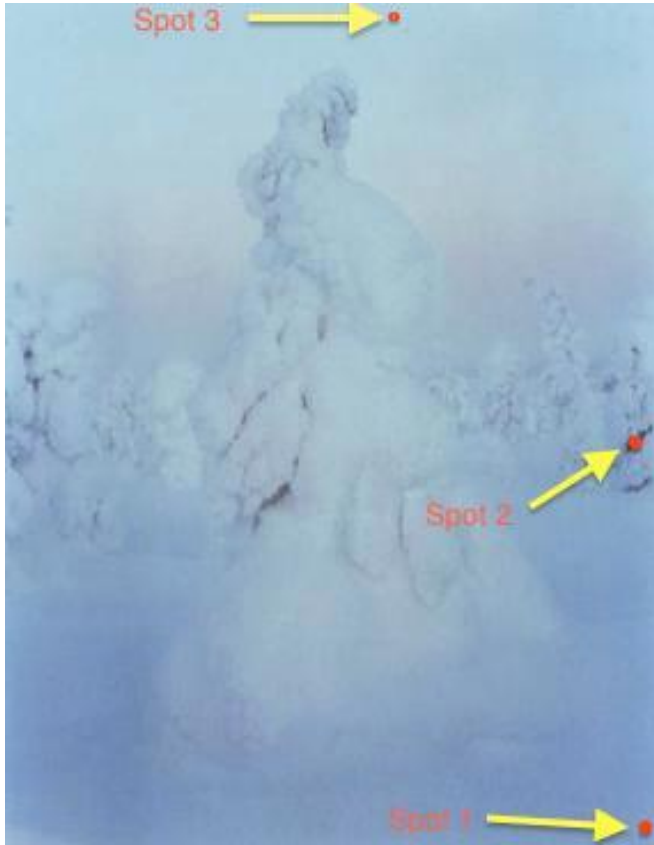
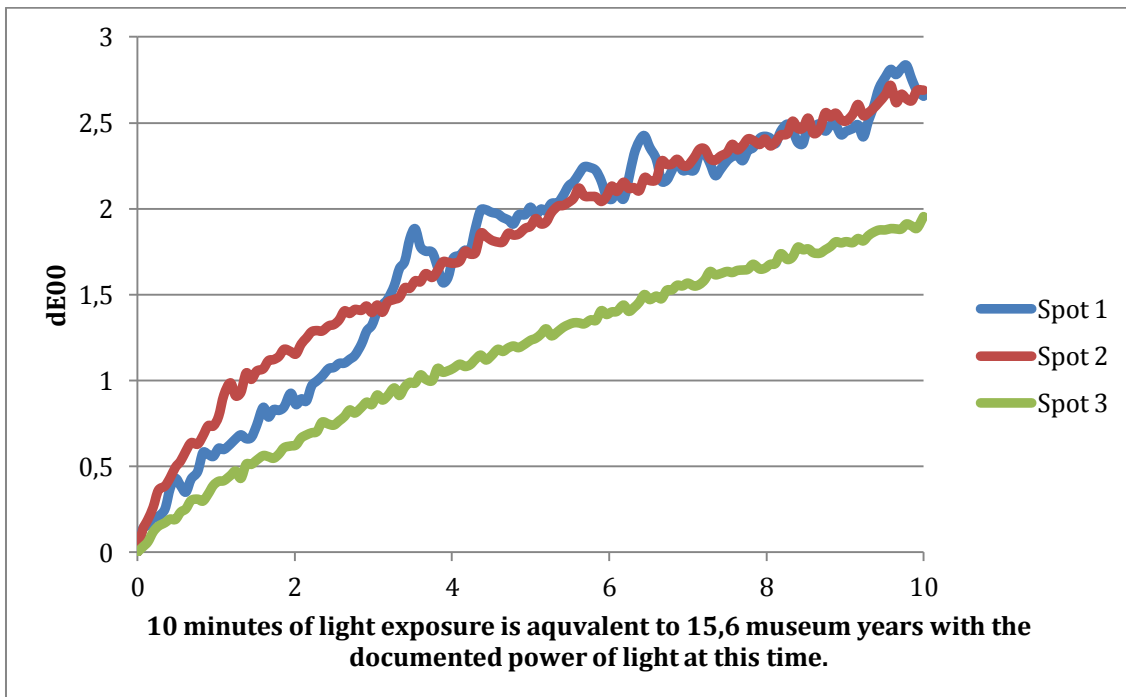


Figure 11. An image of the IRIS print by Kovalainen. The red spots and arrows mark the three measurement points.

Graph 6 The measurement data from the three spots analysed on the Ritva Kovalainen original.



The analysis of the original shows that, different spots on the print will fade to a different extent. The spots with a higher saturation faded more. There were no signs in any of the spots of simply one colour, every spot was comprised of several colour droplets.



Figure 12. Magnified image showing measuring point 2 on the original IRIS print.

6 Discussion

The formulation of the ink used for an IRIS print is highly relevant to how much the print will fade, however, that information is difficult to determine if it has not been documented at the point of production. Thus it is important for any institution collecting IRIS prints, and digital prints in general, to document as much as possible about the origin and materials used for printing of the original prints at the time of acquisition. Additionally, it is as important to inquire as to what paper the print is made on and to estimate the fading in correlation to the ink. This much is true if an institution wishes to estimate the light fastness and therefore 'fit for display' lifetime of a print or collection of prints before acquisition, that is to consider objects in a general manner. However, if the goal is to understand the light fastness of a particular object, then no fore knowledge of the material composition is needed through the use of non-destructive micro light fastness testing using a Micro Fading Tester (MFT).

MFT analysis shows the importance of valuing every IRIS print as an original i.e. as a separate object. Taking all factors into consideration all IRIS prints will most likely fade differently, but none the less all of them will fade. While some IRIS prints will fade due to poor ink, others will fade due to a lesser quality of paper. Some might fade due to bad storage and some due to bad lightning policies during display. Some prints might fade differently than others whilst being stored in the same facility. High usage of a colour more prone to fading, i.e. the yellow, might lead to simultaneous contrast changes. All of the factors mentioned make it difficult to assess the fading of IRIS prints in a general term. The difficulty lies in what knowledge is obtained about the technical properties of the print in hand. If the collection manager and conservator know the technical properties and understand them, there are steps to take to prevent a grave amount of fading.

First and foremost the display policies used at the time of display in an institution pay an enormous part in preventing fading. With the knowledge that IRIS prints fade, and are very sensitive to light, a policy that allow display without fading ought to be very low in lux value. Preferably the display might be narrowed down only to a short period of time.

It can be hard to get attention regarding the importance of preserving cultural objects that are not more than 30 years old. The IRIS prints are such objects. What needs to be emphasized is that none of the IRIS prints will exist in the future in the way the artist intended when producing them.

7 Conclusion

The definition of the problem to this thesis was to examine if a display lighting policy can be developed to minimize the risk to the objects while still allowing access through display. It is possible to establish a lighting policy for display but only if all factors are taken in to consideration. The only reasonable way of preventing fading on all IRIS prints is to do a vast study on as many IRIS prints as possible to establish what light policy is preferable for as many of the prints as possible. This conclusion can be made, due to the fact that the results point to such a huge difference in fading of different IRIS prints.

Having access to a MFT can be a solution in setting a valid and reasonable lighting policy for display. Some institutions have access to an MFT, The Museum of Modern art is one such institution and they do have IRIS prints as a part of their collection. They have the possibility to do analysis of each IRIS print to establish how long and with what dose of lux they can be displayed. Due to the fact that most MFT models are portable it can be possible to do analysis in situ. As with printers and all technologies the apparatuses become more reasonable when it comes to the price. It is likely to be the same with the MFT, In time it will probably be possible to acquire a MFT to most institutions with collections containing digital art.

It can be hard for a conservator to be able to know everything needed to prevent fading of other digitally printed art. Too many changes in the industry over a short period of time generate too many factors to consider. It is likely to be easier and more accurate to assess every object individually. An MFT can do this, and as long as the documentation of the material follows the object there is no reason why we might not have quality digital prints in the future.

8 Summary

IRIS prints became very popular during the 1990's. The prints can be found in many museums and collections today. During a time when digital printing was not considered real art, many artists were still fascinated with the technique and subsequently they started to make some of the first fine art printing with the IRIS technique. The IRIS prints were soon known for the continuous tone and the "fine art feel". Most fine art IRIS prints in collections today are printed on high quality papers from well-known paper producing companies. The fading of the prints was discovered early on. The technique was after all, constructed initially only to make prints with a short life time expectancy, like the pre proof prints for magazines and labels.

The fading of IRIS prints is a fact and with several studies showing that the fading is a complex problem a solution should be possible. Viewing every IRIS print as an original is essential to be able to prevent more fading than necessary. Many IRIS prints will fade differently due to usage of different inks, paper media and saturation etc. Some fading can lead to simultaneous contrast, making the image distorted.

Thorough analysis can set a basis for a valid lighting display policy (Fisher M. 2013). A display of an IRIS print will likely always result in some fading but how much is dependent on what lighting display policy is used and how much knowledge the display manager and conservator have on the subject. Many companies and research facilities have the means to do analysis of IRIS prints. Many of them, like IPI and Wilhelm research also provide with information on how to display these sensitive objects (Image Permanence Institute. 2014, see guidelines).

Many art objects first become intended for conservation when they are in a bad condition. The problem with IRIS prints is that it can be hard to see or realise that they have faded. A regular assessment of the condition of the IRIS prints is necessary to be certain of the condition. The paper quality can conceal the fact that the print has faded. A paper conservator often looks for degradation in the paper, but when it comes to IRIS prints it is often only the image that is degraded and not the paper.

9 Sammanfattning (Summary in Swedish)

IRIS-utskrifter blev mycket populära under 1990-talet. Utskrifterna kan hittas i många museer och samlingar idag. Under en tid då digitala utskrifter inte ansågs vara riktig konst, var samtidigt många konstnärer fortfarande fascinerade av tekniken och därefter började de att göra några av de första digitala utskrifterna på konstpapper med IRIS -tekniken . IRIS skrivaren blev snabbt känd för dess distinkta ”continuous tone” och en "riktig konst känsla ". De flesta IRIS utskrifter i samlingarna idag är utskrivna på högkvalitativt papper från välkända pappersproduktionsföretag. Blekningen som IRIS utskrifterna visade efter kort tid, ligger till grund för denna uppsatts, och den upptäcktes tidigt. Tekniken var konstruerad initialt, endast för att göra utskrifter med en kort förväntad livslängd, liksom korrekturutskrifter för tidningar och etiketter.

Blekningen av IRIS-utskrifter är ett faktum, och trots flera studier som visar att blekning är ett komplext problem, kan en lösning likväl vara möjlig . Att betrakta varje IRIS-utskrift som ett original är viktigt för att kunna förhindra mer blekning än nödvändigt. Många IRIS utskrifter kommer att blekna annorlunda på grund av användningen av olika färger, pappersmedia och mättnad etc. Viss blekning kan leda till simultankontrast, vilket gör att bilden visuellt förvrängs.

Grundlig analys kan ange en bas för en god utställningspolicy när det gäller ljussättning. En utställning av en IRIS-utskrift kommer sannolikt alltid att resultera i att utskriften bleknar något, men hur mycket beror på vilken ljuskälla som används och hur mycket kunskap curatoren och konservatorn har i ämnet. Många företag och forskningsanläggningar har möjlighet att göra analyser av IRIS-utskrifter. Många av dem, som IPI och Wilhelm research, ger också information om hur man visar dessa känsliga objekt.

Många konstobjekt blir först påtänkta för bevarande när de är i dåligt skick. Problemet med IRIS-utskrifter är att det kan vara svårt att se eller inse att de har bleknat. En regelbunden utvärdering av tillståndet på IRIS utskrifterna är nödvändig för att vara säker på tillståndet. Papperskvaliteten kan dölja att utskriften har bleknat. En papperskonservator ser oftast nedbrytning av pappret först, men när det kommer till IRIS-utskrifter är det ofta bara den bilden som är nedbruten och inte papperet.

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Images:

All images taken by the author of this thesis if not stated otherwise.

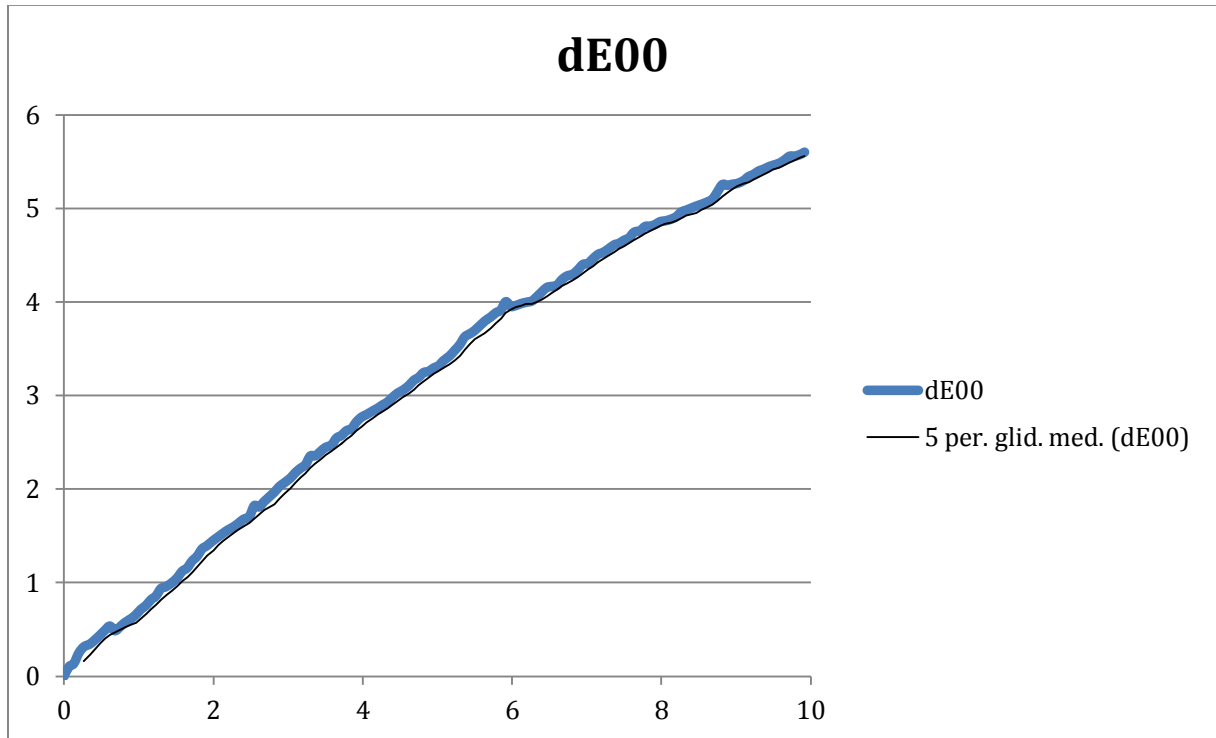
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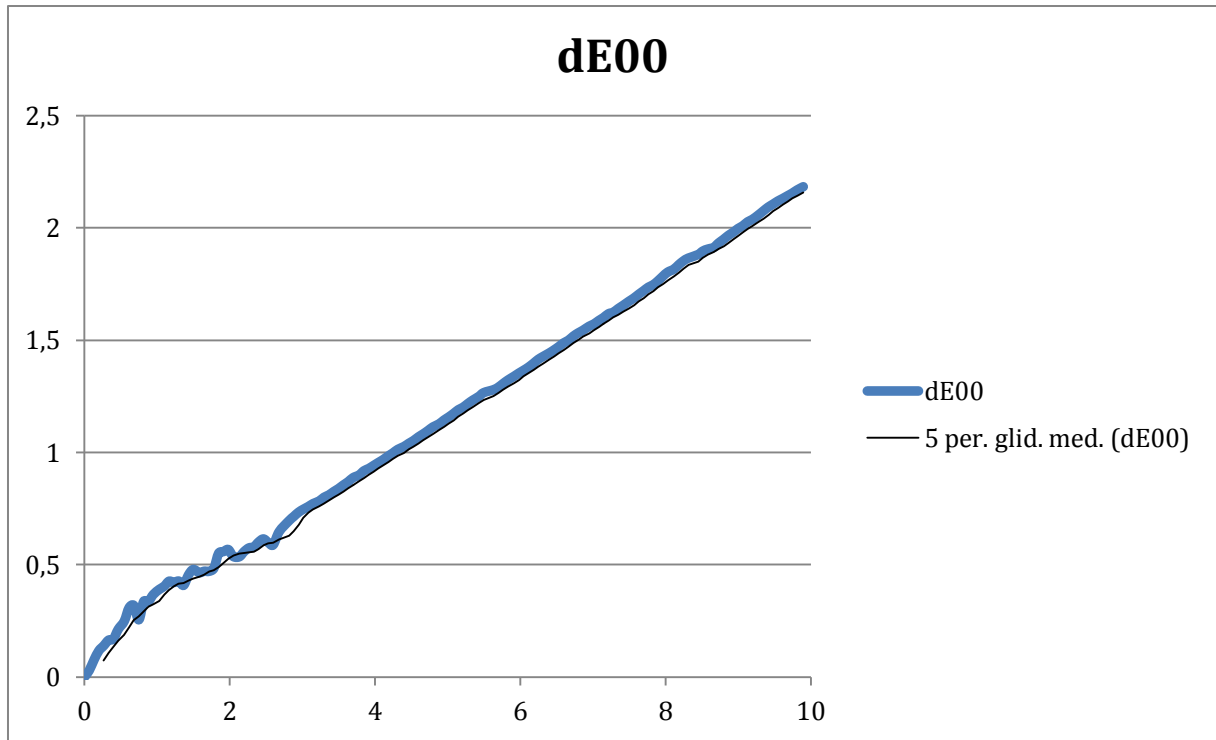
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Appendix

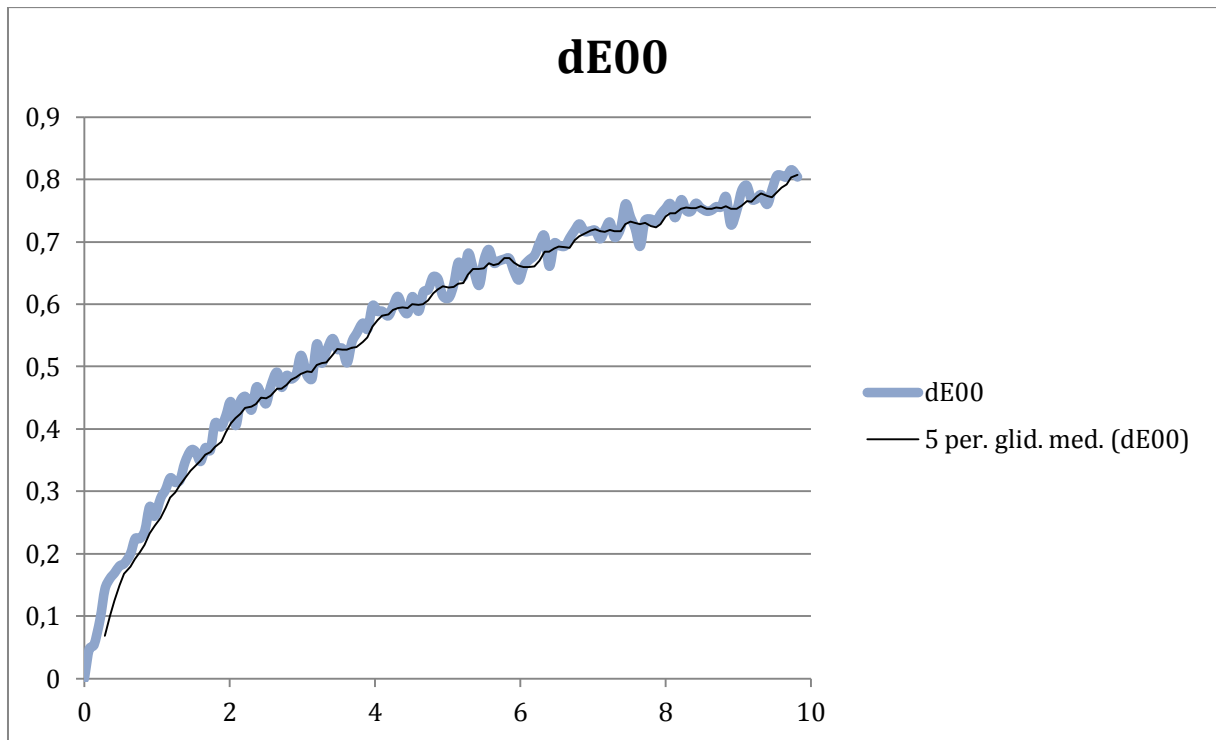
Model materials



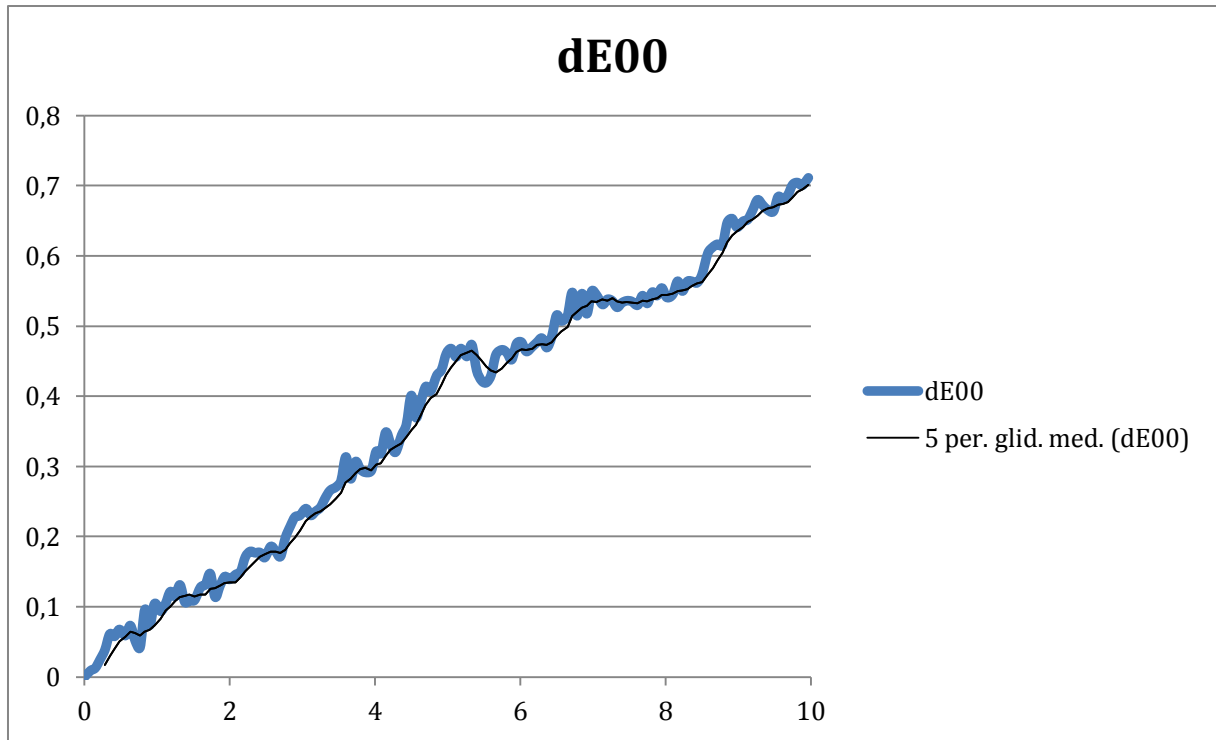
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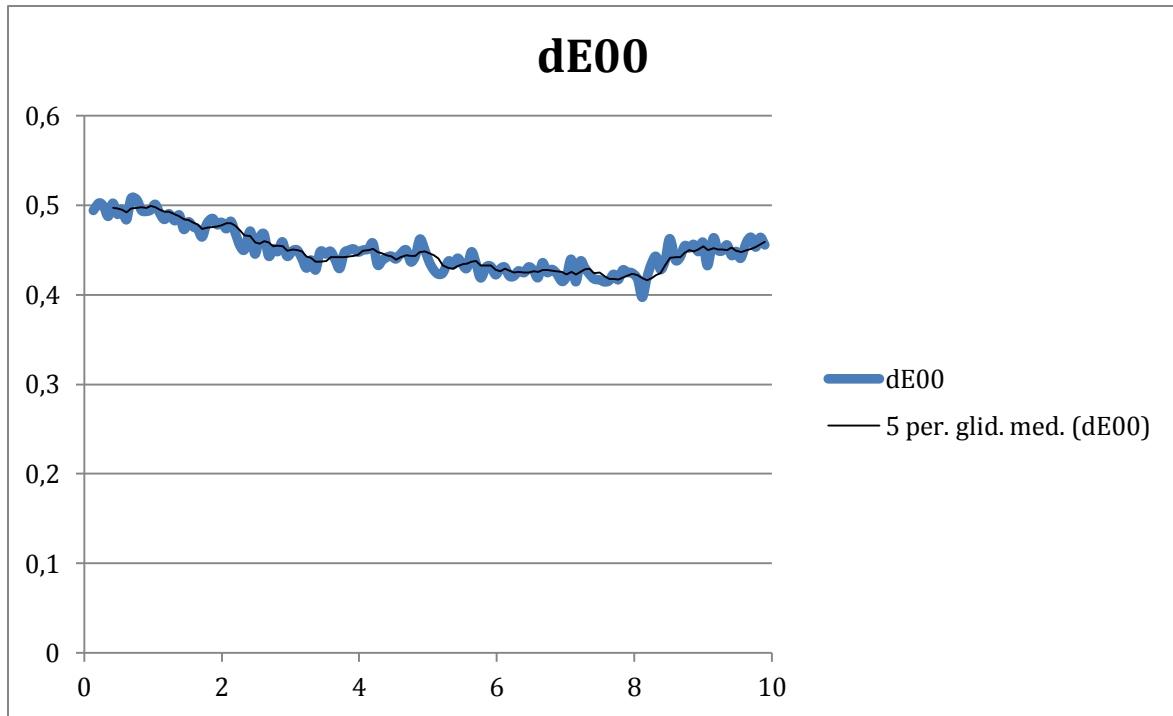
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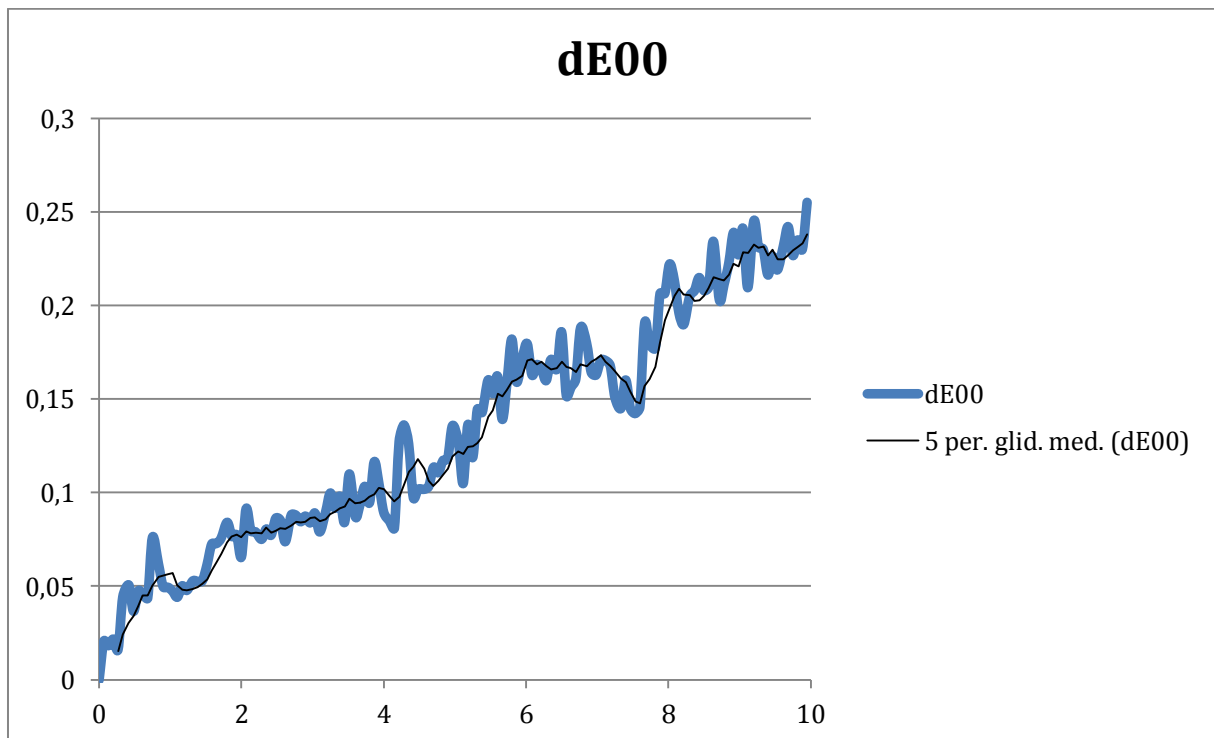
Graph. 3 Conqueror Cyan day 3



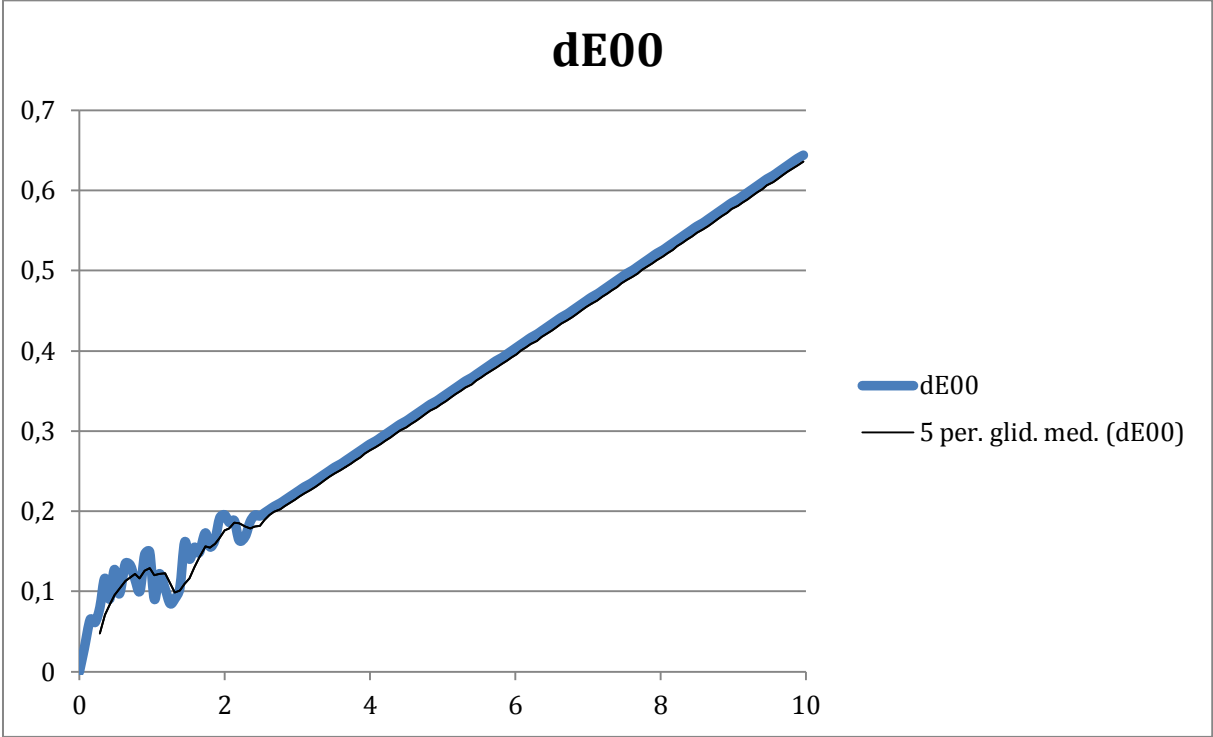
Graph. 4 Conqueror Magenta day 1



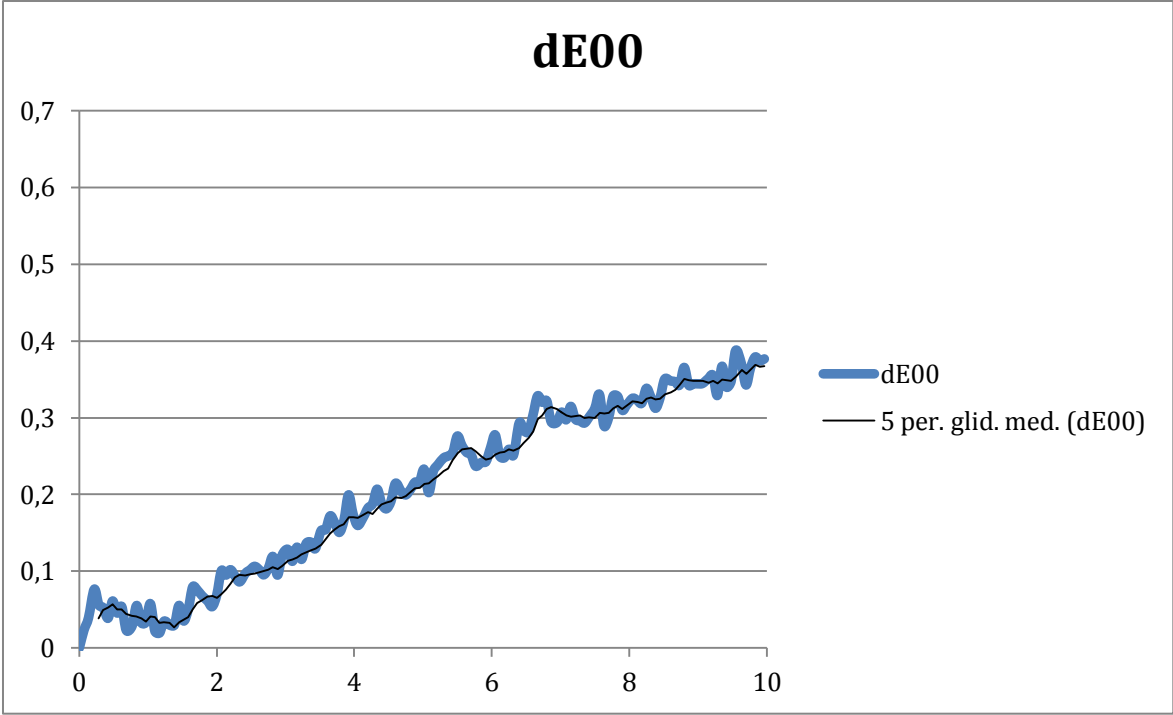
Graph. 5 Conqueror Magenta day 2



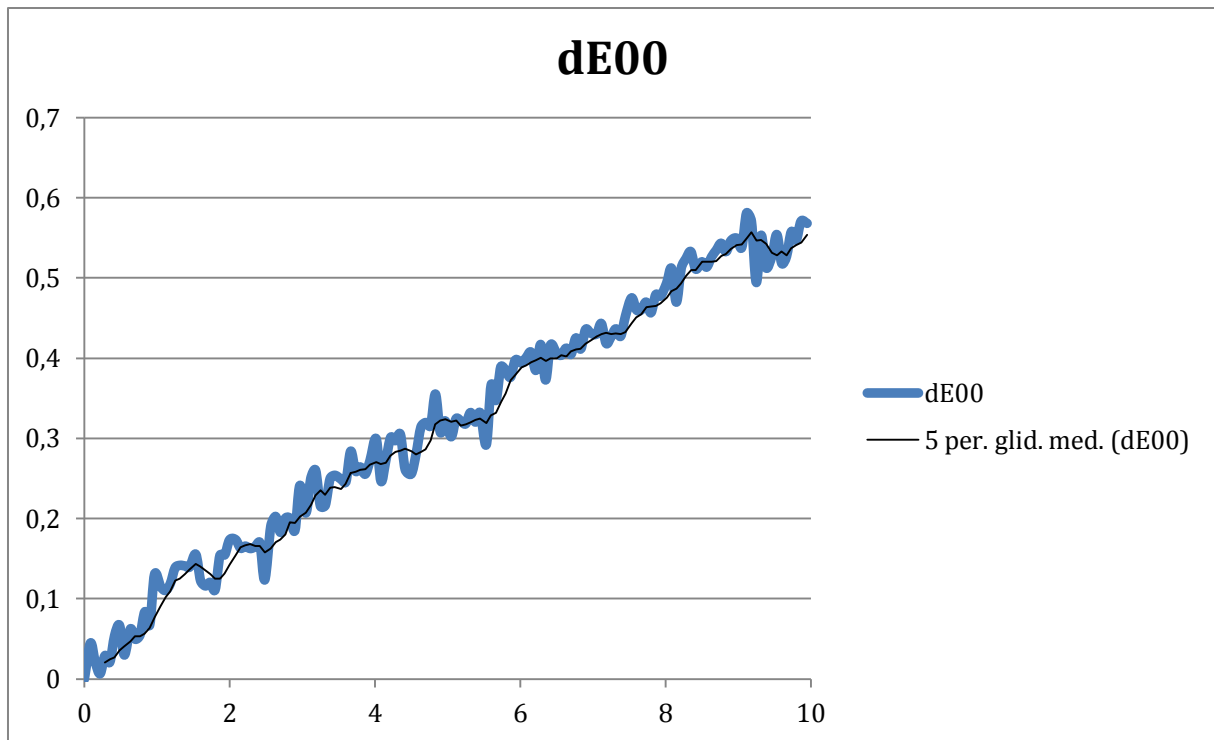
Graph. 6 Conqueror Magenta day 3



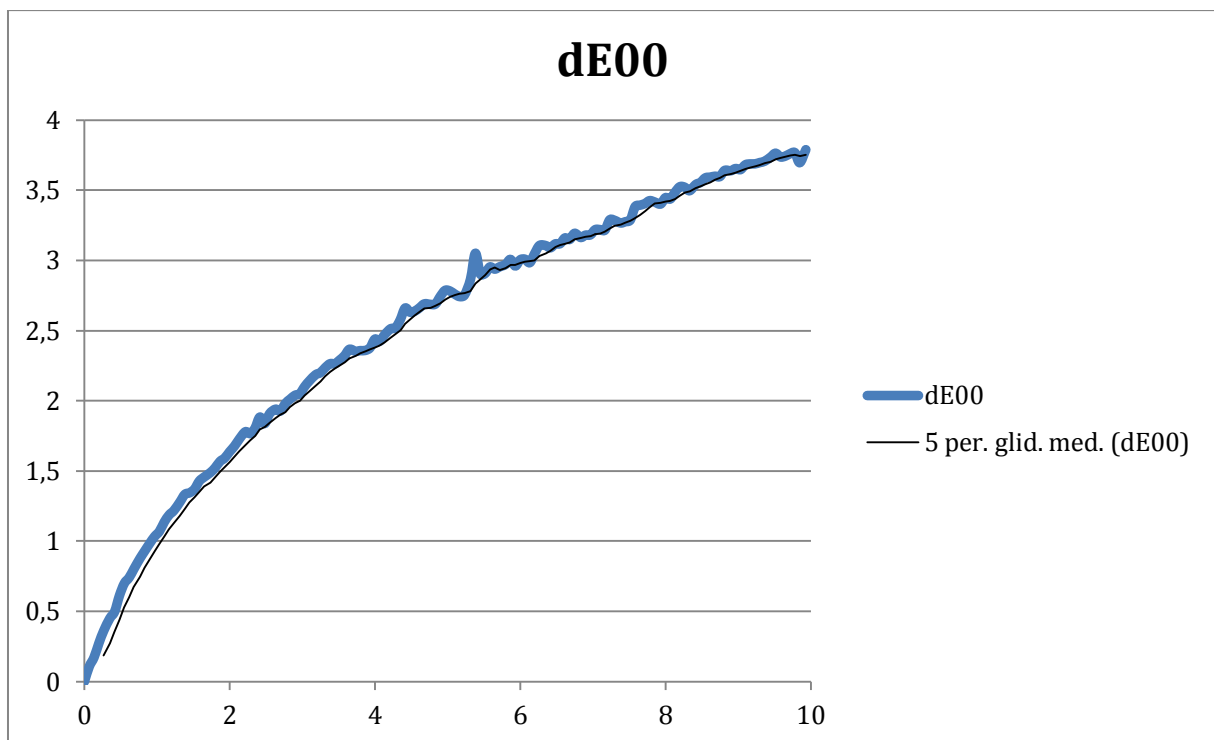
Graph.7 Conqueror Yellow day 1



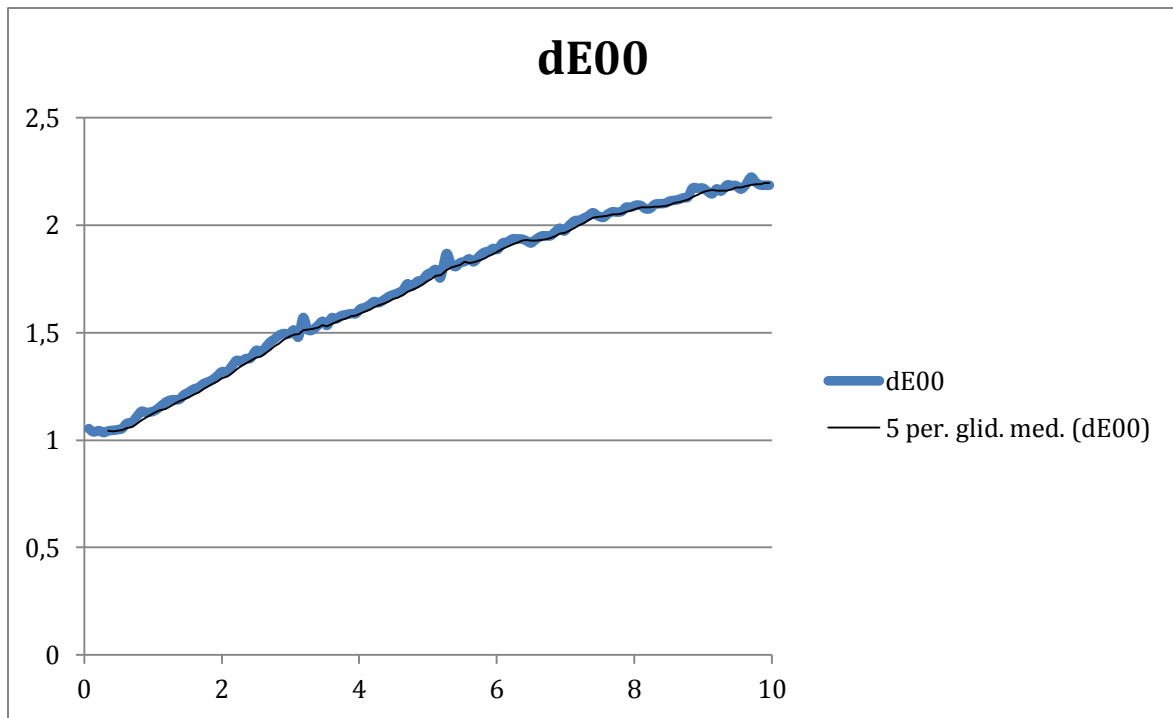
Graph. 8 Conqueror Yellow day 2



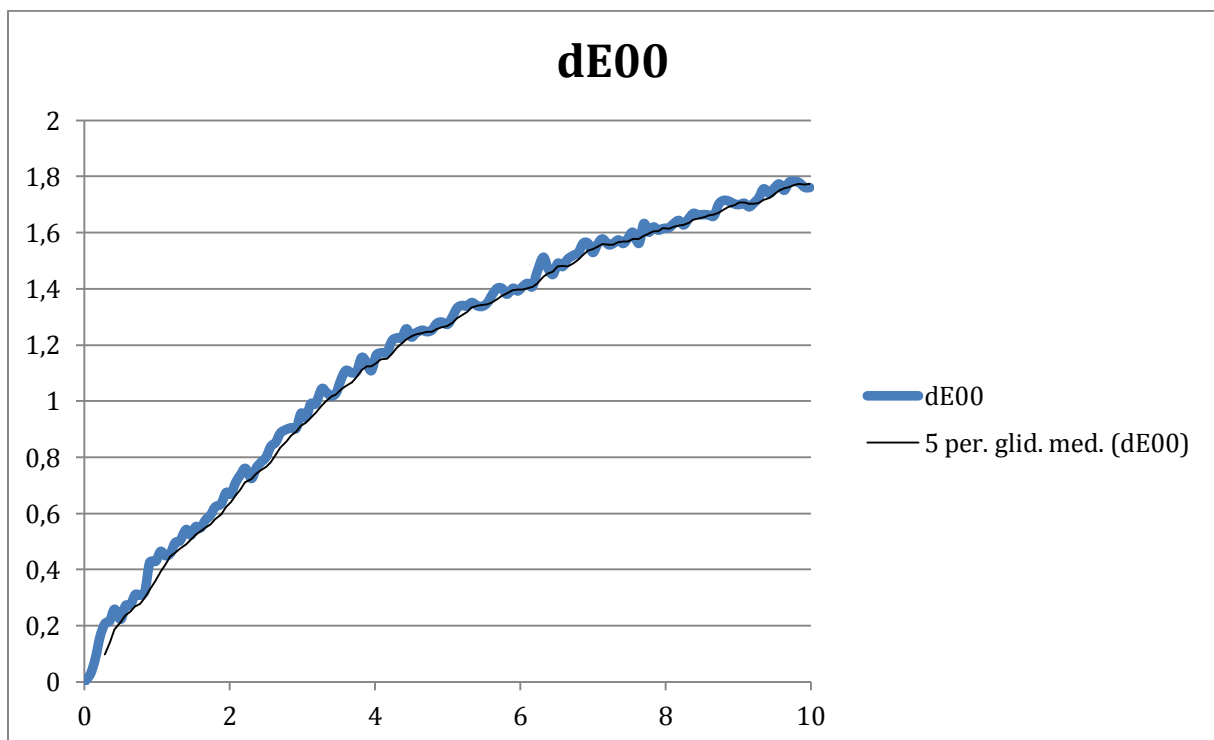
Graph. 9 Conqueror Yellow day 3



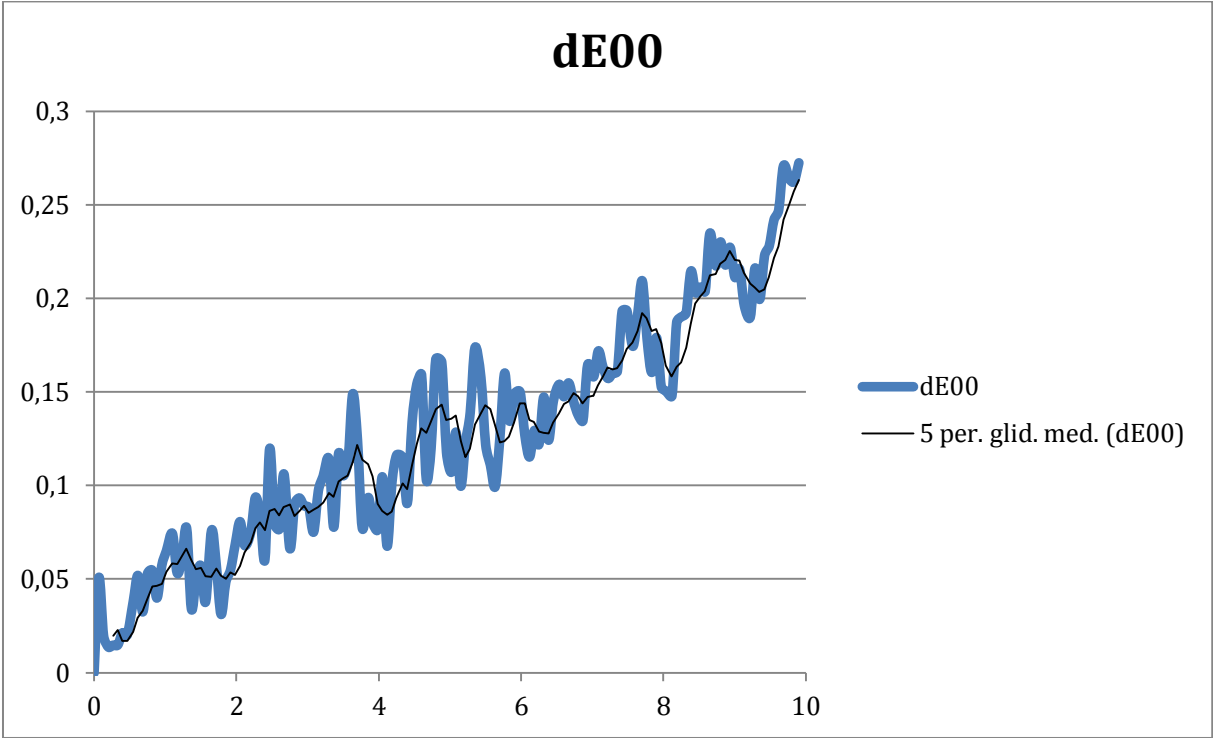
Graph. 10 Svenskt arkiv Cyan day 1



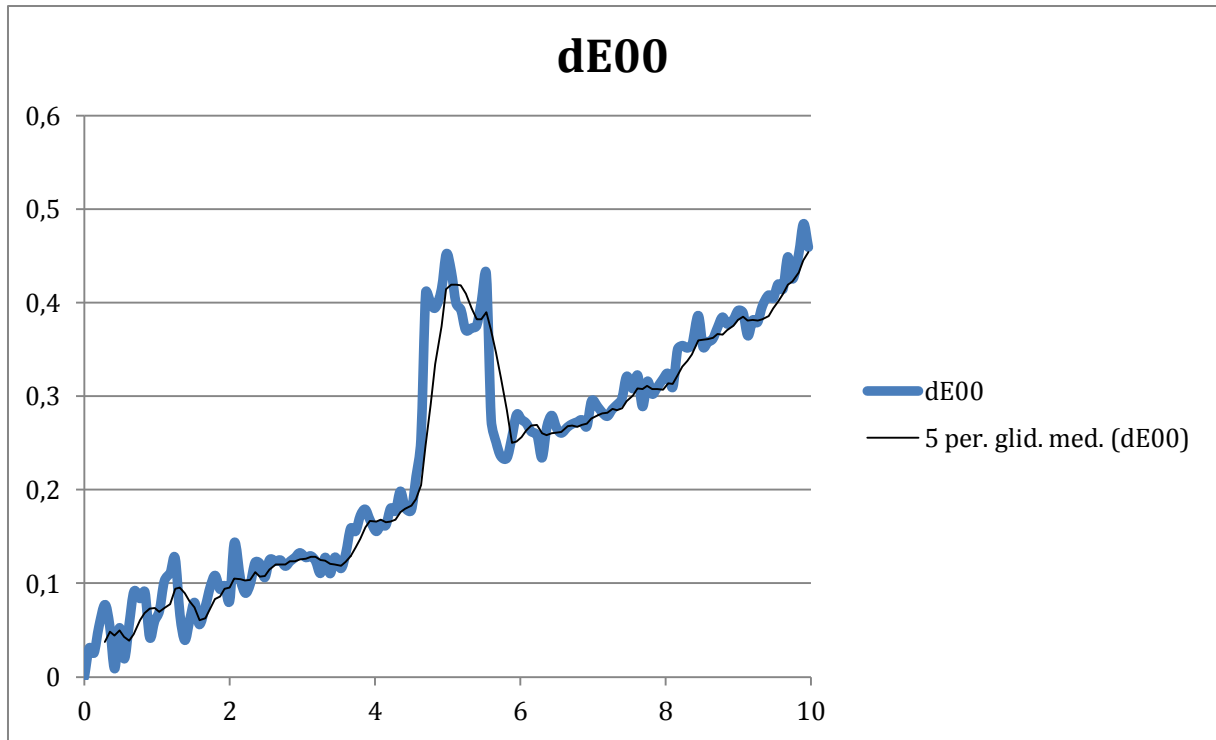
Graph. 11 Svenskt arkiv Cyan day 2



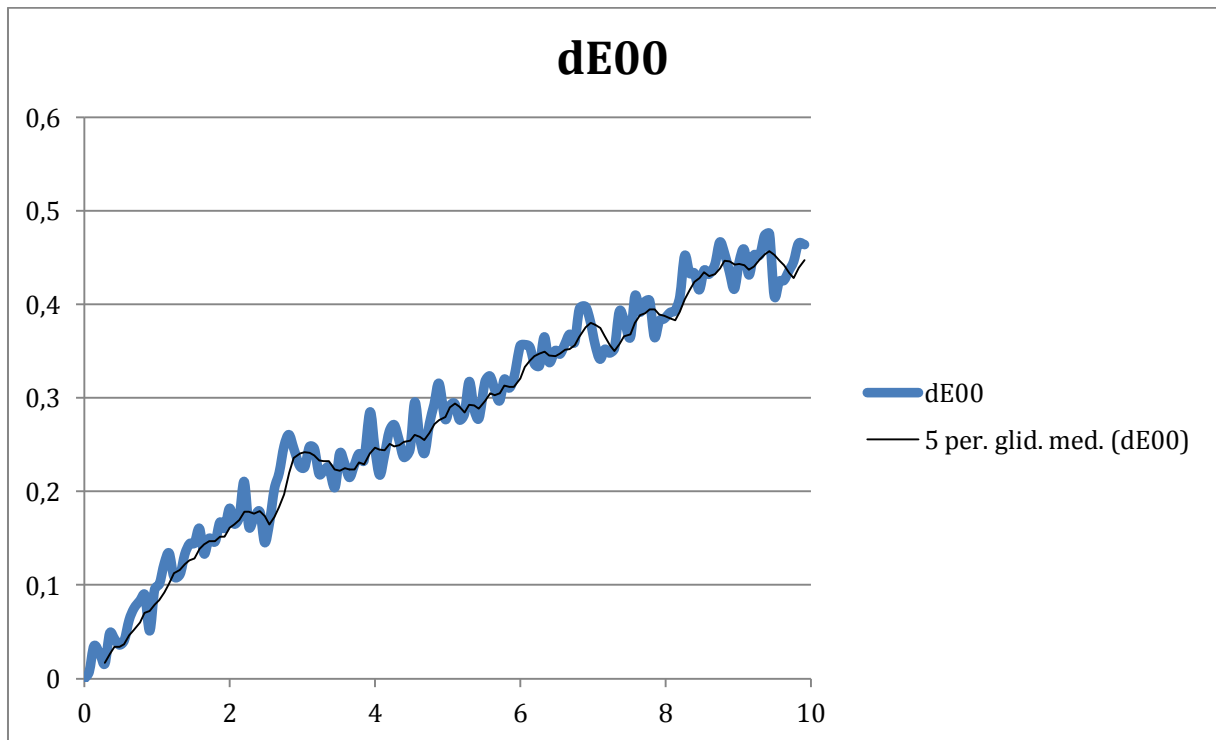
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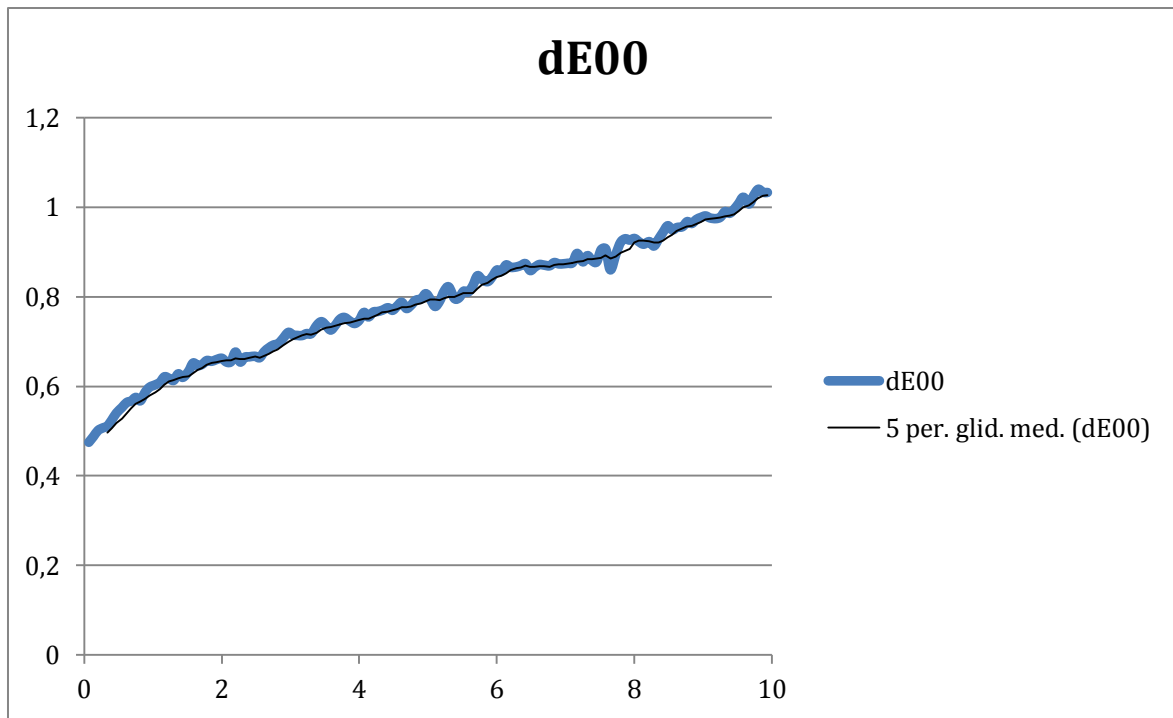
Graph.13 Svenskt arkiv Magenta day 2



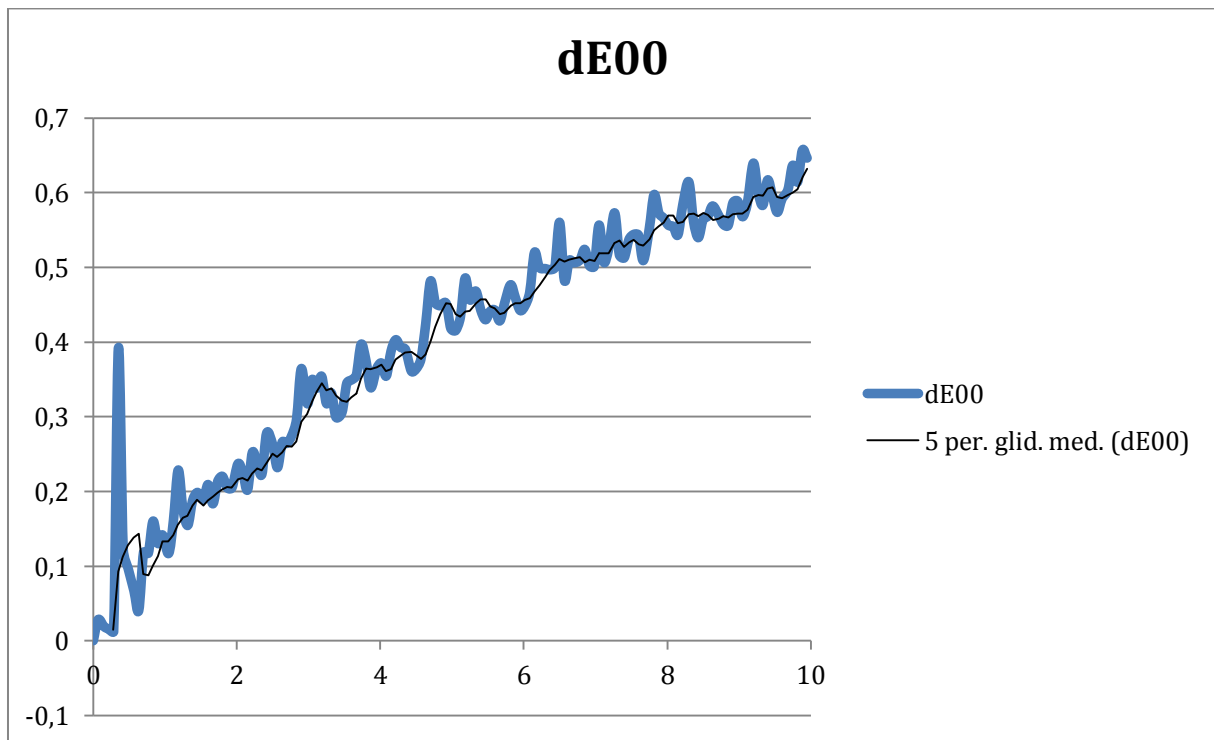
Graph. 14 Svenskt arkiv Magenta day 3



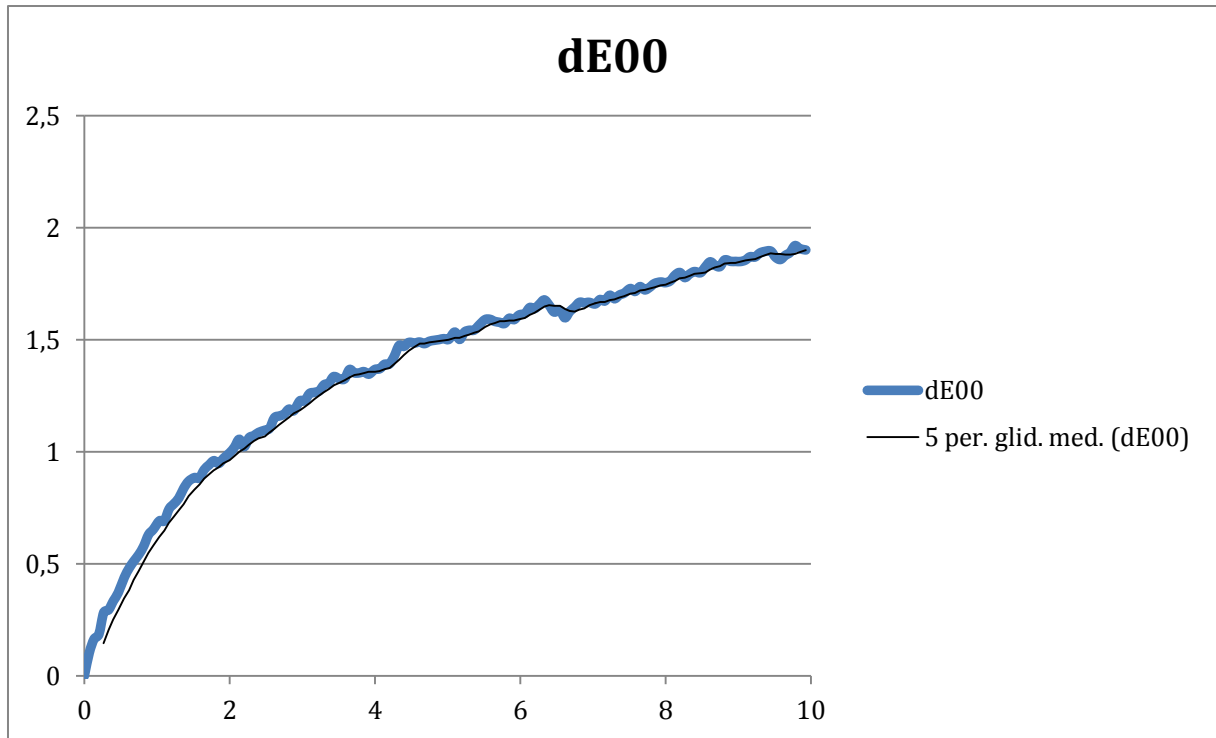
Graph. 15 Svenskt arkiv Yellow day 1



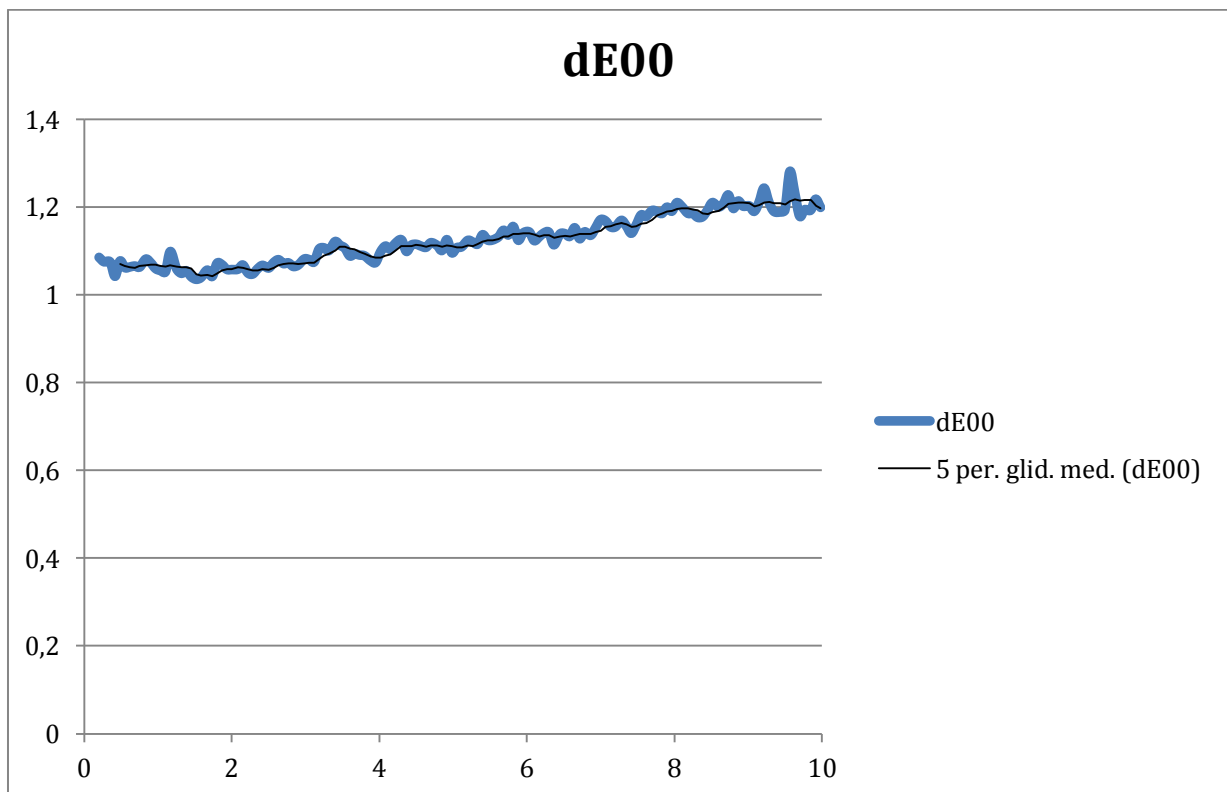
Graph. 16 Svenskt arkiv Yellow day 2



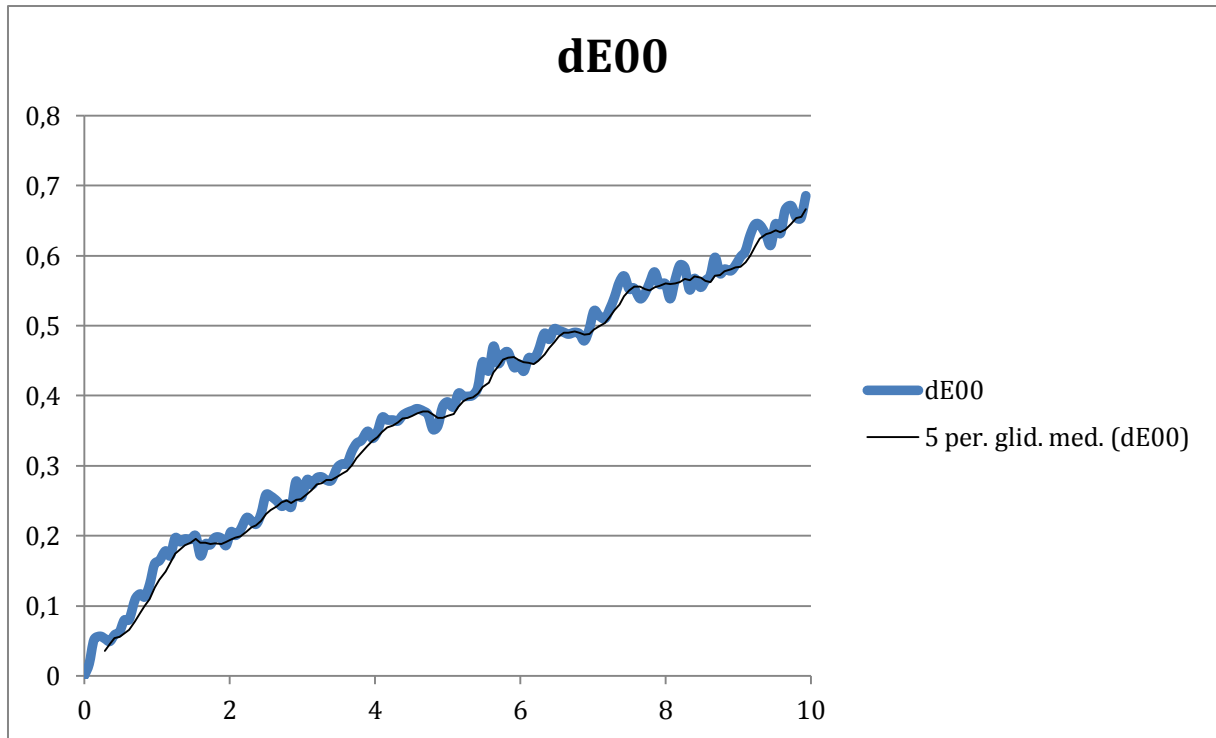
Graph. 17 Svenskt arkiv Yellow day 3



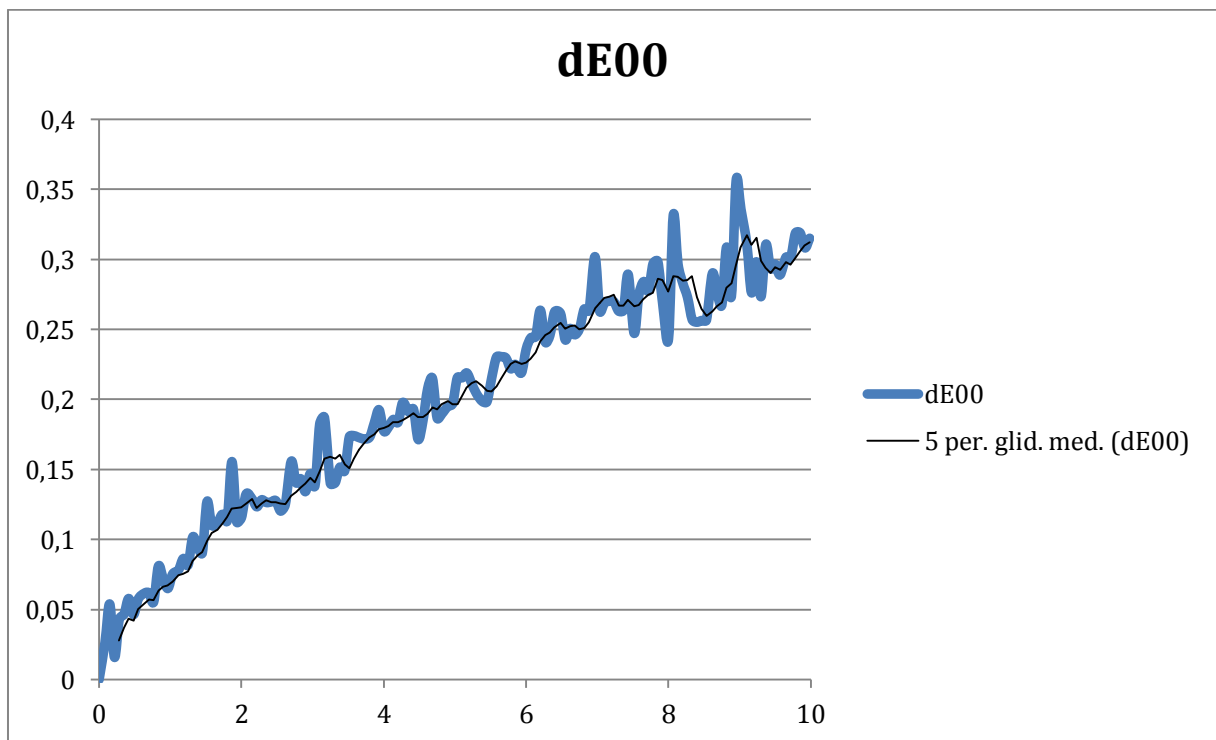
Graph. 18 Mohawk Cyan day 1



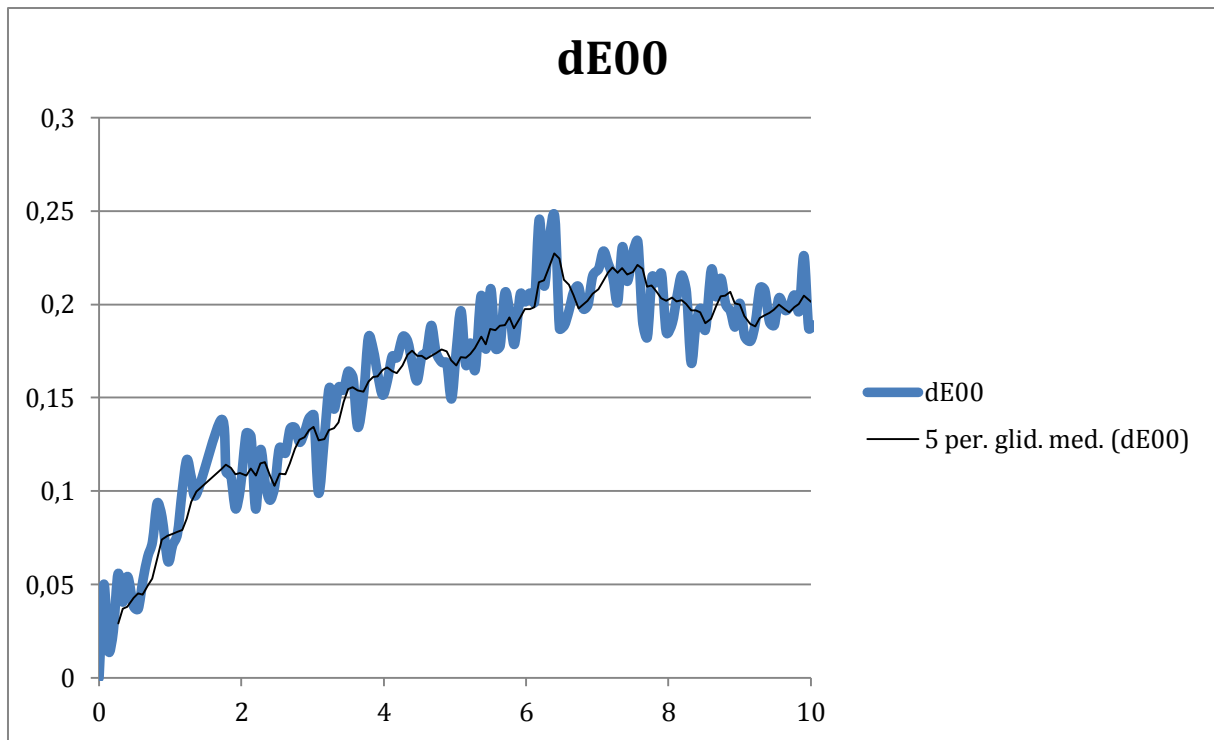
Graph. 19 Mohawk Cyan day 2



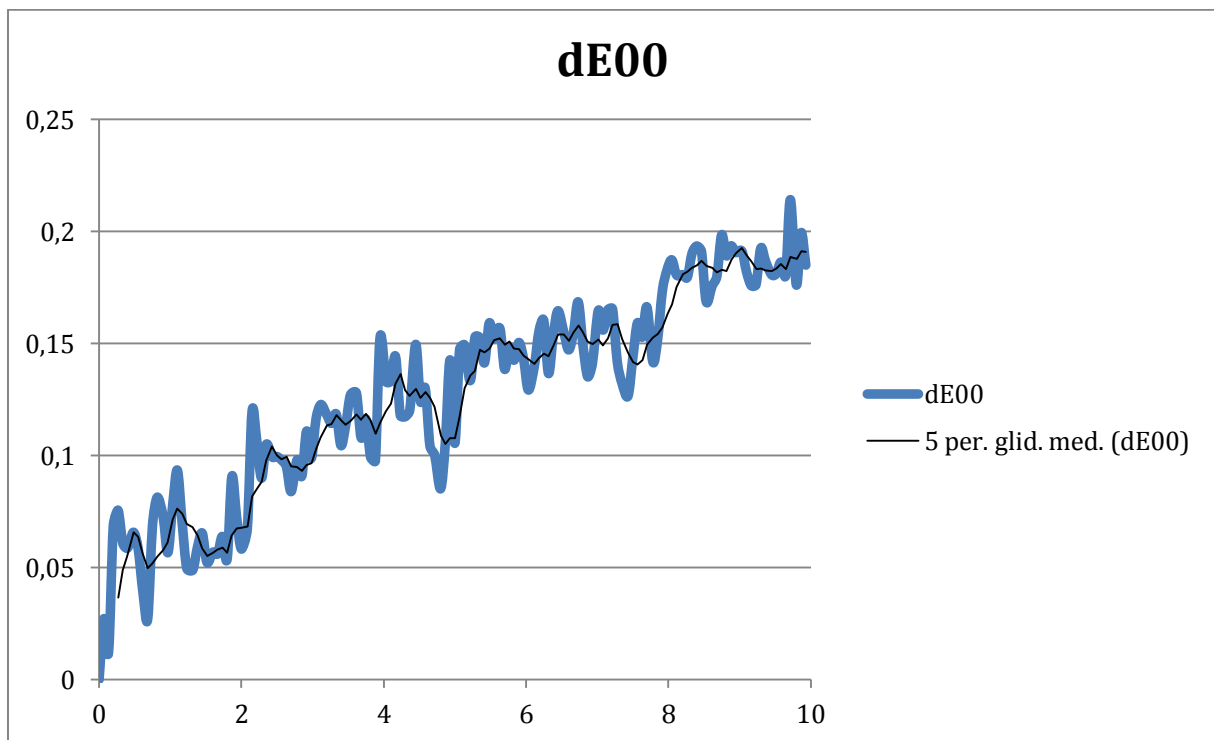
Graph. 20 Mohawk Cyan day 3



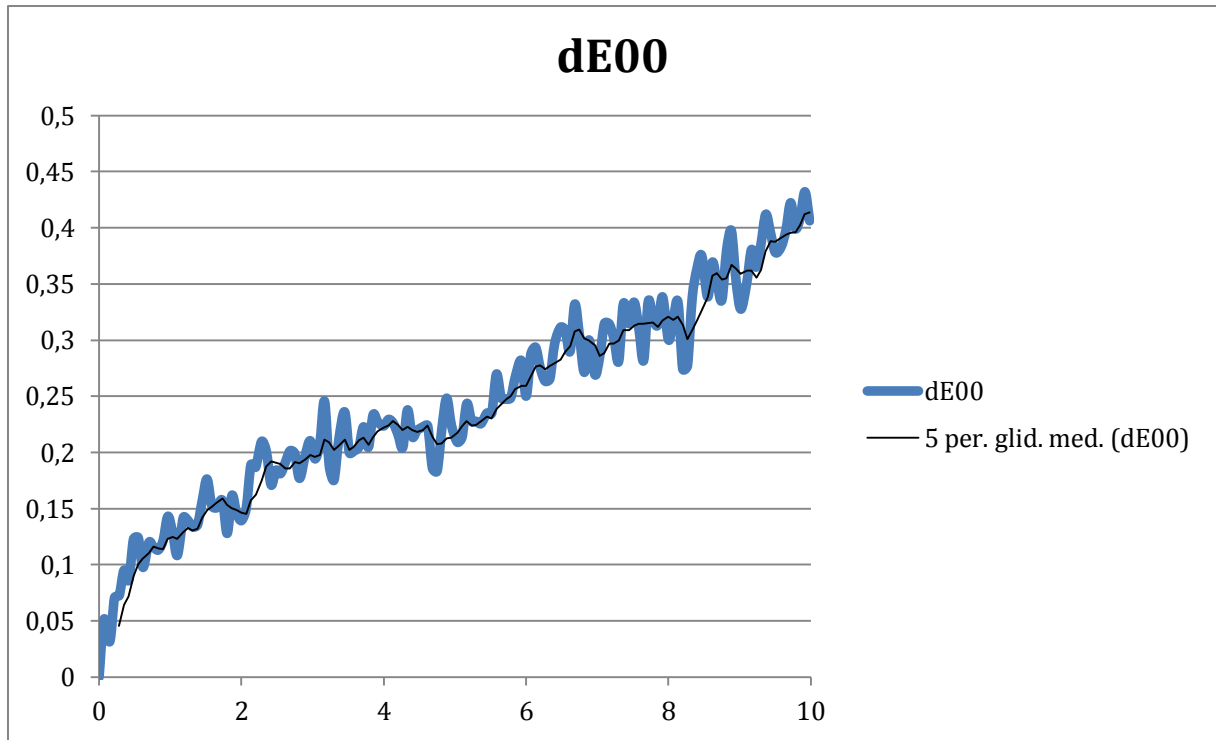
Graph. 21 Mohawk Magenta day 1



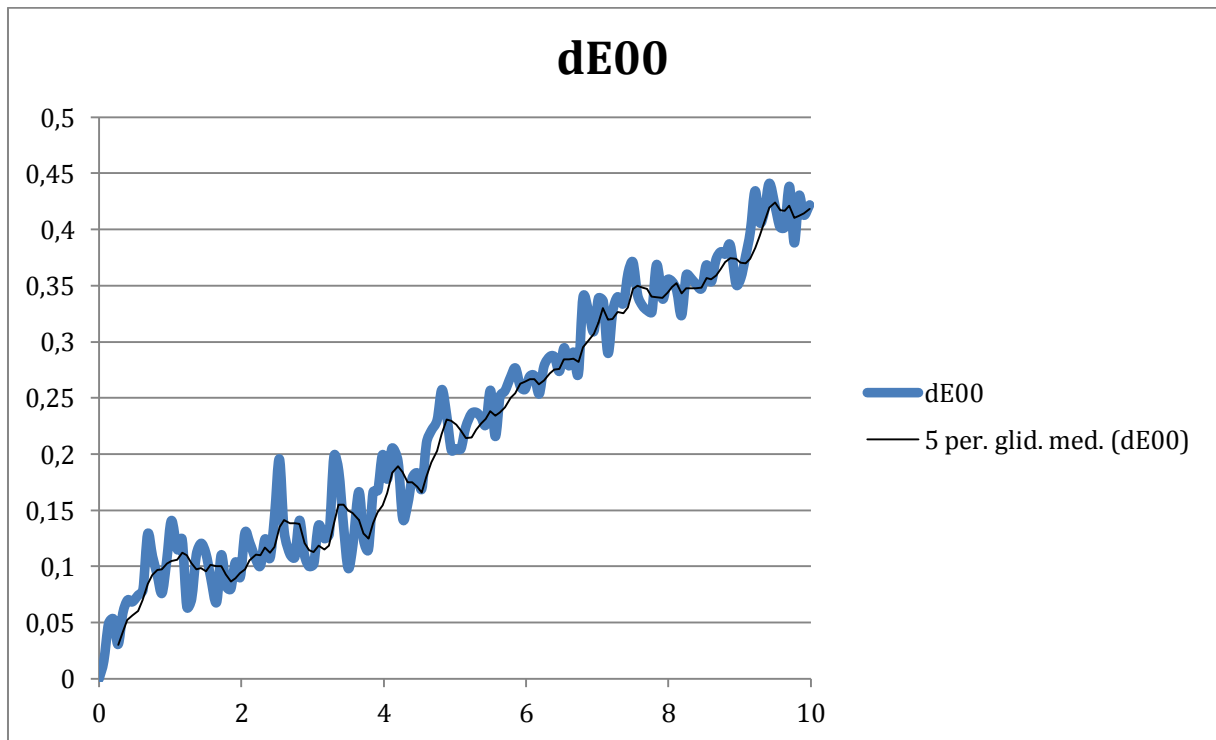
Graph. 22 Mohawk Magenta day 2



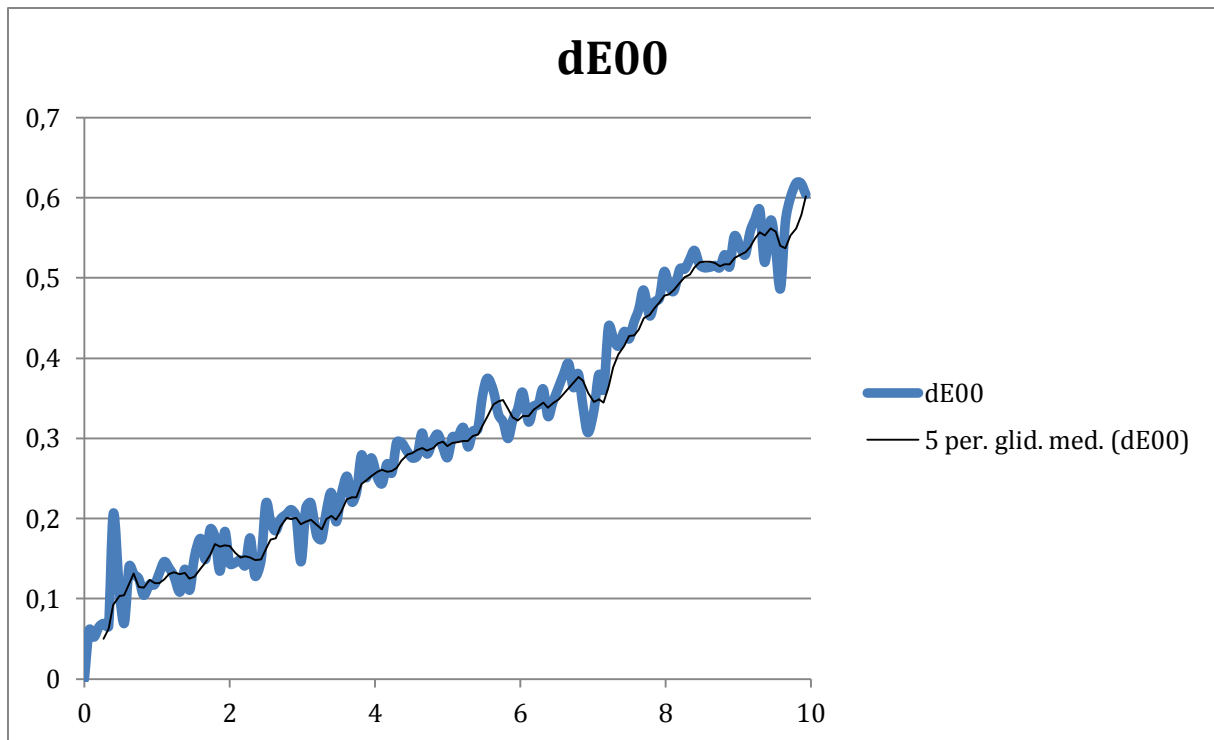
Graph. 23 Mohawk Magenta day 3



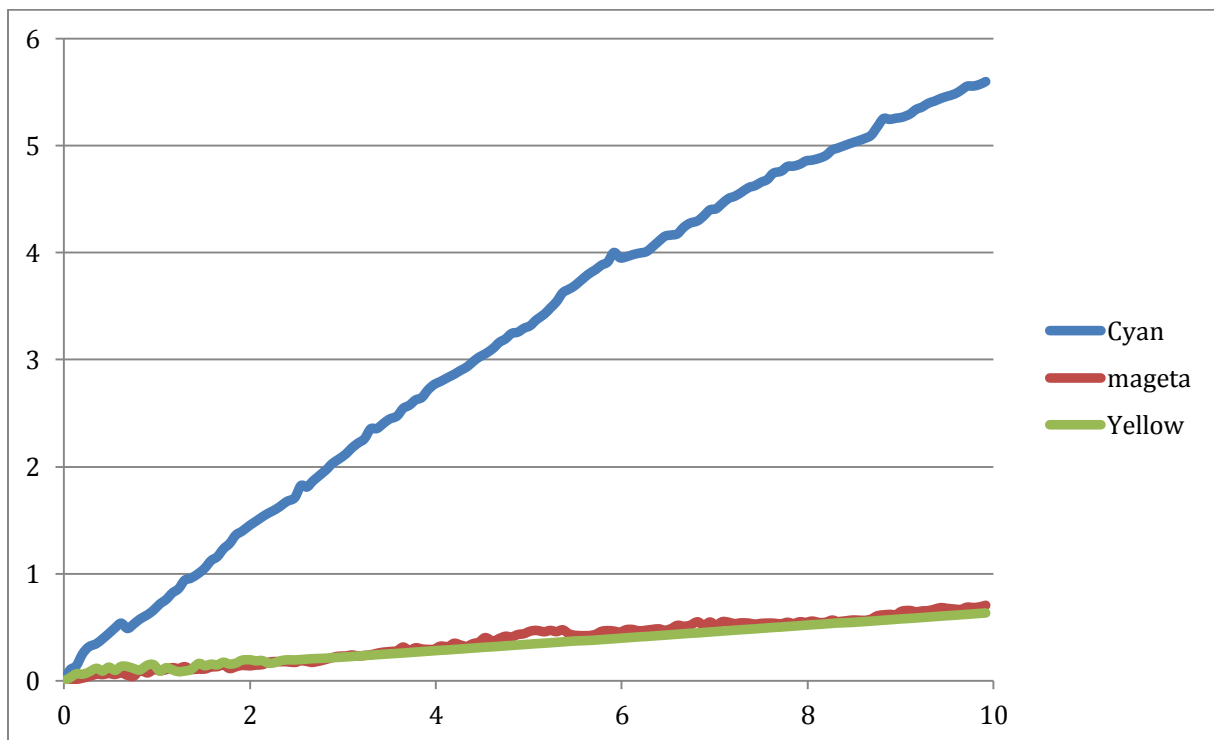
Graph. 24 Mohawk Yellow day 1



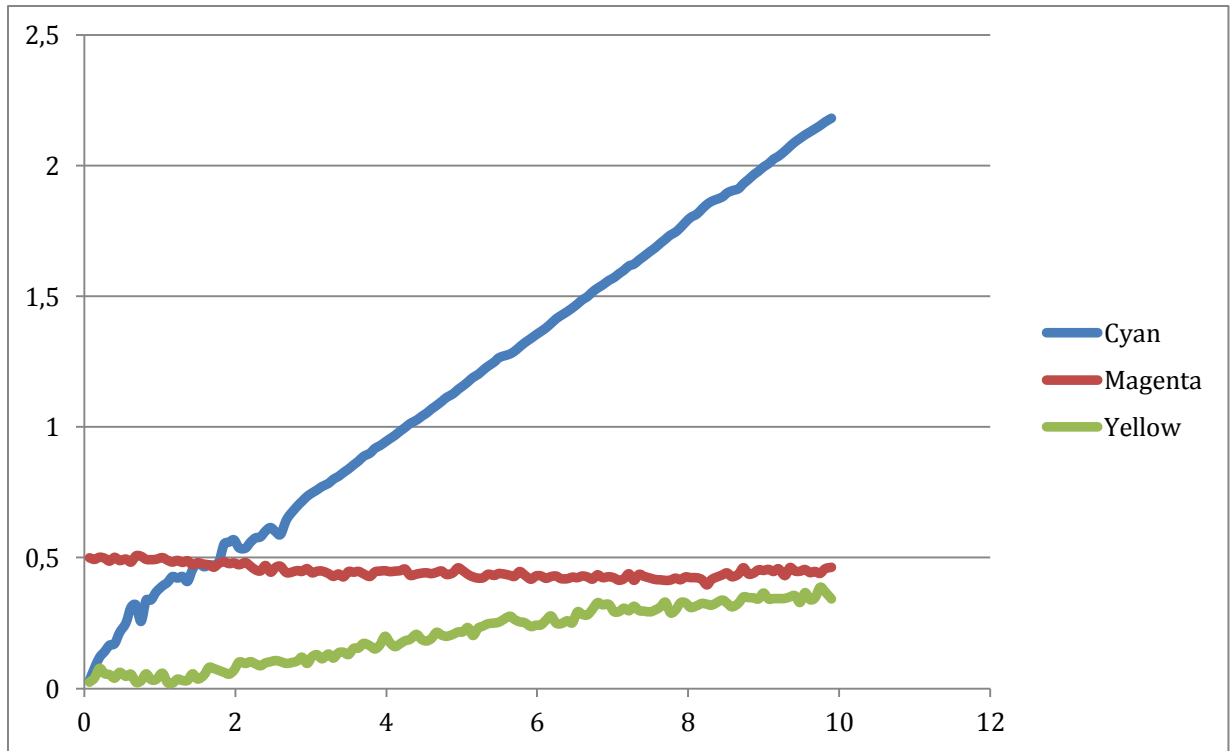
Graph. 25 Mohawk Yellow day 2



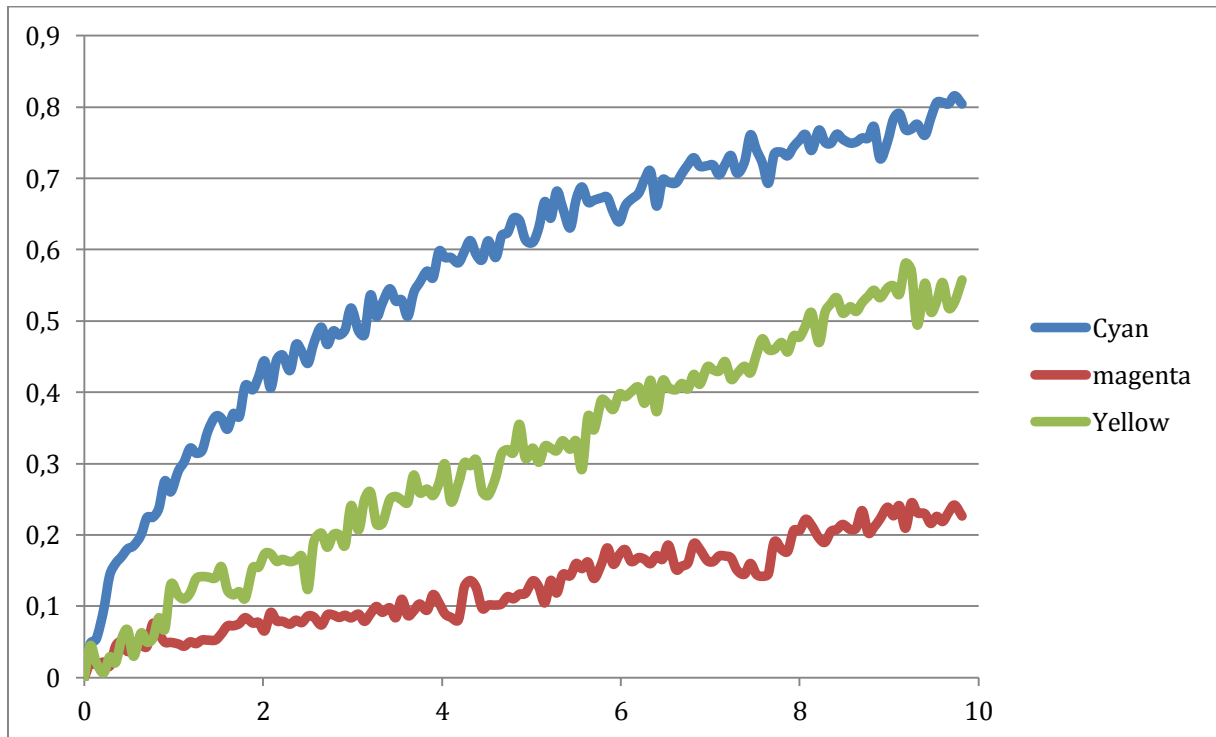
Graph. 26 Mohawk Yellow day 3



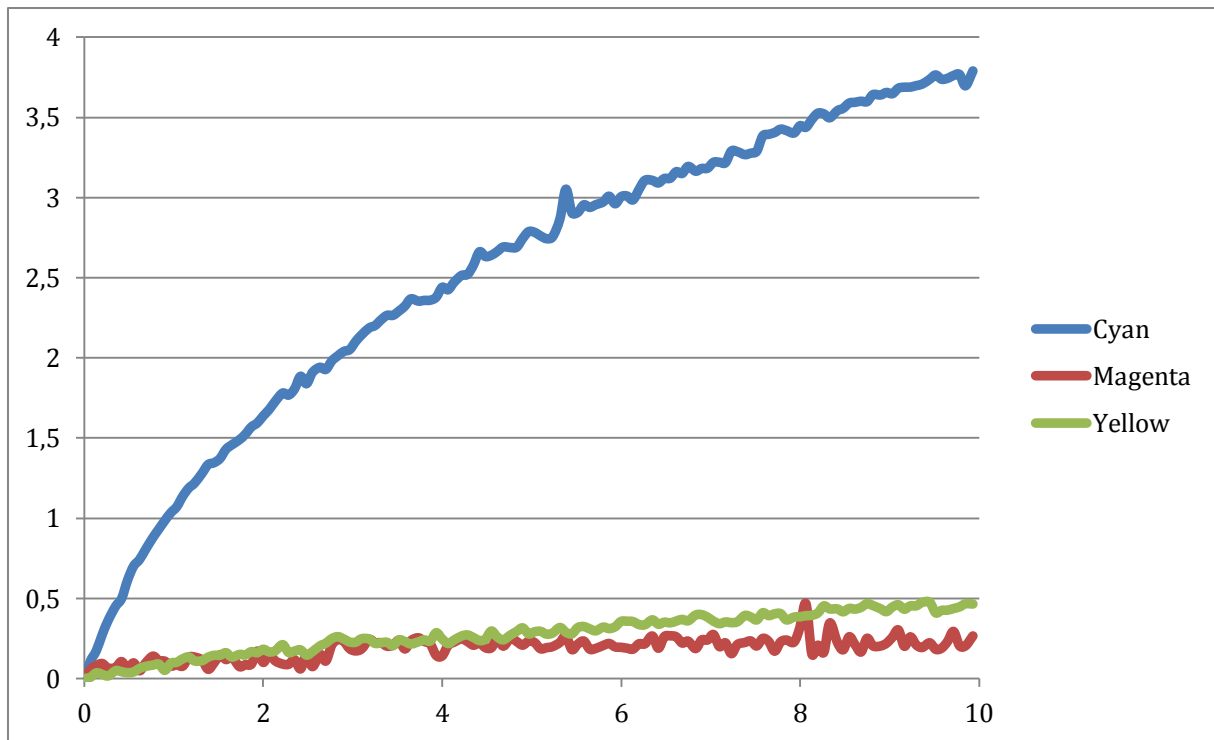
Graph. 27 Conqueror day 1



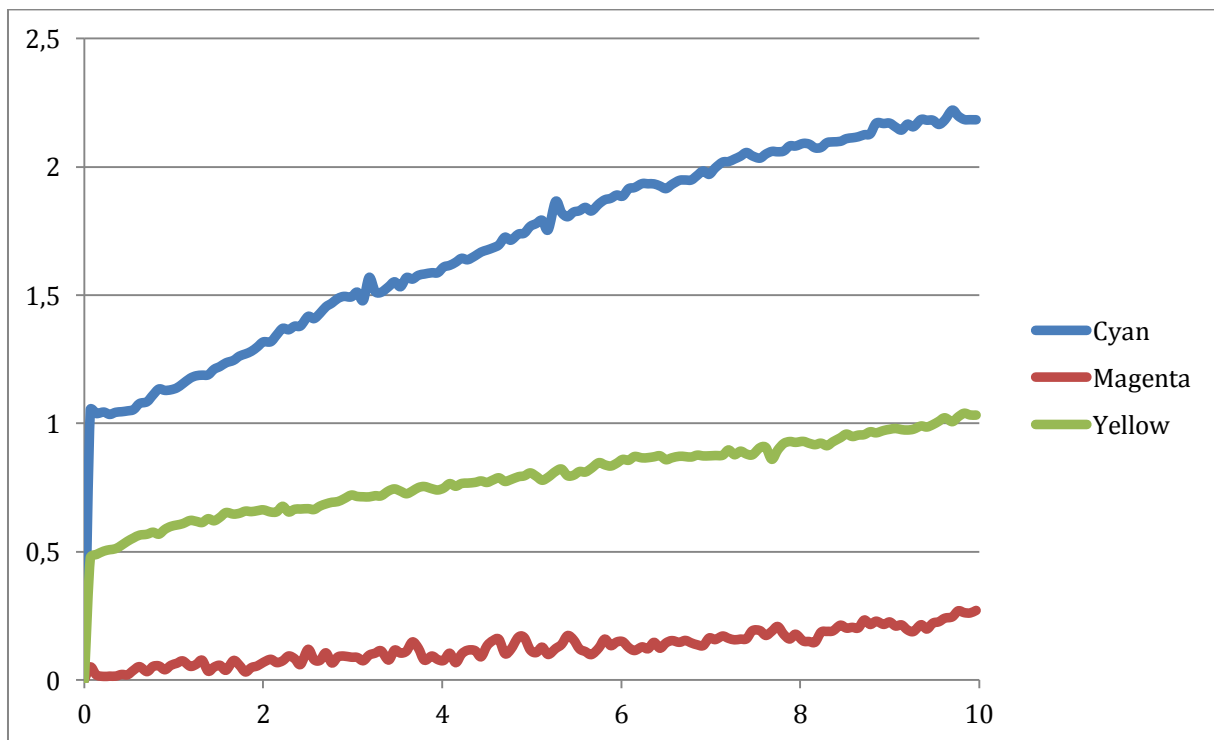
Graph. 28 Conqueror day 2



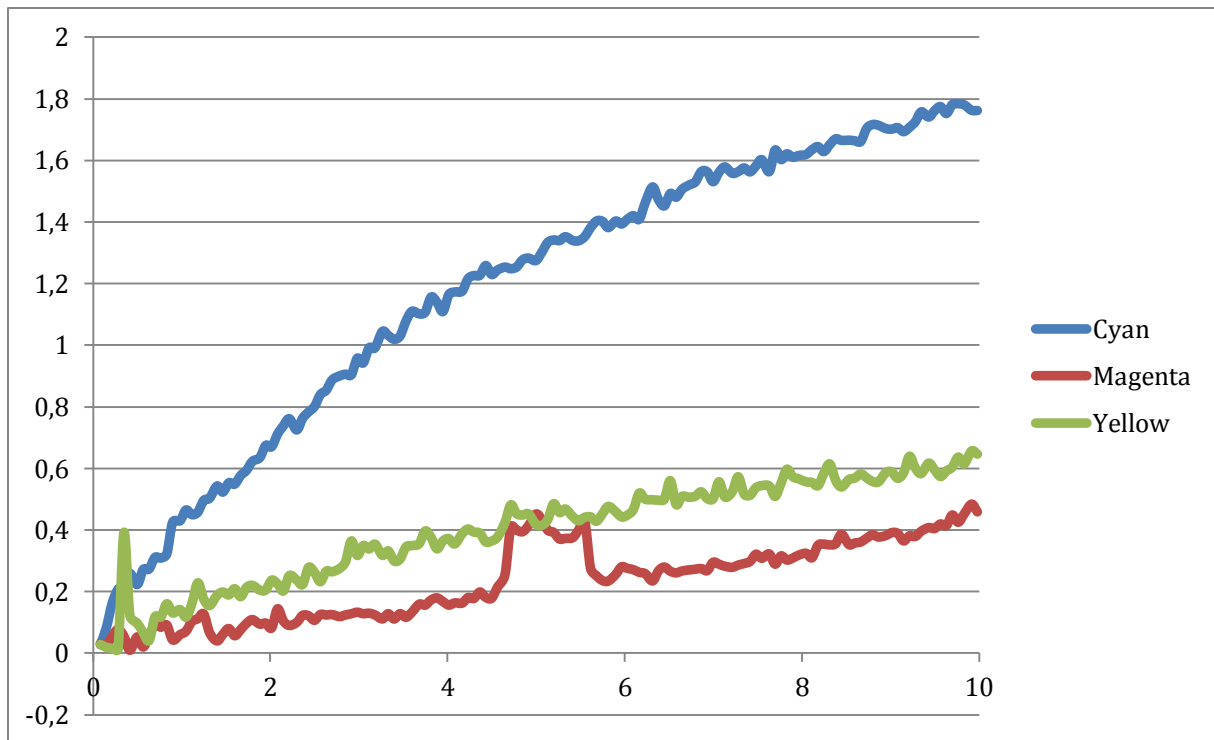
Graph. 29 Conqueror day 3



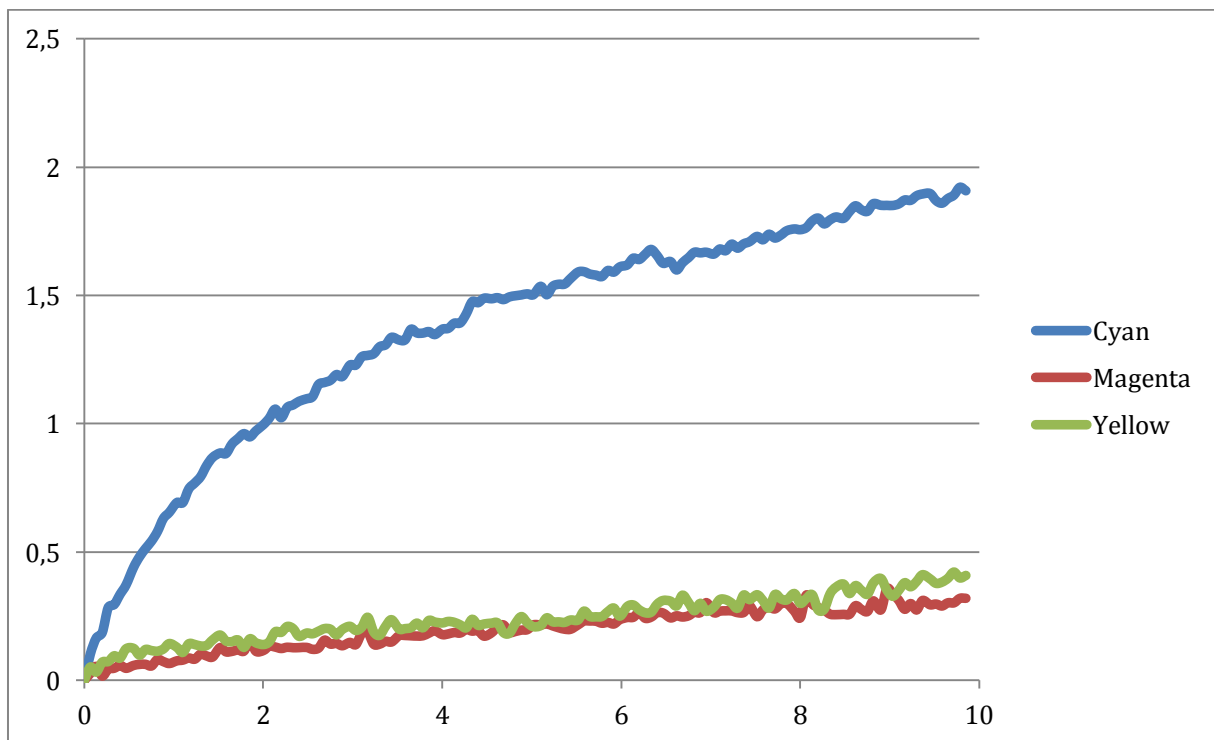
Graph. 30 Svenskt arkiv day 1



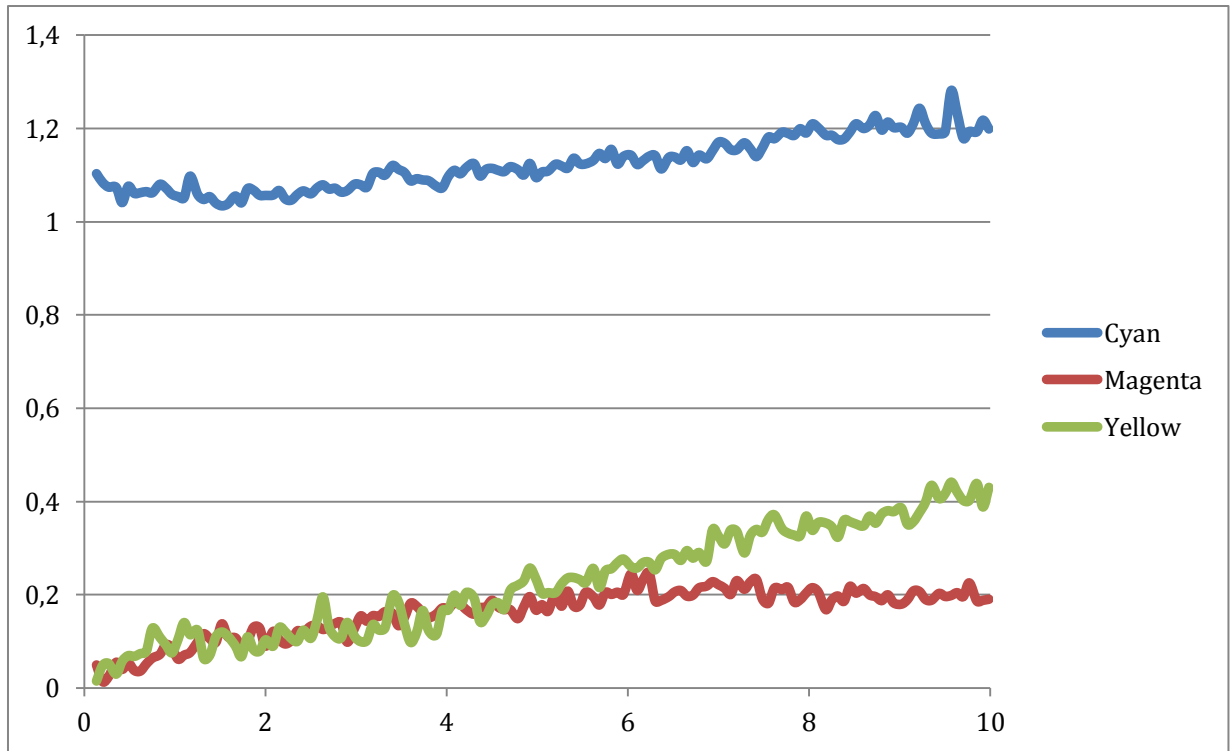
Graph. 31 Svenskt arkiv day 2



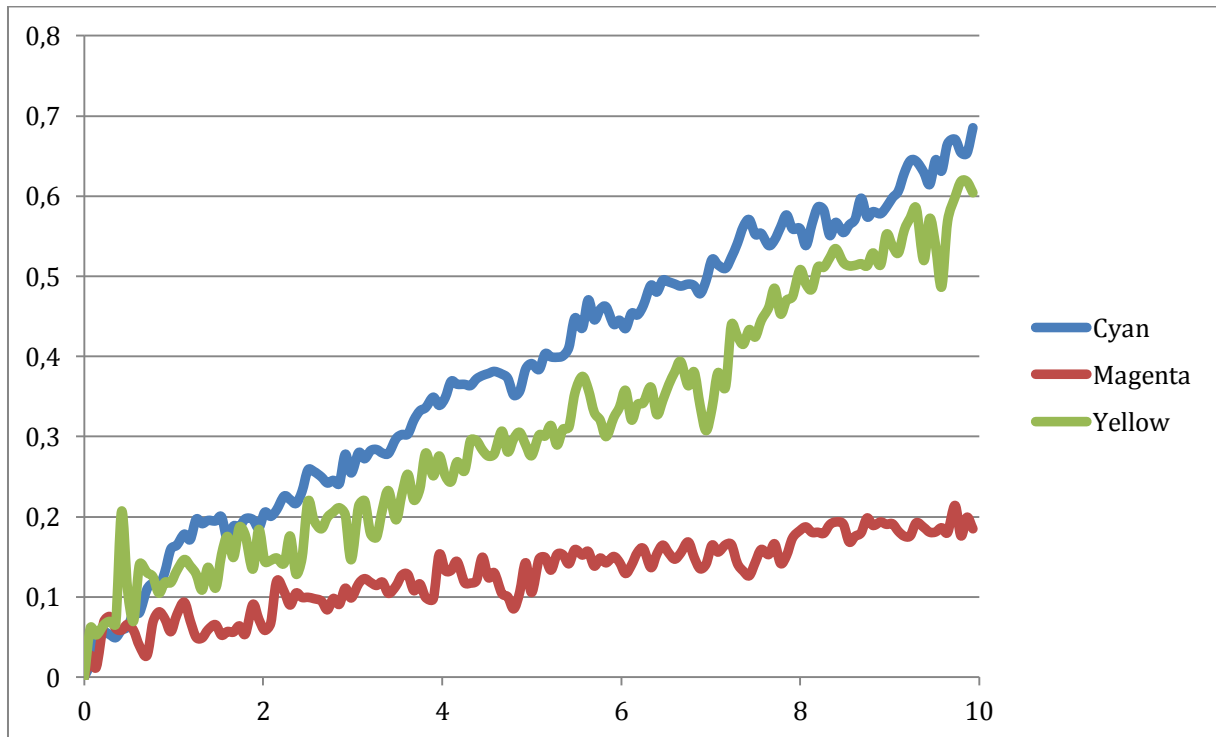
Graph. 32 Svenskt arkiv day 3



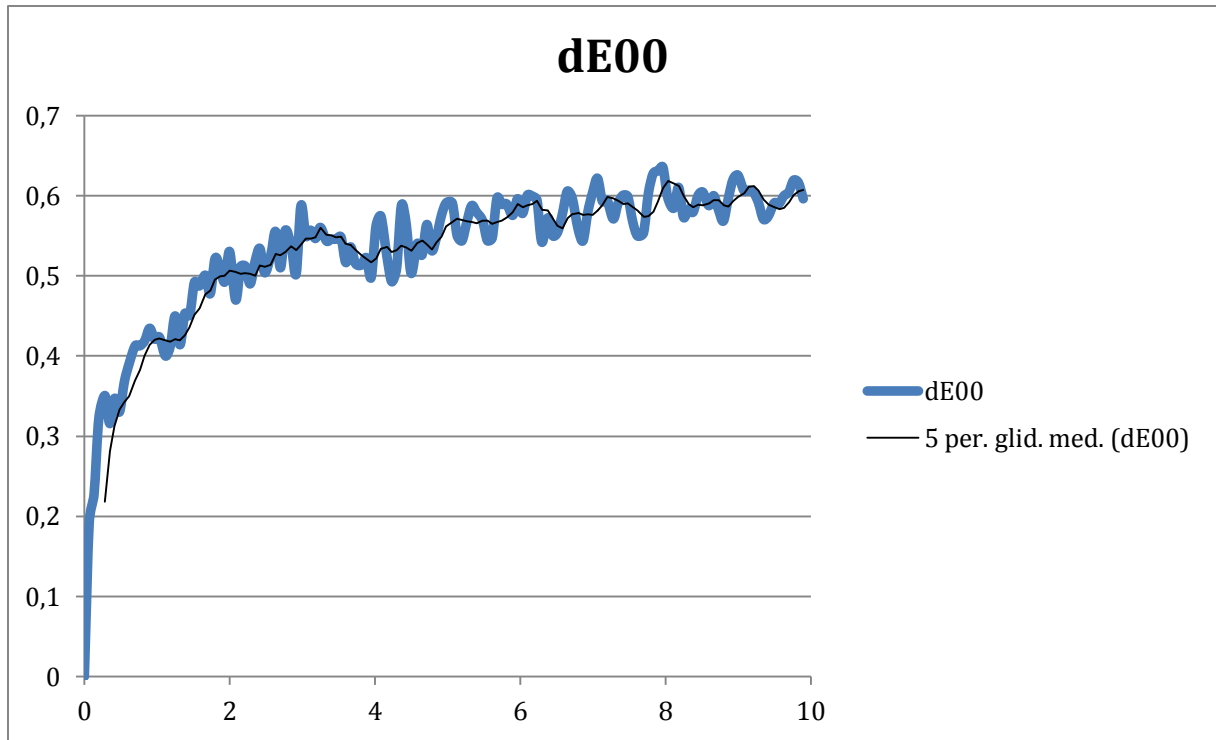
Graph. 33 Mohawk day 1



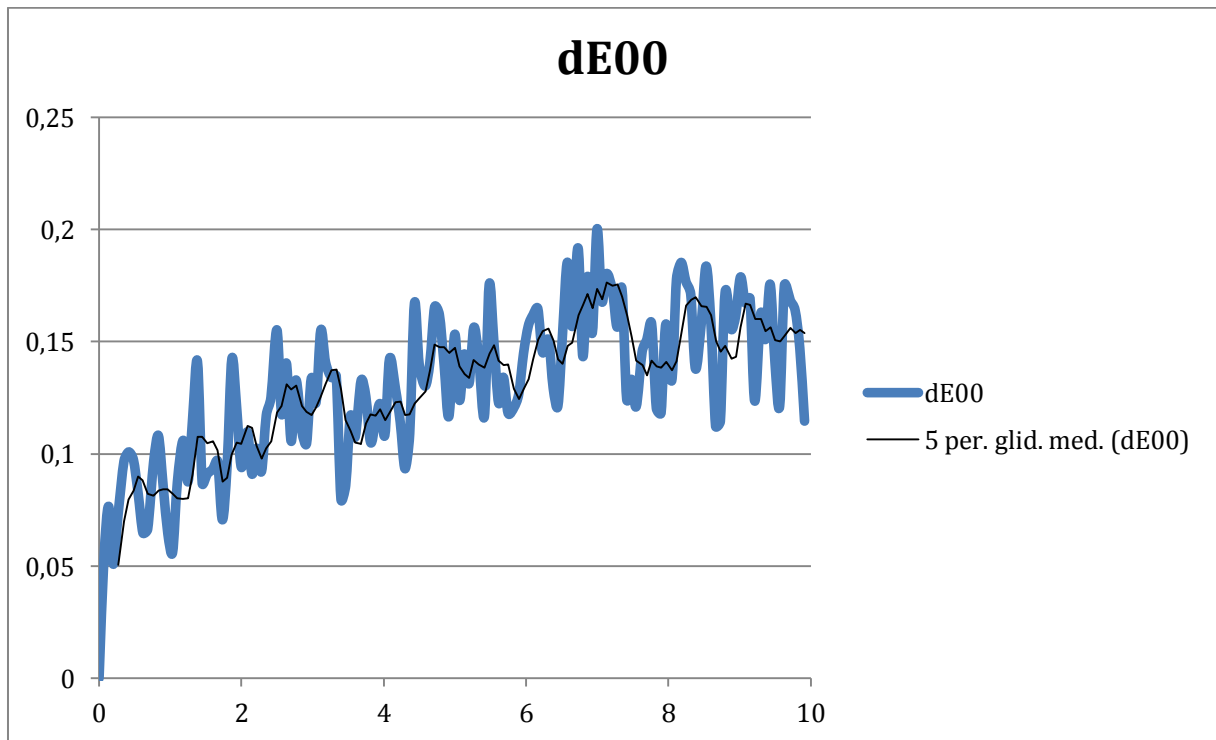
Graph. 34 Mohawk day 2



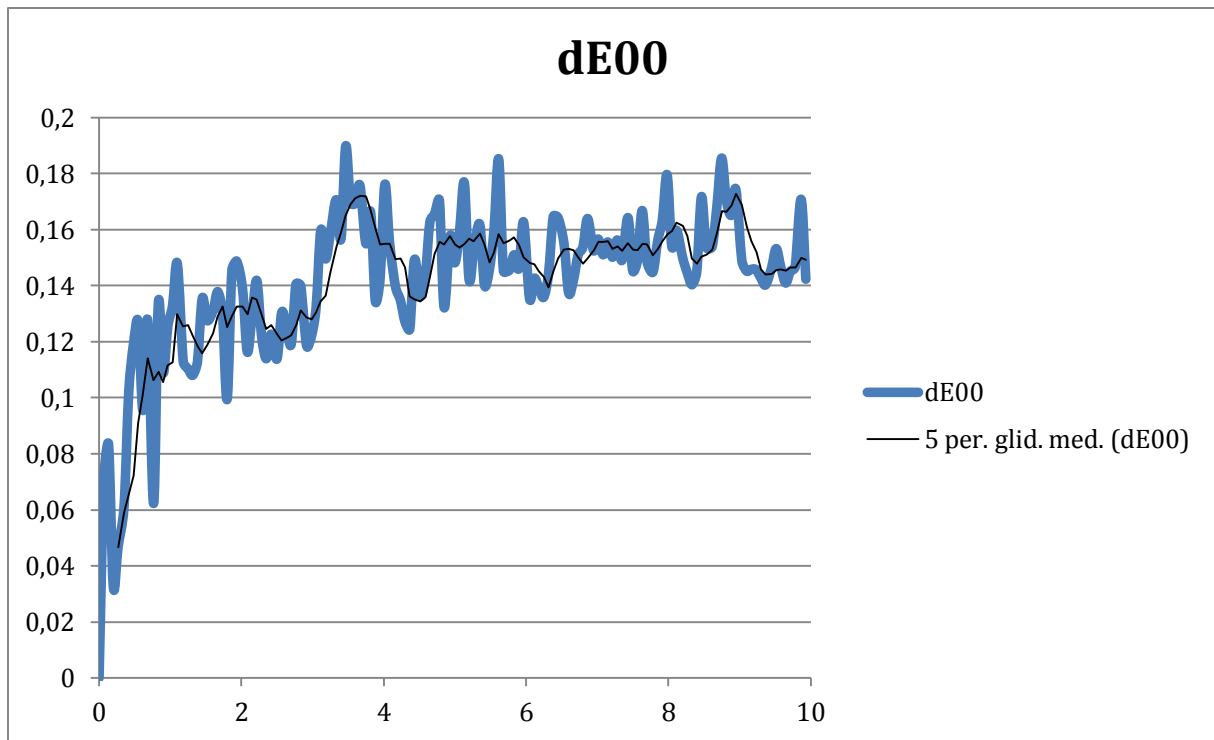
Graph. 35 Mohawk day 3 1



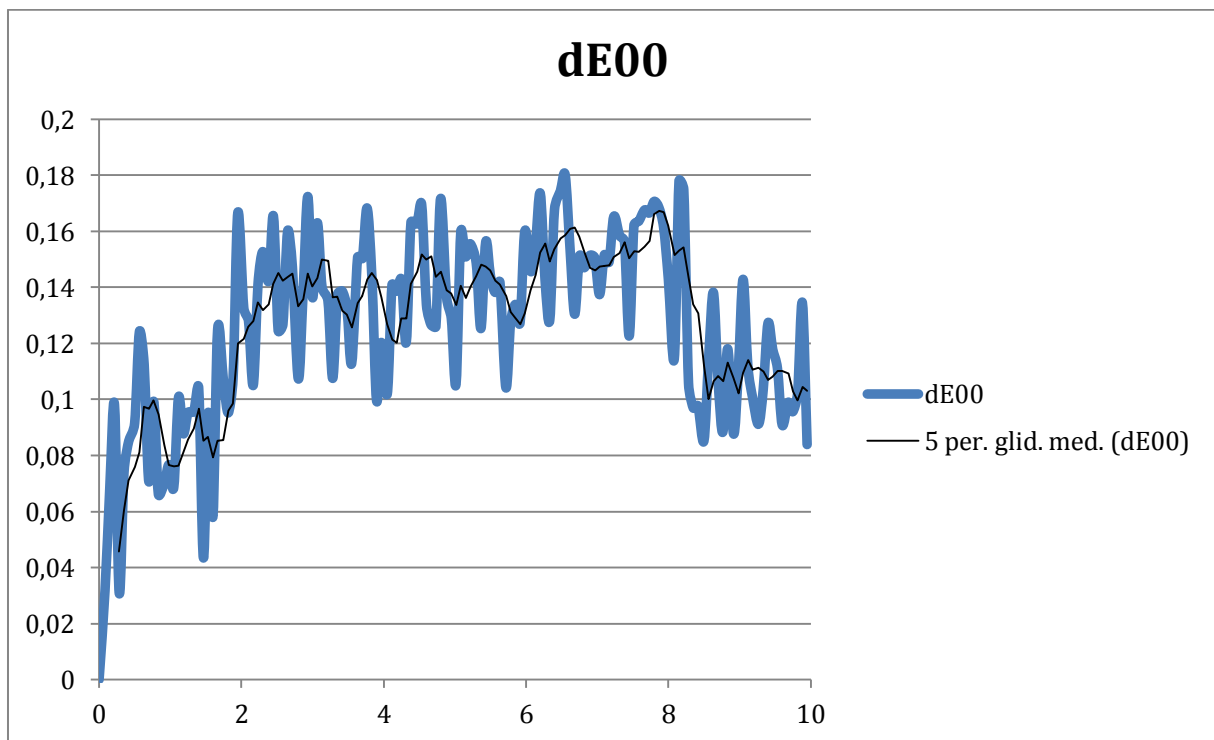
Graph. 36 Reference cyan 100% saturation



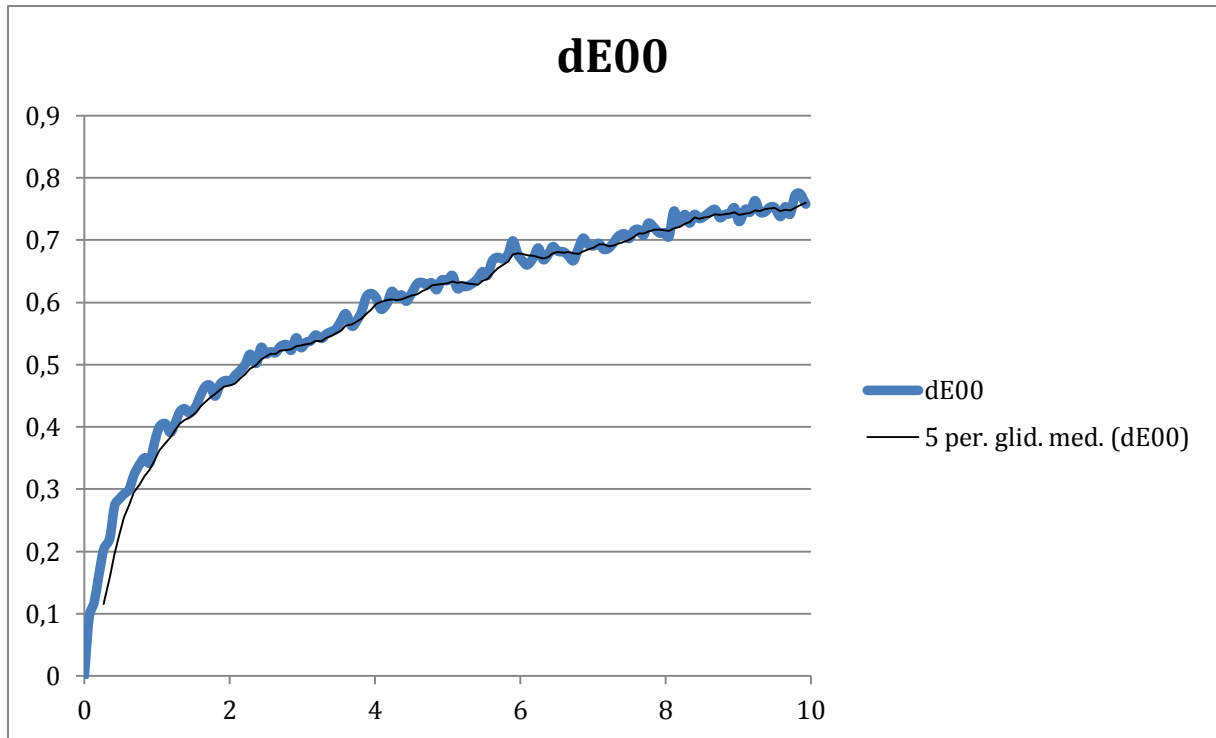
Graph. 37 Reference cyan 50% saturation



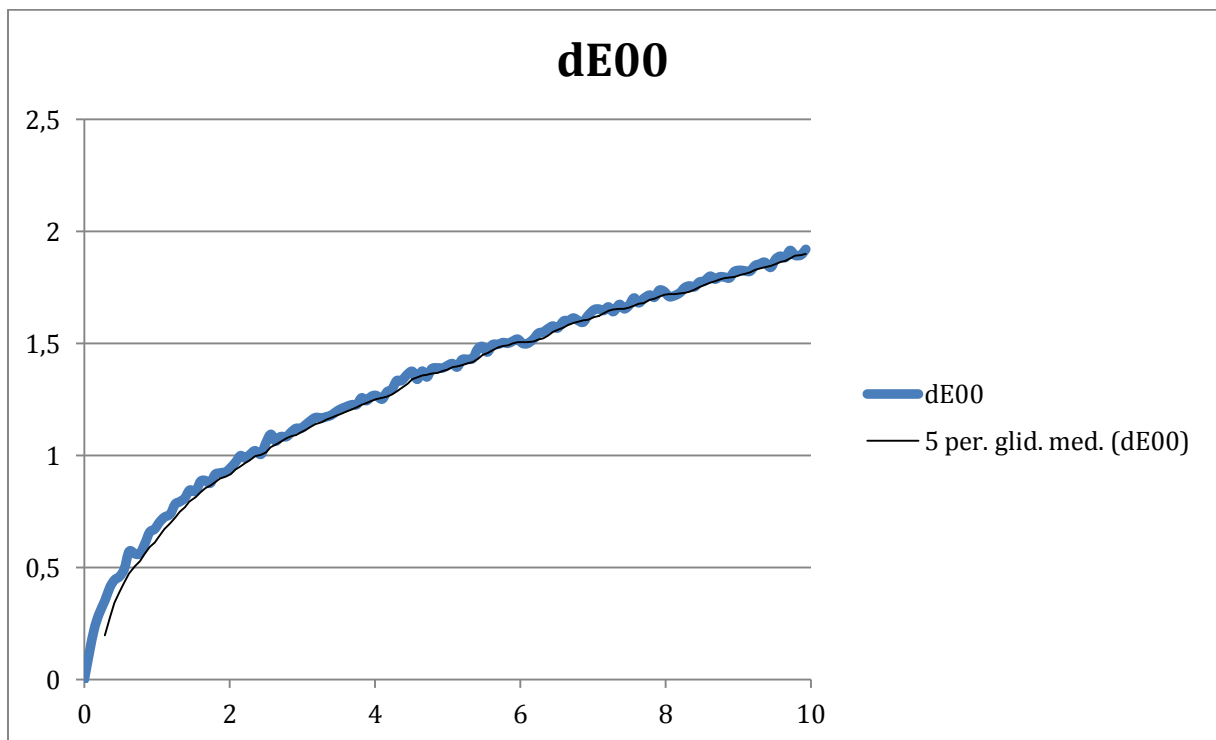
Graph. 38 Reference Magenta 100% saturation



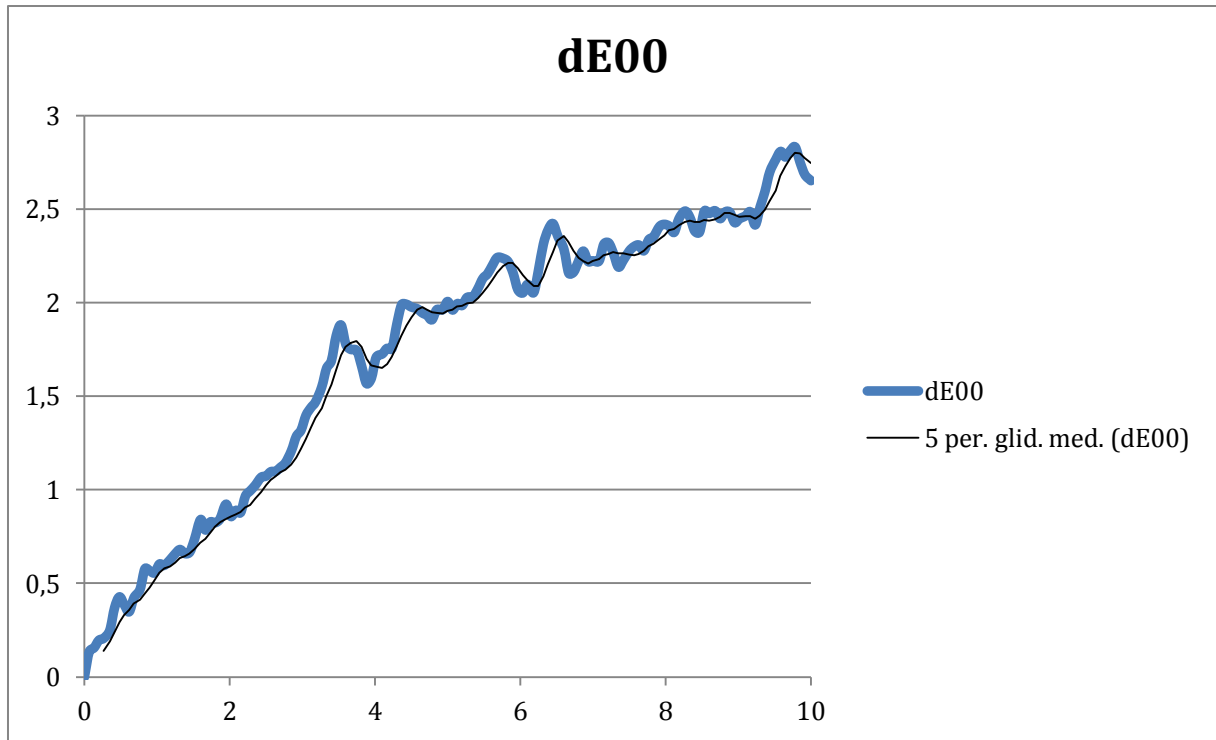
Graph. 39 Reference Magenta 50% saturation



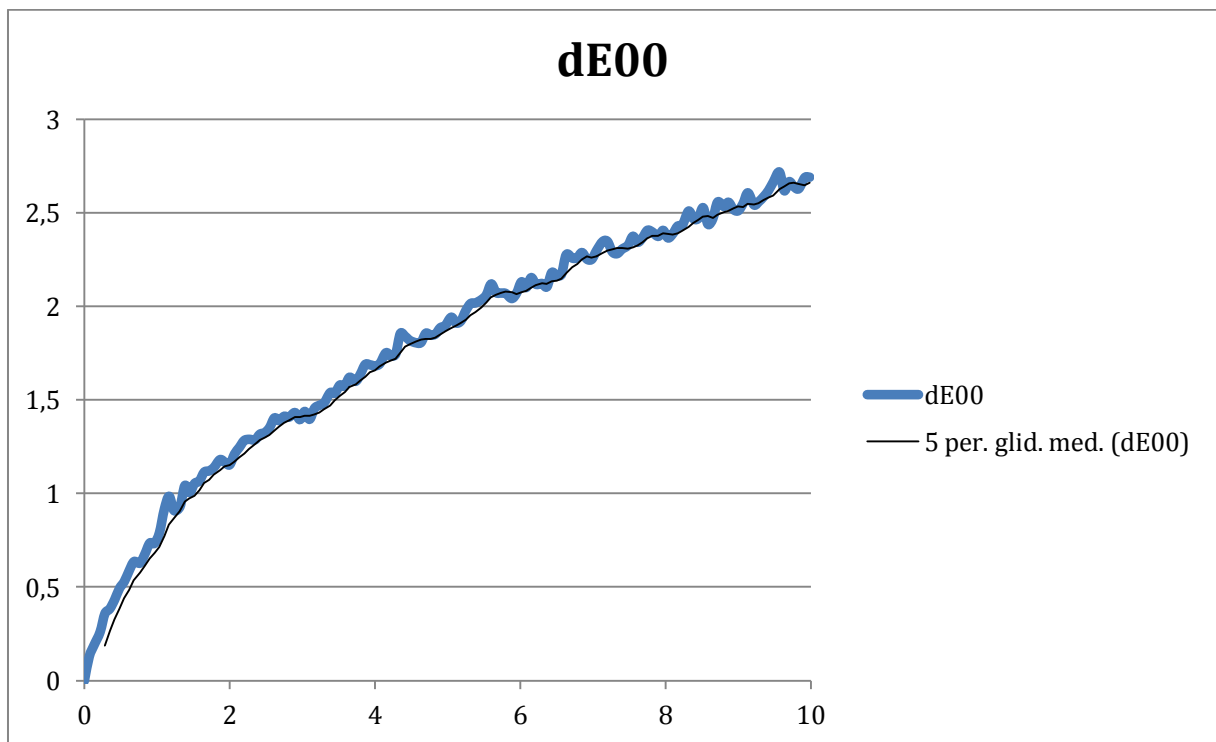
Graph. 40 Reference Yellow 100% saturation



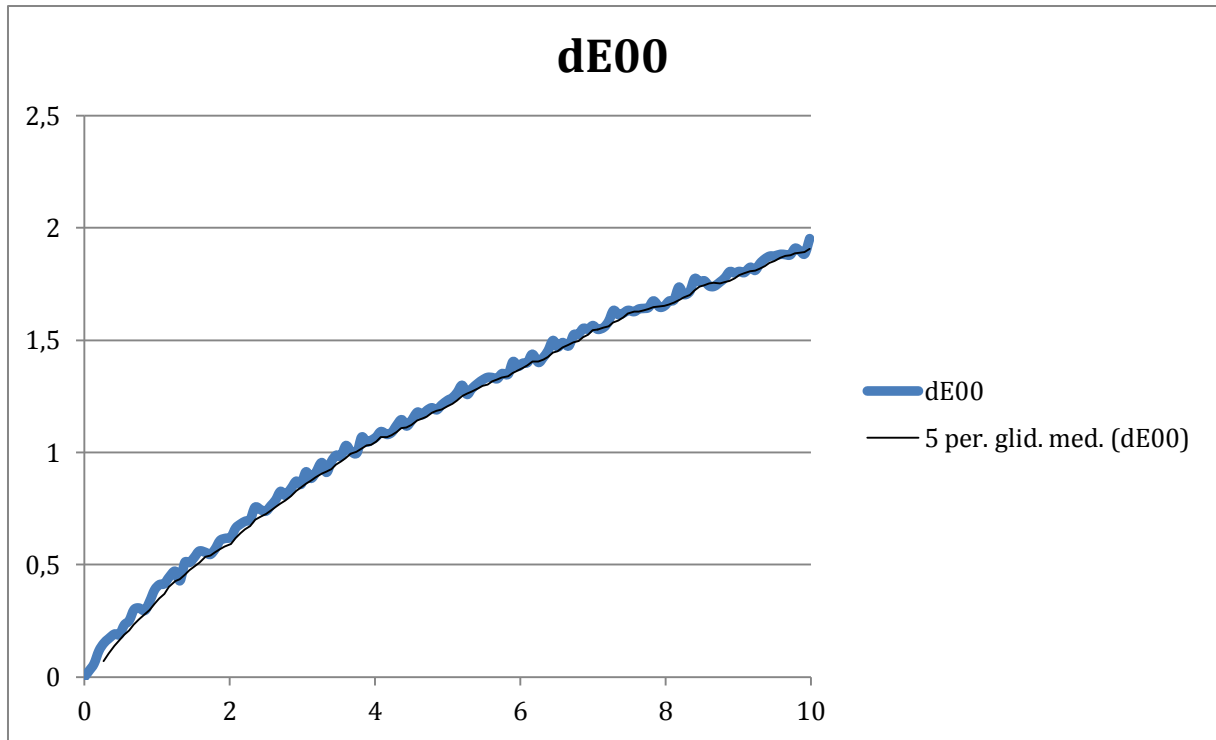
Graph. 41 Reference Yellow 50% saturation



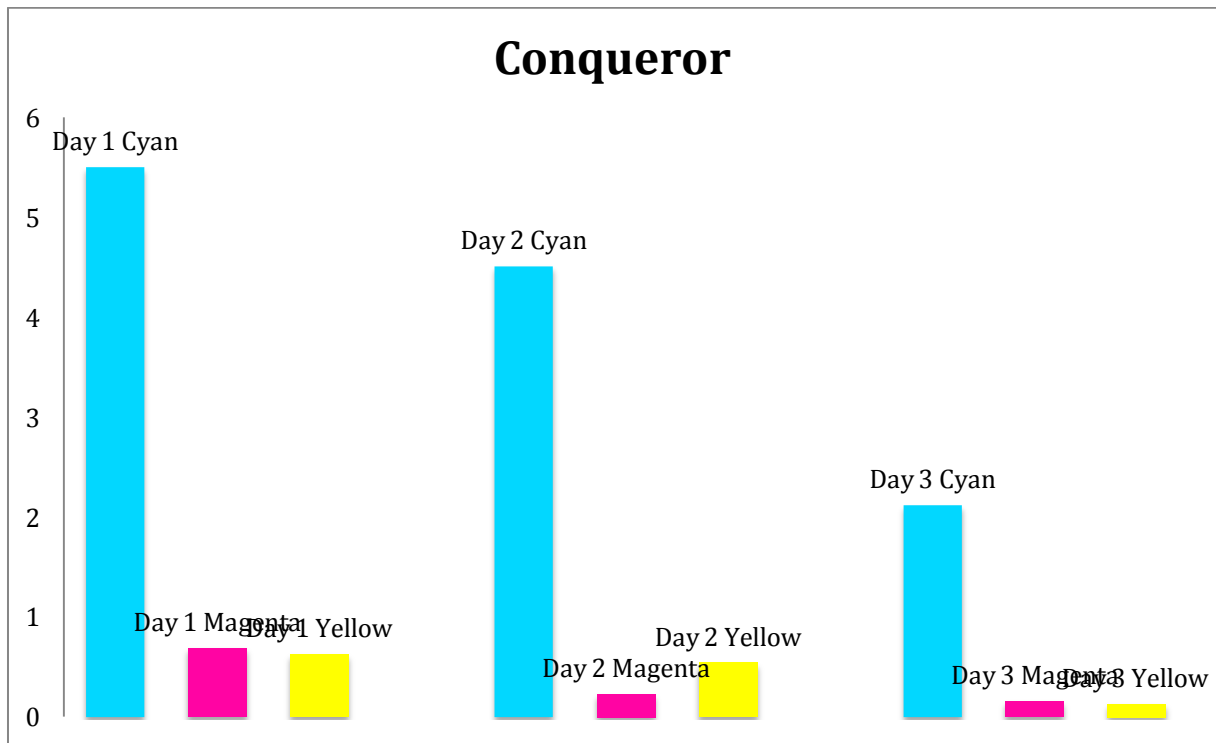
Graph. 42 Spot 1 on original



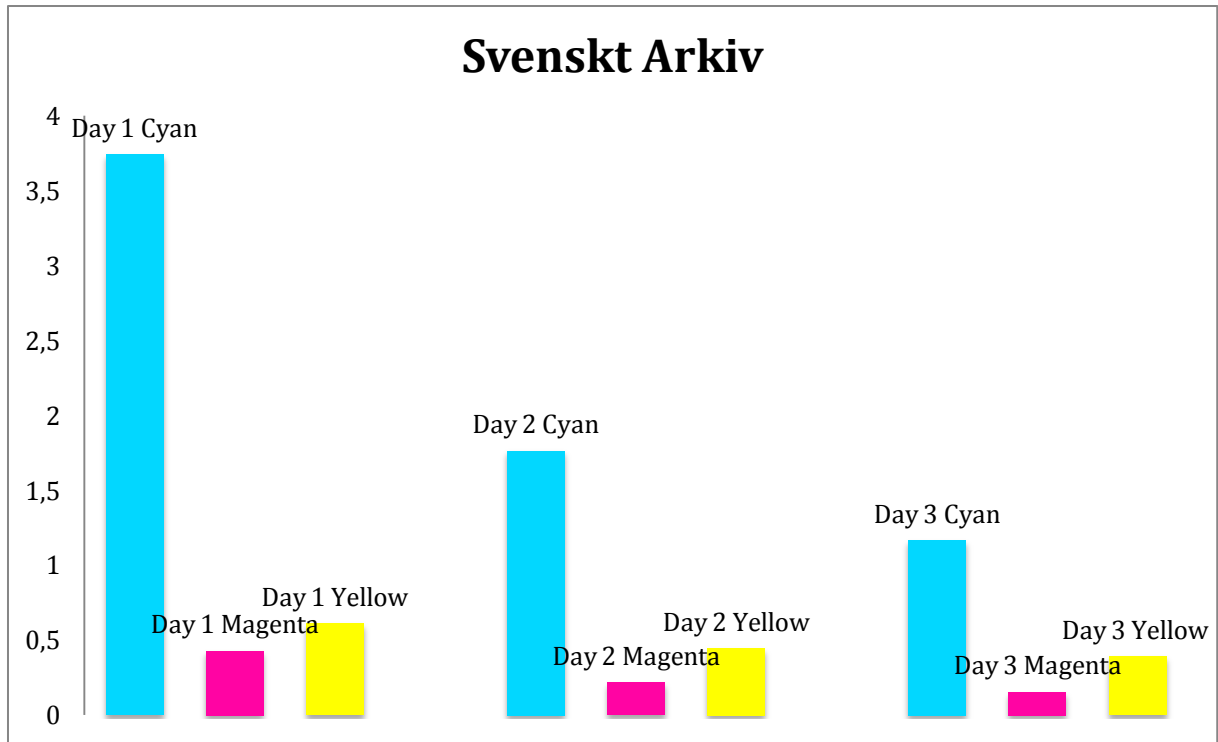
Graph. 43 Spot 2 on original



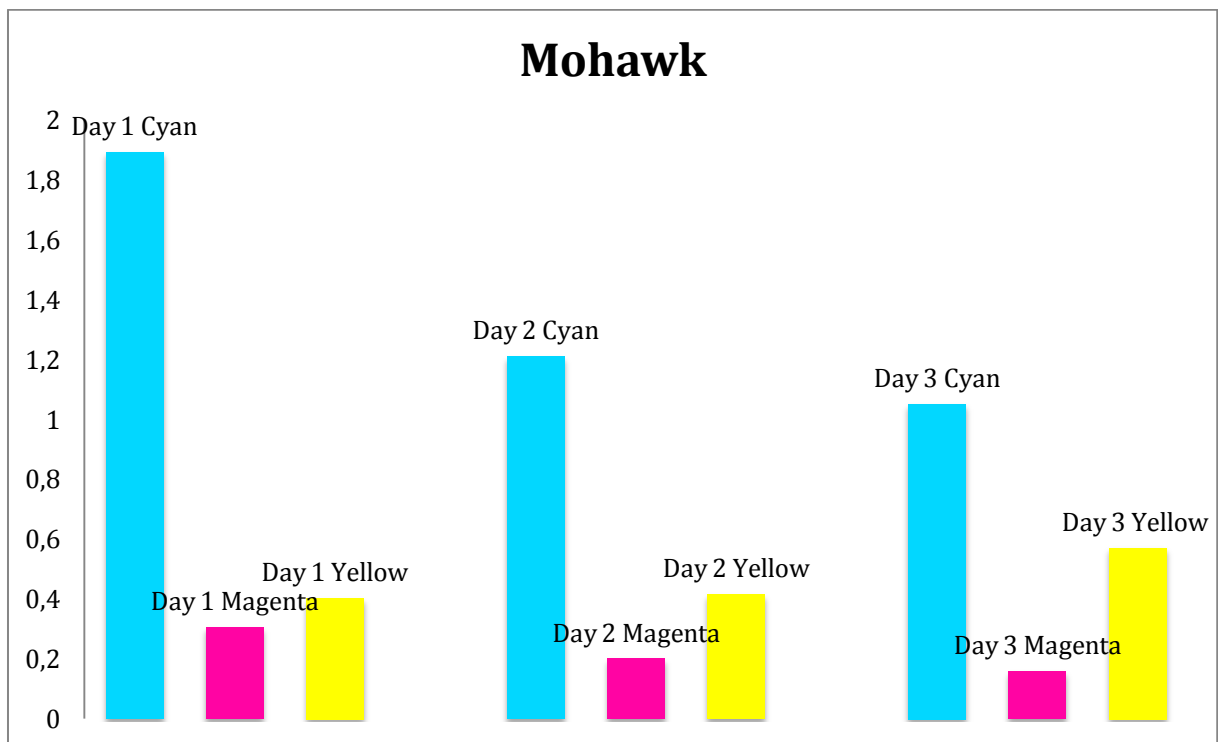
Graph. 44 Spot 3 on original



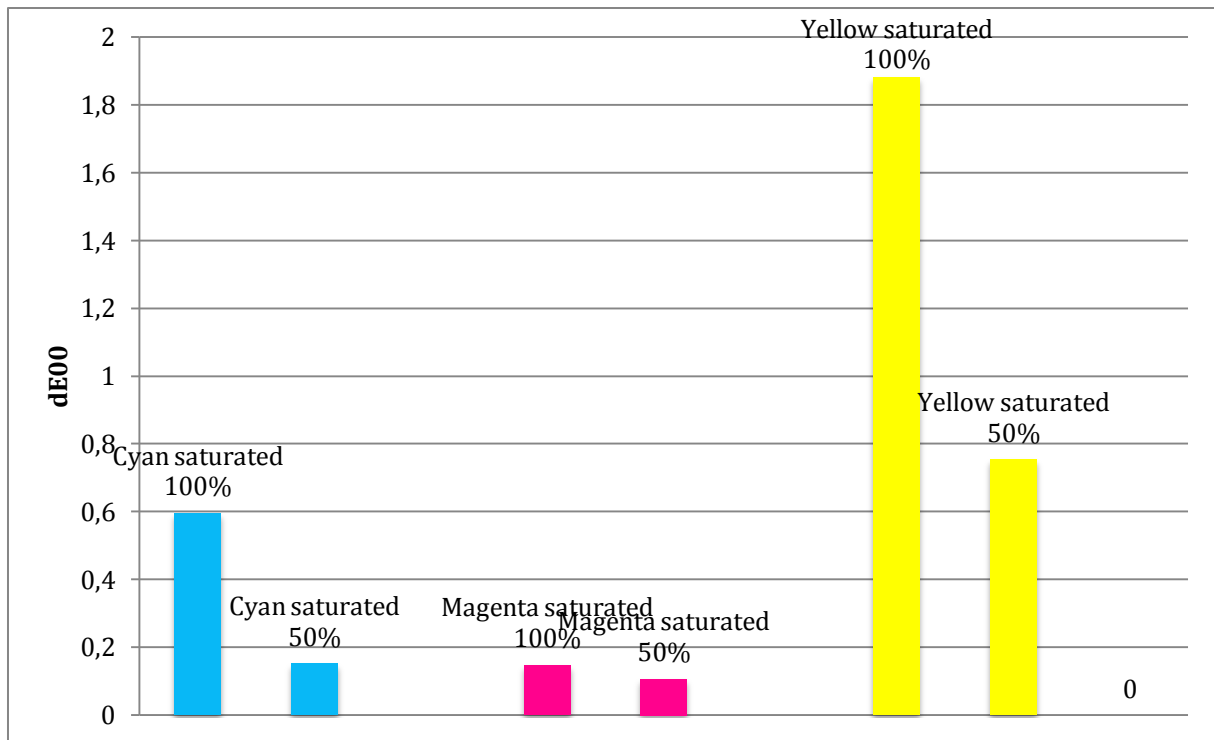
Graph. 45 Conqueror Day 1-3 solvent evaporation



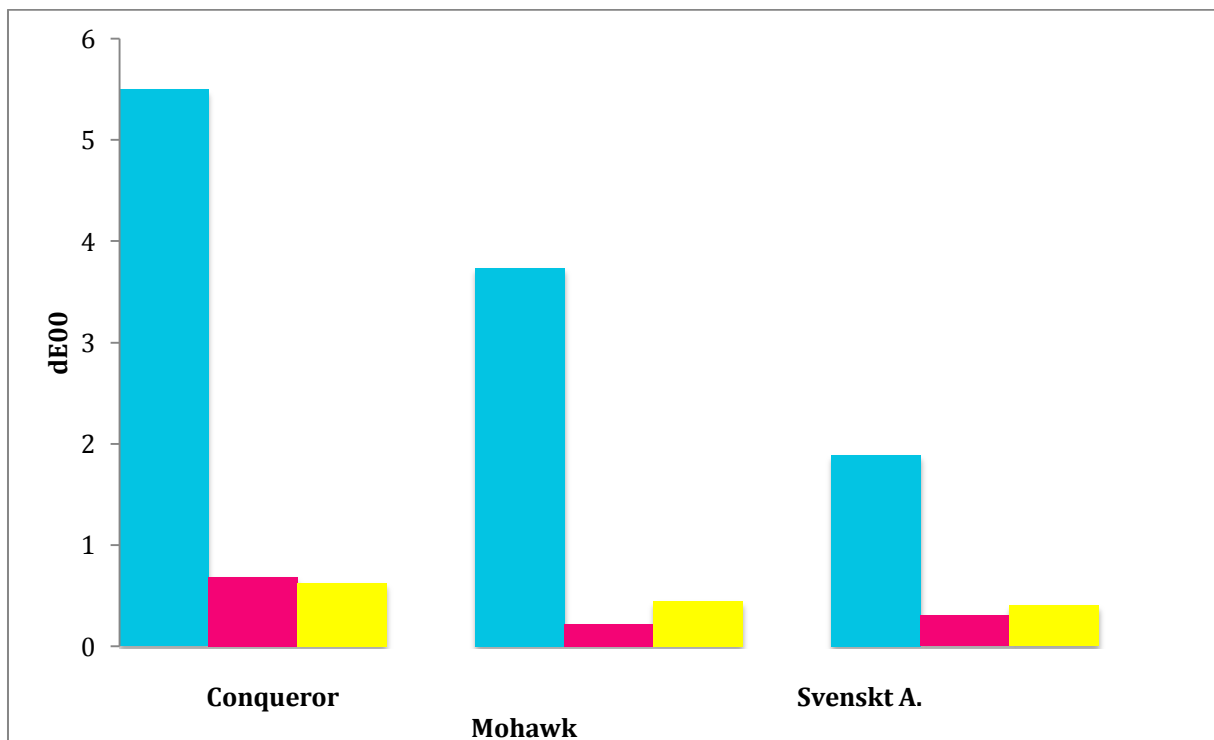
Graph. 46 Svenskt arkiv Day 1-3 solvent evaporation



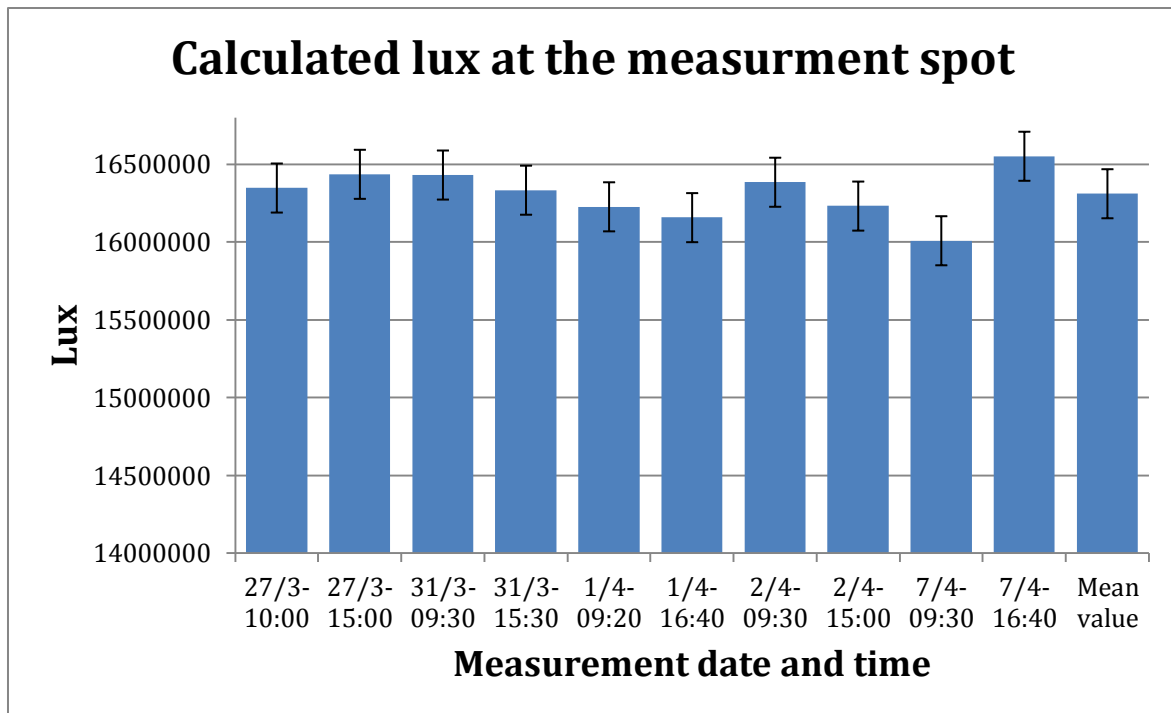
Graph. 47 Mohawk Day 1-3 solvent evaporation



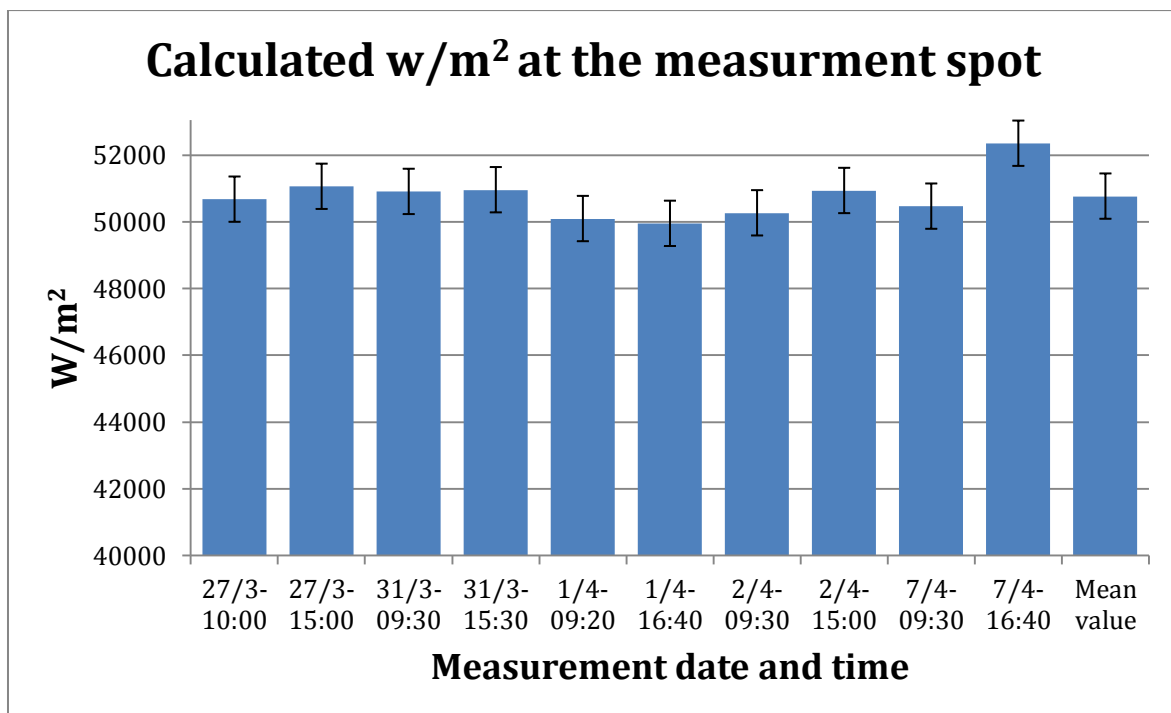
Graph. 48 Reference dE00 100%-50% saturation



Graph. 49 Model material comparison day 1



Graph. 50 Measurements of the lux at the time of analysis



Graph. 51 Measurements of the w/m² at the time of analysis