MEASUREMENT AND CONTROL OF OPTICAL BRIGHTENERS USING INLINE SENSOR TECHNOLOGY

MERJENJE IN NADZOR DOZIRANJA OPTIČNIH BELIL Z UPORABO TEHNOLOGIJE »INLINE« SENZORJEV

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IZVLEČEK

Videz grafičnega papirja je določena z belino in barvno-metričnimi lastnostmi, ki jih spreminjamo z dodatki optičnih belilnih sredstev (OBA) in barvil. Spremljanje in spremembe dodatka OBA in barvil običajno poteka z merjenjem vrednosti na skenerju, ki je nameščen na zvitku papirja.
Takšna običajna praksa ima številne pomanjkljivosti, ki vključuje zamik med doseženimi vrednostmi optičnih lastnosti in časom doziranje dodatkov, nevarnost prekomernega doziranja pri spremembi sestave, ki vpliva na povečanje pretrgov papirnega traku v tehnološkem procesu izdelave in doseženih nerealnih vrednosti končnega izdelka.
V sklopu diplomske naloge smo ugotavljali, kako lahko s pomočjo in-line merilnika BT-5400 UV, izvajamo spremljanje dodatka optičnih belilnih sredstev in merjenje optičnih in barvno-metričnih lastnosti papirja. V eksperimentalnem delu preskušanja smo merilno napravo namestili za dekulatorjem papirnega stroja. Neposredno v papirno snov smo dozirali OBA in dve vrsti barvil, dodatno pa še OBA na klejno stiskalnico.
Dejansko časovno spremljanje vpliva OBA in optičnih ter barvno-metričnih lastnosti neposredno vpliva na zmanjšanje izmeta in bolj kakovostnih tehnoloških pogojev, hitrejše spremembe pri zamenjavi proizvodnega programa oziroma vrste papirja, večje možnosti pri spremembah doziranja med prekinitvami zaradi pretrgov, ko merilne vrednosti niso dostopne.
Namestitev in-line merilnika BT-5400 UV v kombinaciji s krmilno napravo omogoča hitrejšo povrnitev naložbe ter povečanje produktivnosti in kakovosti papirja.

Ključne besede: optična belilna sredstva, barvno-metrične lastnosti, barvila, in-line senzor, krmilna zanka, prihranki

ABSTRACT

The appearance of graphical paper is determined by its brightness and color which is adjusted by optical brightening agents (OBAs) and dyes. This addition of OBAs and dyes is commonly controlled and monitored according to the scanner values of the pope roller.
This common practice has many flaws including the delay between dosage of the additives and the actual measurement, the danger of overdosage when a change in furnish occurs as well as the fact that during a sheet break there is no value which the dosage can be related to as the last measured value does not reflect the reality of the process.
In the scope of a diploma thesis it could be demonstrated how, with help of the inline sensor BT-5400 UV, OBA and dye can be measured and controlled. In a practical example the sensor was installed after the deculator of a fine paper machine. The OBA and two dyes were dosed directly into the pulp suspension as well as a further OBA dosage in the size press.
The real-time measurement of OBA and color allows a reduction of broke production, faster grade changes, avoidance of over- or underdosing and close control during web breaks where scanner values are not available.
The installation of the inline sensor BT-5400 UV in combination with a control loop enables a fast amortization of the investment and an increase in productivity and paper quality.

Key words: Optical brightening agent, color, dye, brightness, inline sensor, control loop, savings

1 INTRODUCTION AND OBJECTIVE

Optical brightening agents are substances which adsorb non-visible UV light (with a wave length of 300 – 400 nm) and reflect this as visible blue light with a wavelength between 400 and 450 nm. OBAs are generally anionic, water-soluble and colorless. OBAs can be categorized according to the number of sulphonic acid groups (Di-, tetra- or hexa-sulphonated). The larger the number of groups, the less affinity the brightener has for cellulose fibers. In grades with a high brightness demand OBAs are added both internally and to the surface.

The aim of this thesis was to examine the optical brightener dosage and its effect through in-line process measurement. It should be checked if a control loop of the brightening agent leads to a higher paper quality and lower production costs. The analysis was carried out on paper machine 6 (PM 6) in the Sappi Biberist mill in Switzerland.

Currently the dosage of the OBA, blue and violet dyes at PM 6 is adjusted manually according to the values of the pope paper scanner. If the value delivered is too high the operator slows the rotation frequency of the pump, thus adding less brightening agent to the system. Is the value measured too low, the frequency of the pump is increased. Due to the late measurement of the pope scanner the operator only sees the result of his actions after a delay. Addi-tionally, the operator has no value which to control the dosage by if there is a web break.

Through the installation in a suitable position the optical brightening agent can be dosed more precisely according to the exact specification of each grade.

Further advantages of this online measurement are faster and securer grade changes. Through permanent process monitoring errors can be recognized and eliminated almost immediately, reducing the production of broke and avoiding unnecessary costs.

Another aim of the thesis was to prove the economic efficiency of a BT-5400 UV sensor and to show that a more constant paper quality and lower costs can be achieved by automation of the optical brightening agent dosage.

Papir za notranjost revije PAPIR je prispevala papirnica Vipap Videm Krško d.d., VIPRINT 70 g/m²

2 BRIGHTNESS AND COLOR MEASUREMENT

2.1 GENERAL

There are approximately 14 methods to describe brightness/whiteness. The most popular are the R457 Brightness (ISO standard 2470) and the CIE Brightness (ISO standard 11475). Color can be described by the CIE L*a*b* color space (Fig. 1). This is a three-dimensional space which covers all observable color and is based on the concept of physical contrary colors.

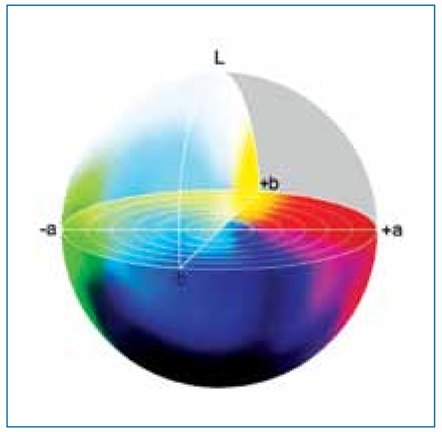

Fig. 1: L*a*b* Color space [1]

2.2 INLINE MEASUREMENT WITH THE BT-5400 UV

The BT-5400 UV is part of the "smart transmitter"- series from BTG and is controlled by an intelligent microprocessor. The sensor can be connected to any point of a 4-20 mA DCS.

Through intelligent algorithms the transmitter can control process parameters. The BT has five analogue signals which it sends to the DCS. These can be calibrated to any optical measurement including L*a*b* values, brightness, ERIC (effective residual ink concentration) or fluorescence. [2]

The measurement is based on reflection and the optical signal is carried to the processor where it is converted to an analogue signal.

2.3 INSTALLATION

The paper machine in Biberist is a fourdrinier machine which produces 34 different grades of wood-free uncoated paper with varying color, brightness and furnish.

Machine data:

- Speed: 600 m/min
- Width: 3.40 m
- Production: 71,000 t/a
- Size press (with OBA)

The signals of the BT-5400 UV for PM 6 were calibrated in accordance with the mill's most important specifications to measure the following properties:

Signal 1 – R457 brightness without UV (% ISO)

Signal 2 – R457 brightness with UV (% ISO)

Signal 3 – a*-value

Signal 4 – b*-value

Signal 5 – Fluorescence (% ISO)

Under the given conditions it was best to place the BT-5400 UV into the accept pipe of the deculator (Fig. 2). The advantage of this measuring point is that the installation can occur without any alterations to the current approach flow. The educated assumption that the OBA had enough time to attach to the fiber before arriving at the measuring point proved correct in later laboratory tests. Another advantage of this position is that there would be no air in the stock after the deculator and that the consistency is rather constant.

3 EFFECTS OF OBA ON THE BRIGHTNESS AND COLOR OF DIFFERENT PAPER GRADES

3.1 DEVELOPMENT OF BRIGHTNESS

It is interesting to see that the fresh pulp slush already has a fluorescence of 3% ISO. This is mainly due to the fact that the pulp is dissolved in white water, which already contains a high portion of unused OBA and the phenomenon that the bleaching process causes minor fluorescence in pulp.

The stock from the machine chest shows an increase of 12% ISO. This results

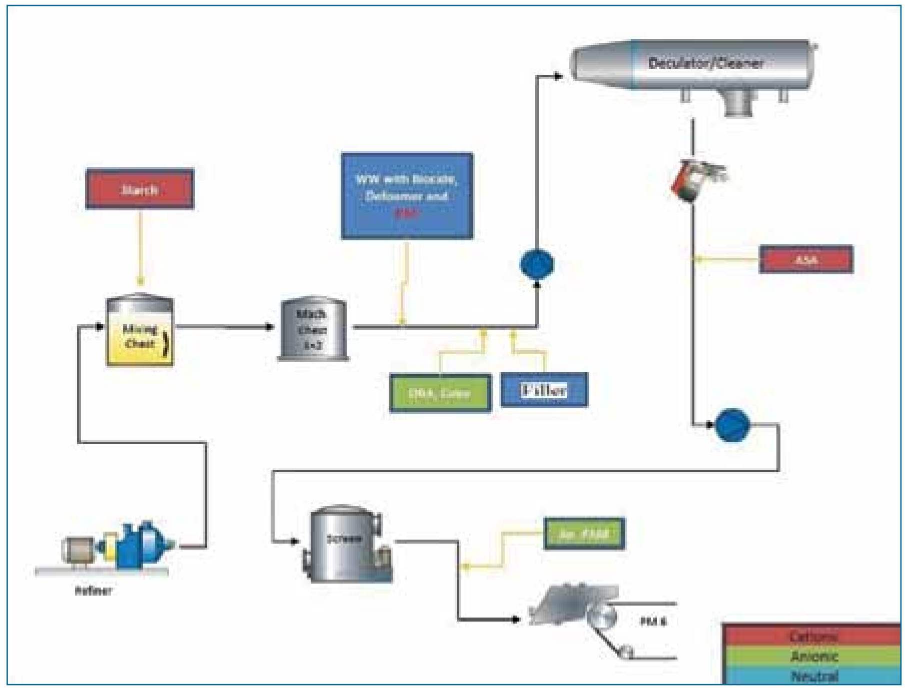

Fig. 2: Installation point in a simplified flow sheet of PM6

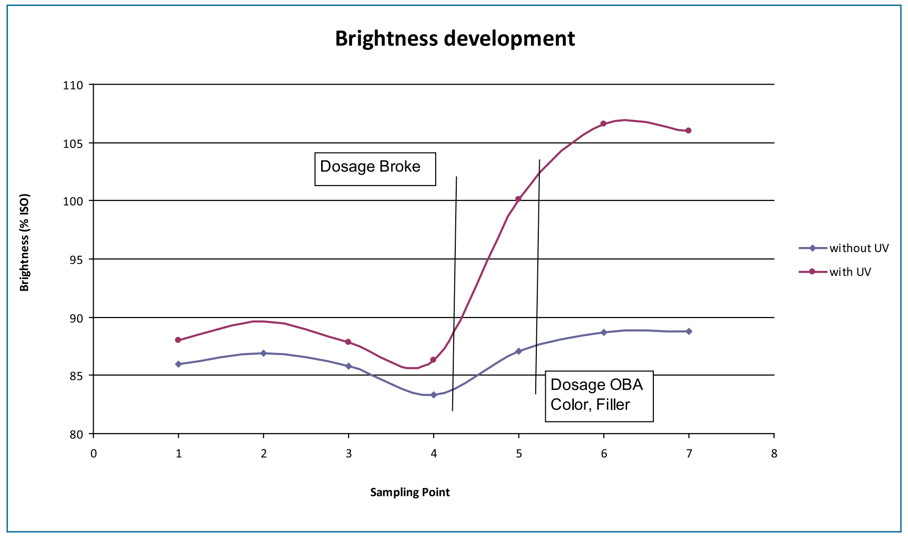

Fig. 3: Development of brightness

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from the addition of broke. The broke is already white and brings in additional OBA which has not bonded with the fibers, both effects causing the increase in brightness. After the addition of optical brightening agent, white water and filler, the brightness increases a further 7% ISO. From the brightness without UV it can be seen that the filler contributes about 1.5% ISO to the total brightness.

The broke has the highest brightness with 107% ISO. One reason for this is that the OBA has the longest time to attach to the fibers, another that the broke actually contains the highest amount of OBA. This high amount is due to the OBA already attached to the broke as well as in the white water, which dilutes the dried broke. Both these factors and the long reaction time result in this high brightness.

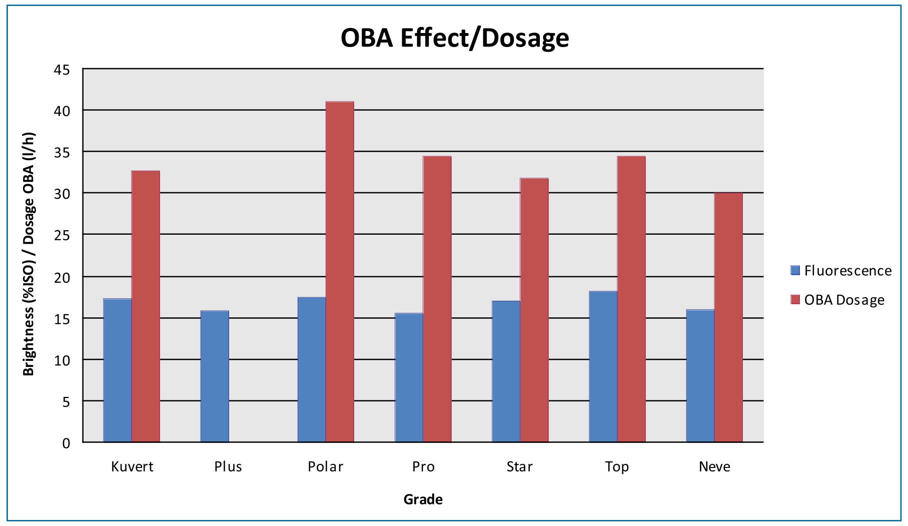

Fig. 5: OBAs effect on brightness in different grades

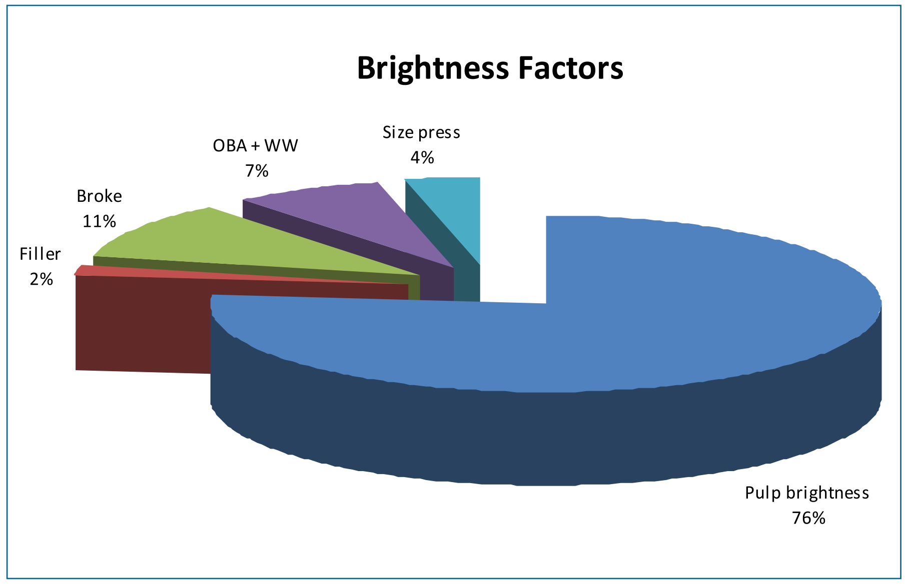

Fig. 4: Factors influencing the brightness

A savings potential of OBA can be seen when looking at the broke contribution percentage of 11% (Fig. 4). If the addition of broke to the furnish increases, less optical brightener is needed. An inline measurement would automatically recognize this and dose less OBA.

3.2 EFFECT OF INTERNALLY DOSED OBA

Illustrated in Fig. 5, is the average dosage of OBA (in liters per hour) and the average fluorescence effect (in % ISO) in different grades. It can be seen that to get a similar effect of the OBA, different grades require different amount of OBA. This is due to the different furnishes, fillers and other properties of these grades.

To examine the effect of optical brightener on the color space values, sheets with different OBA-contents were formed in the laboratory and a*- and b*-values measured, with and with-out UV. Consequently, the sheets formed in the lab do not show the influence of the size press. Small variations of OBA only resulted in a small change of the b*-value. Even less of an effect could be seen in the a*-value. The reason for the a*-value being less sensitive, is that OBA shows its effect in the blue wavelength spectrum (converting UV light to visible blue light). No significant effect can be seen in the a*-value as it is measured in the red/green wavelength spectrum.

3.3 EFFECT OF OBA IN THE SIZE PRESS

The size press recipe is constant for all grades except for the grades "Star" and "Neve". In Fig. 6 the red bars show the average brightness of the base paper of different grades. This varies by up to 2% ISO due to different furnishes, fillers and color. The blue bar shows the difference between the base paper and the sized paper. The sized paper of course has the specification of the finished product (112% ISO).

The grades "Pro" and "Top" are good examples. These have a difference in base paper brightness of 2% ISO but the same size press mixture gives them both 112% ISO brightness. In other words the OBA in the size press is 2% ISO more effective in the grade "Pro" than in the grade "Top".

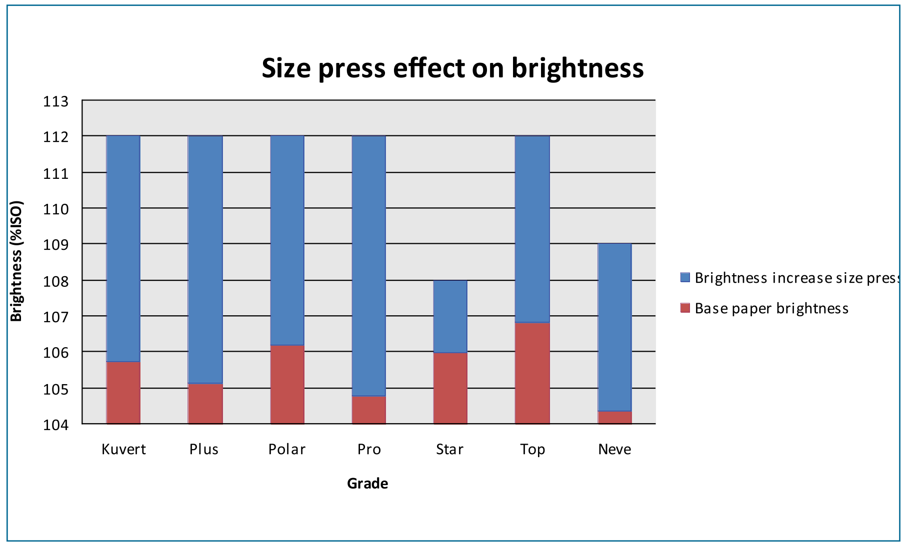

Fig. 6: Size press effect on the paper brightness

This effect can have different causes. One explanation can be that the OBA has a weaker effect on whiter base papers. This can be seen as a type of "buffer" effect. Another reason could be that a maximum brightness of 112% ISO can be reached and that by some grades the OBA is overdosed in the wet end. If this would be the case the final brightness can be controlled by the dosage in the wet end. A further possibility would be different penetration properties of the base paper.

Fig. 7 shows that the OBA in the size press causes a constant decrease of the b*-value of about 2.8 in all grades. In the grade "Star" this is not the case as this is the only grade with a different size press recipe.

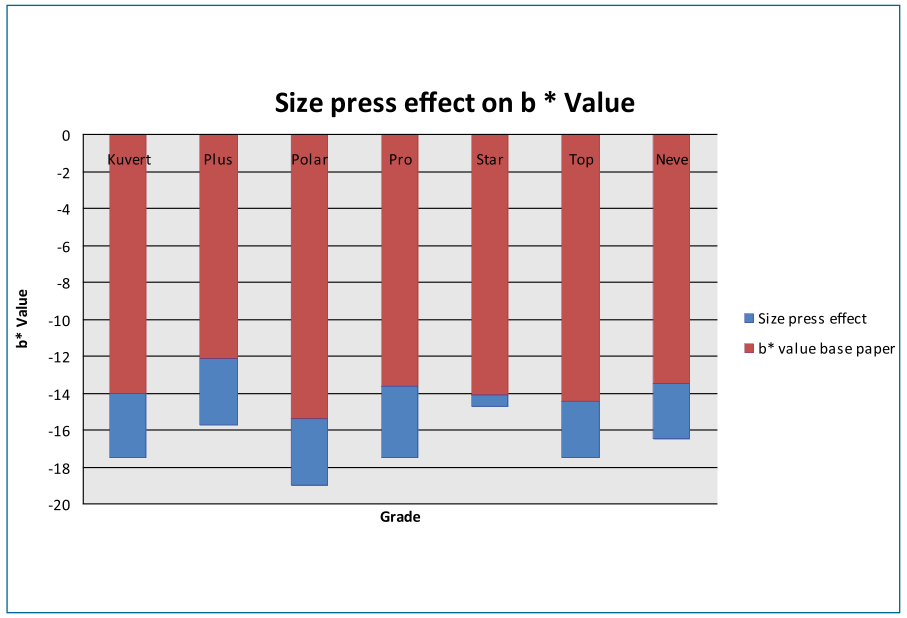

Fig. 7: Effect of the size press on the b*-value

The difference between base paper and sized paper, regarding the b*-value, can therefore be seen as an offset when looking into an automation.

4 POTENTIAL SAVINGS

To justify the investment made in an instrument, clear financial benefits must be proven. These can partly be shown with direct cost savings and partly with other benefits and advantages.

Due to the fact that the machine operators adjust the dosage by the scanner value for the paper to be in specification, the result of their actions can only be seen five minutes later. If further adjustment is needed another five minutes is required and so on.
By using inline instrumentation the delay of five minutes can be cut by at least 60%. This increase in machine efficiency and reduction in broke shows a potential of €40,000 annually.

Machine operators cannot constantly check whether the dye and OBA dosages are at their optimum, it could often be seen that only one adjustment was made during the start of each produced grade and left for the entire grade production as long as the reel measurement was in specification. Many trials have shown a possible average OBA reduction of at least 2 l/h. If this is achieved the savings reached (in accordance to production, OBA price, etc.) would be 13 tons OBA which amount to about €13,000 annually.

When technical defaults occur, such as the blockage of OBA/Dye nozzles or technical defects on the pope scanner measurement, an inline measurement proves to be valuable for premature error recognition to avoid difficulties.

Furthermore a measurement of brightness and color in the stock provides new possibilities for trials regarding different brightener types, dyes, colors or the influence of the size press can be measured and recorded in real-time. Size press recipes can be optimized as there is a direct comparison to the base paper values.

5 SUMMARY

The color and cost of copy paper are the most important aspects influencing the consumer's purchasing decision. These properties can easily and cost-effectively be influenced using optical brightening agents and dyes. The amount of OBA which is in a paper machine system is rarely constant as it is influenced by the furnish, amount of broke used, retention of the system and possibly overdosing of the additive. The common practice of machine staff monitoring and adjusting brightness and color according to the measurement of the pope reel scanner is not optimal for two reasons. For one, the staff cannot constantly monitor and manually adjust the OBA-dosage to adhere to the product specification. Secondly, alterations and process changes can only be detected after a fairly long delay.

A brightness analysis showed that in this particular case, broke used in the furnish contributes around 11% of the total brightness, and white water (with re-circulated OBA) and fresh OBA contribute around 7% of the final paper brightness. Broke has the highest concentration of OBA on the fiber and OBA in solution (OBA that has not attached to the fiber).

An interesting observation made during the thesis which still has to be examined is the equalizing effect the size press has regarding brightness. This effect can be explained by either an overdosage of OBA in the size press or different penetration of the OBA into the sheet.

Through the early measurement and control of brightness a total savings of 53,000€ are created. These originate from producing less broke, faster grade changes and savings in OBA usage. Premature error recognition facilitating a reduction in broke production and downtime, as well as the new possibility of product and process optimization must be considered as well.
The investment in the BT-5400 UV shows a return on investment within six months.

The requirements for automation of the OBA dosage are fulfilled. The sensor delivers correct values for all produced grades. Seeing that during automation the brightness is controlled within certain limits, there is no negative effect on the a*- or b*-value. Due to the stock vary-ing in brightness (caused by different filler and furnish) and the fact that the size press levels the final brightness, the only thing still required to implement automation, are the target values for each grade.

LITERATURE

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