SPECIALIST printing worldwide

PUSHING THE LIMITS

Gerard Rich shows how new technology is meeting the challenges of CTS imaging

Screen printing is the process of choice for a set of industrial printing applications. Customers keep on pushing companies to the limits of rotary and flatbed screen imaging with CTS (or CTP) devices.

Lüscher has analysed the challenges of CTS imaging R&D and this, together with customer tests made in our technical centre over the years and with the practical limits in imaging encountered, have led us to develop the X!Tend software package fully integrated in the Lüscher UV imaging system to measurably boost performance.

THICK FILM SCREEN APPLICATIONS

A previous article for *Specialist Printing Worldwide* focused on improved imaging of very fine graphics. The focus of this article is thick film screen applications. Examples are screens for applications in relief coating, Braille characters, solder paste, gaskets or conductive paste.

For transfer, via screen printing, of thick layers of paste or ink on substrates, the trade-off between high EOM values and high resolution of screen imaging is difficult to reach.

For these thick film screen applications we will demonstrate how X!Tend is a tool that enables users to push the limits of screen

BASICS ABOUT LÜSCHER UV LASER IMAGING

Lüscher introduced UV laser imaging in 2007 for a whole range of applications. It immediately replaced lamp-based systems due to better performance and stability.

The Lüscher system is based on individual laser diodes controlled by digital data scanning the surface of screens to directly harden the emulsion.

The laser diodes are coupled individually to optical fibres carrying the energy to the raster plate and the optic.

The laser light of the whole set of diodes is collected on the raster plate at the entry focal plane of the optic and focused by the optic onto the screen surface.

The diameter of the fibres, the design of the raster plate and the design of the optic determine the resolution of the CTS system with a broad range of possibilities from 600 to 10000dpi and beyond.

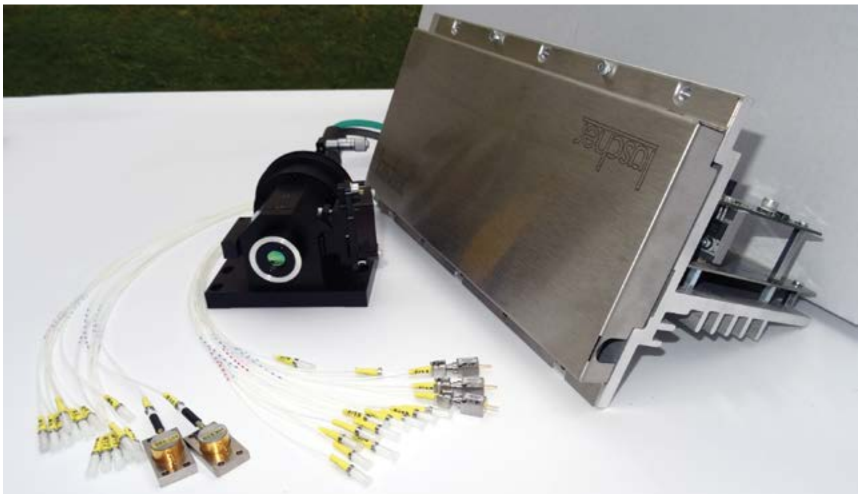
The laser light is highly collimated and penetrates straight into the material leading to sharp accurate imaging results with no possibility of undercutting.

Lasers are permanently controlled for power and the process control is total with no deviations possible.

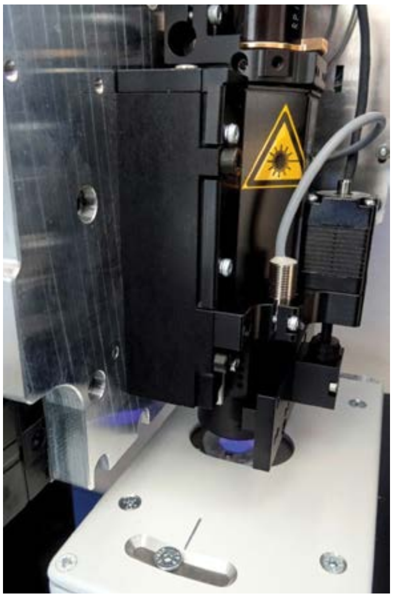
The digital input of MultiDX! is a one bit TIF file. When the pixel is on locally, the laser is on and the emulsion will be cross-linked.

Lüscher has already sold in excess of 150 Flatbed MultiDX! Systems with a large portion of them imaging UV sensitive emulsions, resists or films. ■

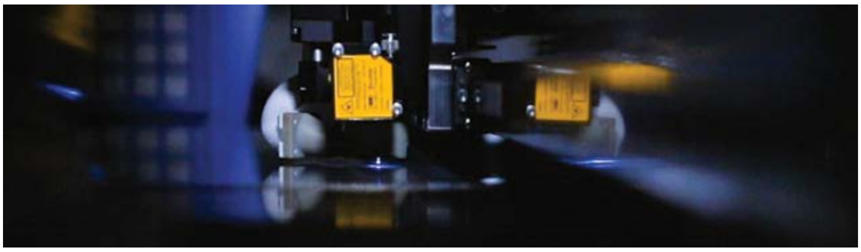
UV laser diode with fibre coupled



An electronic module controlling lasers, laser fibre bundle and optic.



Complete mounted optic assembly with laser measurement box and focus system



Boxout 1: About Lüscher UV laser imaging

printing with quantifiable improvements of imaging.

The basics of the Lüscher imaging system are presented presented opposite in: 'About Lüscher UV laser imaging'.

In the next section, we explain first in detail the challenges of thick emulsions and capillary films preparation. We will use the expression 'thick film' to signify a capillary film or an emulsion coated in multiple passes to build high thickness or EOM. The analysis encompasses flatbed and rotary screen printing. The demonstration in this paper, and unless specified otherwise, is based on the example of a well-known capillary film of 100-micron thickness laminated onto white Polyester of mesh 43. The measured fabric thickness is of 115 microns and the EOM is of 95 microns. Tests on different types of capillary films (brand and thickness) lead to results that will be somewhat different but totally aligned in terms of analysis and trends.

Challenges of thick film imaging in direct laser imaging of screen print forms

Challenge 1: Light scattering and diffuse reflection. The first and main challenge is related to light scattering and diffuse reflection effects in imaging. These effects become ever more critical as the

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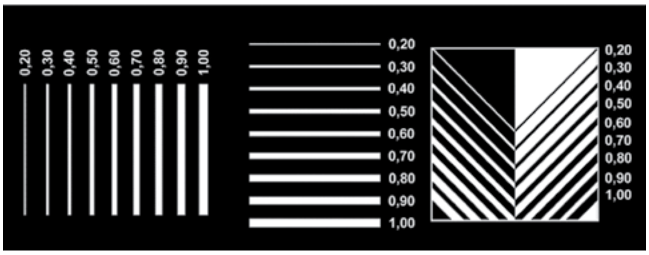

Figure 1: Specific test file used in imaging tests

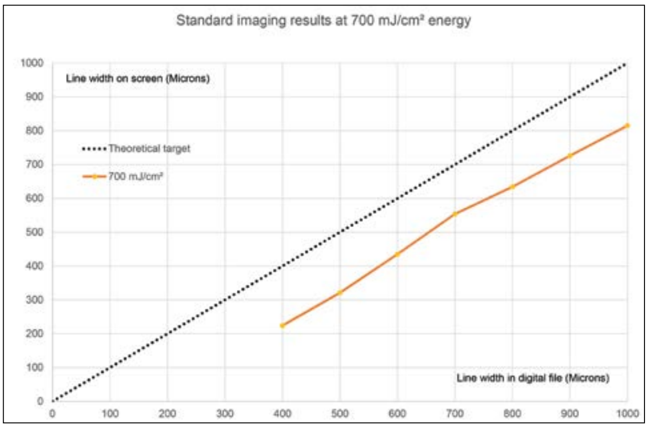

Figure 2: Results of standard imaging of the 100-micron capillary film at optimal level of energy on 43 mesh white polyester

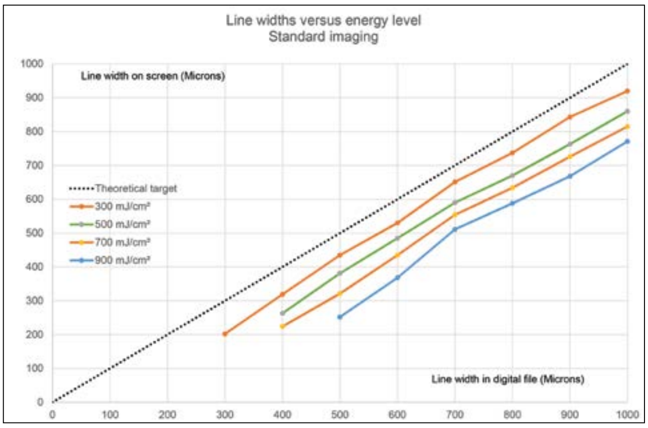

Figure 3: Line widths as a function of energy dispensed with standard laser imaging for the 100-micron capillary film on 43 mesh white polyester

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thickness of the thick film to be imaged gets higher. A significant fraction of screens is still imaged with argentic films in a two steps process. The argentic film is imaged with a negative process and is used to subsequently image the screen under a UV light frame. The difference with the CTS positive direct imaging needs to be explained first. The argentic film, the emulsion (or thick film), as well as the mesh, are scattering light during imaging and the results will be different from CTS. In direct digital imaging, the UV laser light is penetrating straight into the thick film whereas, under a light frame, light comes from different angles. However, laser light is scattered as well inside the polymer layer. Its transparency is not perfect as it would be the case for pure glass.

There is of course, in addition, considerable diffuse reflection of laser light at the interface between the thick film and the mesh. This phenomenon is influenced greatly by the mesh type (white or yellow PET or metal mesh) and is always a contributing factor.

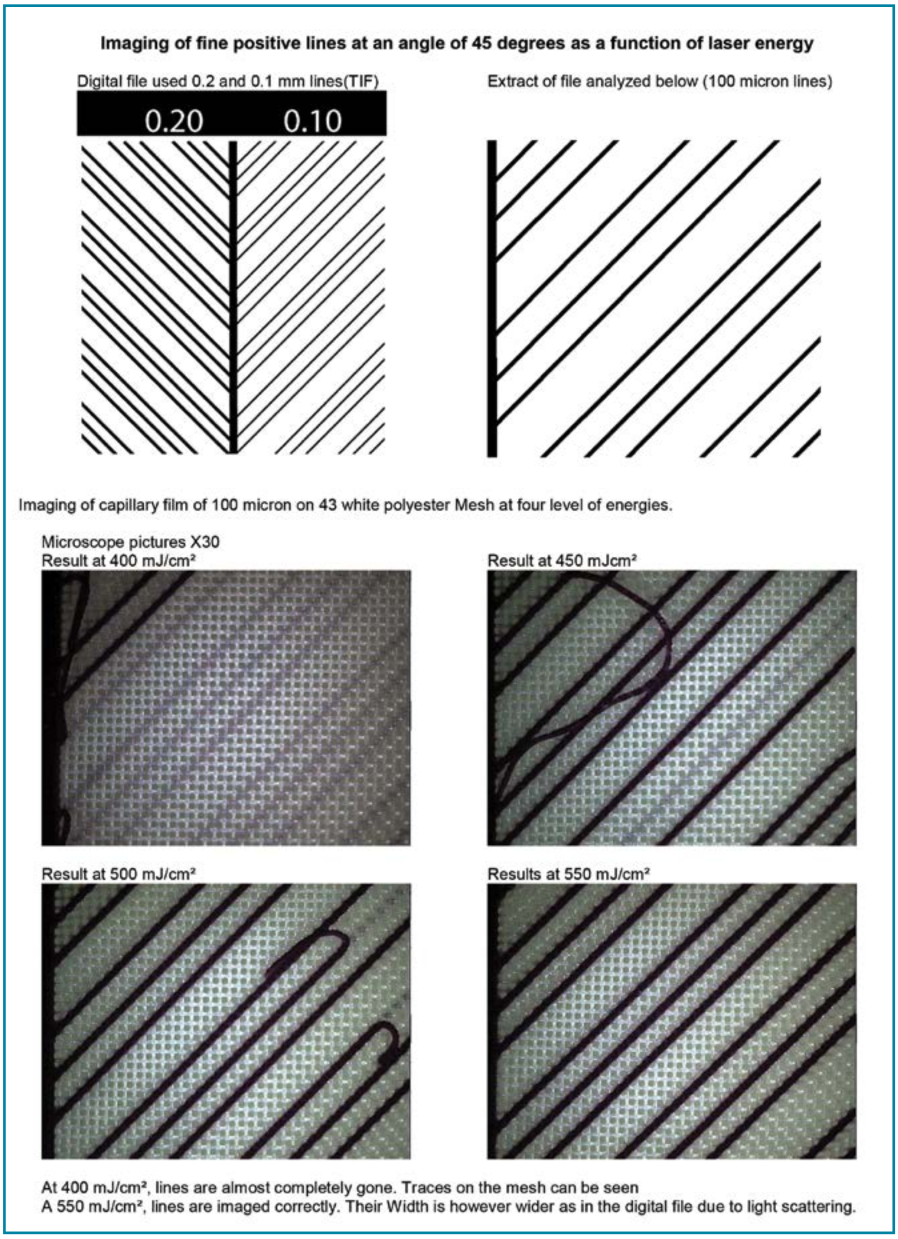
The dramatic impact of light scattering in thick film direct laser imaging will be detailed hereafter. In order to quantify these effects, we designed a specialised test form to measure lines imaged on thick film screens. The TIF file used is reproduced in **figure 1**. The unit used is millimetres.

Basically, we image line widths from 200 microns (0.2 mm) up to 1 mm in steps of 100 microns in several directions in the plane of imaging. Line sizes are easy to measure as imaged on the screen and this is why they are used here. Obviously, the analysis can be transposed to all graphical elements of similar sizes in the particular direction of observation. Theoretically, the thick film line present on the screen after imaging and development should be corresponding to the line size in the TIF file.

Standard laser imaging of the 100-micron capillary film with an energy level which is up to expectations (See below for more on this) leads to results summarised in **figure 2**. The horizontal axis represents the line width in the digital file. The vertical axis is showing the actual line width measured on the finished screen using a microscope.

There are two well-known issues to highlight: glaring differences between the line width on the screen and the theoretical line width in the digital file (an average of 200 microns). It is impossible to image lines below 400 microns as they get closed due to light scattering and swelling of the polymer film during the processing. Both factors add to the issue.

As the industry relies a lot on accumulated experience, the limitations we put light on here are ignored, unknown or at least 'unspoken' with adverse consequences for all players. They simply 'live with it'.



Boxout 2: Minimal energy determination – 100-micron capillary film on 43 mesh white polyester

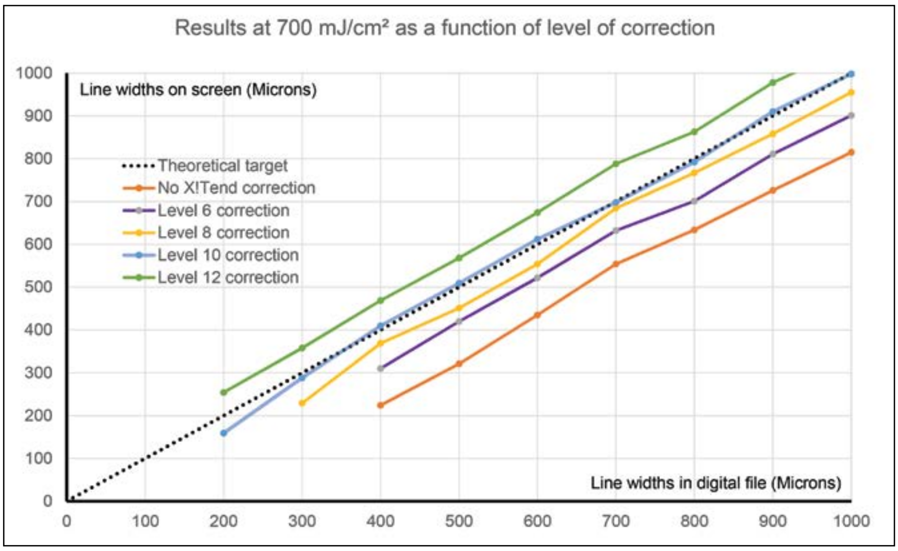


Figure 4: X!Tend imaging results at 700 mJ/cm² as a function of level of correction for the 100-micron capillary film on 43 mesh white polyester

Challenge 2: Securing the bond to the mesh. The second challenge is that there are two chemical processes to be triggered by UV laser light. First, the emulsion has to be crosslinked in order to become insoluble during wash out and, secondly, the bond to the mesh has to be guaranteed for a safe production on press.

In order to achieve a strong bond, due in particular to light absorption in the depth of the emulsion, it may be necessary to increase the level of imaging energy beyond what would be desirable to simply crosslink the emulsion in its thickness. This may limit the imaging performance significantly and, for thick emulsions, often dramatically.

In practical terms, the energy to be dispensed, to get adhesion, is higher than would be desirable to have a nice open screen as seen under a loop on a light table. To make sure that the screen will behave up to expectations with respect to life on press, we need to determine with professional tools the minimum laser energy to dispense. This is done with a specific set of tests.

A dedicated digital file incorporating fine positive lines of 100 microns in this case (the thickness of the film) spaced apart is imaged under increasing levels of energy in small increments. These fine lines configuration is stressing heavily the bond of the emulsion at the mesh interface during wash out. Details are presented in **boxout 2**: 'Imaging of fine positive lines at an angle of 45 degrees as a function of laser energy'.

On top of the box, the specific test file used and a detail of it (lines of 100 microns) is shown.

Below in the box, microscope pictures of the finished screen at 400, 450, 500 and 550 mJ/cm² of laser energy are reproduced (magnification of 30x): up to 400 mJ/cm², all lines are gone. We can see traces of their initial presence on the mesh. At 450 and 500 mJ/cm², lines are partially surviving the process. At 550 mJ/cm² and above, lines are held correctly. However, it should be noted that their width is imaged close to 200 microns at 600 mJ/cm² due to the light scattering effects already discussed.

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From these results, we can deduce that the rock bottom level of laser energy to be used is 550 mJ/cm². To compensate for fluctuations in the process (operator, temperature and batch to batch variability of film and mesh), we recommend to use in this case 700 mJ/cm² as minimal energy level.

To illustrate what the minimal energy request does to the imaging result, we made standard imaging tests with the digital file of **figure 1** at different energies.

Results are summarised in **figure 3**. What we take from this graph is: negative elements such as lines are correctly imaged at 300 mJ/cm² already (looking at them under a microscope) but we know now that they will not survive in printing. At 700 mJ/cm², the result looks unfavourable if compared to 300 mJ/cm². However, using 300 mJ/cm² in production would lead to a disaster on press. This is a cognitive trap to avoid.

Challenge 3: Light energy distribution in the depth of the film. The third challenge is that, because most emulsions pre-existed recent CTS laser systems, the UV laser light absorption in the thickness of emulsions, at the laser wavelength, may be too high to get the job done easily. This requires sophisticated CTP imaging strategies whose discussion is beyond the scope of this article.

These three challenges have been addressed successfully by the Lüscher Technologies' R&D with three technologies unique in this field:

- High resolution imaging
- X!Tend software
- Specialised imaging strategies

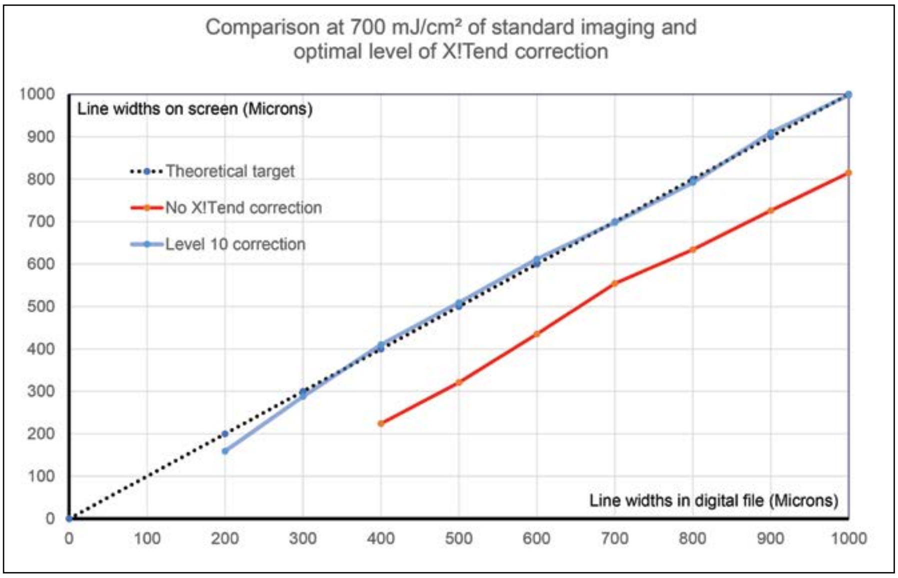

Figure 5: X!Tend imaging results at 700 mJ/cm² under optimal correction for the 100-micron capillary film on 43 mesh white polyester

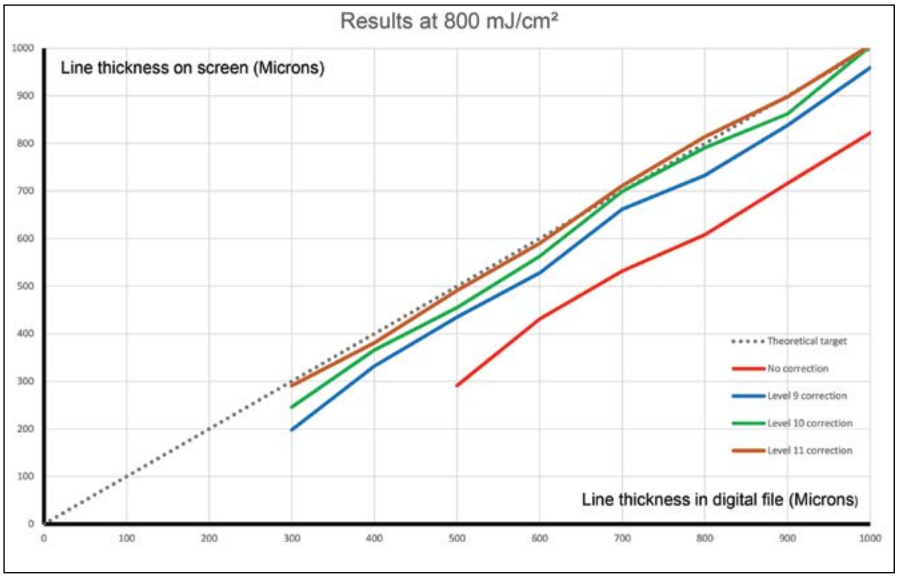

Figure 6: X!Tend imaging results at 800 mJ/cm² as a function of level of correction for the 100-micron capillary film on 43 mesh white polyester

X!TEND SOFTWARE

The X!Tend software is designed to extend the range of imaging capability of any emulsion or capillary film and to increase the fidelity of digital data reproduction on screen. In addition, the X!Tend software widens the window of imaging energy applicable to any emulsion. More laser energy without loss of imaging quality will make the screen more robust and more durable on press.

The corresponding software parameters are stored into templates for maximum comfort in production and can be selected, or not, specifically for types of jobs and the range of emulsions used in production. The software is resolution independent. With higher resolution however, the benefits of more accurate definition of graphics will remain intact.

The X!Tend software uses standard TIF input. There is no need for changes in the prepress department. The desired effects are obtained by simple user specific settings. The selection of settings is based on standard CTS imaging results where deviations between the input file and the result on screens can be measured. It is a kind of 'fingerprint' for stencil making. There are rules of thumb that can be called on as well.

The TIF input is manipulated 'on the fly' during imaging without any loss in imaging speed.

While it is desirable to adapt small negative graphical elements as demonstrated here, it is mandatory not to affect adversely small positive elements (such as shadows and positive fine lines) that need to be imaged properly. They will print negative for screen applications.

The results shown here for graphic and related industrial applications can be transposed for all other applications involving photoresists or dry films.

X!Tend does the job professionally, completely, automatically and for all graphical elements (including raster zones) at any scale.

IMAGING RESULTS OBTAINED WITH THE X!TEND SOFTWARE ACTIVATED

Using the test file in **figure 1**, we imaged the screen with different levels of X!Tend correction at pre-set levels of energy. Results are summarised in **figure 4** at an imaging energy level of 700 mJ/cm²: as you can see from the graph, the actual line width increases steadily with increase of the level of correction and finer lines can be imaged. For standard imaging, lines below 400 microns are closed whereas at correction levels of 10 and 12, 200 microns lines are imaged correctly.

We select correction level 10 as optimal at 700 mJ/cm². See **figure 5**: the line widths imaged correspond to the widths in the digital file with good accuracy. The standard deviation is of 10 microns and the average value difference, within the whole set of data,

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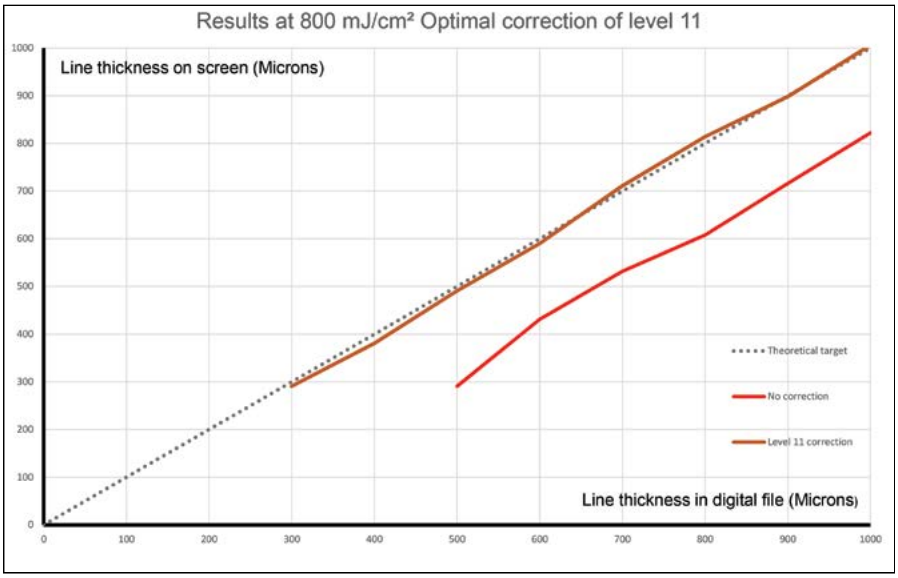


Figure 7: X!Tend imaging results at 800 mJ/cm² under optimal correction for the 100-micron capillary film on 43 mesh white polyester

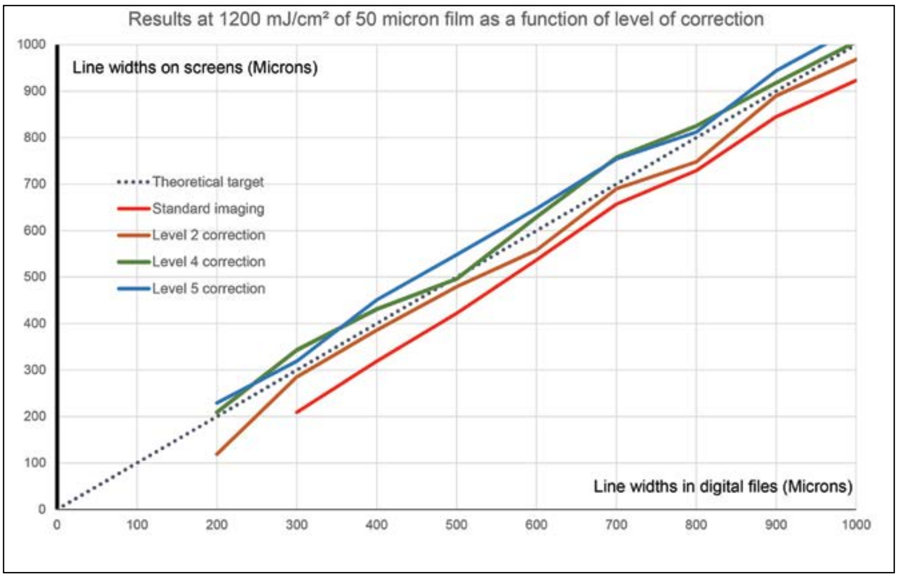


Figure 8: X!Tend imaging results at 1200 mJ/cm² as a function of level of correction for the 50-micron capillary film on 43 mesh white polyester

is within three microns of the target. Lines of 200 microns can be imaged whereas 400 microns is the lower limit under standard imaging conditions. The extension of the printing range and the improvement of fidelity of imaging to the digital data are obvious.

If need be, we can increase the level of imaging energy to 800 mJ/cm² and increase the X!Tend compensation. See **figure 6**.

At this level of energy, Level 11 correction is optimal (**figure 7**).

Please note that lines of 200 microns are no longer open at this correction; 800 mJ/cm² is, however, perfectly okay if the graphic to be printed is compatible with this added limitation in graphical elements size.

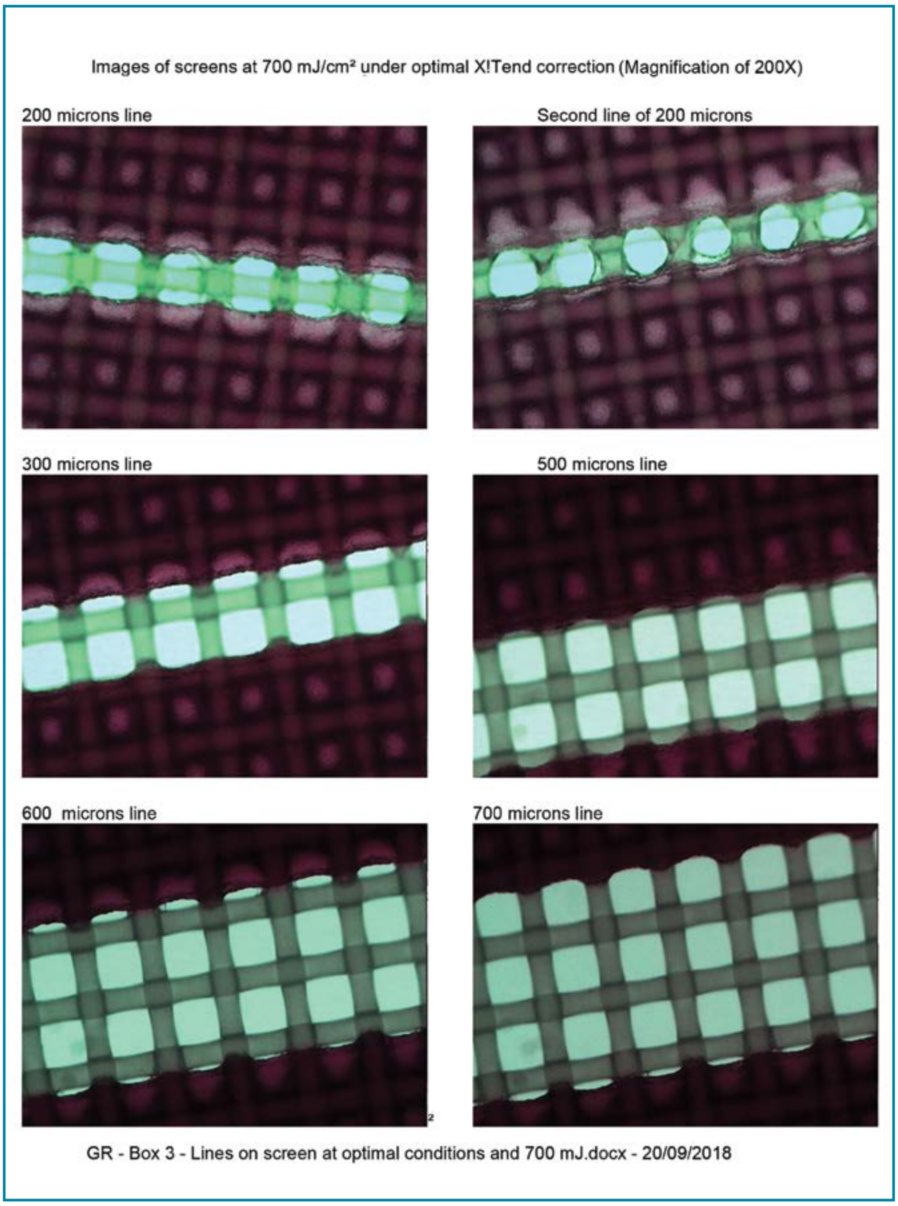
COMPLEMENTARY RESULTS

We have proven that our results are consistent over time and can be used for production purposes. Screen preparation has many manual steps not necessarily always well controlled.

Tests presented above have been duplicated with two batches of film from the supplier, two batches of film applications on screens and two imaging, followed by wash out, campaigns separated by months. All test results overlap well.

We should consider anyway the perturbation in results created by the mesh itself.

For this, see **boxout 3:** 'Images of screens at 700 mJ/cm² under optimal X!Tend correction (magnification of 200X)'. Two different 200 microns lines (on top of the box) are reproduced side by side. The line on the left has a yarn in the middle of it and will print very differently. This is inherent to Screen printing. With the mesh used here, 300 microns (lines or corresponding sizes of other graphical elements) is a reasonable lower limit to consider.



Boxout 3: Complementary results – microscope view at optimal X!Tend correction at 700 mJ/cm² for the 100-micron capillary film on 43 mesh white polyester

The results here can be transposed to different film thicknesses and types. Complementary tests with a 50-micron capillary film from a different brand, mounted on the same mesh, lead to somewhat different results. First of all, this film needs much more energy to get imaged correctly. The film needs a lower level of correction as light scattering is significantly lower for this material. These two parameters are most likely correlated by the specifics of the film chemistry.

Figure 8 shows X!Tend results at 1200 mJ/cm² for this 50-micron film. A level 3 X!Tend correction will do the job here.

CONCLUSION

The X!Tend software, completely integrated into the Lüscher imaging system, is a user-friendly professional tool enabling to radically improve the imaging of thick capillary films and emulsions. It is open in design with user defined settings totally integrated in the output computer and software of Lüscher CTS devices. The fidelity of reproduction of graphics is restored and finer graphics become possible to use in production. Last but not least, optimum imaging quality is made compatible with high life on press. It is qualified for a wide range of emulsions and capillary films. It is applicable as well for negative or positive photoresist applications of any type with all desired imaging resolutions. ■

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