

Global Inkjet Systems Ltd

Inkjet Printhead Technology Overview

Inkjet Forum India

August 2013



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GLOBAL INKJET SYSTEMS
CONTROL | PERFORMANCE | INNOVATION

Agenda

- **Introduction to inkjet technologies**
 - Piezo, thermal, CIJ etc
 - Binary vs. greyscale
 - Ink flow
 - XY scanning and single pass
- **Printheads overview**
 - Focus on printheads for textile printing
 - Nozzle maintenance
- **Inks – importance of formulation & production**

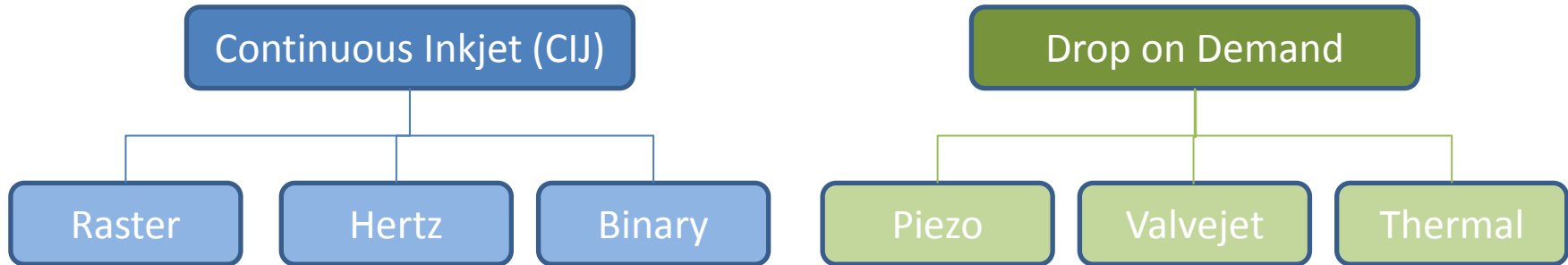


Ink Jet Textile Applications

- Fashion – apparel
- Fashion - accessories
- Home textile
- Carpets
- Flags and banners
- Leather
- Technical textile & automotive



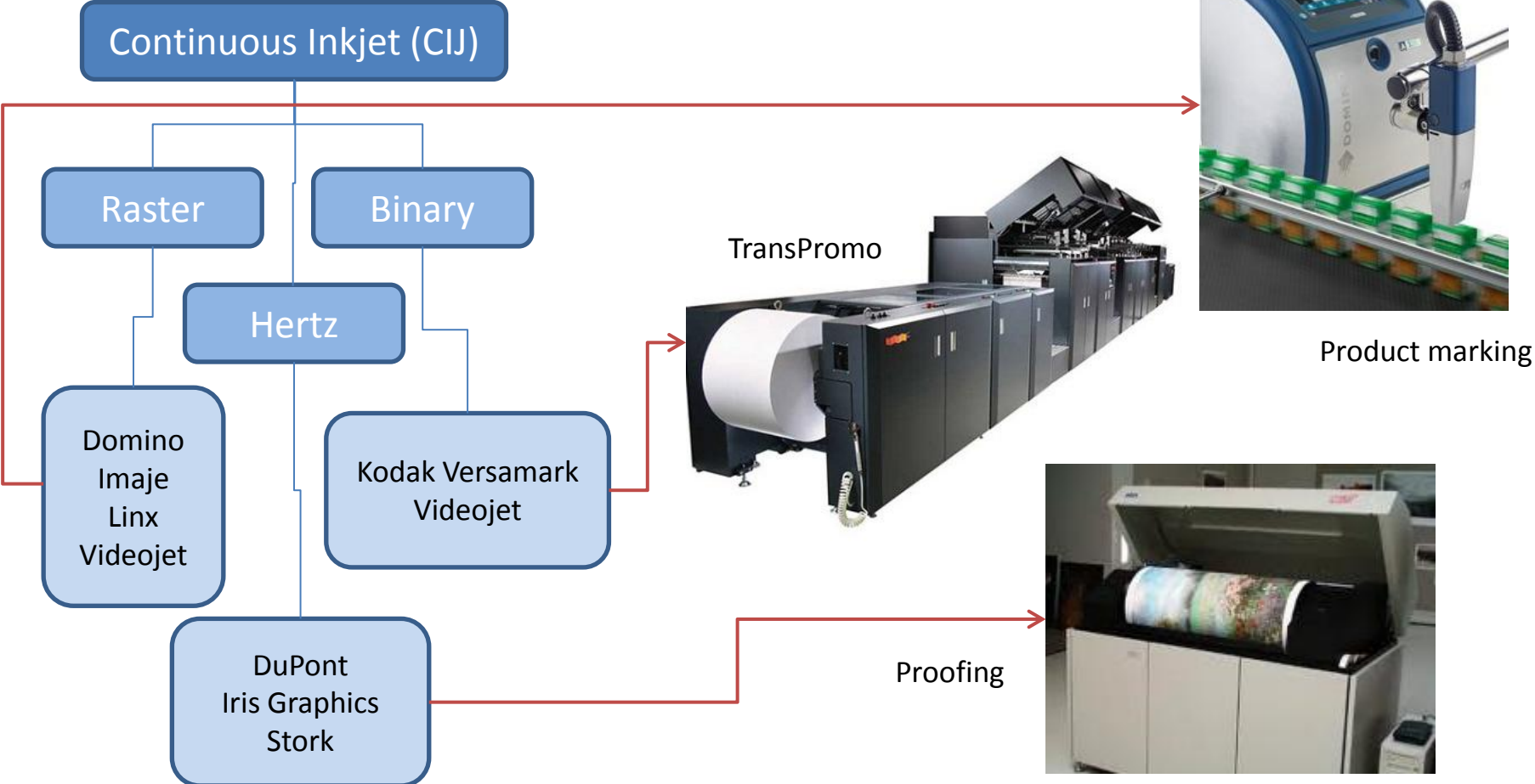
Simplified Chart of Inkjet Technologies



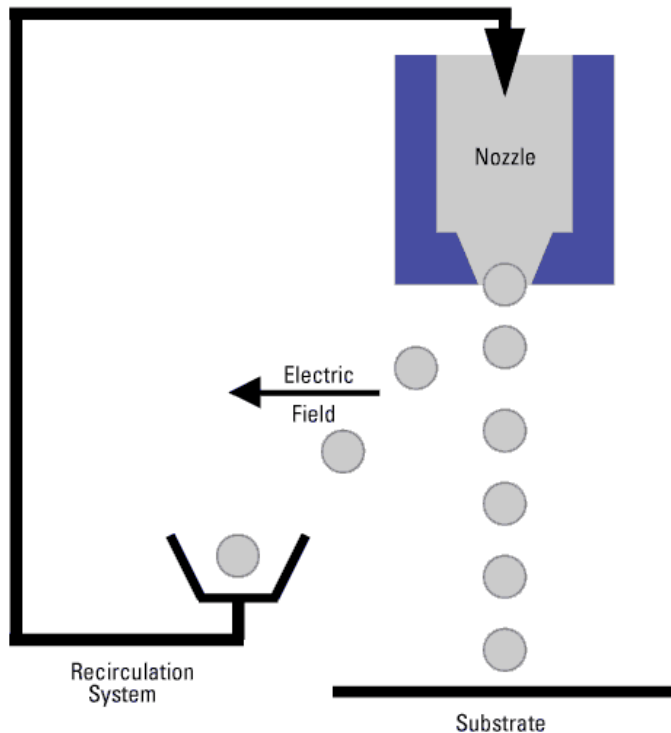
- There are many sub-categories of ink jet and some other technologies, but this presentation will
 - Provide an overview of technologies and terminology of inkjet
 - Concentrate on key technologies being used today in production systems – primarily drop on demand piezo inkjet



Continuous Inkjet



Continuous Inkjet



Continuous Inkjet

- A pump directs the ink from a reservoir to the nozzles, which eject a continuous stream of drops
- Acoustic or ultrasonic pressure waves break the stream of ink into individual droplets
- Drops pass through a set of electrodes which impart a charge onto each drop
- Charge selects drops that are to be printed and drops to be collected and returned for re-use

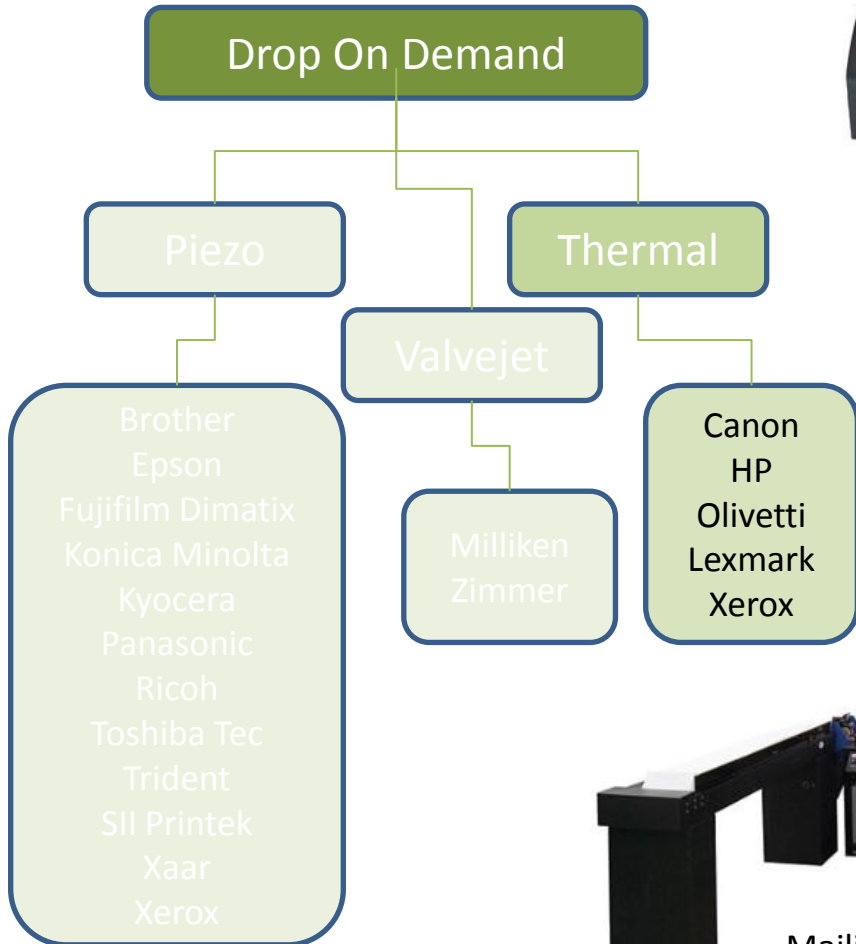


Continuous Inkjet (CIJ)

- **Tencate/Xennia Osiris**
 - Raster CIJ (Imaje)
 - Single pass
 - Up to 30m/min
 - Print width 1.6 or 1.85m
 - 8 colours



Drop On Demand Inkjet - Thermal



Desktop



Graphics



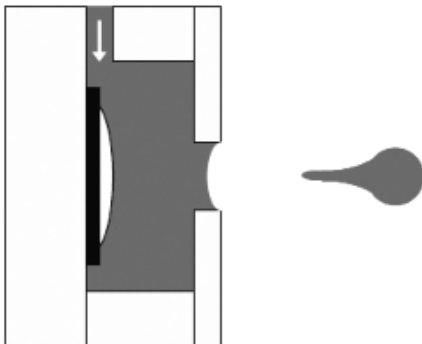
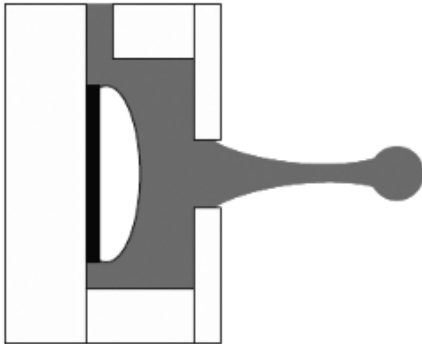
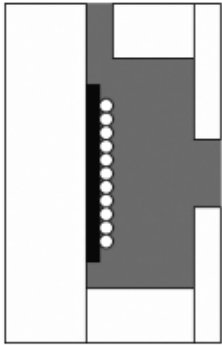
Books



Mailing, addressing



Drop On Demand Inkjet - Thermal



- **Tiny heating element within the ink chamber**
- **Current applied to element, causing it to heat rapidly**
- **The temperature of the resistive element rises to 350-400°C, causing a thin film of ink above the heater to vaporise into a rapidly expanding bubble**
- **Causes a pressure pulse that forces a drop of ink through the nozzle**
- **Ejection of the drop leaves a void in the chamber, which is then filled by replacement fluid in preparation for creation of the next drop**



Drop On Demand - Valvejet

Drop On Demand

Piezo

Thermal

Valvejet

Brother
Epson
Fujifilm Dimatix
Konica Minolta
Kyocera
Ricoh
Toshiba Tec
Trident
SII Printek
Xaar
Xerox

Milliken
Zimmer
Videojet
Domino

Canon
HP
Olivetti
Lexmark
Xerox



Carpets, rugs, fur

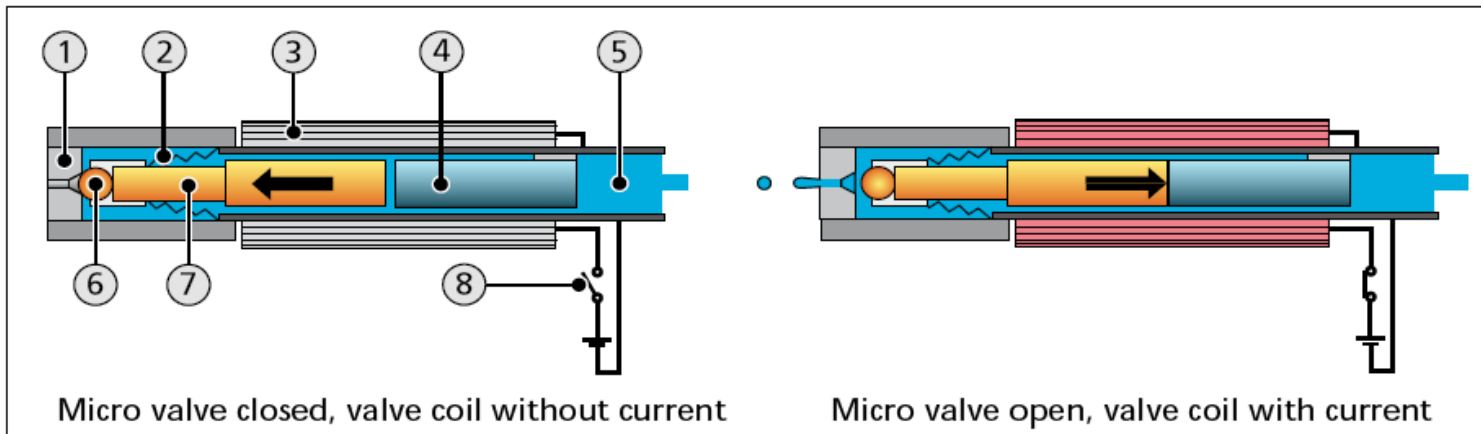


Product marking



Drop On Demand - Valvejet

- **Valvejet**



1. Valve seat, valve nozzle
2. Closing spring
3. Valve coil
4. Stationary anchor

5. Medium
6. Valve ball
7. Mobile anchor
8. Switch

The micro valve is actuated electromagnetically and medium flows through it directly. When there is no current, the micro valve is closed. The closing spring acts on the mobile anchor with the valve ball.

When there is a current feed through the valve coil, the mobile anchor with the valve ball is magnetically pulled by the magnetic field of the stationary anchor. The micro valve opens and the medium emerges.



Drop On Demand - Piezo



Textiles



Desktop



Graphics



In line with flexo



Plastic cards



Ceramics, Laminates



Drop on Demand

Piezo

Thermal

Valvejet

- Brother
- Epson
- Fujifilm Dimatix
- Konica Minolta
- Kyocera
- Panasonic
- Ricoh
- SII Printek
- Toshiba Tec
- Trident
- Xaar
- Xerox

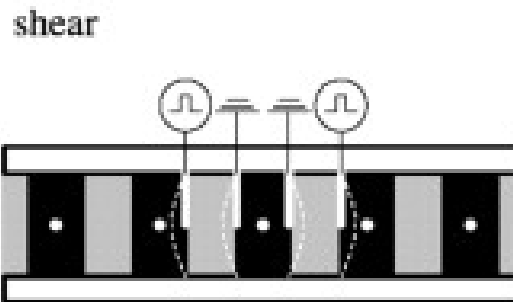
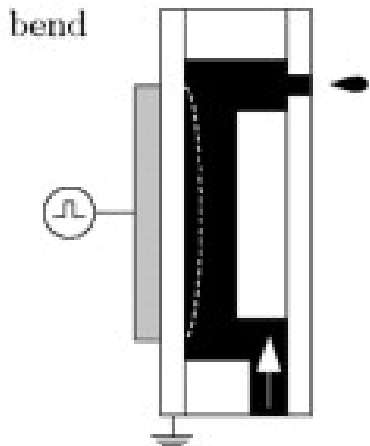
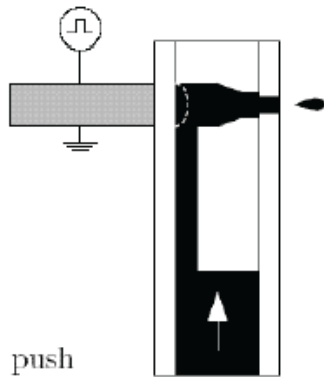
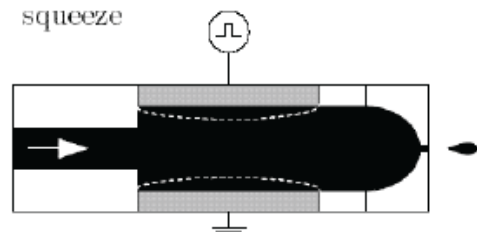
Milliken
Zimmer

Canon
HP
Olivetti
Lexmark
Xerox

Used in a very wide range of applications



Drop On Demand Inkjet - Piezo



- Piezoelectric ceramic material deforms when voltage is applied
- Distortion creates a pressure pulse in the ink chamber
- Causes a drop to be ejected from the nozzle
- Many different modes – shear, bend, push, edge = different configurations of the piezo material and the nozzle



Key Benefits of Piezo Drop On Demand

- **Robust technology for broad range of industrial applications**
 - Proven in production
- **Adaptable configurations to provide higher speeds and print quality**
- **Consistent drop velocity and drop volume**
- **Wide range of ink capability**
 - Enables wide range of applications
- **High accuracy jetting**
- **Long life printheads**
 - Capable of high duty production
 - High reliability (subject to correct use)



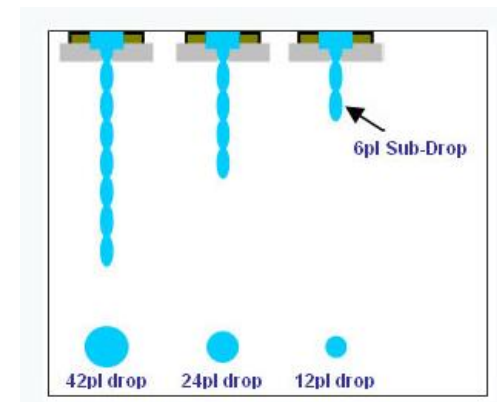
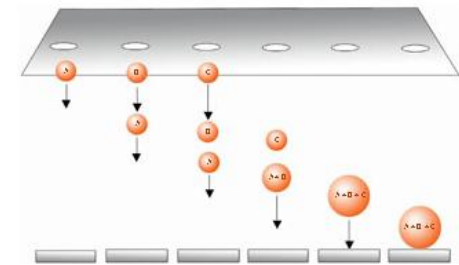
Ink Jet Technologies - Summary

- **Continuous (CIJ) = continuous flow of ink**
 - Method to produce drops
 - Method to select drops
 - Method to recover and control the ink
 - High speed capability
 - Typically low resolution, but high resolution capable
- **Drop On Demand (DOD) = drop of ink only generated when needed**
 - No drop selection or deflection required
 - Each nozzle fires only as required – nozzles can be inactive
 - Nozzle maintenance and good ink formulation required
 - Actuation mechanism required with enough energy to generate drop at required velocity to eject and reach substrate successfully
 - Actuation methods – most common are thermal and piezo
 - Piezo dominant technology in textile printers



Binary vs. Greyscale

- **Binary**
 - One drop size
 - On or off
- **Multi-pulse binary**
 - Special mode offered by some printheads
 - Ability to create larger drops (all same size)
- **Greyscale**
 - Variable number of drops
 - Drops coalesce in flight or at nozzle plate
 - Directly vary drop volume
 - Vary waveform according to drop size required
 - Apply different waveforms to each bank of piezo



Greyscale Printing

Source: Dimatix



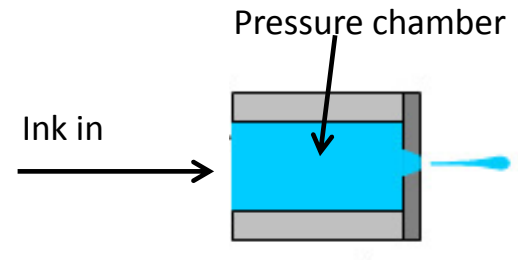
Grayscale for close viewing, smooth tones and fine type

Small drops for ultra-close viewing

Large drops for long-distance viewing



Ink Flow

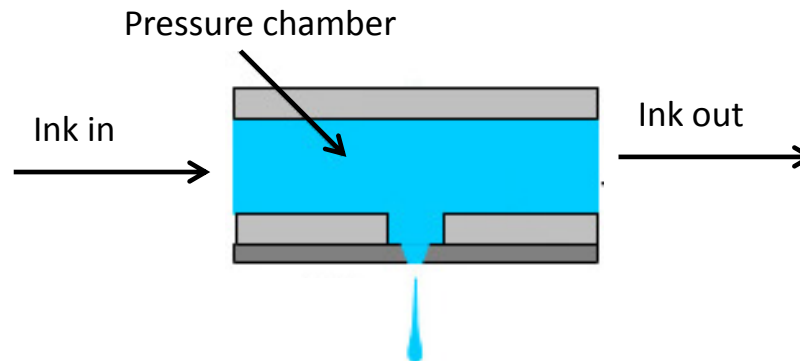


- **End shooter/single ended**

- Ink flows into the channel and exits only through the nozzle

- **Recirculating/through flow**

- Ink flows continuously through the channel and exits the nozzle only when required

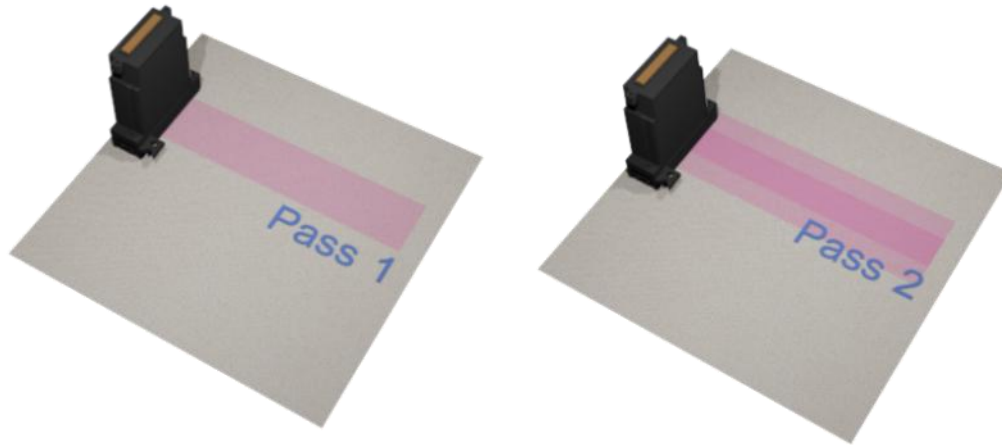


Diagrams source: Xaar web site



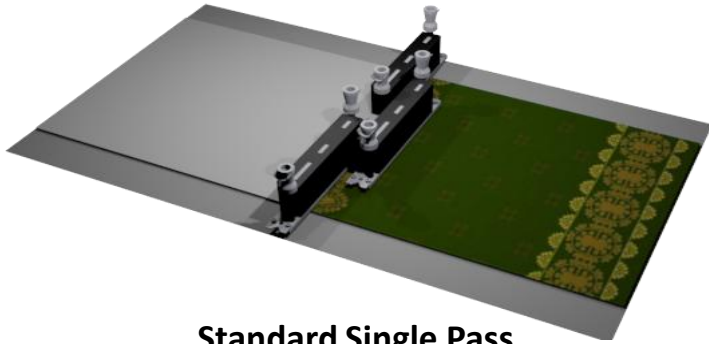
Scanning XY

- **One pass printing**
 - High productivity
- **Multipass printing**
 - Passing two or more times over the same line of image data
 - Typically 2 different nozzles print on the same line

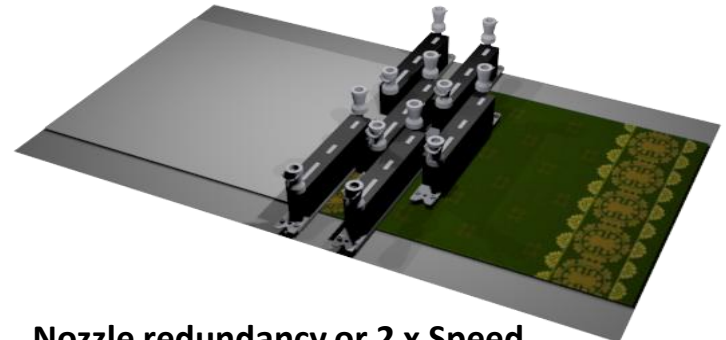


Single Pass Printing

- **Fixed array of printheads**
 - High productivity
 - Established in many other industrial applications (ceramics, labelling etc)
 - Emerging in textile
 - Reliability critical



Standard Single Pass



Nozzle redundancy or 2 x Speed



MS La Rio



Piezo Inkjet Printheads for Textile Printing

(in alphabetical order)



Epson DX5 Series

- **360 DPI, 1,440 nozzles arranged in 8 x 180 rows**
- **One printhead can print 8 different colours at the same time with 180 dpi resolution, or 4 different colours with 360 dpi resolution**
- **Greyscale - from 3.5pl to 10pl**
- **Used in many textile printers e.g. Mimaki, Robustelli etc**



Robustelli Monna Lisa



Epson DX5 printhead



Fujifilm Dimatix Q-Class Polaris Series

- 512 nozzles - 4 rows of nozzles
- 200 dpi one-colour (all 4 rows)
- 100 dpi two-colour (2 rows per colour)
- VersaDrop binary jetting capability
 - 15pl drop (40kHz) & up to 30pl (25kHz)
 - 35pl drop (30kHz) & up to 90pl (13kHz)
 - 85pl drop (20kHz) & up to 150pl (10kHz)
- Used by e.g. Kornit Digital

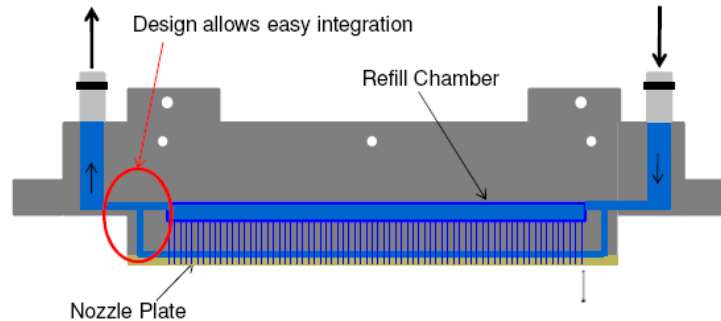


Kornit Allegro



Fujifilm Dimatix StarFire SG1024 Series

- 1024 nozzles
- 400dpi 4 grey levels
- Incorporates VersaDrop binary and greyscale jetting
- RediJet – continuous ink circulation at the nozzle



- Removable/replaceable coated metal nozzle plate
- Precise registration points
 - Allows multiple printheads to be accurately arrayed into print bars
 - Reduces set-up and alignment costs during nozzle replacement or printhead exchange
- Used by e.g. Indian Textile Engineers



ITE



Konica Minolta 512i

- **360 x 360 dpi greyscale**
- **Drop frequency 20kHz**
- **~14pl sub-drop**
- **Print width 72mm**
- **Many new systems shown at recent ShanghaiTex**
 - Shenyang Sky Air-Ship
 - Colorjet India
 - JHF
 - Flora Digital

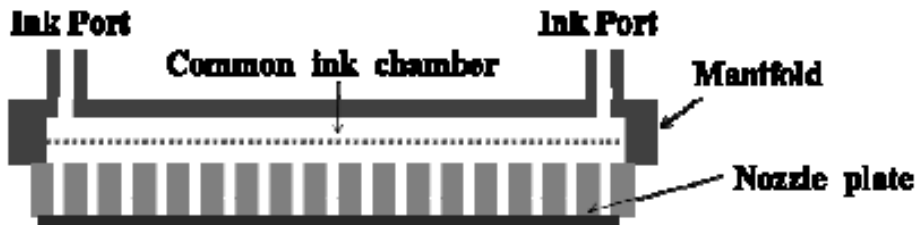


Shenyang Sky Air-Ship Rainbow 1800 series; 8 or 16 heads;
4 or 8 colour; 1.8m wide; 720 x 360dpi 8 heads = 55 sq.m/hr



Konica Minolta 1024i Series

- S, M, L versions
- 360 x 360dpi greyscale
 - 3 levels
- 72mm wide - slim & compact design
- Ink recirculation



KM1024i



- Use by e.g. KM Nassenger

Longitudinal cross section of KM1024i
Source: IS&T NIP conference 2011



Kyocera KJ4B-QA (30kHz)

- 2656 nozzles
- 600 x 600dpi
- Greyscale - Up to 4 levels
 - 5pl, 7pl, 12pl, 18pl
- 108mm wide
- 75m/min linear
- 30kHz
- Used by e.g. MS Italy, Stork Prints, La Meccanica



MS Italy LaRio

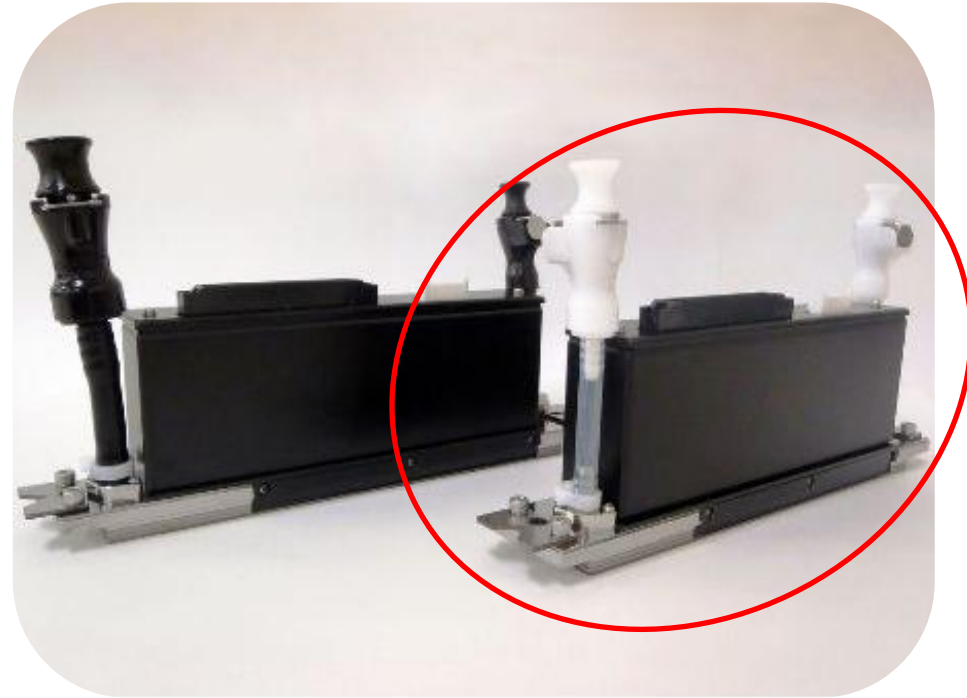


La Meccanica Qualijet



Kyocera KJ4B-YH (40kHz)

- 2656 nozzles
- 600 x 600dpi
- Greyscale up to 4 levels
 - 5pl, 7pl, 12pl, 18pl
- 108mm
- 100m/min linear
- 40kHz

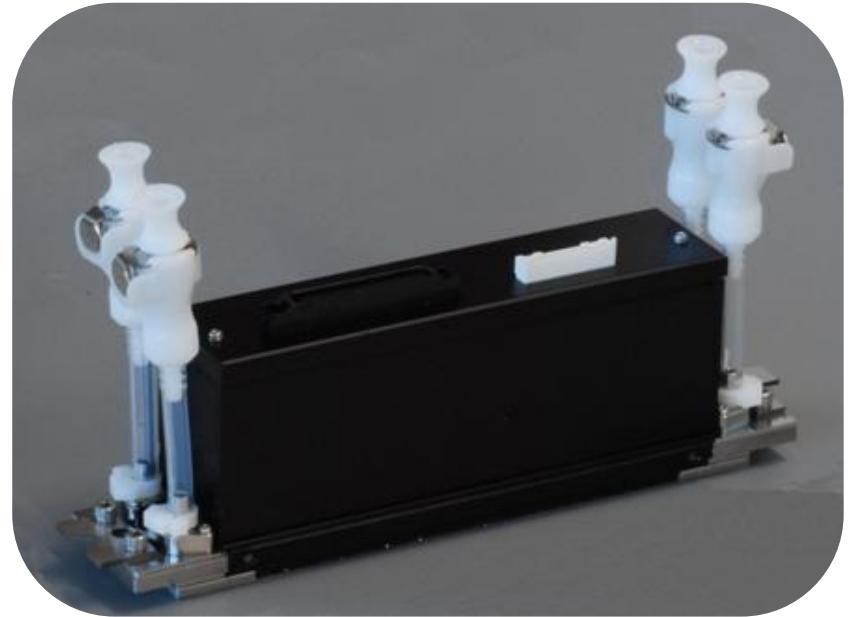


KJ4B-YH



Kyocera KJ403T-W06S

- **2656 nozzles**
- **Two colour (1328 nozzles each)**
- **300 x 300dpi**
- **112mm wide**
- **152m/min**
- **30kHz**

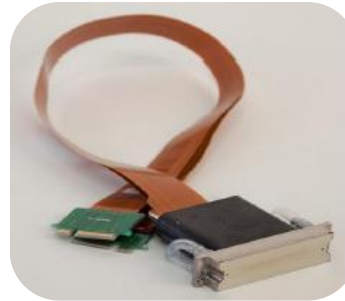


KJ403T-W06S



Ricoh Gen4/4L

- **Gen 4**
 - 384 nozzles (2 rows)
 - 32mm wide
 - 300dpi
- **Gen 4L**
 - 384 nozzles (two rows)
 - 150dpi
- **Used by e.g. Mimaki, Durst**



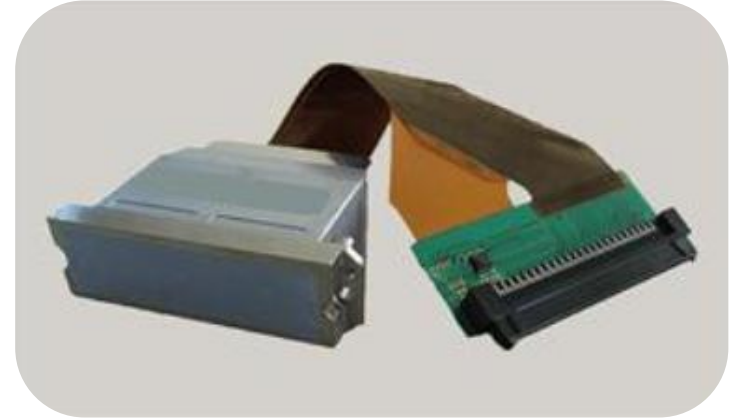
| Gen4 Family of Solutions | | | | | | | | |
|--------------------------|--------|--------|--------|-------------|--------|--------|-------------|--------|
| | Gen4 | | | Gen4L/15 pL | | | Gen4L/27 pL | |
| Electronics | Common | | | Common | | | Common | |
| Native Drop Sizes | 7 pL | | | 15 pL | | | 27 pL | |
| Selectable Drop Sizes | 7 pL | 14 pL | 21 pL | 15 pL | 30 pL | 45 pL | 27 pL | 54 pL |
| Frequency | 30 kHz | 20 kHz | 20 kHz | 30 kHz | 20 kHz | 20 kHz | 30 kHz | 14 kHz |
| Maximum Temperature | 60C | | | 80C | | | 80C | |

Images courtesy of Ricoh



Ricoh Gen5

- **1280 nozzles (4 rows)**
- **54mm wide**
- **600dpi - 8 greyscale levels**
- **UV, solvent, aqueous**
- **Four separate independent ink manifolds**
 - 1, 2 or 4 colour support
 - One colour: 600dpi
 - Two colour: 300dpi
 - Four colour: 150dpi
- **75m/min binary 30kHz**
- **50m/min double & triple drop 20kHz**
- **Stainless steel nozzle plate**
- **Built in 20 μ filter**
- **Used by e.g. ATPColor, MTEX, Mimaki**



Ricoh Gen 5

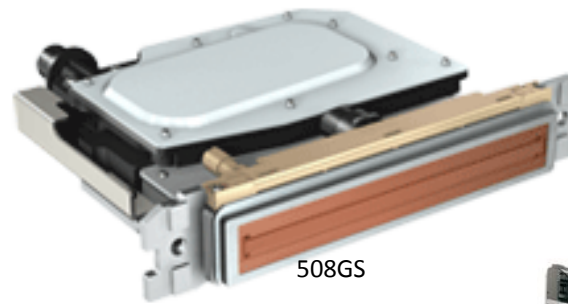


APTColor DPP-740-G5



SII Printek – 508GS

- 180dpi
- 508 nozzles
- 8 levels of greyscale
- 12,24,36,48,60,72,84pl drop sizes
- 71.8mm print swath
- Used by e.g. Zimmer, d-gen, Toshin, Hollanders



508GS



Zimmer Colaris



Toshin 2020



D gen Telios



SII Printek – 1020GS & 2040GS Series

- 180, 360 or 720 npi
- Greyscale and variable binary mode
 - 7pl sub drop version
 - 12pl sub drop version
- 1020GS can be run as a 2-colour printhead
- 2040GS can be run as a 4-colour printhead



| | | | |
|--------------------------|-----------------------------|-----------------------|--|
| Active nozzles | 1020 or 2040 | Drop volume* | 7 to 49 pL (7pL drop) or 12 to 84 pL (12 pL drop) |
| Numbers of modules | 2 or 4 | | |
| Native nozzle resolution | 180, 360, 720 [npi] | Jetting frequency* | Up to 36 [kHz] (7pL drop) or Up to 28 [kHz] (12 pL drop) |
| Print width | 72.1 [mm] | | |
| Number of grey levels | 8 | Maximum productivity* | 1428 [µL/sec] / 2040 head (700 [nL/sec] / nozzle) |
| Ink type | UV / Aqueous (Solvent**) | Dimensions (WxDxH) | |
| | | 135×27.8×127 [mm] | |

* Frequency and drop size depend on ink and ink system

Specifications can be modified without prior notice

** Under development



Why Looking After Your Printer Is So Important

- The technology is breathtaking
- For example:
 - A Kyocera KJ4B 30kHz printhead has 2,656 nozzles
 - Each nozzle can jet up to 30,000 drops of ink per second
 - That is potentially a total of 79,680,000 drops per second
 - On a printer with 8 heads (one per colour) that's 637,440,000 drops per second
- The drops and the nozzles are tiny!

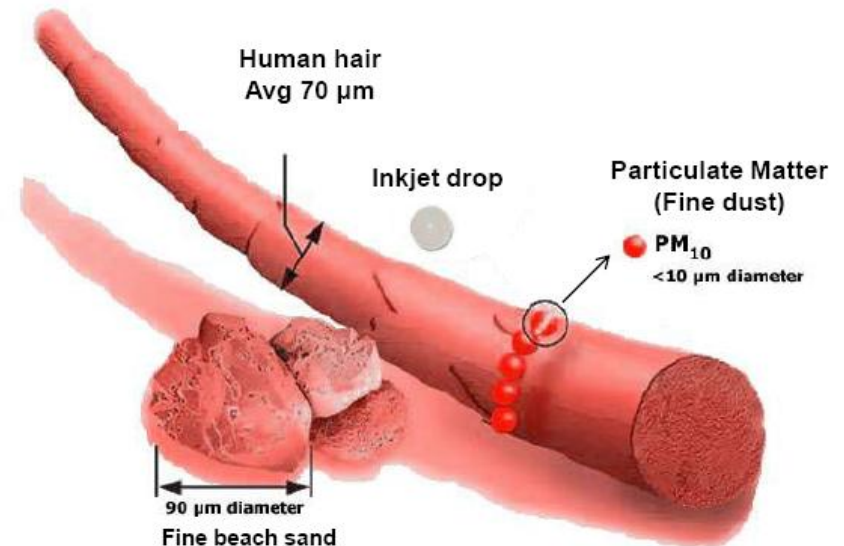


Image and slide concept courtesy of Stork Prints



What Can Cause Problems?

- **Bubbles**
 - Caused by leaks in ink supply system
 - Inks not properly degassed
 - Ingestion through the nozzle
 - Can be averted by;
 - Good degassing
 - Ink supply that avoids bubble traps
- **Jetting**
 - Satellites, microspray during jetting
 - Drops with low velocity will move with airflow
 - Jets can generate air currents
- **No Jetting**
 - Idle (non-firing) nozzles can collect debris
- **Vibration**
 - Can cause ink to weep onto nozzle plate



Used head, all nozzles open



Used head, 1 nozzle open, 2 nozzles clogged



Used head, nozzles open but corrosion → Jet angle problems



What Can Cause Problems?

- **Substrate (e.g. textile)**
 - Dust, fibres, debris
 - Blocks nozzles
 - Semi-blocking nozzles causing drop deviation
 - Can cause scratches during maintenance and so cause drop deviation
 - Misplaced or missing jets
- **Flooding**
 - Can be caused by dust on the nozzle plate, dried ink and/or poor ink pressure
 - Excess ink spreads sideways to neighbouring nozzles
 - Excessive ink causes drops to slow down
- **Environment**
 - Dust, dirt, skin, mites, anything!



Jet angles



Slide content courtesy of Stork Print

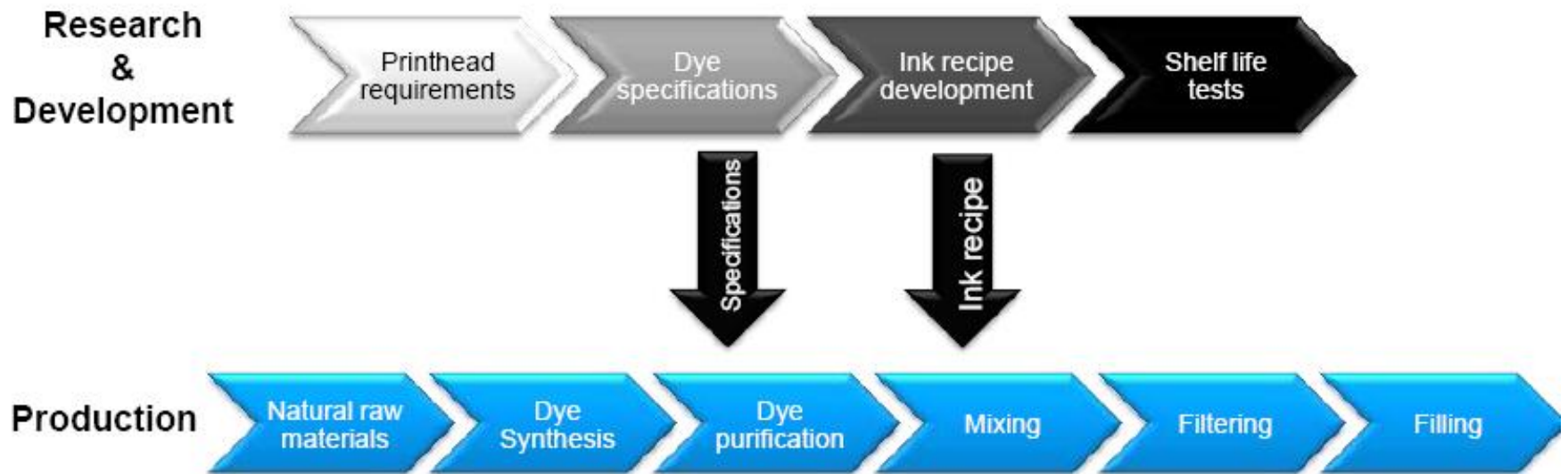


Nozzle Maintenance

- **Nozzle maintenance is essential – features built into your printer as standard**
 - Manual/automatic maintenance cycles
 - Spitting
 - Purging
 - Capping
 - Wiping (dry and wet)
- **Drop formation is very sensitive to ink properties and nozzle condition**
- **Discuss maintenance with your system provider**
 - Comprehensive maintenance systems can have a huge effect on printhead life and replacement costs



Inkjet ink manufacturing process



Slide content courtesy of Stork Prints

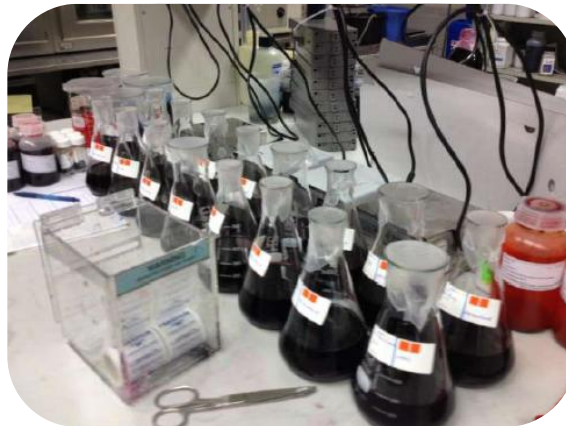


Ink Development

- **Printhead analysis**
 - Materials compatibility
- **Dye purification**
- **Formulation development**
- **Drop analysis**
- **Accelerated shelf life tests**



Slide content courtesy of Stork Prints

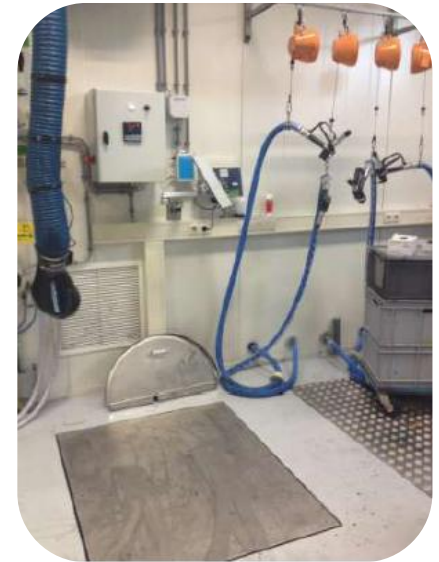


Ink Production

- Dye synthesis and purification
- Raw materials - high precision weight scale
- Purified powder dye mixing in glove box
- Ink mixing – different batch volumes
- High precision filtering
- Degassing (cartridges)



Slide content courtesy of Stork Prints



Acknowledgements & Sources

- Numerous web sources for diagrams and images
- Digital Textile Magazine - <http://www.wtin.com/magazine/digital-textile/>
- Pivotal Resources – Understanding Piezo Technology (IMI Europe Summer School 2010) – www.pivotal.co.uk & www.imieurope.com
- Stork Prints – The Importance of Ink Quality in Digital Textile Printing - Jos Notermans November 2012 <http://www.spgprints.com/>
- IS&T technical archives – www.imaging.org
- Printhead manufacturer web sites:-
 - www.epson.co.jp
 - http://www.fujifilmusa.com/products/industrial_inkjet_printheads/index.html
 - <http://www.konicaminolta.com/inkjethead/>
 - http://global.kyocera.com/prdct/tfc/inkjet_printhead/
 - <http://www.rpsa.ricoh.com/>
 - <http://www.siiprintek.co.jp/eg/>

