Ink Delivery Systems (IDS)
Design Options & Troubleshooting

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Global Inkjet Systems Ltd
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• GIS products enable system builders to reduce development time and get products to market faster
• We provide powerful, flexible & adaptable integration tools to suit your system and application needs
Agenda

• Basic requirements
• Flow modes
• Heating
• Degassing
• Large print bars
• Typical IDS issues
  • Troubleshooting and solutions
Basic Requirements

• **Maintain head pressure at nozzles within required range**
  • At different flow rates
  • Scanning XY systems – withstand the acceleration/deceleration of printhead carriage

• **Filtration**
  • Minimise chance of particles clogging the nozzles

• **Degas**
  • Stop air bubbles reaching the printhead/nozzles
  • Avoid air pockets in ink system

• **Recirculation**
  • Specific printheads

• **Heat the ink**
  • For correct operating temperature (printhead dependent)

• **Low level ink indicator**
• **Change bulk ink tanks on the fly**
• **Reliable system for production environments**
Flow Modes

1. End Shooter
2. Low Flow
3. Adjustable Flow

Pressure Difference
Height Difference
No Flow/End Shooter

- **Basic characteristics**
  - Air pressure range typically 250-500mm between header tank and nozzle plate
  - In this example, negative pressure $P$ (-350mm) applied to balance the positive head of fluid (300mm) and provide a negative meniscus pressure of -50mm at the nozzle plate
Low Flow/End Shooter

• **Basic characteristics**
  • Height difference between the header tanks
  • Same negative air pressure applied to both tanks
  • System constantly tries to level and creates low flow through the printhead
Controlled/Adjustable Flow

- **Basic characteristics**
  - Two pressure values assigned
  - Printhead manufacturers tend to specify the pressure difference
  - Differential air pressure creates flow through the printhead
  - $P_1$ and $P_2$ both adjustable to vary/control the flow rate
# Example Printheads

<table>
<thead>
<tr>
<th>Example Printheads</th>
<th>No Flow</th>
<th>Low Flow</th>
<th>Controlled Flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fujifilm Samba G3L</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Fujifilm Starfire SG1024</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Fujifilm Sapphire 256</td>
<td>✓</td>
<td>(✓)</td>
<td>✗</td>
</tr>
<tr>
<td>Konica Minolta 1024i</td>
<td>✓</td>
<td>(✓)</td>
<td>✗</td>
</tr>
<tr>
<td>Kyocera KJ4B-QA/YH</td>
<td>✓</td>
<td>(✓)</td>
<td>✗</td>
</tr>
<tr>
<td>Kyocera KJ4A-TA/AA/RH</td>
<td>✓</td>
<td>(✓)</td>
<td>✗</td>
</tr>
<tr>
<td>Ricoh MH5440</td>
<td>✓</td>
<td>(✓)</td>
<td>(✓)</td>
</tr>
<tr>
<td>TTEC CF1/CF3</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Xaar 1003</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Xaar 5601</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
</tbody>
</table>

**Key**
- ✓ Required
- (✓) Optional
# Ink Requirements

<table>
<thead>
<tr>
<th>Ink Type</th>
<th>Typical Ink System Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV</td>
<td>Requires heating (most printheads have heaters and/or use heated mounts)</td>
</tr>
<tr>
<td></td>
<td>Degassing is advantageous i.e. best for high frequency/large number of heads</td>
</tr>
<tr>
<td></td>
<td>- but can make ink over-sensitive to curing</td>
</tr>
<tr>
<td>Aqueous</td>
<td>(Requires) degassing</td>
</tr>
<tr>
<td>Oil based</td>
<td>None special</td>
</tr>
<tr>
<td>Solvent</td>
<td>None special</td>
</tr>
<tr>
<td>White/ Ceramic</td>
<td>Requires special pumps due to abrasive ink pigment and particle settling</td>
</tr>
</tbody>
</table>
| Fluid Deposition/ Functional Fluid/ Ink Development | Requires materials compatibility testing  
Typically requires small volumes due to high value of fluid– may affect header tank design/size |
• Ink performance varies with temperature
  • Higher temperature
    • Reduces viscosity
    • Increases evaporation
• Inks have a recommended operating temperature window (consult you ink supplier)
• Temperature most critical at the printhead/jetting

<table>
<thead>
<tr>
<th>Mode of Heat</th>
<th>Comment</th>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-line Heaters</td>
<td>Only work with recirculating systems</td>
<td>Provide fast and controllable ink heating</td>
<td>Cost</td>
</tr>
<tr>
<td>Heated Header Tanks</td>
<td>Typically used in no flow or low flow systems</td>
<td>Lower cost than in-line heaters</td>
<td>Only suitable for low density printing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Temperature control less accurate</td>
</tr>
<tr>
<td>Heated Head Plates</td>
<td>Can be used with all flow modes</td>
<td>Provides uniform thermal environment</td>
<td>Thermal expansion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduces workload on printhead/ink system heating</td>
<td>Adds cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Improving thermal control</td>
<td></td>
</tr>
</tbody>
</table>
Degassing

- **(Required) for aqueous inks**
  - Sometimes not used on small systems to save cost
- **Recommended for some UV inks**
  - Typically on large, high print frequency systems
- **Contactor must be right size for flow rate and compatible with ink**
- **Vacuum must be applied**
  - High vacuum for aqueous ink
  - Lower vacuum for UV ink
  - Risk stripping all oxygen out of the ink and cause curing

Image source: Membrana
Manifold system
- Popular design
- Cost efficient to implement
- Can be prone to air traps
  - Trapped air can sit at top of manifold
- Can be difficult to fill
- Extendable

Custom header tanks
- Header tank acts as manifold
- Valve for each printhead
- Equal flow resistance
- Extendable
Common Issues Attributed to IDS

- Weak Nozzles
- Late or Grouped Jetting
- Misdirected Jets
- Unreliable Jetting
- Process Direction Density Variation
- Cross Process Density Variation
- High Print Speed Variation
- Print Density Uniformity
- Print Density Uniformity
- Printhead Life
- Hard to Prime
- Blocked Nozzles
- Blocked Printheads
- Nozzle Plate
- Air In Printhead
- Ink On Nozzle Plate
- Drop Ejection
- Failing Nozzles During Print
- Weak Jets at Start of Swathe
Common Issues with Alternative Causes

- Waveform / Electronics
- Environmental / Media / Mechanical
- Printhead Lifetime
- Blocked Nozzles
- Blocked Printheads
- Hard to Prime
- Print Density Uniformity
- Process Direction Density Variation
- Cross Process Density Variation
- High Print Speed Variation
- Print Heads
- Misdirected Jets
- Unreliable Jetting
- Late or Grouped Jetting
- Weak Jets at Start of Swathe
- Weak Jet Nozzles
- Falling Nozzles During Print
- Air in Printhead
- Ink On Nozzle Plate
- Hard to Prime
- Printhead
- Ink Delivery System
- Drop Ejection
Typical IDS Issues

• **Trapped air**
  
  • **Symptoms**
  
  • Difficult morning start up
  • Ink dripping from nozzle plate, even when pressure set correctly
  • Intermittent printing
    • Heads may print well for short time until air moves into the head
    • Heads may print well for low density images but fail quickly for high density images

• **Solutions**
  
  • Ink degassing
  • Avoid tubing with uphill path or loops
  • Correct tube size (not too small or too large) – restricted flow can lead to air being sucked into the nozzle as the head fails to pull ink through the system
  • Avoid restrictions in valves & fittings
Typical IDS Issues

• **Poor pressure control**
  • **Symptoms**
    • Ink dripping at the head or air sucking into the head
    • Variations in optical density in the image – volume of ink in each drop is affected
  • **Causes**
    • Vacuum pump on continuously creates loss of pressure
    • Dirt in vacuum pump diaphragm
    • Vacuum setting incorrect
    • Pulses from pump
  • **Solutions**
    • Control of vacuum pressures +/- fluctuations
    • Smooth flow control – not pulsing
    • Maintain adequate flow of ink – don’t run out
Typical IDS Issues

• **Sedimentation**
  • **Symptoms**
    • Heads clog
    • Parts of the ink system clog – filters etc.
    • Reduced flow to heads
  • **Causes**
    • Heavily pigmented inks
    • Unstable dispersion
  • **Solutions**
    • Recirculating flow mode
    • Adjustable flow rate useful
    • Avoid pigment collection points
    • Use special pumps – resistant to abrasion which can wear internal components
    • Agitation of ink – in bulk tank

Image source: Porvair filters
Typical IDS Issues

• **Materials compatibility issues**
  • **Symptoms**
    • Blocked nozzles
    • Ink starvation
    • Swelling of tubes
    • Failure of the system
  • **Solutions**
    • Can be difficult to fault find
    • Can cause expensive problems
    • Choose components carefully and do sufficient materials compatibility testing
      • Material can leech into the ink
      • FEP or PTFE (not silicone!)
Typical IDS Issues

• General system unreliability
  • Causes
    • Unsuitable components e.g. ink pump type
    • Poor quality components
    • Poor control logic/software
  • Solutions
    • Appropriate components e.g. ink pump type
    • Good quality components
    • Tried and tested components
    • Implement industry standard control techniques/software
Summary

• **Insure against future problems by careful design and planning**
  • Materials compatibility, correct components, follow ink and printhead manufacturer guidelines etc.

• **Over-specify on prototype**
  • Simplify and cut cost when proven

• **Low flow use with end shooter printheads is growing**
  • No flow for CMYK
  • Low flow for W

• **Recirculating/controlled flow printheads increasing**
  • More demanding for IDS design and implementation
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