GIS | GLOBAL INKJET SYSTEMS

Understanding Ink/Fluid Delivery Systems

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IMI Inkjet Age of Materials Conference

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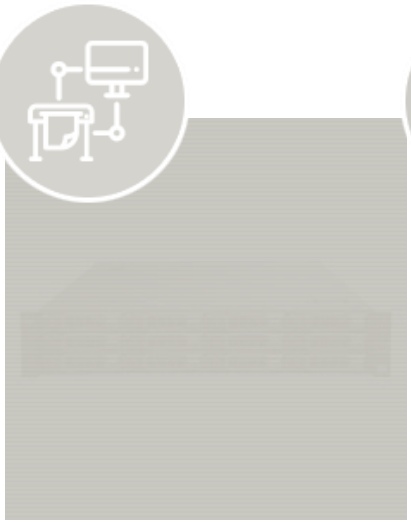
IMI
Emerging Technology Events in North America

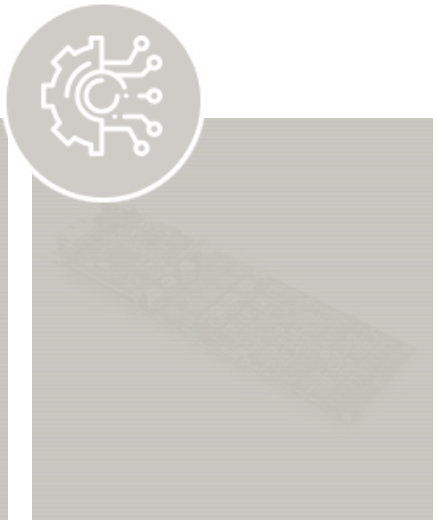
GIS – Company Overview

- Leading provider of technology solutions to industrial inkjet systems builders
- Supported printhead manufacturers
  - Fujifilm Dimatix, Konica Minolta, Kyocera, Ricoh, SII, Toshiba Tec, Xaar
- Founded November 2006
  - Privately owned
- Based in Cambridge, UK
  - Technical support in UK, China and Japan
- Employees 70
- Patent protected technology
- Supplier & partner to over 130 customers worldwide

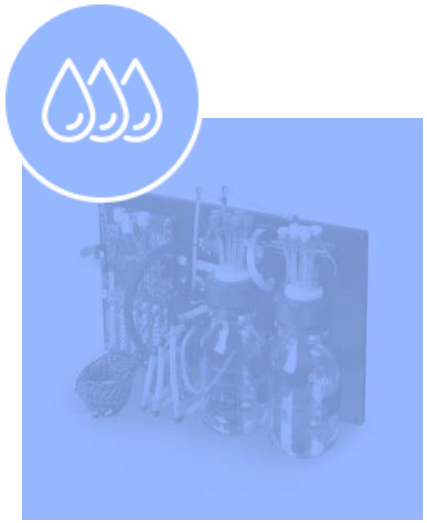
GIS – Products



Control & Image Quality Software
Atlas®



Print Controllers
Drive Electronics



IDS
Ink Delivery Systems

Agenda

- Main functions and basic requirements of ink delivery systems (IDS)
- Design considerations and control
- Flow modes and printhead types
- System requirements
- Typical IDS issues

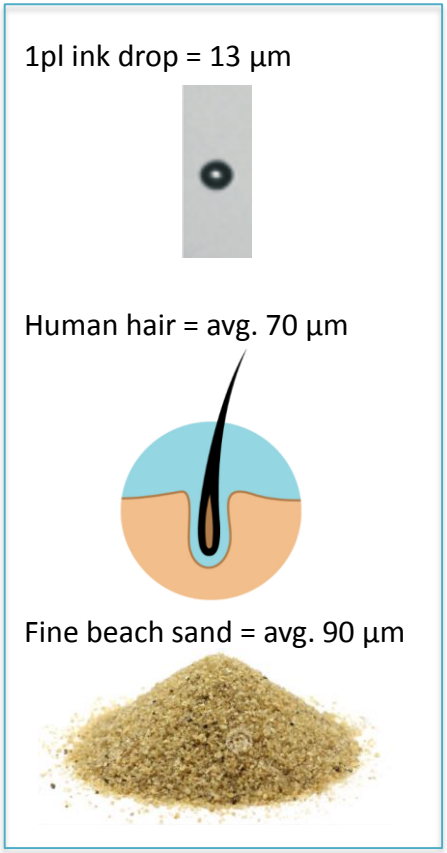
Image source: GIS

Overview of IDS Control Functions

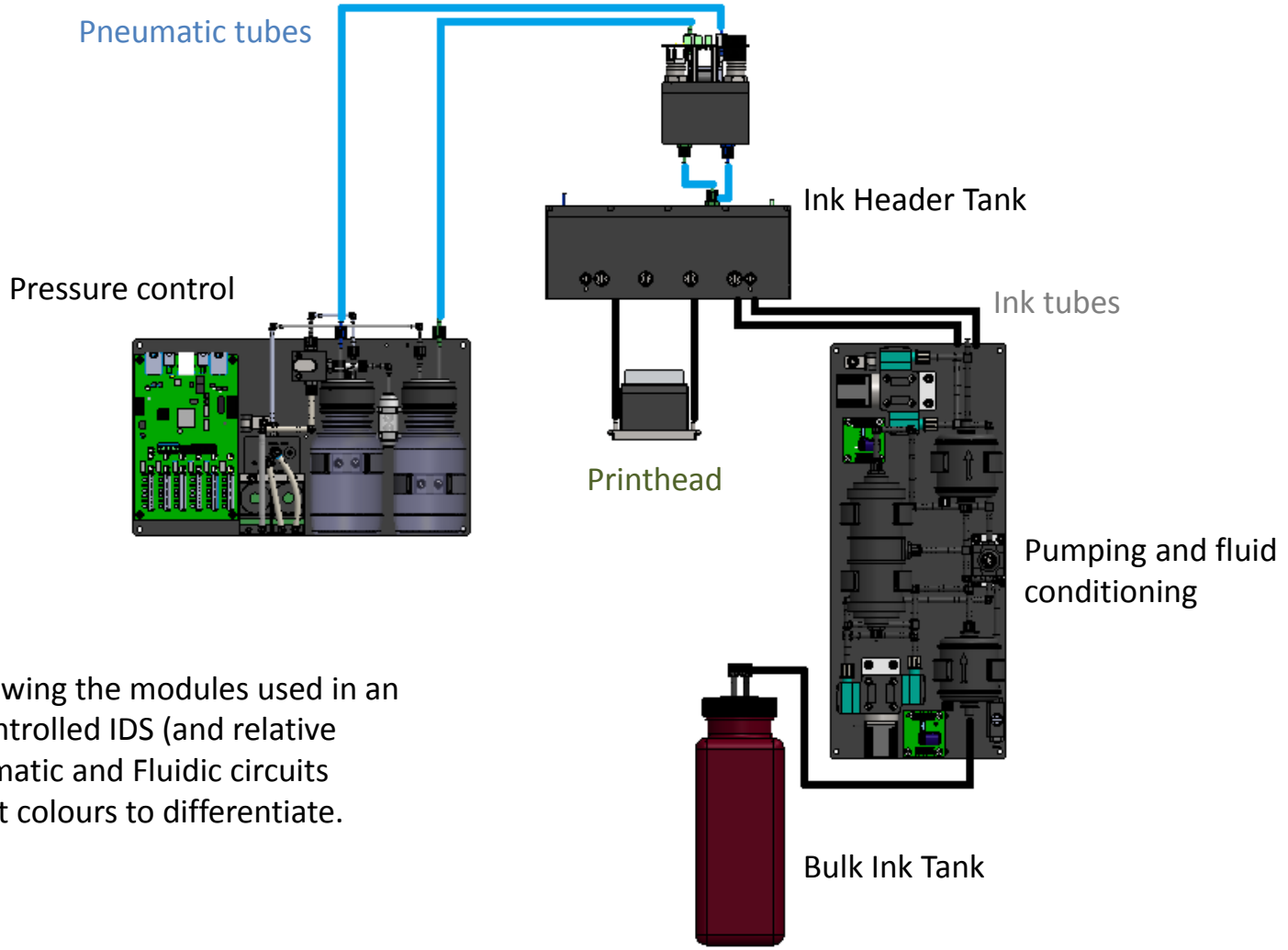
- **Pneumatic pressure control**
  - Meniscus pressure control
    - Regulating the pressure at the nozzle plate of the attached printheads during use
  - Pressure differential control
    - Managing the flow rate of the fluid through the attached printheads
  - Rapid pressure adjustments
    - Regulating the applied pressures to compensate for any acceleration/deceleration of a printhead carriage
- **Ink pumping**
  - Control for pumping of ink to and from the Ink tank and printheads
- **Fluid conditioning**
  - Filtering, Degassing & Heating
- **Purging**
  - Apply a positive pressure to the ink in the printhead
    - Low pressure and high pressure purge (required by some printheads)

Overview of IDS Operational Functions

- **Fluid Conditioning**
  - **Filtering (essential)**
  - **Degassing (optional)**
    - Reduce dissolved gas in the fluid - reliability and performance
    - Absorb any trapped air in the system over time
  - **Heating (optional)**
    - For correct operating temperature (fluid/printhead dependent)
- **Flow modes**
  - Support for high, low or no recirculation rates
- **System Configurations**
  - Suitable pressure control for fluid set used by colour
  - Efficient fluid path for thermal or degassing control
  - Selecting components to match scale of system



Example Ink System



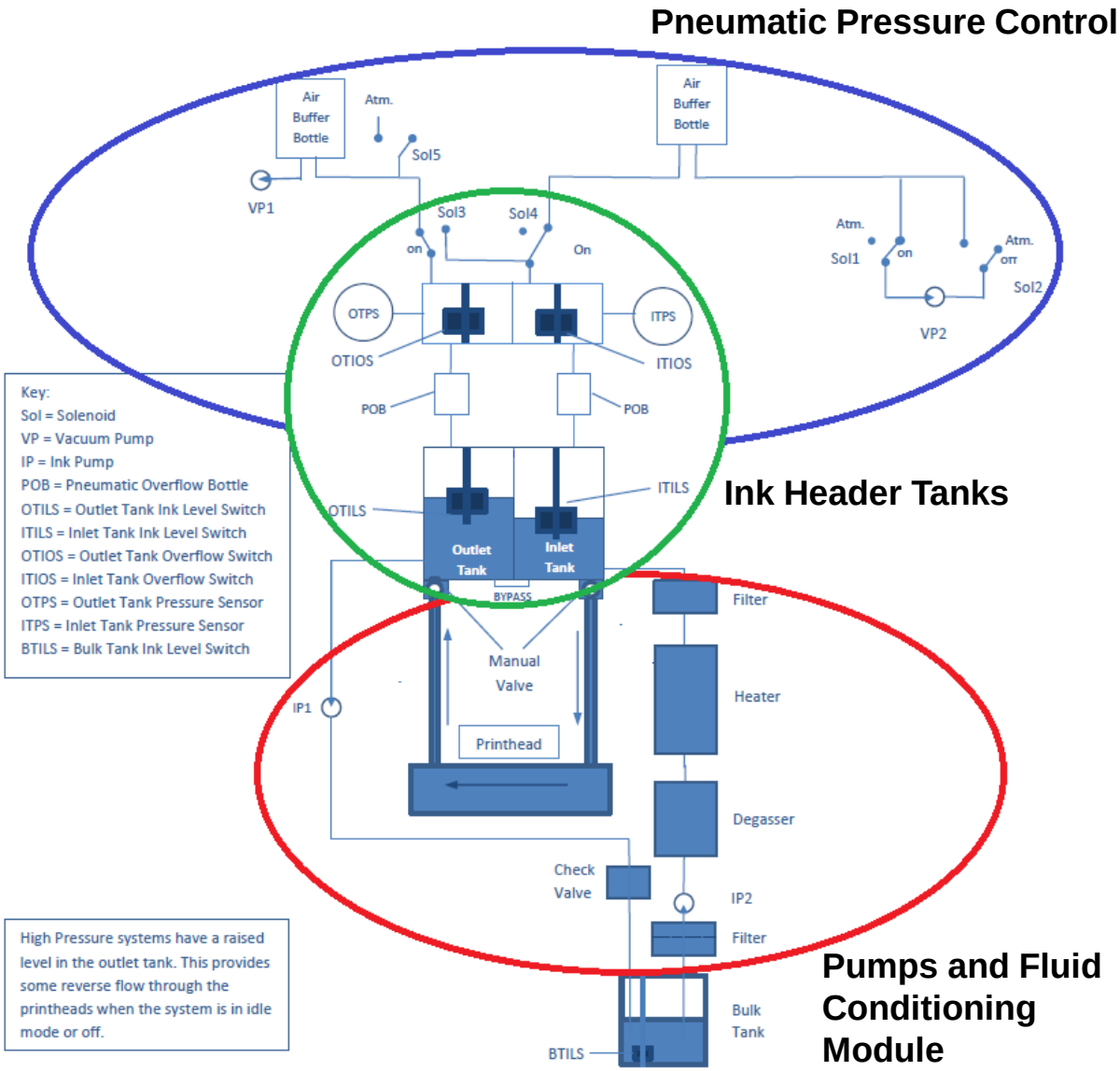
Simple layout showing the modules used in an pneumatically controlled IDS (and relative positions). Pneumatic and Fluidic circuits shown in different colours to differentiate.

Image source: GIS

GIS Controlled Flow – High Pressure system example

Example Schematic of a System

Example of system schematic showing operational logic and interactions.
Illustrates the interaction of the component parts



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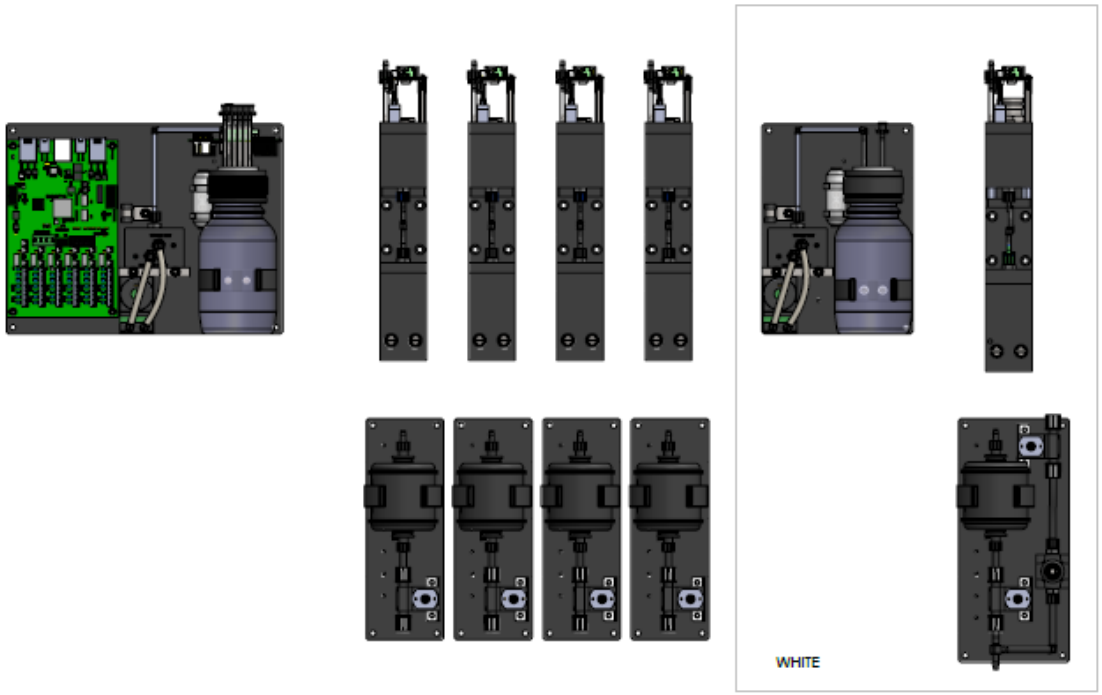
Pressure Control

- **Shared or individual pressure**
  - Shared pressure gives economic scaling & Individual pressure gives specific control where required
  - Can be used together on a system to give the best cost/functionality result



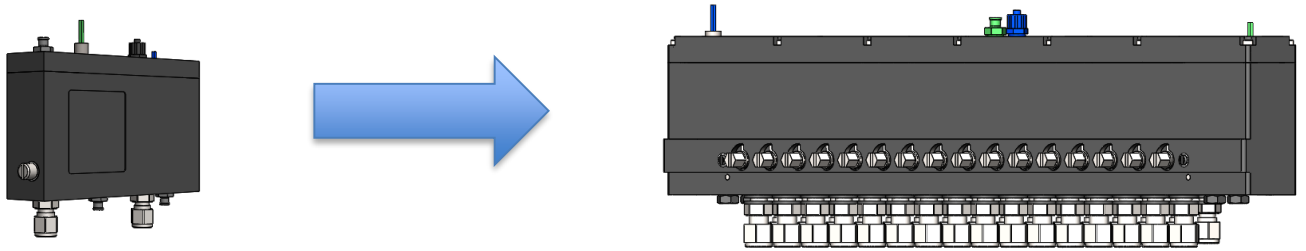
Example shows shared pressure CMYK and individual pressure White

Image source: GIS

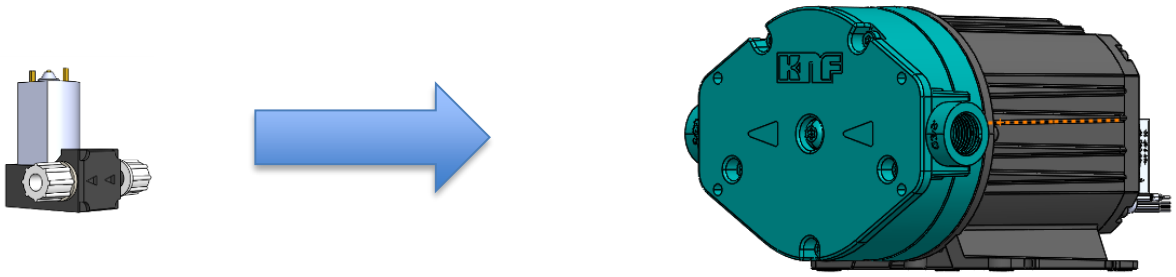
Application Matching

Important to consider selection of component parts to allow a wide range of applications and printhead configurations

- **Single printhead or multiple printheads per Ink Tank for the controlled supply and of ink for different print widths**



- **Pump size and pressure range options to match required flows depending on scale of system and Printhead requirement**



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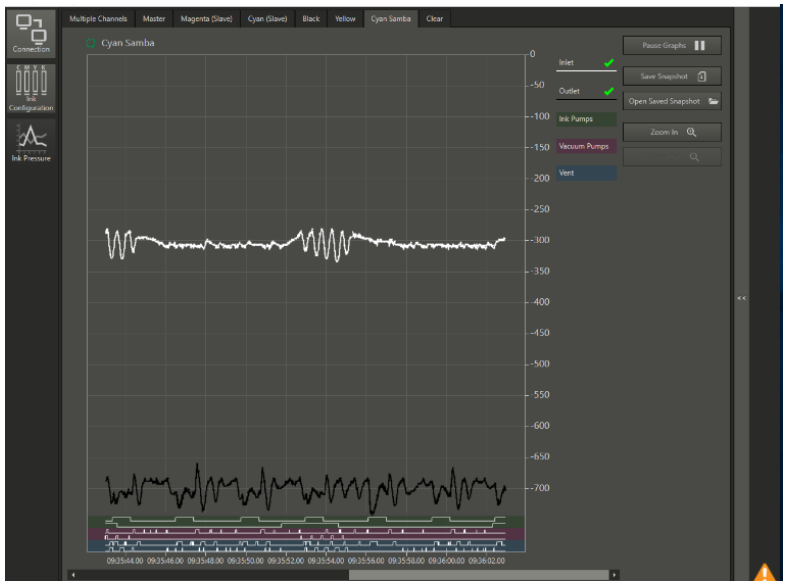
Software Interface - GUI

- **System monitoring and control**
  - User friendly GUI
  - Control of standard ink system operations
  - Graphing tools – real time pressure, pump & solenoid activity etc.



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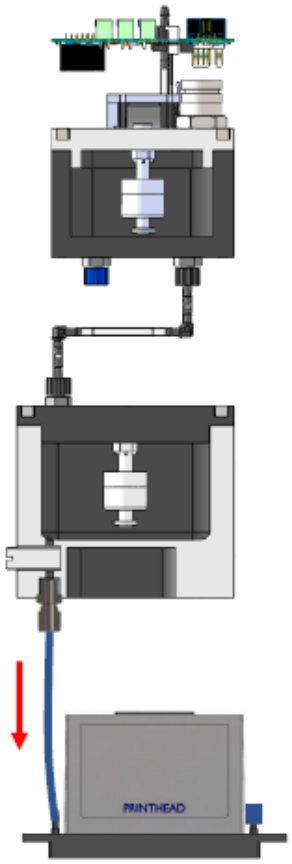
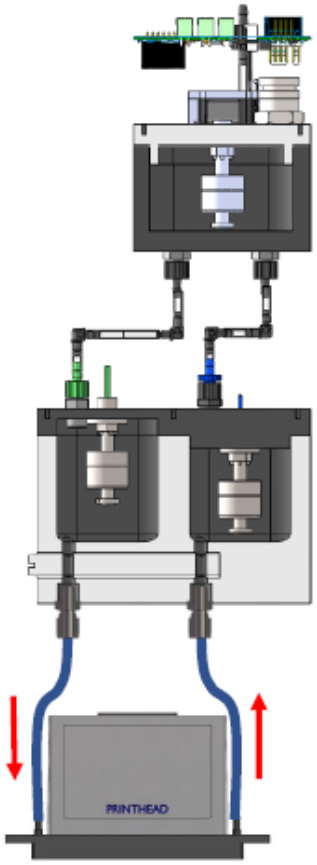
Flow Modes

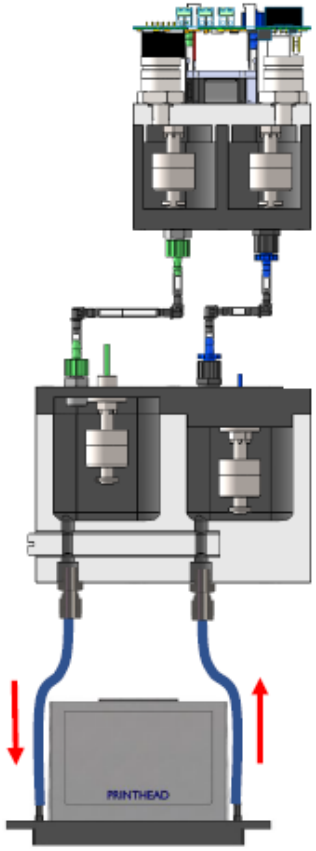
Experience shows that there is a ‘functional’ advantage to have flowing ink, but this has to be balanced against cost/footprint of the system – unless specifically required by the printhead



No Flow



Low Flow



Controlled Flow

Image source: GIS

No Flow/End Shooter

- **Basic characteristics**
  - Simplest style of system
  - Lower cost
  - Suitable for printheads which operate in end shooter configurations or low consumption applications, which are not sensitive to fluid temperature supply or dissolved gas
  - Low weight of modules over printhead (scanning systems)
  - 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

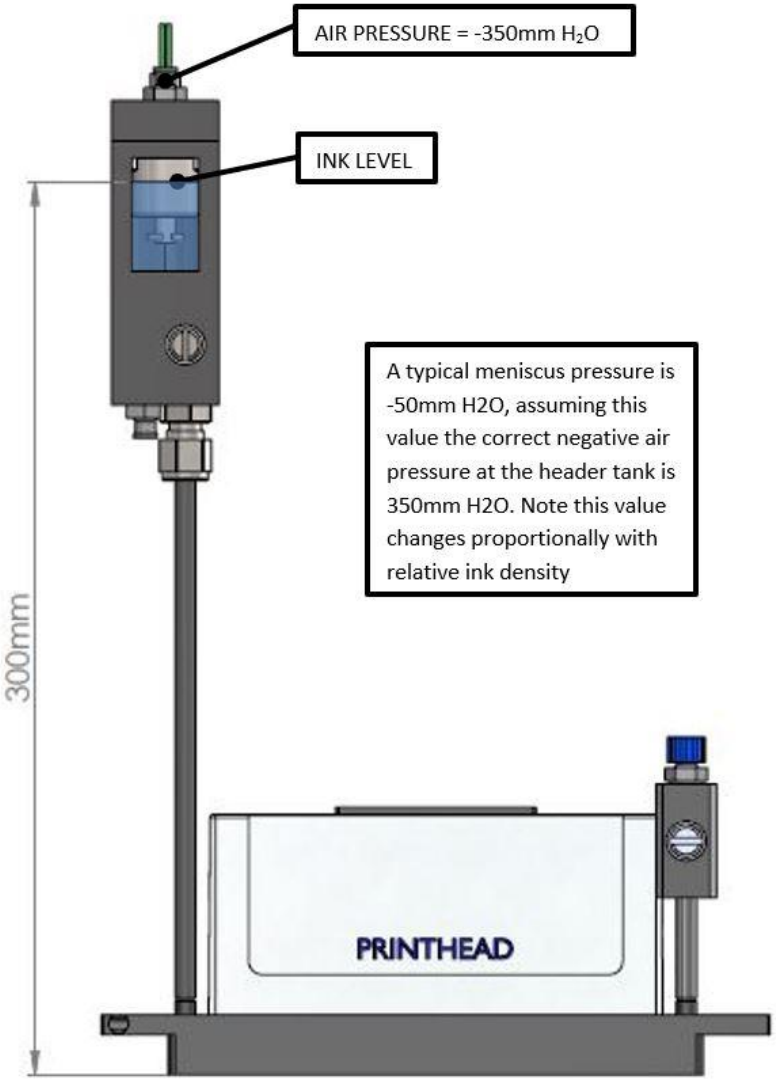


Image source: GIS

Low Flow/End Shooter

- **Basic characteristics**
  - Difference between the fluid level in the header tanks results in a low flow through the printhead as the levels equalise
  - Supports printheads with an inlet and outlet port
  - Can increase reliability
  - Option to apply degassing
  - Option to heat the header tanks to assist thermal control of printhead if required
  - No flow vs low flow - advantage in operation for a relatively minor cost increase
    - Even if installed as a basic system - would allow for the addition of degassing or tank heating at a later date if required

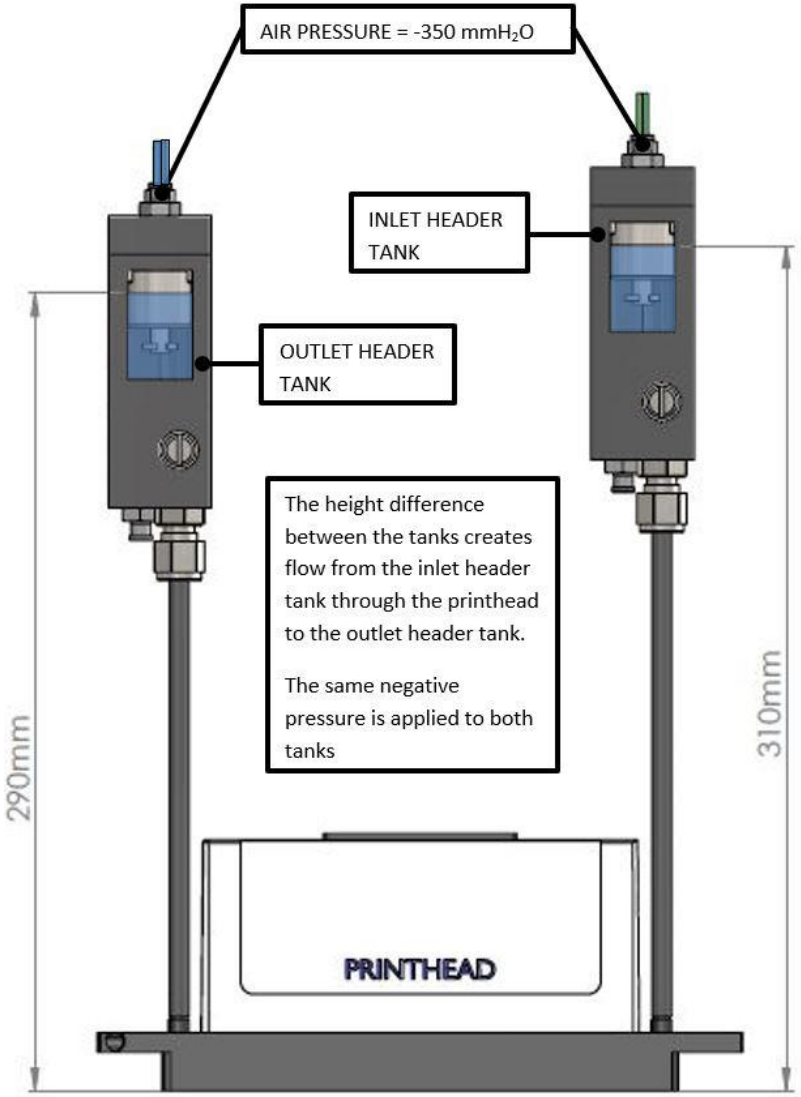


Image source: GIS

Controlled/High Flow

- **Basic characteristics**
  - Controls two pressure environments to generate a pressure differential across a printhead
  - Pressure difference can be adjusted to suit the printhead and fluid combination used
  - Allows thermal control of printhead (with in-line heater)
  - Allows effective degassing of printhead (optional)
  - Allows effective priming of printhead
  - Gives increased reliability
  - System operation and fluid condition is more consistent and any environmental effects minimalised

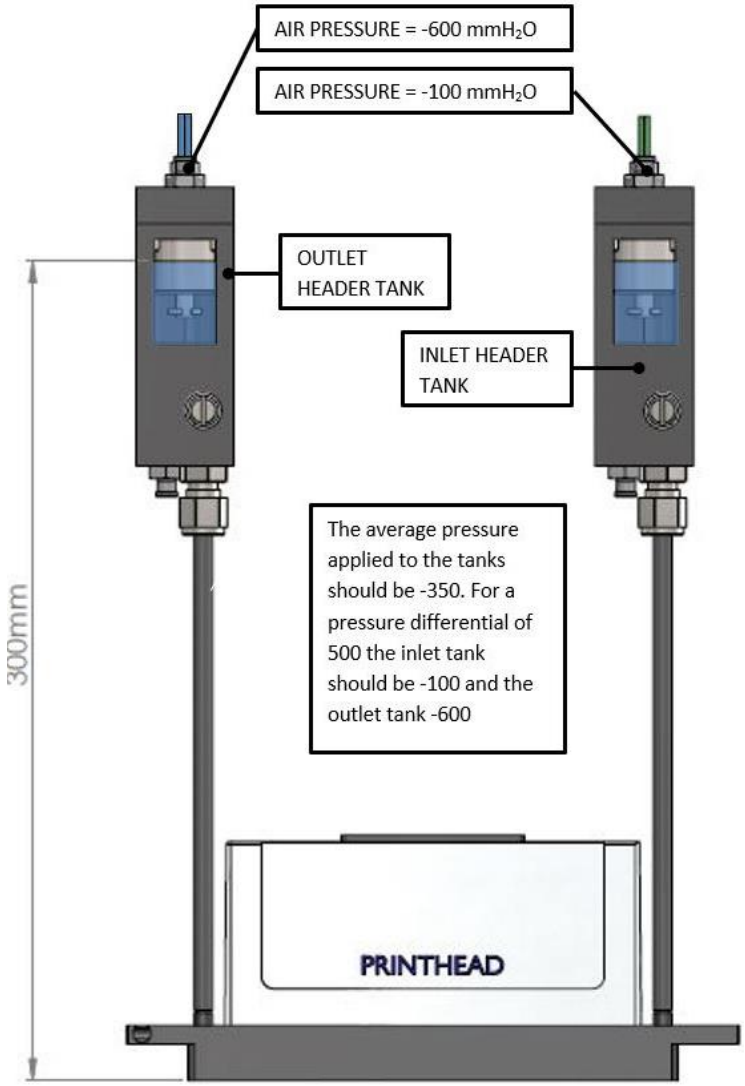


Image source: GIS

Controlled Flow – High Pressure Systems

- **Controlled flow++**
  - Enables control of greater pressure environments which supports the full operating capacity of the latest printheads and larger systems
- **High Pressure configuration options for recirculation**
  - Designed to generate both positive and negative pressure environments
  - Allows the control of high pressure differentials (±2000mm H_2O) across a printhead
    - Can be run at lower pressures like a standard Controlled Flow system
  - Enables high fluid flow for reliability, thermal control and heavy pigmentation use
- **Large drop printheads which can operate at high flow rates**
  - Ricoh MH5421F
  - Xaar 1003/2001
- **Small drop printhead operating at a high pressure differential**
  - Xaar 5601

Printheads & Flow Modes - examples

Example Printheads	No Flow	Low Flow	Controlled Flow	High Pressure
Fujifilm Samba G3L/G5L	✗	✗	✓	(✓)
Fujifilm Starfire SG600	✗	✗	✓	(✓)
Fujifilm Sapphire 256	(✓)	✓	✗	✗
Konica Minolta 1024i	(✓)	✓	✗	✗
Kyocera KJ4A/B-AA/QA	(✓)	✓	✗	✗
Ricoh MH5441	(✓)	(✓)	✓	(✓)
Ricoh MH5421F	✗	✗	(✓)	✓
TTEC CF1/CF3	✗	✗	✓	✗
Xaar 1003	✗	✗	(✓)	✓
Xaar 5601	✗	✗	(✓)	✓

Key

✓ Optimal

(✓) Optional

Ink/Fluid Requirements

Ink Type	Typical Ink System Requirements
All Fluids	• Materials Compatibility testing – Either direct testing or confirmation by fluid supplier of behaviour with wetted materials • Filtration for the protection of system components and Printheads
UV Cure	• Requires heating to achieve optimum operating viscosity • Degassing usually recommended - best for high frequency/large number of heads.
Aqueous	• (Requires) degassing
Oil based	• None special
Solvent	• Specific material use
White/ Ceramic	• Robust material options available to handle abrasive ink pigments
Fluid Deposition/ Functional Fluid/ Ink Development	• May require small volumes due to high value of fluid– may affect header tank design/size

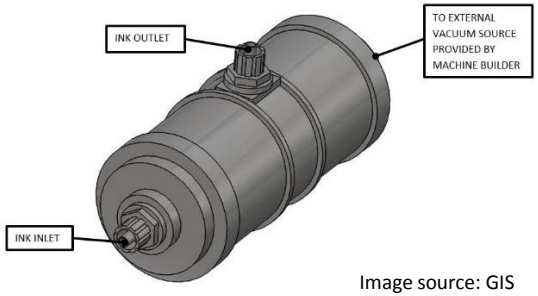
Heating

- **Ink performance varies with temperature**
  - A higher temperature reduces viscosity of the ink
  - Maintaining an elevated ink temperature can allow thermal regulation even when ambient is varied
- **Inks have a recommended operating temperature window (consult you ink supplier)**
- **Temperature most critical at the printhead/jetting**

Mode of Heat	Comment	Pros	Cons
In-line Heaters	• Only work with recirculating systems	• Provide fast and controllable ink heating	• Adds cost
Heated Header Tanks	• Typically used in no flow or low flow systems	• Lower cost than in-line heaters • Usable for Low Flow systems	• Only suitable for low density printing • Temperature control less accurate
Heated Head Plates	• Can be used with all flow modes	• Provides uniform thermal environment • Reduces workload on printhead/ink system heating improving thermal control	• Thermal expansion • Adds cost • Adds complexity

Degassing

- **Contactor must be right size for flow rate and be compatible with the ink**
- **Vacuum must be applied**
  - High vacuum for aqueous ink
  - Lower vacuum for UV ink
- **Can improve reliability and operating limits for the application**
  - Generally makes the printhead less susceptible to any variations
  - Improves the stability of a fluid's behaviour within the printhead as fire frequency is increased allowing a more productive solution
- **Required for aqueous inks**
  - Sometimes not used on small systems to save cost
- **Recommended for UV inks**
  - Typical on large, high print frequency systems



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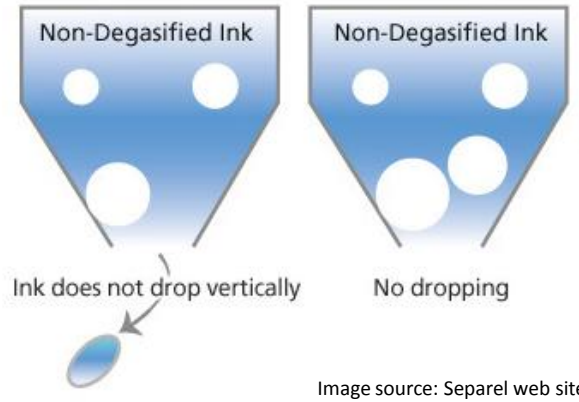

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Typical IDS Issues

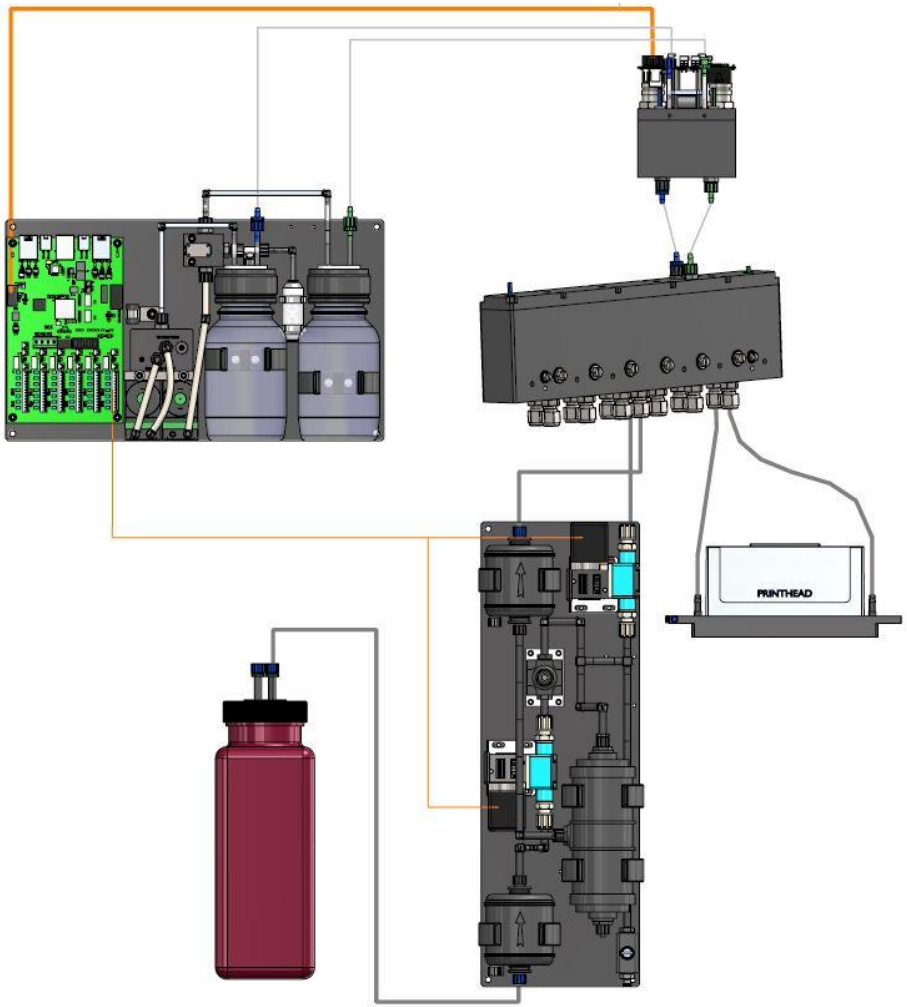
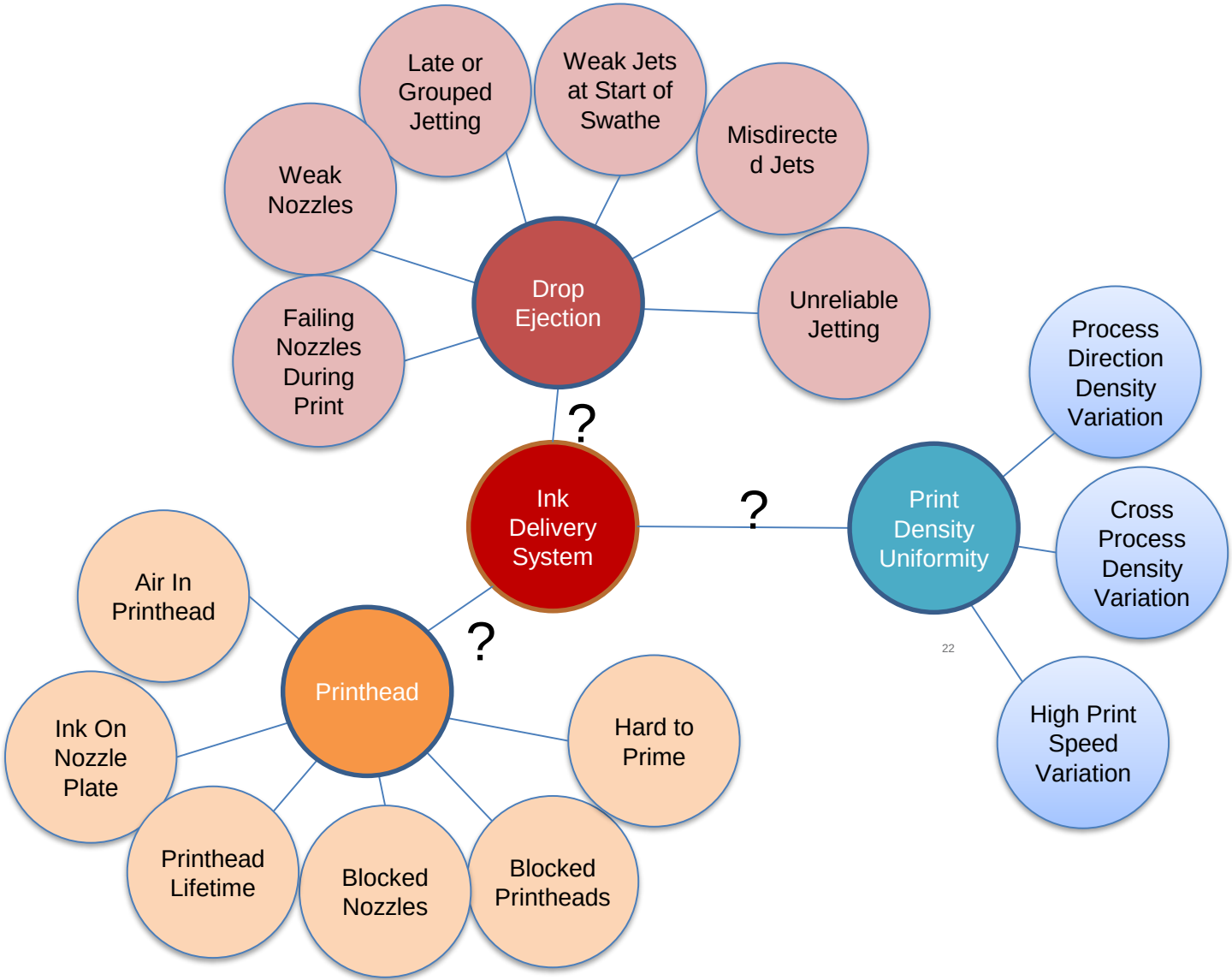
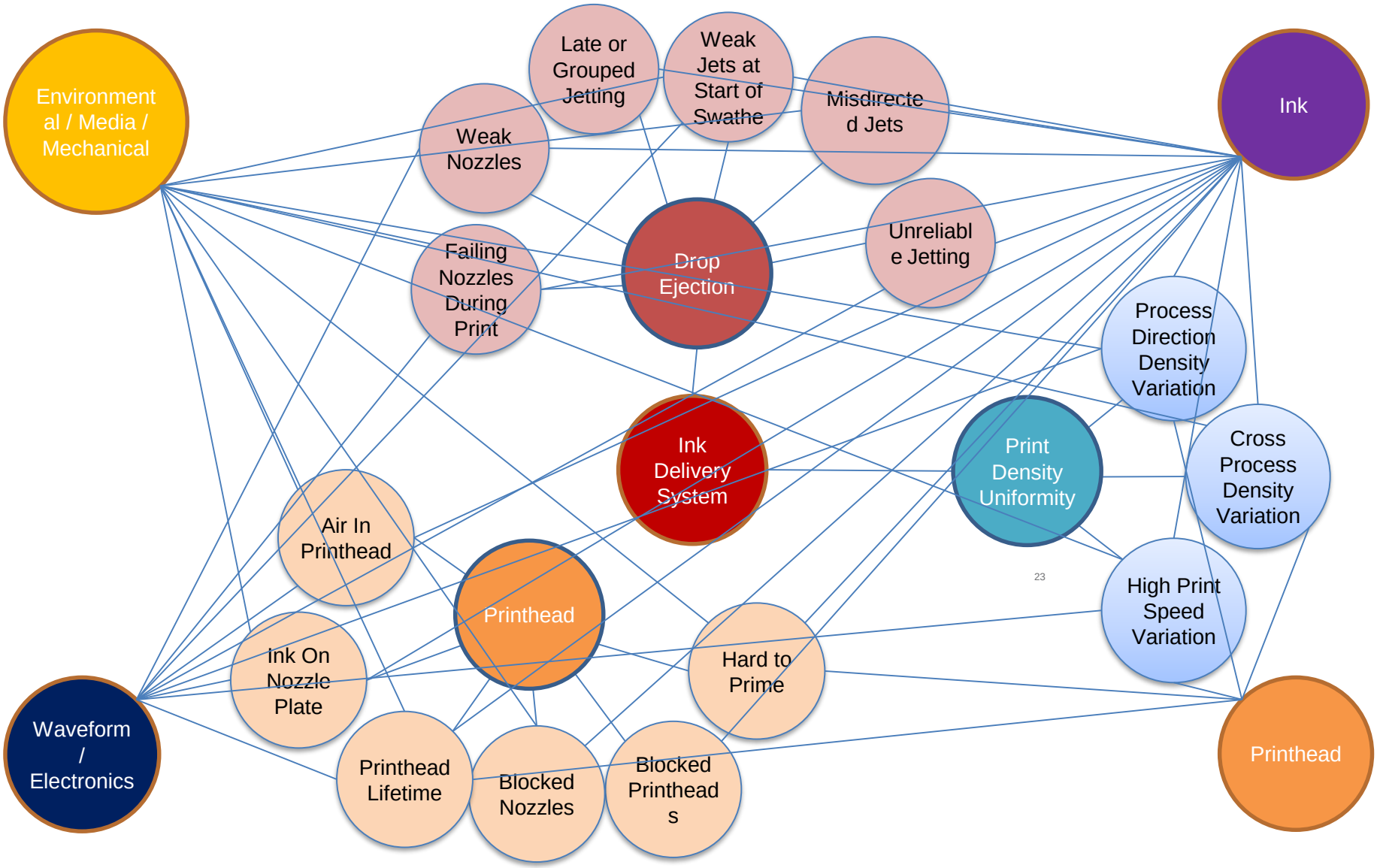


Image source: GIS

Common Issues Attributed to IDS



Common Issues with Alternative Causes



System Design & Integration

- IDS components are more than just a simple kit of parts
  - Critical building blocks
  - Overall printing system designs can have a significant impact on the specifications of the IDS parts used and their operational performance and durability

- **Materials compatibility**
- **Printhead choice**
- **Module placement**
- **Pipe diameter & length**
- **Fixtures & fittings**
- **Heater location**
- **Movement**
  - Scanning systems
  - Energy chains

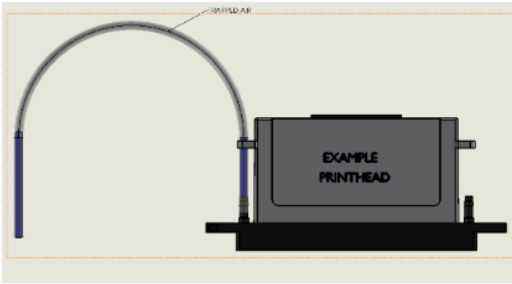
- **Operating environment**
- **Fluid choice**
- **Pressure drop**
- **Consumable life & access**
- **Appropriate parts**
  - Stresses to components
  - Lifetime performance

Materials Compatibility

- **Fluid selection is a key parameter in every project**
- **Risks**
  - Mechanical failure of parts - swelling, shrinking, brittleness
    - Leaking fluids
    - Blockages of the fluid path or the printheads
  - Fluid composition damage – leeching into fluid
    - Damage to printhead
    - Consumables cost – replacing damaged parts
  - Failure of the system
    - Downtime of the machine
    - Lost Production for the customer
  - Materials failures can range from a sudden failure to a slow degradation
- **Solutions**
  - Materials Compatibility testing – kits available
    - Can take time to complete thoroughly – start early in project to minimise risks
  - Use of suitable materials – different options available
  - Working with proven fluids

Air in the Fluid Lines

- **Symptoms**
  - Foam generation
  - Impact to printhead
    - 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
    - Ink dripping from nozzle plate, even when pressure set correctly
    - Head to head variation in behaviour
  - Impact to Ink System
    - Pump airlock on start
    - Pump stalling in operation
    - De-prime when inactive
- **Solutions**
  - Correct printhead pressure settings to avoid air ingestion
  - Correct fittings and tube selection to avoid leaks
    - Avoid restrictions in valves & fittings
    - Avoid tubing with uphill path or loops
  - Effective priming of printhead
  - Ink degassing
  - Never let Bulk Tank run empty (draws air directly into the system)



Contamination

- **Risks**
  - Printheads contaminated
    - Missing or deviant lines in print (print quality)
    - Permanent damage to printhead (replacement cost)
  - Ink system contaminated
    - Reduced pump efficiency
    - Poor recirculation – reduced flow at heads (possible starvation)
- **Solutions**
  - Flush pipes, filters and other system components before printhead connection
    - Ideally a system will be recirculated at temperature for ~1hr before the printheads are introduced
    - Any new part is a potential source of contamination
  - Correct size and rating of filters must be used
    - Planned replacement schedule
  - Ensure Materials Compatibility for all parts used with fluid
    - Use specific pump materials – different mechanical and chemical resistances available
  - Settling from fluid
    - Avoid low flow areas in ink system
    - Agitation of ink (in bulk tank)

Image sources: Pall filters

General System Unreliability

- **Common causes**
  - Wrong design for application (one size does not fit all)
    - A small system can't do a large job
  - Insufficient maintenance or training
  - Incorrect system settings
- **Solutions**
  - Collaboration during design & selection process
  - Environmental control and cleanliness
  - Use of correct scale of components
    - Large enough pumps, correct rated filters, etc…
  - Suitable training and ownership
  - Implement industry standard control techniques/software
    - Suitable control at required rates

Image source: GIS

Looking After an IDS

- **Scheduled maintenance**
  - Record when units are commissioned and parts changed
  - Ink conditioning parts – filters and degassers
  - Mechanically active parts – pumps, valves and solenoids
- **Fluid care**
  - Only use in-date inks
  - Verified Materials Compatibility
- **Avoid physical damage**
  - Any possible trapping or pulling of pipes and wires
  - Positioning of parts to reduce any impact risk
- **Use in a controlled environment**
  - Avoid temperature and humidity extremes
  - Avoid significant electronic noise
  - Reduce exposure to contamination

Summary

- **Insure against future problems by careful design and planning**
  - Materials compatibility, correct components, follow ink and printhead manufacturer guidelines etc.
- **Over-specify on prototypes**
  - Simplify and cut cost when application is proven
- **Training and maintenance will improve lifetime and consistency of use**
  - Cleanliness will always help
- **Low flow use with end shooter printheads is growing**
  - Greater control options than No flow, enabling more applications
- **Recirculating/controlled flow printheads increasing**
  - Enables the advantage of greater stability and control

- **Acknowledgements**

  GIS Ink System Team for their help in preparing this presentation

THE QUEEN'S AWARDS FOR ENTERPRISE

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