

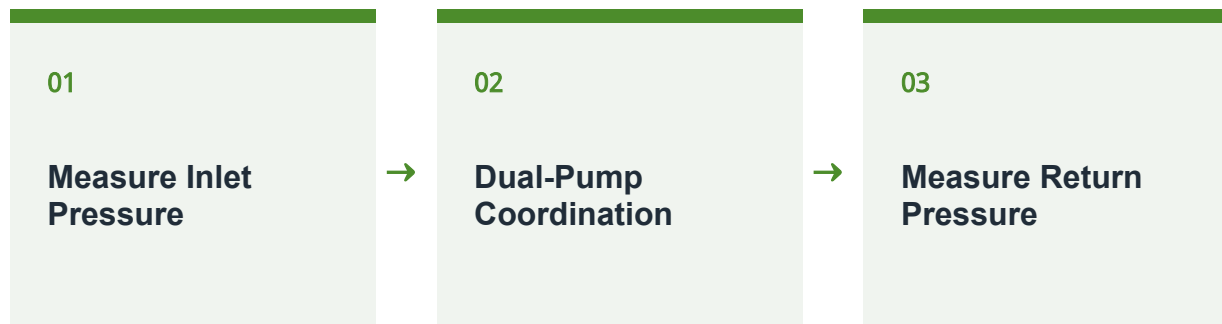
FULL-LOOP INK CIRCULATION / PRODUCT GUIDE

FCS

Full-Loop Ink Circulation System

Two pressure sensors · Dual-pump PID control · Multi-orientation printing

Stable ink supply and return along robotic motion paths



Use pressure feedback at both ends of the printhead to close the loop for ink supply, printing and ink return.

Supports the S series / Curved surfaces, irregular parts and multi-direction printing

PRODUCT CATALOGUE / 2026.09

01 / System positioning

Full-loop circulation supports printing at multiple orientations

FCS combines supply-and-return circulation with pressure feedback at both ends of the printhead to support printing as orientation changes.

FCS / Full-loop Circulation System

Ink flows from the tank through the supply pump to the printhead inlet, then through the return outlet and pump back to the tank. Two pressure sensors near the printhead provide feedback for dual-pump closed-loop control.

Different application focus from the CCS small loop

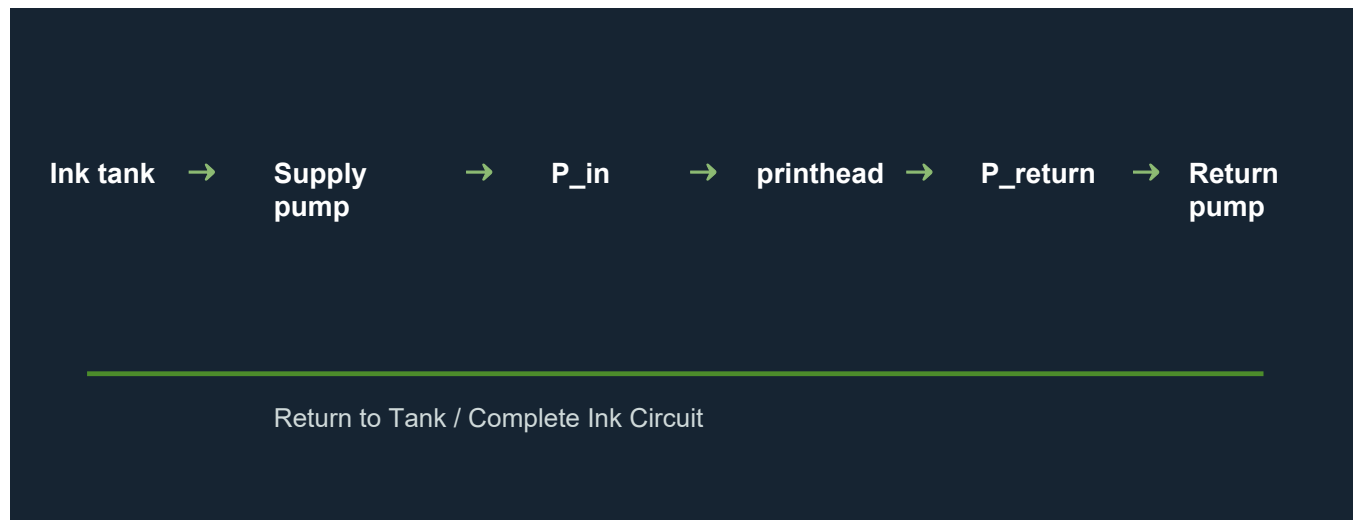
Circulation Range	CCS refreshes ink in the compatible printhead's internal flow path; FCS manages the complete supply and return circuit.
Control focus	FCS coordinates the supply and return pumps using inlet pressure, return pressure and their differential as feedback.
Typical workspace	FCS supports multi-orientation printing with robotic arms, rotary fixtures, curved surfaces and irregular parts.

“Full-loop circulation” refers to the system-level supply-and-return circuit. Whether ink circulates behind the nozzles still depends on the chosen printhead.

02 / Control architecture

Two pressure measurements and two PID control loops

Measure pressure changes at the printhead inlet and return and use them as adjustable control variables.



01 / INLET

Supply-pump PID control

Adjust the supply pump using inlet-pressure feedback to keep inlet pressure within the specified operating range.

02 / RETURN

Return-pump PID control

Adjust the return pump using return-pressure feedback to maintain the target pressure differential between supply and return.

Key control variable: $\Delta P = P_{in} - P_{return}$

Sensors near the printhead help reveal pressure changes caused by hose losses, changing orientation and dynamic motion. Actual response depends on the pumps, tubing, sensors and control settings.

03 / Multi-orientation printing

Change printhead orientation to follow the workpiece

The printhead need not remain fixed and facing down. FCS provides a pressure-control basis for side printing, tilted or upward printing, and robotic paths.

01 / SIDE

Side and tilted printing

For bottles, container sides and sloped surfaces, combined with fixture positioning and print-distance calibration.

02 / UPWARD

Upward and reverse printing

Provides options for restricted layouts, subject to verification of the nozzle negative-pressure window and air-ingress risk.

03 / ROBOT

Robotic motion

Change printhead orientation with workpiece curvature; validate path, speed and acceleration.

04 / FIXTURE

Rotary fixtures

Work with tilting or rotary positioning fixtures for multi-face continuous printing.

A 360° orientation concept requires complete-machine validation

The closed-loop ink circuit is only the starting point. Confirm allowable printhead orientation, hose motion, pressure at the nozzle meniscus, robot acceleration, trigger synchronization, print distance and curing for each application.

For curved surfaces, irregular parts and multi-face products

Plan printhead orientation and path around the workpiece shape rather than relying solely on turning the product.

Cylinders and curved surfaces

Maintain working distance along the curve

Irregular housings

Avoid raised and obstructed areas

Multi-face printing

Connect side and end faces along a planned path

Robotic workstations

Adjust the printhead to the workpiece orientation

Turn movement capability into stable printing

Workpiece and Motion Path Positioning accuracy, surface-normal angle, speed and curvature changes.

Printing and ink path Print distance, trigger timing, pressure profile and finished-product quality.

The final orientation range and line speed depend on sample printing and on-site integration tests.

Continuous flow improves conditions for demanding inks

Like CCS, FCS uses circulation to reduce local settling, trapped bubbles and drift in operating conditions.

01 / PIGMENT

Highly pigmented and white inks

Continuous flow reduces settling of heavy pigments in stagnant ink paths.

02 / BUBBLES

Remove Bubbles through Circulation

A suitable circulation route can carry bubbles to a venting or treatment point in the circuit.

03 / VISCOSITY

Higher-viscosity liquids

With a compatible printhead, flow rate and temperature control, expand the range of fluids that can be tested.

04 / UPTIME

Long continuous operation

Continuous supply and return help maintain ink conditions at the printhead inlet.

Shared principles, with limits set by the printhead and ink

Public information on internal circulation in printheads such as Xaar TF provides a reference for managing settling and bubbles. The FCS system loop is not the same as circulation behind those nozzles. Validate flow rate, filtration, degassing and maintenance for the actual configuration.

The S series uses the new FCS ink supply concept

Combine full-loop ink circulation with S-series printhead modules, selecting print width, resolution, speed and print distance for the job.

S SERIES × FCS

The S series is a printer series supported by FCS. Confirm the printhead module and ink solution for the specific model and project configuration.

Printhead module Follow the S1, S2, S3, S4 selection system in series S and choose by task.

Multiple Orientations For fixed fixtures and robotic printing, verify allowable printhead orientations for each application.

Long-Throw Capability Test longer print distances with compatible long-throw printer models.

Maximum 50 mm / determined by model and application scene

This is a potential long-throw application limit for compatible models, not a distance guaranteed by FCS alone. Drop size, ink, printhead, waveform, line speed, substrate and site conditions affect placement and clarity.

Validate dynamic printing conditions with real workpieces

Test progressively from static positions to motion paths, recording pressure, nozzle status and print quality.

Printheads and ink	Verify allowable orientations, flow range, operating viscosity and compatible materials.
Pressure curve	Record inlet pressure, return pressure and their differential across orientations, starts, stops, acceleration and deceleration.
Pipeline setup	Check hose length, bend radius, cable-chain movement and the ink-return path.
Print Synchronization	Coordinate robot paths, encoder signals or triggering, print distance and curing.
Acceptance of finished products	Check print clarity on curves, corners, long runs and samples after a stop and restart.

Printing in any direction is a project design goal. Deliverable speed, acceleration and orientation range must be established by full-machine sample testing.

Specify FCS from the workpiece and motion path

Provide the workpiece, ink, print content and robot motion range to configure the system and validate samples.

Workpiece Information Materials, curvatures, reachable surfaces and positioning methods.

Print job Print dimensions, distance, line speed, accuracy and curing requirements.

Motion Conditions Printhead orientation range, acceleration, circulation hoses and installation space.

Ink and Printheads Pigment, viscosity, operating temperature and specified S-series module.

Acceptance and inspection methods Pressure records for each orientation, first-piece samples, continuous runs and restart samples.

Technical note

Published printhead and ink-supply examples support the general principles of circulation and multi-orientation printing. The FCS architecture is described in FHES product information; project tests determine specific performance.



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