



Product Bulletin

■ Fluidics Station 450 Design Improvements

The fluidic operations performed on the Affymetrix GeneChip® cartridges are crucial to the delivery of high-quality results. The Fluidics Station 450 from Affymetrix incorporates new features and important design improvements to enhance the operation and performance of the GeneChip system.

This product bulletin outlines important attributes regarding these design improvements and the impact on Fluidics Station 450 operation and performance. Internal and external testing on the Fluidics Station 450 has validated equivalent performance to the Fluidics Station 400, as measured by a number of parameters, and is described in an Affymetrix Tech Note.

Design Improvements	Benefit
Three position sampling with individual vial detection	<ul style="list-style-type: none"> Flexible loading and operation to meet script and user requirements No increase in liquid volume required
Unattended operation ("Walk away freedom")	<ul style="list-style-type: none"> No interruptions to operator during the run- simply "load and go" Labor savings
Modular design	<ul style="list-style-type: none"> Existing Fluidics Station 400 customers gain access to new functionality and robust design of Fluidics Station 450 Protects customer's existing investment in GeneChip instrumentation Fluidics processing capability can grow with GeneChip array usage
Improved cartridge loading through redesigned door mechanism	<ul style="list-style-type: none"> Easier cartridge loading Secure fluidic connections Reduced potential for leaks
Improved vial loading through redesigned vial loading mechanism	<ul style="list-style-type: none"> Reduced likelihood operator will contact the needle Less chance of sample contamination Repeatable vial detection through non-contact sensors
New sample detection sensor	<ul style="list-style-type: none"> Robust performance Elimination of fluid errors caused by sample carryover
Leak path isolation	<ul style="list-style-type: none"> Critical fluidic components are protected from potential damage Should leaks occur, single channel enables rapid identification and resolution by user
Improved user diagnostics	<ul style="list-style-type: none"> User can quickly identify/correct faults without need for service call

Figure 1. Features of the Fluidics Station 450.

Three position sampling with individual vial detection

Based on the fluidic script initiated, the Fluidics Station 450 will automatically prompt the user for one, two, or three Eppendorf vials containing stain and antibody needed for proper script operation. Vial positions are labeled for intuitive operation and error elimination.

The operator loads all of the vials at the beginning of the run and then lowers a handle that moves all three of the sample

needles in tandem. A precision-ground, stainless steel pivot mechanism provides repeatable needle motion, while a ball bearing catch provides smooth needle engagement. The sample probes are spring loaded and retract to eliminate accidental contact with the operator. Likewise, when the lever is down and vial absent, a feature in the vial holder protects the operator from accidental contact with the sample needle.

Non-contact optical switches provide reliable performance, as there are no moving

Figure 2: When the operator presses the vial lever down, the sample probes will contact the bottom of any vials that are present. This bottoming action lifts the cantilever arm and causes the beam interrupter to block the optical beam. The interrupted beam of the optical switch indicates to the Fluidics Station 450 that the vial is present. The Fluidics Station 450 compares the state of each switch against what is expected in the script and will continue to the next step only when the expected vials are detected.

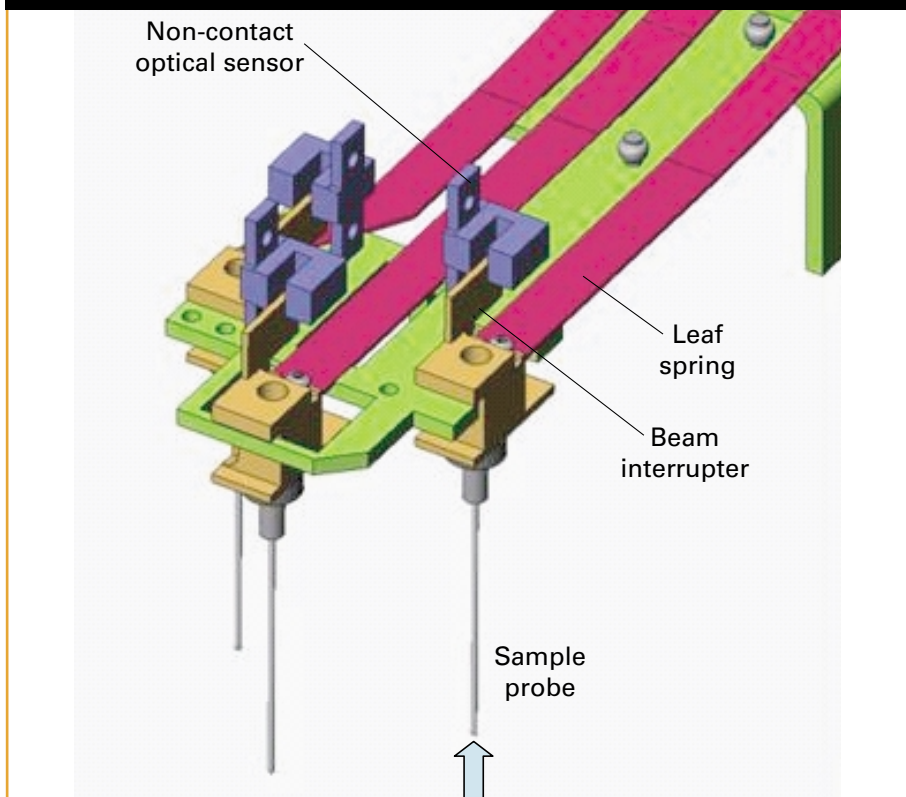


Figure 3: Possible annual labor cost savings with the Fluidics Station 450.

Cost Savings Example

Fluidics Station 450 Labor savings:

- 1.25 direct labor hours saved per Fluidics Station run
- 3 Fluidic Station runs per day @ 4 arrays per run
- 4 days per week of Fluidic Station use ➔ 15 hours direct labor hours saved per week or 780 hours per year

Direct Labor Costs:

- Laboratory technician cost @ \$45,000 per year
- Hourly direct labor cost = \$45,000/2080 hours = \$21.63 per hour

Fluidics Station 450 Cost Savings = 780 hours x \$21.63 per hour savings = \$16,875 annually

parts to wear out. A software 'debounce' feature eliminates false detection caused by vibration or user motion. The leaf spring used in the cantilever arm provides a repeatable force to bottom the needle on the vial and eliminates the potential for fatigue failure from repeated flexing. The leaf spring controls the location of sample needles without the use of sliding parts, which can bind. Mechanical stops prevent over-travel of the leaf spring, making possible the repeatable location of the sample needles into the vials without requiring any operator contact of the sample probes.

Unattended Operation

The fluidic scripts for the Fluidics Station 450 are denoted by the '_450' suffix. They maintain the same timing of sequences as the Fluidics Station 400, but enable unattended operation by detecting the three vials and controlling the sequence by which liquid is removed from the vials. Walk away capability frees the operator to perform other tasks and responsibilities that can improve the workflow of GeneChip array analysis and other laboratory operations.

In many situations, unattended operation will result in faster completion of fluidic operations, as potential delays waiting for an operator to replace a vial are completely eliminated. Many sites have dedicated operators for the washing and staining procedure. Unattended operation can significantly reduce direct labor costs by saving three to four hours per day, as indicated in the example in Figure 3.

Modular Design

The front panel is divided into sections attached to each module on the Fluidics Station 450. Module replacement by the user is much easier, and this modularity provides new product offerings to GeneChip system customers. See Figure 4.

Fluidics Station Model	Modularity Enables...
Fluidics Station 450	New four-module product replaces Fluidics Station 400
Fluidics Station 450 Upgrade	Fluidics Station 400 customers can upgrade their existing base station to gain 'walk-away capability' and design improvements

Figure 4: Modules can be individually replaced in the Fluidics Station 450



Self-aligning pins in the base, coupled with the use of a single mounting screw, have simplified the time and effort required to replace a module. External testing has validated the ability for customers to quickly and properly replace modules, providing additional service options, and the assurance of higher system uptime, as spares can be kept on site.

Improved Mechanical and Fluidic Interfaces with the GeneChip® Cartridge

A number of design modifications have been implemented to improve the interaction between the Fluidics Station 450 and the GeneChip cartridge.

CARTRIDGE ORIENTATION

Keyed features on the Fluidics Station 450 door and GeneChip cartridge ensure proper orientation and eliminate the risk of damage to both the cartridge and instrument during loading.

LINEAR DOOR MOTION AND CARTRIDGE ENGAGEMENT

The Fluidics Station 450 door and mechanism move in a straight-line manner to align the cartridge with the instrument's heater block and fluid probes. The motion is accomplished by a locking cam mechanism attached to an ergonomically designed handle. Non-contact optical sensors confirm that the GeneChip cartridge or wash block is properly engaged.

ELEVATED GUIDE RAILS AND PRECISION BUSHINGS

The rails upon which the door mechanism slides have been repositioned above the GeneChip cartridge septa. This location eliminates the potential for corrosion from salt solution contact. Precision bushings have been selected for their low friction, zero maintenance characteristics, and repeatable motion. These preventative

measures ensure years of smooth sliding action for the cartridge loading mechanism.

REDUCED ACTUATION FORCE

Through an optimized cam design and repositioning of the cartridge door handle, handle motion is smooth and consistent. The force to open and close the door has been reduced, yet still provides proper engagement.

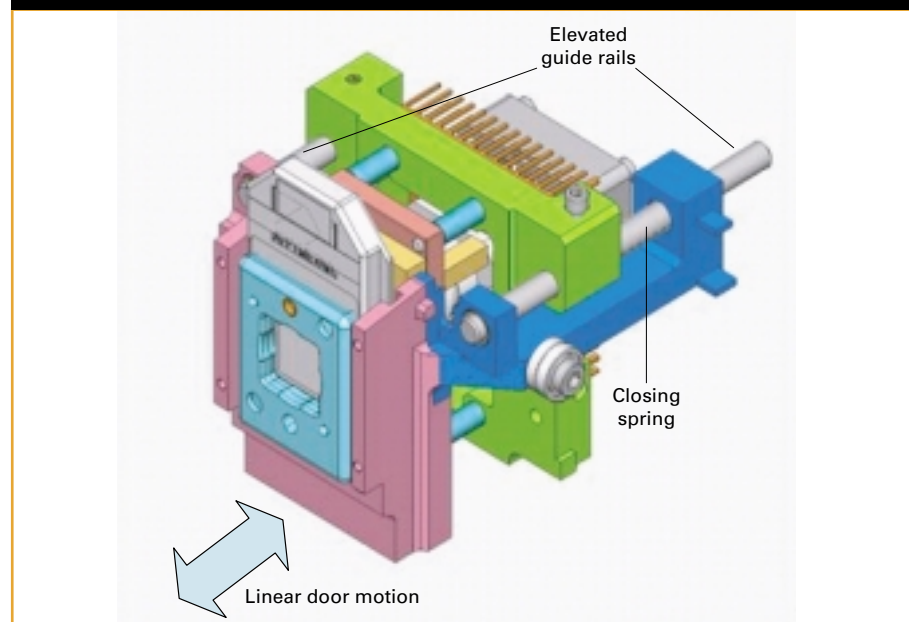
CLOSING SPRING

As the operator releases the door lever, predefined forces provided by the mechanism's spring ensure proper engagement of critical features of the Fluidics Station 450 to the GeneChip cartridge and the wash block. The engagement force has been optimized by extensive testing of springs with different stiffness.

ALIGNMENT PINS

As the door closes, the cartridge is engaged by tightly toleranced pins that key precisely located features on the cartridge. The pins make initial contact with the cartridge, ensuring proper positioning prior to

Figure 5: Design modifications improve interaction between Fluidics Station 450 and the GeneChip cartridge.



the fluid probes piercing the septa of the GeneChip cartridge. This eliminates potential damage to the fluid probes or cartridge caused by misalignment. The alignment pins also protect the fluid probes, should the cartridge not be inserted fully.

CONTROLLED DEPTH OF PENETRATION OF FLUID PROBES

Redesign of the sensor block ensures fixed depth penetration of the fluid probes into the GeneChip cartridge. High-tolerance alignment features have been added to the fluid probes to fix their location in the mounting assembly. These features eliminate the potential for the probes to rotate or shift position, and ensure repeatable fluidic connection between the instrument and the cartridge.

IMPROVED FLUID PROBE DESIGN

A new process has been developed to fabricate the side port of the probes. The port location is controlled, reducing the possibility of leakage. The diameters of the port and flow path have been enlarged, and the surface finish on the inside diameter has been modified to eliminate flow disturbances that can create foaming.

SIMPLIFIED MAINTENANCE PROCEDURE

The replacement of maintenance parts by service personnel is facilitated by easy, on-site disassembly. Important maintenance parts can be changed without requiring removal of the module or the faceplate.

New Fluidic Detection Sensor

Real-time liquid detection is useful in ensuring that fluidic operations on GeneChip arrays are being completed properly and with the minimum amount of buffer and stain. Additionally, it can identify problems caused by improper or missing reagents.

The presence or absence of fluids is detected by electronic circuitry that measures the conductivity of the liquid present between the fluid probes that contact the GeneChip cartridge. Voltage is applied in

Figure 6: Diagnostic messages are displayed on the system's LCD.



very short duration pulses, avoiding concern of sample degradation due to a voltage potential. Each measured conductivity value is compared against established threshold values in the individual script to determine if the proper liquid is present. If the threshold value is not reached, liquid is either not present or there may be an operator-induced problem in mixing or installing the solutions. Detection of these different situations is important to ensure quality of GeneChip array analysis.

In the Fluidics Station 450, a specially designed circuit board creates an electrical circuit with the fluid probes that pierce the septa of the cartridge. Mounted on the backside of the heater block, these electronics are protected from potential damage that may be caused by leaks.

The conductivity is measured between the fluid probes, thus sensing the conductivity of the liquid in the cartridge. This method has many advantages over prior sensor designs. First, the conductivity probes are much farther apart, minimizing false positives caused by liquid draining down the walls of the sensor block utilized in the Fluidics Station 400. Second, the conductivity probes are larger, minimizing false negatives caused by the surface of the probe becoming non-conductive from protein buildup. Every time the cartridge is removed, the probes are wiped clean by the septa on the cartridge. Furthermore, the conductivity path is renewed with every cartridge replacement, eliminating the chance of solids buildup in the conductivity path. Trapped solids can lead to false negative or positive liquid detection, depending upon their conductivity.

Leak path Isolation

The module's integral bezel has been designed to accommodate a 'drip tray' to divert any leaks away from internal components. Fluids are directed down the front of the pump door and into a 'gutter' along the front of the Fluidics Station 450's base. This path provides for easy visual detection and corrective action by the operator.

Improved User Diagnostics

The Fluidics Station 450 now generates comprehensive diagnostic messages to assist the operator in troubleshooting activities. These messages are displayed on the system's LCD. See Figure 6.

This sequence is continuously repeated on the display until corrective action is taken. In the example, the additional information enables the operator to consider which reagent may be the cause of the problem, and if the same problem is present across multiple modules at the same time it could flag a mix-up in placement of Wash A and B, or an improperly mixed reagent resulting in the unexpected conductivity. These messages also support more effective dialogue with Affymetrix technical support.

New troubleshooting information that accompanies the Fluidics Station 450 directs the operator to take appropriate action. See Figure 7.

Figure 7: Fluidics Station 450 Troubleshooting Quick Reference Card.

Reported Error	User Action
Error While Filing	<p><i>Cause: system detects improper conditions while filing.</i> Note where in protocol error occurred Identify and correct potential causes</p> <ul style="list-style-type: none"> — Missing or insufficient stain or antibody in vial? — Wash or DI water empty? Air bubbles in line? — Leaks? <p>Identify if chip is filled</p> <ul style="list-style-type: none"> — If important to recover fluid in chip, then run Recovery script, followed by Resume function — If not important to recover fluid in chip, run Resume function
Missing Fluid Error	<p><i>Cause: system detects improper conditions.</i> Note where in protocol error occurred Identify and correct potential causes</p> <ul style="list-style-type: none"> — Missing or insufficient stain or antibody in vial? — Wash or DI water empty? Air bubbles in line? — Leaks? <p>Identify if chip is filled</p> <ul style="list-style-type: none"> — If important to recover fluid in chip, then run Recovery script, followed by Resume function. — If not important to recover fluid in chip, run Resume function.
Invalid Command	<p><i>Cause: Communications error detected.</i> Note where in protocol error occurred Identify if chip is filled. If important to recover fluid in chip, then run Recovery script.</p> <ul style="list-style-type: none"> — Attempt to rerun script if sample loss can be tolerated. If problem persists, contact Affymetrix for service. — If sample loss cannot be tolerated, do not attempt to rerun script. Contact Affymetrix for service.
Improper Script	<p><i>Cause: User is attempting to run a Fluidics Station 400 script on Fluidics Station 450.</i> Download proper Fluidics Station 450 script and continue.</p>
Sensor Timeout	<p><i>Cause: User has waited too long to perform the requested action.</i> Run Resume function to continue.</p>
Temperature Timeout	<p><i>Cause: Temperature has not reached required level in expected time.</i> If ambient temperature is within operating specifications (15-30 degrees C), contact Affymetrix for service.</p>
Valve Motion Error	<p>Run Home script and run desired script again. If problem persists, contact Affymetrix for service.</p>
Valve Not Homed	<p>Run Home script and run desired script again. If problem persists, contact Affymetrix for service.</p>
Valve Out of Position	<p>Run Home script and run desired script again. If problem persists, contact Affymetrix for service.</p>

Summary

Significant design modifications have been implemented on the Fluidics Station 450 to provide new capabilities and robust performance to users of the GeneChip system. These modifications improve the critical mechanical and fluidic interfaces between the Fluidics Station and the GeneChip array. They are expected to assist the researcher in producing high-quality genomic information in a more cost-effective manner.

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