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1. MilkoScan™ FT3 — Service Manual

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PROPRIETARY OF FOSS

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Rev.	Date of Issue	Revised Material				
1	2019-09-03	First issue.				
2	2020-07-27	Updates in general.				
		Added information of Touch Screen/Display.				
		Added Special tools and Service Tools.				
		Added FossServiceScan description.				
		Updated Conductivity Module.				
		Added Removal and Replacement procedure for Conductivity				
		Module.				
		Added Removal and Replacement procedure of Instrument ID				
		Chip.				
		Added Standardization procedure.				
		Added Verification procedure.				
		Added torque values for tightening screws and nuts				in
		Removal and Replacement procedures.				
		Updated Error & Warning Messages, Diagnostic	.			
		Added Error & Warning Messages, Product.				
		Added Error & Warning Messages, Instrument.				
		Added Error & Warning Messages, Measurement		.		
		Added Error & Warning Messages, Prediction.				
		Added Error & Warning Messages, DRV.				
		Added Error & Warning Messages, RACM.				

Rev.	Date of Issue	Revised Material				
		Added Error & Warning Messages, Data Exchange			.	
		Added Error & Warning Messages, O thers.				
		Added 7-segment display information.				
3	2021-09-23	Updates in general.				
		Updated Error & Warning Messages, Diagnostic	.			
		Updated Error & Warning Messages, DRV.				
		Updated Error & Warning Messages, RACM.				
		Added Error & Warning Messages, IFU.				
		Added Firmware update instructions.				
		Updated Removal and Replacement of Main Control PCB.				

		Added PCB LED description in General Troubleshooting				.	
		Added Approval of Replaceable Parts.					
		Added adjustment procedure of Pipette Motor replacement					.
		Added a tool more in Service Tools.					
4	2022-04-13	Updates in general.					
		Updated Factory Standardization Adjustment		.			
		Added an updated Electrical Diagram FT3	.				
		Added Removal and Replacement of H	-stage Seat.				
		Added Troubleshooting of Poor Water Quality			.		
		Removed Verification Procedure (by error)	.				eratures and Regulators (PM Remote).

		Added power info in schematic of General Troubleshooting	-
		Driver Control PCB.	
		Added Removal and Replacement of Valve V1 -V10 Repair Kit.	
8	2026-03-18	General update of the manual	
		Added Removal and Replacement of Backlight PCB for both	
		Pump 1 and Pump 2.	
		Updated General Troubleshooting - Others (Backlight).	
		Added Factory Reset.	
		Updated Fault Tracking Tables.	
		Updated Removal and Replacement of Interferometer	
		procedure.	
		Updated Preventive Maintenance - On Site procedure.	
		Updated pictures of Care menu page.	
		Updated Tech Spec - Power Consumption.	

1. Important Instructions

1.1. Service Guidelines

> See 6009 5107 Guidelines for Service Engineers for general support and safety guidelines.

This Service Manual is a part of the support documentation for this product. See section **Error! Reference source not found., Error! Reference source not found.,** for an overview of User and Service Documentation.

1.2. Service Documentation

This Service Manual is included on the Service USB memory stick (if available) which contains the complete support documentation for this product.

- If available, the Service USB memory stick also includes animations illustrating working principles, process flows, and service procedures.

See section 8 Document References for an overview of User and Service Documentation.

1.3. Self-Service Support

The CSS Toolbox on SharePoint (**https://fossanalytical.sharepoint.com/sites/css-tct/SitePages/Home.aspx**) contains all available support information. Please visit the CSS Toolbox regularly for the latest updates on documents and software.

1.4. Contacting Service for Additional Support

For support on this product, please open a ticket in the Global Helpdesk CRM system or contact **Global Helpdesk** or **+45 4820 8400**.

1.5. ESD Information

Parts of this instrument, e.g., PCBs, are sensitive to Electro Static Discharge (ESD). All exposed components should be handled using ESD protection.

1.5.1. ESD Protection Rules :

- Handle all ESD-sensitive parts with an ESD wristband connected to earth.
- Transport all ESD-sensitive parts in ESD-protected bags or boxes.
- Check your ESD protection regularly to secure its function and quality.

1.5.2 Available ESD Material from FOSS:

- 6004 9720 ESD-kit including wrist strap.

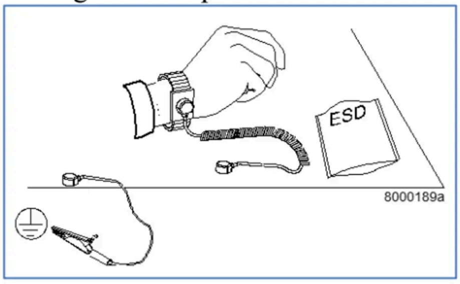

Fig. 1   ESD equipment

Caution

Functional Earth. The ESD grounding point of the instrument can be found:

- Behind the cover plate in front of the Driver Control PCB (Fig. 2)
- On the rear panel with the Power Switch and Power Connector (Fig. 3)

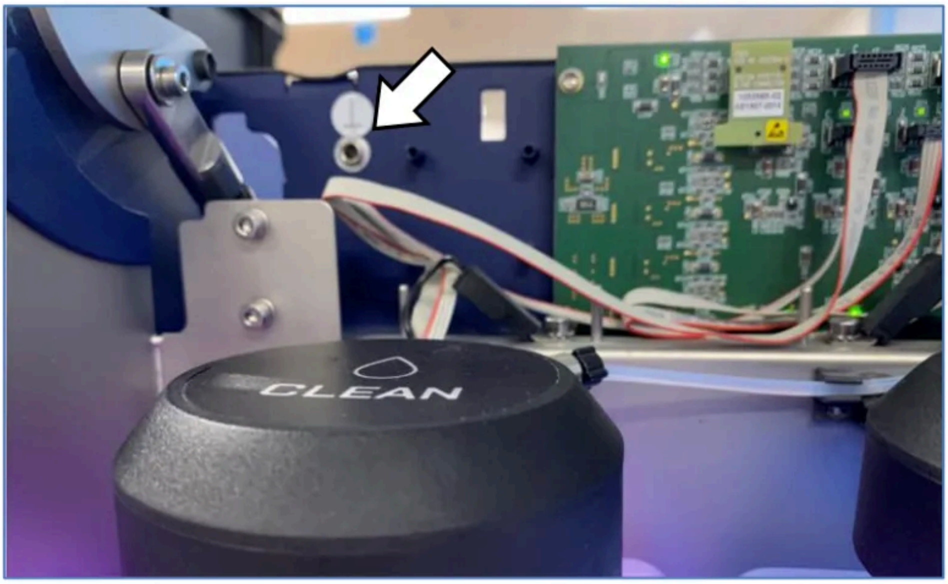

Fig. 2   Functional Earth connection point-on front side

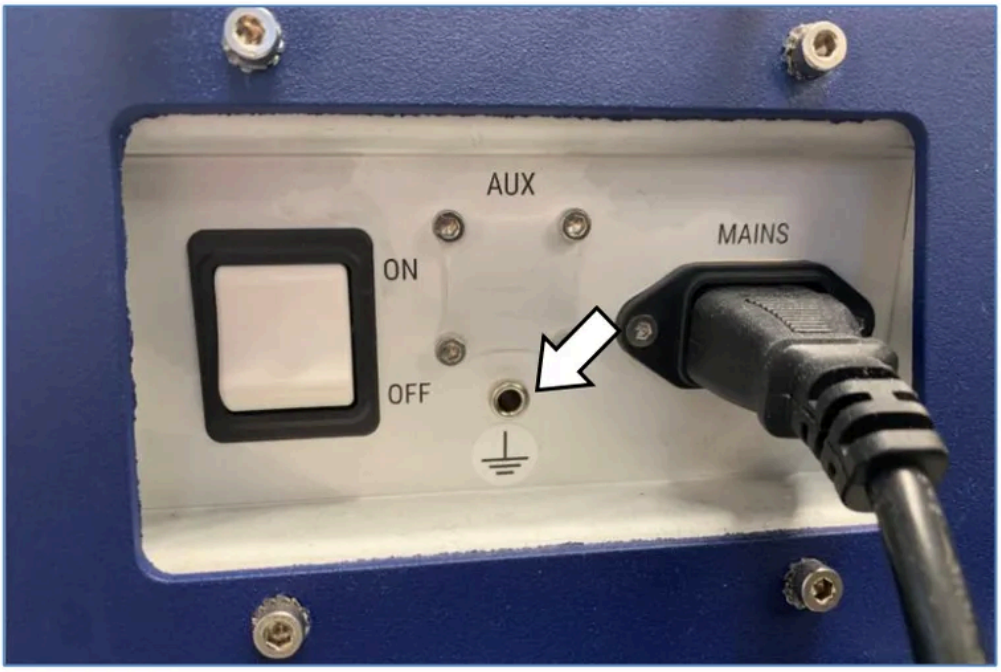

Fig. 3   Functional Earth connection point-on rear side

1.6 Precautions

This Service Manual is addressed to service personnel. Please read the manual carefully and act accordingly.

1.6.1 Safety Symbols

Explanation of safety symbols used in this manual.

- The symbols in this manual identify important safety information intended to prevent personal injury and equipment damage.
- The table below shows each symbol and its meaning, such as Warning, Caution, and Electrical Hazard.

Symbol	Description
	General hazard.
	Electrical shock hazard.
	Corrosive.
	Inhalation hazard.
	Hot surface.
	Laser.
	Heavy lift.
	Read the manual.
	Functional Earth.
	General prohibition.

Table 1 Safety Symbols

Safety Terminology

Explanation of safety terms used in this manual.

This section defines the safety-related terms used throughout the manual to ensure consistent understanding and proper application of safety instructions.

Term	Description
Warning	Danger to human safety.
Caution	Danger to product performance/operation.
Note	Important supplementary information.

Table 2 Safety Terminology

1.7 Personal Safety

Warning: Electrical shock hazard
When the cabinet is open, hazardous 115/230 VAC is present.
Only certified personnel are permitted to ope n the cabinet door and cover.
Switch off the Mains Power before working inside the cabinet whenever it is safe to do so.

Warning: Corrosive hazard
Reagents must be handled accord ing to the Material Safety Data Sheet (MSDS) supplied with each reagent.

MSDS documents in local languages can be downloaded from the Sales & Service Toolbox here.
Avoid contact with eyes and skin, and always wear appropriate protective equipment such as safety goggles and gloves.

Warning: Inhalation hazard
Reagents must be handled in accordance with the relevant Material Safety Data Sheet (MSDS).
MSDS documents in local languages are available for download from our SharePoint Toolbox here.
Wearing protective gloves, protective clothing, and eye or face protection is mandatory.

Warning: Burn hazard
Internal modules may reach temperatures up to 45°C (113°F) and can cause burns or injury.
Allow components to cool before servicing.

Warning: Cutting hazard
Use caution when removing or replacing the Pump Piston glass, as it may break during handling and cause cuts to fingers or hands.

1.8 Product Safety

Caution

Anyone operating this device must read the Safety Manual before use.

Caution

Anyone installing or servicing this device must follow the documented procedures to prevent damage to modules, components, wires, tubes, and other parts.

Caution

Waste from the instrument must be handled in accordance with local regulations. The composition of Foss reagents is provided in the MSDS in local languages can be downloaded from the SharePoint Too

Caution

Before working inside the instrument, any accumulated static charge on the Service Engineer's body must be discharged. This can be achieved by wearing a grounded antistatic wrist strap connected to the instrument's Functional Earth.

1.9 Warranty Policy

Warranty conditions are specified in the order confirmation, invoice, or contract with the FOSS representative. Warranty applies only when the following conditions are met:

1.9.1 Product Handling and Maintenance

- The product has been installed, maintained, adjusted, and calibrated according to FOSS documentation.
- The instrument has been properly maintained as recommended by FOSS.

- The product has not been used for purposes other than those intended by FOSS.
- The product has not been altered or repaired using non-original FOSS parts or by unauthorized personnel.
- Only original FOSS consumables and accessories, or equivalents recommended by FOSS, have been used.

1.9.2 Software and PC Usage

- Only software authorized by FOSS must be installed on any product PC.
- Any external product PC complies with FOSS recommendations.
- The PC must not be used for non-operational purposes (e.g., playing computer games, including preinstalled games).

1.9.3 General Conditions

- The product has not been handled in a manner contrary to ordinary practice.
- The Customer/User has followed all written instructions and documentation provided by FOSS.

1.9.4 Parts Subject to Wear

- Certain components are expected to have a shorter lifetime than the instrument. These parts are listed in the User Manual, product software, or Owner's Guide.
- Liability for worn parts is limited to cases of extraordinary wear caused by defective materials or manufacturing errors.

2. Technical Description

2.1 General

The MilkoScan™ FT3 is an FTIR-based electronic milk analyzer designed for the analysis of liquid dairy products, including milk, cream, and yogurt.
One of its major advancements over earlier generations is the removal of the need

for homogenizers. Instead, the instrument performs multiple measurements—known as subsampling—to deliver highly representative results.
For particularly challenging or viscous samples, such as Crème Fraîche, the system automatically engages its H-stage to maintain measurement accuracy and reliability.

2.2 Hardware Descriptions

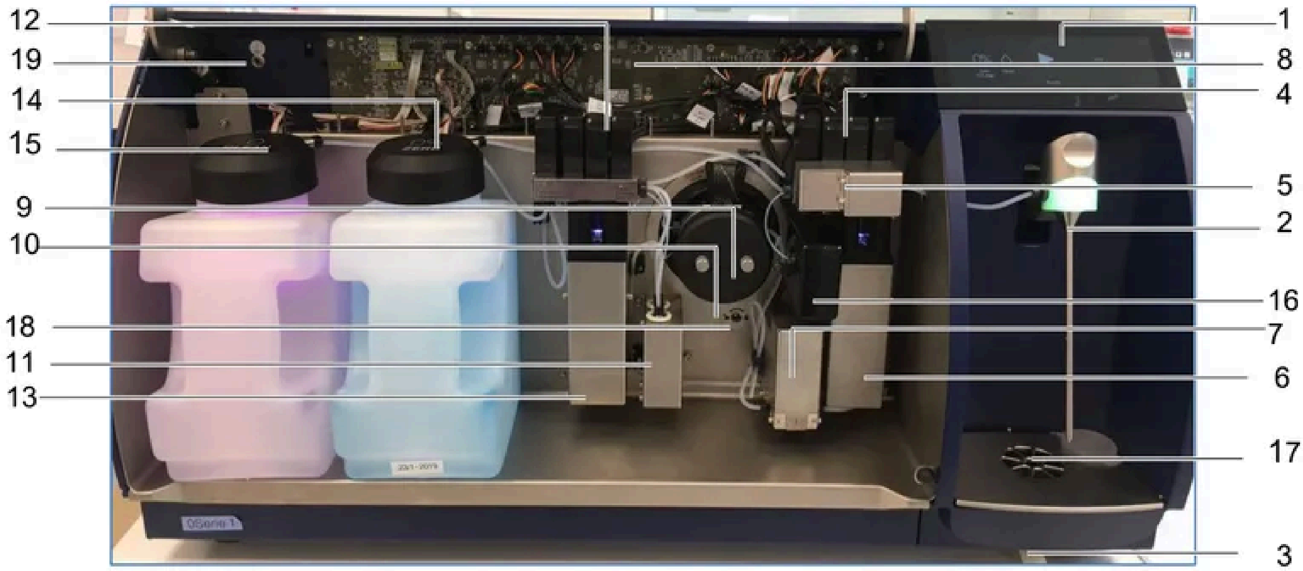

Fig. 4 Front of the Main Unit

1 - Touch screen

2 - Sample Pipette with LED

3 - Waste tube

4 - Valves on Manifold

5 - H-stage Valve

6 - Pump

7 - Back-pressure Valve

8 - Driver Control PCB

9 - Detector /Cuvette

10 - Inline Filter

11 - Conductivity Module

12 - Valves on Manifold

13 - Pump

14 - Zero Pipette and Container

15 - Clean Pipette and Container

16 - PreHeater

17 - Waste Funnel

18 - Transport Lock

19 - Functional Earth

Table 3 Front of the Main Unit

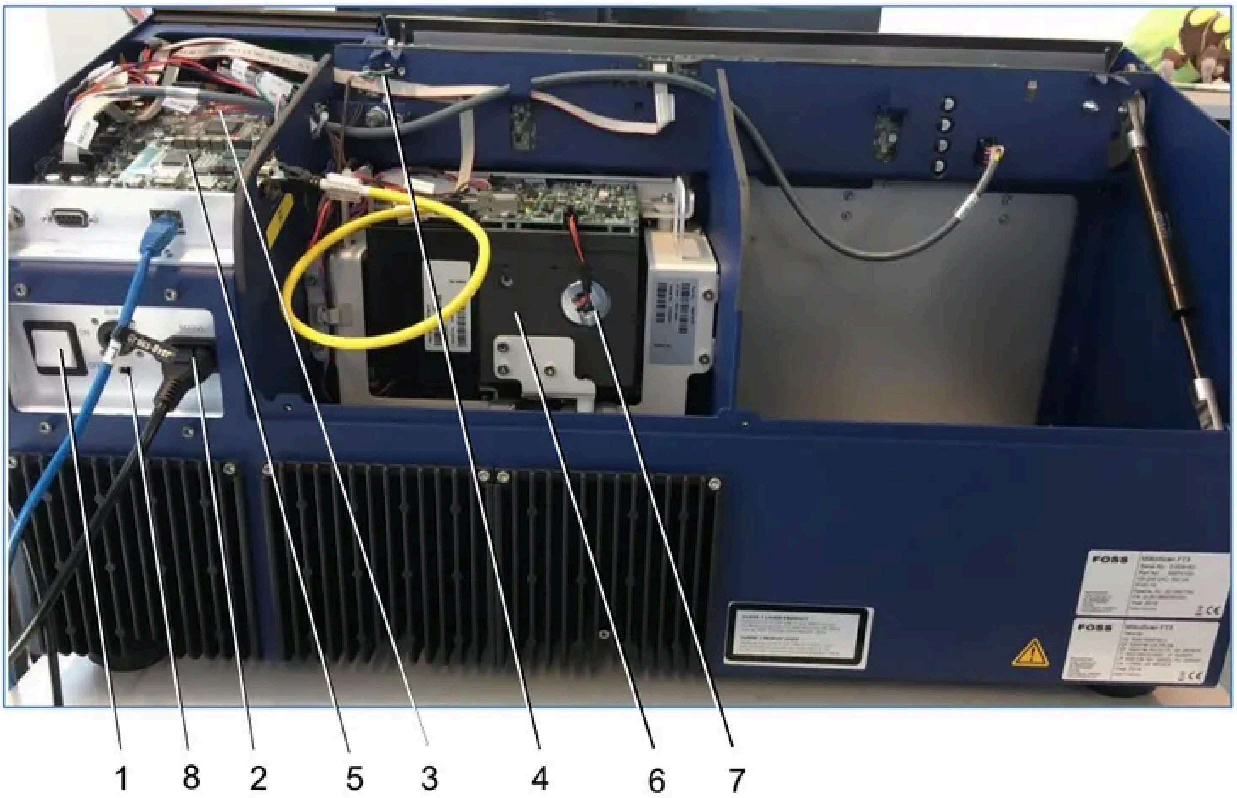

Fig. 5 Rear of the Main Unit

1 Power switch

2 Mains power connector

3 Control PCB

4 ID chip

5 Ethernet Swit ch (Sync Board)

6 Interferometer w/IR Source

7 De-Humidifier

8 Functional Earth

Table 4 Rear of the Main Unit

2.2.1 Main Unit

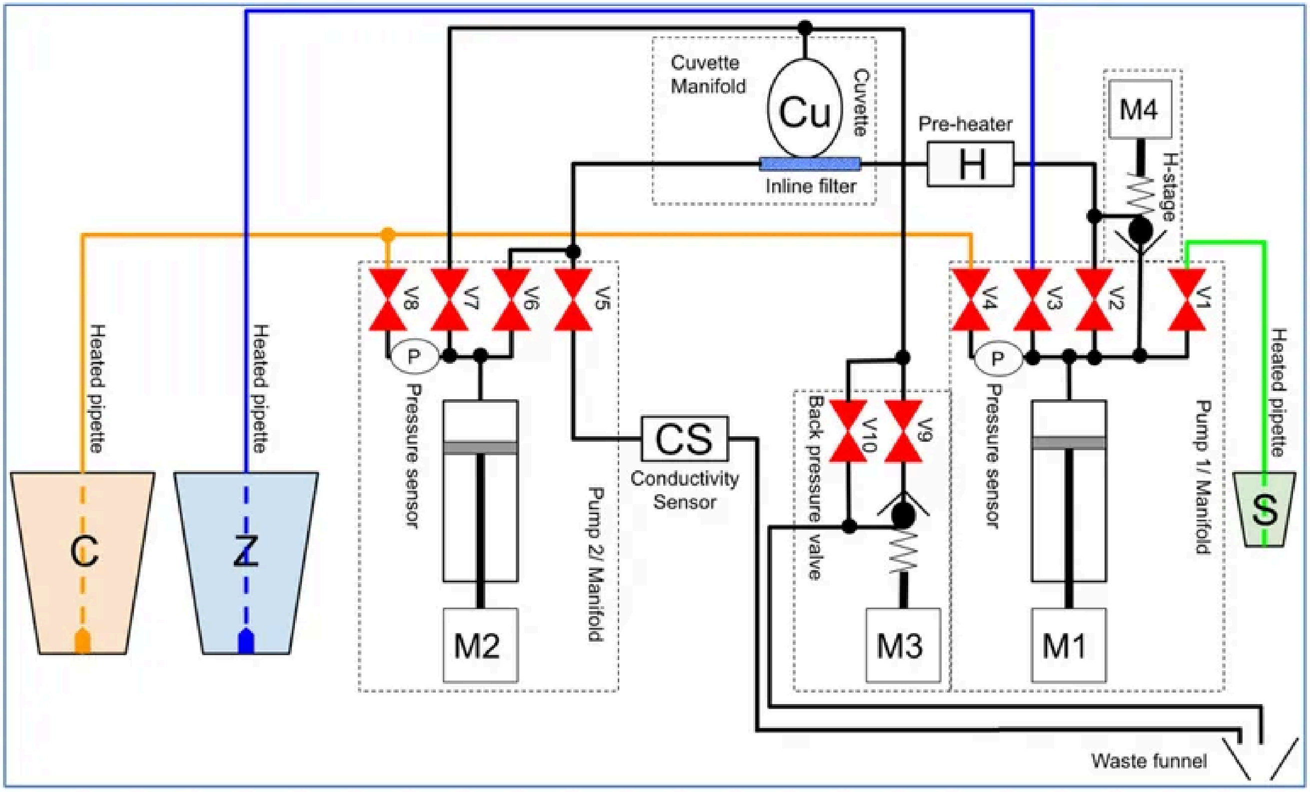

Fig. 6 Software illustration

2.2.1.1 General

The MilkoScan™ FT3 flow system is engineered to handle more viscous and particle-rich samples than previous MilkoScan™ instruments. Because the system operates without homogenizers, it relies on subsampling, which requires rapid

start-and-stop flow control. To meet these demands and maintain analytical accuracy, the system incorporates several key design features:

- Adaptive pumping system that continuously monitors pressure during sample intake.
- Heated Pipette that reduces sample viscosity immediately upon entry.
- Low hydraulic resistance, achieved through a larger-diameter pipette and a minimized intake path.
- High-pressure tolerance (up to 9 bar), enabling ultrafast stop-and-go operation.
  To safeguard sensitive components - such as the cuvette windows made of Calcium Fluoride (CaF_2), spaced only 50 µm apart - an inline Cuvette Manifold filter prevents particles larger than 34 µm from entering the Cuvette.

2.2.1.2 Touch Screen/Display

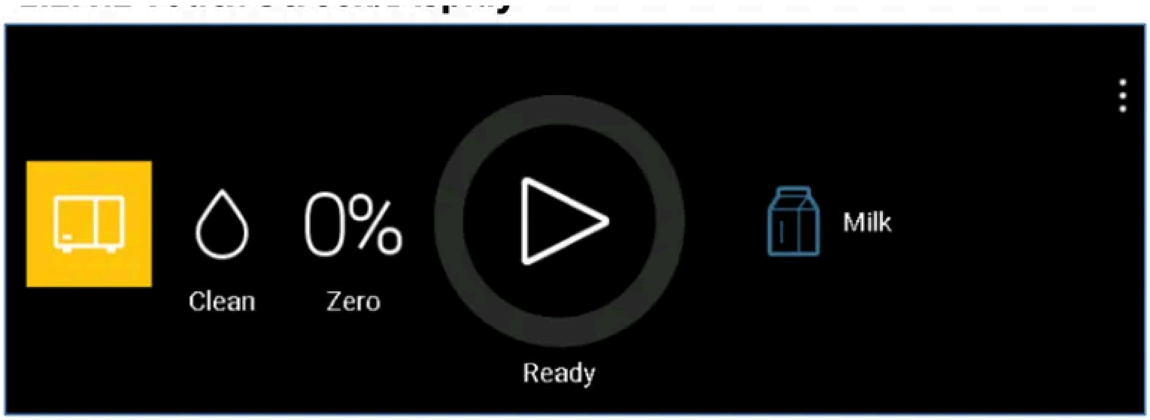

Fig. 7 Touch Screen/Display

Touch Screen/Display (Fig. 7) serves as the operator interface, providing quick access to essential functions such as sample analysis, zero setting, and cleaning. It allows the instrument to be operated without the computer interface for routine tasks.

Only commonly used functions are available on the touch screen; advanced operations must be performed through the computer user interface.

The touch screen provides access to the following options and information:

- Start or stop analysis.
- Analysis progress button.
- Product selection for analysis.
- Events, error and warning indicator.
- Zero and Clean start buttons.
- IP settings.
- Restore Factory settings.
- Erase all stored IP addresses.
- Reset Driver Control PCB settings to default.
- Reset Main Control PCB settings to default.
- Restart the instrument.
- Format file system on the PCB's.

In May 2025, a new touch-screen spare part was introduced following the discontinuation of components used in the previous version. Although the old version is no longer in production, any units already in local stock may still be used. All functionality remains unch

> Note: : The new touch screen requires software version 9.5.0.62 or newer, available in the SharePoint Tool B ox

2.2.1. 3 Sample Pipette Unit

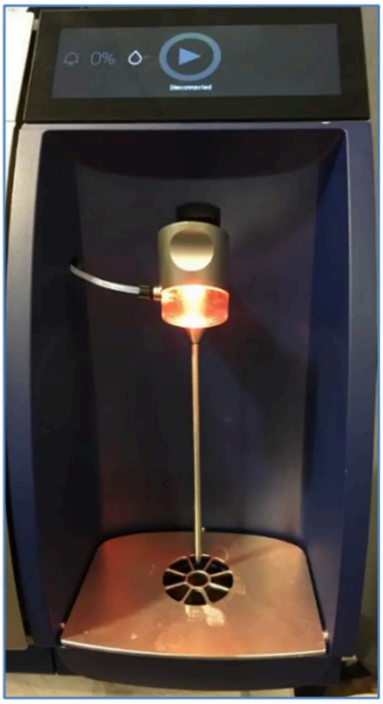

Fig. 8 Sample Pipette Unit

The Sample Pipette (Fig. 8) is the primary physical interface between the user and the instrument. The Sample Pipette Unit consists of the Pipette, Pipette Head, Pipette Head PCB, Intake tube, Pipette cover, Waste Manifold, Waste drawer, and Waste cover.

The Pipette functions as a first-stage Heater through a double-pipe construction containing a copper wire positioned between the tubes and connected to the pipette head PCB. The outer tube includes a cone-shaped intake that facilitates external cleaning after sample aspiration.

The Pipette features a bi-stable tilt mechanism, allowing it to tilt approximately 35° toward the user for convenient sample cup placement. It remains in this position until manually or automatically released. This design reduces splashing and enhances overall usability.

If the user does not initiate a cleaning sequence, the instrument automatically performs a back-flush of the pipette to clean the flow system. If the Pipette is tilted, the instrument first returns it to the vertical position to prevent splashing onto the floor.

The Pipette also includes a multi-color LED, controlled by the Pipette Head PCB, to indicate instrument status:

- Red: Error state - measurement not possible.
- Orange Intake in progress.
- Yellow: Descaling - measurement not possible.
- Purple: Cleaning - measurement not possible.
- Green: Ready for analysis.
- Green (low): Sample cleanup - new sample can be placed.
- Blue: Zero Setting
  The sample temperature must be between 5°C and 40°C (40°F and 104°F).

2.2.1. 4 Pump Units

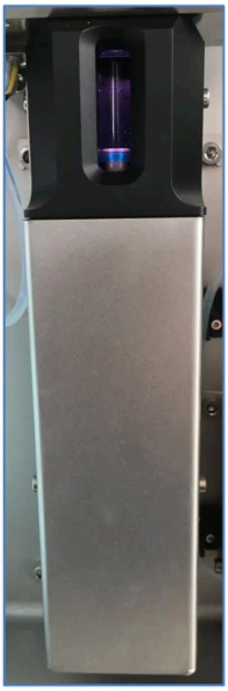

Fig. 9 Pump Units

The MilkoScan FT3 uses two Piston/Syringe Pumps (Fig. 9) driven by Stepper Motors. Each Pump is connected to a Manifold equipped with a second-stage Heater, Temperature Sensors, a Pressure Sensor, and four electrically operated valves.

- One Pump acts as a feed pump while the other receives a defined fraction of the sample volume.
- The Pumps regulate the ratio between sample flow through the Cuvette and flushing the Inline Filter.
- Reverse flow into the Cuvette is supported for particle-rich samples and for routine back-flushing of the Inline Filter.
  A push-pull operating mode between the two Pumps enhances cleaning efficiency by generating foam during the cleaning cycle, improving removal of residues from both the Inlet Filter and the Cuvette.
- Each Pump consists of a Glass Tube housing the Piston.
- Glass Tubes are backlit to allow easy visual monitoring during operation and maintenance.

2.2.1.5 Valves

Fig. 10 Valve

Fig. 11 Valves - Pump Manifolds

Each of the two Pump Manifolds is equipped with four electrically actuated valves (Fig. 11) which regulates the flow system.

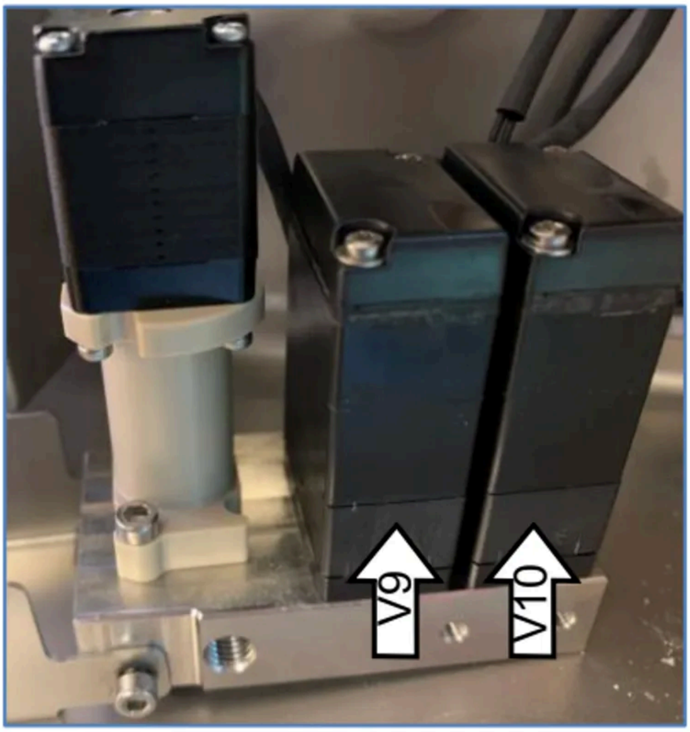

Fig. 12 Valves - Back Pressure Manifold

Manifold	Valves	Position
Pump Manifold 1	V1 - V4	V1 (right) → V4 (left)
Pump Manifold 2	V5 - V8	V5 (right) → V8 (left)
Back Pressure	V9 - V10	V9 (front) → V10
Manifold		(rear)

Table 5 Valve position

High-Pressure Valve V1-V4: Rated up to 32 bar, with a nominal operating pressure of up to 20 bar. A built-in safety function opens valve V1 if the pressure exceeds 30 bar.

Low-Pressure Valve V5 - V10: Rated up to 12 bar, with a nominal operating pressure of up to 8 bar.

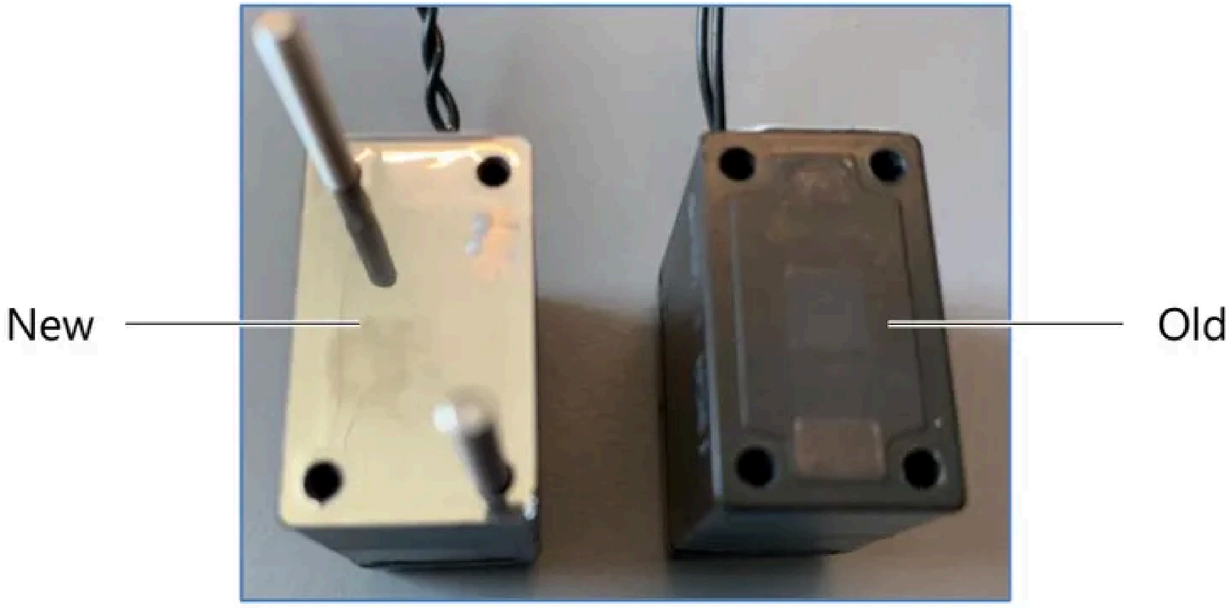

Fig. 13 Valves disassembled

Starting from instrument S/N 9193 4234, valves V1, V4, and V8 are manufactured with a built-in metal foil/membrane (Fig. 13, left = New), to prevent corrosion by isolating the solenoid from liquid ingress. Valves V2, V3, V5, V6, and V7 continue to be supplied without the metal foil/membrane (Fig. 13, right = Old).
For instruments produced before S/N 9193 4234, all valves (Valve V1 - V10) were supplied without the metal foil/membrane (Fig. 13, right = Old).

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Note: : All new spare parts now include the metal foil/membrane
for improved durability (Fig. 13, left = New).
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2.2.1.5.1 Valve Repair Kits

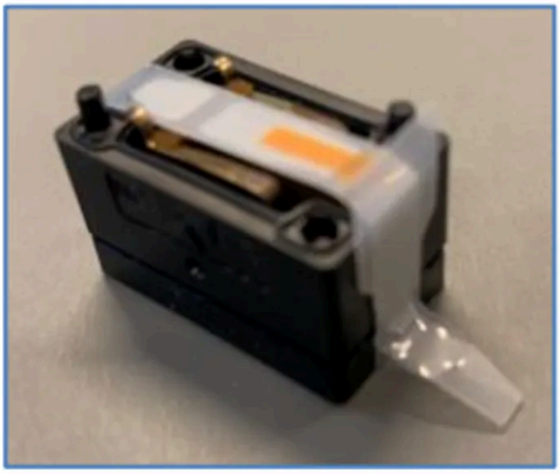

Fig. 14 Valve Repair Kit

Solenoid failures are uncommon; most valve-related issues arise from membrane defects or wear in the tipping mechanism. Solenoid failures are uncommon; most valve-related issues arise from membrane defects or wear in the tipping mechanism (Fig. 14) consisting of the lower part of the valve, including the membrane and the housing for the tipping mechanism.
Two kits are available:

- High-Pressure Kit: For Valves V1 - V4 (rated up to 32 bar).
- Low-Pressure Kit: For Valves V5 - V10 (rated up to 12 bar).
  These kits offer a cost-effective way to extend valve service life and reduce instrument downtime.

2.2.1.6 Back Pressure Valve

Fig. 15 Back Pressure Valve

The Back-Pressure Valve (Fig. 15) maintains a stable positive pressure in the system to ensure a consistent light path and prevent air bubbles from forming in the Cuvette. Air bubbles can scatter infrared (IR) energy passing through the sample, resulting in inconsistent measurements.

On the MilkoScan™ FT3, the Back-Pressure Valve is driven by a Stepper Motor, enabling electronic verification of backpressure during every Zero Setting. When required, the system automatically adjusts the pressure to maintain optimal operating conditions. The Stepper Motor also fully opens the Valve whenever no sample is being measured, allowing a flushing sequence that cleans the Valve and Membrane for reliable performance.

Two low-pressure valves - V9 and V10 - are located upstream of the Back-Pressure Valve:

- Valve V10 opens to allow liquids to bypass the Back-Pressure Valve.
- Valve V9 opens to direct liquids through the Back-Pressure Valve.
  Only one of these valves is open at any given time, although both may be closed simultaneously.

2.2.1.7 H-stage

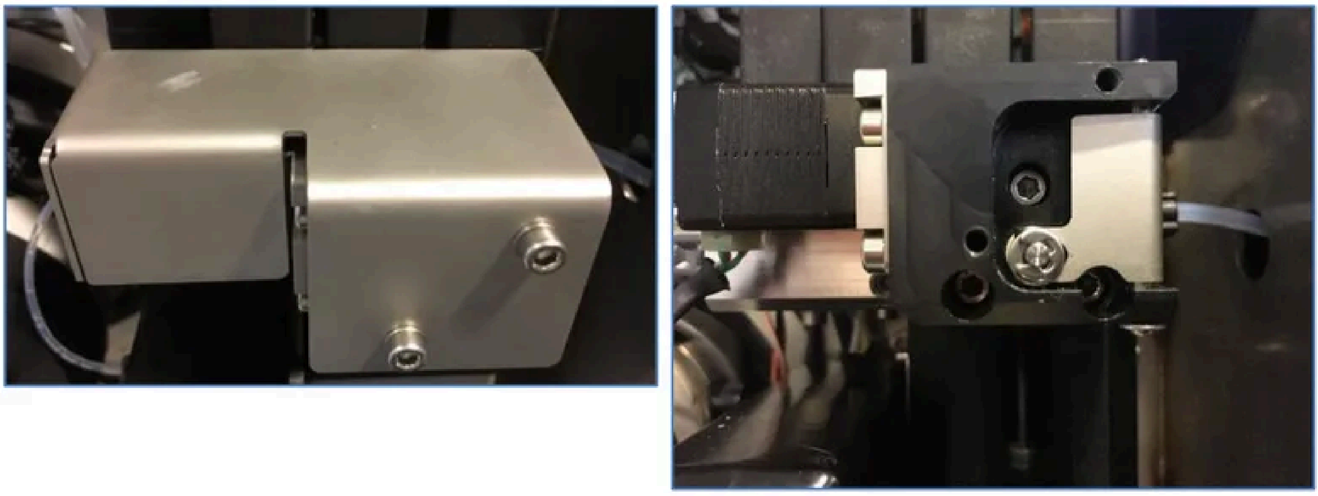

Fig. 16 H-stage

The purpose of the H-stage (Fig. 16) is to homogenize large fat droplets found in challenging products, such as Crème Fraiche. The H-stage uses a traditional ball-and-seat homogenizer design, but in this system it is motorized with a Stepper Motor. This enables the pressure to be set and automatically adjusted for effective homogenization at much lower sample pressures than those required by the FT1 and FT2 models.

The H-stage is configured in the Product Configuration for specific products and is activated only when those products are measured. At all other times, the H-stage is bypassed. When no sample is being analyzed, the Stepper Motor fully opens the H-stage to flush the ball-and-seat assembly, ensuring it remains clean.

Since May 2025, the Inner Housing/Pressure Housing and H-stage mechanics have been updated to a new design. Externally, the old and new H-stages appear identical except for the part-number (P/N) label, as the changes relate primarily to internal tolerances. However, the difference in the Inner Housing/Pressure Housing is noticeable.

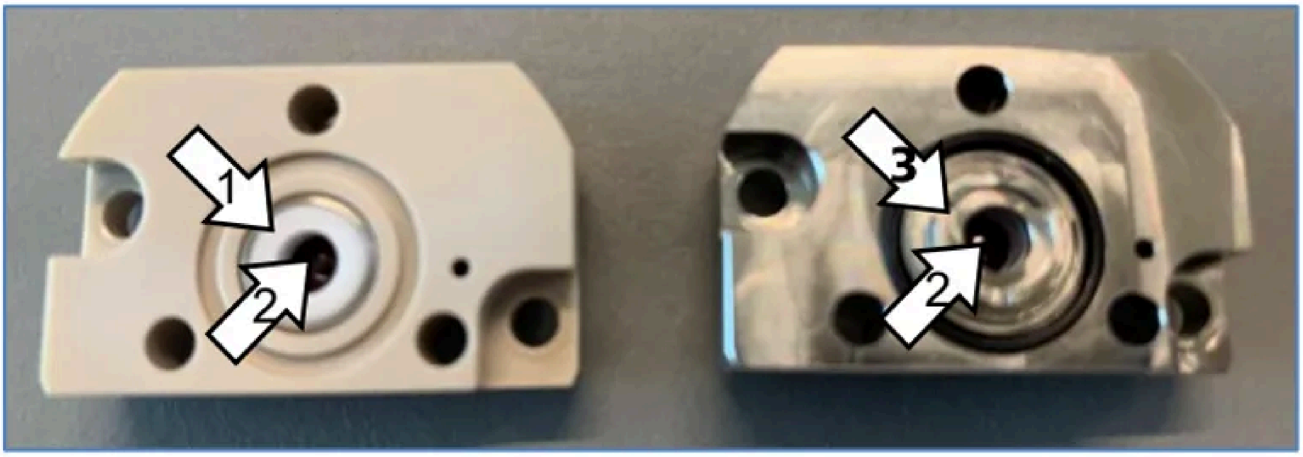

Fig. 17 Inner Housing/ Pressure Housing (left = old; right = new)

- **The old version (Fig. 17, left):**

The previous design was made of PEEK material, with the homogenizer (Fig. 17, pos. 1) and ruby ball (Fig. 17, pos. 2) pressed into position. Due to the tight tolerances, any slight misalignment in the H-stage mechanics could force the homogenizer out of position, causing it to jam during operation.

- **The new version (Fig. 17, right)**:

The updated design is made of metal and still uses the same pressed-in homogenizer with the ruby ball (Fig. 17, pos. 2). A nut (Fig. 17, pos. 3) tightened to a specified torque, has been added to prevent the H-stage mechanics from displacing the homogenizer. This nut is factory-set and must not be adjusted.

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Note: : Since the new Pressure Housing (Fig. 17, right) has an
expected lifetime >2 years, the Pressure Housing has been
removed from the PM Kit since January 2026.
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2.2.1.8 Sample Heater (PreHeater)

Fig. 18 Sample Heater (PreHeater)

The Sample Heater (PreHeater) (Fig. 18) serves as the third stage of sample heating. Its function is to raise the sample temperature to the measuring level of 42 °C ± 1 °C (107 °F ± 2 °F) before the sample enters the Cuvette.

2.2.1.9 Cuvette

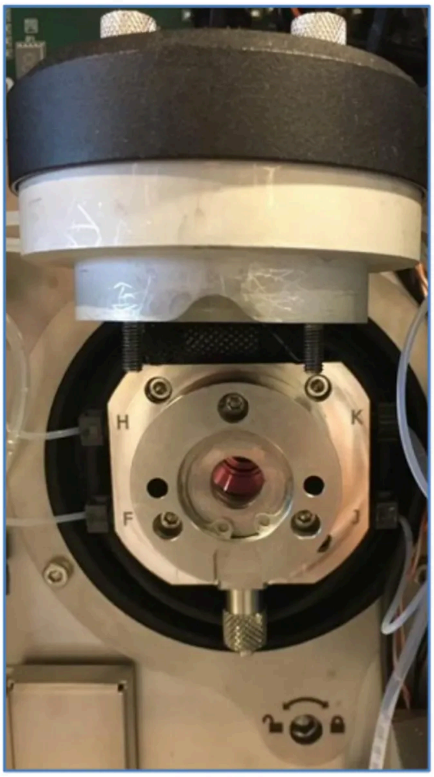

Fig. 19 Cuvette

See description in 2.2.2.7 Sample Cell (Cuvette).

2.2.1.10 Detector

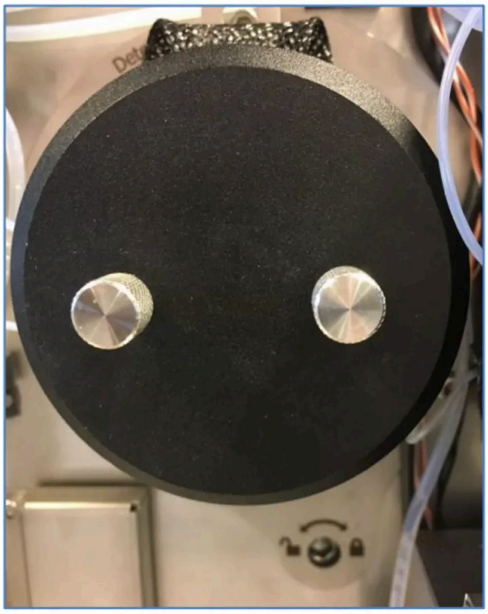

Fig. 20 Detector

See description in 2.2.2.8 IR Detector.

2.2.1.11 Inline Filter

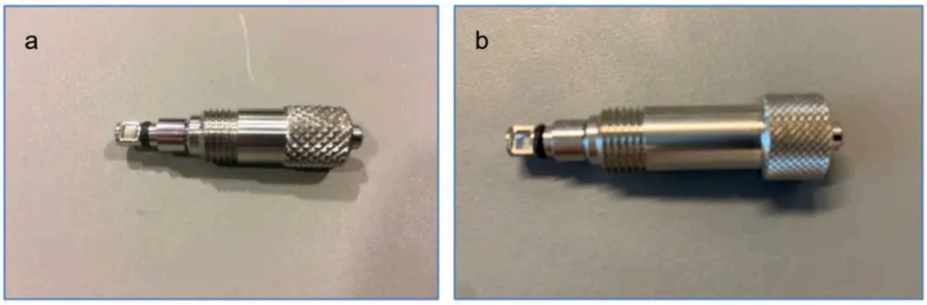

Fig. 21 Inline Filter

The purpose of the Inline Filter (Fig. 21a, old short version) (Fig. 21b, new extended version) is to prevent particles larger than 34 µm from entering the Cuvette. The filter is user-removable and can be rinsed under running water; in some cases, a brush may be needed to remove particles adhering to the filter surface.

The MilkoScan™ FT3 instrument performs thorough internal cleaning of both the

system and the Inline Filter, so routine manual cleaning by the customer is generally unnecessary. External cleaning should only be performed when the Diagnostic System detects a blockage and instructs the user to clean the filter.
A similar Inline Filter with a 25 µm mesh has also been introduced. When analyzing multiple samples of cocoa milk, the standard filter may clog more quickly due to the high fiber content, which can be difficult to remove. The finer-mesh version helps prevent fibers from becoming trapped in the filter.

2.2.1.12 Conductivity Sensor (Optional)

Fig. 22 Conductivity Sensor

The purpose of the Conductivity Sensor (Fig. 22) is to measure (or estimate) the freezing point depression of the liquid by determining its electrical conductance. The sensor consists of a series of metal discs (electrodes) arranged in sequence, through which the liquid flows. The spaces between the electrodes are made of insulating material. An electrical current is applied between two excitation electrodes, maintaining a constant voltage at two sensing electrodes. The resulting current is therefore proportional to the liquid's conductivity.

The Conductivity Sensor is calibrated using the Clean liquid, meaning it is recalibrated automatically every time the instrument undergoes a cleaning cycle. If the instrument is purchased without the Conductivity Sensor, an easy upgrade option is available (see chapter 3.6.64 Upgrade FT3 with Conductivity Sensor). The necessary cabling is already installed, and the connector for the sensor is located behind a cover. Similarly, if the instrument was purchased with the sensor, it can be easily removed (see chapter 3.6.65 Downgrade FT3 without Conductivity Sensor).

2.2.1.13 Zero Pipette Unit and Zero Container

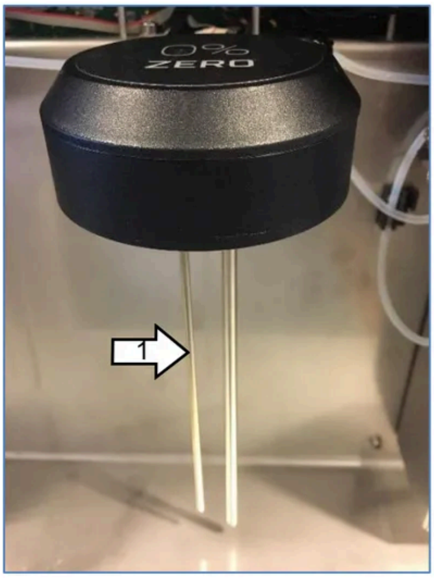

Fig. 23 Zero Pipette Unit and Zero Container

The Zero Pipette Unit (Fig. 23, left) serves as the input mechanism for transferring the Zero reagent from the Zero Container (Fig. 23, right) to the Pump 1 Module. The reagent is drawn into Pump 1 when the pump is activated and Valve V3 is opened.

The pipette features a double-pipe construction with a copper wire positioned between the pipes, functioning as a heater and directly connected to the Pipette Head PCB. The outer tube incorporates a cone-shaped intake to facilitate cleaning. A Liquid Sensor (conductivity-based) (Fig. 23, left, pos. 1) detects the presence of liquid beneath the pipette and verifies whether the liquid is the correct Zero solution. If the solution does not match specifications, a warning is triggered.

The Container Lid includes a colored LED that emits blue light into the Container for visual indication.

Additionally, the Pipette is spring-loaded to maintain a vertical position during operation.

2.2.1.14 Clean Pipette Unit and Clean Container

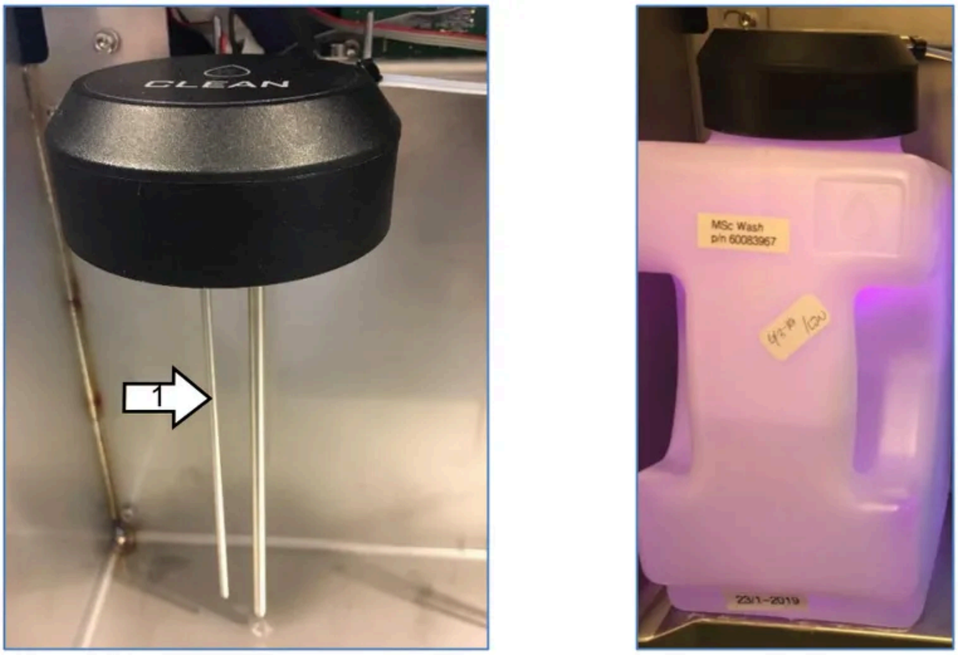

Fig. 24 Clean Pipette Unit and Clean Container

The Clean Pipette Unit (Fig. 24, left) serves as the input mechanism for transferring the Clean reagent from the Clean Container (Fig. 24, right) to the Pump 1 and/or Pump 2 Modules. The reagent is drawn into Pump 1 or Pump 2 when the respective pump is activated and the corresponding valve (Valve V4 or V8) is opened.

The pipette features a double-pipe construction with a copper wire positioned between the pipes, functioning as a heater and directly connected to the Pipette Head PCB. The outer tube incorporates a cone-shaped intake to facilitate cleaning. The Liquid Sensor (conductivity-based) (Fig. 24, left, pos. 1) detects the presence of liquid beneath the pipette and verifies whether the liquid is the correct Clean solution. If the solution does not meet specifications, a warning is triggered.
The Container Lid includes a colored LED that emits purple light into the Container for visual indication.

Additionally, the pipette is spring-loaded to maintain a vertical position during operation.

2.2.1.15 Interferometer (IFU)

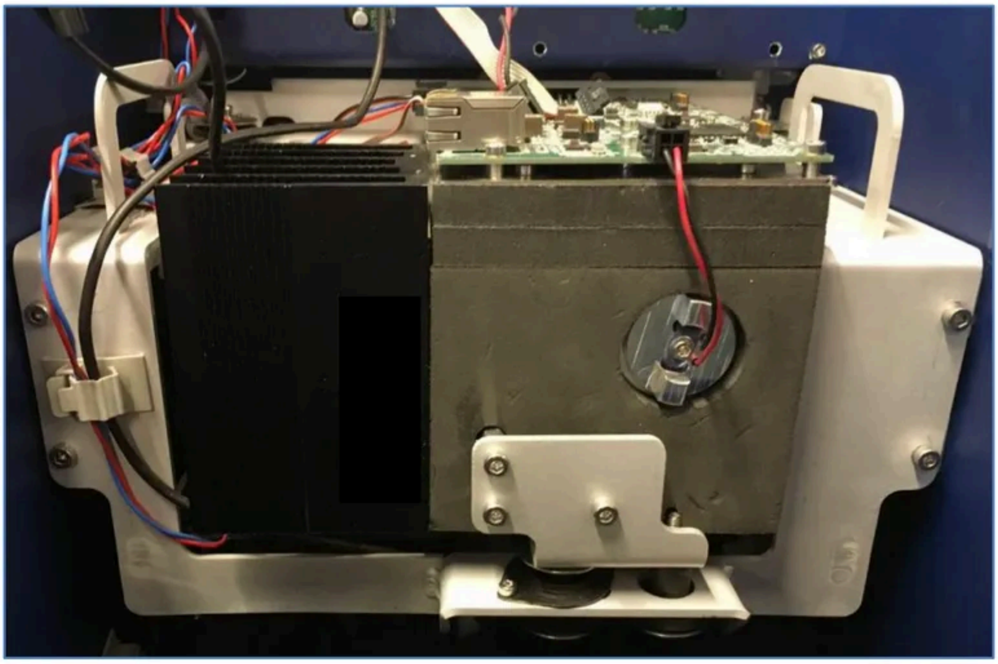

Fig. 25 Interferometer (IFU)

See description in 2.2.2 Measuring System/IFU Theory.

2.2.2 Measuring System/IFU Theory

2.2.2.1 General

The Interferometer (IFU) in the MilkoScan™FT3 generates interferograms of the sample contained in the cuvette. To predict results, these interferograms are processed using FTIR (Fast Fourier Transform – Infrared) algorithms, which convert the interferograms into full single-beam spectra. These spectra cover the infrared wavelength range from approximately 2 µm to 11 µm.

Fourier Transformation, named after Joseph Fourier (1768–1830), is a mathematical technique that, in simple terms, decomposes a function - such as an interferogram - into a continuous spectrum of its frequency components. This process enables the analysis of complex signals by representing them as a sum of simpler sinusoidal functions.

A single-beam Spectrum can be described as a curve representing the energy level at each wavelength within the measured range. In other words, it shows how much energy is absorbed by the sample's constituents at any given wavelength.

2.2.2.2 The interferometer System

The Interferometer in the MilkoScan™FT3 is a Michelson-type interferometer.

Albert Abraham Michelson invented the Michelson interferometer—the most widely used configuration in optical interferometry - around 1880. This design creates an interference pattern by splitting a beam of light into two paths, reflecting the beams back, and then recombining them.

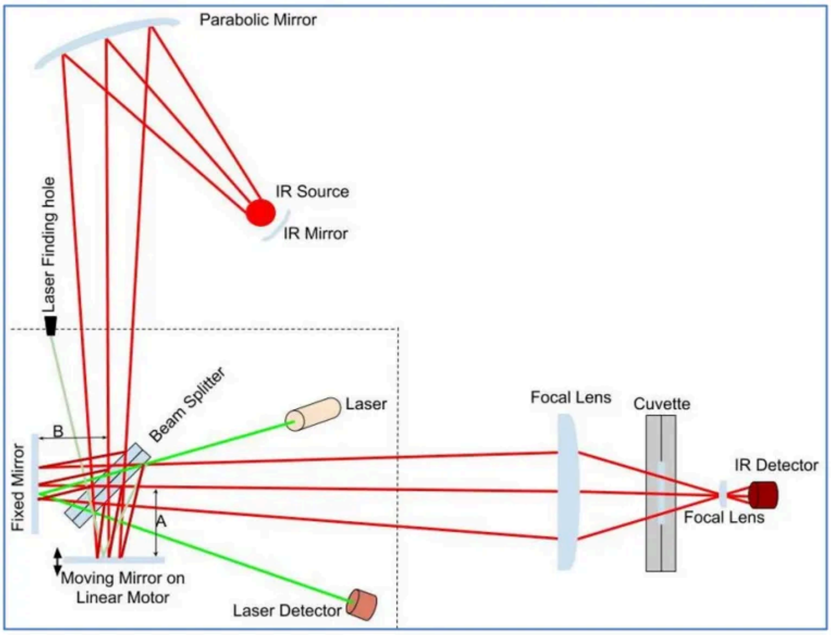

Fig. 26 Interferometer

The Interferometer must be maintained at a constant temperature of approximately 40 °C (104 °F) and low humidity. To achieve a stable operating environment, the system uses:

- A 10 mm foam cover on the Thermo Box for insulation
- An integrated heating/cooling system combined with a heat sink and a thermoelectric heater/cooler (Peltier element) for precise temperature control

- An electronic Dehumidifier mounted inside the Thermo Box to regulate humidity

2.2.2.3 IR Source

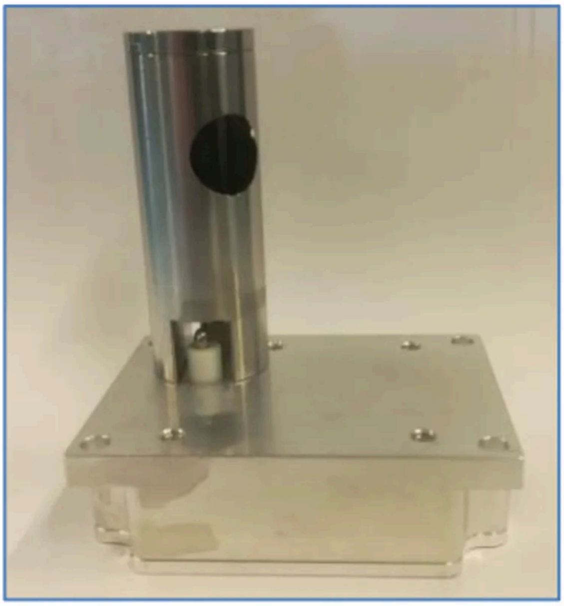

Fig. 27 IR Source

The IR Source Module is installed in the Source Housing, which is mounted on the side of the IFU. In case of failure, only the IR Source Module needs to be replaced. The IR source uses a pig-tail filament that heats to approximately 800 °C (1472 °F), emitting radiation across wavelengths from 0.7 µm to 50 µm. While the IR Source appears as a red-hot glowing body, the emitted radiation is invisible to the eye but can be felt as heat.

The Source operates at 24 V with a current of about 0.4 A, resulting in a power output of approximately 9.4 W.

A non-adjustable off-axis parabolic mirror is used to collimate the light before it enters the Interferometer.

2.2.2.4 Beam Splitter

The Beam Splitter is a specialized, gold-coated optical component that reflects approximately 50% of the incoming beam's energy while transmitting the remaining 50%, thereby creating two beams of identical wavelength and phase. Within the Interferometer, two types of beams are used: the IR beam and the Laser beam. Each of these beams is divided into two by the beam splitter. Interference - and thus the formation of an interferogram - occurs only when the two IR beams or the two Laser beams recombine and overlap precisely on their respective Detectors. The Beam Splitter is an integrated internal part of the IFU and is non-replaceable. In the event of a defect, the entire Interferometer must be replaced.

2.2.2.5 Fixed Mirror

The Piezoelectric effect, discovered around 1880, derives its name from the Greek word Piezein, meaning “to squeeze” or “apply pressure.” When mechanical pressure is applied to a crystal, its shape or size changes, and as a result, a voltage can be measured across the crystal. Conversely, when a voltage is applied to the crystal, it undergoes a slight deformation.

Although the dimensional change is in the nanometer range, it can generate extremely strong forces. The Piezoelectric effect is observed in many types of crystals and is widely used in precision positioning and actuation systems.

The Fixed Mirror is mounted on three Piezoelectric elements, which can change height by a few microns when a voltage of ±150 V is applied. When the Piezo elements are not powered, the mirror returns to its mid-position.

At the factory, the Fixed Mirror mechanism is first manually adjusted to achieve an adequate (maximum) IR signal (Peak-to-Peak). Then, by applying a specific voltage pattern to the Piezo elements, the system fine-tunes the mirror position to optimize the IR signal. When power is removed, the piezo elements revert to their original size; however, a memory function reapplies the same voltage pattern to restore the adjusted position, when power again is available.

This voltage application occurs every time the MilkoScan™FT3 is powered up and a measurement is initiated.

The Fixed Mirror is an integrated internal part of the IFU and is non-replaceable. In case of a defect, the entire Interferometer must be replaced.

2.2.2.6 Linear Motor/Moving Mirror

The Linear Motor moves the Moving Mirror back and forth at a uniform speed.
This speed is digitally controlled and regulated based on zero-crossing pulses from the laser interferogram.

- Full travel: From end stop to end stop, the mirror moves approximately 1.9 mm in about 3 seconds, corresponding to roughly 9,000 zero-crossing pulses. These values vary slightly between IFUs due to mechanical differences.
- Measurement mode: The mirror travels 2,300 zero pulses, equivalent to 0.49 mm over 0.177 seconds.
  During each travel, the Moving Mirror passes a point where the distance to the Beam Splitter equals the distance from the Beam Splitter to the Fixed Mirror (distance “A” = distance “B” in Fig. 26). At this position, all wavelengths reaching the Detectors have traveled the same distance and are therefore in phase. This results in maximum signal output.
  The Interferometer is mounted on shock-absorbing supports to prevent minor vibrations from disturbing the mirror’s uniform motion.

The Linear Motor is an integrated internal part of the IFU and is non-replaceable.
In case of failure, the entire Interferometer must be replaced.

2.2.2.7 Sample Cell (Cuvette)

Fig. 28 Cuvette

The construction of the Cuvette (Fig. 28), Manifold, and Inlet Filter (Fig. 21), is designed to ensure that filtering occurs as close as possible to the Cuvette.
The sample is measured by IR transmission in a Calcium Fluoride (CaF_2) cell with a 50 µm path length, the Cuvette referred to as the cuvette. The Inlet Filter is positioned inside the Cuvette Manifold, directly at the Inlet to the measuring cell. The Cuvette Manifold - and therefore the cuvette - is temperature-controlled to a set point of 42°C ±1° (108°F±2°). Temperature regulation is managed by the Detector PCB.

The Standardization method used in MilkoScan™FT1 and FT2, which compensated for Cuvette glass wear, is replaced in MilkoScan™FT3 by a prediction algorithm that estimates path length changes during Zero Setting. Before the Cuvette reaches its maximum allowable wear, a warning message is displayed to the operator.

The Cuvette cannot be disassembled for repair; once worn, it must be replaced.

2.2.2.8 IR Detector

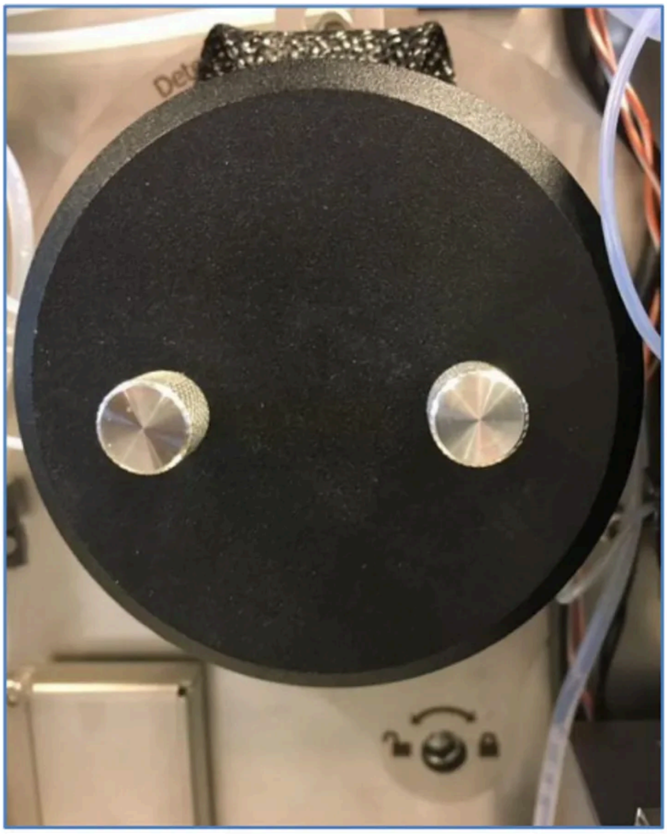

Fig. 29 Detector

The IR Detector (Fig. 29) functions as a highly sensitive thermometer. In practical terms, the IR energy within the IFU can be considered heat energy. During a sample scan, the Detector records the energy (temperature) distribution across the IR beam's wavelength range.

At specific wavelengths, sample constituents such as Fat, Lactose, SNF, Protein, and others absorb energy, altering the energy pattern across the spectrum. These changes are captured by the IR Detector and reflected in the sample's Interferogram. Using Fast Fourier Transformation and calibration algorithms, these variations are quantified and displayed as parameters such as % Fat, % Protein, etc. Because the Detector operates as a sensitive thermometer, it is also affected by ambient temperature fluctuations. To ensure stability, the IR Detector is temperature-controlled via a heating plate integrated into the Detector PCB.

2.2.2.8.1 IR Interferogram

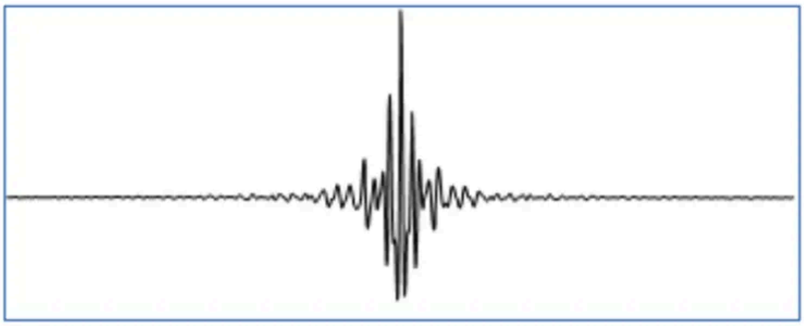

Fig. 30 IR Interferogram

The IR Interferogram (Fig. 30) is generated from the IR signal that has passed through the sample in the Cuvette. At their respective wavelengths, the sample’s constituents absorb energy in proportion to their concentration. Consequently, the IR signal - and thus the interferogram - contains information about the concentration of each constituent in the sample.
A Laser is a device that produces light - or other electromagnetic radiation - with unique properties through quantum-mechanical effects. The term LASER stands for Light Amplification by Stimulated Emission of Radiation.

Radiation from an ideal Laser exhibits three distinctive characteristics:

- Single wavelength: It emits light at one specific wavelength.
- Directional beam: All waves propagate in precisely the same direction, forming a thin straight beam rather than a cone-shaped one.
- Phase coherence: All waves travel in phase with each other.

2.2.2.9 Laser Diode

The Laser Diode emits a beam with a wavelength of approximately 850 nm. Although this wavelength is temperature-sensitive, the system regulates the Linear Motor speed so that the laser interferogram frequency remains constant at 1200 Hz. Since 850 nm is outside the visible range for the human eye, special instruments are required for laser beam alignment.
The Laser Diode is non-adjustable and non-replaceable. In case of failure, the entire Interferometer must be replaced.

2.2.2.10 Laser Detector

The Laser Detector is mounted on the same PCB that also houses the Laser Diode, Pre-Amplifier, Interface, Pre-Amplifier for the Linear Motor, Piezo Interface for Fixed Mirror adjustment, and the Temperature Sensor.

The Laser signal, or Laser Interferogram, is a 1200 Hz sine wave. It is used to monitor the movement of the Linear Motor and to trigger the A/D converter, which converts the IR interferogram into digital values.

The Laser Detector is non-replaceable. In case of failure, the entire Interferometer must be replaced.

2. Untitled