



USER HANDBOOK


FMS-MK1000

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FMS International Inc.

 <https://fms-filtration.com/>



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1 CONTROL CHANGE

Version	FW version	Comments
1	2	Initial draft

2 INTRODUCTION

This handbook describes the key features of the FMS-MK1000 system, a plug and play system to monitor contamination in industrial equipment lubricated systems. The core of the system is the measuring module, which is based on the patented technology of digital image and video. It quantifies particles greater than 4 microns present in fluids and classifies them related to the ISO, NAS or SAE standards.

The system includes data displayed in an HMI screen to get direct readings from the measurement system, where are trended and stored. Remote communications are also available to ensure full communication.



Figure 1. FMS – MK1000.

The internal device is protected through the following patents:

- European Patent n. 16382179.6
- US Patent n. 15/496,430

3 KIT DEFINITION

The FMS Smart Monitoring kit includes the following subsystems:

- FMS OilWear 2.0 system: Sensor that measures fluid contamination and condition using optical acquisition systems and digital image processing algorithms. Periodical images are obtained, processed in the sensor and the information obtained is delivered via digital output.
- Integrated stepper pump: gear pump with speed control embedded in the HMI. In case the pump is not needed, an additional needle valve is implemented.
- HMI: 7" color screen to control the sensor and peripherals.
- Interfaces: Hydraulic, power supply, alarm relay and Ethernet communication interfaces.

4 FMS-MK1000 INTERFACES

The system is provided with hydraulic interfaces based on a female 1/8" BSP port.



Figure 2. Hydraulic interfaces of FMS-MK1000.



Figure 3. Side interfaces of FMS-MK1000.

Additionally, SMK has additional interfaces on the side:

- Power supply button.
- Power supply: M12-A coded 5-pin female connector.
- Ethernet: M12-D coded 4-pin female connector
- USB port.

PIN	FUNCTION	OW-WIRE COLOUR CODE
-----	----------	---------------------

2	VDC IN	White
3	GND IN	Blue
4	NO Relay	Black
5	GND Relay	Gray

Figure 4. FMS-MK1000 power supply pinout (connector side).



5 GENERAL SPECIFICATIONS

ELECTRICAL				UNIT.
	Nominal	Minimum	Maximum	
Power supply	24 VDC	22	28	V
Consumption	600 mA	400	800	mA
Electrical Inlets/Outlets	M12x5pA M12x4pA			
Communications	HMI Remote connections via VNC			
Ethernet	IP, FTP, SSH M12x4pD			
Dimensions				
Height	300			mm
Width	350			mm
Depth	200			mm
Weight				
When circuit empty	9,5			Kg
Operating temperature		-20	70	°C
Humidity RH		0	95	%
Inlet pressure		2	16	bar
Operating oil flow	0.2 (adjustable)			l/min
Housing	IP65			
MATERIALS				
Wettable Material	BK7, Aluminum, VITON,			
External Material	Aluminum, Brass			
Connections	1/8" BSP female			
Certifications	CE			
Branding	Serial Number, Logo.			
Lifetime	Revision 2-3 years			
Calibration	Following ISO 11171 standards			
Viscosity	540 (max)			cSt

Figure 5. FMS-MK1000 general specifications.

6 USER FEATURES

The FMS-MK1000 is controlled via an HMI screen with the following features:

- Test tag and CSV storing
- Trend visualization
- Pump control
- Digital output based on alarms
- FTP and VNC communication
- Remote communication available

Some of the features of the screen are available only when using a USB stick.

Be careful, the USB stick will be formatted when connecting to the HMI USB port. All previous information will be erased.

6.1 HMI

6.1.1 Main screen

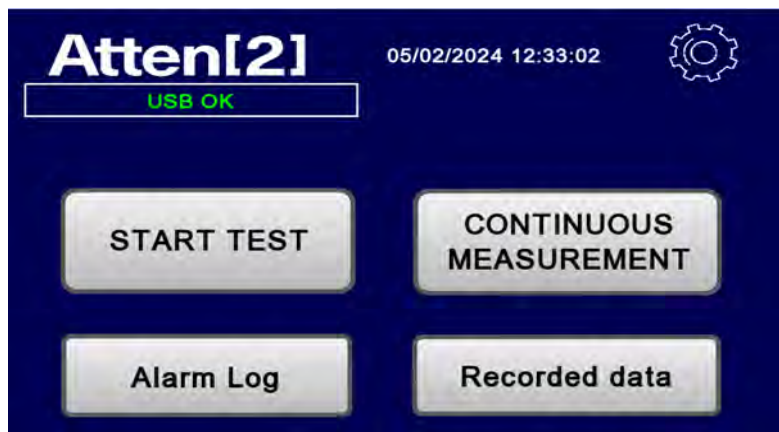


Figure 6. Main HMI screen.

The following options are available.

- Configurations: access to the configurations screen.
- Start test: This allows the customer to introduce test information and run a test.
- Continuous measurement: starts a test without storing data.
- Alarm log: Access to daily alarm log stored in the USB memory.
- Recorded data: access to previously recorded data in USB memory.

The screen will block measurements for 120 seconds after booting, while the message “sensor starting process” is flashing.

6.1.2 Password and configuration screen

Alarms configurations are password protected. The default user password is “1234”. After the password

window, the configuration screen is shown.

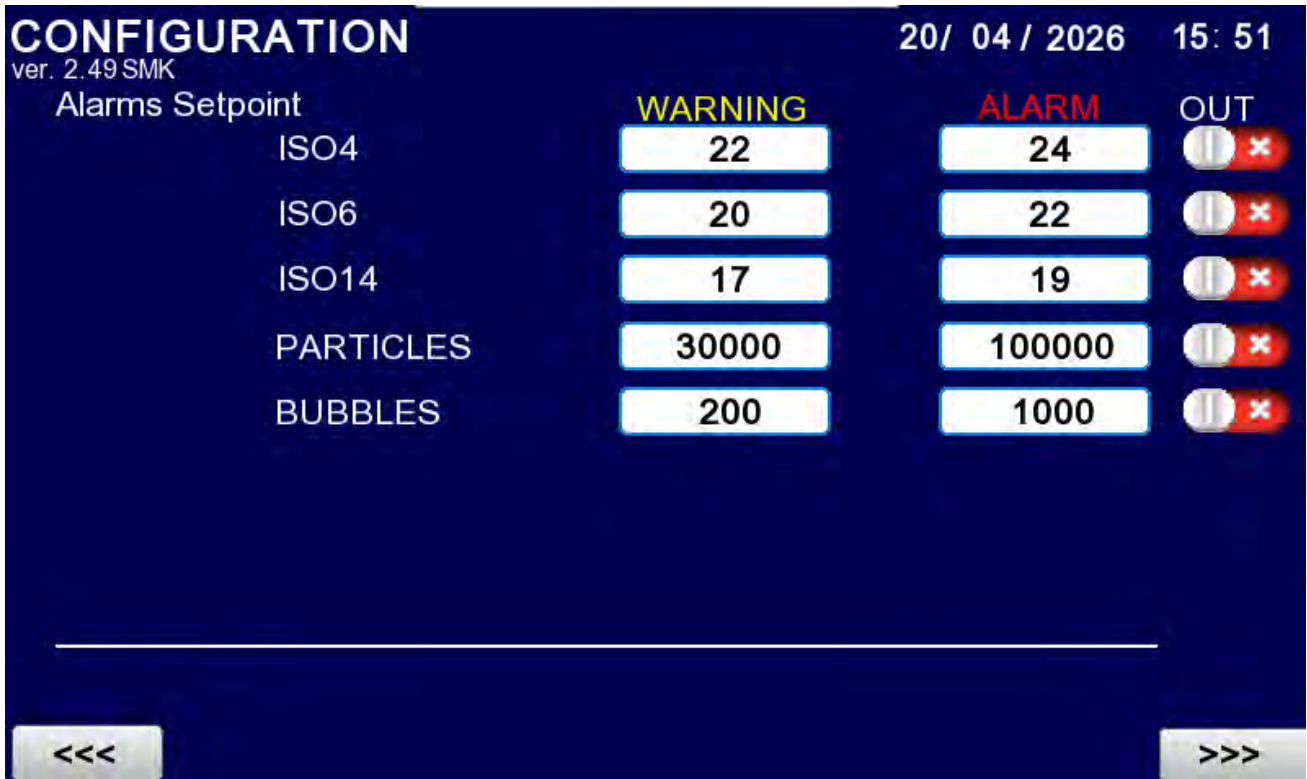


Figure 7. Alarm setting screen.

The following features are available:

- Date and time adjust, clicking on the appropriate value.
- Warning and alarm setting
 - A warning will be displayed in yellow color and will be logged in the alarm log.
 - The alarm will be displayed in red color, will close the relay (if the tick is active) and will be logged in the alarm log.
- Change password: This allows to change the user password. The default password is 1234.

A second configuration screen is available:

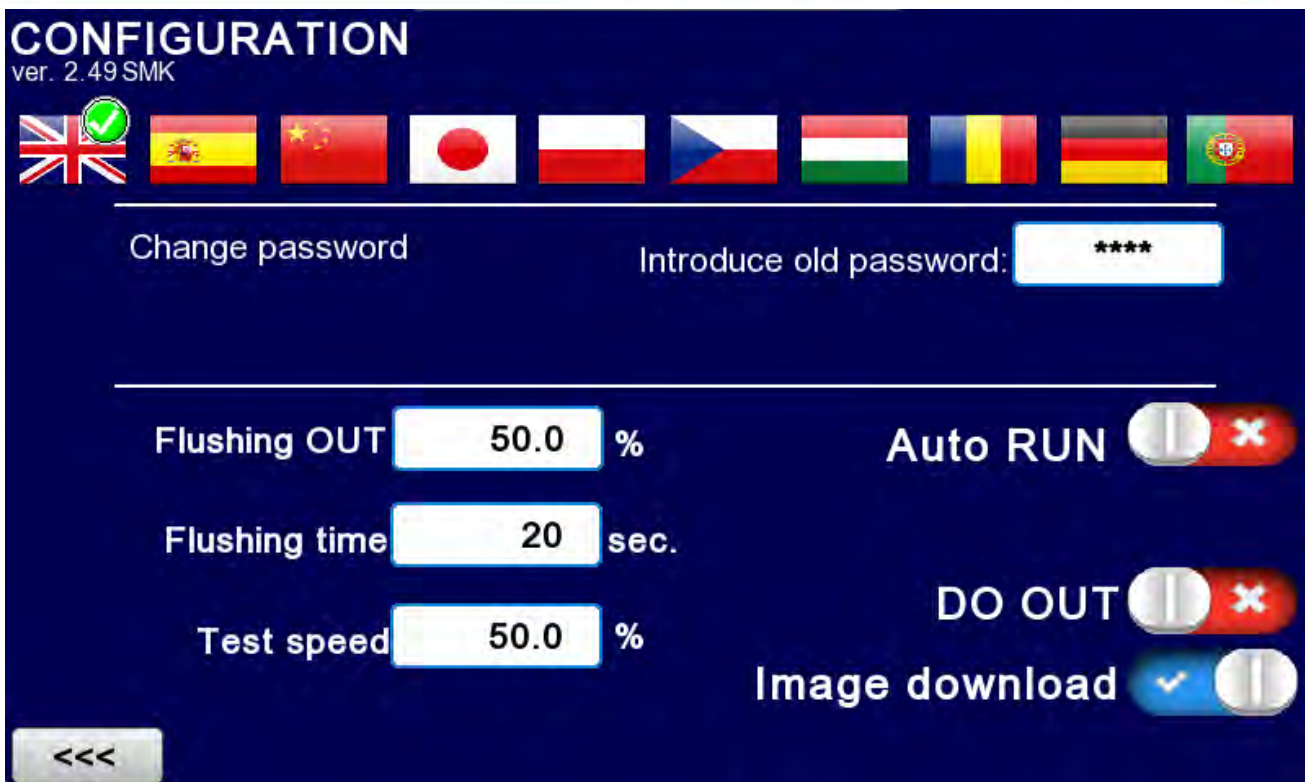


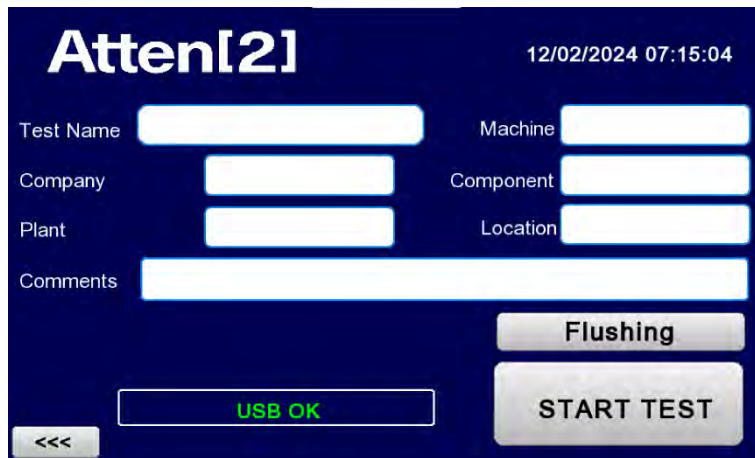
Figure 8. Configuration screen.

The following features are available:

- Auto-run feature: This feature allows the system to automatically start measuring after powering up. Data will be stored under Log Data general name.
- DO Out: Digital output manual switch, for integrating purposes.
- Pump parameters: These parameters allow the configuration of flushing main parameters and also default pump speed.
- Language selection: By selecting the appropriate flag, the HMI will be translated into language. English, Spanish, Chinese, Japanese, Polish, Czech, Hungarian and Romanian are available.
- Image download: This tick will enable the image USB storage process.

6.1.3 Start test screen

Once the start test button is pressed, the following screen will appear.



The image shows a dark blue screen titled "Atten[2]" with a timestamp "12/02/2024 07:15:04" in the top right. The screen contains several input fields: "Test Name", "Machine", "Company", "Component", "Plant", and "Location". Below these is a larger "Comments" field. At the bottom, there is a "Flushing" button, a "START TEST" button, and a "USB OK" button with green text. A back arrow button is located in the bottom left corner.

Figure 9. Start test screen.

Test names need to be filled in to start the test. If the USB is extracted during this screen, the following message will appear.



Figure 10. USB warning message.

Test name will be unique, this means that subsequent tests with the same name will be saved in the same file as the first one.

6.1.4 Data screen

The last result will be shown on the data screen. This screen is accessed after the start test screen or the continuous measurement button.

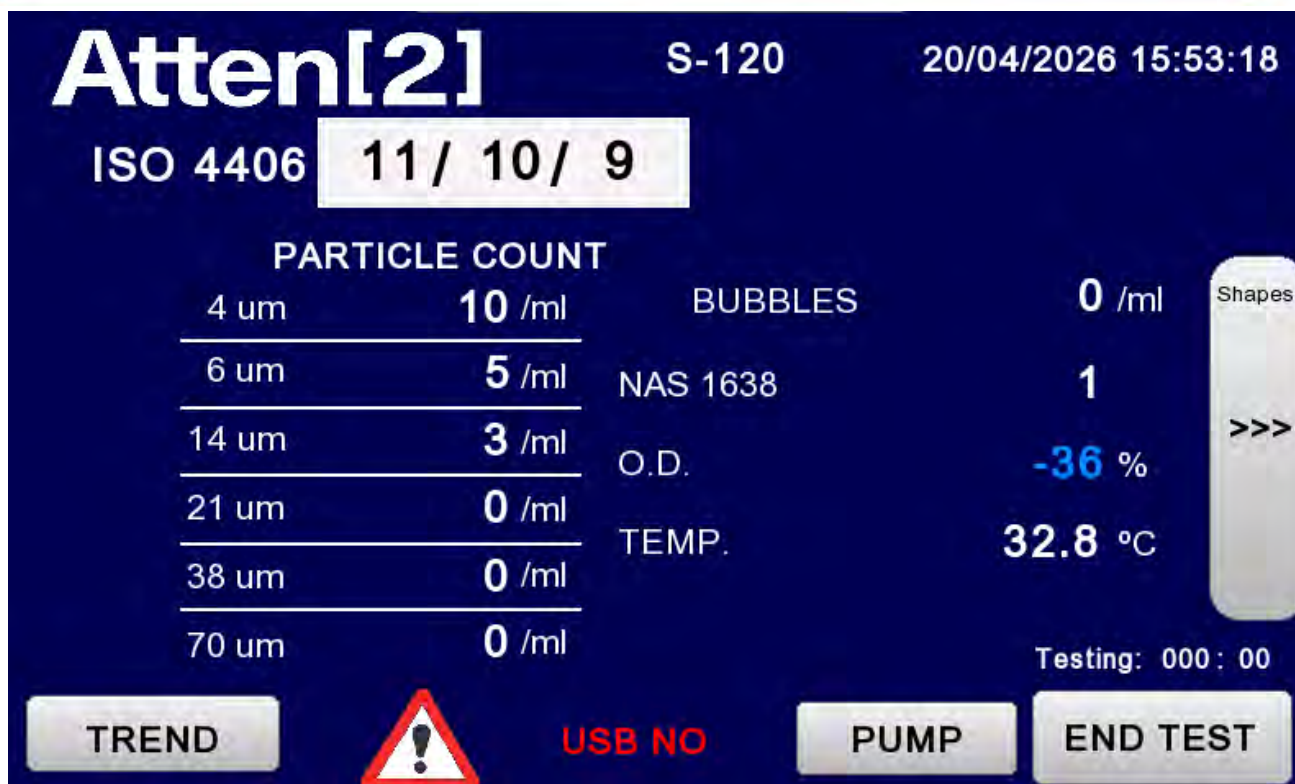


Figure 11. Data screen.

The following buttons are available depending on the unit:

- Trend: It will lead to the trend screen.
- On the right side, access to shape data is available using the right button.



Figure 52. Shape screen.

6.1.4.1 Trend screen

The following screen will show the trend values for the different sensor parameters.

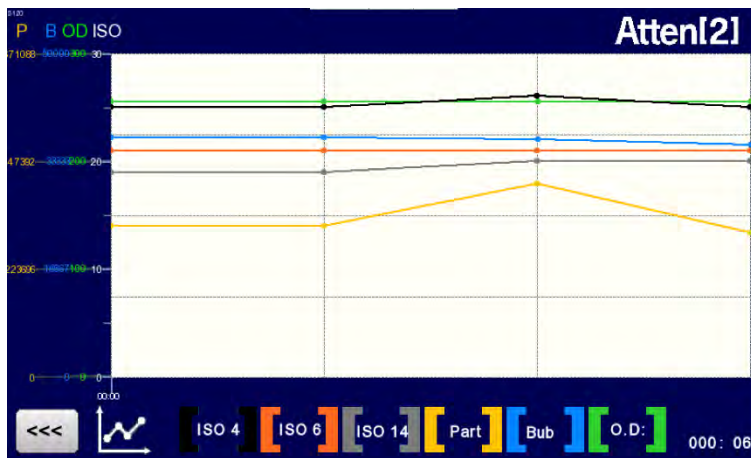


Figure 13. Trend screen.

The following features are available:

- Graph and Y-axis: Data will be depicted in the main graph, and Y-axis are adjustable using the bottom-left button. An automatic configuration for the total particle counts is available.



Figure 14. Y-axis limits on the trend screen.

- Trend selection: based on the bottom buttons, different trend lines can be selected or unselected.

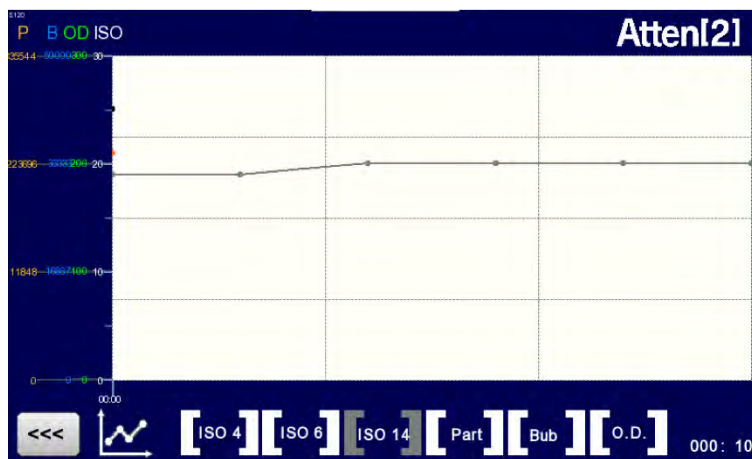


Figure 15. Unselected trends.

6.1.4.2 Alarm acknowledgement

Alarm information will pop-up on the screen after an alarm is currently activated or has been active in the past. It will show as a warning button on the bottom-left.

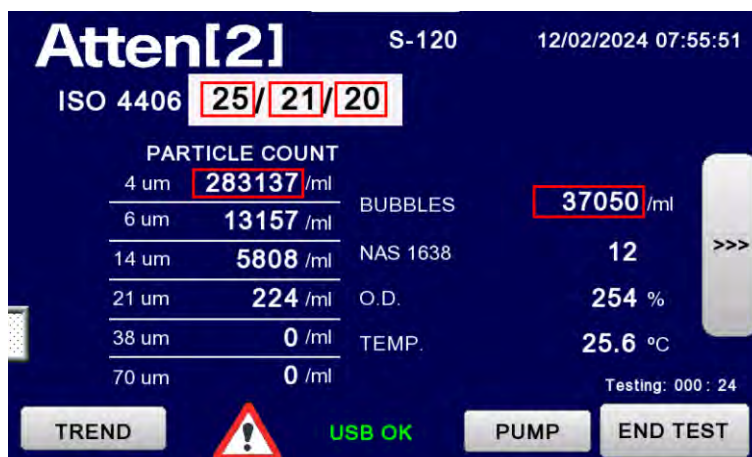


Figure 16. Alarm button on data screen.

Pressing the button will lead to show active alarms (in red) and pressing the “ACK” button will acknowledge them (yellow) and set the status back to OK. New alarms will pop-up the warning sign again.



Figure 17. Alarm acknowledgement process.

6.1.5 Alarm log

A daily record of the alarms is available. After pressing the button, an alarm list will show together with the timestamp and status.



Figure 18. Alarm log.

6.1.6 Recorded data

In the main screen, access to the recorded data is provided.

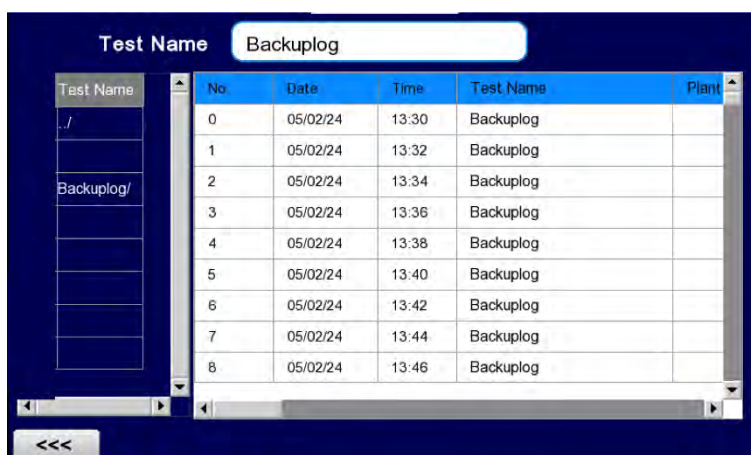


Figure 19. Recorded data screen.

On the left side, the list of tests stored is shown. When the test name is introduced in the upper text bar, data from this test is shown in the table below.

6.2 USB data extraction

USB is used as a data storage system. Data is stored in specific folders:

- Test CSV files are stored in the path /export/Data, each filename includes a timestamp and the test name.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Date	Time	Test Name	Plant	Component	Company	Machine	Location	Comments	ISO 4	ISO 6	ISO 14	Total Particles	Total Bubbles	Temperature	Flow
2	18/05/2021	16:53	prueba1							10.0	6.0	8.0	5	4000 0.0		195
3	18/05/2021	16:55	prueba1							10.0	6.0	8.0	5	4000 0.0		195
4	18/05/2021	16:57	prueba1							10.0	6.0	8.0	5	4000 0.0		195
5	18/05/2021	16:59	prueba1							10.0	6.0	8.0	5	4000 0.0		195
6	18/05/2021	17:01	prueba1							10.0	6.0	8.0	5	4000 0.0		195
7	18/05/2021	17:03	prueba1							10.0	6.0	8.0	5	4000 0.0		195
8	18/05/2021	17:05	prueba1							10.0	6.0	8.0	5	4000 0.0		195
9	18/05/2021	17:07	prueba1							10.0	6.0	8.0	5	4000 0.0		195
10	18/05/2021	17:09	prueba1							10.0	6.0	8.0	5	4000 0.0		195
11	18/05/2021	17:11	prueba1							10.0	6.0	8.0	5	4000 0.0		195
12	18/05/2021	17:13	prueba1							10.0	6.0	8.0	5	4000 0.0		195
13	18/05/2021	17:15	prueba1							10.0	6.0	8.0	5	4000 0.0		195
14	18/05/2021	17:17	prueba1							10.0	6.0	8.0	5	4000 0.0		195

Figure 20. CSV file example.

- Event logs are stored in /event/Event, each file contains daily alarms.

	A	B	C
1	TIME	ACT	CONTENT
2	12:13:24	0	Alarm ISO 4
3	12:13:24	0	Alarm ISO 6
4	12:13:24	0	Alarm ISO 14
5	12:15:00	0	Alarm Particles
6	12:15:00	0	Alarm Bubbles
7	12:18:00	2	Alarm Particles
8	12:18:00	2	Alarm Bubbles
9	12:20:01	0	Alarm Particles

Figure 21. Event log example.

Please do not modify the USB data structure. Any additional modification in the file structure will lead to format the USB in the next HMI connection, and data deleting.

6.2.1 Image downloading

In this version, possibility to store images in the USB has been implemented. Please note that this procedure is allowed every 4 minutes and that is limited to FMS-MK1000 stand-alone performance. Another SW cannot be capturing images at the same time.



Figure 22. Image download activation button.

Once this is done, images will be stored locally in the USB main folder.

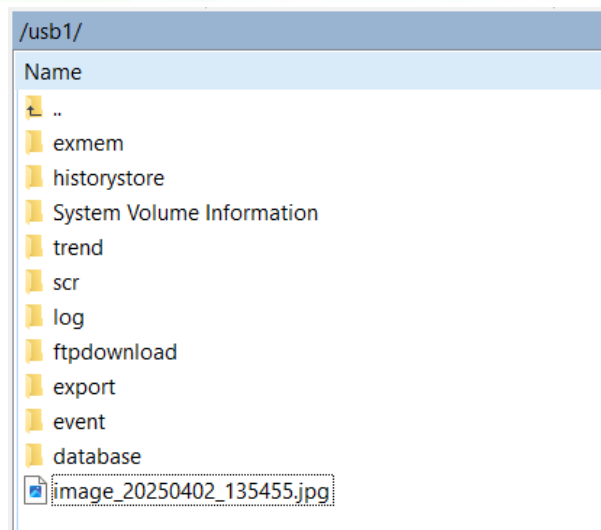


Figure 23. USB information with images.

6.3 Remote communications

6.3.1 Modbus map

6.3.1.1 Introduction

Modbus is a communications protocol located at levels 1, 2 and 7 of the OSI Model, based on the master/slave (RTU) or client/server (TCP/IP) architecture, designed in 1979 by Modicon for its range of programmable logic controllers (PLCs). Having become a de facto industry standard communications protocol, it is the most widely available for the connection of industrial electronic devices.

Modbus allows the control of a network of devices and communicates the results to a computer. Modbus is also used for the connection of a supervisory computer with a remote unit (RTU) in supervisory systems data acquisition (SCADA). There are versions of the Modbus protocol for serial port and Ethernet (Modbus/TCP). Information from this section has been obtained from the Modbus organization reference documentation.

Each device in the Modbus network has a unique address. Any device can send Modbus commands, although usually only one master device is allowed. Each Modbus command contains the address of the device to which the command is sent. All devices receive the frame, but only the recipient executes it. Each of the messages includes redundant information that ensures its integrity at reception. The basic Modbus commands allow an RTU device to be controlled to modify the value of one of its registers or to request the contents of those registers.

Modbus is based on an approach of coils, registers and functions. The Modbus data model distinguishes between digital inputs (discrete input), digital outputs (coils), input registers, and holding registers. The digital inputs and outputs occupy one bit, while the registers, both input and holding, occupy two bytes. MODBUS uses a 'big-Endian' representation for addresses and data items. This means that when a numerical quantity larger than a single byte is transmitted, the most significant byte is sent first.

Primary tables	Object type	Type of	Comments
Discretes Input	Single bit	Read-Only	This type of data can be provided by an I/O system.
Coils	Single bit	Read-Write	This type of data can be alterable by an application program.
Input Registers	16-bit word	Read-Only	This type of data can be provided by an I/O system
Holding Registers	16-bit word	Read-Write	This type of data can be alterable by an application program.

Figure 29. Types of data registers in the Modbus protocol.

Each device defines its coils and registers in its physical memory where information is stored, and the master sends or extracts this information. To extract the information, the master requires to send information regarding the function and the value.

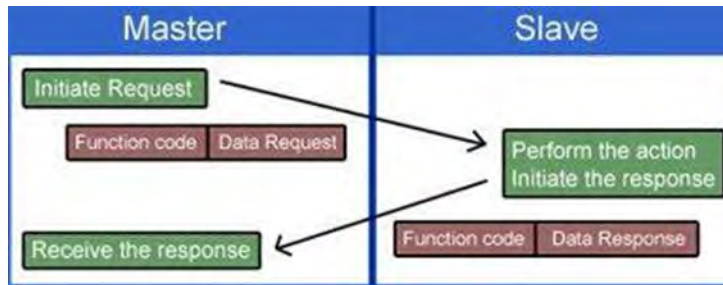


Figure 30. Modbus communication schema.

6.3.1.2 Modbus address definition

Depending on the communication protocol selected, Modbus address information is different.

Type	Modbus TCP/IP
Interface	Ethernet
Address	192.168.1.5
Port	502
Slave ID	10

6.3.1.3 Results data registers

In the next table the FMS-MK1000 Modbus map can be found.



Parameter		Unit	SMK - INPUT	
			Data type	Modbus register address
SMK Information	SMK Status	-	short	/*10*/
	Flow rate	ml/min	float	/*134- 135*/
	Test time	hours	short	/*50*/
	Test time	minutes	short	/*52*/
	Pump speed*	%	short	/*55*/
ISO 4406 Code	>4 microns	-	float	/*100 - 101*/
	>6 microns	-		/*102 - 103*/
	>14 microns	-		/*104 - 105*/
	>21 microns	-		/*106 - 107*/
	>38 microns	-		/*108 - 109*/
	>70 microns	-		/*110 - 111*/
Particle count	>4 microns	p/ml	int	/*112 - 113*/
	>6 microns	p/ml	int	/*114 - 115*/
	>14 microns	p/ml	int	/*116 - 117*/
	>21 microns	p/ml	int	/*118 - 119*/
	>38 microns	p/ml	int	/*120 - 121*/
	>70 microns	p/ml	int	/*122- 123*/
Bubble count	>4 microns	b/ml	int	/*124- 125*/
OD	-	%	sshort	/* 136 */
Shapes	Cutting	p/ml	short	/*126*/
	Sliding	p/ml	short	/*129*/
	Fatigue	p/ml	short	/*127*/
	Fiber	p/ml	short	/*128*/
	Unknown	p/ml	short	/*130*/
Temperature	[°C]	°C	float	/*131 - 132*/
NAS 1638 (per 100 ml)	-	-	short	/*133*/

Figure 31. FMS-MK1000 summarized Modbus map.

- Status: The following options are available: 0-SMK stopped, 1-No storing test, 2- Storing test, 3-Test ended (stopped).

The Modbus map of FMS-MK1000 contains different features that are not explained in this document. Please contact Atten2 for additional information.

6.3.1.4 Modbus integration

A successful Modbus integration in an acquisition system requires that several topics are considered:

- Register Addresses and Functions: Modbus data is obtained through a combination of functions and registers. Some Modbus acquisition systems require the introduction of both function and register in the same area. For example, reading a Modbus INPUT register “1001”, requires introducing “41001”, that is the combination of function 4 “READ INPUT REGISTERS” plus the register 1001.

				Function Codes		Section		
				code	Sub code		(hex)	
Data Access	Bit access	Physical Discrete Inputs	Read Discrete Inputs	02		02	6.2	
		Internal Bits	Read Coils	01		01	6.1	
		Or	Write Single Coil	05		05	6.5	
		Physical coils	Write Multiple Coils	15		0F	6.11	
	16 bits access	Physical Input Registers	Read Input Register	04		04	6.4	
		Internal Registers	Read Holding Registers	03		03	6.3	
			Write Single Register	06		06	6.6	
		Or	Write Multiple Registers	16		10	6.12	
			Physical Output Registers	Read/Write Multiple Registers	23		17	6.17
			Mask Write Register	22		16	6.16	
			Read FIFO queue	24		18	6.18	
		File record access	Read File record	20		14	6.14	
	Write File record		21		15	6.15		

Figure 32. Table of public functions in Modbus.

- Modbus offset: In the Modbus/TCP protocols, the addresses are encoded using 16 bits with a number between 0 and 65,535. These are 0-based addresses. Therefore, the Modbus protocol address is equal to the Holding Register Offset minus one. Some acquisition devices have predefined offset, but others do not. So, it is essential to check that the address is pointing to the correct register.
- Confusion about Little-Endian vs Big-Endian Word Order: Although Modbus.org standard documents

provide some guidance for implementing the Modbus protocol, they do not address the question of word order beyond the register level. Modbus implementers must make an arbitrary choice as to which address of the register pair contains the most significant word of 32-bit values such as IEEE-754 single-precision floats and signed or unsigned 32-bit integers. Most programs for communicating with Modbus slaves can be configured for either register word order, but the most common default word order today is Little-Endian.

- Register sectioning: Some of the data contained in the sensor Modbus map encapsulates two different data values in the same register, one in each byte. The acquisition system should be able to section this data and interpret this data separately.
- Data type interpretation: Different programming languages offer different names for the variable types available. Once collected, registers must be interpreted correctly. The following table defines the variables as proposed by the sensor interface, with expected ranges.

Variable type	Bytes	Range	Definition
INT	4	0-42949697295	Unsigned 32-bits integer
FLOAT	4	$\pm 1,5 \times 10^{-45}$ - $\pm 3,4 \times 10^{38}$	Floating number
SHORT	2	0-65535	Unsigned 16-bits integer
SSHORT	2	-32767 - +32767	Signed 16-bits integer
CHAR	1	0-255	Unsigned 8-bits integer

Figure 33. Variables definition and range.

6.3.2 Relay output

The unit has a relay output based on the alarms provided by the HMI. The relay is configured as normally opened, so every time an alarm is reached the contact will automatically close, permitting the activation of additional circuits. The electrical parameters for the relay are shown below.

Item	Value
Relay type	SPDT
Contact type	Normally opened
Max voltage	250Vac
Max current	5A

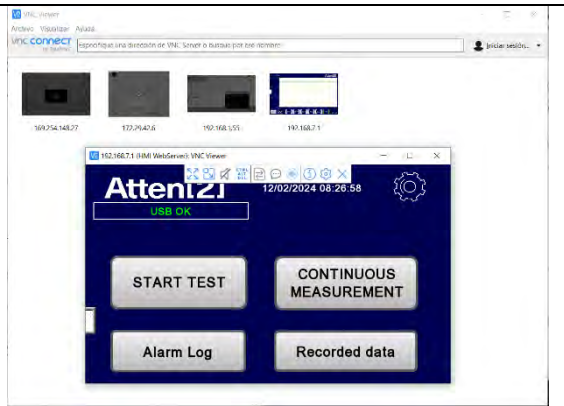
Figure 34. Relay connection parameters.

6.3.2.1 VNC connection

Virtual Network Computing (VNC) is a graphical desktop sharing system that uses the Remote Frame Buffer protocol (RFB) to remotely control another computer. To use it, the HMI screen and VNC host should be in the same network. VNC Host such as Unviewed can be used.

The connection parameters are the following:

Password: 1234 (only monitoring)
For full permission, please contact Atten2.

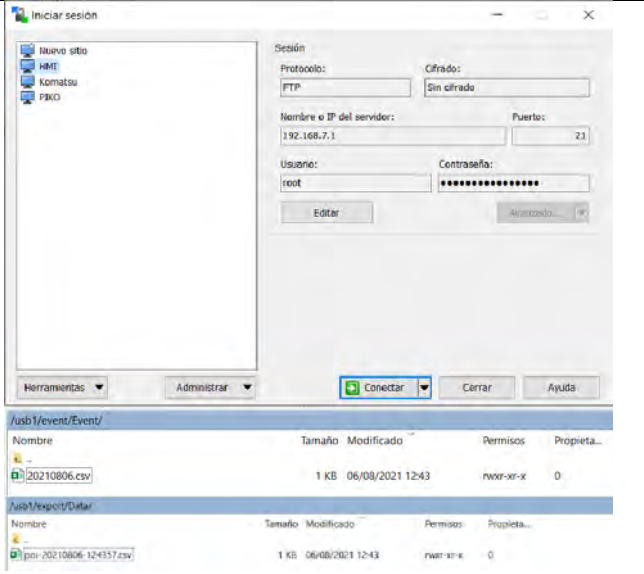


6.3.3 FTP server

HMI can be accessed as an FTP server, with access to internal memory and USB external memory.

The connection parameters are the following:

User: root
Password: please contact Atten2.



7 MAINTENANCE

Since this unit is designed to take measurements with different fluids, it is recommended that you perform a cleaning procedure periodically to improve the response and durability of the FMS-MK1000. Follow this procedure carefully.

1. Disconnect the unit from the power supply.
2. Next, disconnect the hydraulic hoses connected to the FMS-MK1000. Note that doing so may cause some of the remaining oil in the hoses to spill. It is strongly recommended to have a drain pan or other means of containment ready for the cleaning procedure.
3. Next, flush the system with petroleum ether or heptane. Continue this process until the fluid coming out looks the same as new fluid. Note that solvents are volatile substances; consult the material's safety data sheet before use.
4. After flushing the fluid, allow the system to dry. Ensure that the compressed air supply line is filtered and free of moisture.
5. Finally, reconnect the fittings to the system. The unit is now ready for the next measurement.

8 TROUBLESHOOTING

Issue	Solution
HMI doesn't power up when connecting the cable	Please check on-off switch. Please check the power supply, please check cable integrity. Please ensure voltage and current are correct.
The screen is not allowing to press Start Test or Continuous Measurement button	Please wait for 120 seconds for the system to start. Please restart the screen. The internal elements have been disconnected, please make sure all the units are working properly,
A message "PLC no response" is showing on the screen	The internal elements have been disconnected, please make sure all the units are working properly,
Data is not consistent	Please ensure flow regulation at 0,2 l/min. Please check bubble content to ensure air entrainment. Bubble content should be limited to 200 b/ml for optimal performance.
Bubble alarms appear flashing	Bubble content is out of optimal specifications. Please check bubble content to ensure air entrainment. Bubble content should be limited to 200 b/ml for optimal performance.