User Guide Supplement – MODBUS RS485 Physical Layer COI/FEX100/MOD–EN

WaterMaster FEX100–MB
Electromagnetic flowmeter

The perfect fit for all water industry applications

Introduction

This publication contains information specific to the MODBUS®-enabled WaterMaster with RS485 physical layer (model FEX100-MB). It must be read in conjunction with the WaterMaster Programming Guide (IM/WMP) and WaterMaster Modbus Parameter Tables Supplement (COI/FEX100/MOD/TBL–EN).

The model name FEX100-MB is applicable to several variants of the WaterMaster flowmeter system (for example, FEV1xx, FEF1xx, FET1xx). Refer to data sheet DS/WM-EN for details of specific order codes.

WaterMaster FEX100-MB follows the specification for Modbus Over Serial Line V1.02, using 2-wire TIA/EIA-485 (RS485) physical layer.

The Company

We are an established world force in the design and manufacture of instrumentation for industrial process control, flow measurement, gas and liquid analysis and environmental applications.

As a part of ABB, a world leader in process automation technology, we offer customers application expertise, service and support worldwide.

We are committed to teamwork, high quality manufacturing, advanced technology and unrivalled service and support.

The quality, accuracy and performance of the Company's products result from over 100 years experience, combined with a continuous program of innovative design and development to incorporate the latest technology.

Quality Control

The UKAS Calibration Laboratory No. 0255 is just one of the ten flow calibration plants operated by the Company and is indicative of our dedication to quality and accuracy.

UKAS Calibration Laboratory No. 0255

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1 MODBUS

1.1 MODBUS Protocol

MODBUS protocol is a messaging structure used to establish master-slave / client-server communication between intelligent devices. MODBUS is an open standard that is owned and administered by an independent group of device manufacturers called the Modbus Organization (www.modbus.org).

Using the MODBUS protocol, devices from different manufacturers exchange information on the same communications bus without the need for special interface equipment.

1.2 MODBUS and ABB Products

ABB instrumentation devices, such as WaterMaster, are often available in variants that support the MODBUS RTU protocol and are capable of being integrated into such installations.

For more details, see www.abb.com/fieldbus and follow the MODBUS link.

1.3 Acronyms and Abbreviations

aka	Also known as.
Device	A master or slave connected to the MODBUS network.
EDD	Electronic Device Description (used by masters for easy integration of device parameters into the system).
Ip / Input	In the context of MODBUS, this refers to data passed into a master device (for example, from a slave device). In the context of other flowmeter functionality, this refers to signals being received by the transmitter.
Master	A device that polls one or more slave devices and always initiates communication.
n/a	Not applicable
OIML	International Organization of Legal Metrology.
Op / Output	In the context of MODBUS, this refers to data passed out of a master device (for example, to a slave device). In the context of other flowmeter functionality, this refers to signals being driven from the transmitter.
Q	Flowrate
RS485	TIA/EIA-485 standard.
RTU	Remote Terminal Unit. Refers to the binary form of MODBUS protocol over serial line.
Rx	Receive or Receiver
Slave	A device that responds to requests from a master and never initiates communication.
Tx	Transmit or transmitter

1.4 MODBUS Interface

Physical layer	TIA/EIA-485 (RS485), 2-wire
Supported baud rates	9.6kbps to 115.2kbps
Supported protocol	RTU
Device stub length	250 mm (9.8 in.)
System integration support	Parameter Tables supplement document, EDD

2 Installation

2.1 Installation Overview

An RS485-MODBUS configuration without repeater has one trunk cable or 'bus', along which devices are either daisy-chained directly or via short 'tap' cables / spurs, as shown in Fig. 2.1. The use of repeaters between several RS485-MODBUS bus lines is also possible.

Up to 32 stations (master or slaves) can be linked to one bus line, although in special circumstances, some installations may permit more than this. The use of bus amplifiers (repeaters) can be used to extend the network further.

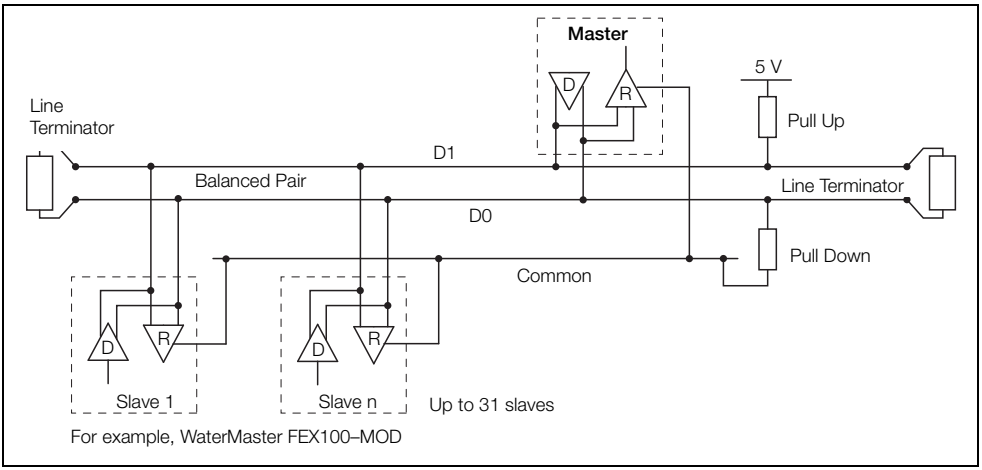


Fig. 2.1 Typical MODBUS RS485 2-Wire Network Installation

The WaterMaster FEX100-MB flowmeter has dual wiring terminals for RS485 connections. These provide a means of connecting the "in" and "out" bus cables for daisy-chaining directly onto the bus or else the WaterMaster can be connected via a tap cable using just one pair of these terminals.

2.2 Cable Properties

The end-to-end length of the trunk cable must be limited. The maximum length depends on the Baud rate, the cable (gauge, capacitance or characteristic impedance), the number of loads on the daisy chain and the network configuration (2-wire or 4-wire).

For 9600 Baud rate and AWG26 (or wider) gauge, the maximum length is 1000 m (3280 ft.). Where 4-wire cabling is used as a 2-wire cabling system the maximum length must be divided by 2.

The tap cables must be short, never more than 20 m (65.6 ft.). If a multi-port tap is used with n derivations, each one must have a maximum length of 40 m (131 ft.) divided by n.

The maximum serial data transmission line length for RS485 systems is 1200 m (3937 ft.). The lengths of cable that can be used are determined by the cable type, typically:

- Up to 6 m (19.7 ft.) – standard screened or twisted pair cable.
- Up to 300 m (984 ft.) – twin twisted pair with overall foil screen and an integral drain wire – for example, Belden 9502 or equivalent.
- Up to 1200 m (3937 ft.) – twin twisted pair with separate foil screens and integral drain wires – for example, Belden 9729 or equivalent.

Category 5 cables may be used for RS485-MODBUS to a maximum length of 600 m (1968 ft.).

For the balanced pairs used in an RS485-system, a characteristic impedance with value higher than 100Ω is preferred especially for 19200 and higher Baud rates.

2.3 Line Termination

RS485 specifications recommend terminating the end of the bus at both ends in order to reduce interference caused by signal reflections that can cause communications errors.

A Line Terminator is required at both ends of the bus as the communications waveform propagates bi-directionally along the bus. These must be connected directly on the main trunk, not on any tap cable. Note that, extra terminators must not be connected to the bus.

Each line termination must be connected between the two conductors of the balanced line: D0 and D1, as shown in Fig. 2.1.

Line termination may be a 150Ω value (0.5W) resistor, although a serial capacitor (1 nF, 10V minimum) with a 120Ω (0.25W) resistor is a better choice when a polarization of the pair must be implemented.

2.4 Line Polarization

When there is no data activity on an RS485 balanced pair, the lines are not driven and are thus susceptible to external noise or interference. To ensure that its receiver stays in a constant state when no data signal is present, the signal lines need to be biased from a single point on the bus (for example, at or close to the Master).

A pair of resistors (values between 450Ω and 650Ω) must be connected on the RS485 balanced pair to bias the signals, as shown in Fig. 2.1:

- a Pull-Up Resistor to a 5V Voltage on D1 circuit
- a Pull-Down Resistor to the common circuit on D0 circuit.

WaterMaster FEX100-MB requires that such biasing is provided externally on the bus.

3 Configuration

Warning.

When connecting a WaterMaster FEX100-MB series electromagnetic flowmeter to a MODBUS RS485 network:

- Use cable that meets specifications for reliable RS485 communications.
- Ensure that RS485 signals are not reversed.
- Ensure that a line terminator is fitted each end of the RS485 bus segment.
- Ensure all data lines are routed clear of the source of any strong electrical and magnetic fields.
- Refer to the relevant User Guide for all other installation and connection details.

3.1 Network Connections

MODBUS network connections are made to the terminal blocks on the WaterMaster FEX100-MB backplane PCB located below the cartridge assembly (refer to Fig. 3.1). Remove the cartridge assembly to get at these terminals and put the cartridge back in place before powering up the instrument.

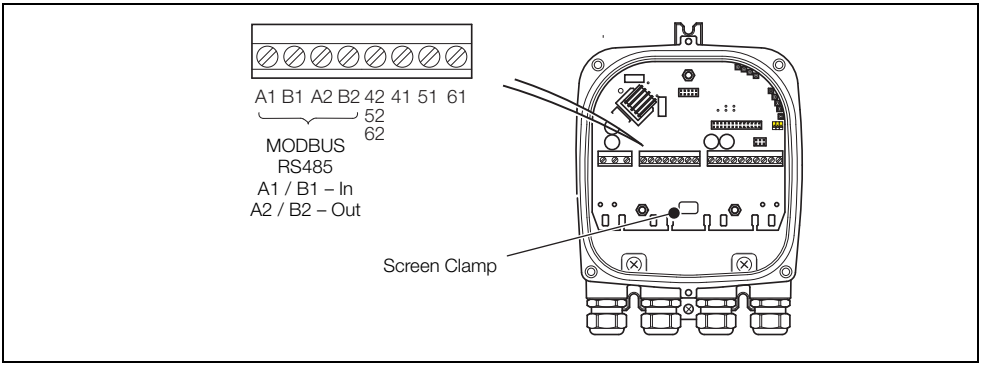


Fig. 3.1 WaterMaster FEX100-MB RS485 Backplane Wiring Terminal Connections to MODBUS Network

FEX100-MB Backplane PCB Terminal Ident	RS485 Signal Names	
A1	A (aka D0, TxD- / RxD-)	cable in, towards master
B1	B (aka D1, TxD+ / RxD+)	
A2	A (aka D0, TxD- / RxD-)	cable out, away from master
B2	B (aka D1, TxD+ / RxD+)	
Comms Screen	C (aka SC, G, Reference)	screen clamp for both inward and outward RS485 cables.

Table 3.1 WaterMaster FEX100-MB RS485 Backplane Wiring Terminal Connections to MODBUS Network

Warning. Refer to the WaterMaster User Guide before making any electrical connections.

3.2 Setting MODBUS Slave Address

The MODBUS Slave Address for a WaterMaster FEX100–MB instrument can be set remotely from a master by changing the corresponding parameter with a MODBUS command or it can be set locally via its keypad and display menu system as shown by the following sequence.

Where the MODBUS Master sets the Slave Address for the instrument, this value is stored and used in preference to any existing Slave Address value that the instrument previously had.

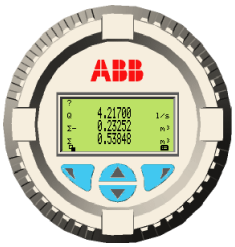
Note that whenever the MODBUS Slave Address is set, the device begins using the new address setting straight away.

Starting from the Operator page normally showing on the WaterMaster FEX100-MB display, the Slave Address can be changed via the local display menu system as follows:

1 Depending on the display configuration, the Operator page will show one or more of the flowmeter measurement values. Press the ◢ to enter the menu system.

The *Access Level* page will show.

Note. Press the ◥ move backwards out of the menu system on any page, except when editing a value where the right arrow must be pressed to OK acceptance of the value.



2 Use the ▲ and ▼ to select the *Advanced* access level.

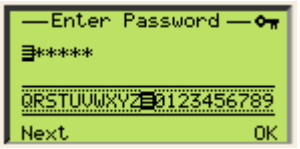
Press the ◢ to select entry to this access level.

3 Select the password characters using the ▲ and ▼ to scroll though the alpha-numeric list.

Press the ◥ to move the cursor to the next space.

Press the ◢ to OK acceptance of the entered password and attempt login.

Note. The menu system returns to the Operator page if an invalid password is entered. Unless changed by the user, the default Advanced password is blank.



4 Use the ▲ and ▼ to show the various menu pages until the *Communication* menu page appears.

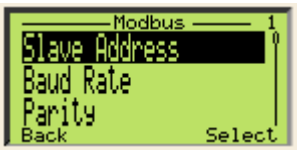
Press the ◢ to select entry to this menu.

5 Use the ▲ and ▼ to select the *Modbus* option.

Press the ◢ to select entry to the *Modbus* menu page.

6 The *Slave Address* option should show as selected on the *Modbus* menu page.

Press the ◢ to select this option. (Use the ▲ and ▼ to scroll through options if *Slave Address* is not selected.)



7 The current *Slave Address* setting will show.

Press the ◢ to edit this value if required else press the ◥ to exit from the *Slave Address* setting page without changing the current value.

8 Increment or decrement a digit by using ▲ and ▼.

Use the ◥ to move the cursor to the next digit. Press the ◢ to OK acceptance of the value and exit the edit page.

3.3 Configuration using Local Display

The WaterMaster FEX100-MB local display menu system contains options for configuring certain MODBUS related parameters, located under the *Modbus* option of the Communication menu page:

All items under the 'Modbus' menu are readable at all access levels. Write access to certain writable items is only possible at 'Advanced' access level or higher.

Refer to section 3.2, page 7, Setting MODBUS slave address and also the WaterMaster User Guide for more details on accessing menu pages on the local display.

Menu Item	Description
Slave Address	Setting MODBUS Slave Address value.
Baud Rate	Bit rate for MODBUS RS485 communications.
Parity	Parity setting: none, even, odd.
Comms Mode	Enables or disables MODBUS RS485 communications.
Stop Bits	Number of stop bits: 1, 2.
Word Swap	Order that words are transmitted for multi-word data types (applies to 32bit and 64bit data types such as single and double precision floating point values). **Note.** Set to 'Disabled' if using with the WaterMaster's MODBUS EDD component.

Table 3.2 Modbus menu page options

3.4 Configuration using an EDD

Configuration of WaterMaster FEX100–MB instrument parameters and monitoring of measurement values is possible with an EDD interpreter application using the WaterMaster FEX100–MB EDD file.

The EDD should be included in the device catalogues of Modbus Master systems that support EDD technology. Refer to Modbus Master manufacturer for details.

4 Error and Warning Handling

The WaterMaster FEX100-MB flowmeters maintain sets of alarms for indicating error and warning conditions. These values are readable as MODBUS Coils and provide access to the same alarm information as found from the local HMI.

An alarm can be the result of a real operating condition, or from a simulated condition, or by setting a single alarm directly through alarm simulation, as shown in Fig. 4.1.

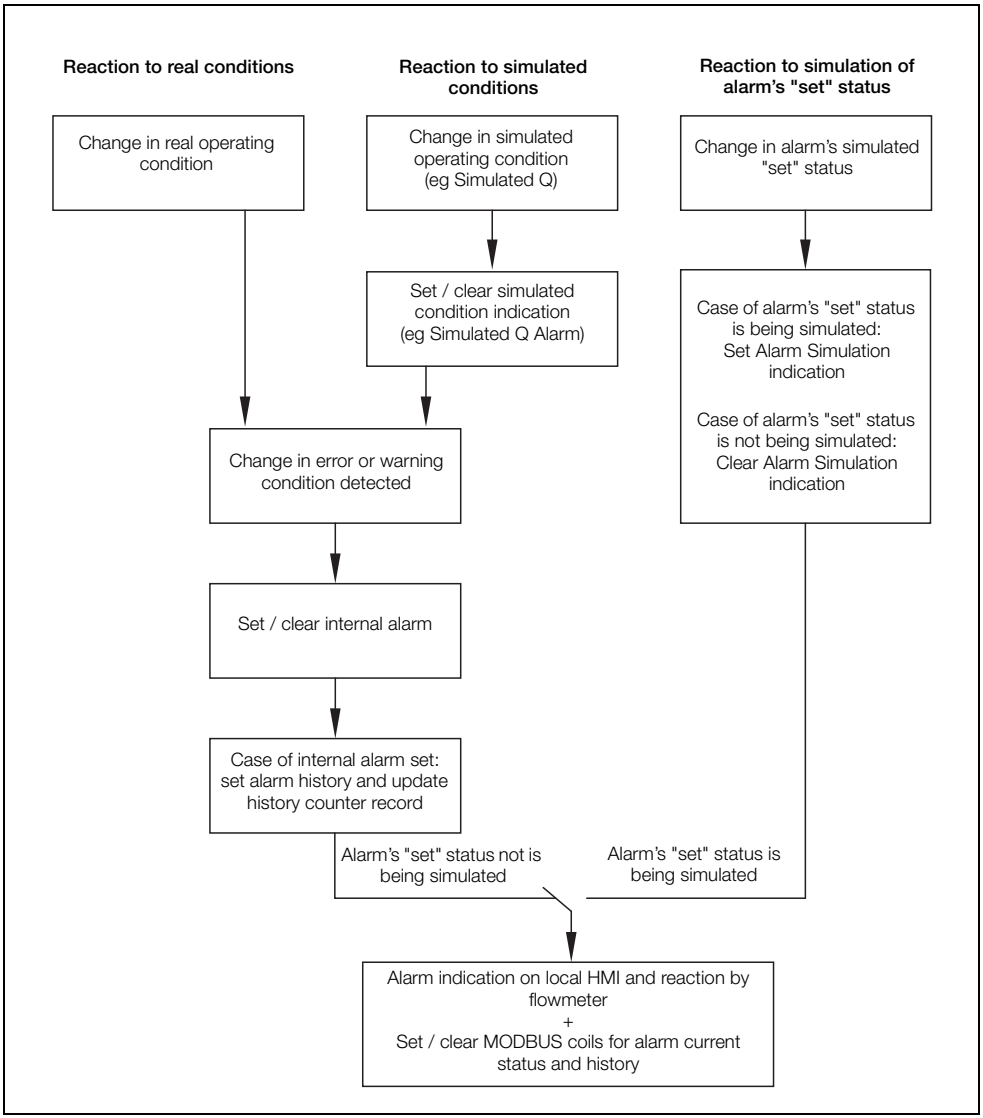


Fig. 4.1 WaterMaster Error and Warning Activities

There are three types of parameter related to each alarm indication and associated information:

Alarm Information	Description
Alarm	Indication that is set automatically by the WaterMaster in response to present operating conditions. Cleared automatically by the WaterMaster when the alarm condition ends.
Alarm History	Indication that is set whenever the corresponding alarm is set and persists until the alarm history is cleared.
Alarm History Counter	Record of the number of triggers for each alarm plus timestamp and duration of its last activation. Persists until the alarm history is cleared.

Table 4.1 Alarm Information Descriptions

All alarm histories and their corresponding history counter records are cleared simultaneously using the 'Clear Alarm History' parameter (via either local HMI or via MODBUS command).

The following table details the alarm definitions using NAMUR NE107 classification codes.

Refer to the Troubleshooting section of the WaterMaster Programming Guide (document IM/WMP) for details on the possible cause for each alarm and any suggested corrective action.

Refer to the Modbus Paramater Tables supplement for the details required to access these values via MODBUS commands. Unused alarm bits will always return a value of 0 (indicating alarm condition not set).

The NAMUR alarm classification code is of the form Xppp.aaa, where:

X	Classification Code: M Maintenance Required Instrument operation is valid, but device could lose some capability due to an external condition and may require maintenance in the short-term / mid-term. S Out Of Specification Instrument is operating outside the specified measurement range. Diagnostics indicate a drift in the measurement, internal problems in the device, or the consequence of some process influence (for example, empty pipe). C Check Function Instrument is temporarily non-valid due to some type of maintenance activity. F Failure Instrument operation is non-valid due to a malfunction at the device level. _ No corresponding NAMUR classification.
ppp	Priority number: 001 to 050 None (low priority) 051 to 100 Maintenance required 101 to 150 Out of specification 151 to 200 Check function 201 to 254 Failure (high priority)
aaa	Alarm number: 000 to 099

Table 4.2 NAMUR alarm classification codes

Alarm Number	Description	NAMUR NE107 format alarm code
0	Unused	n/a
1	Logic Op1 Simulated	C168.001
2	Pulse Op1 Simulated	C174.002
3	Logic Op2 Simulated	C164.003
4	Pulse Op2 Simulated	C172.004
5	Logic Op3 Simulated	C160.005
6	Low Q	S132.006
7	High Q	S136.007
8	Q reached 103% of Qmax value	S140.008
9	Simulated Q (& velocity)	C182.009
10	Calibrator in use	C186.010
11	Display Overrange	M080.011
12	Totalizer Reset	_030.012
13	Poor Sensor Comms	M090.013
14	Unused	n/a
15	Tx Memory Fail	F250.015
16	No Sensor Detected	F252.016
17	Measurement Offline	F220.017
18	Empty Pipe	S150.018
19	Unused	n/a
20	Unused	n/a
21	Sensor Electrodes Open Circuit	S147.021
22	Sensor Electrodes Short Circuit	S146.022
23	Unused	n/a
24	Sensor Installation Fault	F247.024
25	Sensor Coil Open Circuit	F238.025
26	Sensor Coil Short Circuit	F236.026
27	Coil Loop Resistance	F234.027

Table 4.3 NAMUR NE107 format alarm code

Alarm Number	Description	NAMUR NE107 format alarm code
28	Tx Hardware	F232.028
29	Bad Flow Data	F230.029
30	Sensor Electrode Voltage Problem	S105.030
31	OIML Self Check	M098.031
32	Measurement Starting	S148.032
33	Unused	n/a
34	Sensor Not Calibrated	S110.034
35	Sensor / Tx Calibration Mode Mismatch	F248.035
36	ROM Error	F253.036
37	RAM Error	F254.037
38	Unused	n/a
39	Alarm Simulation	C190.039
40	Tx NV Memory Check Alarm	F248.040
41	Unused	n/a
42	Unused	n/a
43	Unused	n/a
44	Unused	n/a
45	Unused	n/a
46	Unused	n/a
47	Unused	n/a

Table 4.3 NAMUR NE107 format alarm code

Appendix A – FEX100-MB MODBUS Datasheet

Applicable standards	TIA/EIA-485 (RS485), 2-wire
Protocols supported	MODBUS® RTU (Modbus Over Serial Line V1.02)
Modbus device type	Slave
Communications media	TIA/EIA-485 (RS485), 2-wire, galvanically isolated
Bus connection	Wiring terminals A1/B1 (in) and A2/B2 (out)
Slave address range	1..247
Baud rates supported	9.6kbps 19.2kbps 38.4kbps 57.6kbps 115.2kbps
Communication parameter options	Start bits: 1 Data bits: 8 Stop bits: 1, 2 Parity: none, even, odd
Configuration	Local HMI (display and keys) MODBUS commands
Integration support	Parameter Tables supplement document EDD

Table A.1 FEX100-MB MODBUS datasheet

Appendix B – Declaration of MODBUS Conformance

ABB WaterMaster FEX100-MB series flowmeters have been approved by an independent authorised certification laboratory for use in MODBUS networks with a connection to TIA/EIA-485 (RS485) 2-wire physical layer.

Certification of MODBUS specification conformance covers the following areas:

- MODBUS RTU protocol conformance.
- Declared function codes are specified correctly.

A copy of the conformance certificate is available for download from the WaterMaster product pages of the ABB website www.abb.com.

Products and customer support

Automation Systems
For the following industries:
— Chemical & Pharmaceutical
— Food & Beverage
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— Drive Systems
— Force Measurement
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Controllers & Recorders
— Single and Multi-loop Controllers
— Circular Chart and Strip Chart Recorders
— Paperless Recorders
— Process Indicators

Flexible Automation
— Industrial Robots and Robot Systems

Flow Measurement
— Electromagnetic Flowmeters
— Mass Flowmeters
— Turbine Flowmeters
— Wedge Flow Elements

Marine Systems & Turbochargers
— Electrical Systems
— Marine Equipment
— Offshore Retrofit and Refurbishment

Process Analytics
— Process Gas Analysis
— Systems Integration

Transmitters
— Pressure
— Temperature
— Level
— Interface Modules

Valves, Actuators and Positioners
— Control Valves
— Actuators
— Positioners

Water, Gas & Industrial Analytics Instrumentation
— pH, Conductivity and Dissolved Oxygen Transmitters and Sensors
— Ammonia, Nitrate, Phosphate, Silica, Sodium, Chloride, Fluoride, Dissolved Oxygen and Hydrazine Analyzers
— Zirconia Oxygen Analyzers, Katharometers, Hydrogen Purity and Purge-gas Monitors, Thermal Conductivity

Customer support
We provide a comprehensive after sales service via a Worldwide Service Organization. Contact one of the following offices for details on your nearest Service and Repair Centre.

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Tel: +44 (0)1453 826661
Fax: +44 (0)1453 829671

USA
ABB Inc.
Tel: +1 215 674 6000
Fax: +1 215 674 7183

Client Warranty
Prior to installation, the equipment referred to in this manual must be stored in a clean, dry environment, in accordance with the Company's published specification.
Periodic checks must be made on the equipment's condition. In the event of a failure under warranty, the following documentation must be provided as substantiation:
— A listing evidencing process operation and alarm logs at time of failure.
— Copies of all storage, installation, operating and maintenance records relating to the alleged faulty unit.

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