

Magnetic Flowmeter Handbook

ADMAG

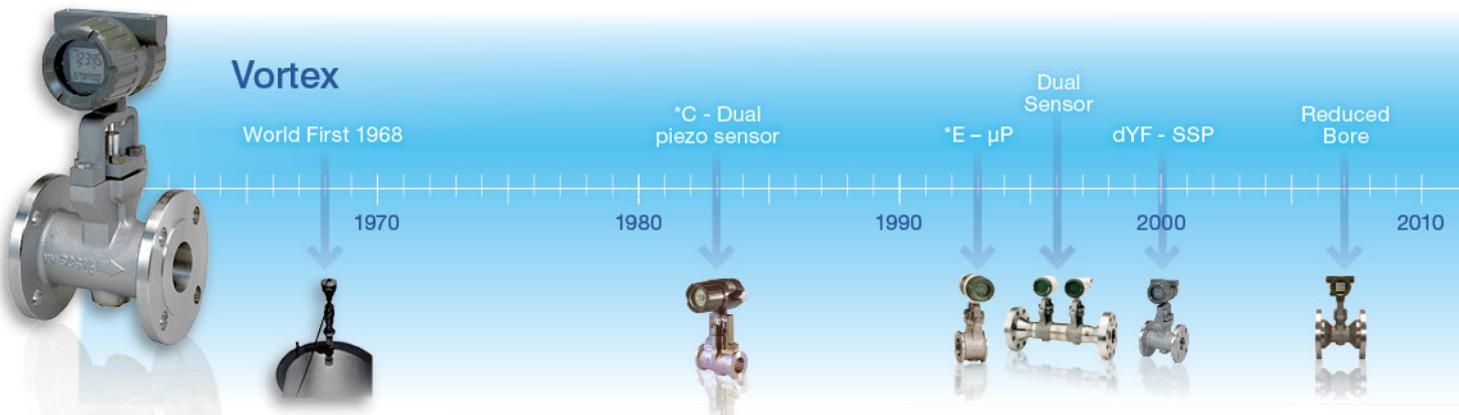


Product family	Measurement				Fluid type						Properties									
	Volumetric flow	Mass flow	Temperature	Density	Steam	Gases	High viscosity liquids	Low viscosity liquids	Conductive liquids	Non-conductive liquids	Without auxiliary energy	High measurement accuracy	For large size	Low pressure loss	Solid content	Wide dynamic range	Bi-directional measurement	High process temperatures	High process pressures	Custody transfer
Magmeter		ADMAG	●	○			●	●	●			●	●	●	●	●	○			
Coriolis		ROTAMASS 3	●	●	●	●	●	●	●	●		●		○	●	●	●	●	●	●
Vortex		digitalYEWFLO	●	○	●	●	●	○	●	●	●	●	●	●		○		●	●	
Variable area / Rotameter		RAMC	●	○		●	●	○	●	●	●	●		●				●	●	
		RAGN (glass)	●	○			●	○	●	●	●	●		●	●					
Differential pressure		DPharp	●	○	○	●	●	○	●	●	●	●	●	●			○	●	●	●
Ultrasonic		US 300	●	○					●	●	●		○	●	○	●	●	●	●	

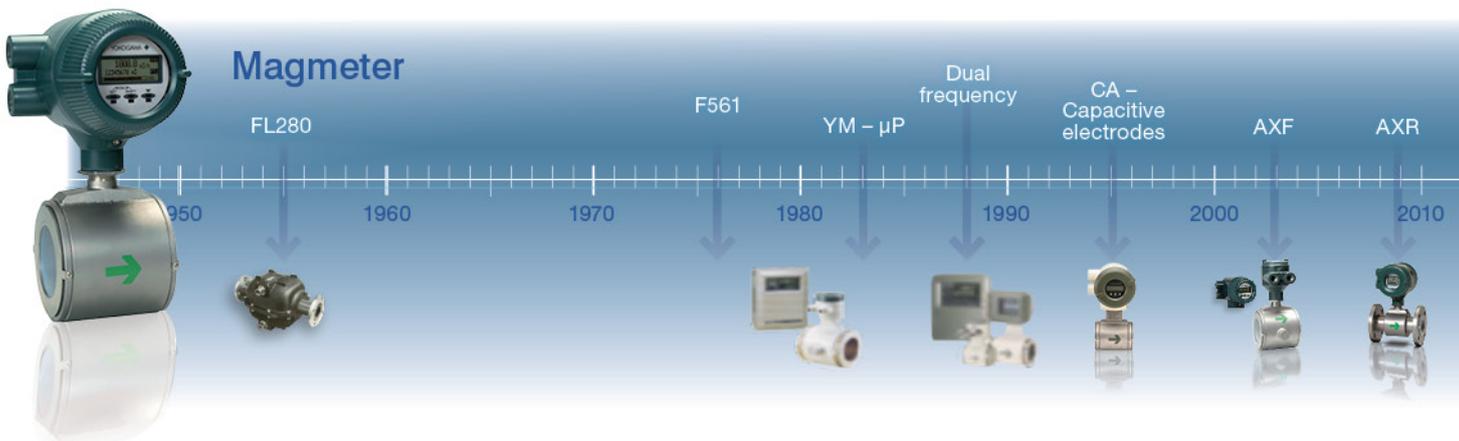
● best choice ○ possible

Flowmeter History

Yokogawa was founded in Japan in 1915 and its initial focus was on electric metering. Based on its avionics and control expertise, Yokogawa began researching flowmeter technology in 1933.

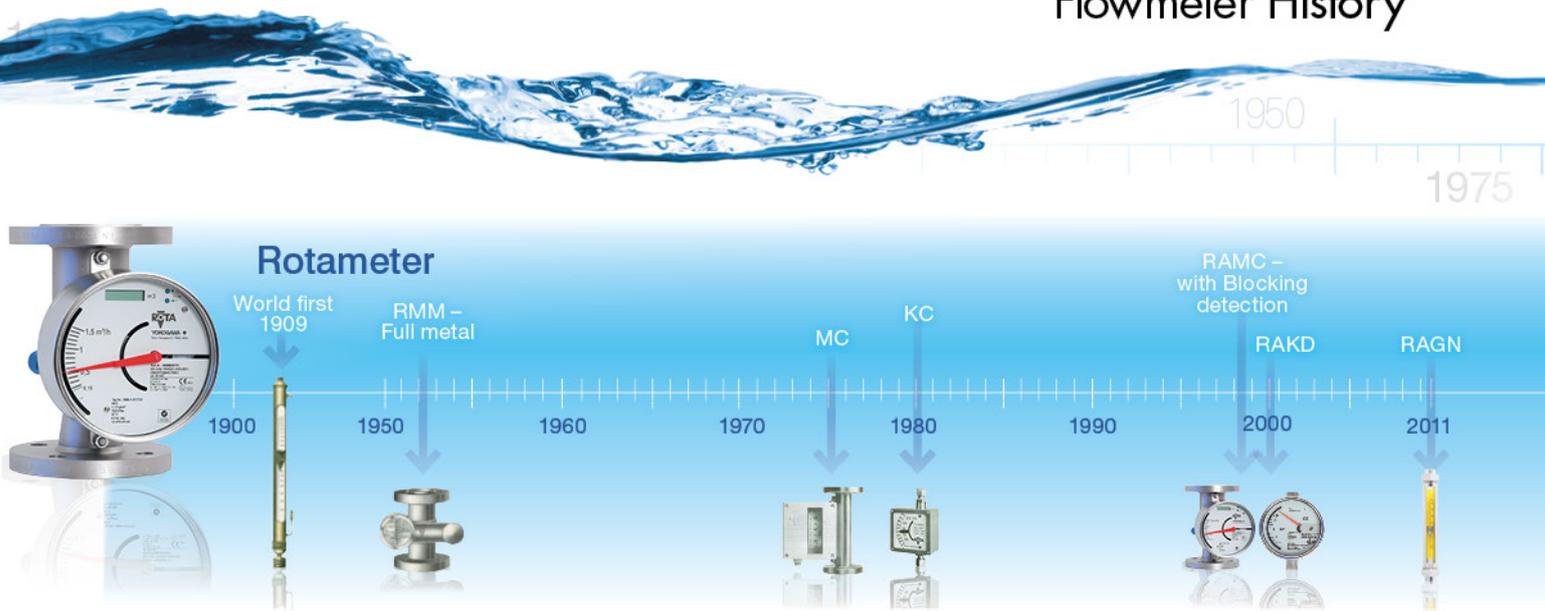


The year 1968 marked the first milestone in this undertaking with Yokogawa's development of a vortex flowmeter and its success in bringing this product to market. At the core of this product concept was Yokogawa's reliable metering technology for a wide application range. These design fundamentals are still valid today.

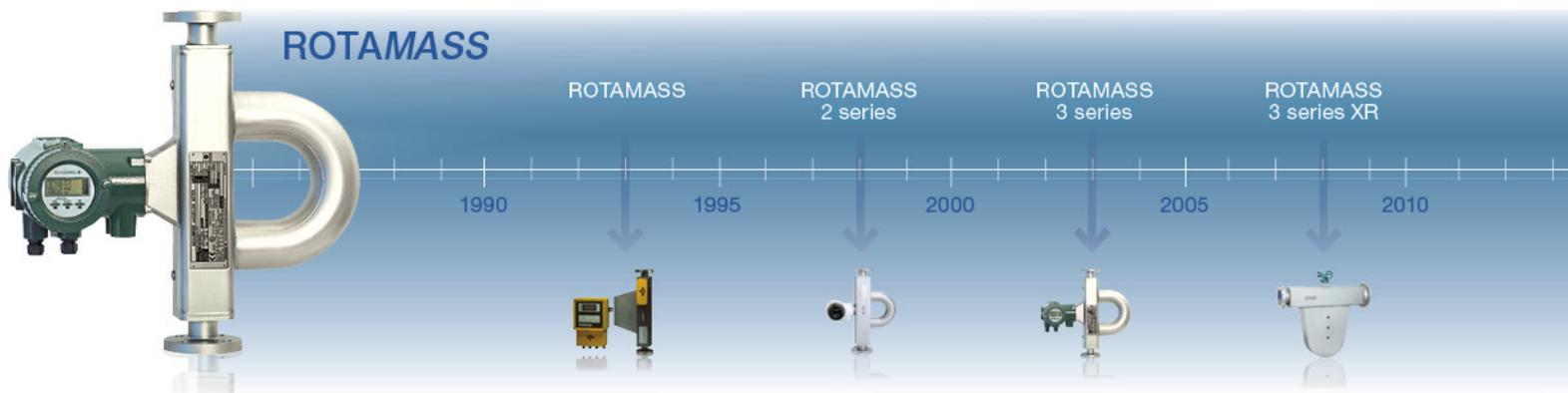


During the 1970s, Yokogawa responded to huge process industry demand for reliable flowmeters of various types. In 1983, Yokogawa concluded a strategic merger with Japan's Hokushin Electric Works, a flowmeter manufacturer. Combining their respective strengths in vortex and magnetic flowmeter technology, the two companies formed Yokogawa Hokushin Electric and went on to focus on flowmeter development, with an uncompromising commitment to quality and reliability. The first milestone after the merger was the release of ADMAG series with dual frequency excitation in 1988.

Flowmeter History



In the 1990s, Yokogawa strengthened its focus on flowmeters through cooperation with and the eventual acquisition of the German flowmeter manufacturer ROTA. In so doing Yokogawa gained access to 100 years of flowmeter expertise and completed its flowmeter portfolio by adding the Rotameter (variable area) and Rotamass (Coriolis) product lines.



Although a truly global enterprise, a dominant portion of Yokogawa's business is still in Japan, where it maintains 24 branch offices and has 17 Group companies, 109 representative offices, and 160 service offices providing products, solutions, and services to its Japanese client base.

To limit product lead times, the company has manufacturing operations in numerous countries. These are as follows:

- Asia Pacific: China, India, Japan, Korea, Singapore
- Europe: Germany, the Netherlands
- Americas: USA, Brazil

Yokogawa maintains Global Response Centers in Bahrain, Brazil, China, India, Japan, Korea, the Netherlands, Taiwan, Singapore, and the United States, providing around the clock support 365 days a year, for the entire range of Yokogawa products.

Yokogawa's businesses are as follows:

Production control systems, field instruments and recorders, solution systems, semiconductor testers, test and measurement products, optical communication equipment, life science systems, and aviation equipment.

YOKOGAWA ELECTRIC CORPORATION
 YOKOGAWA CORPORATION OF AMERICA
 YOKOGAWA EUROPE B.V.
 YOKOGAWA ENGINEERING ASIA PTE. LTD.
 YOKOGAWA CHINA CO., LTD.
 YOKOGAWA MIDDLE EAST B.S.C.(c)

<http://www.yokogawa.com/fld/>
<http://www.yokogawa.com/us/>
<http://www.yokogawa.com/eu/>
<http://www.yokogawa.com/sg/>
<http://www.yokogawa.com/cn/>
<http://www.yokogawa.com/bh/>

Magmeter History And Working Principle

Electromagnetic flowmeters (magmeters) are among the most widely used flowmeter types today. If conditions are suitable for their use, magmeters produce superior results as they rely on a measurement principle that is non-intrusive and produces no pressure loss. Magmeters may be used on all commercially available pipe sizes.

Where it all began:

In 1832, Michael Faraday (1791 – 1867) assembled a large scale open channel magmeter and attempted to use this to measure the flow of water passing under London's Waterloo Bridge. His design concept was rather unusual, utilizing:

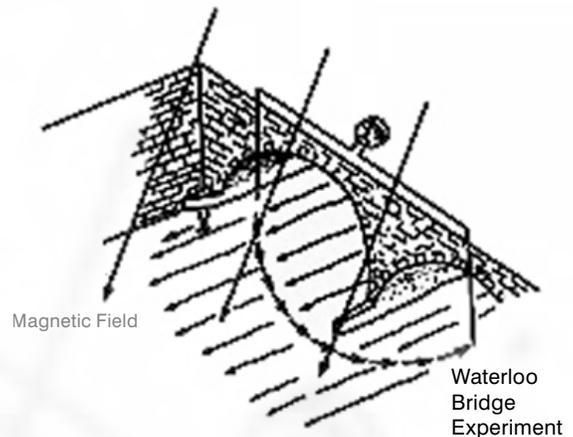
- magnetic field provided naturally by the earth, together with
- two large sheet-metal electrodes lowered from Waterloo Bridge into the river Thames to
- determine the flowrate of the river Thames in London

The result was not a 100% success due to electrochemical and thermoelectric effects as well as the unavailability in that day of highly sensitive instruments that could measure μ Volt signals.

The next steps in development of the magmeter:

- In 1915, the Americans M.W. Smith and Joseph Slepian filed a patent for "A device to measure the speed of a boat by means of magnetohydrodynamics."
- In 1930 the same idea was adapted to closed conduits by the Briton E.J. Williams.
- In 1952 the Dutch company Tobi-Meter introduced the first commercial magmeter.
- In 1962 the British scientist J.A. Shercliff published the "Theory of electromagnetic flow-measurement."

Today there are a few dominant global companies providing more than 200,000 magmeter instruments annually to all industries.



Michael Faraday

Magmeter History and Working Principle

The development of robust and superior magmeters for common industrial applications presents major challenges to designers and engineers.

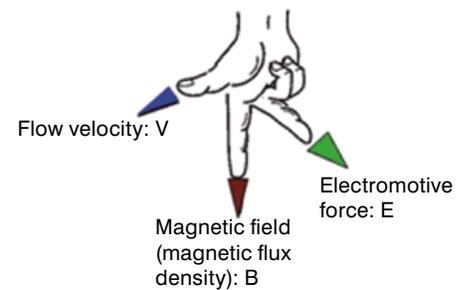
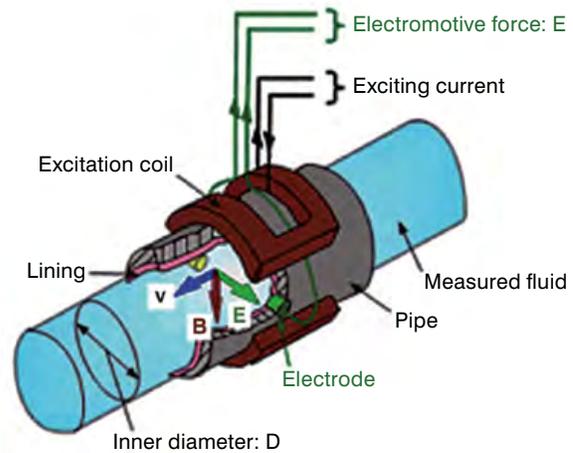
As shown in the drawing to the right, magmeters consist of the following elements:

- Non ferromagnetic flowtube
- Non conductive liner
- Excitation coils
- Electrodes

The generated magnetic field is perpendicular to the fluid flow direction, allowing measurement of the electromotive force E , which, according to Faraday law of induction ($E_{\text{flow}} \sim B * v * D$), is proportional to fluid flow velocity in the pipe.

The overall merits of this design are obvious:

- There is no obstruction in the pipe and therefore no pressure drop caused by the magmeter.
- It works on all commercially available pipe sizes.
- The impact on measurement accuracy by flow disturbances in the media is negligible, thus require less upstream and downstream straight pipe run.



Magmeter designs can be easily adapted to suit industry requirements and applications:



Integral Flange Type



Remote Ceramic Type



Food and pharmaceutical:
sanitary versions

Recent advances in magmeter technology include electrodeless magmeters for adhesive applications, installation-cost-effective two-wire magmeters, and fieldbus versions for digital communications applications.

ADMAG AXF™

The Solution For All Your Magmeter Applications



The AXF series is based on decades of Yokogawa experience with magmeters. The AXF series continues the tradition of high quality and reliability that is synonymous with the Yokogawa name and has innovative functions and technologies such as dual frequency excitation that deliver high level performance.

Retaining all the features and functions of the ADMAG series, AXF flowmeters have a number of optional features such as enhanced dual frequency excitation, as well as electrode adhesion diagnostics and replaceable electrodes for particularly difficult applications. Users benefit as the result of greater reliability and lower total cost of ownership.

Advanced technology

Dual frequency excitation method

Unique to Yokogawa, dual frequency excitation provides the best of AC and pulsed DC excitation. Yokogawa is capable of measuring tough slurries, like an AC meter, and having at the same time the zero stability and accuracy of a pulsed DC meter. Low frequency excitation ensures zero stability, while high frequency excitation achieves slurry noise reduction and fast 0.1 second response times necessary for batching applications. Other benefits are low power consumption and the ability to perform measurements with positive displacement pumps.

Enhanced dual frequency excitation method

Enhanced dual frequency excitation with a high frequency of 160 Hz is also available as an optional feature. This ensures highly stable measurements in difficult applications such as high concentration slurries and low conductivity water. High-speed pulse output pulse rates up to 10,000 Hz are now supported for high speed applications such as short batch processes.

High accuracy calibration option

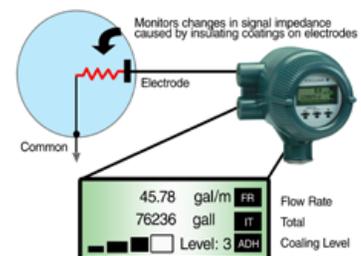
The standard accuracy is 0.35% of reading. Also available as an optional feature is high accuracy calibration rated at 0.2% of reading.

Improved minimum conductivity

The AXF converter can measure fluids with conductivity as low as 1 $\mu\text{S}/\text{cm}$.

Advanced adhesion diagnostics

The adhesion diagnosis function is provided as a standard feature on all AXF magmeters. With this function, the impedance of the wetted portion of the electrode is monitored. A four level bar graph on the AXF converter's LCD display indicates the coating level. When the impedance reaches the third level a warning is displayed; when the impedance reaches the fourth level, an alarm can be triggered and displayed.



Reliable design

Yokogawa has always focused on quality, durability, and reliability of its primary measuring elements and the AXF is no exception. The AXF is constructed from a welded stainless steel body with a reinforced neck, injection molded PFA liners with metal retaining plate for superior chemical resistance, high purity ceramics liner for abrasive resistance or various other liners for challenging applications. Along with our electrode construction, we have an electrode/liner combination that can suit any magmeter application.

User-oriented functionality

Clear and versatile indicator

The LCD indicator employs a large, backlit full dot-matrix that can facilitate one to three lines displays. When an alarm condition occurs, a full description of the countermeasure is indicated.

Easy setup parameter

The most frequently used parameters are arranged

in a group at the top of the parameter menu. These menus can be accessed via the infrared switches on the display.

Infrared switches

Infrared switches permit programming through the glass without the need to open the enclosure cover. The design of the infrared switches give them the feel of mechanical switches and provide consistent operation.

Full dot matrix

Infrared switches



Flexible electrical connection direction

The converter or the terminal box can be rotated arbitrarily to change the directions of electrical connection on site.

Sizes	2.5 mm to 2600 mm (0.1" to 104")
End Connections	Flange or wafer or sanitay (clamp, union, butt weld)
Electronics	Integral or remote
Measuring Range	0 to 191000 m ³ /h (0 to 869000 GPM - US)
Liner Material	Ceramic, EPDM, PFA, PU, Natural soft rubber
Electrode Material	Stainless steel 1.4404 / 316L, Hastelloy C276 equiv. 2.4819
	Platinum, Tantalum, Titanium, Tungsten carbide
Process Temperature Range	-40° C to +180° C (-40F to +356° F)
Pressure Range	Up to 4 MPa (290/580 psi)
Ambient Temperature	-20° C to +60° C (-4° F to + 140° F)
Accuracy*	± 0.35% (standard), ± 0.2% (optional)
Conductivity	≥ 1 μ S/cm
Indicator	3 line graphical display, multi-language
Hazardous Approvals	ATEX, FM, DSA, IEC EX, T11S, GOST
Signal Outputs/Inputs	4 to 20 mA
	Pulse/alarm output, status input
Communication	HART, BRAIN, Foundation Fieldbus, PROFIBUS
Power Supply	80 to 264 V AC, 47 to 63 Hz
	90 to 130 V DC, 20.4 to 28.8 V DC/AC
Protection Class	Protection Class IP67/8 (NEMA 4X)

Special options on request.

* of measured value

ADMAG AXR[®]

Next Generation Two-wire Technology



Why two-wire?

When the first magmeter was introduced to the market in the mid 1950s, it was thought that measurement stability could only be achieved with a large excitation current, something that is only possible with a four-wire device. In recent years, however, interest in two-wire magmeter technology has increased due to the need to save energy. The ADMAG AXR was developed to meet both needs, consuming just 1/80 to 1/100 the power of conventional four-wire flowmeters while delivering the same high level of measurement stability.

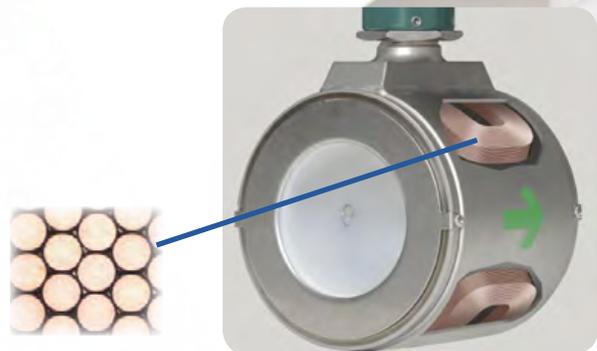
Key technologies

Dual frequency excitation

Dual frequency excitation is a unique Yokogawa technology that combines the flow noise immunity from high excitation frequencies with the excellent zero stability from low excitation frequencies. This technology realizes a high signal to noise ratio and enables the reduction of excitation current to fulfill the power requirements of two-wire technology

Super high density coil

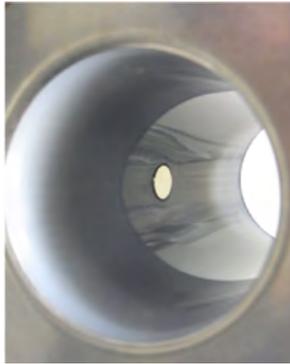
To generate a strong magnetic field with reduced excitation current requires an increase in the number of coil turns. Yokogawa utilizes a super high density coil with a regular alignment that has 1.5 times the number of coil turns of the conventional four-wire AXF. In addition, the carefully aligned winding contributes to the generation of a well-distributed magnetic field and improves measurement linearity.



Super high density regular alignment coil

Special surface finished electrodes mirror-finished PFA liners

Special surface finished electrodes and liners reduce the flow noise that is typically generated when media flow over a rough surface. Special manufacturing techniques give the AXR liner a smoothness of $Ra \leq 0.1 \mu\text{m}$ that reduces flow noise. Adhesive process fluids are also less likely to adhere to the smooth liner. The following pictures show the fluid coating on two flow tubes used in the same process.

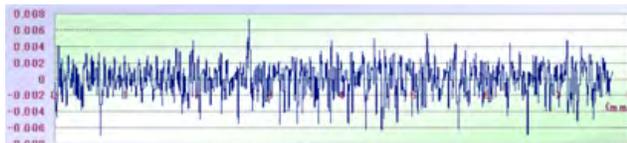


[AXF]

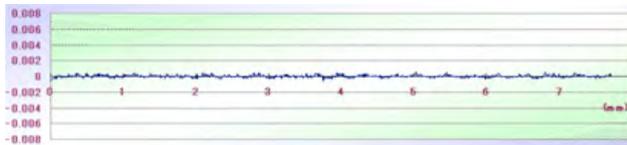


[AXR]

[Sample test result]

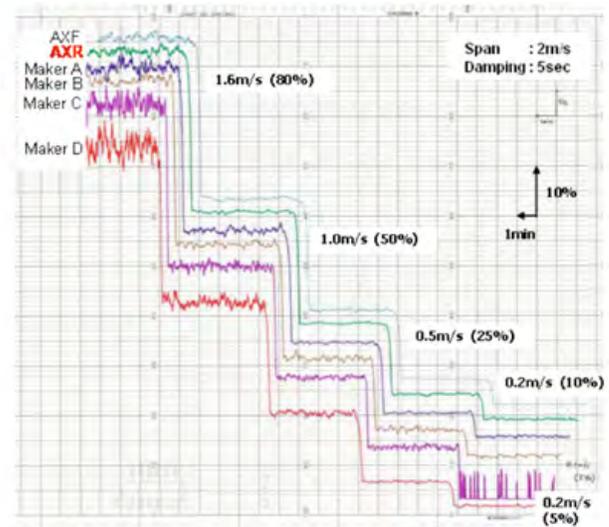


Roughness of 1.33 μm of super PFA (standard)



Roughness of 0.09 μm of super PFA (mirror finished)

Thanks to the design features described above and the use of a unique electric circuit design with DC noise immunity, the AXR two-wire magmeter delivers the same excellent process and flow noise resistance as a four-wire device. With low velocity flows and light slurry fluids that normally would degrade the S/N ratio, the AXR achieves stable output. It is the first two-wire magnetic flowmeter with the reliability required for use in control loops.



User benefits

Energy saving (initial costs/operating costs)

According to the actual calculations of an AXR user in the USA, the expected savings from replacing a four-wire device with the AXR is \$1000 to \$2000 in initial costs and \$15 in annual operating costs. The replacement of a mechanical two-wire flowmeter with the more energy efficient AXR also significantly reduces energy loss and operating costs.



The AXR can reduce annual CO₂ emissions from 73 kg to 1.4 kg



ADMAG AXR[®]

High Performance Loop Powered Magmeter

The AXR series is based on decades of Yokogawa's experience with magmeters. The AXR series continues the tradition of high quality and reliability that is synonymous with the Yokogawa name and has innovative new functions and technologies such as dual frequency excitation that promise high level performance.

The AXR two-wire magmeter can be installed in a two-wire system without any AC power source, thus drastically reducing the initial instrumentation cost. The AXR is the first two-wire magmeter to use dual frequency excitation, ensuring immunity to flow noise and achieving excellent stability for instrumentation. Like Yokogawa's four-wire magmeters, the AXR has user-friendly functions and offers unsurpassed performance and field proven durability.

Advanced technology

Dual frequency excitation method

Unique to Yokogawa, dual frequency excitation provides the best of AC and pulsed DC excitation. Simultaneous low and high frequency excitation ensures the magmeter reads stable with minimum power consumption.

High-speed pulse output

In addition to current output, pulse, alarm, or status output may be selected. Multiple-range, forward and reverse flow measurement, and flow rate upper/lower limit alarm functions are provided, and a high speed 10,000 Hz pulse output is achieved.

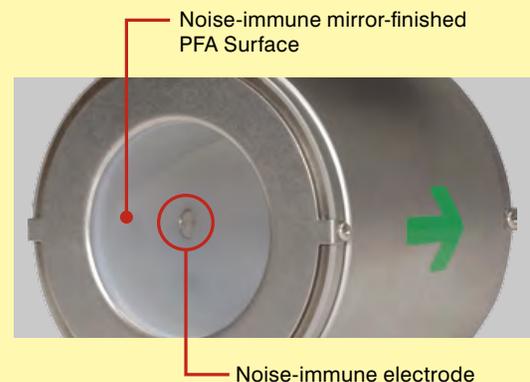
High accuracy

The AXR achieves an accuracy of 0.5% of reading under normal flowrate conditions.

Noise resistance

Due to its construction and use of special coated electrodes and mirror finished liners, the AXR's electric noise immunity is comparable to that of a four-wire device.

Structure Immune to Flow Noise



Advanced diagnostics and functionality

Fluid adhesion level diagnosis

The AXR converter regularly monitors changes in the electrode circuit impedance caused by the build-up of insulating coatings. A four level bar graph on the converter's LCD operating panel indicates the coating level. When the impedance reaches the third level a warning is displayed; when the impedance reaches the fourth level an alarm can be triggered and displayed.

Reduced instrumentation costs

Reduced wiring costs

The two-wire system reduces the wiring costs drastically. Direct connection with DCS is possible.

AC power sources are not necessary. The AXR can be looped powered with almost all distributors, signal conditioner cards, or input modules.

Energy savings

Compared with four-wire magmeters, the AXR can drastically decrease power consumption. The AXR has an average power consumption of 0.3 watt.

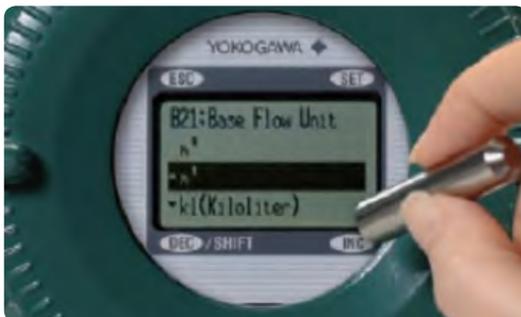
Reliable construction

Yokogawa has always focused on the quality, durability, and reliability of its primary measuring elements, and the AXR is no exception. The AXR is constructed from a welded stainless steel body with a reinforced neck, injection molded PFA liners with metal retaining plate for superior chemical resistance applications. Along with our electrode construction, we have a combination that can suit any magmeter application.

User-Friendly functionality

Clear and versatile indications

The full dot matrix LCD indicator facilitates various displays such as one to three lines and multi-lingual display. In an alarm condition, a full description of the countermeasure is indicated.



Easy setup parameter

The most frequently used parameters are arranged in a group at the top of the parameter menu. In addition to push buttons, the magnetic switches allow users to set parameters without opening the cover.

Flexible electrical connection direction

The converter or the terminal box can be rotated arbitrarily to change the directions of electrical connection on site.

Specification

Structure	Integral flowmeter
Excitation Method	Dual frequency excitation
Nominal Pipe Size (unit: mm (Approx inch))	General-purpose use: 25 (1.0) to 200 (8.0) Explosion proof type: 25 (1.0) to 100 (4.0)
Supply Voltage	Operating voltage range 14.7 to 35 V DC Two-wire system
Output Signals	Current output Digital output (One output can be selected from pulse, alarm or status outputs.)
Electrode Material	Stainless steel-JIS SUS 326L (AISI 316L SS/EN 1.4404 EQUIVALENT), Hastelloy C276 equivalent, Tantalum, Platinum-iridium
Fluid Temp.	-40 to 130°C (-40 to 266°F) [depends on model type]
Ambient Temp.	-40° to 55°C (-40F to 131°F)
Accuracy	0.5% of rate (Note 1) [depends on nominal pipe size and fluid condition]
Fluid Conductivity	10 micro-S/cm or larger (note 2) [depends on nominal pipe size and fluid condition]
Lining	Fluorocarbon PFA (Mirror-finished lining surface)
Lay Length (unit: mm (Approx inch))	Code 1: Wafer; size 80 (3.0) to 200 (8.0), Flange; size 25 (1.0) to 200 (8.0) Code 2: Wafer; size 25 (1.0) to 100 (4.0)
Indicator	Full dot-matrix LCD
Operational Switch	4 magnet switches (including push switches)
Self Diagnosis	Electrode adhesion diagnosis, Coil open, etc.
Alarm Message	With countermeasure is indicated (English, German, French, Italian, Spanish, Japanese)
Options	Direction change of the electrical connection, special gaskets, bar-magnet for operation of magnet switches, etc.

Note 1: The accuracy of a product before shipment is defined as totalized value at the result of calibration test in our water actual flow test facility.

Note 2: For a fluid with large flow noise (pure water, pure alcohol or others), or a fluid with low conductivity and low viscosity, the output fluctuates and is impossible to measure accurately.

ADMAG AXR[®]

Reduce Cost And Improve Performance



In industrial automation the two-wire technology has many advantages compared to four-wire devices. Unfortunately, there are some limitations with two-wire devices, with the main challenge being limited power supply to deliver performance at an acceptable level. Yokogawa has overcome this technology barrier by developing the AXR two-wire magmeter to deliver reliable and stable performance. That is providing great benefits to the industry

Lower installation costs

The biggest advantage of using a two-wire magmeter is the reduction of installation costs. The cost savings include:

1. Only one pair of cable is required. An extra power cable is not necessary. In a medium- or large-sized plant, the cost savings can be quite significant.
2. The two-wire AXR is a loop powered device. There is no need for a power supply or a backup power system (uninterruptible power supply).
3. Easy installation and connectivity to the control room and an overall reduction in labor costs.



Four-wire magmeter



Two-wire magmeter

Lower operating costs

A four-wire magmeter consumes an average of 10 to 20 watts of power. This is considerably more than a two-wire magmeter, which on average consumes approximately 0.2 watts. The lower power consumption also has the benefit of reducing annual CO₂ gas emissions from 73 kg to 1.4 kg.

With its low power requirements, the AXR is ideal for use in remote locations, where power is supplied by solar panels.

Installed Cost Savings of Up to \$1,000 to \$2,000 per unit



Four-wire

≈



Two-wire

Replacement of traditional two-wire devices

Flow measurement in many plants is often still based on traditional technologies. The types of meters in use include turbine meters and differential pressure flowmeters with various types of primary flow elements creating pressure loss.

It may no longer be justifiable to use older measurement devices. Some are quite difficult to handle, are vulnerable to problems such as blockages, and require frequent maintenance.

These days, instrumentation engineers are trying to adapt or replace these older measurement technologies with new flow measurement technologies that provide better process visibility, reliability, accuracy and less pressure loss.

Consideration must be given to questions such as whether it is necessary to cut piping so that a new type of flowmeter can accommodate the process. One of the most difficult barriers to the implementation of newer technologies is the fact that many of these older flowmeters are of the two-wire type, and many times the applicable newer technologies are four-wire devices. Changing to a four-wire flowmeter entails significant added costs for power supplies and cabling. Though many two-wire flowmeters are



Traditional technology is not as accurate as new technology and requires more maintenance due to wear and tear on moving parts. With its two-wire technology, the ADMAG AXR magmeter presents an ideal replacement solution with no pressure loss. And with its short face to face length, pipe modifications can be kept to a minimum.

available, their performance tends not to be good enough to justify the cost of this replacement.

The AXR overcomes this problem. With its two-wire design and good reading stability, the AXR is the perfect solution for your application need. Sizes range from 25 mm (1") to 200 mm (8"), with various types of process connection such as ANSI, EN, and JIS flanges. A wafer type process connection with a short face to face length is also available, allowing you to minimize pipe modifications.

ADMAG CA

Measuring the impossible when nothing else will work



The ADMAG series is based on decades of Yokogawa experience with magmeters. The ADMAG series continues the tradition of high quality and reliability that is synonymous with the Yokogawa name

The ADMAG CA magmeter measures the un-measurable with the ability to meter fluids with conductivity as low as $0.01\mu\text{S}/\text{cm}$. The non wetted capacitive electrode plates, which are mounted on the outer surface of a ceramic flow tube and not in contact with the fluid, are capacitively coupled to the fluid. In addition, the ADMAG CA Magmeter employs an advanced high-frequency excitation method. This revolutionary design is an excellent alternative to other flow technologies, as it can provide accurate, reliable measurement of low conductivity liquids such as pure water as well as coating process flows and high concentration slurries.

Advanced technology

High Frequency Excitation

Ultra low Conductivity Measurements

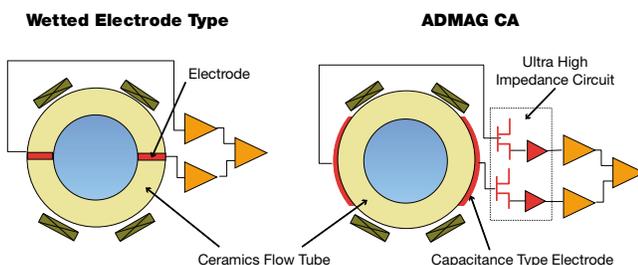
Accuracy Specification

Non-wetted Electrodes

Ceramic Liner - Excellent on corrosive fluid and abrasive fluid

Coating resistant

Mirror finished surface



The benefits range from reducing slurry or process noise, eliminating potential leak paths and is for high coating process applications.

Ceramic Liner - Excellent on corrosive fluid and abrasive fluid

Ceramic liner tubes have many advantages over fluoropolymer (PFA/PTFE) or other liner materials like rubber. Yokogawa uses alumina ceramic (Al_2O_3) for its ceramic liner tubes, which demonstrates excellent characteristics for a broad range of applications.

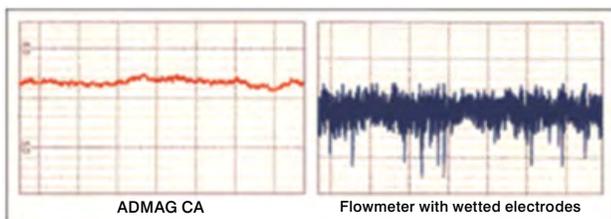
The Alumina ceramic (Al_2O_3) used in the ADMAG CA has a purity of 99.9%.

These properties of the ceramic liner provide:

- Excellent insulating characteristics
- Excellent resistance to abrasion, ensuring accurate measurements even with highly abrasive slurries
- Excellent resistance to corrosive fluids
- Excellent durability under high temperature and high pressure conditions without additional metal tube

Coating resistant

Non-wetted capacitive electrodes can measure electromotive force through capacitance including coating insulating material, offering steady measurement. Field-proven applications such as latex, reclaimed oil, hot spring water, red mud, and dye which had been difficult in the past to measure using conventional magmeters is now possible utilizing the ADMAG CA. The following figure compares the outputs of measurement between a wetted electrode type and the ADMAG CA when there is grease on the inside of the tube.



Mirror finished surface

By means of a special magnetic polishing process, the inner surface of the ceramic liner tube can be given a mirror finish. This polishing method is advantageous in eliminating problems such as abrasive irregularities and dull edges and will reduce the coating affects of your process. The mirror finished ceramic liner tube has a surface roughness of Ra 0.1 μm .

Specification

Size mm (Inches)	15 (0.5)- 200 (8)
Excitation	High frequency
Flow span m/s (ft/s)	0.5 (1.64) -10 (32.8)
Min. fluid conductivity ($\mu S/cm$)	As low as 0.01
Protection	IP67, NEMA4X, JIS C0920 watertight type
Hazardous area classification	FM, CSA, TIIS(JIS)
Accuracy	$\pm 0.5\%$ of flowrate (Depends on nominal pipe size and fluid conditions)
Repeatability	$\pm 0.1\%$ of flowrate (1 mm/s min.)
Lining material	Ceramic
Electrode Construction	Non-wetted plate electrodes installed on outside of ceramic tube
Fluid pressure	-0.1 MPa to 4 MPa: Ceramic lining size 50 mm or smaller -0.1 MPa to 2 MPa: Ceramic lining size 80 mm or greater
Fluid temperature	-10 deg C to 120 deg C
Process connection	JIS 10K/20K/F12, ANSI 150/300, DIN PN10/16: Wafer
Output signal	4-20 mA DC, pulse, or alarm (transistor contact: 30 V DC, 200 mA max.)
Function	Variable damping time (1 sec min.), self-diagnostics, loop test, BRAIN communication
Indicator	7-seg. LCD with back light
Power supply voltage	80-264 V AC/47-63 Hz or 100-130 V DC, 20.4-28.8 V DC
Maximum power consumption	14 W

Note 1: The accuracy of a product before shipment is defined as totalized value at the result of calibration test in our water actual flow test facility.

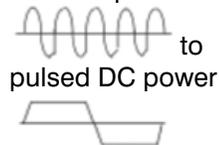
Note 2: For a fluid with large flow noise (pure water, pure alcohol or others), or a fluid with low conductivity and low viscosity, the output fluctuates and is impossible to measure accurately.

Dual Excitation For Stable Measurement In Any Application

AC and pulsed DC excitation

The magnetic flowmeter takes its name from the magnetic field that must be present within the flowtube in order to generate a flow signal.

Fifty years ago, electromagnets were first utilized for this purpose, and were powered with AC voltage. The AC power generated sufficient magnetic flux density to get useful flow signals from vacuum tube amplifiers. With the development of transistors, integrated circuits, μ -processors and digital technology, excitation power to the coils was reinvented from AC power



The constant magnetic field generated by the coils allowed one non flow related error signal to be eliminated. This greatly improved magmeter zero stability and was a significant breakthrough leading to industry acceptance of this flowmeter technology.

Due to the technologies that were first in use, the change from AC to pulsed DC excitation caused also a drop in the excitation current < 100 mA, coinciding with the change in excitation frequency from the high frequency 50/60 Hz to the low frequency of approx 6 Hz. This negatively impacted the magmeter's immunity to flow noise. Flow noise occurs with many liquids and applications and has many different

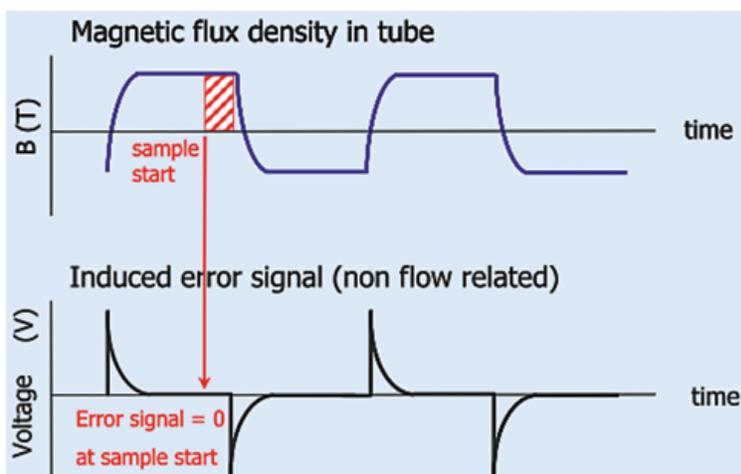
causes, but in the end it is the result of an unstable electrolytic voltage. This fluctuating electrolytic voltage makes it impossible to extract the flow signal in a stable condition. This explains why both AC and pulsed DC type meters remain in use today.

Not so for Yokogawa. The advantages of high frequency excitation and low frequency excitation were carefully studied and it was clear from the

very beginning of the Yokogawa magmeter development that a commercially acceptable solution was needed that would combine the advantages of both methods to produce a new excitation concept:

Dual frequency excitation

The milestones in the development of this Yokogawa technology

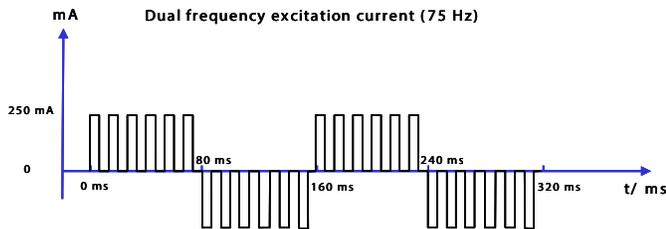


were:

- Accomplishment of high zero stability from low frequency pulsed DC technology
For high accuracy
- Accomplishment of high excitation current
For a strong magnetic field, the basis for a superior signal / noise ratio
- Accomplishment of high frequency excitation
For generating stable flow signals with a fast response time even with unstable electrolytic voltages (flow noise) are present

Dual Excitation For Stable Measurement In Any Application

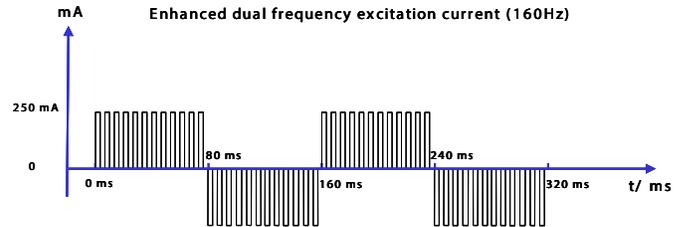
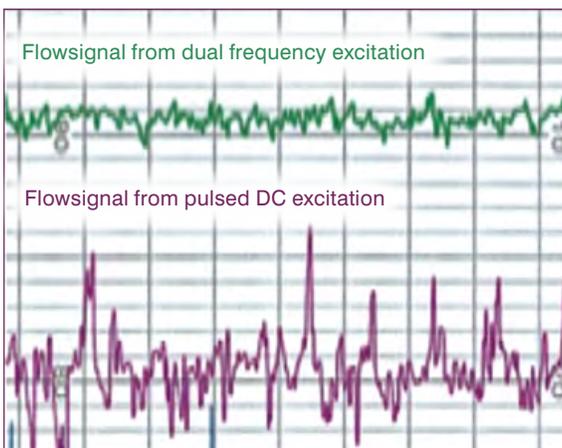
Painstaking research into material selection, signal conditioning, and magnetic field management eventually delivered the Yokogawa technology breakthrough of dual frequency excitation: the permanent side-by-side presence of two different excitation frequencies.



The use of specialized magnetic materials capable of suppressing eddy currents together with special excitation voltage conditioning enables Yokogawa to switch a high 250 mA excitation current in a few milliseconds.

Providing flow data every 13 ms from the high 75 Hz excitation frequency improves flowmeter performance by a factor of 10 compared to standard pulsed DC type magmeters.

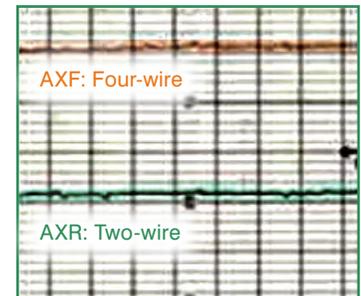
With the AXF magmeter family, even an enhanced 160 Hz excitation frequency is possible, making the non-intrusive magmeter principle attractive in the most challenging applications.



One common application for the dual frequency excitation technique is applications where batches are of a short duration, for example, having filling times below one second. For the required accuracy, it is essential to generate flow data with response times ranging from 10 to 20 ms.

One special but very common application is the measurement of water with conductivity as low as

1 $\mu\text{S}/\text{cm}$. Low conductivity water generates so much flow noise that standard pulsed DC meters do not work at all. For low conductivity fluids like de-ionized water, only dual frequency magmeters with high excitation currents and high excitation frequencies can deliver performance in such applications.



Ready for two-wire technology.

The above described dual frequency excitation concept is one of the most important building blocks in a solution to the latest challenge in the magmeter industry: producing a two-wire magmeter with the same flow performance as a four-wire magmeter. The challenge with a two-wire magmeter is obtaining a stable flow signal even with a very small excitation current. In this two wire concept, dual frequency excitation has played a key role.

For further details on the AXR two-wire magmeter, please see the additional information AXR "two-wire technology"

PFA Liner Durable Under Any Process Condition

The superiority of PFA to PTFE as a liner material

Why Yokogawa uses PFA in AXF series flowmeters

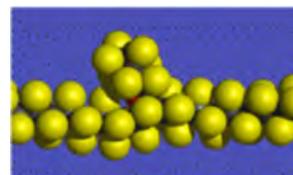
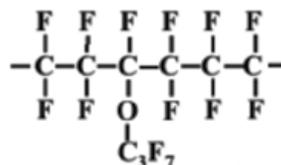
In its magmeters, Yokogawa employs liners made of perfluoroalkoxy (PFA) resin. PFA offers equivalent heat and chemical resistance as PTFE, but additionally the material flexibility enables injection molding. PFA is used mainly in chemical plants and in semiconductor manufacturing equipment. Super PFA, which offers lower wash-out of fluorine ions and particles, is widely used in the semiconductor industry. Yokogawa uses the highest grade Super PFA, resulting in further improvements for a smoother surface and increased permeation resistance. As demonstrated by in-house tests using a 35% hydrochloric acid solution, Super PFA delivers approximately three times the permeation resistance of conventional PFA.

Comparison of PFA and PTFE

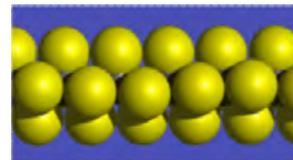
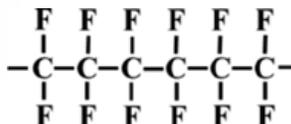
In general, all surfaces inside a magmeter, with the exception of the electrodes, must be lined with insulating materials (liner). There are many kinds of liner materials, and the performance of

magmeters largely depends on these materials. Fluoropolymers are considered the most versatile among the various liner materials, and PFA and PTFE are the two main fluoropolymers used as liners in magmeters. Although

PFA and PTFE have almost the same corrosion resistance, PFA offers far superior performance compared to PTFE as a liner. PTFE cannot be used for an injection molding process due to its high melt viscosity and low heat flowability. When used in magmeters, PTFE is either “bonded” to the inner surface of the flowtube by mechanical fit or by bonding adhesives. Pin holes also tend to form in PTFE, and therefore it has weaker corrosion resistance than PFA. With injection molding, PFA can form stable layers without pin holes, thus it is the ideal liner material for magmeters, offering superior corrosion resistance at high temperatures.



[Molecular architecture of PFA]



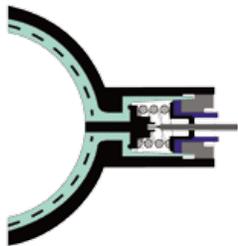
[Molecular architecture of PTFE]



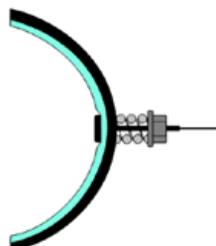
Construction

Advantages of PFA versus PTFE

With injection molded PFA, the sealing structure of electrodes can be significantly improved. As shown in the following figures, any process fluid that permeates the liner does not reach the electrode room as its wall is also protected by the PFA liner. With a conventional PTFE liner, only internal insertion type electrodes can be used. As a result, process fluid that permeates can reach the electrode compartment and cause signal deterioration.



Construction of the electrode for PFA liner



Construction of the electrode for PTFE liner

PFA superiority under negative pressure

In order to securely affix the PFA liner to the inner surface of a flowtube, a metal retaining plate, called punched plate, is welded to the inner pipe surface and then the PFA resin is injection-molded onto it. As a result, PFA resin enters each hole, and the lining is securely fixed with the flowtube. In contrast, the PTFE liner easily delaminates under negative pressure because it is only bonded to the surface.



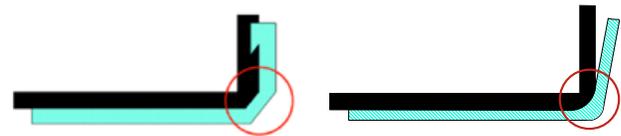
Structure of metal retaining plate for PFA liner



Deformed PTFE liner

Comparison of liners under abrasive process conditions

While fluoropolymer liners are not always ideal for use with slurries, they are often used in slurry and corrosive applications such as those typically found in the pulp and paper industry. As shown below, the PFA liner withstands strong abrasion. The difference is that, with injection molding, the thickness of the PFA liner can be increased along the edges. In contrast, the PTFE liner is a tube of uniform thickness that is bonded to the pipe, and it tends to break away entirely, starting at the edges.



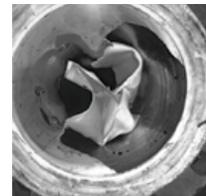
PFA Liner at an edge

PTFE Liner at an edge

Below pictures show damaged magmeters liners. In case of PFA, the abrasion to liner occurs gradually, thus measurement continues. In case of PTFE, the measurement stops once it fails. Moreover leakage will occur and cause danger to the operation.



PFA Liner



PTFE Liner

Conclusion

With their PFA liners, Yokogawa's magmeters demonstrate superior material characteristics, and this highly reliable construction enables stable process measurement for customers.

Ceramic Liner For Superior Abrasive & Chemical Resistance

Advantages of ceramics

Ceramic liner tubes have many advantages over fluoropolymer (PFA/PTFE) or other liner materials like rubber. Yokogawa uses alumina ceramic (Al_2O_3) for its ceramic liner tubes, which demonstrates excellent characteristics for a broad range of applications.

Advantages of ceramic liner tube

- Excellent insulating characteristics
- Excellent resistance to abrasion, ensuring accurate measurements even with highly abrasive slurries
- Excellent resistance to corrosive fluids
- Excellent durability under high temperature and high pressure conditions without additional metal tube

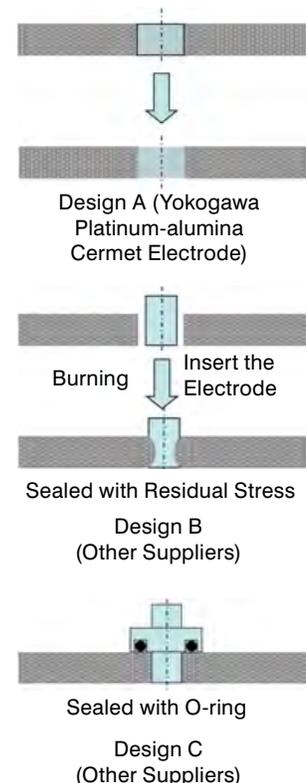
Engineered to withstand

Yokogawa produces its own ceramics in-house, starting with granular material (powder) and proceeding to processing, burning, and inspection. Alumina ceramic (Al_2O_3) with a purity of 99.9% contains almost no impurities. Ceramic liner tubes are cast in rubber molds and burned in ovens at strictly controlled temperatures.

Platinum-alumina cermet electrodes, made by burning a mixture of alumina and platinum powder, have a seamless structure, eliminating the necessity for a seal. Ceramic liner tubes from other magmeter suppliers generally use a solid platinum rod as an electrode, which is sealed by contractile force during burning or by using an O-ring.



With design B, large residual stress around the electrode may cause defective sealing or cracking to occur; with design C, performance depends on the quality of the seal achieved with the O-ring, and the ceramic liner tube easily cracks due to the residual stress around the electrode hole.





Liquid penetrant test

Tested for mechanical strength

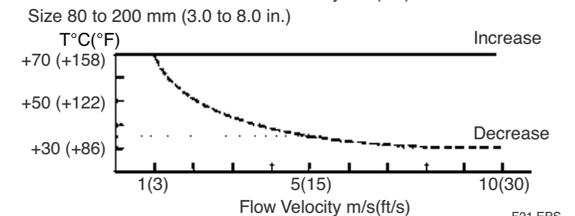
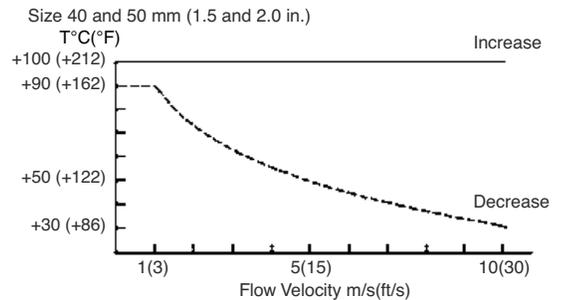
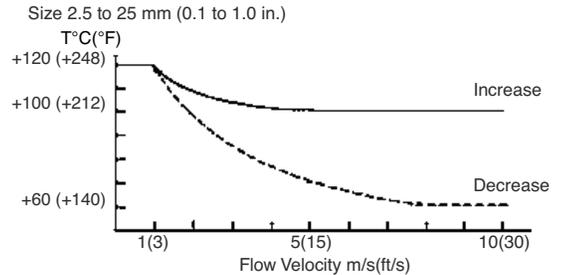
Ceramics are excellent materials in many ways, but if they are used improperly, they tend to crack easily. Yokogawa's ceramic liner tubes meet the same safety standards as metal

pipes. All ceramic liner tubes are strictly thermal shock tested, inspected for micro-cracks, and pressure tested at 1.5 times of the maximum pressure rating.

Mirror finished ceramic liner tube

Before measuring sticky fluids, it is important to take into consideration relevant design factors such as flow velocity and pipe diameter. At the same time, the adhesion-resistance of the magmeter must be considered. The smoother the surface of a magmeter's liner, the less likely it is that adhesion will occur.

By means of a special magnetic polishing process, the inner surface of the ceramic liner tube is given a mirror finish. This polishing method is advantageous in eliminating problems such as abrasive irregularities and dull edges. The mirror finished ceramic liner tube has a surface roughness of $Ra < 0.1 \mu m$.



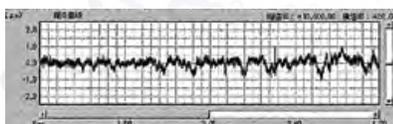
F21.EPS



Surface of ceramic liner tube (standard)



Surface of ceramic liner tube (mirror finished)



High adhesion resistance of liner tube and electrodes in a magmeter, is very important for long term reliable measurement. It is supported by the integrated platinum-alumina cermet electrodes with no gaps that can cause adhesion. High adhesion resistance is thus achieved through the synergistic effect with the smooth surface of the ceramic liner tube.



Ceramic liner tube with platinum-alumina cermet electrode (Mirror finished)

Electrode Construction For Uninterrupted Operation

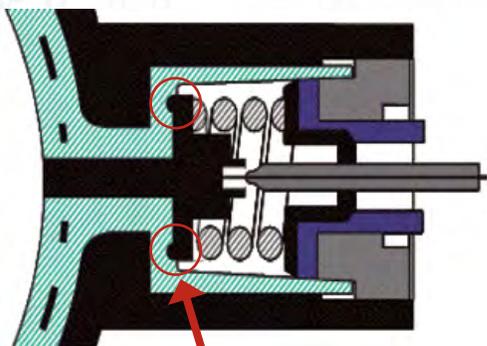
Measuring Electrodes

The electrodes are one of the most important components in a magmeter: it efficiently detects the μV level electromotive force generated by a fluid flowing through a magnetic field. The electrode, a wetted part, is made of materials such as 316L, Hastelloy-C*, titanium, tantalum, or platinum that ensure sufficient corrosion resistance. While there are a variety of electrode types for different applications, Yokogawa's PFA-lined magmeters basically are either of the external or internal insertion type.

External and internal insertion type

External insertion electrodes

This type of electrode is inserted into the flow tube from the electrode housing side and is pushed into place by a spring. The spring applies an even pressure to maintain a seal and hold the electrode in place so that it can withstand pressure fluctuations. In addition, the integrated PFA liner into the electrode compartment enhances the sealing reliability. This design enables to have the electrodes flush with the pipe wall, as desired for mechanical abrasive applications.

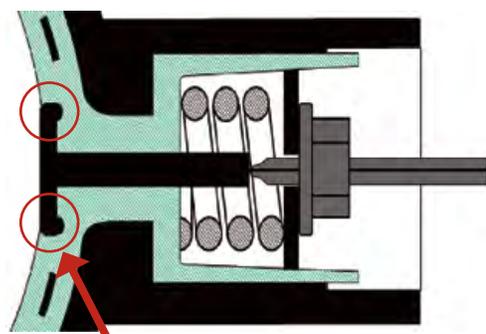


Sealing point

External insertion electrode assembly

Internal insertion electrodes

This type of electrode is inserted into the electrode housing from the flow tube side and is pulled into place by a spring. The electrode seal is located on the surface of the liner inside the flow tube to minimize gaps. This electrode type is ideal for sanitary applications and provides an excellent self-sealing capability required for special high-pressure applications. And since the two-wire magmeter is using bigger diameter electrodes to reduce the flow noise, it also uses this type of electrode construction.



Sealing point

Internal insertion electrode assembly

*Hastelloy is a registered trademark of Haynes International, Inc.



Testing with an Helium-leakage detector

Helium-leakage test

The electrodes are assembled by skilled workers using special tools, and their torque settings are strictly controlled. An Helium-leakage test is conducted to ensure the reliability of each electrode coming off the assembly line.

Replaceable electrodes

The adhesion diagnosis function is provided as a standard feature with all Yokogawa AXF series magmeter. With this function, the impedance of the wetted portion of the electrode is monitored and an alarm is issued when the adhesion of insulating material reaches a certain stage. Replaceable electrodes are a convenient solution: the fouled electrode can be easily removed with a special tool and after cleaning, it can be re-installed easily.

Replaceable
"cassette"
electrode



ADMAG

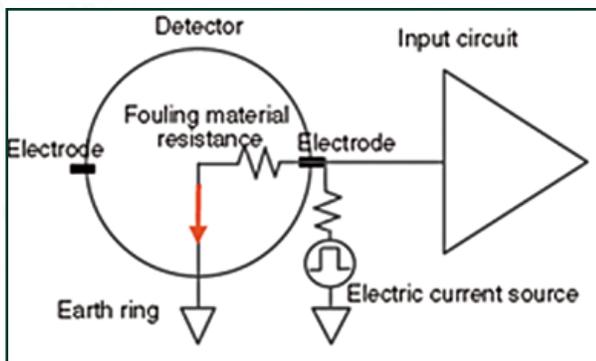
Advanced Diagnostic For Increased Process Visibility

Technology advances have made it easier to troubleshoot problems that occur in measurement. Utilizing advance diagnostics, a better understanding of the process condition can be achieved without having to stop the process. Furthermore, it allows preventive measures to be taken before a problem actually occurs.

Adhesion diagnosis

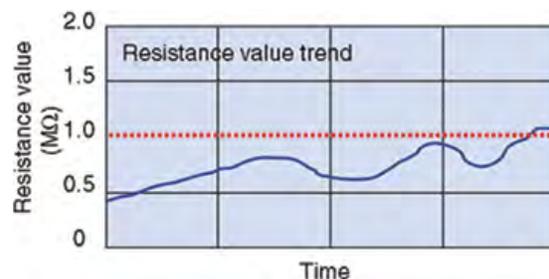
A common problem in magmeter measurement is electrode fouling. Deposits on the electrodes increase impedance, thus causing the flowmeter reading to become unreliable and erratic.

Experienced engineers who know the process well are able to guess that adhesion on the electrodes may be the cause of this problem. On the other hand periodic maintenance may be scheduled to regularly clean the electrode.



Yokogawa's magmeter measure the electrode impedance by sending a square wave signal from the electrode to the grounding ring. The square wave frequency is set so, that it has no influence on the flow rate measurement.

The impedance can be monitored and an alarm can be sent if the adhesion reaches a threshold level.



With this functionality, even inexperienced engineers can determine when adhesion occurs. Periodic maintenance is not necessary, as maintenance is only needed when impedance reaches the threshold level.

Applications where this diagnostic function is useful:

1. Slurries and dirty applications that create electrode adhesion over time.
2. Applications where scaling occurs due to changes in process conditions (such as drop of process temperature, or in batch processes).



Empty pipe detection

Any magmeter must be completely filled to function correctly. However, incorrect installation or a process problem (such as cavitation or a vacuum) may result in entrained gas inside the measuring tube. This will cause the flow reading to fluctuate and cause errors in measurement.

Yokogawa magmeters have an empty pipe detection function. This detects this condition by utilizing the two measuring electrodes. No additional electrode is necessary. This guarantees flow tube integrity and ensures leaks do not go

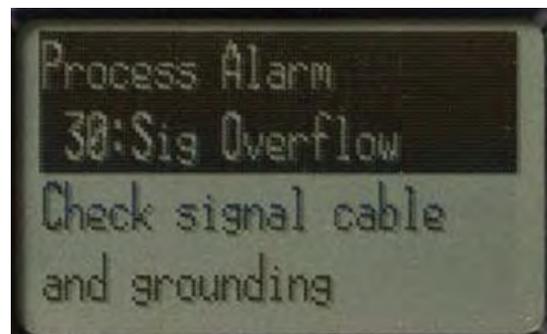
undetected. Other suppliers utilize additional electrodes to provide empty pipe detection. Empty pipe detection ensures stable and accurate measurements.

Interactive indicator

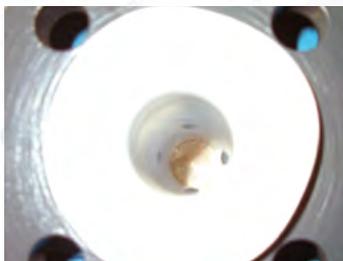
The parameter menu is interactive and easy to use. The display also shows warning or error messages as well as error countermeasures. Problems can be quickly identified and resolved.



Yokogawa's two electrode type

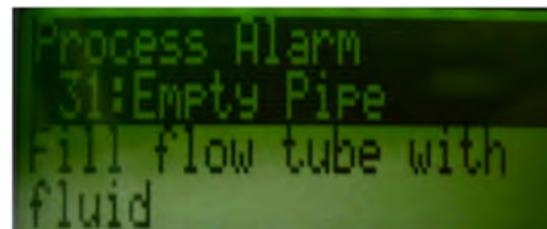


Warning Display



Other suppliers' multi-electrode type

Empty pipe Electrode



Error and countermeasure display

Warning Display:

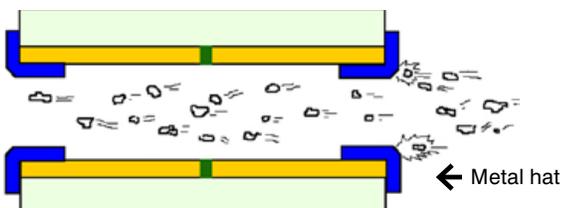
Even for first-time users, parameter setting is easy with all Yokogawa magmeters.

Beyond Standard Our Answer For Your Requirements

Many applications can be served by magmeters. Some of these applications or process conditions are explicitly harsh and demanding, and require customized solutions.

Metal hat grounding ring

Slurry applications include also the blow line service in pulp and paper industry. When the process temperature becomes rather high, the liner edge at the entrance to the flowtube tends to become soft. And with high density slurries, this edge is subject to abrasion.



Metal hats have been designed to protect the liner edge and prolong flowtube lifespan. They are designed to precisely match the inner diameter. Different materials such as 316, Hastelloy-C*, or titanium are available, suiting different process requirements.

When using metal hats with high temperature and/or abrasive slurry applications, they help to prolong the lifetime and reduce maintenance costs.



PFA liner with metal hat

Resistance to abrasion damage



PTFE liner without metal hat

Abrasion damage can happen for several years in just a few months

Custom designed electrodes

In some processes, adhesion and/or scaling can occur inside the flow tube. This scaling may be due to liquid characteristics. The electrode fouling causes measurement error. In the worst case, frequent maintenance may be necessary to ensure measurement accuracy.

These problems can be addressed by using custom designed electrodes with features such as cone extensions or hemispherical extensions.



* Hastelloy is a registered trademark of Haynes

Rigid Construction For Installation Flexibility

Rotatable converter case

User friendliness is one of the design concepts of the AXF and AXR. The converter housing of the AXF and the AXR can be easily rotated to facilitate access when connecting cables or performing other maintenance work. This also can be done to adjust the viewing position of the LCD display.



The converter case can be rotated between the angles of -140° and 180°.

Robust construction

Vibration resistance

Vibration from the piping can place stress on the magmeter neck, which bears the weight of the converter case. Under actual site conditions, such mechanical stress over time can cause damage to the neck. In addition to having reinforced necks, the weight of the AXF and AXR converter cases has been reduced. This strong and robust construction gives our AXF and AXR magmeters excellent resistance to mechanical stress.

Robust neck design

In many cases, damage occurs at the point where the neck is welded to the meter body.

The traditional design, in which the neck is directly welded to the meter body, is more vulnerable to mechanical stress caused by pipe vibration.

The AXF and AXR utilize a casted neck. This engineered neck design gives them superior vibration resistance compared to other products on the market.



FieldMate™

Multiple Platforms to match your plant's needs

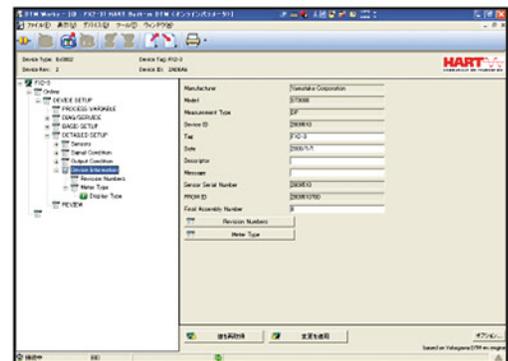
"FieldMate is a versatile configuration and maintenance tool
for all smart devices across all communication protocols"

Introducing the latest addition to the FieldMate family

FieldMate Basic Lite **NEW!**

FieldMate Lite is a basic configuration tool for all yokogawa smart devices. It utilizes built in DTMs to allow you to configure and commission your Yokogawa devices. FieldMate can communicate with all smart communication protocols and even Yokogawa Wireless ISA100.11a devices.

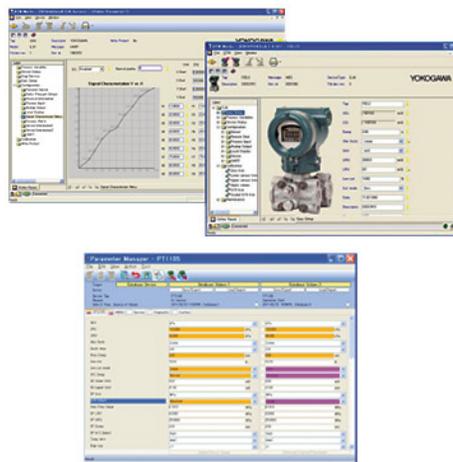
To experience the versatility of FieldMate, FieldMate Lite is available for download for free from the Yokogawa website. FieldMate lite will give you a chance to experience the ease of use and versatility of the more complete FieldMate packages. www.Yokogawa.com



To experience the full capabilities of this one stop configuration tool,
we recommend our field tried and trusted full versions

FieldMate Basic

Providing you with a graphical interface with intuitive user display optimized for field devices. Supports all vendors DTMs and using the inbuilt DTM can create dedicate displays for devices for those that don't. It is a convenient and simplified approach for configuration and maintenance of all smart devices across the most popular communication Protocols.



FieldMate Advance

Advance adds off line database function for up to 300 devices which maintains a complete record for all device configuration and maintenance activity. Setup your devices settings before you go out to the field, Replacing different devices? FieldMate can convert parameter settings from one vendors device to another's for quick painless swap over's.

Multiple
Protocol
Access



BRAIN



A90-TCS-444v 1st Ed: Mar. 2012

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YOKOGAWA 

FieldMate ADVANCED

Device Maintenance Database

Device configuration templates

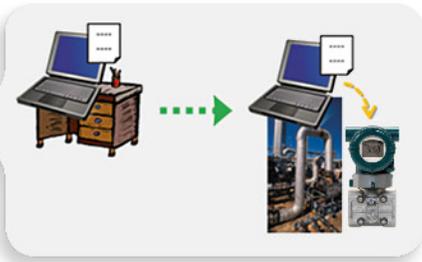
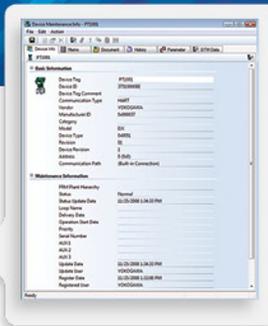
Device Conversion

Support for multiple users

Off line setup

PRM Synchronization

Data comparison by
Parameter Manager



FieldMate BASIC

Full configuration of
all field Devices

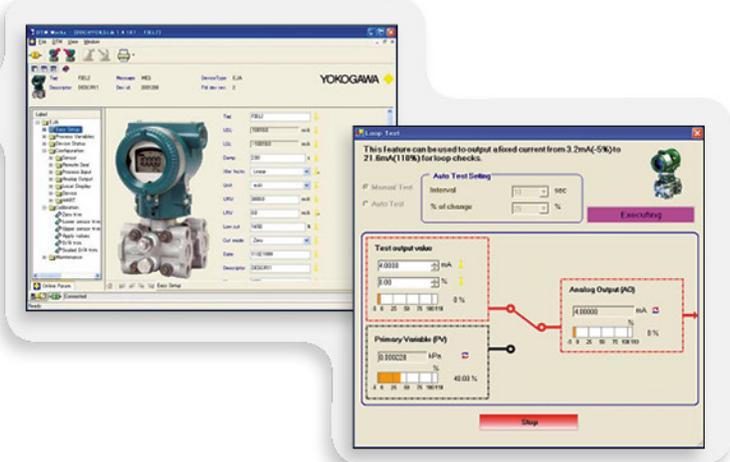
Full Graphical Display

All Yokogawa DTMs

3rd party DTM support

Device Diagnostic Viewer

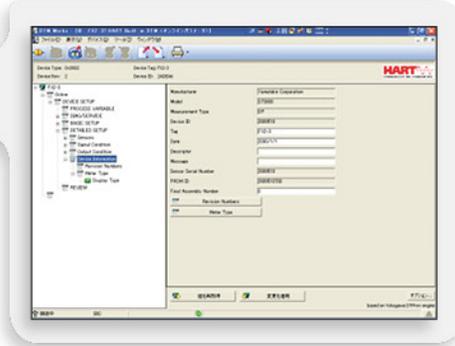
Audit Trail Log



FieldMate Basic LITE

Configuration of Yokogawa
devices only

Built in DTMs



For more information on FieldMate and other YOKOGAWA products, contact your local sales office or visit us at www.Yokogawa.com