TWO-WIRE AND FIELDBUS-POWERED MAGNETIC FLOWMETER REPORT

Prepared by

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Two-Wire Magnetic Flowmeter Market Analysis

Four-wire magnetic flowmeters utilize two power wires and two signal wires. Two-wire magnetic flowmeters derive their power from their signal wiring and do not need power wiring. This creates the distinct advantages of simplifying installation, reducing engineering/installation cost by eliminating the need for power wiring/conduit, and enabling the ability to replace other two-wire flowmeters with little electrical rework. Disadvantages generally include inferior performance and more stringent applicability constraints.

Worldwide Magnetic Flowmeter Market (2005)

The expected size of the 2005 magnetic flowmeter market is tabulated below.

Worldwide Magnetic Flowmeter Market	330,000 units
Worldwide Two-Wire Market	10,900 units (3.3%)

We are told that other market researchers estimate the worldwide magnetic flowmeter market size in 2005 to be approximately 360,000 units, or approximately 10 percent higher. We believe that this in within the error band of the majority of market research reports in this market. Despite this difference, the magnetic flowmeter market is substantially large that it will not materially affect this analysis. Further, we are told that other researchers estimate the worldwide two-wire magnetic flowmeter market to be 2% of the total market, or 7200 units in 2005. We found the two-wire magnetic flowmeter market to be significantly larger, both in units and as a percentage of the worldwide magnetic flowmeter market. We believe that our methodology is possibly more accurate than that used by other researchers. The worldwide magnetic flowmeter market appears to be growing at approximately 6% per year, so 2006 forecasts should reflect that growth.

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Potential Two-Wire Magnetic Flowmeter Market (2005)

Technological barriers that limit the applicability of two-wire magnetic flowmeters exist. Applications in which two-wire magnetic flowmeters are not currently applied include:

- large line sizes
- electrodeless primaries
- low conductivity liquids
- ceramic primaries
- partially full flows
- high accuracy requirements
- fast response
- high noise liquids (slurries)
- low cost installations

In the chemical industry, more than approximately 80% of four-wire magnetic flowmeters can likely be replaced by two-wire magnetic flowmeters. However, chemical industry magnetic flowmeter applications are dominated by sufficiently conductive liquids in pipe sizes less than 200 mm. Other industries, such as water, waster water, and pulp/paper, are dominated by larger pipe sizes that cannot be served by existing two-wire magnetic flowmeters. Given existing offerings, we estimate that the potential market for two-wire magnetic flowmeters is approximately 40% of the total magnetic flowmeter market.

Potential Worldwide Two-Wire Market	132,000 units
Worldwide Two-Wire Market as of 2005	10,900 units (8.3%)

Future technological developments that allow application of two-wire technology to larger pipe sizes, lower conductivity, and high noise flows will likely increase applicability to approximately 80 percent of the total magnetic flowmeter market.

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Two-Wire Magnetic Flowmeter Market Share by Manufacturer (2004)

Seven manufacturers of two-wire magnetic flowmeters were identified. Most of the designs can derive power from a 4-20 mA signal current loop. One manufacturer (Hitachi) offers a two-wire magnetic flowmeter system that requires only two wires between its primary and its powered (four-wire) electronics that can be mounted remote from the primary, such as in a control room. As such, this magnetic flowmeter system technically fits the characterization of a two-wire magnetic flowmeter cited above because only two wires are required to the primary. However, this design is not considered herein because it is not a two-wire loop-powered device compatible with a standard instrument signal such as 4-20 mA or standard pulse input.

The estimate and assessment of the two-wire magnetic flowmeter market for 2004 is presented in the following table with manufacturers listed in order of when their current equipment was introduced to the market. 2004 data is used because 2005 data for third and fourth quarters was not available at the time of writing.

	Worldwide	North America	Introduction to Market	General Trend
Toshiba	<50 units	<20 units	1997	-----
ABB	950 units	150 units	1998	Down
Endress+Hauser	2200 units	150 units	2000	Steady Up
Krohne	800 units	<50 units	2001	Steady Up
Aichi Tokei Denki	1600 units	<50 units	2002	Steady Up
Yamatake	3000 units	150 units	2003	Large Up
Total	8600 units	<500 units		Steady Up

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The above information paints a mixed picture of this market with some manufacturers increasing, some manufacturers decreasing, and others with almost no sales. However, the trends correlate quite well with when the respective flowmeters were introduced into the market.

The early designs (ABB and Toshiba) are generally exhibiting negative growth. The middle-aged designs of two-wire magnetic flowmeters (Endress+Hauser and Krohne) are exhibiting positive growth. One of the newest designs (Yamatake) exhibits strong positive growth. The current Yamatake model replaces their original two-wire magnetic flowmeter that was introduced in 1992. The trend of the other recent design (Aichi Tokei Denki) is difficult to gauge because of a one-time sales spike in 2003. However, the sales growth of its two-wire magnetic flowmeters has been generally positive since its original introduction in 1983.

	Two-Wire Sales 2003	Two-Wire Sales 2004	Two-Wire Sales 2004 vs. 2003
Toshiba	<100 units	<50 units	-----
ABB	1500 units	950 units	-37 %
Endress+Hauser	1800 units	2200 units	+22 %
Krohne	700 units	800 units	+14 %
Aichi Tokei Denki	2000 units	1600 units	See Below
Yamatake	1700 units	3000 units	+76 %
Total	7800 units	8600 units	+10% (See Below)

The two-wire magnetic flowmeter market grew approximately 10 percent from 2003 to 2004. However, this growth rate is artificially low due to the one-time spike in Aichi Tokei Denki sales. Removing the effect of the spike resulted in market growth of approximately 18 percent from 2003 to 2004.

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Two-Wire Magnetic Flowmeter List Prices

We analyzed list prices for ABB, Aichi Tokei Denki, Endress+Hauser, Krohne, and Yamatake two-wire and four-wire magnetic flowmeters. Toshiba pricing was not considered because of Toshiba's relatively small market share.

List prices for flanged designs varied by as much as 30 percent between manufacturers. ABB list prices are highest while Yamatake's list prices lowest across all sizes. This is consistent with the ABB trend of decreasing sales and Yamatake's trend of increasing sales. Endress+Hauser and Krohne two-wire magnetic flowmeters generally trended closer to Yamatake pricing.

List pricing for Yamatake's wafer design was lower than the list prices for its flanged design. Aichi Tokei Denki's list pricing for its wafer design was over between two and three times Yamatake's list prices. This is consistent with Aichi Tokei Denki's difficulty selling magnetic flowmeters outside of the Japanese market.

The following table contains list pricing for two-wire magnetic flowmeters.

Two-wire Magnetic Flowmeter Pricing

List prices (Sept 2005) - Teflon or similar liner - No transmitter options

			1	2	4	8
ABB	DT4311 with XT	Flange	3500	3900	4300	-----
E+H	Promag 23P	Flange	2800	3300	3500	5300
Krohne	Optoflux 4040C	Flange	3200	3200	3600	-----
Yamatake	MTG 18A	Flange	2800	2900	3300	4500
Aichi Tokei Denki	EMARG 2W	Wafer	5300	6400	8500	14700
Yamatake	MTG 18A	Wafer	2400	2400	3000	-----

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Two-Wire versus Four-Wire Magnetic Flowmeter List Prices

Further, we analyzed list prices for ABB, Aichi Tokei Denki, Endress+Hauser, Krohne, and Yamatake two-wire and four-wire magnetic flowmeters. Toshiba pricing was not considered because of Toshiba's relatively small market share.

ABB two-wire flanged magnetic flowmeter list prices are 10% to 20% higher than those of their own four-wire flanged magnetic flowmeter and approximately 50 percent higher than their own wafer magnetic flowmeter. Aichi Tokei Denki's two-wire magnetic flowmeter list prices are between 50 and 100 percent higher than their corresponding four-wire magnetic flowmeters. This price premium is consistent with weak sales outside of the Japanese market. The list prices of Endress+Hauser two-wire magnetic flowmeters are approximately ten percent higher than their corresponding four-wire magnetic flowmeters. Krohne's list pricing for two-wire magnetic flowmeters was between the prices for comparable four-wire wafer and flanged magnetic flowmeters with a tendency to be closer to the (higher) flanged pricing. Yamatake two-wire magnetic flowmeters were as much as 10 to 30 percent less than their four-wire magnetic flowmeters. This price discount is consistent with Yamatake's sharp increase in the sale of their two-wire magnetic flowmeters.

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The following table contains list pricing for two-wire and four-wire magnetic flowmeters.

Two-Wire and Four-Wire Magnetic Flowmeter Pricing

List prices (Sept 2005) - Teflon or similar liner - No transmitter options

Shading = Four-Wire

Bold = Two-Wire

			1	2	4	8
ABB	**DT4311 with XT**	**Flange**	**3500**	**3900**	**4300**	**-----**
	DX4311 with XE	Flange	3200	3300	3400	4500
	DX1475W with XE	Wafer	2400	2600	2900	-----
Aichi Tokei Denki (1 USD = 110 JPY)	**EMARG 2W**	**Wafer**	**5300**	**6400**	**8500**	**14700**
	SU (Pulse Output)	Wafer	-----	3900	4900	7500
E+H	**Promag 23P**	**Flange**	**2800**	**3300**	**3500**	**5300**
	Promag 53P	Flange	2400	2700	3300	5000
Krohne	**Optoflux 4040C**	**Flange**	**3200**	**3200**	**3600**	**-----**
	Optoflux 4300	Flange	3200	3200	3600	4600
	Optoflux 5300	Wafer	3000	3600	4400	-----
Yamatake	**MTG 18A**	**Flange**	**2800**	**2900**	**3300**	**4500**
	MGG 18	Flange	3900	4300	4700	5700
	MTG 18A	**Wafer**	**2400**	**2400**	**3000**	**-----**
	MGG 18	Wafer	2900	3200	3500	4500

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Price Discounts

Discounting the price of magnetic flowmeters is common due to the perception that the market moves entirely due to competitive pressures. While some smaller customers will pay list price for their magnetic flowmeters, discounts of over 40 percent may be offered on large projects. In addition, the pricing structure of the market is such that customers in some verticals, such as food/beverage and pharmaceuticals, receive small discounts, whereas customers in other verticals, such as water and wastewater, receive relative large discounts.

Discounts are generally not as deep for two-wire magnetic flowmeters because large projects usually do not contain large numbers of two-wire magnetic flowmeters (that are typically requested by the purchaser to reduce installation costs). On many smaller projects, purchasers are willing to pay a premium for two-wire magnetic flowmeters as compared to four-wire magnetic flowmeters that cost more to install. In addition, competition between two-wire magnetic flowmeters is not common so manufacturers are generally under less pressure to discount.

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Magnetic Flowmeter Performance

Performance of the different two-wire magnetic flowmeter models is generally similar at high flow velocity. Performance degrades as velocity decreases. There is a significant difference between the performances of the different two-wire magnetic flowmeter models at low velocity.

The performance of the two-wire magnetic flowmeters was compared to their four-wire counterparts. Note that these flowmeters were selected to reflect the four-wire magnetic flowmeter that the manufacturer would offer as an option to their own two-wire magnetic flowmeter. Therefore, the four-wire magnetic flowmeters selected are representative of four-wire magnetic flowmeters offered by that manufacturer.

The analog output accuracies of both two-wire and four-wire magnetic flowmeters operating at the relatively high velocity of 2 meters per second are generally below 1% of rate. Simply put, there is little performance advantage for four-wire magnetic flowmeters at relatively high velocities.

The analog output accuracy of two-wire magnetic flowmeters operating at 0.1 meter per second with a 2 meter per second full scale is degraded due to the reduced signal-to-noise ratio that results from energy limitations. The ABB, Endress+Hauser, Krohne, and Toshiba two-wire magnetic flowmeters specifications indicate performance of between 4.5% and 12% of rate at this low velocity condition. This performance is inferior to the average four-wire magnetic flowmeter performance of 2.5%.

However, the Yamatake and Aichi Tokei Denki two-wire magnetic flowmeters exhibit performance of between 2% and 3% of rate that is similar to the average four-wire magnetic flowmeter performance. Therefore, the performance advantage of four-wire magnetic flowmeters is somewhat dependent on which manufacturer is considered to be the competition for the application.

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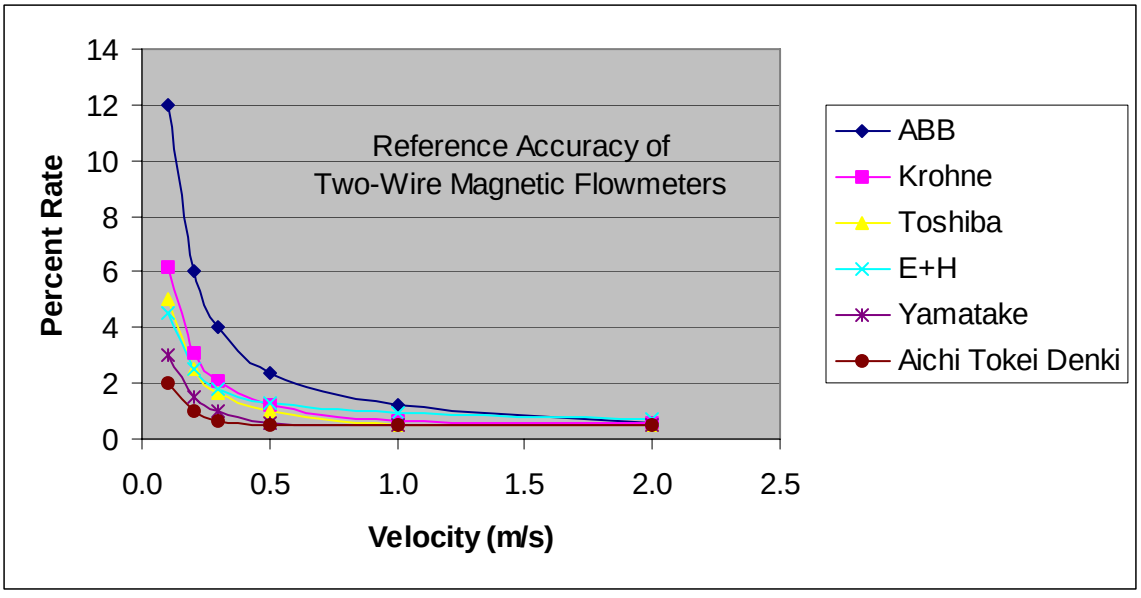
The following table and graph contain reference performance information for two-wire magnetic flowmeters offered by each manufacturer.

Reference Accuracy of Two-Wire Magnetic Flowmeters

Analog Output Accuracy (% rate at 0-2 m/s full scale)

Supplier	Model	0.10	0.20	0.30	0.50	1.00	2.00	m/s
ABB	COPA-XT (DT4311)	12.00	6.00	4.00	2.40	1.20	0.60	% rate
Krohne	Optoflux 4040C	6.20	3.10	2.07	1.24	0.62	0.56	% rate
Toshiba	LF140	5.00	2.50	1.67	1.00	0.50	0.50	% rate
E+H	Promag 23P	4.50	2.50	1.83	1.30	0.90	0.70	% rate
Yamatake	MTG18A	3.00	1.50	1.00	0.60	0.50	0.50	% rate
Aichi Tokei Denki	EMARG 2W	2.00	1.00	0.67	0.50	0.50	0.50	% rate
Average Two-Wire		5.45	2.77	1.87	1.17	0.70	0.56	% rate



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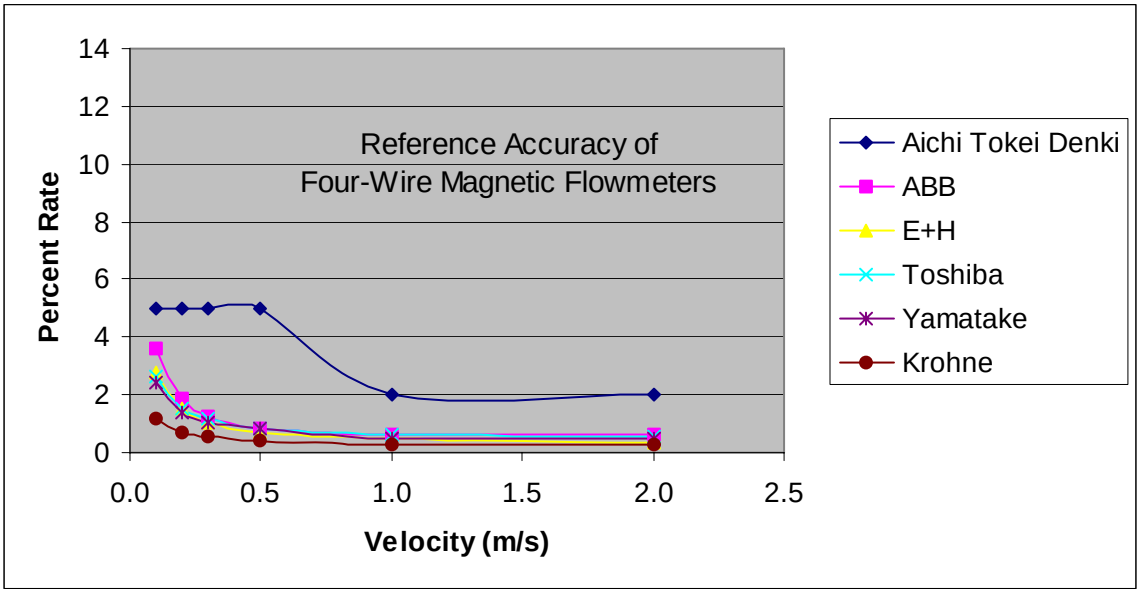
The following table and graph contain reference performance information for their likely four-wire magnetic flowmeter counterparts for the two-wire magnetic flowmeters in the previous table and graph.

Reference Accuracy of Four-Wire Magnetic Flowmeters

Analog Output Accuracy (% rate at 0-2 m/s full scale)

Supplier	Model	0.10	0.20	0.30	0.50	1.00	2.00	m/s
Aichi Tokei Denki	SU (Pulse Output)	5.00	5.00	5.00	5.00	2.00	2.00	% rate
ABB	DX4311 (XE)	3.60	1.85	1.27	0.80	0.60	0.60	% rate
E+H	Promag 53P	2.80	1.50	1.07	0.72	0.48	0.33	% rate
Toshiba	LF410 / LF 430	2.65	1.53	1.15	0.85	0.63	0.56	% rate
Yamatake	MGG 18	2.40	1.40	1.07	0.80	0.50	0.50	% rate
Krohne	Optoflux 4300	1.20	0.70	0.53	0.40	0.30	0.25	% rate
Average Four-Wire (models with analog output)		2.53	1.40	1.02	0.71	0.50	0.45	%rate



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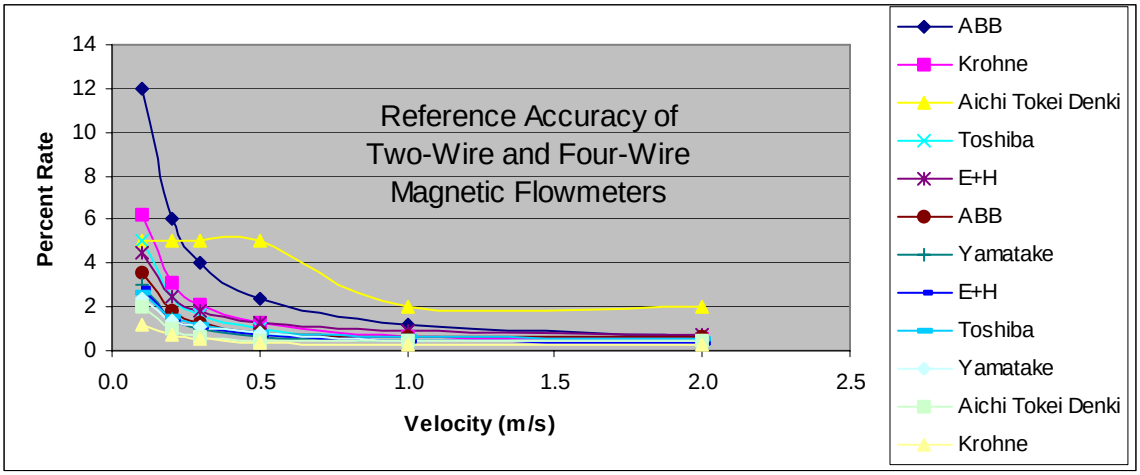
The following table and graph contain reference performance information for all of the models where the two-wire magnetic flowmeters are in **bold** for convenience.

Reference Accuracy of Two-Wire and Four-Wire Magnetic Flowmeters

Analog Output Accuracy (% rate at 0-2 m/s full scale)

Supplier	Model	0.10	0.20	0.30	0.50	1.00	2.00	m/s
ABB	**COPA-XT (DT4311)**	**12.00**	**6.00**	**4.00**	**2.40**	**1.20**	**0.60**	**% rate**
Krohne	**Optoflux 4040C**	**6.20**	**3.10**	**2.07**	**1.24**	**0.62**	**0.56**	**% rate**
Aichi Tokei Denki	SU (Pulse Output)	5.00	5.00	5.00	5.00	2.00	2.00	% rate
Toshiba	**LF140**	**5.00**	**2.50**	**1.67**	**1.00**	**0.50**	**0.50**	**% rate**
E+H	**Promag 23P**	**4.50**	**2.50**	**1.83**	**1.30**	**0.90**	**0.70**	**% rate**
ABB	DX4311 (XE)	3.60	1.85	1.27	0.80	0.60	0.60	% rate
Yamatake	**MTG18A**	**3.00**	**1.50**	**1.00**	**0.60**	**0.50**	**0.50**	**% rate**
E+H	Promag 53P	2.80	1.50	1.07	0.72	0.48	0.33	% rate
Toshiba	LF410 / LF 430	2.65	1.53	1.15	0.85	0.63	0.56	% rate
Yamatake	MGG 18	2.40	1.40	1.07	0.80	0.50	0.50	% rate
Aichi Tokei Denki	**EMARG 2W**	**2.00**	**1.00**	**0.67**	**0.50**	**0.50**	**0.50**	**% rate**
Krohne	Optoflux 4300	1.20	0.70	0.53	0.40	0.30	0.25	% rate



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Magnetic Flowmeter Technical Comparison

Flanged two-wire magnetic flowmeters are available in pipe sizes of 10 through 300 mm, however not all pipe sizes are available from all manufacturers. Aichi Tokei Denki and Yamatake offer wafer designs while Endress+Hauser offers a sanitary design. All manufacturers offer integral transmitters. However Yamatake also offers a remote transmitter.

Two-wire magnetic flowmeters operate using less energy than their four-wire counterparts. This results in a reduction of the signal-to-noise ratio that makes measurement more difficult. This is especially prevalent in liquids with low conductivity, when fast response to velocity change is required, and in liquids (slurries) that generate noisy signals.

Magnetic flowmeter performance degrades as conductivity decreases and approaches its lower limit. Test reports describing flow tests performed on ABB, Endress+Hauser, and Krohne two-wire magnetic flowmeters (WIB - July 2003) indicate the following maximum deviations based upon testing at 10, 20 and 50 µS/cm. The maximum deviation for the two-wire magnetic flowmeters is stated at the minimum specification limit for the flowmeter. The maximum deviation for the four-wire magnetic flowmeters is stated over the entire range of 10-50 µS/cm.

	Two-Wire		Four-Wire	
	Max. Deviation (% rate)	Conductivity (µS/cm)	Max. Deviation (% rate)	Conductivity (µS/cm)
ABB	0.6	50	0.6	10 - 50
Endress+Hauser	0.8	50	0.4	10 - 50
Krohne	0.3	20	0.35	10 - 50

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Two-wire magnetic flowmeters are generally more sensitive to conductivity than their four-wire counterparts. Significant errors can occur as conductivity decreases. Note that conductivity limits for two-wire magnetic flowmeters are predominantly between 20 and 50 µS/cm as compared to predominantly between 3 and 20 µS/cm for four-wire magnetic flowmeters.

In general, the response time of a given manufacturer's two-wire magnetic flowmeter is the same or greater (inferior) to that of their four-wire magnetic flowmeter. Specifically, the response times of two-wire magnetic flowmeters are between 0.2 and 1 seconds whereas four-wire magnetic flowmeters are between 0.03 and 1 seconds. However, it should be noted that the amount of noise present at the analog output of two-wire magnetic flowmeters is significantly higher than that present in four-wire magnetic flowmeters. Test reports describing flow tests performed on ABB, Endress+Hauser, and Krohne two-wire magnetic flowmeters (WIB - July 2003) indicate that the noise associated with the analog output of two-wire magnetic flowmeter is two to six times larger than for a four-wire magnetic flowmeter from the same manufacturer (depending upon operating conditions). Therefore, the response time of two-wire magnetic flowmeters in actual operation may be higher than indicated by the response time specifications because damping may have to be added in order to obtain a smooth (and usable) output signal.

Two-wire magnetic flowmeters are generally not applied to liquids such as slurries that generate significant electrical noise due to the contact between the electrode and the flowing solids. ABB two-wire magnetic flowmeter guidelines stipulate that the liquid be clean. Yamatake recommends using their four-wire magnetic flowmeter for liquids containing more than approximately 3 percent solids.

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Technical Comparison of Two-Wire Magnetic Flowmeters

		ABB	Aichi Tokei Denki	E+H	Krohne	Toshiba	Yamatake
Primary		COPA-XT (DT4311)	EMARG 2W	Promag 23H / 23P	Optoflux 4040C	LF140	MTG18A
Size - Flange	mm (inch)	15-100 (0.5-4)	50-300 (2-12)	25-200 (1-8)	10-150 (0.38-6)	25-100 (1-4)	25-100 (1-4)
- Wafer	mm (inch)	-----	20-300 (0.75-12)	-----	-----	-----	2.5-200 (0.1-8)
- Sanitary	mm (inch)	-----	-----	2-100 (0.1-4)	-----	-----	-----
Limit - Conductivity	uS/cm	50	20	50	5-20	50	10
Transmitter		-----	-----	Promag 23	IFC040K	LF240	-----
Input Impedance	megohms	Data Not Available	100	1,000,000	1,000,000	Data Not Available	80
Mounting - Integral	---	Yes	Yes	Yes	Yes	Yes	Yes
- Remote	---	-----	-----	-----	-----	-----	Yes (70m)
Hazardous Locations							
- NEC	---	I,2; I,BCD	-----	I,2, II, III	I (pending)	-----	I
- IS Electrodes	---	Yes	-----	Yes	Yes	-----	Yes
- IS	---	-----	-----	Yes	-----	-----	-----
Communications	---	HART	-----	HART	HART	HART	HART
Response Time	sec	< 5 (5 tau)	0.2	0.2	0.2	Not Available	0.5

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Technical Comparison of Four-Wire Magnetic Flowmeters

		ABB	Aichi Tokei Denki	E+H	Krohne	Toshiba	Yamatake
Primary		DX4000	SU-SY	Promag 53H / 53P	Optoflux 4300	LF410 Series	MGG18
Size - Flange	mm (inch)	3-600 (0.1-24)	50-350 (2-14)	2-25 (0.1-1)	10-3000 (0.38-120)	15-400 (0.5-16)	25-1100 (1-44)
- Wafer	mm (inch)	3-100 (0.1-4)	50-200 (2-8)	-----	-----	15-200 (0.5-8)	2.5-200 (0.1-8)
- Sanitary	mm (inch)	3-100 (0.1-4)	-----	2-100 (0.1-4)	-----	25-100 (1-4)	-----
Limit - Conductivity	uS/cm	5	50	5-20	5-20	5	3
Transmitter		XE	-----	Promag 53	IFC 300	LF420	MGG14C
Input Impedance	megohms	Data Not Available	Data Not Available	1,000,000	>10,000,000,000	Data Not Available	Data Not Available
Mounting - Integral	---	Yes	Yes	Yes	Yes	Yes	Yes
- Remote	---	Yes (DX3000)	-----	Yes	Yes	Yes	Yes
Hazardous Locations							
- NEC	---	I, BCD	-----	I,2	I	I, BCD	I, 2
- IS Electrodes	---	Yes	-----	Yes	Yes	Yes	Yes
- IS	---	-----	-----	-----	-----	-----	-----
Communications	---	HART, Profibus, Foundation Fieldbus	-----	HART, Profibus, Foundation Fieldbus	HART, Profibus (fut.) Foundation Fieldbus (fut.)	HART	DE, HART Foundation Fieldbus
Response Time	sec	1 (DX3000 = 0.125)	Not Available	0.03	0.1	Not Available	0.5

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Magnetic Flowmeter Distribution Channels

In North America, diverse distribution channels are generally competing over four-wire magnetic flowmeter sales because few users specify two-wire magnetic flowmeters and few manufacturers promote their two-wire magnetic flowmeters. Direct sales people are reluctant to spend the time and effort to convince potential customers to purchase two-wire transmitters when it is easier to offer four-wire magnetic flowmeters. Since distribution in North America is made up of some direct sales, manufacturers' reps, and some stocking distributors, this effect is more prevalent. For commission-based salespeople, or discount-based distributors, "missionary work" is difficult and expensive, so unless they are given incentives to sell new products, they tend to ignore them. These incentives are not necessarily monetary. Pricing advantages or specification exclusives also act as valuable motivators for reps and distributors.

It is unlikely that the newer two-wire designs are taking significant market share from other two-wire flowmeter technologies, flatly because there is not much market share to take. However, analysis indicates that the market for newer designed two-wire magnetic flowmeters is growing. Therefore, we anticipate it to displace a significant portion of four-wire magnetic flowmeters (see above).

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Penetrations of two-wire magnetic flowmeters into the European and North American markets are similar, so most two-wire magnetic flowmeters are sold into Asia. The most likely locations for two-wire magnetic flowmeter sales are Japan where four-wire magnetic flowmeters are likely being displaced and Asia, especially in China, India, and other countries where new plants are installing infrastructures suitable for the installation of two-wire magnetic flowmeters. Both major two-wire magnetic flowmeter manufacturers (Yamatake and Endress+Hauser) have presence in both types of markets (developed and developing) so both have similar experiences. The two-wire magnetic flowmeter market is growing, but the majority of sales are not displacing other flowmeter technologies. Therefore, two-wire magnetic flowmeter market growth is likely occurring at the expense of the four-wire magnetic flowmeter sales.

Manufacturers have directed their distribution channels to attempt to achieve significant market growth by both offering state-of-the-art two-wire magnetic flowmeter designs and campaigning them. Moreover, it is clear from the growth numbers posted by Yamatake (and to a lesser extent Endress+Hauser and Krohne) that expensive marketing and advertising campaigns are not necessary to achieve significant growth. Of course, the numbers are small enough that a significant (200%, for example) growth might not translate into that many units or that much revenue. However, manufacturers with modern two-wire designs who also are willing to spend marketing dollars to campaign them can position themselves for rapid and significant growth.

In general, sales correlate to the quality of design as compared to current four-wire magnetic flowmeters as well as the extent that two-wire magnetic flowmeters are promoted.

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Two-Wire Magnetic Flowmeter Projected Market Growth

Two-wire magnetic flowmeter market growth beyond 2006 is difficult to estimate because additional manufacturers are investigating the development or already designing new two-wire magnetic flowmeters that are anticipated to be introduced to the market in late 2006 and beyond.

Further complicating the ability to forecast this market beyond 2006 is that the quality of the new designs relative to four-wire technology is not known. Some companies may move toward elimination of four-wire designs, while others may only choose to counter competitive two-wire designs. Designs with performance and applicability comparable to the manufacturer's four-wire magnetic flowmeters will displace their own four-wire sales and other technologies (to some extent). Even thought the displacement of other technologies should be small, it will offer a "foot in the door" to new customers. Designs with performance and applicability that is better than the manufacturer's existing two-wire flowmeters could take significant market share from the existing manufacturers of two-wire and (especially) four-wire magnetic flowmeters.

Annual sales and sales growth of two-wire magnetic flowmeters (worldwide) are estimated in the table below.

	2003	2004	2005	2006
Annual Sales	7800 units	8600 units	10,900 units	13,700 units
Sales Growth	-----	+10 %	+27 %	+26 %

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Two-Wire Magnetic Flowmeter Sales

The implementation of two-wire magnetic flowmeter technology simultaneously creates advantages and disadvantages. Yet despite the advantages, 2005 sales of two-wire magnetic flowmeters are expected to be only about three percent of the total magnetic flowmeter market. Some of the disadvantages appear to be the reasons for this relatively low market penetration including:

- Application limitations, such as clean fluids only and relatively high conductivity limits as high as 50 µS versus <5 µS for four-wire magnetic flowmeters.
- Generally inferior performance (especially at low velocity) when compared with equivalent four-wire magnetic flowmeters for the same application made by the same manufacturers
- Slower response time when compared with four-wire magnetic flowmeters
- Higher price when compared with four-wire magnetic flowmeters that generally exhibit better performance. Users want two-wire magnetic flowmeters with performance and applicability that is not compromised.
- Company purchasing agreements that dictate a particular manufacturer that does not offer two-wire magnetic flowmeters. This can be difficult to change.
- Company design standards that dictate the purchase of four-wire magnetic flowmeters can be difficult (and close to impossible) to change. Changing CAD drawings, installation details, and other procedures is often rejected as too expensive and difficult to implement.
- Some manufactures have little or no promotion for two-wire magnetic flowmeters and may not speak highly of the technology. For example, one manufacturer cites limited applicability (clean liquids) and most have high conductivity limits. In general, sales people were often noted to be negative about two-wire magnetic flowmeters. After all, why do the work to promote two-wire magnetic flowmeters when it is easier to sell the four-wire units?

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- Limited applicability of two-wire magnetic flowmeters on a project can result in providing both two-wire and four-wire magnetic flowmeters. This may not be a problem for the manufacturer, but it is an inconvenience for the user who now has two installation details for the same type of equipment. This can cause confusion and errors in the design/installation. Designing a versatile two-wire magnetic flowmeter can reduce the effect of this issue.

One person summed it up by saying that the two-wire magnetic flowmeter is a "product without a market."

Nonetheless, despite these negatives, this market appears to be able to offer substantial potential if two-wire magnetic flowmeters are easy to apply and can exhibit performance similar to that of four-wire magnetic flowmeters.

Two-wire magnetic flowmeters have not been able to produce significant new sales of magnetic flowmeters at the expense of other technologies. However, it has been able to "open the door" to new customers.

The "disconnect" between the positive things that people say about two-wire magnetic flowmeter technology and its relatively small market size appears to be at least partly the quality of the two-wire magnetic flowmeters being offered.

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Manufacturers offering older designs do not promote the technology and are losing sales. And in an attempt to bolster their four-wire sales, these manufacturers are perpetuating the misinformation that two-wire magnetic flowmeters have application limitations and that four-wire magnetic flowmeters are always superior to two-wire devices. For example, one manufacturer cites that its two-wire application limitations to include clean liquids while three manufacturers require conductivity over 50 µS. Manufacturers offering recent designs with performance approaching that of four-wire magnetic flowmeters are increasing sales.

Further, these manufacturers are sometimes able to use their two-wire magnetic flowmeter offering to enter plants that would otherwise be closed to them without this product. In addition, two-wire magnetic flowmeters can provide entry to OEMs, machine builders, and system integrators who can modify their design to incorporate two-wire magnetic flowmeter features that reduce their costs and equipment size. Once they incorporate two-wire magnetic flowmeters into their equipment, they can generate sizable repeat orders as they continue to sell and manufacture their equipment.

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Fieldbus-Powered Magnetic Flowmeter Market Analysis

Two-wire magnetic flowmeter technology is an enabling technology for the development of fieldbus-powered magnetic flowmeters because solutions to the power and signal/noise limitations of two-wire magnetic flowmeters can be utilized to develop a fieldbus-powered magnetic flowmeter.

Two-wire magnetic flowmeters must operate on limited power. This requirement becomes especially acute at low velocity when the current output approaches 4 mA. This low current limits the amount of power that can be applied to the coil that in turn reduces the voltage generated at the electrode and/or reduces the number of times per second that the measurement is made. Lower coil current decreases the signal-to-noise ratio at low velocity and makes the measurement more difficult and generally less accurate. Reducing the frequency with which the measurement is made reduces the response time of the flowmeter.

Fieldbus-powered instruments have similar power restrictions. Power management techniques and signal processing algorithms used for two-wire magnetic flowmeters can be leveraged into the development of a fieldbus-powered magnetic flowmeter.

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Fieldbus-Powered Magnetic Flowmeter Market

There are no fieldbus-powered magnetic flowmeters available on the market at this time. However, two-wire magnetic flowmeters that are currently available support the HART Communications Protocol, which is in itself a fieldbus. Implementations of HART fieldbus installations have been growing faster than either Foundation Fieldbus or Profibus installations in process automation applications (data from Hart Communications Foundation, August 2005).

It is anticipated that other fieldbus-powered magnetic flowmeters will be introduced to the market starting in late 2006 or 2007. Assuming that these fieldbus-powered magnetic flowmeters exhibit performance and applicability similar to four-wire magnetic flowmeters, sales of fieldbus-powered flowmeters will displace the majority of the existing (externally-powered) fieldbus magnetic flowmeters. Sales of fieldbus magnetic flowmeters currently account for approximately 15 percent of the total magnetic flowmeter market. It is anticipated that this percentage will rise to 25 percent by 2008 as more new plants are constructed with fieldbus infrastructure, as older plants selectively adopt fieldbus technology, and as more OEMs design fieldbus technology into their equipment.

At that time, magnetic flowmeter users will either have an analog infrastructure or fieldbus infrastructure. Two-wire magnetic flowmeters will fill most analog infrastructure needs across many industries and primarily displace four-wire magnetic flowmeters. Fieldbus-powered magnetic flowmeter will fill most fieldbus infrastructure needs and will primarily displace existing fieldbus magnetic flowmeters. Therefore, both two-wire and fieldbus-powered magnetic flowmeters will be necessary in the foreseeable future.

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Both two-wire and fieldbus-powered magnetic flowmeters will displace other flowmeter technologies to some extent. Manufacturers could use this to "get their foot in the door" to develop new customers. While a significant number of units may be sold to replace other technologies on an individual basis, no major displacement of other technologies is expected. However, both two-wire and fieldbus-powered magnetic flowmeters will displace four-wire and (externally-powered) fieldbus magnetic flowmeters respectively.

Potential Two-Wire and Fieldbus-Powered Magnetic Flowmeter Market

Four-wire and (externally-powered) fieldbus magnetic flowmeters will be needed for applications that cannot be handled using two-wire or fieldbus-powered magnetic flowmeters. Nonetheless, it is estimated that the potential market for two-wire and fieldbus-powered magnetic flowmeters will eventually approach 80 percent of the total magnetic flowmeter market.

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Strategy for Managing the Magnetic Flowmeter Market

Users typically purchase magnetic flowmeters with either an analog output or fieldbus compatibility.

As two-wire (analog) technology evolves, sales of two-wire magnetic flowmeters will displace an increasingly larger percentage of four-wire magnetic flowmeters. Two-wire magnetic flowmeters will also displace other technologies to a much smaller extent. When introduced, sales of fieldbus-powered magnetic flowmeters will displace most (externally-powered) fieldbus magnetic flowmeters. Fieldbus-powered magnetic flowmeters will also displace other technologies to a much smaller extent.

Therefore, there will be markets for both two-wire and fieldbus-powered magnetic flowmeters and both should be developed. Central to both is the development of low power magnetic flowmeter technology. This can be developed concurrently for both flowmeters.

From a performance perspective, two-wire and fieldbus-powered magnetic flowmeters should (as a minimum) be designed with performance and applicability similar to that of a typical four-wire magnetic flowmeter. Failure to do so would result in a product that likely will not sell well.

From a technical perspective, two-wire and/or fieldbus-powered magnetic flowmeters function on a limited power budget. Two-wire magnetic flowmeter measurement is most difficult at low velocity near its 4 mA output. The additional power available to the flowmeter at higher velocity can be used to improve the signal-to-noise ratio and provide better measurement.

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In contrast, fieldbus-powered magnetic flowmeters can operate on a fixed (albeit low) power budget. Depending upon amount of power available from the fieldbus, performance may improve at low velocity and degrade at high velocity as compared to a two-wire magnetic flowmeter. Therefore, development should focus on the flowmeter (two-wire or fieldbus-powered) that exhibits the most stringent power budget in each velocity range. Further, the development of an intrinsically safe fieldbus powered magnetic flowmeter should be considered.

From a maintenance perspective, development of diagnostics software that continuously checks the health of the magnetic flowmeter should be considered.

At present, the potential market for two-wire magnetic flowmeters is larger than the potential market for fieldbus magnetic flowmeters. However, it is estimated that four times as many fieldbus magnetic flowmeters are sold. Entry into the market with either a new two-wire or fieldbus-powered magnetic flowmeters will involve convincing users to not purchase either four-wire or (externally-powered) fieldbus magnetic flowmeters.

Once low power magnetic flowmeter technology is developed, it is not clear whether the two-wire or fieldbus-powered magnetic flowmeter should be developed first. There are arguments for and against each. A new fieldbus magnetic flowmeter could expand sales to new customers, but the manufacturer may not get bid requests from these potential customers. A new two-wire magnetic flowmeter could provide more sales by displacing the competition offering four-wire magnetic flowmeters.

In summary, the market for two-wire and fieldbus-powered magnetic flowmeters will grow. Manufacturers who fail to plan for this eventuality will lose market share. With the increasing pace of technological development, the loss of market share could come suddenly.

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