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**Energy Management Consultation and Training Project (EMCAT):  
Demand-Side Management**

## **MUNICIPAL WATER PUMPING**

**TIRUPPUR (TAMIL NADU)  
INDIA**

**Trip Report**

**March 8 - 22, 1997**

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## TABLE OF CONTENTS

Background .....	1
Existing Systems .....	2
Energy and Water Costs .....	4
Site Visits & Observations .....	5
Energy Analysis .....	7
Pumps .....	7
Motors .....	7
Leaks .....	9
Energy Opportunities .....	11
Summary .....	13

### Appendices

- A: Transmission System Data
- B: Photos
- C: U.S. Motor Efficiency Table
- D: Ultrasonic Flow Meters
- E: Residential Water Meters

## BACKGROUND

Tiruppur, located in the Coimbatore district of Tamil Nadu, is a town of approximately 300,000 persons. The town is governed by the Tamil Nadu District Municipal Act of 1994, and the water system is controlled by the Tamil Nadu Water and Area Development Board (TWAD). Tiruppur is an industrial area, specializing in textiles and knitted cloth production. The industrial establishments are flourishing, exporting materials valued at over one billion dollars in 1996. Tiruppur accounts for 90 percent of India's knitwear exports. The municipal district and the industrial district are separate, and the industrial district is forced to truck water to Tiruppur from outlying areas. The industrial area is heavily dependent on water, making this an expensive part of their operation. The municipality obtains its water from the Bhavani River, located approximately 55 kilometers from the town.

The population of Tiruppur has grown steadily at an annual rate of 3.6% for the past three decades. Population and industrial growth have increased the demand for water, and it has become expensive to supply water to the city. In addition, because of the logistics and topography of the city and the water source, several large pumps are required to pump water to the city. Rising electrical costs have been a main contributor in the increasing costs of water. Since the municipality and the industrial district are separate, their water supply systems are also separate. Rather than pumping water, the industrial district relies on tanker trucks to haul water into the district each day.

Because of the significance of Tiruppur, several organizations have come together to propose a environmental infrastructure demonstration project. These organizations include the following:

USAID - Financial Institutions Reform and Expansion Project  
New Tiruppur Area Development Corporation  
Infrastructure Leasing and Financial Services, Ltd.  
Tiruppur Exporter's Association  
Government of India

This demonstration project's components include water supply, municipal sewerage treatment, effluent treatment plant, road improvement, land development and telecommunications. In July 1995, USAID approved twenty-five million dollars in funding support for the water supply and municipal sewerage components. They have proposed a new water supply system for the industrial district, which will increase the supply of water and should lower the cost per unit. As part of this new system, they expect the Tiruppur municipality to share a portion of the water and the costs. This discussion is ongoing, although the design for the proposed system has been completed and the system was to be bid in early 1997.

## EXISTING SYSTEMS

Tiruppur's growth has resulted in expansion of the systems supplying water to the city and surrounding areas. Originally borewells were constructed to service the city. As the need exceeded the capacity of these wells, the city developed a more comprehensive system to service the whole city. These systems are briefly described below.

### *Scheme I*

For many years, the city of Tiruppur depended on open wells for its water supply. In 1939, the population of Tiruppur was 52,500, and the need for water exceeded the capacity of the existing system. A larger well was dug at that time, although this well was dependent upon the monsoon rains to replenish the water level. Inconsistent monsoons were responsible for dwindling and/or inconsistent water supplies. In 1955, a comprehensive water supply system, referred to as Scheme I, was designed. It was constructed and implemented in 1962, pumping water from the Bhavani River to Tiruppur. This system was designed with the objective of meeting the needs of the city and seven nearby villages. At the time of the design, it was assumed that the city's population would be 80,000 in 1976 and 125,000 in 1991. In actuality, the 1991 population was over 200,000. Scheme I was designed to provide 7,265,000 liters of water /day, of which Tiruppur was to receive 5,450,000 liters/day. This quantity was designed to provide a per capita value of 68 liters of water per day. Growing population and dwindling water supplies forced the municipality to develop another water source.

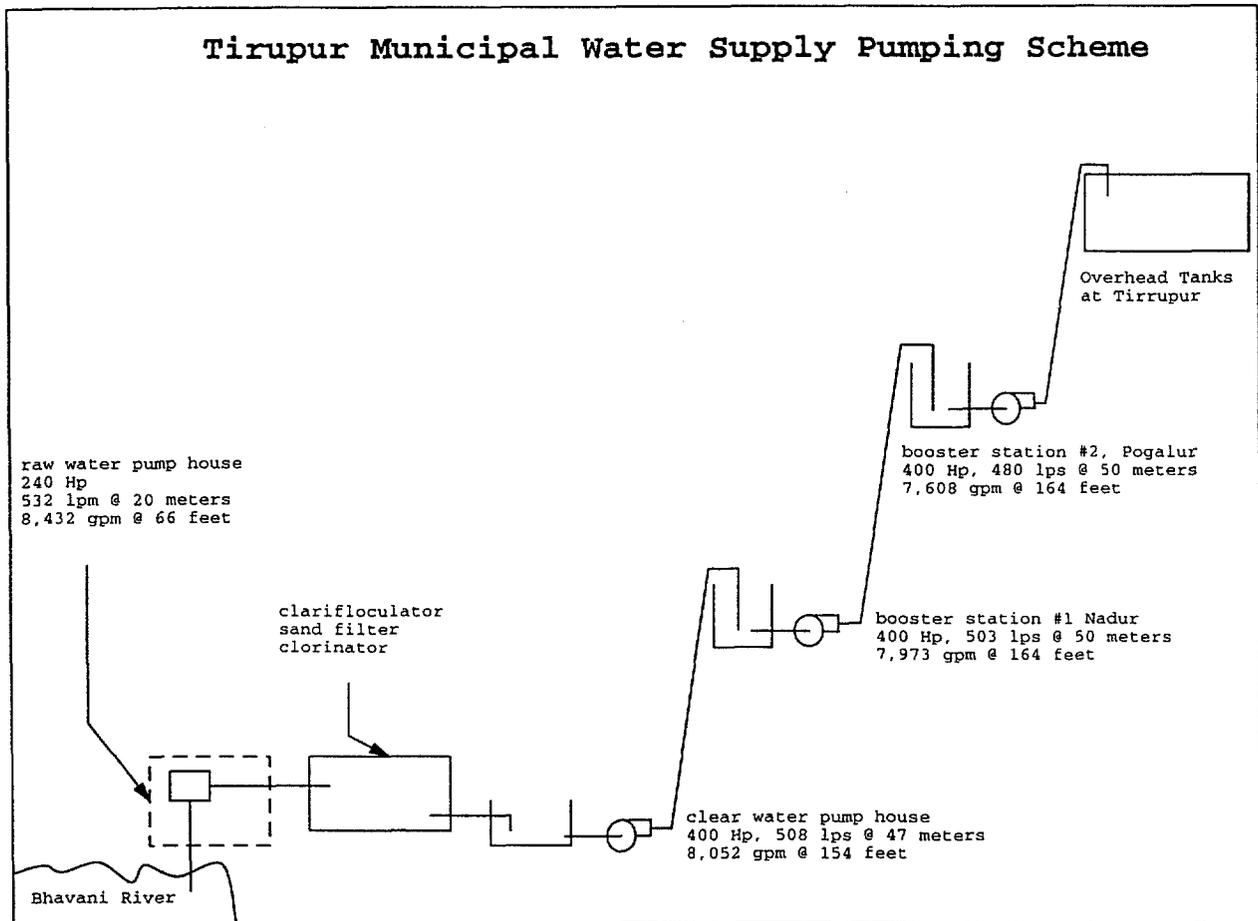
### *Scheme II*

Scheme II was designed and implemented in 1990. This system also utilized the Bhavani River as a source. It was intended to serve a population of 225,000 in 1996 and 300,000 in the year 2011. This system was designed to provide a per capita quantity of 110 liters per day, or a total production of 46 million liters per day. At the present time, not all of the distribution piping has been completed, and at least one district in the city is not served by this system. Currently, the system is only intended to pump 21 hours a day, rather than 24 hours a day under full operation. At 21 hours a day, the water production is approximately 42 to 43 million liters per day. The remaining distribution piping should be completed within the year, and then the system would be required to run 24 hours a day. However, it should be noted that the demand for water has increased faster than the design anticipated.

The development of the Tiruppur water system has also benefitted the neighboring villages along the route that the water is pumped. The villages are supplied with water, the intent being to fill their reservoirs twice a day. However, there are apparently no controls or valves on the piping, nor are there any measuring devices to determine how much water is delivered to each village. The reality seems to be that, since the villages are between the river source and Tiruppur, they get all of the water they want before Tiruppur gets water. And since the cost of delivering water to the villages is subsidized by Tiruppur, they do not have a concern over the quantity that they take. The official, unconfirmed estimate is that the villages consume 7 million liters of water per day.

Both Schemes I and II rely on three pumping stations to transfer clear water to the city. The first of these is located at the treatment plant at Mettaupalayam, the second at Nadur, and the third at Pogalur. From Pogalur the water is pumped to the city reservoirs (refer to *Figure 1* for the transmission piping diagram for Scheme II). Appendix B contains photos of Scheme I and II equipment. Each of these three pumping stations works independently in that the pumps take water from one reservoir and pump it to the next reservoir.

Figure 1



5

## ENERGY AND WATER COSTS

There are many issues facing the municipality regarding the water supply. First, there is the main issue of adequate supply. Second, the municipality is facing rapidly escalating costs, which are mainly attributable to increasing electrical costs. Electrical costs are Rs. 2.1/kWh, with a demand charge of Rs. 100/kVA-month. The maximum demand is approximately 500 kVA at each pumping station. The electrical costs have risen to account for 60% to 70% of the total cost of supplying water. The electrical costs are expected to continue to rise, and they are expected to reach 75% of the operating expenditure during the 1996-1997 fiscal year.

In addition to Tirrupur's increasing population, several other factors have made the water supply inconsistent. Since the main source of water is the Bhavani River, the availability of water is dependent on the amount of rainfall from the monsoons. During periods of low rainfall, there is less water to draw from. This either reduces the quantity of water available, or degrades the quality of water that is provided (as a result of extra silt in the water from the monsoons). Another concern is the electrical service to the pumping stations. There are many periods when low voltage is supplied. At those times, the maintenance crews have to shut off the pumps to keep from damaging them. During the spring months, these periods can be as long as 6 to 8 hours per day. Obviously, when this happens the city is deprived of water. The electrical supply (Tamil Nadu State Electricity Board) relies heavily on hydro plants for generation of electricity. When the river water is low, they cannot generate electricity.

Tiruppur officials requested an energy audit because of the high cost of electricity and their interest in trying to control or reduce these costs. They cited three main options that they were interested in:

- a. Improving the efficiency of the existing pumps
- b. Replacement of the existing pumps with energy saving pumps
- c. Non-conventional energy sources

6

## SITE VISITS & OBSERVATIONS

Discussions with the staff of the Tiruppur municipality led to the conclusion that energy analysis work should take place in the transmission system of Scheme II. Visits were made to the head works at Mettupalayam, located on the Bhavani River, and to the pumping stations at Nadur and Pogalur. (See Appendix A for data on Scheme II transmission pumps.)

At Mettupalayam, two vertical turbine pumps lift river water into a treatment plant. The raw water is cleaned and then enters the clear water pump house. From there it is pumped to a reservoir at Nadur, where it is further pumped to a reservoir at Pogalur. It is then pumped to the City, where it is distributed. As mentioned previously, there are many places along the route where water is diverted to local villages. This can be observed in the design values for the water flow rate shown in *Figure 1*. At the clear water pump house at Mettupalayam, the pump is designed to move 508 liters per second (8,432 gpm). By the time the water reaches Pogalur, the design calls for 480 liters per second (7,608 gpm) to be pumped. This difference is due to the water being taken by the local villages.

At each pump house, there are two main pumps in parallel. The system is designed such that one pump is a standby, while the other pump operates. The parameters of the three pump houses is shown in *Table 1* below:

**Table 1 Pump House Parameters**

	<b>Mettupalayam</b>	<b>Nadur</b>	<b>Pogalur</b>
flow rate, lps (gpm)	508 (8,052)	503 (7,973)	480 (7,608)
head pressure, meters (feet)	47(154)	50 (164)	50 (164)
Horsepower	400	400	400

Each pump house has two priming pumps. Their role is to pump water into the housing of the larger pumps. This ensures that the larger pumps do not operate without water in their housing upon start-up (a very detrimental situation which leads to early pump failure).

The design for this system calls for the pumps to operate continuously once the entire system is completed. Currently, the system is intended to operate only 21 hours a day because not all of the distribution piping has been completed. However, electrical supply problems force the pumps to be shut off for many hours a day, especially in the late winter and early spring. This is evident on data sheets from the 24-hour circular chart recorder obtained from Nadur for three days in March, 1997. This data is summarized below:

**Table 2 Sample Pump Operation Data - Nadur**

<b>Date</b>	<b>Hours of operation</b>	<b>Hours not operating</b>
March 9	22.25	1.75
March 10	16.5	7.5
March 11	23.75	0.25

7

The pumps and motors are turned off for as many as 6 to 8 hours a day because of low-voltage conditions. Obviously, with the pumps turned off, the city cannot get water. This dependency on the local electrical supply is one "weakness" in the design of the water supply system.

The transmission piping is composed of prestressed concrete, 600 mm in diameter. This type of piping has a higher friction factor than steel piping, thus typically requiring greater energy to pump water. The pumps must overcome all friction induced by the piping as well as elevation changes due to pumping water uphill. Any unnecessary friction (referred to as head pressure) results in having to use larger pumps to force water through the piping.



## ENERGY ANALYSIS

In analyzing the pumping systems, the two major pieces of equipment that need to be evaluated are the pump(s) and the motor(s). However, another major area of interest is the general integrity of the system. For water systems, this usually refers to leakage. Each of these items will be discussed in greater detail below.

### Pumps

Pumps are simple mechanical devices designed to move a fluid, often water. The pump typically consists of a set of blades (impeller), a housing, and a motor. Pumps are designed to move a given quantity of fluid against a resistance, or pressure. These two factors, flow rate and pressure, determine the size of the pump required to meet the specified conditions. Normally, pumps can have different sizes of impellers and motors, so that one housing can be matched up for different conditions. This flexibility also provides opportunities for energy improvements in the operation of the pumps.

In designing systems, the designer calculates the expected pressure and fluid flow rate that the pump will encounter. It is usual for the designer to then add a factor of safety to one or both of these values, ensuring that the pump will meet the minimum required performance. This "oversizing" results in potentially inefficient operation. Therefore, once a system is installed, actual flow and pressure readings should be conducted to determine the exact requirements that exist in the system. The manufacturer's data and pump curves should then be consulted to determine if a different size impeller or motor could meet the system requirements.

Pump optimization must take place in the field, and cannot be accomplished in the design phase. Measurements are required to determine where the pump is actually operating on the pump curve. Measurements of pump performance were not taken during this trip, although the operating staff had data from existing in-place instrumentation. While instrumentation was installed at the three pump houses, some of it is broken and no longer operates. The instrumentation that does operate may not be accurate, as it has not been calibrated since being installed. The observed data does, however, give a general understanding of the operation of the system.

### Motors

Although the transmission system motors are not very old, they were probably not very efficient when they were new. Compared to newer, energy-efficient motors (especially those made in the U.S.), they would now be considered to be quite inefficient. *Table 3* illustrates the resultant savings from typical motors. The second column illustrates a very conservative one percent improvement in each size motor. The third column illustrates a five percent improvement and savings in each size motor. Even the five percent savings is considered to be conservative for most Indian motors.

**Table 3 Motor Savings Resulting from Efficiency Improvement**

HP	1% Savings Rs. Per Year	5% Savings Rs. Per Year
25	4,946	24,730
40	7,922	39,588
50	9,892	49,460
60	11,876	59,352
65	12,860	64,298
75	15,838	74,190
85	16,816	84,080
90	17,806	89,030
100	19,784	98,920
150	29,676	148,380
170	33,632	168,160
240	47,532	237,408
250	49,462	247,350
300	57,600	296,760
400	79,136	395,680

Column 2 savings are per motor and at an electrical rate of Rs. 2.1/kWh. Column 2 is based on an assumed one-percent efficiency gain (from 84% to 85%). These savings are very conservative, as the existing motors are probably not even 84% efficient. Column 3 represents a five-percent savings (from 80% to 85%). New motors manufactured in the U.S. are typically more than 85% efficient, although this varies with size (see Appendix C for U.S. motor efficiency ratings). Indian motors are not as efficient as the standard U.S. motor, and are much less efficient than U.S. high-efficiency motors.

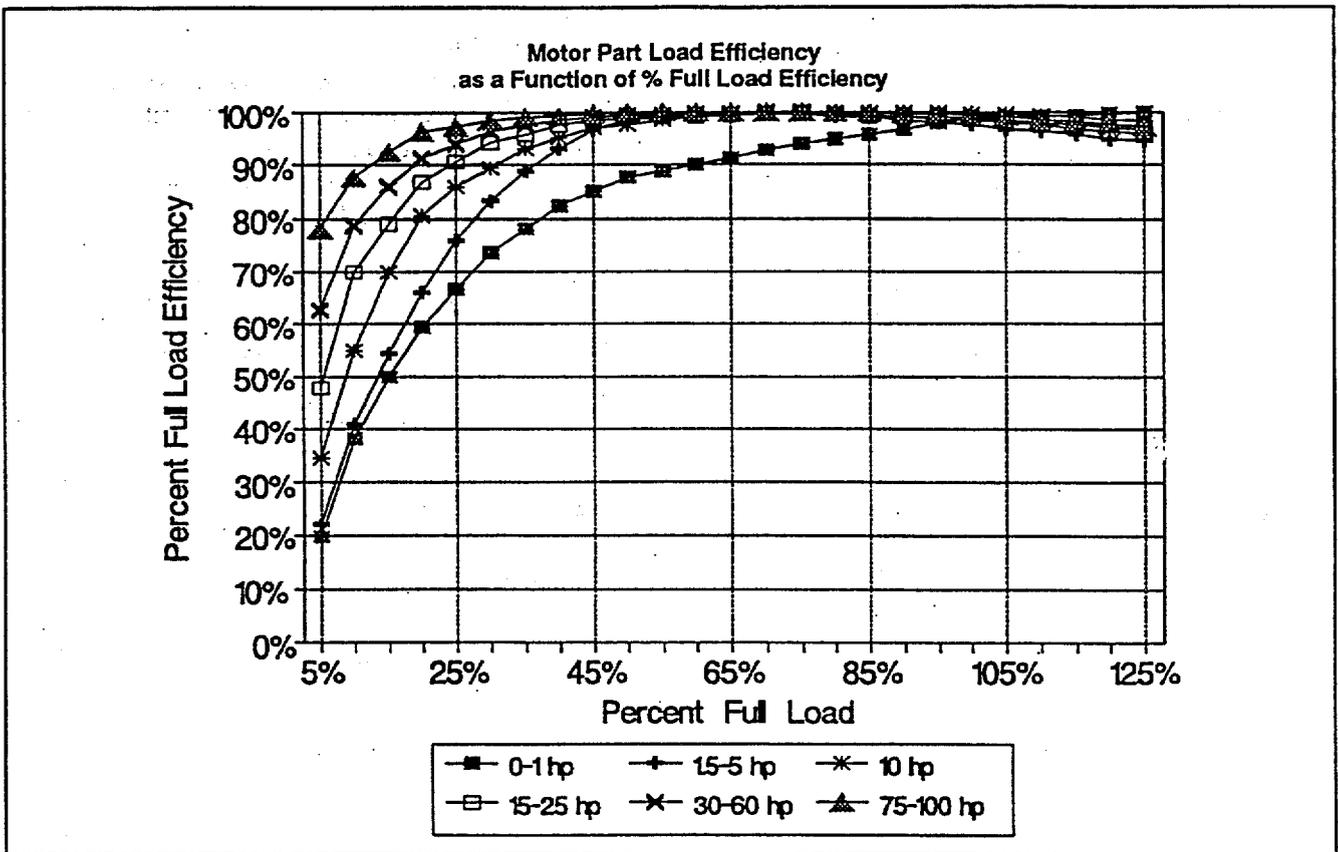
The equation to calculate energy savings is:

$$ES = 0.746 \times HP \times \text{cost} \times \text{hours} \times [100/EM - 100/NM]$$

where ES = annual energy savings  
HP = motor horsepower  
Cost = energy cost/kWh  
hours = number of hours of operation per year  
EM = existing motor efficiency  
NM = new motor efficiency

Another factor affecting motor efficiency is the percentage of loading. *Figure 2* shows how motor efficiency varies with motor size and loading. While motor sizing is not so critical for efficiency in larger motors such as those used in the transmission system, it becomes more important in smaller systems (such as distribution motors). This suggests that the potential for finding energy savings may be greater in the distribution system than in the transmission system, since larger motors tend to be efficient over a much larger range than smaller motors.

Figure 2



As mentioned earlier, this system also incurs frequent low-voltage conditions, forcing the staff to shut the system down periodically. Low-voltage conditions cause motors to run hotter, slip more, produce less torque, and have a shorter life expectancy. Efficiency impacts for low-voltage conditions are shown in *Figure 3*. This figure indicates that a ten percent drop in voltage results in a two percent loss in efficiency, resulting in an added annual fuel cost of Rs. 41,150 (\$1,175) for just one of the transmission pumps. Since there are three pumps, this totals Rs. 123,450 (\$3,525) per year.

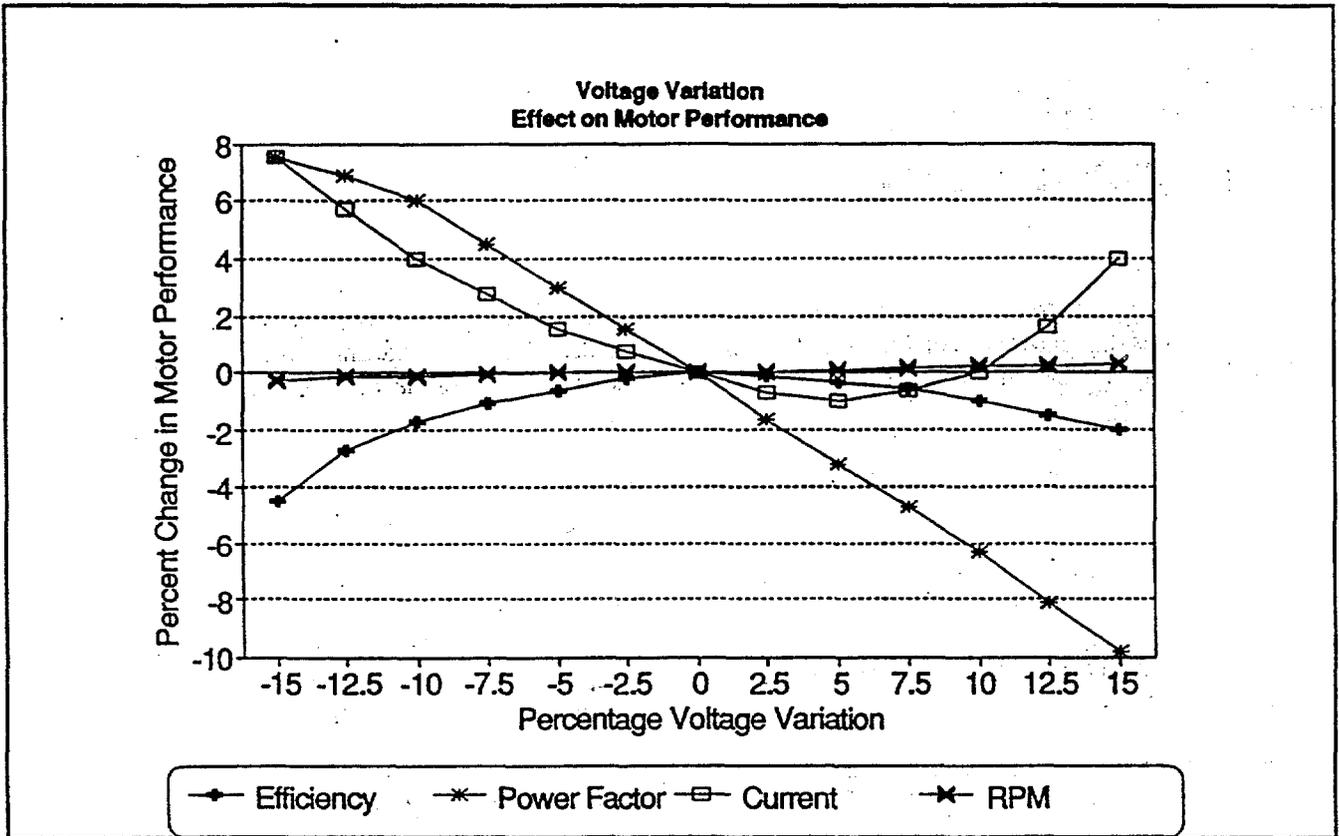
### Leaks

Leaks were observed in many parts of the system. Every drop of water lost in the system is very expensive, since it has already been pumped from the river. Costly electricity is wasted in moving water to the City and then allowing it to leak from the system.

A water leakage rate of one drop per second will ultimately amount to 192 gallons per month, or 727 liters per month. A desired production rate per person would be about 110 to 140 liters per day. Therefore, over a month's time, a drop per second would provide enough water for 5 to 6 people-days. A drop per second is quite a slow leak, and multiple, heavier leaks would severely compound this loss. It is easy to see that the water leakage rate is not a

trivial matter, and all possible steps should be taken to improve system maintenance and eliminate all leaks.

Figure 3



12

## ENERGY OPPORTUNITIES

Tiruppur is dependent on water from the Bhavani River (at a distance of about 55 kilometers). Therefore, this water must be pumped or trucked to the city. Either method is expensive and dependent on the fuel costs associated with the particular system (electricity for the pumps or diesel fuel for the trucks). The current system of pumping water is preferred under most circumstances, since the system can operate 24 hours a day.

Data for the existing transmission pumps was obtained from the Tiruppur staff. Beacon Weir pump data indicates that the three sets of transmission pumps are similar, but they have different impeller sizes because of different flow rates and head pressures. (The flow rates vary because of the water being extracted by local villages. The head pressure varies with the topography and the distance pumped.) The main savings opportunity with large pumps such as these would be the pump impeller size. The size of the impeller is directly related to the quantity of water pumped. For instance, the head pressure for the pumps at Nadur is the same as that for Pogalur. However, the quantity of water pumped at Pogalur (7,608 gpm) is less than that at Nadur (7,973 gpm), because of the impeller size. Calculations were made on the pumps and the potential for changing the impellers' sizes. The original design of the system is such that a further reduction of impeller size would prevent the pumps from delivering water to the desired reservoirs. Therefore, an impeller change would not be practical for this system.

As mentioned earlier, concrete piping is used in the transmission system. This piping has a rougher surface than steel piping, which adds greater friction and resistance to flow. Therefore, the system has to be designed to overcome this added resistance. One way to do this is to simply put in larger pumps and motors, another method is to oversize the piping. In essence, this was done in the design of this system, since the design employed a very low flow rate for the water. Calculations have shown that the piping was oversized to compensate for the higher friction factor. Therefore, even though the piping has a high resistance, it is still energy- efficient because it is oversized.

The system is, however, dependent on the availability and the quality of the electricity being supplied. As mentioned earlier, the system is shut down for several hours a day during the spring because of low-voltage conditions. Therefore, this would be a good situation in which to consider a cogeneration system or an engine-driven pump. These systems are very expensive, but they would be able to provide water continuously as opposed to the existing system which must be shut off when the electricity quality varies. Because a system like this would be an improvement over the existing system, it can not be compared on energy cost savings alone. Providing water to the city 24 hours a day has a social benefit beyond what the existing system can deliver.

Scheme I has a diesel cogeneration for the head works and treatment plant. Therefore, they are already experienced in using these systems. The Tiruppur staff estimated that Scheme II would require a 500 kVA cogeneration system, using approximately 75 liters of diesel fuel per hour. An operating cost comparison of the cogeneration system for one pump is shown in *Table 4*.

B

**Table 4 Annual System Operating Costs  
(one 400-HP Pump)**

	<b>Existing System</b>	<b>Cogeneration</b>
Electricity Costs	Rs. 64.2 lakhs (\$183,563)	-
Diesel Costs	-	Rs. 59.13 lakhs (\$168,942)
Savings	-	Rs. 511,740 (\$14,621)

This cost is based on a full year's operation, assuming a cost of Rs. 0/liter for diesel fuel and electricity costs of Rs. 2.1/kWh. (Demand is Rs. 100/kVA/month, with an additional 5% surcharge on the total electrical costs.) The estimated costs for a 500 kVA system is Rs. 27.5 lakhs (\$78,570), installed. At this cost, the system has a 5.4 year payback. The larger benefit is that the use of cogeneration systems allows the water supply system to function continuously and keeps it independent of the local electrical service. This has a social benefit to the city in that it allows continuous delivery of water without interruptions related to power quality or low-voltage situations. (There are additional concerns, such as maintenance of the cogeneration system. However, this should be minimal, and it appears that current staffing is sufficient to handle this need. )

Its reliability and ability to increase the system's hours of operation make cogeneration an attractive possibility. This option should also be considered for the future water supply project, since the reliability of the electrical supply will continue to be an issue. The city should seriously consider cogeneration for Scheme II and request proposals from suppliers to verify costs and savings. Assuming that these numbers are still favorable, they should then hire a local consulting firm (or assign two or three of their own staff ) to design the system.

4

## SUMMARY

The Tiruppur officials should be congratulated for realizing the impact of the rapidly rising cost of energy on their pumping costs, and for trying to control those costs. They are interested in exploring opportunities to reduce energy costs in their existing water systems, including both short- and long-term suggestions. We have made the following observations and recommendations as a result of the visit to Tiruppur, the discussions with staff, and site visits to the transmission sites.

The efficiency of the existing pumps is acceptable, and very little can be done to improve their efficiency. Replacement of the pumps would also provide only marginal benefits. However, motor replacement may be much more practical, and data should be collected to determine the efficiency of the existing motors. New, high-efficiency motors should be analyzed as potential replacements for the existing motors.

Cogeneration or engine-driven pumps should be investigated for the entire system to determine if they would be a cost-effective alternative to electricity supplied by the local grid. This type of equipment would eliminate the weakest link in the pumping system, the reliability of the electrical supply system.

1. Portable measurement equipment should be obtained so that the staff can obtain accurate readings of the performance of the water system. Equipment should be portable so that measurements can be taken at any location. See Appendix D for typical measuring instrumentation.
2. Water usage meters should be installed at all users so that accurate readings of the consumption can be obtained by the city. see Appendix E for typical residential water meters.
3. Water tariffs should be raised to reflect the actual costs of treating and delivering water to the residents. Greater efforts should be expended to collect payments.
4. A complete energy audit should be undertaken, especially of the distribution system (where most of the inefficiencies in pumping are likely to occur). The transmission system is already energy-efficient, and there are no large-scale improvements that can be made to that system. The audit should include taking measurements of pump and motor performance.
5. The city should review its maintenance program, especially in regard to leaks within the piping and pumping system. All leaks should be eliminated, valves and pumps repaired, etc.
6. Distribution pumps should be reviewed to determine if they are oversized. If they are, impeller sizes should be investigated to determine if they can be changed to smaller sizes to save energy.

**Appendix A**  
**Transmission System Data**

## System Data

**Location:** Mettupalayam (Head Pump House)

**Number of Pumps:** 2 vertical turbine pumps      **Hours of Operation:** 21/day

**Operating Scheme:** 1 pump operates, 1 is standby

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## Pump Data

**Manufacturer:** Jyoti (Vadodara)

**Year Installed:** 1992

**Model Number:** 550T03

**Serial Number:** B550D1F500

**Flow rate:** 31,950 LPS

**Head:** 25 meters

**RPM:** 1450

**Impeller size:** NA

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## Motor Data

**Manufacturer:** Crompton Greaves

**Year Installed:** 1992

**Model Number:** 381039 92

**Serial Number:** N22763

**Frame type:**

**Horsepower:** 240

**kW:** 180

**Volts:** 415

**Amps:** 301

**RPM:** 1,470

17

## System Data

**Location:** Mettupalayam Pump House #1

**Number of Pumps:** 2

**Hours of Operation:** 21

**Operating scheme:** 1 pump operates, 1 is standby

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## Pump Data

**Manufacturer:** Beacon Wehr (Madras)

**Year Installed:**

**Model Number:** BW SDA350450 BDS

**Serial Number:** W0053692

**Flow rate:** 508.2 LPS

**Head:** 47.0 meters

**RPM:** 1480

**Impeller size:** NA

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## Motor Data

**Manufacturer:** AEI Motor (Calcutta)

**Year Installed:**

**Model Number:**

**Serial Number:** 135493/5

**Frame type:** RW12040

**Horsepower:** 400

**kW:** 300

**Volts:** 415

**Amps:** 494

**RPM:** 1,480

## System Data

**Location:** Mettupalayam Pump House #1

**Number of Pumps:** 2 vacuum priming pumps      **Hours of Operation:** NA

**Operating scheme:** Started prior to starting main pumps

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## Pump Data

**Manufacturer:** Ashu Engineering & Plastics Pvt. Ltd.

**Year Installed:**

**Model Number:** LRV8 "CI" Brand Maneklal      **Serial Number:** 488

**Flow rate:** 156 m<sup>3</sup>/hour      **Head:**

**RPM:**      **Impeller size:**

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## Motor Data

**Manufacturer:** GEC

**Year Installed:**

**Model Number:** 132S      **Serial Number:** 1S-325

**Frame type:**      **Horsepower:** 7.5      **kW:** 5.5

**Volts:** 415      **Amps:** 11.9      **RPM:** 1 440

19

## System Data

**Location:** Nadur Pump House

**Number of Pumps:** 2

**Hours of Operation:** 21 hours/day

**Operating scheme:** 1 pump operates, 1 is standby

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## Pump Data

**Manufacturer:** Beacon Wehr Ltd., Madras

**Year Installed:** 1992

**Model Number:** SDA350/450 RDS

**Serial Number:** W0016892

**Flow rate:** 503.13 LPS

**Head:** 50 meters

**RPM:** 1,480

**Impeller size:** 427 mm

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## Motor Data

**Manufacturer:** AEI Motor, Calcutta

**Year Installed:** 1992

**Model Number:**

**Serial Number:**

**Frame type:** RW12040

**Horsepower:** 400

**kW:** 300

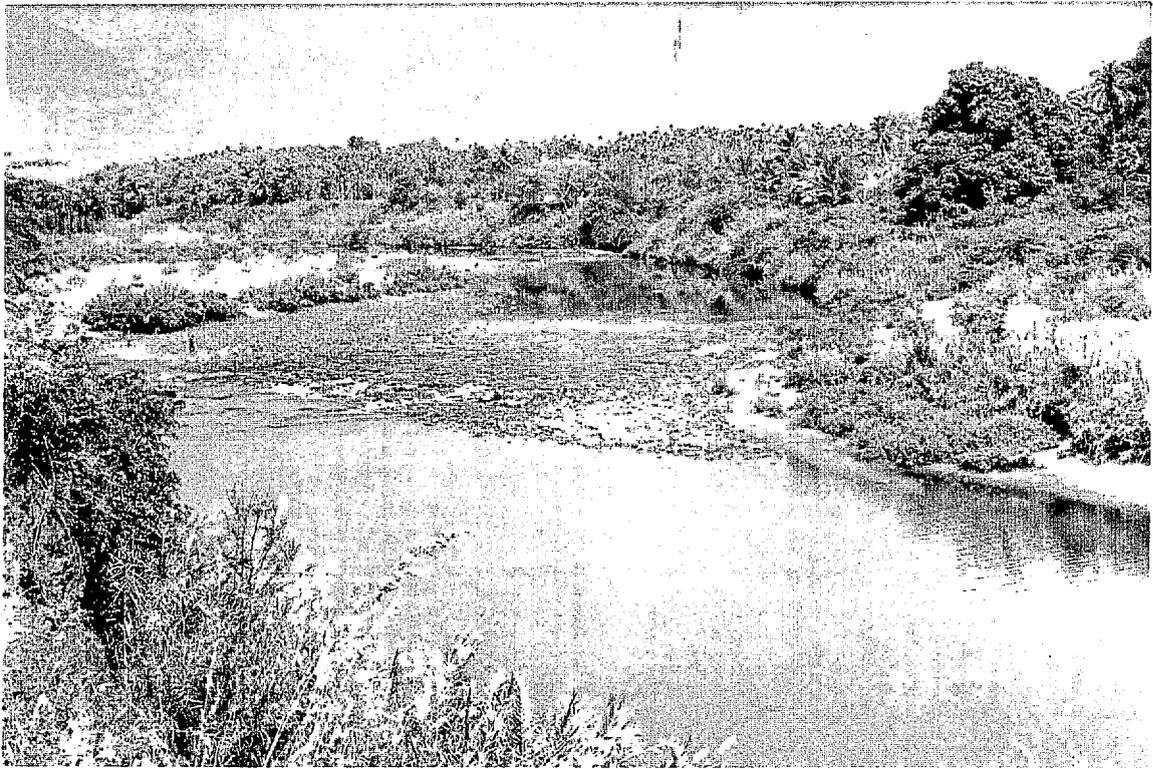
**Volts:** 415

**Amps:** 494

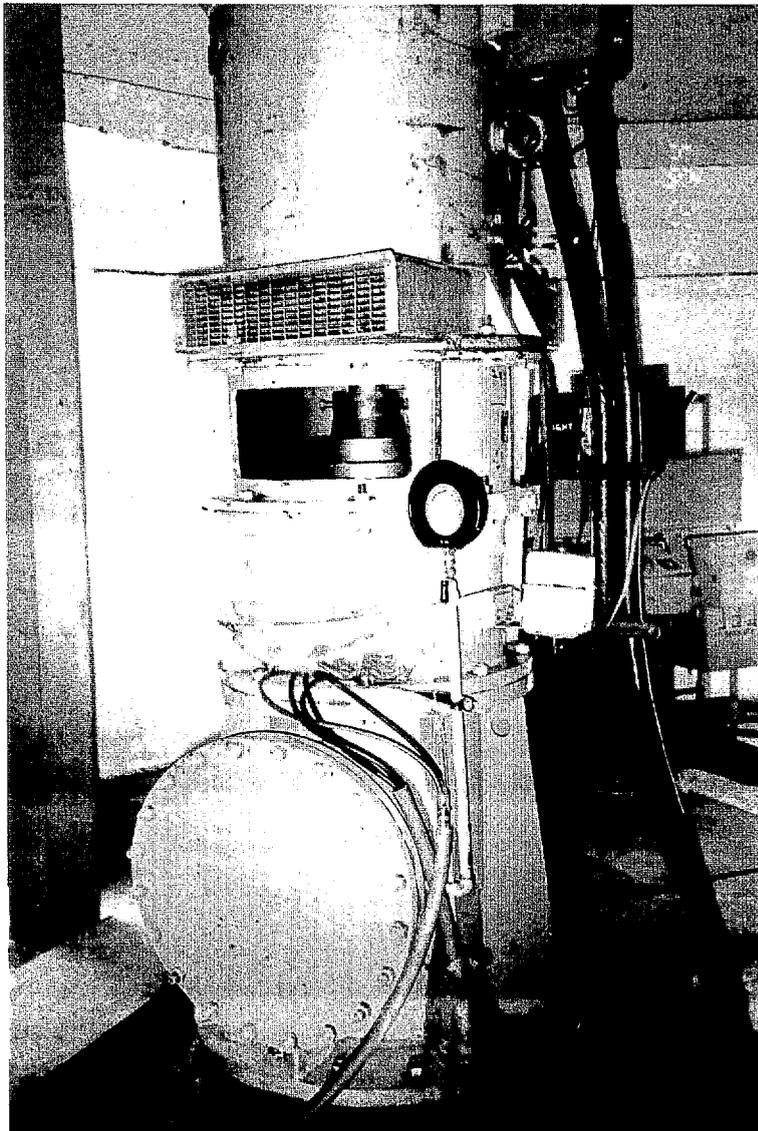
**RPM:** 1,480

**Appendix B**

**Photographs**

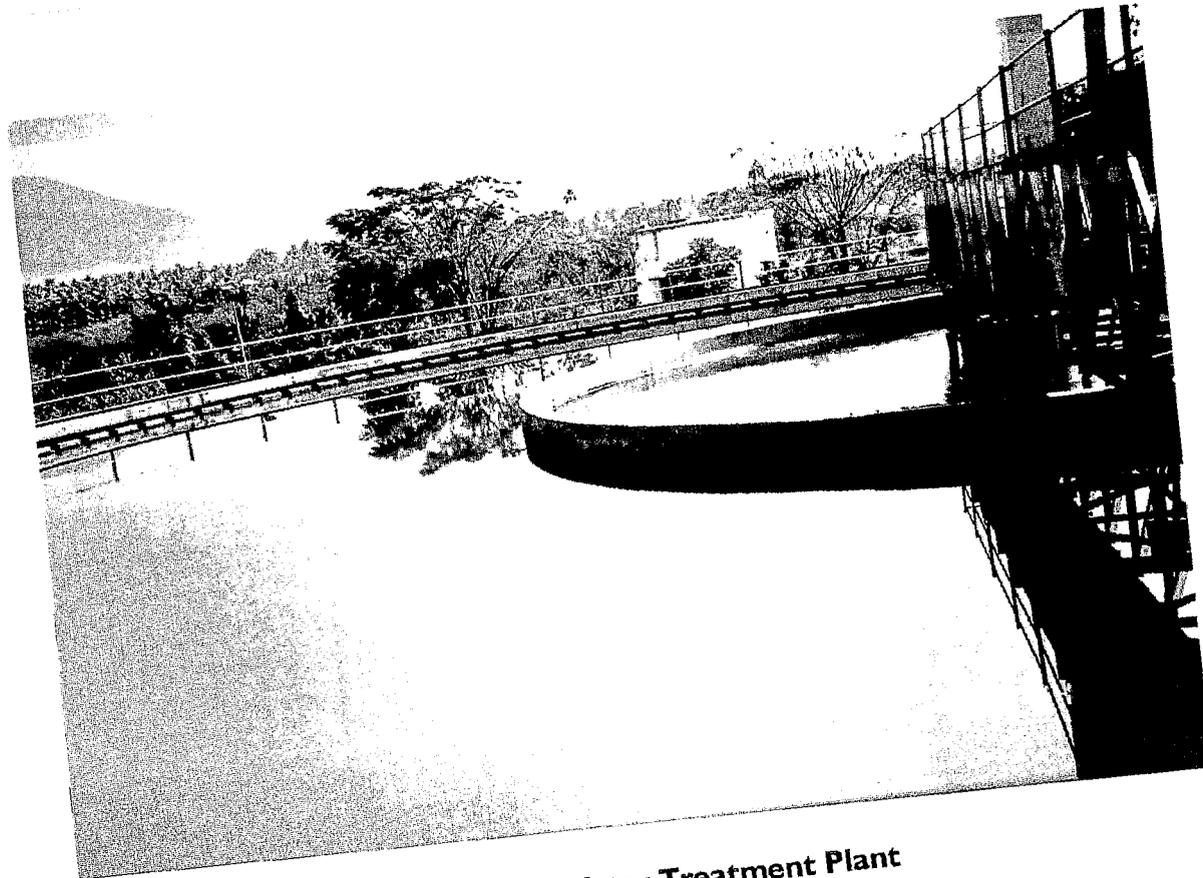


**Photo #1 - Bhavani River below the Scheme II Pump Entrance**

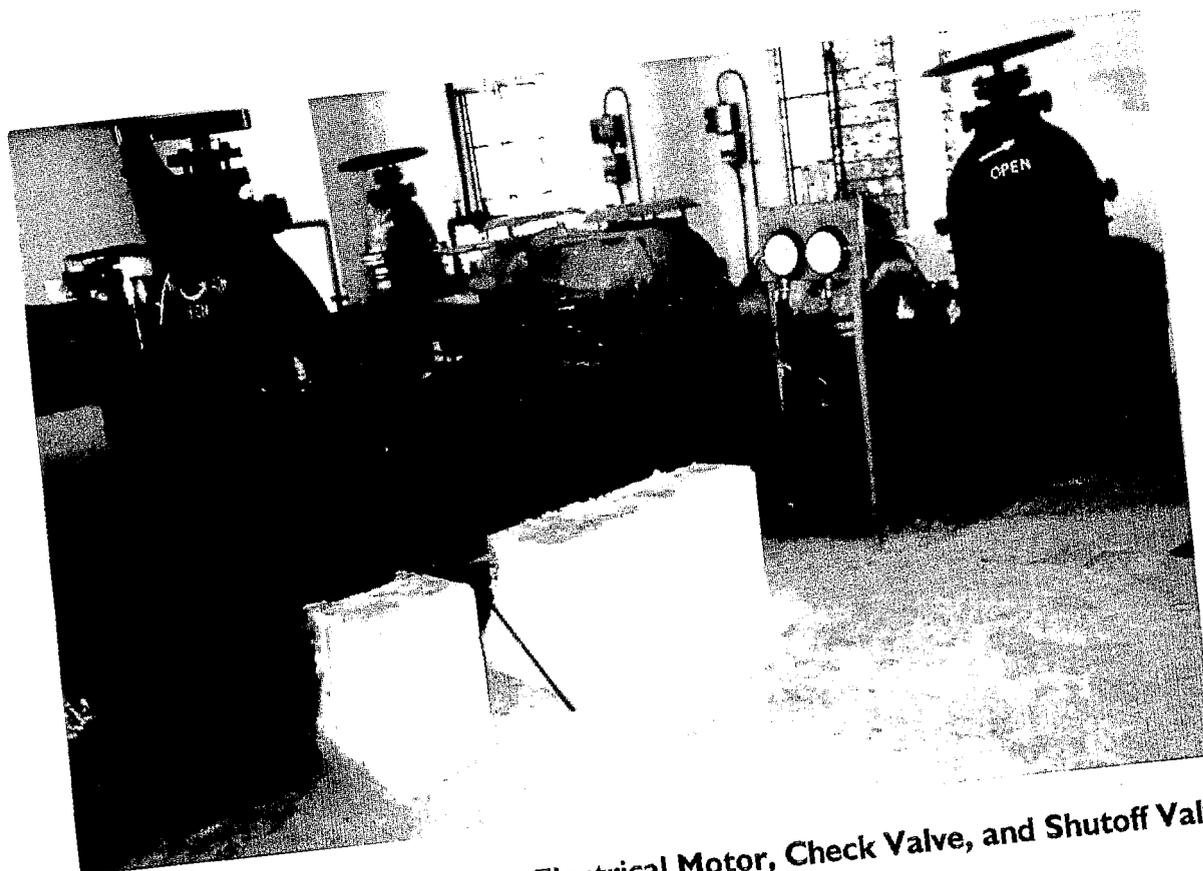


**Photo #2 - Turbine Pump  
and Electrical Motor**

22

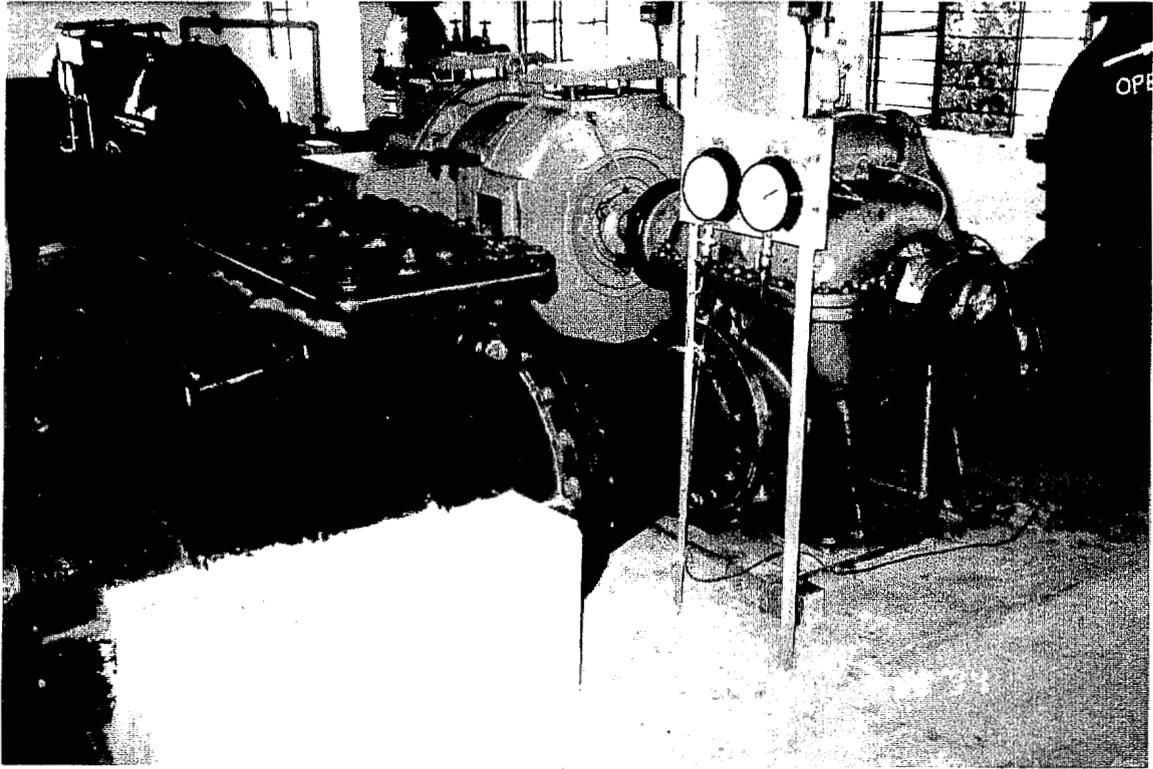


**Photo #3 - Water Treatment Plant**

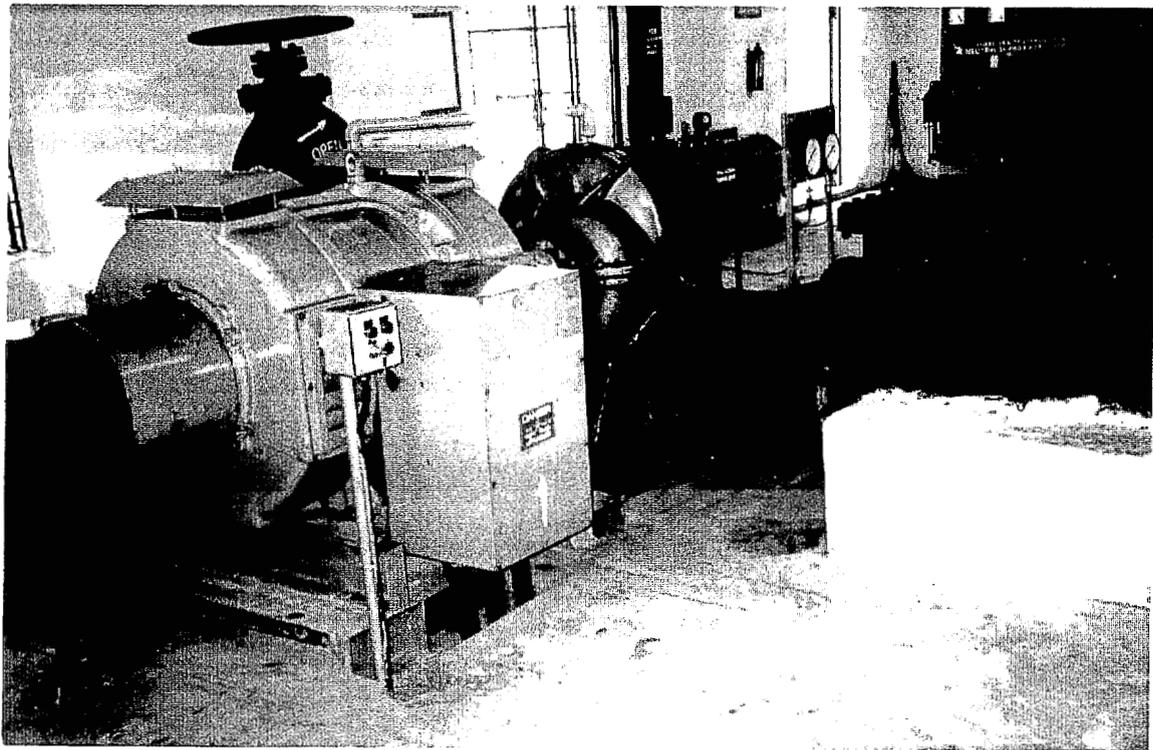


**Photo #4 - Transmission Pump, Electrical Motor, Check Valve, and Shutoff Valve**

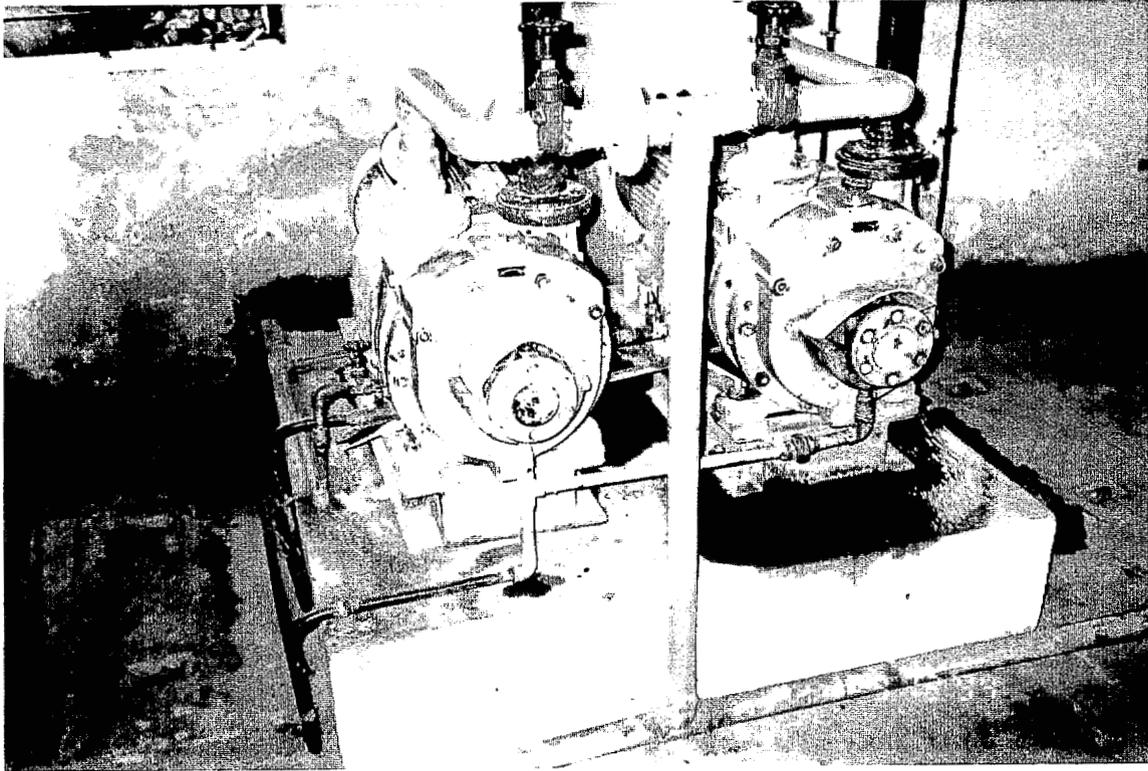
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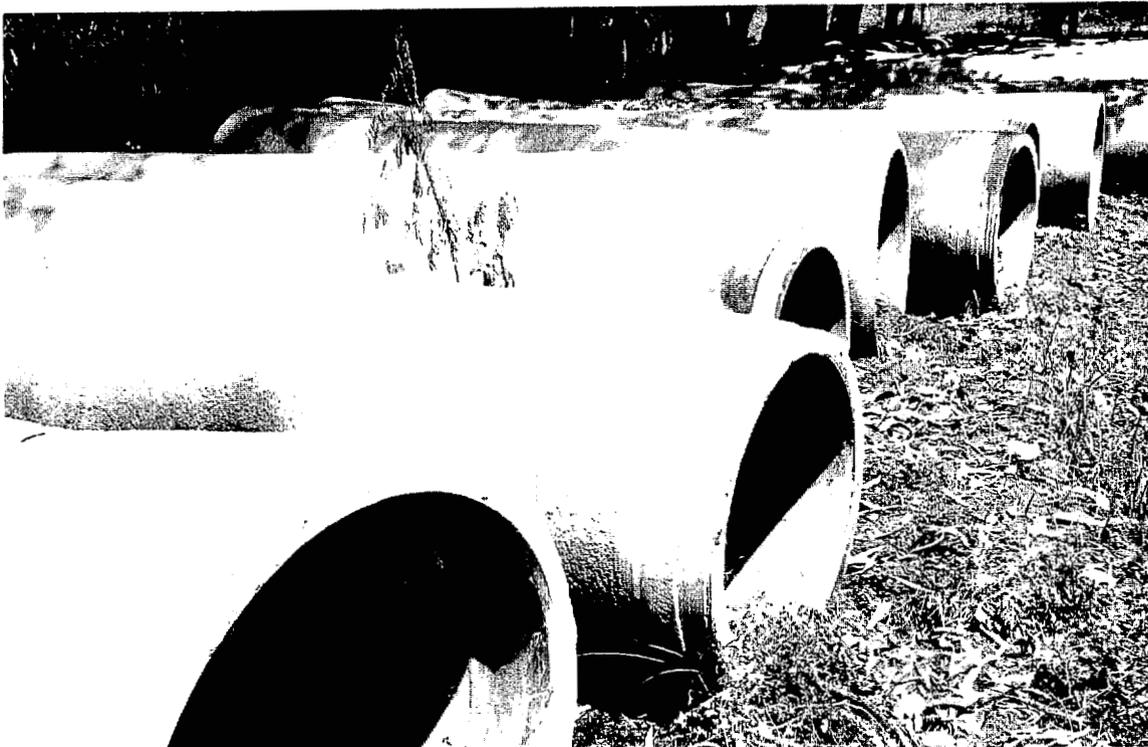
**Photo #5 - Close-up of Pump, Motor, and Check Valve**



**Photo # 6 - Photo of Electrical Motor and Pump**



**Photo #7 - Priming Motors for Transmission Pumps**



**Photo #8 - Extra Concrete Piping, Showing Liner**

**Appendix C**  
**U.S. Motor Efficiency Table**

26

# 1996 MOTOR EFFICIENCY LEVELS

NEMA Premium Efficiency Responsible Power Management									NEMA High Efficiency Responsible Power Management								
HP	Minimum Efficiencies RPM				Minimum Efficiencies RPM				HP	Minimum Efficiencies RPM				Minimum Efficiencies RPM			
	3600	1800	1200	900	3600	1800	1200	900		3600	1800	1200	900	3600	1800	1200	900
1	75.5	82.5	80.0	74.0	81.5	82.5	80.0	74.0	1	78.5	85.5	82.5	77.0	84.0	85.5	82.5	77.0
1.5	82.5	84.0	85.5	77.0	82.5	84.0	84.0	75.5	1.5	85.5	86.5	87.5	80.0	85.5	86.5	86.5	78.5
2	84.0	84.0	86.5	82.5	84.0	84.0	85.5	85.5	2	86.5	86.5	88.5	85.5	86.5	86.5	87.5	87.5
3	85.5	87.5	87.5	84.0	84.0	86.5	86.5	86.5	3	87.5	89.5	89.5	85.5	86.5	88.5	88.5	88.5
5	87.5	87.5	87.5	85.5	85.5	87.5	87.5	87.5	5	89.5	89.5	89.5	87.5	87.5	89.5	89.5	89.5
7.5	88.5	89.5	89.5	85.5	87.5	88.5	88.5	88.5	7.5	91.0	91.7	91.7	88.5	90.2	91.0	91.7	91.0
10	89.5	89.5	89.5	88.5	88.5	89.5	90.2	89.5	10	91.7	91.7	91.7	91.0	91.0	91.7	92.4	91.7
15	90.2	91.0	90.2	88.5	89.5	91.0	90.2	89.5	15	92.4	93.0	92.4	91.0	91.7	93.0	92.4	91.7
20	90.2	91.0	90.2	89.5	90.2	91.0	91.0	90.2	20	92.4	93.0	92.4	91.7	92.4	93.0	93.0	92.4
25	91.0	92.4	91.7	89.5	91.0	91.7	91.7	90.2	25	93.0	94.1	93.6	91.7	93.0	93.6	93.6	92.4
30	91.0	92.4	91.7	91.0	91.0	92.4	92.4	91.0	30	93.0	94.1	93.6	93.0	93.0	94.1	94.1	93.0
40	91.7	93.0	93.0	91.0	91.7	93.0	93.0	91.0	40	93.6	94.5	94.5	93.0	93.6	94.5	94.5	93.0
50	92.4	93.0	93.0	91.7	92.4	93.0	93.0	91.7	50	94.1	94.5	94.5	93.6	94.1	94.5	94.5	93.6
60	93.0	93.6	93.6	91.7	93.0	93.6	93.6	92.4	60	94.5	95.0	95.0	93.6	94.5	95.0	95.0	94.1
75	93.0	94.1	93.6	93.0	93.0	94.1	93.6	93.6	75	94.5	95.4	95.0	94.5	94.5	95.4	95.0	95.0
100	93.6	94.5	94.1	93.0	93.0	94.1	94.1	93.6	100	95.0	95.8	95.4	94.5	94.5	95.4	95.4	95.0
125	94.5	94.5	94.1	93.6	93.6	94.5	94.1	93.6	125	95.8	95.8	95.4	95.0	95.0	95.8	95.4	95.0
150	94.5	95.0	95.0	93.6	93.6	95.0	94.5	93.6	150	95.8	96.2	96.2	95.0	95.0	96.2	95.8	95.0
200	95.0	95.0	95.0	94.1	94.5	95.0	94.5	93.6	200	96.2	96.2	96.2	95.4	95.8	96.2	95.8	95.0

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**Appendix D**  
**Ultrasonic Flow Meters**

# Ultrasonic Meters Go With the Flow

Ultrasonic flowmeters, especially clamp-on types, offer ease and accuracy in measuring the flow of liquids and gases under a variety of conditions. They are especially useful when pipe diameters are large, or when corrosive, toxic, or sanitary fluids must be metered.

**Michael J. Riezenman**  
New York, N.Y.

**U**ltrasonic meters measure water flow in skyscrapers, wastewater treatment facilities, nuclear power plants, and Trident submarines. They are being used more and more in a number of applications because they offer several advantages over other technologies:

- They allow measurement without penetrating the pipe wall. Clamp-on meters also cause zero pressure drop inside.
- They offer turn-down ratios in excess of 1000:1, an unheard-of number with any other approach.
- They are often less expensive than alternative approaches—in both initial cost and maintenance.

Noninvasive measurement is always attractive. Sometimes its benefits border on necessity. For instance, no one wants to shut down a nuclear reactor to install or maintain a flowmeter. Similarly, violating the integrity of a sterile-water pipe in a pharmaceutical plant can cost a fortune in resanitization and certification procedures. On a submarine,

choosing a clamp-on meter over an in-line (wetted) unit means eliminating a potential leak—something submarine designers are always eager to do.

The range of ultrasonic flowmeters makes them a good choice for functions from sewer-water monitoring to HVAC applications. Sewer flows can vary from a trickle of liquid waste in dry weather to a torrent of rainwater during a storm. The hot and chilled water flows in a building vary enormously. Ultrasound can cover the entire range in both cases.

Because clamp-on ultrasonic flowmeters strap onto the outside of a pipe, their cost is virtually constant regardless of the size of the pipe. The financial advantage over in-line meters for large pipes is obvious. In addition, there are savings in maintenance. Replacing or repairing an in-line meter on a large pipeline is expensive, not only in its direct costs but also in losses from shutting down. Clamp-on ultrasonic meters rarely need servicing. And when they do, the loop isn't interrupted. The ease and economy of adding a clamp-on ultrasonic flowmeter to an existing loop is also important when a plant manager considers adding flowmeters to increase efficiency. Being able to add a meter without interrupting operations may make the difference between adding it and doing without it.

Ultrasound has already become the dominant technology in open-channel flow measurement, where no one disputes its advantages, but for closed pipes, many potential users don't believe the technology can match the accuracy of more conventional measurement techniques. Others, including both instrument makers and users, argue about the relative efficiencies of wetted meters and clamp-on devices. Some also harbor misconceptions about the benefits and effective applications of transit-time and Doppler measurements.

In the early days of ultrasonic flow measurement, manufacturers were better at selling meters than making them. Understandably, a user who was disappointed by one of those instruments may still mistrust ultrasonic units. This is unfortunate because in most cases they offer greater accuracy than competitive technologies.

## The Transit-Time Approach

Ultrasonic meters are often divided into two main categories: transit time and Doppler. Of the two, the transit-time meter offers the best potential for high-accuracy measurements under the widest range of conditions.

The operating principle of this meter is simple. Two ultrasonic transducers are positioned at different points along the length of a pipe and on opposite sides of it, angled so that they face each other (Figure 1). Alternatively, they can be mounted on the same side, in which case the sound is bounced off the opposing wall. Each transducer acts alternately as a transmitter and a receiver, first transmitting a pulse of ultrasonic energy to the other transducer and then receiving one. The electronic circuitry to which both transducers are connected measures the time the pulses take to travel in each direction.

The upstream and downstream times will not be the same because the path of the pulses has a component that is parallel to the fluid flow direction. A component of the fluid velocity will add to the velocity of propagation of the downstream pulse and subtract from that of the upstream one. Referring to Figure 1, the difference between the two transit times will be:

$$1/T_{AB} - 1/T_{BA} = [C + V(X/L)]L - [C - V(X/L)]L \quad (1)$$

where  $T_{AB}$  is the downstream transit time from point A to point B;  $T_{BA}$  is the upstream time;  $C$  is the velocity

of sound in the fluid;  $X$  and  $L$  are as defined in Figure 1; and  $V$  is the average velocity of the fluid between the transducers. Rearranging the terms of Equation 1 yields:

$$V = (L^2/2X)(T_{BA} - T_{AB})/T_{AB}T_{BA} \quad (2)$$

This relates the velocity of the fluid to the upstream and downstream transit times and to a pair of linear dimensions.

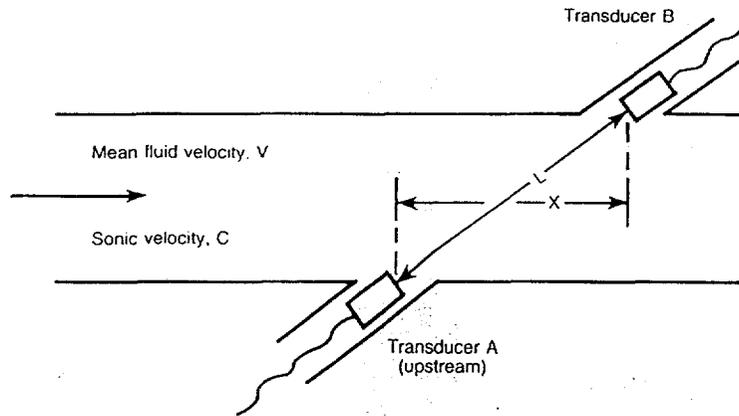
Of course, fluid velocity is not the same at every point in a pipe; even if it were, it isn't the same as volumetric flow. Most of the controversy about ultrasonic flow measurement stems from these two facts.

A velocity measurement is converted into a measure of volumetric flow by multiplying it by the flow area of the pipe. The meter automatically calculates this from the values the user programs for outside diameter and wall thickness. The calculation will be inaccurate if the user is casual about those numbers—for example, either taking published nominal values as precise or not accounting for the increase in a wall's thickness from mineral deposits.

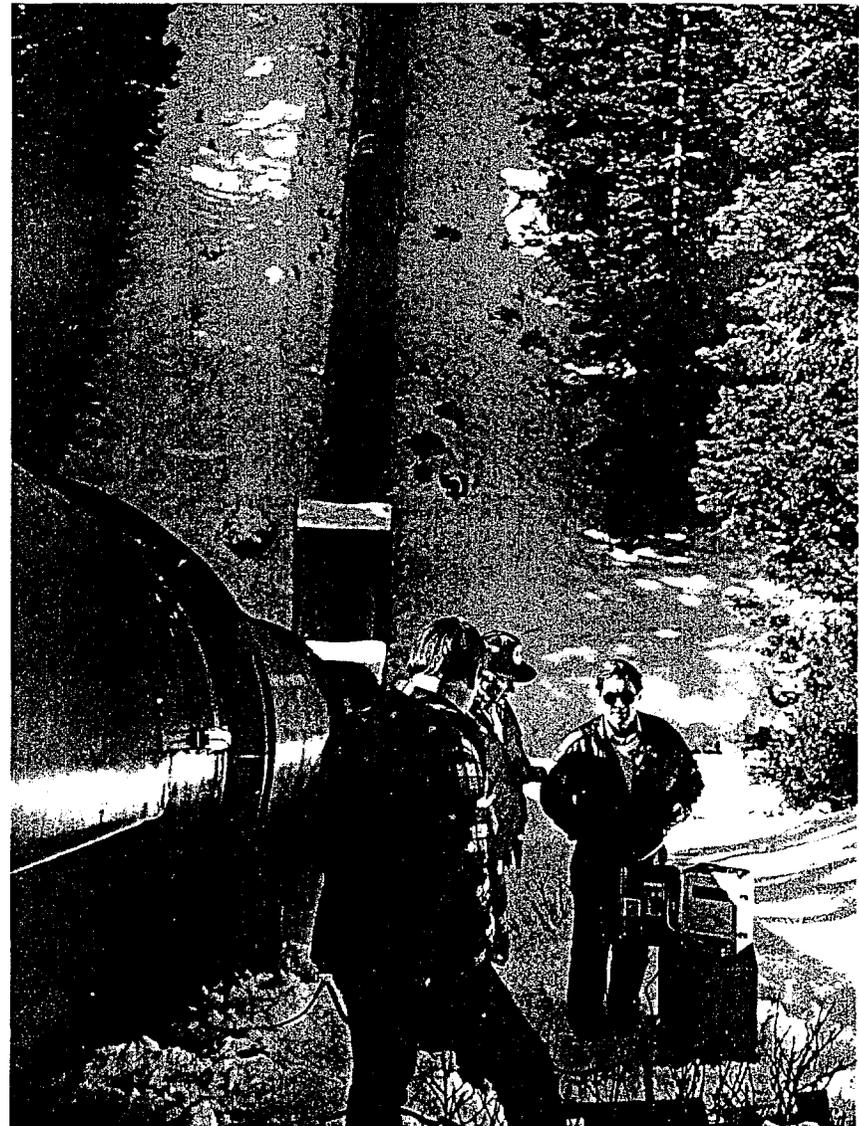
Critics frequently cite this potential inaccuracy as a reason to avoid the technology. They reason that clamp-on meters, which transmit their acoustic signals through the pipe wall, are especially vulnerable to inaccuracy because users have no way to assess pipe conditions or dimensions. Fortunately, that is not true. The problem is not so much in verifying pipe dimensions as it is in recognizing that they must be verified. A tape measure or caliper is all that's needed to verify outside diameter and an ultrasonic wall thickness gage will give all the additional data for the calculation.

Other misconceptions relate to flow profile. An ultrasonic flowmeter must measure the average flow in the pipe. Critics question how it can do this if its beam samples the flow along only one thin slice. In most cases, the tilted-diameter meter path used by simple transit-time instruments provides a measurement that can be related reliably to the average velocity, provided the flow profile is fully developed and not distorted. As Doug Baumel at Controlotron Corp. (Hauppauge, N.Y.) points out, that is no different from the requirement for traditional instruments.

Any flow monitor (a turbine, orifice plate, magnetic device, or ultrasonic unit) requires a certain amount of straight pipe run to deliver its rated accuracy. Ultrasonic units perform best when a fully developed



**Figure 1. Transit-time technique with wetted transducer.** This technique measures the difference between upstream and downstream times to determine flow velocity. It is the only flow-measuring technique that actively measures zero flow. The technique works well with clamp-on devices.



**Measuring cooling water flow.** A portable transit-time instrument is being used to measure the cooling water flow through a large-diameter pipe from a facility of Pacific Gas and Electric.

Controlotron

flow profile is achieved. But the other meters simply suffer the unavoidable errors when there is only a limited straight run. Ultrasonic units may be positioned to minimize the error and, if necessary, multiple-path units can almost entirely eliminate the error.

Errors are not a problem when flowmeters are used on submarines, where long straight runs are rare. Baumel explains that the key is to position the sensors so that the acoustic beams go along a path that truly samples the flow. That means that if a horizontal pipe makes a bend, the user must realize that the flow will be faster on one side than on the other. To get a representative sampling of the flow, transducers are mounted on the sides of the pipe so that the beams go through both the high- and low-flow regions. Mounting the transducers on the top and bottom of the pipe would lead to errors.

If the flow is distorted in more than one plane, it may be necessary to use a multiple-path scheme in which up to four beams sample the flow in different planes to ensure that a valid average velocity can be acquired. The data gathered by the beams are processed automatically by the meter. So, from the user's point of view, the only difference between a single-path meter and a multiple-path system is that the latter costs more and delivers more accurate results in difficult situations.

A unique advantage of clamp-on ultrasonic instruments is that they allow the user to assess whether they are sampling the flow adequately. If a single-path transit-time flow sensor is mounted in several orientations around a pipe and the flow readings are checked to see that they stay the same in the various planes, then the flow is fully developed and the readings are valid. No other technology allows for such verification without the use of external equipment.

Despite these advantages, many experts feel that better results can be obtained with wetted ultrasonic meters. Kevin Brown at NuSonics, Inc. (Tulsa, Okla.), believes that uncertainties about the thickness of pipe walls and the positioning of transducers make clamp-on meters less accurate than wetted ones. Lawrence C. Lynnworth at Panametrics, Inc. (Waltham, Mass.), feels that wetted meters are usually more accurate than clamp-on ones because with wetted meters the manufacturer is usually responsible for machining the spoolpiece. Lynnworth thinks that provides the best possible con-

trol over, and knowledge of, such critical dimensions as internal diameter. With wetted transducers, the manufacturer has more control over the frequency and the acoustic path in the fluid, both of which affect accuracy and response time. Lynnworth doesn't insist that wetted transducers are always more accurate. He simply feels that, as a practical matter, clamp-on instruments are so easy to use that they are more likely to be abused or misapplied than wetted transducers.

Baumel claims that his experience demonstrates both the theoretical and practical superiority of clamp-on meters. He thinks that wetted-transducer instruments create unpredictable disturbances in the flowing fluid. At sufficiently high velocities, the transducers sticking into the stream can cause cavitation. The bubbles thus created will probably form an acoustically insulating shield around the transducers and render the meter inoperative.

### The Doppler Alternative

Bubbles caused by cavitation around transducers are a fairly rare phenomenon in flow measurement, but they are not the only thing that can interfere with transit-time meters. Suspended solids can also be a problem. Although transit-time flowmeters can tolerate a certain percentage of reflectors in the fluid, there is a point at which the scattering and attenuation cause the meter to stop. But this is an improvement over a few years ago, when the slightest reflection caused transit-time meters to shut down.

That doesn't mean that ultrasonics cannot be applied to "dirty" fluids. But a different approach must be used—the Doppler technique, in which the reflective contaminants are actually the basis of the system. Acoustical energy is transmitted into the fluid; reflected off the suspended particulates, bubbles, or even discontinuities in the flow; and picked up by a receiving transducer located next to the transmitter. Movement of the reflector toward or away from the transducers causes a frequency shift that corresponds to the speed of the reflector. So, like the transit-time instrument, the ultrasonic Doppler meter measures velocity and calculates flow from it.

It sounds simple and in principle it is. In practice, however, a number of factors confuse it. One is the fact that all of the particles in a flow do not move in the same direction at the same speed at the same time. Gravity may cause some to rise and others

to fall. Local flow disturbances may push them in various directions. And they will probably collide, so that some will be moving against the flow for brief periods. The entire population of particles or bubbles will, of course, move at the average flow rate. But how can one be sure that the Doppler meter is getting its reflection from an average reflector? In general, it isn't even possible to tell how deeply the beam is penetrating into the flow. That is, one generally cannot control or know the location of the particles on which the measurement is based.

In the early days of ultrasonic flow measurement, it was precisely these problems with Doppler meters that gave the technology its questionable reputation. Today, however, manufacturers use sophisticated signal-analysis techniques to eliminate much of the uncertainty. In its simplest form, the Doppler technique probably never will achieve the precision of transit-time measurements, which have the advantage over simple Doppler systems of being able to average the flow along a path that traverses the entire flow profile; nevertheless, the Doppler technique can yield excellent results in a variety of situations.

At Controlotron, fast Fourier transform techniques are used to analyze the return spectra and to distinguish between echoes from fluid velocity and those from pump noise, pipe vibration, and other corrupting influences. Polysonics, Inc. (Houston, Tex.), which specializes in Doppler flow measurements in liquids, also uses sophisticated digital filtering techniques.

Controlotron feels that the transit-time approach is inherently more accurate than Doppler and it is developing its transit-time meters to work in ever dirtier fluids; Polysonics is going in the other direction. A mainstay of its research is to make its Doppler meters work in ever cleaner media. Controlotron boasts that it has used transit-time techniques successfully to measure the flow in coal-oil and coal-water slurries with up to 80 percent solids. Polysonics has used Doppler methods to measure the flow of liquids with no particles or bubbles. The condition was an extremely quiet environment with substantial flow disturbances from which reflections could be detected reliably.

The most obvious way to make a Doppler system work with acoustically clean liquids is to raise its operating frequency: the higher the frequency, the shorter the wavelength

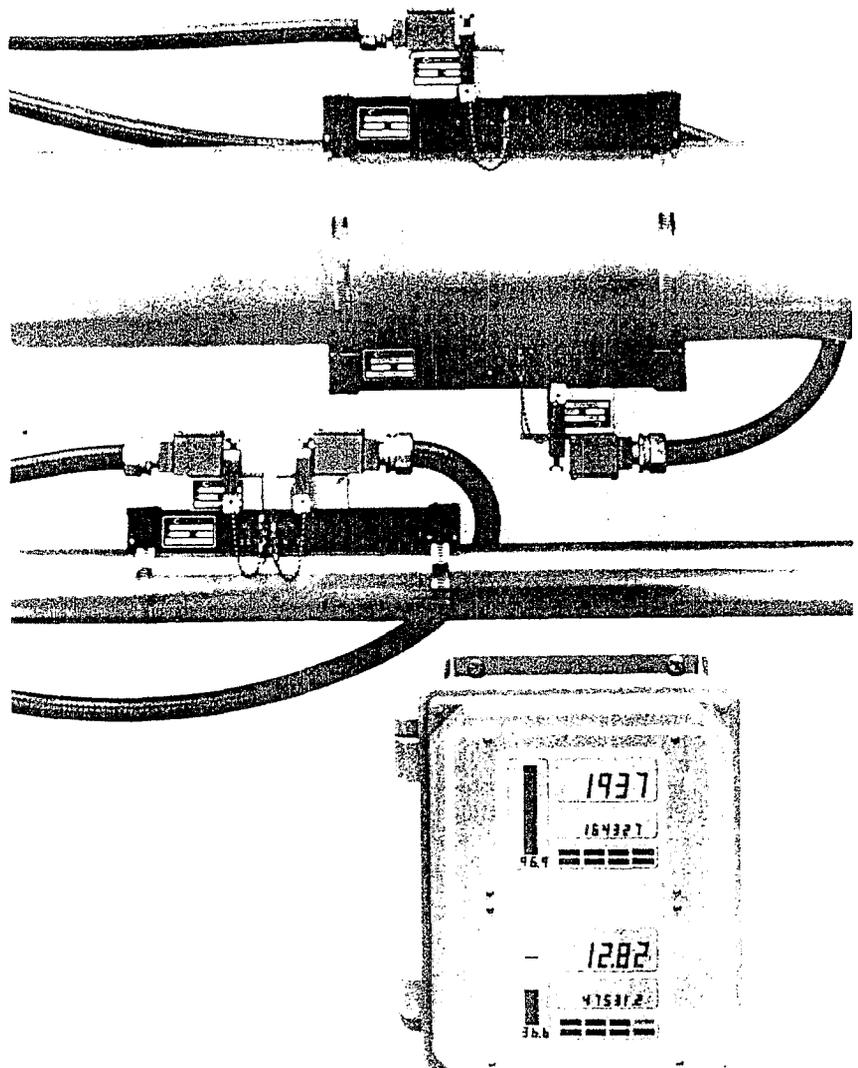
and the stronger the reflections from tiny particles. Unfortunately, short-length waves also reflect better from swirls, eddies, and other disturbances in the flow stream. Polysones has found that, by boosting power levels and sticking with frequencies on the order of 0.5 to 1.0 MHz, it can extend the applicability of Doppler systems. Boosting the power of its transmitted signals increases reflector returns, thus raising signal-to-noise ratios and improving overall performance. Unfortunately, higher power and cleaner fluid also mean that the signals can travel a considerable distance down the pipe. Then reflections may come from unexpected places, some of which may cause erroneous readings. Clean-liquid Doppler applications therefore require that sensors be located very precisely. Special care must be taken to ensure that reflections are not obtained from partially open valves, reduced pipe sections, or other elements that restrict flow, because the elevated frequencies generated within them can lead to erroneously high readings.

Transit-time and Doppler systems now have a tremendous amount of overlap in their applications, so the choice between them no longer needs to be based on the acoustical cleanliness of the flowing liquid. It can instead be based on performance and cost. In general, Doppler systems are less expensive than transit-time instruments and, for a significant number of applications, they offer more than enough measurement accuracy. When the highest accuracy and repeatability are required, transit-time is a better choice. Transit-time meters also produce valid readings at flow rates approaching zero. Doppler systems have a minimum flow velocity below which they can't be used.

A meter that functions both ways is being field tested by Panametrics. It is aimed at applications with clean liquids that unexpectedly turn out to be dirty—either literally or because of bubbles or other disturbances. The meter would automatically switch from its transmission mode to reflection operation without any changes in hardware; the transducers are operated in a different way and a different software program processes the acquired data. It is not clear yet whether the approach will be economically viable.

### It's a Gas

So far, ultrasonic flowmeters have been used almost exclusively to measure liquid flows. In fact, their appli-



**Transit-time meter.** The two sensors do not always have to be located opposite each other, as on the larger pipe (top). They can also operate in a reflective mode, with the sensors collocated, as on the thinner pipe (bottom).

cation to gases is so unusual that many engineers do not believe it's possible to measure gas flows with ultrasound. According to Lynnworth, there is a popular misconception that gas causes severe attenuation of ultrasonic waves; he says the real problem is not attenuation but coupling. An acoustic mismatch is caused by the low-density and low-sonic velocity of gas on the one hand and the relatively high acoustic impedance of the transducer on the other. So the problem is not attenuation of the ultrasound in the gas; it's getting the waves launched in the first place.

Panametrics has had some success in this area with specially designed wetted transducers, which are used in its flare-gas monitoring systems. Flare gas—the variable-composition gas burned at the tops of flare stacks at oil refineries—is an ideal application for ultrasonic monitoring for at least three reasons: its flow rate var-

ies from a trickle under most conditions to a torrent when a pressure-relief valve opens; it often fouls meters with moving parts; and safety regulations prohibit the use of pressure-dropping restrictions in flare-gas lines. These considerations make the use of orifice plates—the usual gas-measuring technology—unacceptable.

It remains to be seen whether ultrasound will be a viable mainstream technology for measuring gas flow. The British Gas Co. is experimenting with the technology in its North Sea fields and Panametrics is evaluating a four-path natural gas unit. Researchers hope the final results will be positive, if only because of the inconvenience of orifice-plate stations, which require multiple plates to handle a wide range of flow rates. If ultrasound delivers the accuracy for gas measurements that it does for liquids, its success in this area will be almost guaranteed. ■

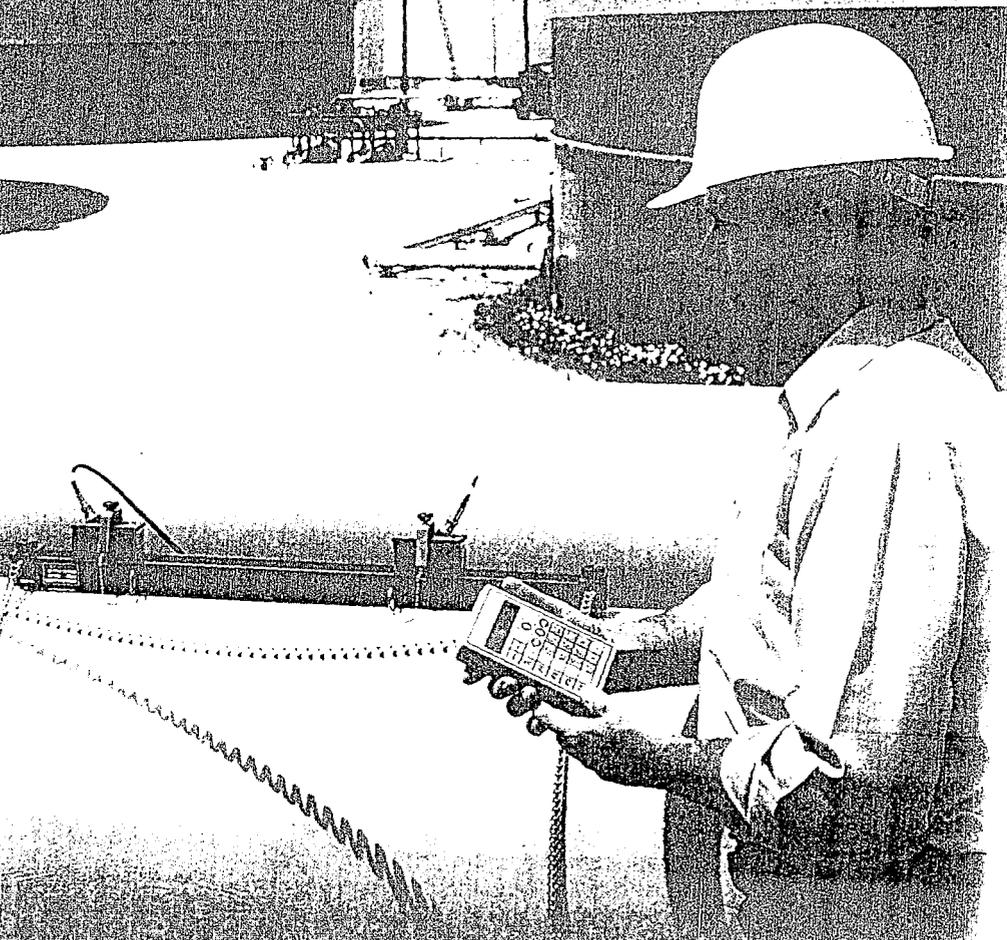
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32

# CONTROLTRON

## SYSTEM 990 UNIFLOW

Universal Transit-Time  
Clamp-On Ultrasonic Flowmeter  
Flow Management/Control Data Network



*An Extraordinary New  
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Function and Performance*

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# PORTABLE UNIFLOW Easy Use for Periodic Flow Survey In-Line Flowmeter Calibration

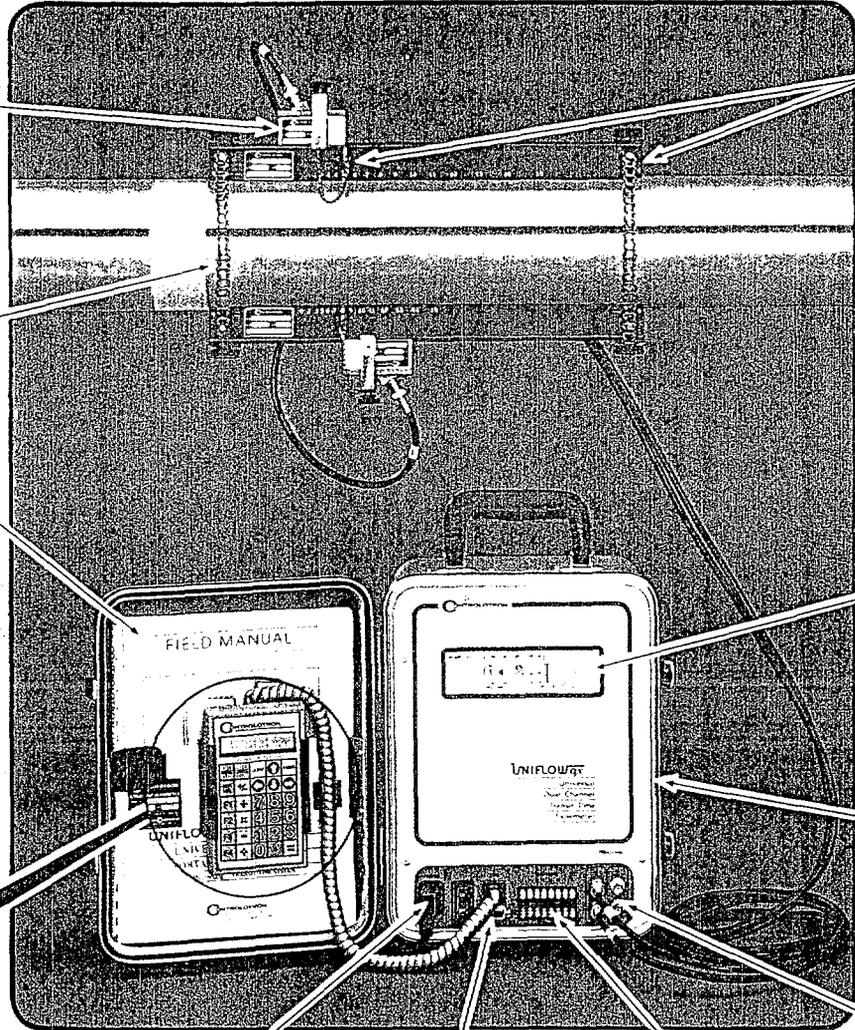
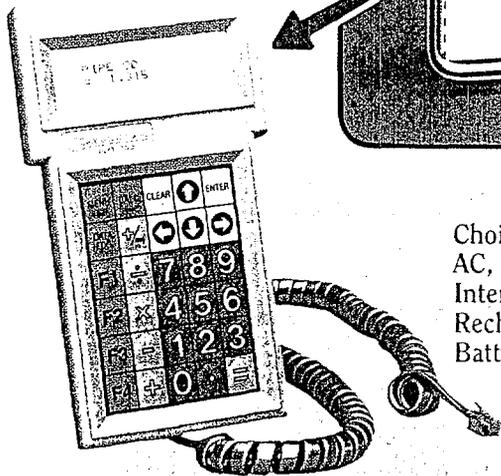
994P Single or 994DP Dual Channel Portable permits simultaneous dual pipe flow measurement for simple flow tracing, flow balance or leak detection.

Patented Universal 991 Ultra-Stable Metallic Clamp-On Transducers (shown in Direct Mode).

"Universal" Size Stainless Steel Mounting Chain

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995T Hand-Held CDU Terminal removable from cover for convenient hand-held operation.



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Sealed cable available for incremental velocity.

Dual Channel shown in single channel operation.

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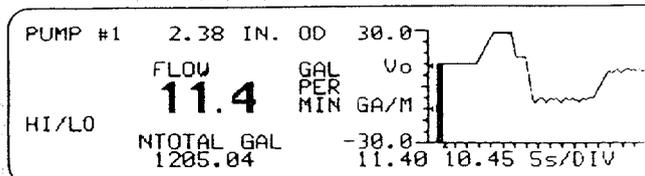
34

# o Carry - Simple to Use - Widely Applicable Flow System Maintenance, , and Flow Balancing.

## GRAPHICS DISPLAY SCREENS

### 1. Digital Display with Stripchart

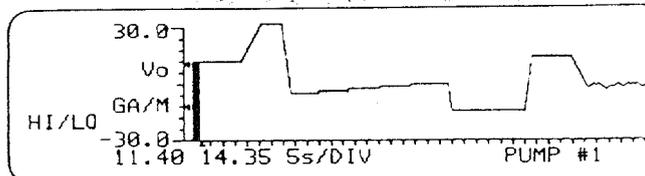
On one screen see your Flow Rate and Total in digital units of your choice, plus an Analog Stripchart with user selected data, span and timebase. Flow and operating condition alarms are brought to your attention by on-screen indicators. Site name and pipe OD shown on screen.



### 1. Digital Display with Stripchart

### 2. Stripchart

Valuable for trend analysis, the full screen Stripchart lets you see events that occurred while you are away from the site. Select either flow rate data, or process condition related liquid sonic propagation velocity or signal strength.



### 2. Stripchart

### 3. Dual Channel Datalogger

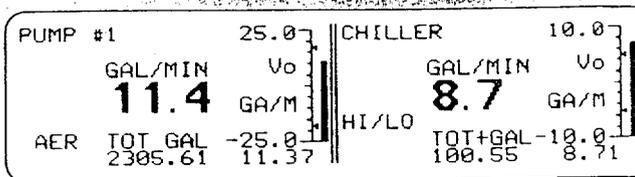
Use the 995 CDU to tell Uniflow what data you want to collect, and how often to collect it. Then either view the data on the Graphics Screen, or print it out on Uniflow's 996P transportable AC/Battery 80 column Printer.

>03.14.88	12.35	PUMP #1	72S	12.2GPM
936.88GAL	1479V <sub>s</sub>			
>03.14.88	12.36	PUMP #2	72S	10.1GPM
1224.43GAL	1480V <sub>s</sub>			
>03.14.88	12.37	PUMP #1	72S	11.7GPM
1280.05GAL	1479V <sub>s</sub>			
>03.14.88	12.38	PUMP #2	72S	15.0GPM
1432.88GAL	1479V <sub>s</sub>			

### 3. Dual Channel Datalogger

### 4. Dual Channel Digital and Analog Barchart

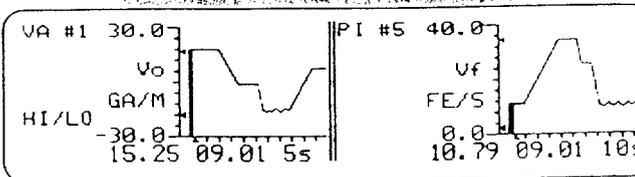
This display lets operators keep track of flow in two pipes simultaneously, complete with Flow Total and Status for each pipe.



### 4. Dual Channel Digital and Analog Barchart

### 5. Dual Channel Stripchart

Ideal for answering the question, "Where is the flow going?", this user settable display also makes a wide variety of trend and process diagnostic questions easy to answer.



### 5. Dual Channel Stripchart

## 992TC TRANSDUCER CARRY CASE KIT



Makes System 990 truly portable by keeping cables, transducers, mounting tracks, 996PSP Pipe Simulator and all transducer accessories in one convenient shoulder strap case.

# Controlotron's SYSTEM 990 UNIFLOW

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## Performance - Function - Applicability - Economy

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### Superior to Conventional Intrusive Flowmeters!

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## WHAT IS SYSTEM 990 UNIFLOW?

Uniflow\* fulfills the potential of Clamp-On Transit-Time Flowmeter technology. It outperforms conventional flowmeters, whether Magmeter or Orifice Plate, Venturi or Turbine, Vortex or any other type of Ultrasonic flowmeter. Its reliability, economy and low installation cost will make it your preferred choice. And its wide applicability lets you use Uniflow in place of the many different flowmeters you now need for different applications.

**Uniflow is Universal.** It operates on just about any size and type of pipe, and most liquids. It provides any flowmeter function that you need. Uniflow offers Portable and Dedicated NEMA 4 models, in Single and Dual Channel versions. It provides three functions in one affordable instrument:

Flowmeter...Stripchart Recorder...Datalogger

**Uniflow is easy to use.** No need for complicated instruction manuals. Uniflow's user-friendly Hand-Held Terminal talks to you in English (some models available in German, Spanish or French) and lets you tell Uniflow just what you want it to do. Little or no training is needed. It even tells you how to mount the transducers, and its Installation Menu never needs words spelled out. Just choose from its list of options to obtain a host of functions not available in most conventional flowmeters.

## WIDE APPLICABILITY

Uniflow combines Controlotron's MultiPulse™ System, and patented, award winning TransX™ Transmission and Wide Beam transducer technologies. The result is a clamp-on flowmeter of unprecedented ability to handle many different application conditions! Uniflow operates accurately with higher levels of liquid aeration, cavitation and liquid non-homogeneity than any previous Ultrasonic flowmeter.

Uniflow users can standardize on field programmable Uniflow in place of the many different flowmeters often used for different applications. Users may stock basic NEMA 4X or 7 Uniflow models. Then, plug-in only the standard Analog or Digital Data Function Modules needed for each application. Uniflow is easily installed at new sites, or moved from obsolete sites to new and different applications. Portable Uniflow can be used to demonstrate the superior performance expected of Dedicated Uniflow models over any previously used conventional flowmeter.

## IS UNIFLOW ECONOMICAL?

Uniflow cost compares favorably with all types of conventional flowmeters of lesser function and performance. Dual Channel and Four Channel models offer even greater savings. Portable Uniflow makes even "one shot" flow measurement affordable.

\* Uniflow is a trademark of Controlotron.

## WHAT DOES UNIFLOW DO?

**FLOW MEASUREMENT** It measures the flowrate of most liquids in most pipes between 1/2 and 216 inches OD (1/4 to 360 inches available). You choose your preferred digital flow rate display units.

**FLOW DISPLAY OPTIONS** Uniflow offers a choice of LCD Graphics Display, for Digital, Stripchart and Datalogger data display, or large Digital format LCD Display of Flowrate, Total and Alarm Status. Lower cost "Blind" models are also offered.

**FLOW TOTALIZER** Choose Positive, Negative, Net or Batch/Sample Flow Total, with up to 7 digits of display precision, and in any volume units that you choose at the site. A pulse output drives remote totalizers.

**DATALOGGER** Never a need to write down data. Uniflow's unique DataSaver will record any data you tell it to, instantly, or at any time interval that you choose. Later you can review this date/time stamped data on the optional Graphics Screen, or output to Uniflow's optional 996P Printer or a Personal Computer via its RS-232 full modem compatible port.

**STRIPCHART** Uniflow's optional Graphics Display makes a Stripchart record of analog flow data. Choose either flow rate or liquid sonic property data, "chart speed" and data scaling. Uniflow adds report time stamps, and lets you review past flow trends at your convenience.

**STATUS ALARMS** Uniflow keeps watch on all flow and application conditions, such as Empty Pipe, Hi/Lo Flow Alarm, Reverse Flow, Fault, and Liquid Aeration. Selected alarms operate relay outputs.

**DATA OUTPUTS** Uniflow has programmable spanned and absolute flowrate data outputs, such as 4 to 20 mA, 0 to 10 volts, pulse rate and alarm relays. In addition, it reports either real-time or memorized digital flowrate, total and alarm status data to your computer from its industry standard RS-232 Port at selectable rates up to 9600 Baud.

**DIAGNOSTICS** Uniflow has a Diagnostic Menu which lets you see and control Uniflow operating conditions. Or if you like, run Uniflow diagnostic tests with the transducers either on your pipe, or on Uniflow's unique 996PS Pipe Simulator. The Diagnostic Menu also shows application conditions.

**LIQUID ANALYSIS** Uniflow measures liquid sonic propagation velocity, closely related to liquid physical properties. Users can identify the liquid for interface detection, and in many cases compute the liquid density for mass flow measurement. Uniflow can also detect liquid aeration. This ability allows Uniflow to publish an aeration number, Vaer, which represents the degree of aeration present in the application.

# DEDICATED UNIFLOW

**Better Performance, Reliability and Economy  
than Magmeters, Vortex, Venturis, Turbines  
and Orifice Plates in Most Applications.**

## System 990N Uniflow Dedicated NEMA 4X Field Programmable Flow Computer

Large Digit LCD  
Flow, Total, Analog  
Bar chart and Status  
Display for each  
Channel.  
Dual Channel  
Graphics Display  
Optionally Available.

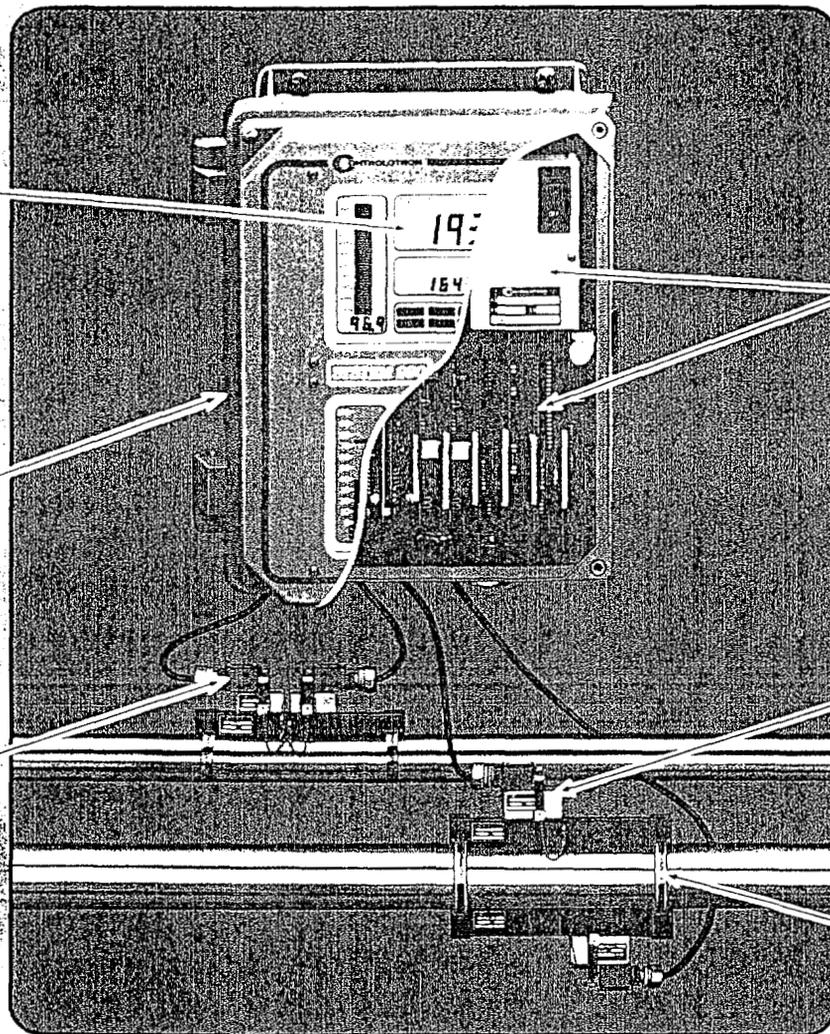
NEMA 4X Case,  
suitable for  
essentially all field  
environments.  
Intrinsically safe  
models available.

Transducers mount  
in either Direct or  
Reflect Mode with  
PinStop location  
accuracy. Tracks  
mount in just  
minutes (shown  
in Reflect Mode).

All printed circuit  
modules, including  
power supply,  
plug-in for simple  
function upgrade or  
maintenance.

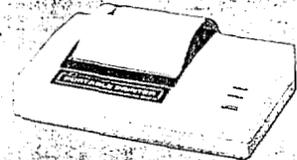
Weatherproof,  
submersible, NEMA 4  
Transducers are  
intrinsically safe  
(shown in  
Direct Mode).

Stainless Steel  
Track Mounting  
Straps.



Use the 995T Hand-Held CDU to tell Uniflow the pipe size you want to work on, and what you want it to measure, display, record or control. It takes only minutes to setup a site and install transducers, and only seconds to recall a previously saved site. Used only for Site Setup and Installation, only one 995T Hand-Held CDU is needed to service many individual 990N NEMA 4 Systems.

The 996P Portable Thermal Printer features quiet, high-contrast printing. An RS-232C serial connector is provided for interconnection to a Flow Display Computer. A rechargeable battery allows printing up to 1,500 character lines, before recharging. This printer is provided in a convenient soft carry case.



# Wide Applicability Lets You Standardize Eliminates Need for Different Flowmeters

## MODELS AVAILABLE

Controlotron's System 990 offers any construction you need for your application...whether Portable, NEMA 4X Intrinsically Safe, or NEMA 7 Explosion Proof. Choose the power source you need...100/120 or 220/240 VAC, or 9 to 36 VDC, or internal, rechargeable Battery. Choose from highly economical "Blind" units, or have your choice of LCD Graphics or Integral Digital Display. In short, whatever your preference...it's probably available as a Uniflow standard!

### PORTABLE UNIFLOW MODELS

#### Single Channel Portable UNIFLOW

The Single Channel Portable 990P Uniflow is ideal for applications that only need periodic flow measurement, to save the cost of a permanent flowmeter installation. Use it to test your pumps and valves as part of your plant's preventative maintenance program. Check the calibration of your conventional flowmeters. Or use it to see how well a Dedicated NEMA 4X or 7 Uniflow will operate as a replacement for a conventional intrusive flowmeter.

Of special convenience for users of Portable Uniflows are the models with integral Rechargeable Battery. These are of especial value for use in areas remote from power or hazardous.

#### Dual Channel Portable UNIFLOW DP

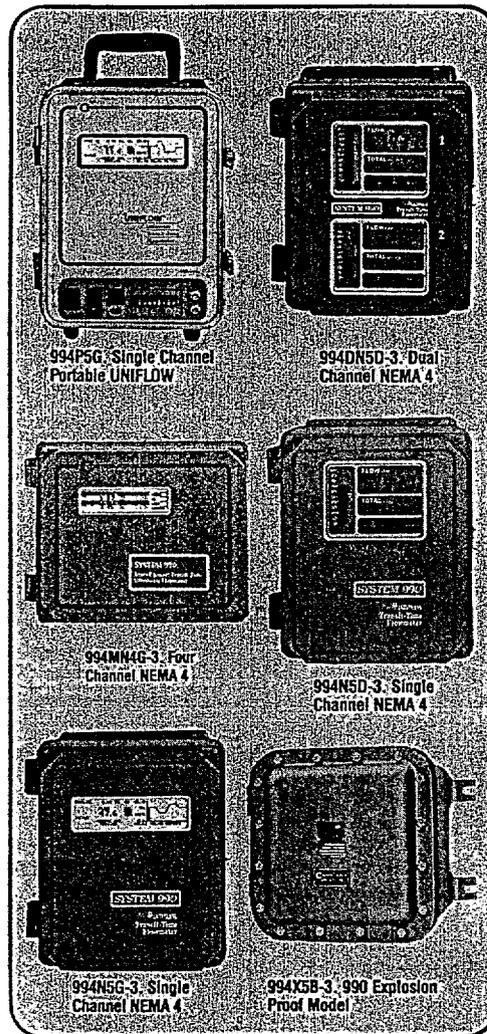
Dual Channel Portable 990DP Uniflow (shown on page 3) has all the functions of the Single Channel Portable, but with the added benefits of simple flow balancing, flow tracing and leak detection. 990DP operates both channels simultaneously so that interactive manifold effects can be observed.

### DEDICATED UNIFLOW MODELS

#### Single Channel Dedicated NEMA 4X

Available with either Graphics or Digital Display, or as a "Blind" flow transmitter, the Single Channel 990N NEMA 4X model is the "workhorse" of the Uniflow family. 990N contains all the flow functions of the Portable models, including optional Datalogger, Stripchart and industry standard RS-232 I/O Data Port.

Dedicated models are field programmable. Users can stock standard Uniflow models and easily program them for different applications, as they arise. Then simply plug-in any needed standard Uniflow Function Modules, such as Analog Data, Alarm Relay or RS-232 I/O Port, to a compatible 994 Flow Computer.



#### Dual/Four Channel Dedicated NEMA 4X

The Dual Channel Dedicated 990DN NEMA 4X and Four Channel 990MN NEMA 4X Uniflows have all the features of the single channel model, but support multiple independent pipe sizes simultaneously, using time share multiplexing.

When supplied "Blind", these models provide the ultimate in economy, and will generally result in lower per channel cost than most conventional flowmeters. When supplied with either the Dual Channel Graphics Display or Dual LCD Digital Displays, each channel is functionally equivalent to separate Single Channel 990N models.

#### Dual Beam System Models

When faced with the need for highest possible accuracy, for custody transfer or pipeline leak detection applications, consider the advantage of Controlotron's 990DBN Dual Beam System. Here, crossed orthogonal sonic beams eliminate any crossflow error produced by upstream elbows or disturbances, and assure exceptional data stability. 990DBN is the preferred alternative to intrusive 4 Path Chordal flowmeters, offering better performance at much lower cost.

#### Dedicated NEMA 7 Explosion Proof Models

Uniflow is available in NEMA 7 construction in both single channel (990X) and dual channel (990DX) models for those applications for which Factory Mutual certified Intrinsically Safe construction is not sufficient. Industry standard digital and analog data outputs are provided, plus an optional remote digital data display. Also available in the Single Channel model is an integral Digital Display. Dual Channel models are capable of supporting remote NEMA 7 Digital LCD Displays for each channel.

For help in selecting your Preferred Model, request Bulletin 990SELECT and 990 Application Information Form.

## UNIFLOW ACCESSORIES

#### 996P TRANSPORTABLE PRINTER

The 996P Transportable 80 column battery operated Printer lets you make a hard copy of memorized Uniflow datalogger information, output from Uniflow's RS-232 Port, anytime you need it, even in the field.

#### 996PSP PIPE SIMULATOR

996PSP permits simple Uniflow equipment test. Simply place Uniflow's transducers on its 996PSP. Then view Uniflow's Diagnostic Display to confirm that both Flow Computer and Transducers are operating properly.

#### 996D REMOTE DIGITAL DISPLAY

Available in either panel mount or NEMA 4 construction, the 996D provides users with remote data display from either a Blind or display equipped NEMA 4X or 7 Flow Computer.

# on Controlotron's UNIFLOW... ers on Different Applications.

## UNIFLOW FEATURES

### FAST SIMPLE INSTALLATION

Uniflow's universal applicability is invoked by "telling" it the few things it needs to know to measure flow accurately at any site. Just tell it the pipe size, the kind of data you wish to measure and your preferred data units, offered on a convenient "no spelling required" Menu List. How long does this take? Less than 5 minutes!

Then install Uniflow clamp-on transducers. They are Pin Stop located for quick and repeatable installation. Just put the pin at the computed Spacing Indices on the mounting track and place the transducer against the pin. No need to measure spacing or read obscure ruler scales to obtain the most precise installation possible...and without any special training. How long? Usually under 5 minutes.

Portable and some Dedicated Uniflow models can Save as many as 16 different Site Setups for instant Recall when revisiting a periodically surveyed site. This avoids need for highly trained personnel to conduct routine data collection.

Portable Transducers are conveniently carried in their own Carry Case, together with their Mounting Tracks, Cables, Pipe Conditioner, Coupling Compound and Pipe Simulator, used to check entire 990 System operation. There is also a Portable Flow Computer Soft Case available to protect your portable computer during transit.

### SIMPLE OPERATION SETUP

Uniflow has no conventional "adjustments." Its Menu asks you how you want it to operate. Simply tell Uniflow to set its Empty Pipe Alarm. Then tell it to set Zero Flow (even if flow can't be shut down). Tell it how fast you want it to respond to flow changes, and such like. Uniflow will behave just as you tell it to.

### DUAL CHANNEL UNIFLOW DP

The Portable Dual Channel Uniflow DP supports a variety of applications that would otherwise require two separate flowmeters. For example, use it for Flow Balancing or Leak Tracing, or Pump and Valve diagnostics.

### HIGH TEMPERATURE OPERATION

Uniflow transducers use patented Controlotron Metallic construction to permit operation at far higher temperatures than any other Ultrasonic flowmeter up to 450°F. They also provide far better data calibration stability than that obtainable with ordinary plastic transducers.

### HIGH RELIABILITY

Uniflow's all digital design uses low power components, substantially reducing internal temperature rise which is the main cause of early failure. There are no adjustments to "drift" in the primary flow detection circuits, as all system calibration is controlled digitally. All circuits are protected against ESD, the main cause of "unexplained" circuit failure. And Uniflow has a substantial reduction of component count, greatly reducing the potential for electronic failure.

### SIMPLE MAINTAINABILITY

Uniflow uses all Plug-In Module construction. Even its power supply plugs in. In the unlikely event of a component failure, operation is restored in minutes by simple replacement from a small supply of guaranteed interchangeable spare modules. And Uniflow's built-in Diagnostic Display helps to identify the probable source of any problem quickly, whether due to equipment or application conditions.

Like all other Controlotron Ultrasonic flowmeters, Uniflow can be tested in the field, so that there is never a need to return it to the factory for operation check.

### INTRINSIC SAFETY

Uniflow is designed to meet international intrinsic safety standards for hazardous areas. NEMA 4X (IP65) and NEMA 7 (Flameproof) systems are available with U.S. (FM) approval for use in Class I and II, Division 1 and 2, Groups C, D, E, F, G areas; European Standard (CENELEC) transducer certification for EEx m II T5 use with all 990 systems is available; Canadian (CSA) certification and European Standard EEx ia II T5 certifications are pending. Contact your representative to discuss your needs.

## APPLICATIONS

Uniflow's wide applicability, excellent performance, moderate cost and non-intrusive design makes it suitable for use in essentially every application now serviced by conventional flowmeters such as Orifice Plates, Magmeters, Turbines, Vortex, Venturi and Coriolis devices. Typical applications include:

Petroleum Production & Pipelines  
Chemical  
Water and Waste Water  
Nuclear Power Coolant Flow  
Condensate  
Milk and Related Food Products  
Beer and Wine

Molten Sulphur  
Aircraft Fuels  
Hydraulic Fluids  
Chilled and Hot Water  
Deaerated Coal Slurries  
Paper and Pulp Slurries  
Deaerated Drilling Mud

Paint Application Control  
Solvents  
Product Custody Transfer  
Radioactive Wastes  
Liquified Gasses (Ethylene, Propane, LPG)  
Heating Oil

# A New Standard in Flowmeter Accuracy and Rangeability...

## Made Possible by UNIFLOW's

# MultiPulse™ and TransX™ Technology.

## HOW UNIFLOW WORKS

Uniflow is a Clamp-On Flowmeter which detects liquid flow rate by its effect on the Transit-Time of Ultrasonic Pulses, alternatively injected through the pipe wall in the upstream and downstream directions by Controlotron's patented ultrastable metallic transducers. Each transmission is not a single pulse, as in prior types of ultrasonic flowmeters, but rather as many as 100 pulses, resulting in the extraordinary sensitivity and calibration stability of Uniflow's MultiPulse™ System.

Uniflow also benefits from its patented TransX™ Transmission System. This is a method by which Uniflow measures the sonic properties of the application's pipe, and automatically optimizes its ultrasonic beam transmission. This gives Uniflow its Universality, the ability to operate on most pipes and most liquids, and its extraordinary immunity to such conditions as liquid aeration and non-homogeneity.

## HOW DOES UNIFLOW PERFORM?

### EXTRAORDINARY PERFORMANCE

Uniflow's Digital MultiPulse™ System uses no analog circuits, not even phase locked loops. This produces the greatest precision, sensitivity and stability ever achieved in an ultrasonic flowmeter. Flow response is extremely linear over its full  $\pm 40$  fps range (including zero flow), and is virtually drift free.

Uniflow's SMARTSLEW™ real time data analysis results in extremely low data scatter, even at high slew rate settings. When set for its fastest flow response rate, Uniflow is ideal for flow control or detection of flow transients which would be missed by slower flowmeters. Slower response can be selected, if desired, to avoid reporting flow pulsations which are not of interest.

Uniflow intrinsic calibration accuracy is usually within 1% to 2% in most applications and within 1/4% to 1% if flow calibrated.\* Intrinsic repeatability will generally be within 1/2% for most pipe sizes.

## SYSTEM 990 UNIFLOW SPECIFICATIONS

### APPLICABILITY

**LIQUIDS:** Any sonically conductive homogeneous liquid of low to moderate aeration (up to 30% maximum).

**LIQUID (PIPE) TEMPERATURE:**  $-40^{\circ}\text{F}$  to  $+250^{\circ}\text{F}$  ( $-40^{\circ}\text{C}$  to  $+120^{\circ}\text{C}$ ) Standard  
 $-80^{\circ}\text{F}$  to  $+450^{\circ}\text{F}$  ( $-60^{\circ}\text{C}$  to  $+230^{\circ}\text{C}$ ) Optional

**PIPE SIZES:** 0.25" to 8" OD (6.35mm to 203.2mm) Specify Group 2 Flow Computer  
0.5" to 24" OD (12.7mm to 609.6mm) Specify Group 3 Flow Computer  
0.5" to 48" OD (12.7mm to 1219.2mm) Specify Group 4 Flow Computer  
0.5" to 216" OD (12.7mm to 5486.4mm) Specify Group 5 Flow Computer  
0.5" to 360" OD (12.7mm to 9144mm) Specify Group 6 Flow Computer

**PIPE MATERIAL:** Any sonically conductive pipe material: Metal, Glass, Plastic, etc.

**PIPE WALL THICKNESS:** 0.01" to 3.00" (0.25mm to 76.2mm)

**LINER MATERIAL:** Any sonically conductive material, Glass, Plastic, Cement, etc., intimately bonded to the pipe interior.

**LINER THICKNESS:** Up to 1" (25.4mm), dependent on material.

**FLOW VELOCITY RANGE:**  $\pm 40$  fps ( $\pm 12.2\text{m/sec}$ ), minimum

### 991 CLAMP-ON TRANSDUCERS

#### PIPE SIZE RATINGS:

- Group 0: 0.25" to 2" (6.35mm to 50.8mm) pipe OD
- Group 1: 0.5" to 4" (12.7mm to 101.6mm) pipe OD
- Group 2: 1.25" to 8" (31.75mm to 203.2mm) pipe OD
- Group 3: 6" to 24" (152.4mm to 609.6mm) pipe OD
- Group 4: 20" to 48" (508.0mm to 1219.2mm) pipe OD
- Group 5: 36" to 360" (914.4mm to 9144.0mm) pipe OD

**RATING:** Intrinsic safe, Radiation Resistant and Submersible available.

**CONSTRUCTION:** Aluminum, stainless steel and special alloy or plastic

**CONNECTORS:** Condulet for NEMA 4, BNC for Portable

### 992 MOUNTING TRACKS

- Available in Direct and Reflect Mounting for all transducer sizes in standard pipe diameter ranges
- PinStop transducer spacing standard for all models

### 994 FLOW COMPUTER

- **POWER:** 100/120 or 220/240 VAC, 1 $\phi$ , 40 VA  
9 to 36 VDC, 20W, portable systems available with internal battery
- **TEMPERATURE:**  $-5^{\circ}\text{F}$  to  $+115^{\circ}\text{F}$  ( $-20^{\circ}\text{C}$  to  $+45^{\circ}\text{C}$ )  
(except for Graphics Models)
- **SIZE:** 10.5" W, 9" D, 13" H (266.7mm W, 228.6mm D, 330.2mm H)
- **WEIGHT:** 12.8 pounds (5.8 kilograms) (without battery)
- **RATING:** Intrinsic safe, NEMA 4X with cover closed
- **MODULES:** Plug-In, Interchangeable W/O special tools
- **RANGES:** Group 2: Transducer Sizes 0, 1 and 2  
Group 3: Transducer Sizes 1, 2 and 3  
Group 4: Transducer Sizes 1, 2, 3 and 4  
Groups 5 & 6: Transducer Sizes 1, 2, 3, 4 and 5

### 994 PERFORMANCE (Standard Conditions)

- **SENSITIVITY:** 0.001 fps (0.3mm/sec) at any flow rate including zero
- **LINEARITY:** 0.003 fps (0.9mm/sec) under standard conditions
- **DATA UPDATE RATE:** 10 Hz
- **SLEW RATE:** 0.1 to 40 ft/sec/sec (0.03 to 12.2m/sec/sec) (settable)
- **FLOW PROFILE COMPENSATION:** Reynold's Number 0 to  $10^7$
- **ZERO DRIFT STABILITY:** 0.02 fps (6mm/sec) for transducer sizes 0 to 2  
0.01 fps (3mm/sec) for transducer sizes 3 to 5

### 995 HAND HELD CONTROL/DISPLAY TERMINAL

- 4 row, 80 character LCD
- 30 Keys, Numeric or Function Identified

\* Submit Application Form for estimate of performance under specific application conditions. For statement of accuracy, site survey is required.

# HOW TO SPECIFY AND ORDER SYSTEM 990 UNIFLOW

Selecting the most appropriate model and optional functions and features, offered in System 990, is quite simple, especially if you follow the procedure below. However, feel free to call on your local Controlotron representative for assistance if needed.

The Uniflow part numbering system is a guide to the process of selecting your preferred model, as well as producing the part numbers of all the system components. The procedure below, gives you an opportunity to consider the many Uniflow system options offered. Check with your local Controlotron representative to assure selection of compatible Dedicated model functions. Note, however, that standard Portable Uniflow Systems are supplied fully loaded, with all available functions and features.

System 990 Dedicated Models use a "Building Block" System. This permits you to order only those functions that you actually need for your application, so as to keep your costs as low as possible. If, at a later time, a new function is required, most can be added merely by plug-in of the desired Function Module into a compatible 994 Flow Computer.

Uniflow Systems include the following Components:

- Series 991 Transducers
- Series 992 Transducer Accessories
- Series 993 AFAC Module
- Series 994 Flow Computer and Function Modules
- Series 995 Hand-Held Control Display Unit
- Series 996 Remote Accessories

Specifying and ordering System 990 Uniflow equipment involves the following steps:

1. Determine which 990 System best fills your needs, Portable or NEMA 4. Use the Application Information Form to assure application guarantee.
2. Specify the Components of your selected system, choosing the component options which contain your desired features, and their corresponding part numbers.
3. Specify the desired optional plug-in Function Modules and/or Remote Accessories by part number below.
4. Obtain the price and delivery of your selected components, and place your order with Controlotron either through your local Representative or Factory Direct.

Listed below are the part numbers for all Uniflow system components. To construct the component part number which has your desired options, replace the part number LETTERS with the appropriate CODE symbols listed below.

991ABC-D TRANSDUCER	A = MODEL P = Portable N = NEMA 4	B = TYPE M = Metal Body P = Plastic Body V = Sonic Velocity	C = TEMPERATURE S = 250°F (120°C) max. H = 375°F (190°C) max. VH = 450°F (230°C) max.	D = SIZE* OS = 0.25" to 0.5" (6.35mm to 12.7mm) pipe OD 0.0A = 0.25" to 2" (6.35mm to 50.8mm) pipe OD 1 = 0.5" to 4" (12.7mm to 101.6mm) pipe OD 2.2A = 1.25" to 8" (31.75mm to 203.2mm) pipe OD 3.3A = 6" to 24" (152.4mm to 609.6mm) pipe OD 4.4A = 20" to 48" (508.0mm to 1219.2mm) pipe OD 5.5A = 36" to 360" (914.4mm to 9144mm) pipe OD <small>* See 991XA for guidelines in selecting "A" Series Transducers.</small>					
992MTABCD-E MOUNTING TRACK	A = MODEL P = Portable N = NEMA 4	B = TYPE D = Direct Beam R = Reflect Beam H = Hybrid Track	C = STYLE M = Metal XDCR P = Plastic XDCR	D = MATERIAL A = Aluminum S = Steel SH = For VH XDCRS	E = PIPE OD RANGE (min.) (See 990SELECT Manual) OS = 0.25" to 0.5" (6.35mm to 12.7mm) pipe OD 0 = 0.25" to 2" (6.35mm to 50.8mm) pipe OD 1 = 0.5" to 4" (12.7mm to 101.6mm) pipe OD 2 = 1.25" to 8" (31.75mm to 203.2mm) pipe OD 3 = 6" to 24" (152.4mm to 609.6mm) pipe OD 4 = 20" to 48" (508.0mm to 1219.2mm) pipe OD 5 = 36" to 84" (914.4mm to 2133.6mm) pipe OD 5X = 6" to 10" (1.83m to 3.05m) pipe OD 5Y = 10" to 18" (3.05m to 5.49m) pipe OD 5Z = 18" to 30" (5.49m to 9.14m) pipe OD				
992CAB-C TRANSDUCER CABLE	A = MODEL P = Portable N = NEMA 4 NP = NEMA Computer to Portable XDCR PN = Portable Computer to NEMA XDCR	B = ENVIRONMENT S = Standard Temp. D = Plenum Rated W = Submersible Kit	C = LENGTH C = Length in ft.	992MTM-A MAGNETIC TRACK MOUNT KIT	A = PIPE OD RANGE 4 = 20" to 48" (508.0mm to 1219.2mm) pipe OD 5 = 36" to 360" (914.4mm to 9144.0mm) pipe OD				
992TC-A TRANSDUCER CARRY CASE KIT	A = SIZE 0S = Size 0S XDCR, 0 = Size 0 XDCR, 1 = Size 1 XDCR, 2 = Size 2 XDCR, 3 = Size 3 XDCR, 4 = Size 4 XDCR, 5 = Size 5 XDCR (For Portable XDCRS Only)			993A APPLICATION FUNCTION AND CONTROL MODULE	A = MODEL C = Control Only Module M = Datalog Memory & Control Module	994TC PORTABLE FLOW COMPUTER SOFT CASE			
994ABCD-EF FLOW COMPUTER	A = MODEL P = Portable N = NEMA 4X X = NEMA 7 DP = Dual Portable DN = Dual NEMA 4X DX = Dual NEMA 7	MN = Four Channel DBN = Dual Beam NEMA 4X DBP = Dual Beam FTN = Flow Tube NEMA 4X FTP = Flow Tube Portable PB = Portable Blind	B = PIPE OD 2 = 0.25" to 8" (6.35mm to 203.2mm) 3 = 0.5" to 24" (12.7mm to 609.6mm) 4 = 0.5" to 48" (12.7mm to 1219.2mm) 5 = 0.5" to 216" (12.7mm to 5486.4mm) 6 = 0.5" to 360" (12.7mm to 9144.4mm)	C = DISPLAY B = Blind G = Graphics GL = Lit Graphics D = Digital	D = POWER SOURCE S = 100/120 VAC M = 220/240 VAC B = 9 to 36 VDC SB = 115 VAC + Battery MB = 230 VAC + Battery	E = PROGRAM LOADING 1 = Basic Data 2 = Add RS-232 & Datalog 3 = Add Graphics + Stripchart	F = SPECIAL C(n) = Case Option N(n) = CC Nuclear Grade S(n) = Intrinsically Safe		
994-7A ANALOG COMPUTER MODULE	A = MODEL BLANK = Programmable Isolated 4 to 20 mA, 0 to 10 VDC and Pulse Rate Outputs, one per channel. (Single & Dual Channel Systems only) V = Programmable, 0 to 10 VDC Output, one per system. (Four Channel Systems only)			994-8A OUTPUT CURRENT MODULE	A = MODEL M = Dual Programmable 4 to 20 mA Outputs, two per system. (Four Channel Systems only)				
994-10ABC ALARM RELAY MODULE	A = MODEL P = Portable N = NEMA 4	B = TYPE A = Normally Open B = Normally Closed	C = RATING D = Dry Reed (10 VA max.) M = Mercury Wetted (50 VA max.) (Not available in Portable Units or in "NC" Type)	995TA HAND-HELD CDU TERMINAL	A = MODEL BLANK = Standard 995 Hand-Held Terminal 1 = 995 Hand-Held Terminal w/External CDU Option & Case				
995VA UNINTERRUPTIBLE POWER SOURCE	A = POWER SOURCE S = 110/120 VAC M = 220/240 VAC	996P PRINTER	996P-5 PRINTER PAPER, 5 PACK REFILLS	996PSP-A PIPE SIMULATOR	A = XDCR SIZE A = 0, 1, 2, 3 or 4	996DABC REMOTE DISPLAY	A = TYPE D = Digital	B = MODEL N = NEMA 4X P = Panel Mount	C = POWER SOURCE S = 100/120 VAC M = 220/240 VAC

For help in selecting your Preferred Model, request Bulletin 990SELECT and 990 Application Information Form.

41

## SYSTEM 990 UNIQUE FEATURES

The flowmeter furnished shall be the Controlotron System 990 Uniflow Transit-Time Clamp-On Ultrasonic type, or approved equivalent, and shall contain the features listed below:

- MultiPulse™ Flow Detection
- TransX™ Ultrasonic Transmission Optimization
- Metallic Mode Conversion Wide Beam Transducers
- PinStop Universal Mounting Track (no ruler scales)
- 64 × 256 Pixel Graphics Display
- Programmable Stripchart Option for Flow, Liquid Data
- Programmable 64K Memory Datalogger Option
- All Modules Plug-In, including Power Supply
- Numeric Entry Only Hand-Held Programming
- 2 Year Limited Warranty
- 16 Site Setup Memory Option for most Models
- Full Diagnostic Data Access
- Plug-In Function Options:
  - Analog Data Module, 0 to 10 VDC and 4 to 20 mA
  - External Data A/D Converter
  - Alarm Relay Module, 4 Relays per Channel
  - Digital and Graphics Display Computer/Driver
  - RS-232 Serial Data I/O, Selectable Baud Rates
- Intrinsically Safe Construction
- Made in USA

## A WORD ABOUT CONTROLOTRON

Controlotron, completing its third decade of operation, specializes in the manufacture of proprietary instruments for the measurement and control of liquids. All Controlotron products are derived from Company sponsored research and development programs, the heart of our continued ability to provide other new and unique instruments of outstanding value and performance characteristics, such as:

### Portable System 990E:

Thermal Energy Flowmeter

### Dedicated System 990E:

Thermal Energy Flowmeter

### System 990FT:

In-Line Transit-Time Ultrasonic Flowmeter

### System 990FTD:

In-Line Transit-Time Mass Flowmeter  
(Low Flow & Custody Transfer)

### System 990DB:

Dual Beam Flowmeter

### System 990DV:

Mass Flow Flowmeter

### System 990LD:

Leak Detection System

### Portable System 190 Spectra:

Portable Fourier Flowmeter

### Dedicated System 190 Spectra:

NEMA 4X Fourier Flowmeter

### System 1010:

Miniature Aerospace Flowmeter

### System 660:

Clamp-On Pressure Indicator or Switch

### 990 Flow Management/Control Data Network Systems

990DN: Flow Data Network

990EDN: Thermal Energy Data Network

990LD: Pipeline Leak Detector Network

990DVN: Pipeline Custody Transfer Network

990 Portalab: Transportable Maintenance Flow Lab

## RENTAL/PURCHASE PLAN

Users who wish to familiarize themselves with Uniflow prior to purchase may avail themselves of Rental plans (where available). Advance purchase, of the 990PFM-2 or 990NFM-2 Field Manual will provide detailed information beyond this brochure.

## 2 YEAR WARRANTY

This product is warranted for two years from the date of purchase. Please contact Controlotron's Customer Service Department for more detailed information regarding this limited product warranty.

## MISAPPLICATION POLICY

For detailed information regarding our product misapplication policy, please contact Controlotron's Customer Service Department.

## CUSTOMER SERVICE

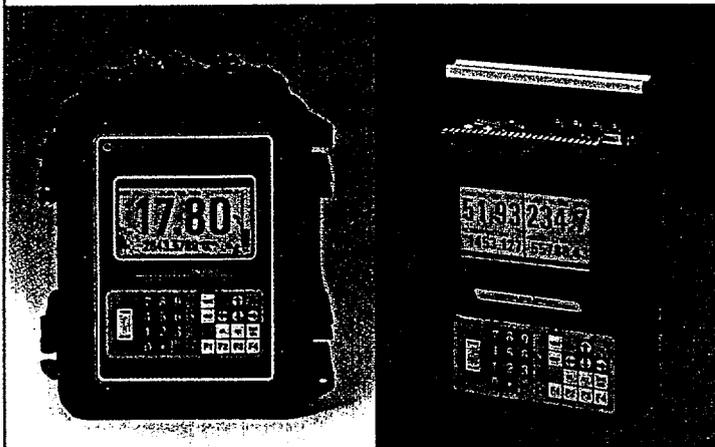
Users of Controlotron instruments enjoy the benefit of worldwide customer service organizations, available on short notice for training, application, installation, demonstration, and maintenance services. Contact us or your local representative for details on these services.

Your Local Representative:

# CONTROLOTRON

155 Plant Avenue, Hauppauge, New York 11788 Phone: (516) 231-3600 • Telex 961-447 • Fax: (516) 231-3334

## CLAMP-ON PORTABLE MULTIFUNCTION FLOWMETERS



System 1010WP

System 1010DP

### GENERAL DESCRIPTION

Portable System 1010 Flowmeters are available in two models, the Miniature 1010P and Weatherproof/Submersible 1010WP. Both are available in either Single Channel or Dual Channel/Path versions, and are otherwise essentially identical in function and features. Operation is based on Controlotron's time proved and award winning Clamp-On MultiPulse Transit-Time Ultrasonic Flowmetering Principle, and is the fifth generation meter produced since Controlotron introduced non-intrusive flowmetering in 1972. Both include optional pipe wall Thickness and Flaw Gauges, and an optional Reflexor Flowmeter for liquids which are highly sonically reflective. Both include a large Graphics Data Screen which provides a wide choice of analog and digital data presentations, with 1 1/8 inch characters to permit visibility from up to 40 feet for Hands Free operation.

System 1010 offers a new level of installation simplicity, providing field manual equivalent on-screen Prompt and Help Menus. PinStop Mounting Frames make transducer installation quick and foolproof. A full on-screen Diagnostic Menu, with Graphic Screen Display, assures ultimate performance. AutoMark™, a series of digital markers encoded in the ultrasonic transmission, provides flow detection accuracy and stability superior to any alternate transit-time flowmeter even when flow and process conditions vary, as is frequently encountered. Portable 1010 can be used on essentially any pipe, for any liquid and for any flowrate, even bidirectional flow.

System 1010 provides flow data in both analog and digital formats, and includes a 200 Kbyte datalogger capacity for storage of data and Site Setups. Site Setups can also be stored in PC memory and transferred to any 1010, either directly, or by modem for remote setup. Data, likewise, is retrievable by downloading or by remote modem dump. Also provided are a variety of liquid Sonic Signature parameters used by many to monitor and identify liquid type and quality, such as non-homogeneity and aeration content.

Dual Channel/Path 1010 Meters make real time flow balance and flow tracing simple to perform. Dual Path operation assures highest accuracy, extending to custody transfer performance in many applications. In addition, they provide Arithmetic functions, permitting pipe flow summation and subtraction, for simple leak detection testing.

All models are available with a wide variety of optional functions, but are preferably purchased as one of the many standard model combinations to provide fastest delivery, often from stock, as well as at lowest possible cost.

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# FUNCTIONS AND FEATURES

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System 1010 offers a wide variety of unique functions and features to make it the most applicable and versatile flowmeter available.

## **Submersible or Miniature Construction**

Users of Portable Flowmeters frequently encounter unfavorable weather conditions. If this happens to you, choose Submersible Model 1010WDP1, submersible to 6 feet (2 m). If not, the convenience of the Miniature Model 1010DP1 will be your best choice.

## **MultiPulse/AutoMark™ Accuracy**

AutoMark™ is a unique Controlotron method of digitally marking 1010's MultiPulse transmission to assure accurate detection of transit-time, and up and down stream transit-time difference. This assures flow measurement accuracy, continued accurate operation under changing process and liquid conditions, plus accurate sonic detection of liquid density for intrinsic Mass Flowmetering.

## **Dual Channel/Path Operation**

System 1010's Dual Channel/Path operation permits accurate real time flow balance and flow tracing, as well as metering of additives. 1010's arithmetic Sum/Difference capability permits totalization of flow in two different pipes, or volume balance leak detection. In Dual Path mode, ultimate accuracy can be obtained even under distorted flow profile conditions near bends and elbows.

## **Optional Thickness and Flaw Gauges**

System 1010 offers both Thickness and Flaw Gauges to assure accurate Site Setup, and assurance that the intended flowmeter installation is free from internal pipe defects which could affect flowmeter performance.

## **Optional Reflexor Flowmeter**

Although System 1010's Transit-Time Flow Detection operates well even under severe aeration conditions there are some applications in which low liquid sonic conductivity precludes such operation. In such cases, 1010's Reflexor, based on Controlotron's award winning Spectra Flowmeter, takes over.

## **FastStart**

FastStart enables users to start operations in minutes merely by selecting the Site's pipe size from the 1010's Pipe Table. Then simply install the recommended transducers at the indicated PinStop spacing indices. The Site Setup may be saved or edited as desired.

## **Graphics Help and Prompt Menus**

All Site Setup and Installation operations are guided by an OnScreen Prompt Menu, plus a HotKey accessible Help Menu. This Field Manual equivalent assures operators quick support while in the field. Graphic Screens provide pictorial guidance for transducer installation.

## **Remote PC Diagnostics and Data Access**

System 1010 supports remote modem access to its Site Setup and diagnostics and datalogger data, avoiding the need for visits to remote installation sites. Site Setups can be installed from PC memory, with full security, to prevent unauthorized calibration alteration.

## **HandsFree MultiGraph Data Display**

1010's 128 x 240 pixel graphic screen permits access to a wide variety of analog and digital data displays, simultaneously displaying data for correlation of process events.

## **Huge DataLogger Memory**

System 1010 provides a 200 Kbyte dynamic memory to facilitate storage of weeks or months of data, or up to 50 Site Setups. Data may be printed on Controlotron's portable printer, or dumped to a PC even remotely via RS-232. Data storage is either automatic at selected time intervals, manually commanded, or event driven.

## **Diagnostic Menu**

System 1010's Diagnostic Menu provides equipment and application condition diagnostic data to assure full confidence in flow data. Self test is provided for on-site or remote support. An automatic Audit Trail records and identifies transient events, such as liquid aeration.

## **SmartSlew**

All 1010 Meters contain SmartSlew which smoothes even pulsating flow to provide a steady Digital or Analog Data Display. Unlike time averaged flow data, SmartSlew quickly detects actual changes in flow rate permitting effective flow rate alarm and control applications.

## **PinStop Installation**

System 1010 PinStop Transducer Mounting Assembly eliminates need to tape measure transducer spacing, for fast accurate installation in most cases.

## **InLine Transducer Support**

System 1010 supports both Clamp-On and InLine Controlotron transducers. Dual Channel Systems can simultaneously support ClampTransit-Time or Reflexor operation on one channel, and InLine on the other.

# HOW TO ORDER SYSTEM 1010

Controlotron's Portable System 1010 Meters are available in a variety of optional models and a choice of functions and features. Completing the Application Information Form will enable Controlotron Sales Representatives to provide you with the most suitable model for your needs, at the lowest possible cost. Usually, one of Controlotron's Standard Models will provide just what you need with fastest delivery and lowest cost. But if your needs call for a different combination of functions and features, simply identify your needs on the System 1010 Components Checklist.

We recommend the following steps in ordering a System 1010 Flowmeter:

1. Consult with your Controlotron Sales Representative who will provide you with literature and an Application Information Form (AIF), like the one appended. Fill it out and return it with a copy of the Checklist, if you need a Custom Model, for review by trained Controlotron staff.

2. Your Controlotron representative will then call on you to discuss the recommended models suggested by your AIF, and provide cost versus functional tradeoff options.

3. Select the model of your choice to receive an instant cost and delivery quotation. Selection of a Standard Model will permit fastest delivery, usually from stock. A Custom Model can also be specified at slightly higher cost and somewhat longer delivery.

4. Users who are currently unfamiliar with Controlotron Clamp-On Transit-Time Flowmeters may request a demonstration, and if preferred, a Risk Free Evaluation program.

If one of the Standard Models listed does not satisfy all your needs, your Application Information Form permits Controlotron to recommend the appropriate choice of models. Note that the Standard Models have their included Functions and Features identified by a Checkmark in the appropriate rows. For a Custom System, simply place a Checkmark in place of the "?" in the row of a desired Function and return it with your AIF. A complete system includes one or more of the items listed.

## 1. Flow Display Computer

## 2. Computer Accessories

Controlotron offers a variety of Standard and Optional Flow Computer Accessories, in accordance with the AIF requirements.

## 3. Transducer(s)

Controlotron manufactures a variety of standard and high temperature transducers to provide best accuracy for the range of pipe wall thicknesses and material which you encounter. Simply specify wall thickness range, pipe material and temperature range on the AIF to receive a specific transducer model recommendation.

## 4. Transducer Mounting/Spacing Hardware

Dependent on the type of transducer best for your applications, and the diameter of the pipes on which they will be used, Controlotron will recommend either Mounting Tracks or Mounting Frames, plus appropriate lengths of Mounting Strap or Chain.

## 5. Transducer Cables and Accessories

Dependent on the Flow Computer and Transducers selected, Controlotron will provide the specified lengths of Transducer Cable. In addition, a variety of standard and optional Transducer Accessories are also available.

### **Risk-Free Evaluation**

Even those who are not yet familiar Controlotron Flowmeters take no risk in obtaining a preferred model. Take a full month after receipt to fully evaluate your selected model on your actual applications. If you are not fully satisfied, and Controlotron cannot help, simply call to arrange return of your equipment before you pay for it.

# SYSTEM 1010 COMPONENTS

	Functions and Features	Standard	Standard	Custom
		Miniature 1010DP1	Submersible 1010WDP1	Flowmeter Model
Choice of Model	Single Channel/Path	X	X	?
	Dual Channel/Path	√	√	?
Standard Functions	Transit-Time Flowmeter Operating System	√	√	√
	Clamp-On + InLine Transducer Tables	√	√	√
	Full Graphics Display (128x240 Pixels)	√	√	√
	Keyboard (32 Keys with Function Control)	√	√	√
	RS-232 Port	√	√	√
	DataLogger and Site Storage (200 KBytes)	√	√	√
	Help Menu with Prompts + Graphics Help	√	√	√
	Diagnostic Menu + Test Connector	√	√	√
	Digital Control Input (Totalizer Control)	√	√	√
	Audio Indicator	√	√	√
	Power Supply/SmartCharger (10 to 18 VDC)	√	√	√
Optional Functions	Thickness/Flaw Gauge Operating System	√	√	?
	Reflexor Flowmeter Operating System	√	√	?
	RTD Temperature Sensor Circuit	√	√	?
	Analog-In Thermal Energy Operating System	√	√	?
	Analog Data Out: 2x4>20+2x0>10+2x5K Pulse	√	√	?
	InfraRed Communication	√	NA	?
Computer Accessories	Analog Input (4), 2x4>20 mA+2x0>10 V	√	√	?
	PeekaBoo 1010P and Transducer Carry Case	√	√	?
	Portable 1010 AC Power Pack/Charger	√	√	?
	Field Manual	√	√	?
	Optional Belt Mount 4 Hour Portable Battery	?	?	?
	Optional 24 Hour Portable Battery & Charger	?	?	?
	Optional PC Data Transfer Program	?	?	?
Transducers	Optional Training Video	?	?	?
	Two Clamp-On 1010 Xdcrs, per App Info Form	√	√	?
Transducer Mounting	Two PinStop Tracks or Frames, as Req'd	√	√	?
Transducer Spacer Index	Two Spacer Bars or Index Strips, as Req'd	√	√	?
Transducer Accessories	Two 1010 Xdcr Cable Assemblies, as Req'd	√	√	?
	Pipe Simulator (For Flow Computer Test)	√	√	?
	Transducer Coupling Compound	√	√	?

## Application Information Form

To obtain assistance from Controlotron in selecting the best 1010 Model for your needs, simply fill out the AIF, below, and mail or Fax to Controlotron Application Engineering.

**Pipe Diameter Range:** from \_\_\_\_\_ in/mm minimum to \_\_\_\_\_ in/mm maximum

**Pipe Wall Thickness Range:** from \_\_\_\_\_ minimum to \_\_\_\_\_ maximum

**Pipe Materials:** Steel  Cast Iron  Ductile Iron  Copper  Other \_\_\_\_\_

**Liquids:** Water Based  Hydrocarbon Based  Compressed Gas

**Environment:** Indoor  Outdoor  Submerged  Hot  Cold

**Temperature Range:** from \_\_\_\_\_ °F or °C to \_\_\_\_\_ °F or °C

**Function:** Flow Measurement  Totalization  Flow Control  Flow Balance  Flow Tracing

Flow Sum/Diff  Liquid Type/Quality  Volumetric Flow  Mass Flow

**Performance:** Absolute Accuracy \_\_\_\_\_ % Repeatability \_\_\_\_\_ %

**Describe Special Functions:** \_\_\_\_\_

\_\_\_\_\_

# SPECIFICATIONS

## APPLICABILITY

### LIQUIDS:

Any sonically conductive liquid or compressed dense phase gas

### LIQUID (PIPE) TEMPERATURE:

-40°F to +250°F (-40°C to +120°C) Standard  
-80°F to +450°F (-60°C to +230°C) Optional

### PIPE MATERIAL:

Any sonically conductive pipe material

### PIPE WALL THICKNESS:

0.02" to 3.00" (0.50mm to 76mm)

### LINER MATERIAL:

Any sonically conductive material, intimately bonded to the pipe interior

### LINER THICKNESS:

Up to 1" (25mm), dependent on material

### FLOW VELOCITY RANGE:

±40 fps (±12m/sec), minimum

## CONNECTORS

### For 1010P and 1010DP:

Standard BNC for Flow & Thickness Gauge  
9 Pin D subminiature (PC-AT pattern male) for RS-232  
Push-In terminal strip for instrumentation input/output  
Multi-Pin Circular Connector for RTD temp. sensors

### For 1010WP and 1010 WDP:

Waterproof Cylindrical Multi-Pin for all connections

## 1010 FLOW COMPUTER

### POWER:

10.5 - 18.5 VDC, supplied with 90 - 240 VAC charger

### TEMPERATURE:

Operate: 32°F to 122°F (0°C to 50°C) for LCD Display  
Storage: -4°F to 140°F (-20°C to 60°C)

## 1010 PERFORMANCE: Standard Conditions

(Greater than 15 diameters upstream & 5 diameters downstream straight run, flowrate greater than 1 fps, non-aerated liquid, Newtonian liquids flowing at Reynolds numbers <2000 or >10000)

### ACCURACY INTRINSIC CALIBRATION:

1% to 2% of indicated or better

### ACCURACY CALIBRATED (Batch):

0.15% of indicated or better

### REPEATABILITY (Small Volume):

Better than 0.5%

### RESPONSE RATE (Damping):

Smart Slew effective from 0.2 sec to 5 min

### DATA UPDATE RATE: 200 ms

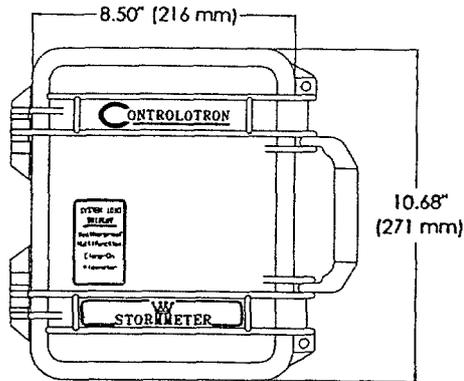
### SLEW RATE: 80 f/s/s (24 m/s/s)

### ZERO DRIFT: Less than 0.05 ft/sec (.015 m/sec)

## GRAPHICS DISPLAY

4.25" X 2.25" (108mm X 57mm), active area with 240 X 128 pixels

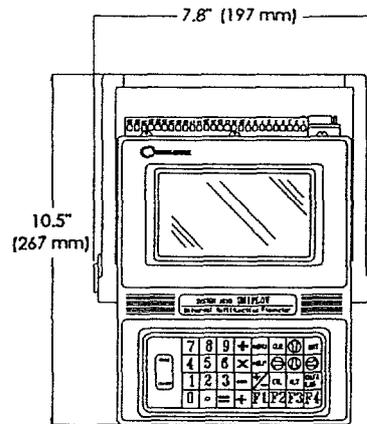
Model 1010WDP Outline Dimensions



Net Weight: 8.0 lbs. (3.64 Kg)

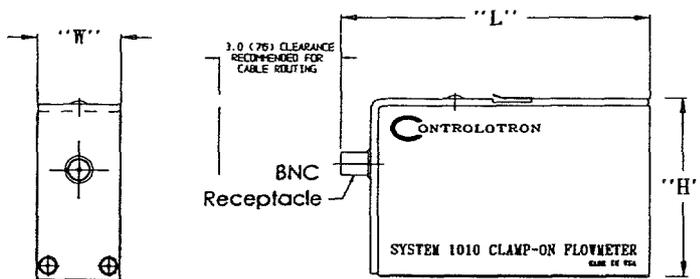
Depth: 6.97" (177 mm)

Model 1010DP Outline Dimensions



Net Weight: 7.5 lbs. (3.4 Kg)

1010 Series Portable Transducer Outline Dimensions



TRANSDUCER PART NUMBER*	"L"	"H"	"W"	NET WT. (PAIR)
101PIPS-B1 101PIPS-B2 101PIPS-B3	2.3 (58)	1.4 (36)	1.0 (25)	0.4 # (0.2kg)
101PIPS-C1 101PIPS-C2 101PIPS-C3	3.6 (91)	2.1 (53)	1.4 (36)	1.0 # (0.5kg)
101PIPS-D1 101PIPS-D2 101PIPS-D3	5.0 (127)	3.0 (76)	1.4 (36)	2.1 # (1.0kg)

\*Color Code: B-Blue, C-Crimson, D-Dark Green

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## PORTABLE 1010 APPLICATIONS

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The Portable 1010 Family is useful in a variety of practical field applications. Its simplicity of installation makes it useful for both experienced and novice user staff, with built in Help Menu and OnScreen Prompts to answer any possible installation or use question. Memorized Site Setups make it convenient to re-visit sites for periodic flow monitoring.

Among the many applications for either 1010DP or 1010WDP are:

- Valve and Pump Operation
- Monitor/Control
- Real-time Flow Balance
- Real-time Flow Tracing
- Real-time Leak Detection Check
- Calibration check of InLine Meters
- Replacement of out of service Meters
- Batch Total Quantity Check
- Chiller and Boiler Efficiency Check
- Periodic Process Operation Check
- Mass Flowmetering and Batch Control
- Liquid Type and Quality Identification
- Pipeline Liquid Interface Detection
- Pipeline Sampling Pacer
- Thermal Energy Custody Transfer
- Mix Ratio Control
- Additive Metering Control
- Pump and Valve Cavitation Detection

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## LIQUID APPLICABILITY

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System 1010, with Reflexor, is applicable to essentially any liquid.

These include:

- Water Based Compounds
- Crude and Refined Petroleum
- Compressed Ethane, Butane & Propane
- Food Products
- Deionized Water, Etchants and Solvents
- Paper Pulp
- Coal and Sand Slurries
- Acids and Hazardous Chemicals
- Thermal Energy Transfer Mixtures
- Raw Sewage
- Municipal Sludges

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## PIPE APPLICABILITY

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System 1010 is applicable to essentially any sonically conductive pipe, from 1/4 inch (6 mm), to 360 inches (1500 mm), such as:

- Steel
  - Copper
  - Aluminum
  - Titanium
  - Plastic
  - Glass
  - Fiberglass (mandril wound)
  - Teflon
  - Ductile Iron
  - Cast Iron
  - Copper Nickel
- and many others.

Intimately bonded plastic, cement and glass pipe liners are acceptable.

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## OTHER PRODUCTS

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System 1010P and 1010WP operate on the same principle as other Controlotron 1010 and 990 products, listed below. Either may be used to determine applicability of a Permanent 1010 or 990 Model, such as:

**1010N** Permanent Mount Flowmeter  
**1010SX** Clamp-On Spool Flowmeter  
**1010FT** In-Line Volumetric/Mass Flowmeter  
**1010FL** In-Line Flare Gas Flowmeter  
**1010LDV** Pipe Line Leak Detection/Mgt  
**1010E** Energy Management Flowmeter

**990P** Portable Flowmeter  
**990N** Permanent Mount Flowmeter  
**990E** Energy Management Flowmeter  
**990FT** In-Line Volumetric/Mass Flowmeter  
**990DB** Dual Beam Flowmeter  
**990DV** Mass Flowmeter  
**990LD** Pipe Line Leak Detection/Mgt

**CONTROLOTRON**

155 Plant Avenue, Hauppauge, NY 11788  
(516) 231-3600 Fax: (516) 231-3334  
Internet: <http://www.controlotron.com>

**Appendix E**  
**Residential Water Meters**



**INFORMATION SOURCE**

This information was obtained from the following source.

Badger Meter Company, Utility Division  
4545 West Brown Deer Road  
P.O. Box 23099  
Milwaukee, Wisconsin 53223-0099  
Contact Person for International Division  
Ms. Isabelle Durso, Tel: (414) 371-5924, Fax: (414) 371-5955

Meter Size	Continuous liters/min	Plastic Casing Meter with Reading on Meter \$ COST	Bronze Casing Meter with Reading on Meter \$ COST	Remote Readout Display Option Additional Cost	Close Proximity Reading Additional Cost	Radio Frequency Pass-by Reading Additional Cost
15 mm bore 20 mm nut or 26 mm nut	57	\$29	\$29	\$15	\$100	\$100
20 mm bore 26 mm nut	95	Not Available	\$37	\$20	\$100	\$100

**REMOTE READOUT DISPLAY**

This feature allows a remote display to be mounted outside a building for the convenience of not needing to enter a building to read the water meter.

**PROXIMITY READING FEATURE**

This device is mounted on the meter so that the meter reader can simply wave a reading wand over the top of the meter and the reading is stored into a hand held reading / memory device. The additional cost is \$3,000 per hand held reading / memory device with wand including software.

**RADIO FREQUENCY PASS-BY READING FEATURE**

This device is mounted on the meter so that the meter reader can simply drive by the meter and receive the reading via radio frequency. The additional cost is \$3,500 per handheld receiving device including software.

**BRONZE VERSUS PLASTIC CASINGS**

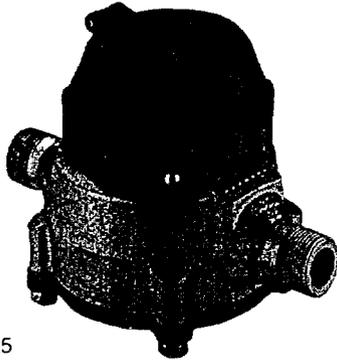
The plastic meters are chosen in areas where thieves are likely to take the meter for the scrap value of the bronze casing.

Size 5/8" (DN 15mm)  
Recordall® Cold Water  
Bronze Disc Meter



BadgerMeter  
Utility Division

# TECHNICAL BRIEF



Model 25

## SPECIFICATIONS

<b>Typical Operating Range</b> (100% ± 1.5%)	1/2 - 25GPM (1.9 to 95 l/m)
<b>Low Flow</b> (Min. 98.5%)	1/4 GPM (1.0 l/m)
<b>Maximum Continuous Operation</b>	15 GPM (57 l/m)
<b>Pressure Loss at Maximum Continuous Operation</b>	3.5 PSI at 15 GPM (0.24 bar at 57 l/m)
<b>Maximum Operating Temperature</b>	80°F (26°C)
<b>Maximum Operating Pressure</b>	150 PSI (10 Bar)
<b>Measuring Element</b>	Nutating disc, positive displacement
<b>Register Type</b>	Straight reading, permanently sealed magnetic drive standard. Remote reading or Automatic Meter Reading units optional.
<b>Register Capacity</b>	10,000,000 Gallons, 1,000,000 Cubic Feet, 100,000 m <sup>3</sup> . 6 odometer wheels.
<b>Meter Connections</b>	Available in bronze and thermoplastic to fit 5/8" spud thread bore diameter sizes. See table below.

### METER SPUD AND CONNECTION SIZES

Size Designation	x	"L" Laying Length	"B" Bore Dia.	Coupling Nut and Spud Thread	Tailpiece Pipe Thread (NPT)
5/8"	x	7 1/2"	5/8"	3/4" (5/8")	1/2"

## MATERIALS

<b>Meter Housing</b>	Cast Bronze
<b>Housing Bottom Plates</b>	Bronze, Cast Iron, Thermoplastic
<b>Measuring Chamber</b>	Thermoplastic
<b>Disc</b>	Thermoplastic
<b>Trim</b>	Stainless Steel, Bronze
<b>Strainer</b>	Thermoplastic
<b>Disc Spindle</b>	Stainless Steel
<b>Magnet</b>	Ceramic
<b>Magnet Spindle</b>	Stainless Steel
<b>Register Lid and Shroud</b>	Thermoplastic, Bronze
<b>Generator Housing</b>	Thermoplastic

## DESCRIPTION

**APPLICATIONS:** For use in measurement of potable cold water in residential, commercial and industrial services where flow is in one direction only.

**OPERATION:** Water flows through the meter's strainer and into the measuring chamber where it causes the disc to nutate. The disc, which moves freely, nutates on its own ball, guided by a thrust roller. A drive magnet transmits the motion of the disc to a follower magnet located within the permanently sealed register. The follower magnet is connected to the register gear train. The gear train reduces the disc nutations into volume totalization units displayed on the register dial face.

**OPERATING PERFORMANCE:** The Badger Recordall Disc meters meet or exceed registration accuracy for the low flow rates (95%), normal operating flow rates (100 ± 1.5%), and maximum continuous operation flow rates as specifically stated by AWWA Standard C700.

**CONSTRUCTION:** Badger Recordall Disc meter construction, which complies with ANSI/AWWA standard C700, consists of three basic components: meter housing, measuring chamber, and permanently sealed register. The water meter is bronze with externally-threaded spuds. A corrosion-resistant thermoplastic material is used for the measuring chamber.

To simplify maintenance, the register, measuring chamber, and strainer can be replaced without removing the meter housing from the installation. No change gears are required for accuracy calibration. Interchangeability of parts among like-sized meters also minimizes spare parts inventory investment. The built-in strainer has an effective straining area of twice the inlet size.

**MAGNETIC DRIVE:** Direct magnetic drive, through the use of high-strength magnets, provides positive, reliable and dependable register coupling for straight-reading, remote or automatic meter reading options.

**SEALED REGISTER:** The standard register consists of a straight-reading odometer-type totalization display, 360° test circle with center sweep hand and flow finder to detect leaks. Register gearing consists of self-lubricating thermoplastic gears to minimize friction and provides long life. Permanently sealed; dirt, moisture, tampering and lens fogging problems are eliminated. Multi-position register simplifies meter installation and reading. Generator-type remote reading and automatic meter reading systems are available for all Recordall Disc meters. (See back of sheet for additional information.) All reading options are removable from the meter without disrupting water service.

**TAMPER-PROOF FEATURES:** Customer removal of the register to obtain free water can be prevented when the optional tamper detection seal wire screw or TORX® tamper resistant seal screw is added to the meter. Both can be installed at the meter site or at the factory.

**MAINTENANCE:** Badger Recordall Disc meters are designed and manufactured to provide long-term service with minimal maintenance. When maintenance is required, it can be performed easily either at the meter installation or at any other convenient location. As an alternative to repair by the utility, Badger offers various maintenance and meter component exchange programs to fit the needs of the utility.

**CONNECTIONS:** Tailpieces/Unions for installations of meters on various pipe types and sizes, including misaligned pipes, are available as an option.

51

## Remote/Automatic Meter Reading Systems

### Remote Reading

The Badger ROM system generates and transmits an electrical pulse up to 5000 feet from the meter to a remote totalizer register without use of external power. See reference chart ROM-1-3. The generator which incorporates test circle and odometer-type totalizer is submersible. The remote register design permits resetting to any desired reading in the field and can be sealed to prevent tampering. See Bulletin ROM-T-5 for detail.

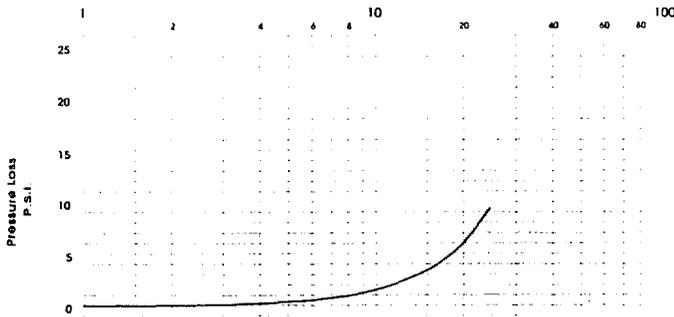
### AMR

The TRACE® radio frequency system or the ACCESSplus® telephone system easily integrate with all Recordall Disc meters. Both technologies provide an efficient meter data retrieval and information management system. The TRACE Transponder and ACCESSplus Remote Module connect to the High Resolution Transmitter register assembly. Complete turnkey systems, including hardware and software, are available to provide a wide range of meter reading information. See Bulletins G-101 (TRACE) and G-102 (ACCESSplus) for details.

TRACE® is a registered trademark of American Meter Company.

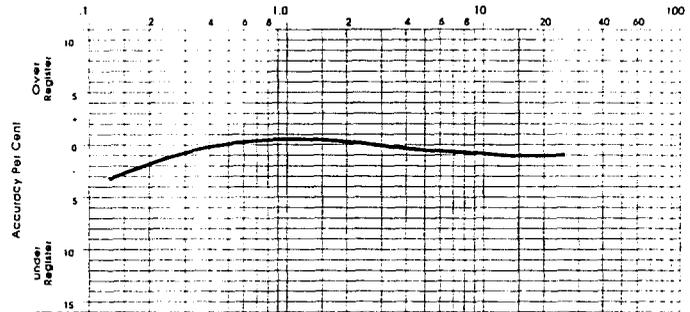
**PRESSURE LOSS CHART**

Rate of Flow, in Gallons per Minute



**ACCURACY CHART**

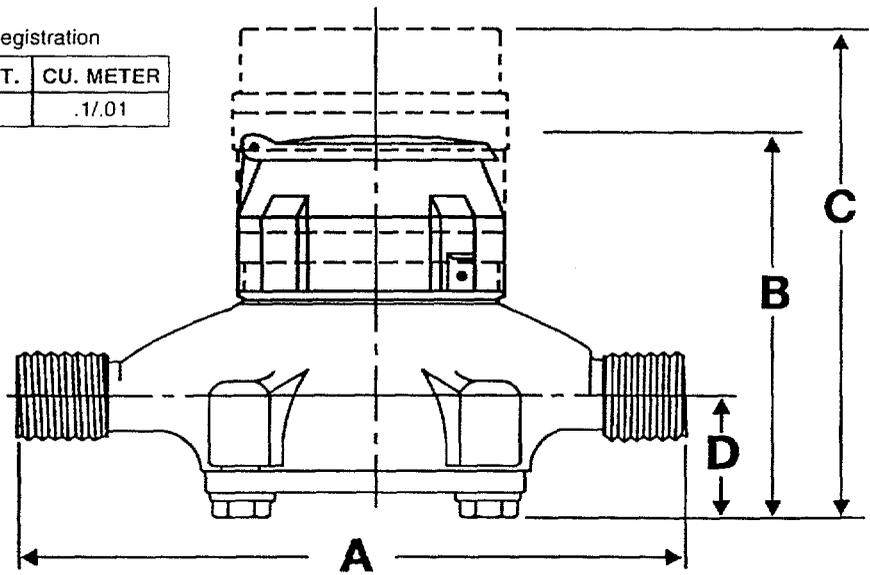
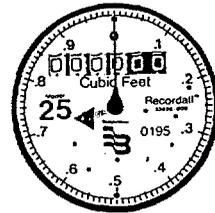
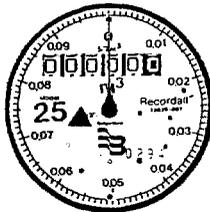
Rate of Flow, in Gallons per Minute



METER SIZE	METER MODEL	A LAYING LENGTH	B HEIGHT REG.	C HEIGHT GEN./HRT	D CENTERLINE BASE	WIDTH	APPROX. SHIPPING WEIGHT
5/8" (15mm)	25	7 1/2" (190mm)	4 15/16" (125mm)	6 5/16" (160mm)	1 1/16" (42mm)	4 1/4" (108mm)	4 1/2 lb. (2.0kg)

Sweep Hand Registration

MODEL	GALLON	CU. FT.	CU. METER
M25	10	1	.1/01



### North/East Region

4545 West Brown Deer Road  
P.O. Box 23099  
Milwaukee, WI 53223-0099  
(414) 355-0400 / (800) 876-3837  
Fax: (414) 355-3653

### South/East Region

P.O. Box 814149  
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Fax: (214) 416-7993

### Western Region

1318 Redwood Way, Suite 125  
Petaluma, CA 94954  
(707) 664-8740 / (800) 656-3837  
Fax: (707) 664-8264



## BadgerMeter, Inc. Utility Division

P.O. Box 23099, Milwaukee, WI 53223-0099  
Fax: (414) 355-2544

An independently owned American company.



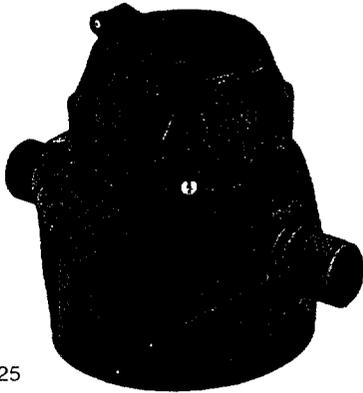
62

Size 5/8" (DN 15mm)  
 Recordall® Cold Water  
 Thermoplastic Disc Meter



BadgerMeter  
 Utility Division

# TECHNICAL BRIEF



Model 25

## SPECIFICATIONS

<b>Typical Operating Range</b> (100% ± 1.5%)	1/2 - 25 GPM (1.9 to 95 l/m)
<b>Low Flow</b> (Min. 98.5%)	1/4 GPM (1.0 l/m)
<b>Maximum Continuous Operation</b>	15 GPM (57 l/m)
<b>Pressure Loss at Maximum Continuous Operation</b>	4.2 PSI at 15 GPM (0.29 bar at 57 l/m)
<b>Maximum Operating Temperature</b>	80°F (26°C)
<b>Maximum Operating Pressure</b>	150 PSI (10 bar)
<b>Measuring Element</b>	Nutating disc, positive displacement
<b>Register Type</b>	Straight reading, permanently sealed magnetic drive standard. Remote reading or Automatic Meter Reading units optional.
<b>Register Capacity</b>	10,000,000 Gallons, 1,000,000 Cubic Feet, 100,000 m <sup>3</sup> . 6 odometer wheels.
<b>Meter Connections</b>	Available in bronze and thermoplastic to fit 5/8" spud thread bore diameter sizes. See table below.

### METER SPUD AND CONNECTION SIZES

Size Designation	x	"L" Laying Length	"B" Bore Dia.	Coupling Nut and Spud Thread	Tailpiece Pipe Thread (NPT)
5/8"	x	7 1/2"	5/8"	3/4" (5/8")	1/2"

## MATERIALS

<b>Meter Housing</b>	Thermoplastic
<b>Housing Bottom Plate</b>	Thermoplastic
<b>Measuring Chamber</b>	Thermoplastic
<b>Disc</b>	Thermoplastic
<b>Strainer</b>	Thermoplastic
<b>Disc Spindle</b>	Stainless Steel
<b>Magnet</b>	Ceramic
<b>Magnet Spindle</b>	Stainless Steel
<b>Register Lid and Shroud</b>	Thermoplastic
<b>Generator Housing</b>	Thermoplastic

## DESCRIPTION

**APPLICATIONS:** For use in measurement of potable cold water in residential, commercial and industrial services where flow is in one direction only.

**OPERATION:** Water flows through the meter's strainer and into the measuring chamber where it causes the disc to nutate. The disc, which moves freely, nutates on its own ball, guided by a thrust roller. A drive magnet transmits the motion of the disc to a follower magnet located within the permanently sealed register. The follower magnet is connected to the register gear train. The gear train reduces the disc nutations into volume totalization units displayed on the register dial face.

**OPERATING PERFORMANCE:** The Badger Recordall Disc meters meet or exceed registration accuracy for the low flow rates (95%), normal operating flow rates (100 ± 1.5%), and maximum continuous operation flow rates as specifically stated by AWWA Standard C710.

**CONSTRUCTION:** Badger Recordall Disc meter construction, which complies with ANSI/AWWA standard C710, consists of three basic components: meter housing, measuring chamber, and permanently sealed register. The water meter is thermoplastic with externally-threaded spuds. A corrosion-resistant thermoplastic material is used for the measuring chamber.

To simplify maintenance, the register, measuring chamber, and strainer can be replaced without removing the meter housing from the installation. No change gears are required for accuracy calibration. Interchangeability of parts among like-sized meters also minimizes spare parts inventory investment.

**MAGNETIC DRIVE:** Direct magnetic drive, through the use of high-strength magnets, provides positive, reliable and dependable register coupling for straight-reading, remote or automatic meter reading options.

**SEALED REGISTER:** The standard register consists of a straight-reading odometer-type totalization display, 360° test circle with center sweep hand and flow finder to detect leaks. Register gearing consists of self-lubricating thermoplastic gears to minimize friction and provides long life. Permanently sealed; dirt, moisture, tampering and lens fogging problems are eliminated. Multi-position register simplifies meter installation and reading. Generator-type remote reading and automatic meter reading systems are available for all Recordall Disc meters. (See back of sheet for additional information.) All reading options are removable from the meter without disrupting water service.

**TAMPER-PROOF FEATURES:** Customer removal of the register to obtain free water can be prevented when the optional tamper detection seal wire screw or TORX® tamper resistant seal screw is added to the meter. Both can be installed at the meter site or at the factory.

**MAINTENANCE:** Badger Recordall Disc meters are designed and manufactured to provide long-term service with minimal maintenance. When maintenance is required, it can be performed easily either at the meter installation or at any other convenient location. As an alternative to repair by the utility, Badger offers various maintenance and meter component exchange programs to fit the needs of the utility.

**CONNECTIONS:** Tailpieces/Unions for installations of meters on various pipe types and sizes, including misaligned pipes, are available as an option.

53

## Remote/Automatic Meter Reading Systems

### Remote Reading

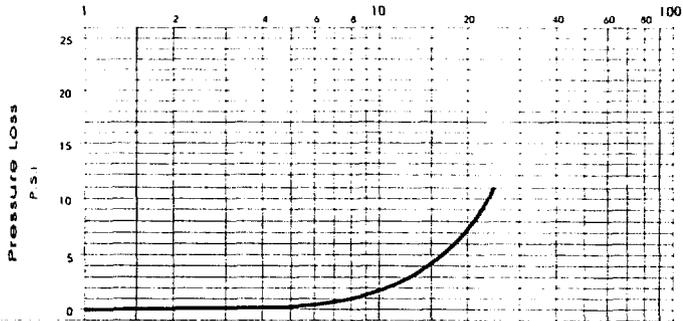
The Badger ROM system generates and transmits an electrical pulse up to 5000 feet from the meter to a remote totalizer register without use of external power. See reference chart ROM-1-3. The generator which incorporates test circle and odometer-type totalizer is submersible. The remote register design permits resetting to any desired reading in the field and can be sealed to prevent tampering. See Bulletin ROM-T-5 for detail.

### AMR

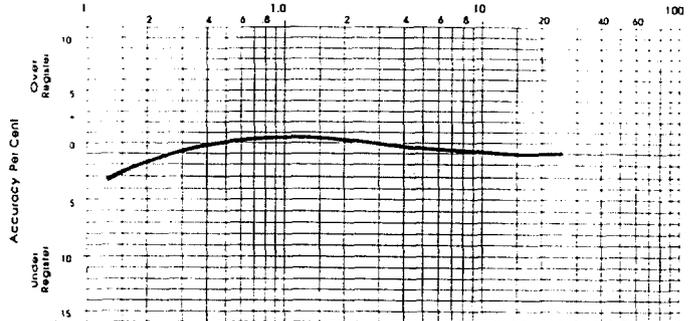
The TRACE® radio frequency system or the ACCESSplus® telephone system easily integrate with all Recordall Disc meters. Both technologies provide an efficient meter data retrieval and information management system. The TRACE Transponder and ACCESSplus Remote Module connect to the High Resolution Transmitter register assembly. Complete turnkey systems, including hardware and software, are available to provide a wide range of meter reading information. See Bulletins G-101 (TRACE) and G-102 (ACCESSplus) for details.

TRACE® is a registered trademark of American Meter Company.

**PRESSURE LOSS CHART**  
Rate of Flow, in Gallons per Minute



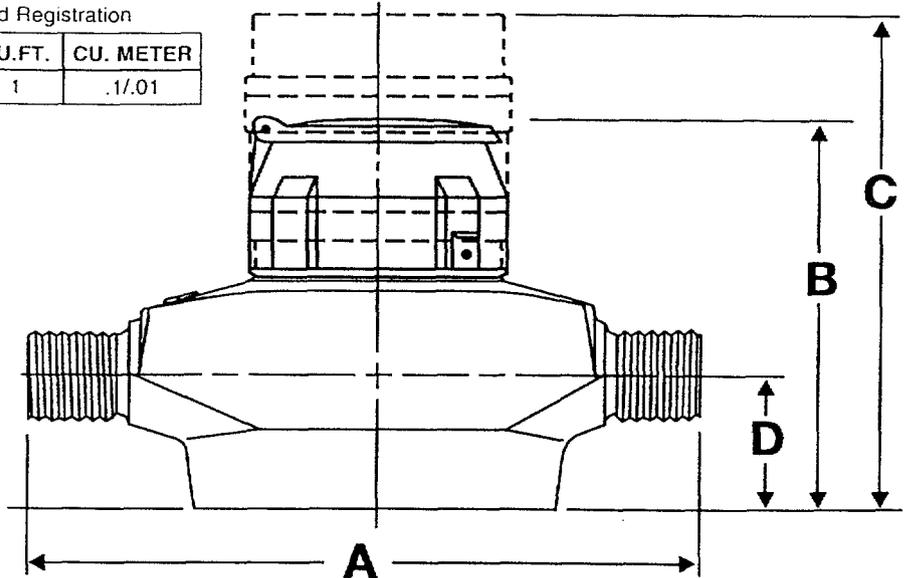
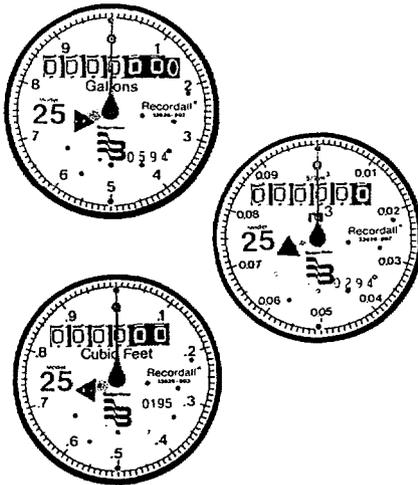
**ACCURACY CHART**  
Rate of Flow, in Gallons per Minute



METER SIZE	METER MODEL	A LAYING LENGTH	B HEIGHT REG.	C HEIGHT GEN./HRT	D CENTERLINE BASE	WIDTH	APPROX. SHIPPING WEIGHT
5/8" (15mm)	25	7 1/2" (190mm)	5 1/16" (128mm)	6 7/16" (163mm)	1 3/4" (44mm)	4 3/16" (122mm)	2 1/2 lb. (1.0kg)

Sweep Hand Registration

MODEL	GALLON	CU. FT.	CU. METER
M25	10	1	.1/.01



### North/East Region

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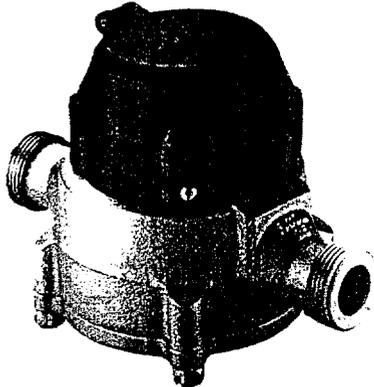


Size 5/8 x 3/4" (DN 15mm)  
 Recordall® Cold Water  
 Bronze Disc Meter



BadgerMeter  
 Utility Division

# TECHNICAL BRIEF



Model 25

## SPECIFICATIONS

<b>Typical Operating Range (100% ± 1.5%)</b>	1/2 - 25 GPM (1.9 to 95 l/m)
<b>Low Flow (Min. 98.5%)</b>	1/4 GPM (1.0 l/m)
<b>Maximum Continuous Operation</b>	15 GPM (57 l/m)
<b>Pressure Loss at Maximum Continuous Operation</b>	2.8 PSI at 15 GPM (0.19 bar at 57 l/m)
<b>Maximum Operating Temperature</b>	80°F (26°C)
<b>Maximum Operating Pressure</b>	150 PSI (10 bar)
<b>Measuring Element</b>	Nutating disc, positive displacement
<b>Register Type</b>	Straight reading, permanently sealed magnetic drive standard. Remote reading or Automatic Meter Reading units optional.
<b>Register Capacity</b>	10,000,000 Gallons, 1,000,000 Cubic Feet, 100,000 m <sup>3</sup> . 6 odometer wheels.
<b>Meter Connections</b>	Available in bronze and thermoplastic to fit 3/4" spud thread bore diameter sizes. See table below.

### METER SPUD AND CONNECTION SIZES

Size Designation x	"L" Laying Length	"B" Bore Dia.	Coupling Nut and Spud Thread	Tailpiece Pipe Thread (NPT)
5/8" x 3/4" x	7 1/2"	5/8", 3/4"	1" (3/4")	3/4"

## MATERIALS

<b>Meter Housing</b>	Cast Bronze
<b>Housing Bottom Plates</b>	Bronze, Cast Iron, Thermoplastic
<b>Measuring Chamber</b>	Thermoplastic
<b>Disc</b>	Thermoplastic
<b>Trim</b>	Stainless Steel, Bronze
<b>Strainer</b>	Thermoplastic
<b>Disc Spindle</b>	Stainless Steel
<b>Magnet</b>	Ceramic
<b>Magnet Spindle</b>	Stainless Steel
<b>Register Lid and Shroud</b>	Thermoplastic, Bronze
<b>Generator Housing</b>	Thermoplastic

## DESCRIPTION

**APPLICATIONS:** For use in measurement of potable cold water in residential, commercial and industrial services where flow is in one direction only.

**OPERATION:** Water flows through the meter's strainer and into the measuring chamber where it causes the disc to nutate. The disc, which moves freely, nutates on its own ball, guided by a thrust roller. A drive magnet transmits the motion of the disc to a follower magnet located within the permanently sealed register. The follower magnet is connected to the register gear train. The gear train reduces the disc nutations into volume totalization units displayed on the register dial face.

**OPERATING PERFORMANCE:** The Badger Recordall Disc meters meet or exceed registration accuracy for the low flow rates (95%), normal operating flow rates (100 ± 1.5%), and maximum continuous operation flow rates as specifically stated by AWWA Standard C700.

**CONSTRUCTION:** Badger Recordall Disc meter construction, which complies with ANSI/AWWA standard C700, consists of three basic components: meter housing, measuring chamber, and permanently sealed register. The water meter is thermoplastic with externally-threaded spuds. A corrosion-resistant thermoplastic material is used for the measuring chamber.

To simplify maintenance, the register, measuring chamber, and strainer can be replaced without removing the meter housing from the installation. No change gears are required for accuracy calibration. Interchangeability of parts among like-sized meters also minimizes spare parts inventory investment.

**MAGNETIC DRIVE:** Direct magnetic drive, through the use of high-strength magnets, provides positive, reliable and dependable register coupling for straight-reading, remote or automatic meter reading options.

**SEALED REGISTER:** The standard register consists of a straight-reading odometer-type totalization display, 360° test circle with center sweep hand and flow finder to detect leaks. Register gearing consists of self-lubricating thermoplastic gears to minimize friction and provides long life. Permanently sealed; dirt, moisture, tampering and lens fogging problems are eliminated. Multi-position register simplifies meter installation and reading. Generator-type remote reading and automatic meter reading systems are available for all Recordall Disc meters. (See back of sheet for additional information.) All reading options are removable from the meter without disrupting water service.

**TAMPER-PROOF FEATURES:** Customer removal of the register to obtain free water can be prevented when the optional tamper detection seal wire screw or TORX® tamper resistant seal screw is added to the meter. Both can be installed at the meter site or at the factory.

**MAINTENANCE:** Badger Recordall Disc meters are designed and manufactured to provide long-term service with minimal maintenance. When maintenance is required, it can be performed easily either at the meter installation or at any other convenient location. As an alternative to repair by the utility, Badger offers various maintenance and meter component exchange programs to fit the needs of the utility.

**CONNECTIONS:** Tailpieces/Unions for installations of meters on various pipe types and sizes, including misaligned pipes, are available as an option.

55

## Remote/Automatic Meter Reading Systems

### Remote Reading

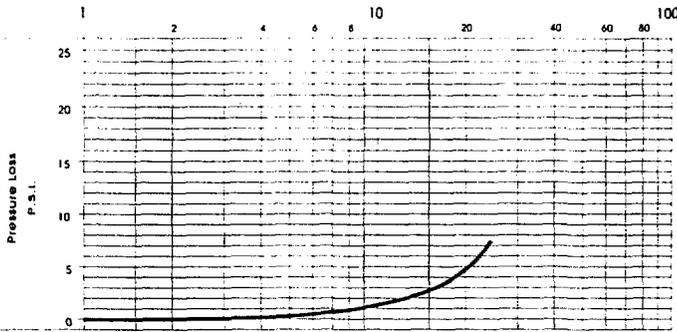
The Badger ROM system generates and transmits an electrical pulse up to 5000 feet from the meter to a remote totalizer register without use of external power. See reference chart ROM-I-3. The generator which incorporates test circle and odometer-type totalizer is submersible. The remote register design permits resetting to any desired reading in the field and can be sealed to prevent tampering. See Bulletin ROM-T-5 for detail.

### AMR

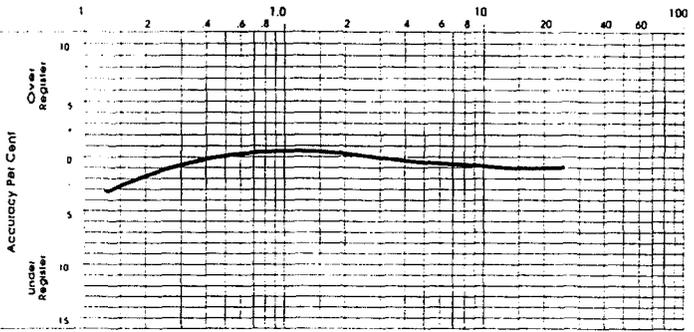
The TRACE® radio frequency system or the ACCESSplus® telephone system easily integrate with all Recordall Disc meters. Both technologies provide an efficient meter data retrieval and information management system. The TRACE Transponder and ACCESSplus Remote Module connect to the High Resolution Transmitter register assembly. Complete turnkey systems, including hardware and software, are available to provide a wide range of meter reading information. See Bulletins G-101 (TRACE) and G-102 (ACCESSplus) for details.

TRACE® is a registered trademark of American Meter Company.

**PRESSURE LOSS CHART**  
Rate of Flow, in Gallons per Minute



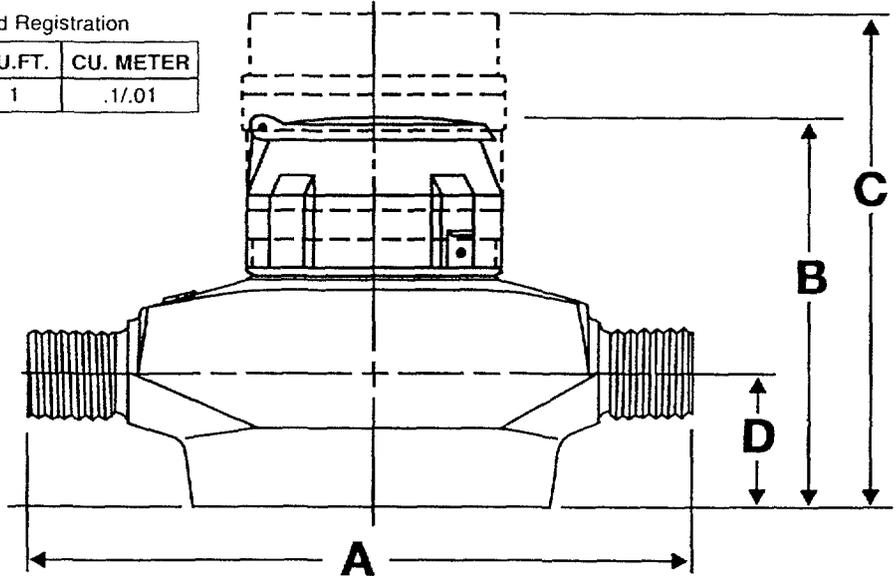
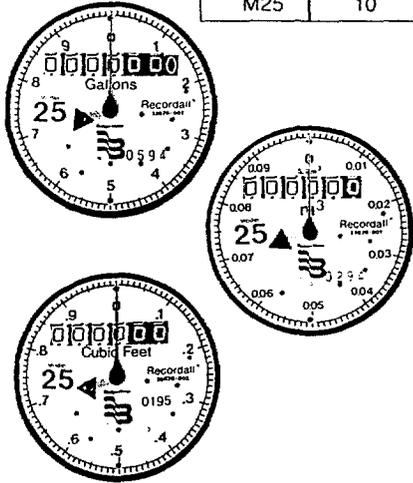
**ACCURACY CHART**  
Rate of Flow, in Gallons per Minute



METER SIZE	METER MODEL	A LAYING LENGTH	B HEIGHT REG.	C HEIGHT GEN./HRT	D CENTERLINE BASE	WIDTH	APPROX. SHIPPING WEIGHT
5/8 x 3/4" (15mm)	25	7 1/2" (190mm)	5 1/16" (128mm)	6 7/16" (163mm)	1 3/4" (44mm)	4 13/16" (122mm)	2 1/2 lb. (1.0kg)

Sweep Hand Registration

MODEL	GALLON	CU. FT.	CU. METER
M25	10	1	.1/01



### North/East Region

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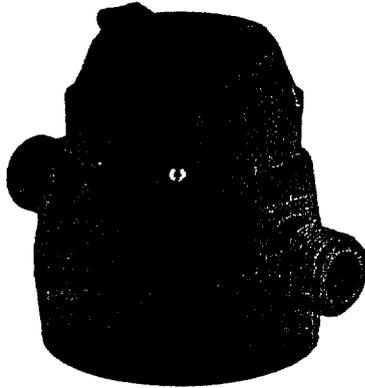
56

Size 5/8 x 3/4" (DN 15mm)  
 Recordall® Cold Water  
 Thermoplastic Disc Meter



BadgerMeter  
 Utility Division

# TECHNICAL BRIEF



Model 25

## SPECIFICATIONS

<b>Typical Operating Range (100% ± 1.5%)</b>	1/2 - 25 GPM (1.9 to 95 l/m)
<b>Low Flow (Min. 98.5%)</b>	1/4 GPM (1.0 l/m)
<b>Maximum Continuous Operation</b>	15 GPM (57 l/m)
<b>Pressure Loss at Maximum Continuous Operation</b>	2.8 PSI at 15 GPM (0.19 bar at 57 l/m)
<b>Maximum Operating Temperature</b>	80°F (26°C)
<b>Maximum Operating Pressure</b>	150 PSI (10 bar)
<b>Measuring Element</b>	Nutating disc, positive displacement
<b>Register Type</b>	Straight reading, permanently sealed magnetic drive standard. Remote reading or Automatic Meter Reading units optional.
<b>Register Capacity</b>	10,000,000 Gallons, 1,000,000 Cubic Feet, 100,000 m <sup>3</sup> . 6 odometer wheels.
<b>Meter Connections</b>	Available in bronze and thermoplastic to fit 3/4" spud thread bore diameter sizes. See table below.

### METER SPUD AND CONNECTION SIZES

Size Designation	"L" Laying Length	"B" Bore Dia.	Coupling Nut and Spud Thread	Tailpiece Pipe Thread (NPT)
5/8" x 3/4"	7 1/2"	5/8", 3/4"	1" (3/4")	3/4"

## MATERIALS

<b>Meter Housing</b>	Thermoplastic
<b>Housing Bottom Plate</b>	Thermoplastic
<b>Measuring Chamber</b>	Thermoplastic
<b>Disc</b>	Thermoplastic
<b>Strainer</b>	Thermoplastic
<b>Disc Spindle</b>	Stainless Steel
<b>Magnet</b>	Ceramic
<b>Magnet Spindle</b>	Stainless Steel
<b>Register Lid and Shroud</b>	Thermoplastic
<b>Generator Housing</b>	Thermoplastic

## DESCRIPTION

**APPLICATIONS:** For use in measurement of potable cold water in residential, commercial and industrial services where flow is in one direction only.

**OPERATION:** Water flows through the meter's strainer and into the measuring chamber where it causes the disc to nutate. The disc, which moves freely, nutates on its own ball, guided by a thrust roller. A drive magnet transmits the motion of the disc to a follower magnet located within the permanently sealed register. The follower magnet is connected to the register gear train. The gear train reduces the disc nutations into volume totalization units displayed on the register dial face.

**OPERATING PERFORMANCE:** The Badger Recordall Disc meters meet or exceed registration accuracy for the low flow rates (95%), normal operating flow rates (100 ± 1.5%), and maximum continuous operation flow rates as specifically stated by AWWA Standard C710.

**CONSTRUCTION:** Badger Recordall Disc meter construction, which complies with ANSI/AWWA standard C710, consists of three basic components: meter housing, measuring chamber, and permanently sealed register. The water meter is thermoplastic with externally-threaded spuds. A corrosion-resistant thermoplastic material is used for the measuring chamber.

To simplify maintenance, the register, measuring chamber, and strainer can be replaced without removing the meter housing from the installation. No change gears are required for accuracy calibration. Interchangeability of parts among like-sized meters also minimizes spare parts inventory investment.

**MAGNETIC DRIVE:** Direct magnetic drive, through the use of high-strength magnets, provides positive, reliable and dependable register coupling for straight-reading, remote or automatic meter reading options.

**SEALED REGISTER:** The standard register consists of a straight-reading odometer-type totalization display, 360° test circle with center sweep hand and flow finder to detect leaks. Register gearing consists of self-lubricating thermoplastic gears to minimize friction and provides long life. Permanently sealed; dirt, moisture, tampering and lens fogging problems are eliminated. Multi-position register simplifies meter installation and reading. Generator-type remote reading and automatic meter reading systems are available for all Recordall Disc meters. (See back of sheet for additional information.) All reading options are removable from the meter without disrupting water service.

**TAMPER-PROOF FEATURES:** Customer removal of the register to obtain free water can be prevented when the optional tamper detection seal wire screw or TORX® tamper resistant seal screw is added to the meter. Both can be installed at the meter site or at the factory.

**MAINTENANCE:** Badger Recordall Disc meters are designed and manufactured to provide long-term service with minimal maintenance. When maintenance is required, it can be performed easily either at the meter installation or at any other convenient location. As an alternative to repair by the utility, Badger offers various maintenance and meter component exchange programs to fit the needs of the utility.

**CONNECTIONS:** Tailpieces/Unions for installations of meters on various pipe types and sizes, including misaligned pipes, are available as an option.



## Remote/Automatic Meter Reading Systems

### Remote Reading

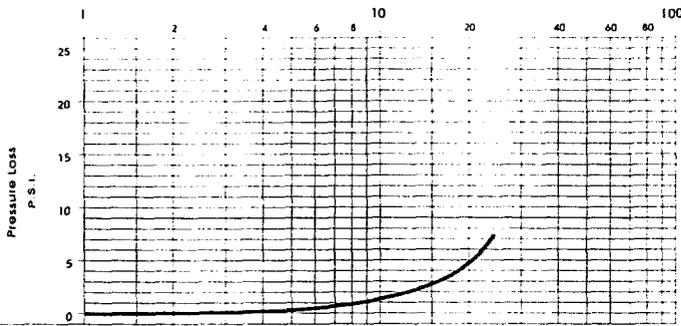
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### AMR

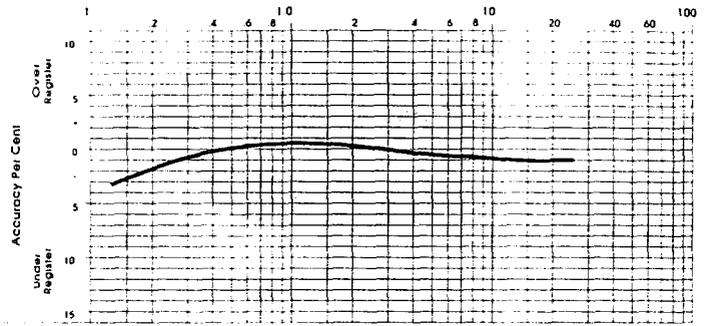
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**PRESSURE LOSS CHART**  
Rate of Flow, in Gallons per Minute



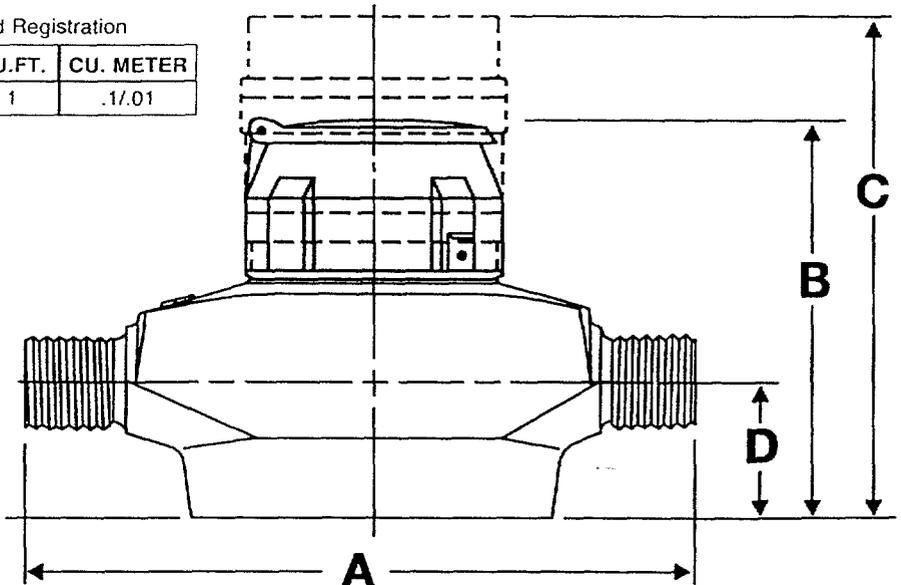
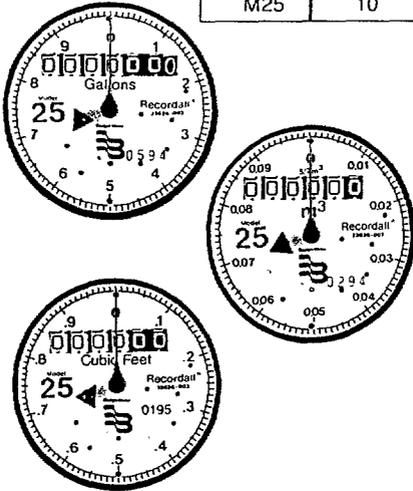
**ACCURACY CHART**  
Rate of Flow, in Gallons per Minute



METER SIZE	METER MODEL	A LAYING LENGTH	B HEIGHT REG.	C HEIGHT GEN./HRT	D CENTERLINE BASE	WIDTH	APPROX. SHIPPING WEIGHT
5/8 x 3/4" (15mm)	25	7 1/2" (190mm)	5 1/16" (128mm)	6 7/16" (163mm)	1 3/4" (44mm)	4 13/16" (122mm)	2 1/2 lb. (1.0kg)

Sweep Hand Registration

MODEL	GALLON	CU.FT.	CU. METER
M25	10	1	.1/01



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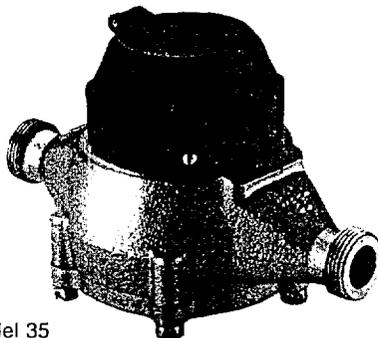
**Western Region**  
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(707) 664-8740 / (800) 656-3837  
Fax: (707) 664-8264

Size 3/4" (DN 20mm)  
Recordall® Cold Water  
Bronze Disc Meter



BadgerMeter  
Utility Division

TECHNICAL  
BRIEF



Model 35

**SPECIFICATIONS**

<b>Typical Operating Range (100% ± 1.5%)</b>	3/4-35 GPM (2.8 to 132 l/m)
<b>Low Flow (Min. 97%)</b>	3/8 GPM (1.4 l/m)
<b>Maximum Continuous Operation</b>	25 GPM (95 l/m)
<b>Pressure Loss at Maximum Continuous Operation</b>	5 PSI at 25 GPM (.37 bar at 95 l/m)
<b>Maximum Operating Temperature</b>	80°F (26°C)
<b>Maximum Operating Pressure</b>	150 PSI (10 bar)
<b>Measuring Element</b>	Nutating disc, positive displacement
<b>Register Type</b>	Straight reading, permanently sealed magnetic drive standard. Remote reading or Automatic Meter Reading units optional.
<b>Register Capacity</b>	10,000,000 Gallons, 1,000,000 Cubic Feet, 100,000 m <sup>3</sup> . 6 odometer wheels.
<b>Meter Connections</b>	Available in bronze and thermoplastic to fit 3/4" spud thread bore diameter sizes. See table below.

**METER SPUD AND CONNECTION SIZES**

Size Designation	"L" Laying Length	"B" Bore Dia.	Coupling Nut and Spud Thread	Tailpiece Pipe Thread (NPT)
3/4" x	7 1/2"	3/4"	1" (3/4")	3/4"
3/4" x	9"	3/4"	1" (3/4")	3/4"
3/4" x 1" x	9"	3/4"	1 1/4" (1")	1"

**MATERIALS**

<b>Meter Housing</b>	Cast Bronze
<b>Housing Bottom Plates</b>	Bronze, Cast Iron
<b>Measuring Chamber</b>	Thermoplastic
<b>Disc</b>	Thermoplastic
<b>Trim</b>	Stainless Steel, Bronze
<b>Strainer</b>	Thermoplastic
<b>Disc Spindle</b>	Stainless Steel
<b>Magnet</b>	Ceramic
<b>Magnet Spindle</b>	Stainless Steel
<b>Register Lid and Shroud</b>	Thermoplastic, Bronze
<b>Generator Housing</b>	Thermoplastic

**DESCRIPTION**

**APPLICATIONS:** For use in measurement of potable cold water in residential, commercial and industrial services where flow is in one direction only.

**OPERATION:** Water flows through the meter's strainer and into the measuring chamber where it causes the disc to nutate. The disc, which moves freely, nutates on its own ball, guided by a thrust roller. A drive magnet transmits the motion of the disc to a follower magnet located within the permanently sealed register. The follower magnet is connected to the register gear train. The gear train reduces the disc nutations into volume totalization units displayed on the register dial face.

**OPERATING PERFORMANCE:** The Badger Recordall Disc meters meet or exceed registration accuracy for the low flow rates (95%), normal operating flow rates (100 ± 1.5%), and maximum continuous operation flow rates as specifically stated by AWWA Standard C700.

**CONSTRUCTION:** Badger Recordall Disc meter construction, which complies with ANSI/AWWA standard C700, consists of three basic components: meter housing, measuring chamber, and permanently sealed register. The water meter is bronze with externally-threaded spuds. A corrosion-resistant thermoplastic material is used for the measuring chamber.

To simplify maintenance, the register, measuring chamber, and strainer can be replaced without removing the meter housing from the installation. No change gears are required for accuracy calibration. Interchangeability of parts among like-sized meters also minimizes spare parts inventory investment. The built-in strainer has an effective straining area of twice the inlet size.

**MAGNETIC DRIVE:** Direct magnetic drive, through the use of high-strength magnets, provides positive, reliable and dependable register coupling for straight-reading, remote or automatic meter reading options.

**SEALED REGISTER:** The standard register consists of a straight-reading odometer-type totalization display, 360° test circle with center sweep hand and flow finder to detect leaks. Register gearing consists of self-lubricating thermoplastic gears to minimize friction and provides long life. Permanently sealed; dirt, moisture, tampering and lens fogging problems are eliminated. Multi-position register simplifies meter installation and reading. Generator-type remote reading and automatic meter reading systems are available for all Recordall Disc meters. (See back of sheet for additional information.) All reading options are removable from the meter without disrupting water service.

**TAMPER-PROOF FEATURES:** Customer removal of the register to obtain free water can be prevented when the optional tamper detection seal wire screw or TORX® tamper resistant seal screw is added to the meter. Both can be installed at the meter site or at the factory.

**MAINTENANCE:** Badger Recordall Disc meters are designed and manufactured to provide long-term service with minimal maintenance. When maintenance is required, it can be performed easily either at the meter installation or at any other convenient location. As an alternative to repair by the utility, Badger offers various maintenance and meter component exchange programs to fit the needs of the utility.

**CONNECTIONS:** Tailpieces/Unions for installations of meters on various pipe types and sizes, including misaligned pipes, are available as an option.



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59

RESOURCE MANAGEMENT  
ASSOCIATES INC

# Remote/Automatic Meter Reading Systems

## Remote Reading

The Badger ROM system generates and transmits an electrical pulse up to 5000 feet from the meter to a remote totalizer register without use of external power. See reference chart ROM-I-3. The generator which incorporates a test circle and odometer-type totalizer is submersible. The remote register design permits resetting to any desired reading in the field and can be sealed to prevent tampering. See Bulletin ROM-T-5 for detail.

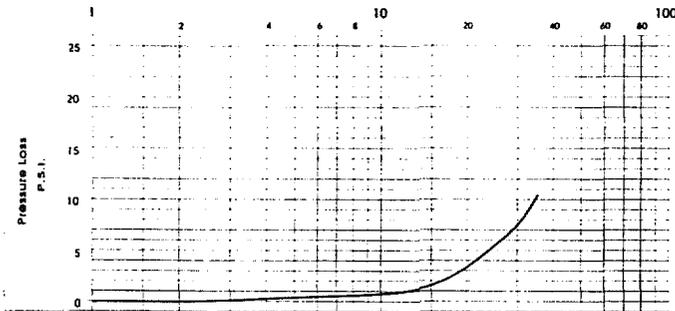
## AMR

The TRACE® radio frequency system or the ACCESSplus® telephone system easily integrate with all Recordall Disc meters. Both technologies provide an efficient meter data retrieval and information management system. The TRACE Transponder and ACCESSplus Remote Module connect to the High Resolution Transmitter register assembly. Complete turnkey systems, including hardware and software, are available to provide a wide range of meter reading information. See Bulletins G-101 (TRACE) and G-102 (ACCESSplus) for details.

TRACE® is a registered trademark of American Meter Company.

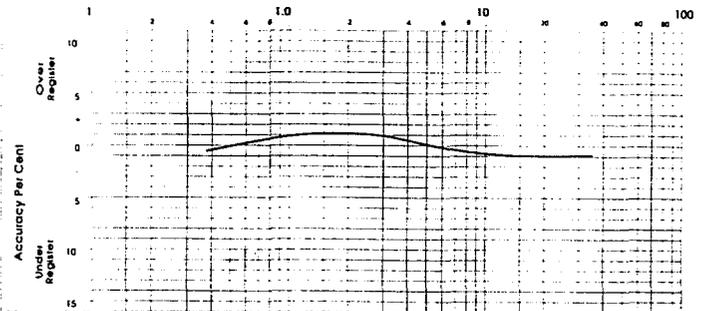
**PRESSURE LOSS CHART**

Rate of Flow, in Gallons per Minute

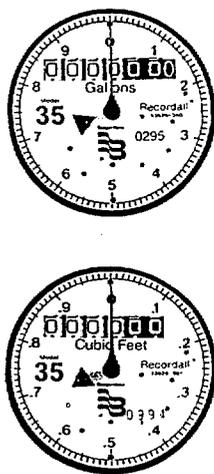


**ACCURACY CHART**

Rate of Flow, in Gallons per Minute

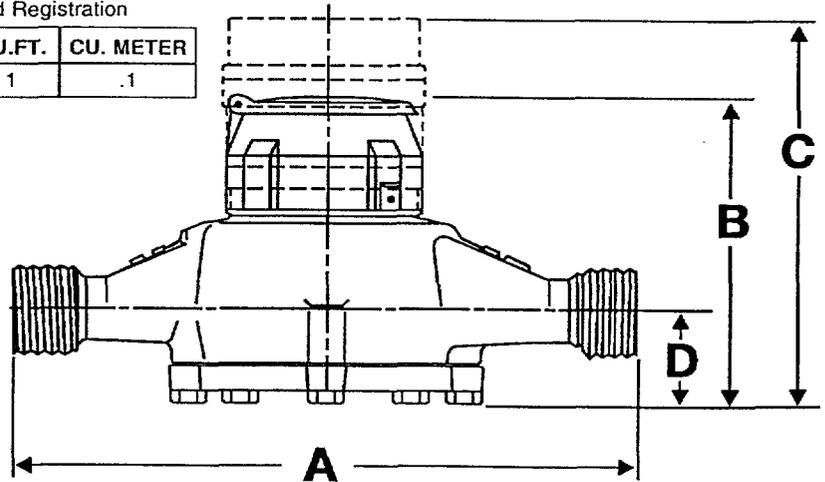


METER SIZE	METER MODEL	A LAYING LENGTH	B HEIGHT REG.	C HEIGHT GEN./HRT	D CENTERLINE BASE	WIDTH	APPROX. SHIPPING WEIGHT
3/4" (20mm)	35	7 1/2" (190mm)	5 1/4" (133mm)	6 5/8" (168mm)	1 5/8" (41mm)	5" (127mm)	5 1/2 lb. (2.5kg)
3/4" (20mm)	35	9" (229mm)	5 1/4" (133mm)	6 5/8" (168mm)	1 5/8" (41mm)	5" (127mm)	5 3/4 lb. (2.6kg)
3/4" x 1" (20mm)	35	9" (229mm)	5 1/4" (133mm)	6 5/8" (168mm)	1 5/8" (41mm)	5" (127mm)	6 lb. (2.7kg)



Sweep Hand Registration

MODEL	GALLON	CU.FT.	CU. METER
M35	10	1	.1



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