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

MUNICIPAL WATER PUMPING

**BANGALORE (KARNAKATA)
INDIA**

Trip Report

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BACKGROUND

Bangalore is a city of approximately five million inhabitants, located in southern India in the state of Karnataka. Bangalore has a thriving metropolitan business climate, with many multinational companies located in the metropolitan area. Bangalore has earned the nickname of "The Silicon Valley of India" because of the preponderance of computer companies located in the region. However, the thriving prosperity of Bangalore though is not without its problems. The population is growing quickly and is predicted to reach 5.5 million by 2001, a 35% increase from 1991. recent water shortage problems have caused renewed concern in Bangalore. Newspaper articles from the Bangalore press for the week of Mary 17 -21, 1977, express concern over the water supply. (See Appendix G.)

The city of Bangalore established a domestic water supply for the city in 1896, one of the first cities in India to do so. This system relied on the Arkavathi River, which is 18 kilometers from Bangalore, and it included a reservoir and a pumping station used to move the water to the city. This system served as the only supply for Bangalore for over thirty years. However, during this time the city population almost doubled, and the need for more water was great. In 1933, a second water supply system was added, again using the Arkavathi River as the source. Located 28 kilometers from Bangalore, the new system provided a significant increase in the supply of water, as the original system remained in operation.

Bangalore experienced large industrial growth during the 1950s and 1960s, placing greater demands on the water supply system. During this period, the Bangalore Water Supply and Sewerage Board (BWSSB) was established and given the responsibility to provide adequate water and sewerage services to the city. During this period, a new plan was developed to tap the Cauvery River, located 98 kilometers from Bangalore. The first stage of this plan went into operation in 1974. Although this system doubled the previous water capacity of the city, it was not sufficient to keep up with the growing demands of the city. Therefore, Stage II (a system identical to that of Stage I) was put into operation in 1982. Stage III of the Cauvery system was subsequently designed, and it began operation in 1993. Stage III was equal in capacity to the sum of Stages I and II, and yet the demand for water was still greater than the supply. *Table I* illustrates the water supply and calculated demand (in millions of liters per day) from 1981 to 2011. This data shows that the existing systems have only been able to provide about one half of the calculated demand for domestic water and that the demand continues to increase.

EXISTING SYSTEMS

The design capacity for the city is currently 705 million liters per day. But the total capacity is not available because of low water levels at the sources, equipment problems, and electrical shortages. Of the 705 million liters per day design capacity, only 486 million liters per day were provided in 1993 (69% of total capacity). This figure rose to 548.8 million liters per day in 1994 (78% of the design capacity). BWSSB staff have estimated that the supply was still only half of the theoretical demand. As a result of the continuing water shortage, Stage IV of the Cauvery system is currently being designed.

Stage IV will be designed and implemented in two phases, with each phase being equivalent in capacity to Stage III. It is estimated that the construction for Phase 1 of Stage IV will begin in 1998. As *Table 1* indicates, the addition of Phase 1 and 2 of Stage IV of the Cauvery system will only approach meeting the ever-increasing demand for water.

Table 1 gives a brief history of the water supply system for Bangalore, and the capacity of water per capita.

Table 1
Bangalore Water Supply

Year	Population	Population Increase, %	Water Source	Capacity Per Capita, Liters/Person-day
1901	163,091	---	Hessarghatta	86
1911	189,485	16	---	74
1921	240,054	27	---	58
1931	309,785	29	T.G. Halli (1933)	45
1941	410,967	33	---	100
1951	786,343	91	---	79
1961	1,206,961	53	---	71
1971	1,664,208	38	Cauvery Stage I (1974)	94
1981	2,921,751	76	Cauvery Stage II (1982)	102
1991	4,130,288	41	Cauvery Stage III (1993)	105
2001	5,576,000	35	Cauvery Stage IV (1998)	174
2011	7,000,000	26	---	139

This table includes estimates of the city's population for 2001 and 2011, as well as estimating the addition of the Cauvery Stage IV water pumping system. The growing population of Bangalore causes tremendous fluctuations in the supply capacity of the water system. In addition, some of the older sources have been drying up, or at least the quantity of water available is greatly reduced from the original design. The original system at Hessarghatta is now drawing only 6 million liters per day (MLD), down from the original design figure of 36 MLD. The T.G. Halli system is also greatly reduced, pumping a maximum of 36 MLD, down from the original design of 140 MLD.

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Because of the shortage of water and the growing population, the BWSSB have begun work on the design for Stage IV. This work is beginning carried out by a team representing Tata Consulting, Mott McDermott (design engineers from England), and a Japanese firm.

Transmission Pumping System Details

Bangalore receives water from two rivers, the Arkavathy and the Cauvery. Both rivers are distant from Bangalore, requiring that the water be pumped to the city. There are two systems providing water from the Arkavathy River –Hesaraghatta and T.G. Halli, and three systems providing water from the Cauvery River – Stages I, II, and III.

The typical system design is for water to be pumped from the river to a treatment plant. From there, clear water is pumped to the city by means of a series of pumping stations. Each pumping station pumps water to the next reservoir, where pumps then move the water to the next reservoir/pumping station. A typical schematic of this pumping arrangement is presented in *Table 2*.

Table 2
Water Transmission Pumping

Source (river)	System	Pumphouse	Pumps	# operating
Arkavathy	Hesaraghatta	---	3 @ 240 HP	3
	T.G. Halli	T.G. Halli	4 @ 1 000 HP	4
			2 @ 2 000 HP	1
			4 @ 530 HP	4
	Tavarekere	6 @ 530 HP	4	
Cauvery	Stage I	T.K. Halli	5 @ 1,675 HP	3
		Harohalli	5 @ 1,675 HP	3
		Tataguni	5 @ 1,675 HP	3
	Stage II	T.K. Halli	5 @ 1,675 HP	3
		Harohalli	5 @ 1,675 HP	3
		Tataguni	5 @ 1,675 HP	3
	Stage III	T.K. Halli	8 @ 2,010 HP	5
		Harohalli	8 @ 2,010 HP	5
		Tataguni	8 @ 2,010 HP	5

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The standard arrangement is for two or three pumps in each pumphouse to be in standby mode, while three to five pumps operate (depending on the system). The operation of the pumps is rotated so that each pump averages about the same number of total hours of operation. The total connected horsepower is 111,790 HP (83,395 MW), of which 62,420 HP (46,565 MW) is designated to be in operation. The actual operation varies somewhat because of maintenance requirements and external reasons, including the reliability and availability of electricity. Details of pumps and motors from the Tataguni pumphouse are presented in Appendix A.

Distribution Pumping System Details

Distribution within the City of Bangalore is provided by fifty-two pumping stations. There are a total of ninety-two distribution pumps, ranging in size from 25 horsepower to 250 horsepower. *Table 3* gives additional detail on the distribution pumps.

Number of Pumps	HP	Number of pumps Operating at a time	Operating Capacity, HP
2	25	2	50
6	40	3	120
36	50	23	1150
4	60	3	180
2	65	1	65
6	75	4	300
1	85	1	85
9	90	7	630
13	100	6	600
6	150	2	300
1	170	0	0
3	240	1	240
3	250	3	750
Totals: 92		56	4470

These pumps vary in age and condition, with many considered obsolete because spare parts are no longer available from the manufacturer. The distribution system suffers from old reservoirs that are undersized for the needs of the city. Water is only distributed to city districts for four to five hours every other day. The main reason for this is claimed to be the size of the reservoirs. Details of several distribution pumphouses are shown in Appendix B.

ENERGY CONSUMPTION & RATES

Despite claim that reservoir capacity is the reason for inadequate distribution, electricity supply and reliability contribute to this situation. In addition to a shortage of water, city officials are concerned about the high cost of electricity for water pumping. This was the basis for the initial discussions between BWSSB officials and USAID. Electricity costs average about seventy million Rupees per month (US\$2 million). The electricity costs constitute about seventy percent of the total cost of providing water to the city. *Table 4* shows the costs for pumping water (both transmission and distribution) for April 1994, through March 1995. Since the cost of providing water is largely dependent on the pumping costs, these costs have been increasing rapidly with the rise in the cost of electricity. In addition, since the mid-1980s, water rates have not kept pace, resulting in an increasing deficit in revenues as shown in *Table 5*. During the past two years, the water rates have risen, but it is difficult to impose sudden, large increases in the rates in order to generate adequate revenues to cover the water costs.

Table 4
Water Pumping Costs, 1994

Transmission		Distribution	
kWh (million)	cost (million Rupees)	kWh (million)	cost (million Rupees)
325.9	501.48	3.99	6.48

Note: Electricity cost ~ Rs. 1.7/kWh (\$0.049/kWh) in 1995

Table 5
BWSSB Deficits and Domestic Tariffs

Year	Deficit (Millions of Rupees)	Domestic Tariff (Rs. Per 1000 liters)	
		Rate	Min. Charge
1987	73	0.45	10.0
1988	569	NA	NA
1989	850	NA	NA
1990	1,536	NA	NA
1991	1,428	0.50	12.5
1992	1,224	0.60	15.0
1993	1,544	0.80	20.0
1994	5,406	NA	NA
1995	NA	0.96	24.0
1996	NA	1.25	31.2
1997	NA	2.40	60.0

NA = Data Not Available

SITE VISITS & OBSERVATIONS

After reviewing the general particulars of the water pumping systems (including the transmission of water from the river source to Bangalore, as well as the distribution of water within the city of Bangalore), it was decided that site visits should be arranged to observe the systems. Visits were scheduled to one portion of the Cauvery system as well as several of the distribution pumphouses within the city. Distribution sites visited include High Grounds Reservoir Pumphouse, Low Level Reservoir Pumphouse, and the Combined Jewel Fitters Pumphouse. Pumphouse #2 of Cauvery Stage 1, which is part of the transmission system, was also visited. Specific data on observed pumps and motors is contained in the Appendix F. However, general observations indicated that many of the distribution pumps observed were not running at the time of the site visit. This was attributed to the size of the accompanying reservoir. In addition, there were many leaks at the pump seals, shutoff valves, and check valves. Operating personnel considered this normal operation and were not attempting to correct the situation. Some of these leaks were substantial, and the loss of water was considerable. Since more than half of the pump systems were leaking, it was assumed that the loss of water itself could exceed one percent of the water pumped. Since only three distribution sites were visited, it is uncertain whether the observations would be considered typical of the other sites. Brief discussions with operating personnel would, however, tend to confirm this opinion. Since the city has a severe water shortage problem, and the cost of pumping water is substantial, it is surprising that water leakage is taken for granted. BWSSB officials estimate that the system has a loss of 30 to 35 percent (including thefts). Many of the pumps and motors were under repair or had been disconnected. Since many of these systems are very old, repair is difficult or impossible. In general, the condition of the distribution system was poor, and a great deal of maintenance is required.

The site visit to the Cauvery pumphouse at Tataguni revealed a much different situation. Stage I of this system was built in 1974, with Stage II built in 1982, and Stage III built in 1981. Very few leaks were observed here. The installation appeared to be professionally maintained and operated. Even with that, monitoring and measurement equipment either did not exist, was not operating, or was not considered reliable.

Meetings following these site visits revealed that BWSSB has recently hired the local TERI (Tata Energy Research Institute) office to conduct an exhaustive three-month energy audit of the entire water pumping system (transmission and distribution). A copy of the TERI work order is included in Appendix H. BWSSB officials had also had previous discussions (as far back as early 1996) with Intesco staff about analyzing a pumping problem that had developed at one of the transmission pumping stations. Apparently the pressure drop in the piping has increased, resulting in the need to operate an additional pump to overcome the drop. This may be a result of piping obstructions. These discussions with Intesco have not progressed, and the system is operating with an additional pump, while the cause of the problem is unresolved.

BWSSB also indicated that they have begun design work on Cauvery Stage IV. This is part of a 41 billion Yen (US\$300 to \$400 million) loan from OECF for the design and installation of this system. The design is expected to be completed later this year, and construction is set to begin in 1998. The design is a joint venture between Tata Consulting Engineers, Pacific Consultants

International (Japan), and Mott MacDonald Water & Environment (Great Britain). Stage IV (Phase 1) will supply Bangalore with an additional 270 million liters of water per day. This system is to be expanded again, to 450 million liters per day by 2011.

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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 typically 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 normal 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 manufacturers data and pump curves should then be consulted to determine if a different size of impeller or motor could meet the system requirements.

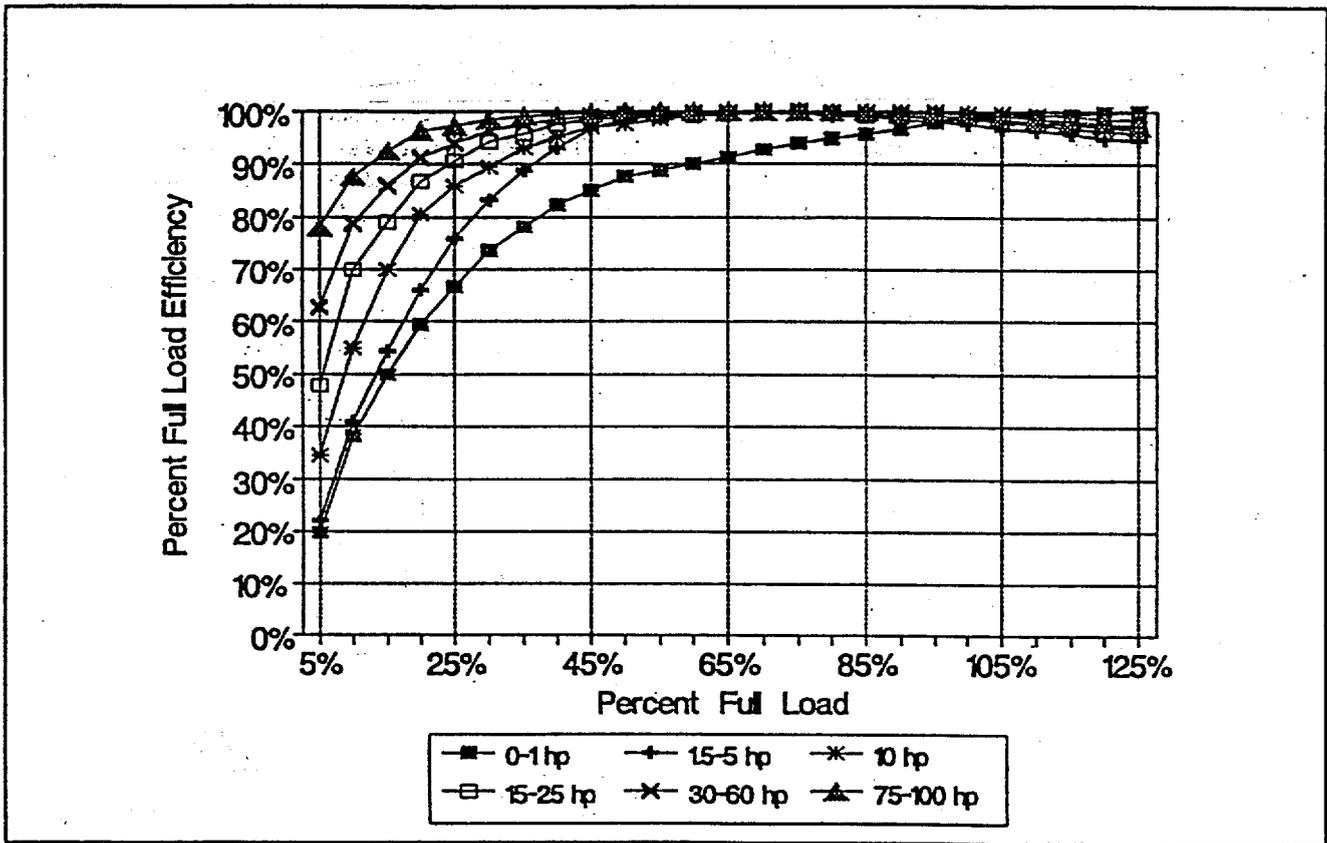
Pump optimization must take place in the field, and cannot be accomplished in the design phase. Measurements are required to determine where the pump is actually operating on the pump curve. Appendix F shows a typical set of pump curves for one pump. The curve illustrates that several sizes of pumps and impellers can be utilized for the pump. Measurements of pump performance were not taken during this trip, and BWSSB staff only had name plate data. Since there have been numerous changes to the water supply system over the years, including changing piping arrangements and flow rates, it is possible that the efficiency of each pump could be increased by several percentage points.

Motors

As mentioned in the previous section, the first consideration regarding motors is to determine if the motor is properly sized. Motors operating at part load tend to be less efficient than properly sized motors. However, this is also a condition of the motor size, as shown in *Figure 1*. The smaller the motor, the more impact part load operation has on the motor's efficiency. In addition, the efficiency of the motor should be examined. Most of the motors, especially those in the distribution system, are quite old. These motors were probably not very efficient when they were new, and would now be considered quite inefficient compared to modern motors (especially U.S. models). *Table 3* shows the number and size of distribution pumps in Bangalore. *Table 6* illustrates the resultant savings from using motors of higher efficiency than those listed. The

second column of *Table 6* presents a very conservative 1% improvement for each size motor. The third column illustrates a 5% improvement and savings for each size motor. Even the 5% savings figure is considered to be conservative.

**Figure 1 - Motor Part Load Efficiency
as a Function of % Full Load Efficiency**



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Table 6
Distribution Motor Savings Resulting From Efficiency Improvements

HP	1% Savings Rs. Per Year	5% Savings Rs. Per Year
25	2,002	10,506
40	3,203	16,809
50	4,004	21,022
60	4,807	25,239
65	5,205	27,329
75	6,009	31,549
85	6,807	35,738
90	7,207	37,840
100	8,008	42,045
150	12,012	63,067
170	13,614	71,476
240	19,219	100,857
250	20,020	105,112

Table 6, column 2 savings are per motor at an electricity rate of Rs. 1.7/kWh. Column two is based on an assumed one percent efficiency gain (from 84% to 85%). These savings are very conservative, as the existing motors are probably nowhere near 84% efficient. Column three 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. Finally, current electricity rates were not obtained, but the table is based on the 1995 value.

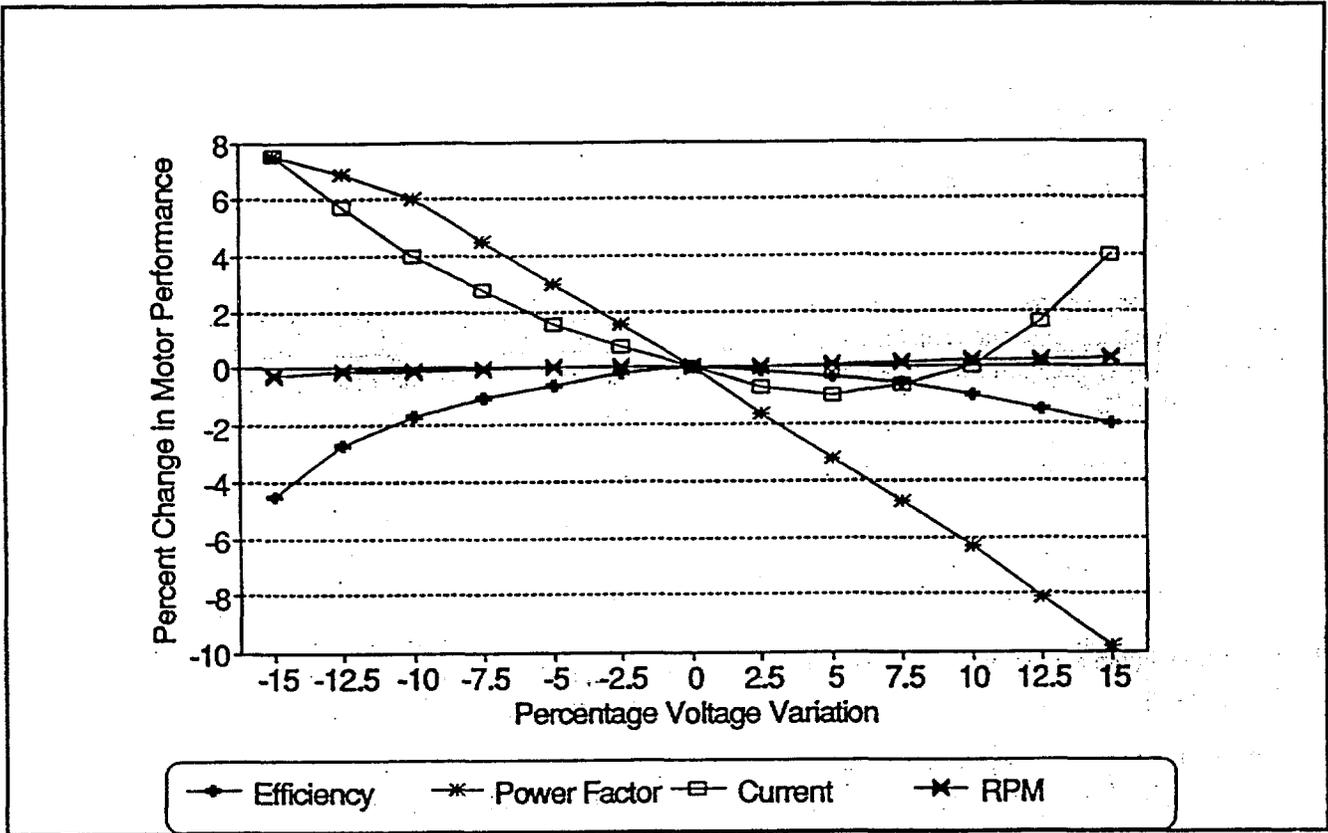
The equation used to calculate energy savings is:

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

- 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 concern regarding motor performance is the effect of low-voltage supply. Figure 2 shows the impact low voltage has on motor efficiency. As can be seen, a voltage drop of 15 percent can reduce efficiency by almost 5 percent. In addition, the motor will run hotter, slip more, produce less torque, and have a shorter life expectancy.

Figure 2 - Voltage Variation Effect on Motor Performance



Leaks

Numerous leaks were observed, especially in the distribution system. Many of these leaks were substantial, amounting to a large loss in water. In addition, every drop of water lost in the distribution system is very expensive, since it has already been pumped from the river. Costly electricity is wasted moving water which is allowed 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. BWSSB aim for a supply rate of 140 liters per person-day. Therefore, over a month's time, a drop per second would provide enough water for 5.2 people-days. A drop per second is quite a slow leak, and the leaks within the distribution system are numerous and much heavier in volume. It is easy to see that the water leakage rate is not a trivial matter, and all possible steps should be taken to improve the maintenance and eliminate all system leaks.

B

ENERGY CALCULATIONS

Several of the distribution pumps were selected for a preliminary analysis. Name plate data (actual operating data was not available) for the pumps shown below was utilized to select U.S. pumps, and then the U.S.-manufactured pumps were compared to the installed Indian pumps.

System	Existing Pump	Suggested U.S. Pumps	
Lower Level Reservoir	Kirloskar	Bell & Gossett	Crane
Conditions:			
Flow rate (gpm):	1,550	1,550	1,550
Head (feet):	75	75	75
Horsepower:	50	40	40

For this system, two U.S. manufacturers of centrifugal pumps were easily identified. Both manufacturers show pump curves meeting the specified flow and pressure conditions at just 40 horsepower, rather than the 50 HP motor that is installed. Referring back to *Figure 1*, the efficiency of a 50 HP motor operating at 80% of load (40/50) does not show any appreciable decline. Therefore, while it costs more to buy a new 50 HP motor than a 40 HP motor, their level of operation is essentially the same.

One other pump systems was analyzed, as shown below:

System	Existing Pump	Suggested U.S. Pump	
Combined Jewel Fitters	Worthington Simpson	Crane	
Conditions:			
Flow rate (gpm):	1,380	1,380	
Head (feet):	90	90	
Horsepower:	85	40	

As noted, this pump is oversized by 45 HP. This is more than double the horsepower needed to produce the specified conditions. As *Figure 1* shows, this motor would have an addition 3% to 5% efficiency loss as a result of being oversized. This would be in addition to the efficiency improvement that could be realized by replacing this motor with a high-efficiency, 40 HP motor. In this case, the installed motor is excessively oversized, and there would be a definite from installing a properly sized motor.

RECOMMENDATIONS

The BWSSB officials should be congratulated for realizing the impact of the rapidly rising cost 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 Bangalore, discussions with BWSSB staff, and site visits to some of the transmission and distribution sites:

1. BWSSB has contracted with TERI to conduct a complete energy audit of their water pumping system. TERI has already begun collecting data for the energy audit, and the audit should be complete by mid-summer, 1997. Because this audit is already under way, USAID's assistance in this area would be redundant and not useful.
2. Assistance was offered to TERI and BWSSB in support of TERI's efforts, where appropriate. This may take the form of identifying energy-efficient equipment to replace existing equipment, or assisting with an energy efficiency workshop.
3. BWSSB and Intesco had also previously discussed the possibility of having Intesco analyze a pumping problem at a main pumping station. This discussion has not been pursued, and the interim solution was to operate an additional pump (which normally would be on stand-by) to overcome increased load. RMA contacted Mr. Vasu of Intesco regarding the situation at BWSSB. Mr. Vasu indicated that he would again contact BWSSB staff to determine if there is an opportunity to investigate the pumping problem, as well as possibly financing large-scale upgrades of the pumping system.
4. BWSSB has commissioned a design team to design a new water supply system (Cauvery Stage IV). The team has been charged with the responsibility of designing a standard system for providing water to Bangalore. It was suggested that the designers be asked to analyze the annual energy usage and costs of their system, and to suggest alternative systems or equipment that would use less energy. The alternatives could be included as part of their design documents, and bidders would be required to bid on the alternatives as well as the base system. This would focus attention on trying to create the most cost-effective system from the beginning, and not just trying to modify an existing system to make it more energy-efficient.
5. The existing system should be totally analyzed to determine the proper sizing of motors and pumps. Motors and pumps that are excessively over-sized should be replaced with properly sized units. All motors should be analyzed to determine if replacement with new, high-efficiency motors is cost-effective.
6. Observations of distribution pumphouses revealed that water leakage is plentiful, and that it does not draw the attention of the BWSSB staff. The transmission system was better operated and there were fewer leaks. However, the presence of leaks and the acceptance of them by the BWSSB staff indicate that there is a need for an improved maintenance program. Considering the costs of supplying water, and the existing water shortage, there is no reason to not make

necessary repairs or replace equipment. A complete maintenance program should be established, and each BWSSB staff member should be required to attend. The maintenance program should emphasize the importance of maintaining a leak-free system, and it should illustrate this by demonstrating the cost of a typical leak.

7. If appropriate, an incentive program could be run by BWSSB to reward employees for contributing energy saving ideas.

8. A general awareness program should be conducted by the City. While this may exist on a minor scale, it should be given greater attention and emphasis. Citizens should be made aware of the water shortage problem and the rising costs of obtaining water from distant rivers.

9. The City should make a greater effort to reduce both the number of customers who do not pay their water bills and the pilferage of water.

10. Information on U.S.-manufactured ultrasonic flow meters is contained in Appendix D. This information was requested by members of the BWSSB staff.

11. Information on U.S.-manufactured residential water usage meters is contained in Appendix E. This information was requested by members of the BWSSB staff.

Appendix A

BWSSB Transmission System Data

System Data

Location: Cauvery Stage #1, 3rd stage pumping

Number of Pumps: 5

Hours of Operation: 24

Operating scheme: 3 pumps operate, 2 in standby mode

Pump Data

Manufacturer: Mather & Platt (Poona)

Year Installed: 1974

Model Number:

Serial Number:

Flow rate: 6950 gpm

Head: 525'

RPM: 1500

Impeller size:

Motor Data

Manufacturer: Bharath Heavy

Year Installed: 1974

Model Number:

Serial Number:

Frame type:

Horsepower: 1675

kW: 1250

Volts: 6.6 kv

Amps: 12,700

RPM: 1500

System Data

Location: Cauvery Stage #2, 3rd stage pumping

Number of Pumps: 5

Hours of Operation: 24

Operating scheme: 3 pumps operate, 2 in standby mode

Pump Data

Manufacturer: Mather & Platt (Poona)

Year Installed: 1982

Model Number:

Serial Number:

Flow rate: 6950 gpm

Head: 525'

RPM: 1500

Impeller size:

Motor Data

Manufacturer: Bharath Heavy

Year Installed: 1982

Model Number:

Serial Number:

Frame type:

Horsepower: 1675

kW: 1250

Volts: 6.6 kv

Amps: 12,700

RPM: 1500

System Data

Location: Cauvery Stage #3, 3rd stage pumping

Number of Pumps: 8

Hours of Operation: 24

Operating scheme: 5 pumps operate, 3 in standby mode

Pump Data

Manufacturer: Mather & Platt (Poona)

Year Installed: 19??

Model Number:

Serial Number:

Flow rate: 9906 gpm

Head: 170 meters

RPM: 1500

Impeller size:

Motor Data

Manufacturer: NGEF Ltd (Bangalore)

Year Installed: 1974

Model Number: A630LK-4

Serial Number:

Frame type:

Horsepower: 2040

kW: 1500

Volts: 6.6 kv

Amps:

RPM: 1500

Appendix B
BWSSB Distribution System Data

System Data

Location: High Grounds Cauvery Pump House (North West)

Number of Pumps: 3

Hours of Operation: 24 Hours/day

Operating scheme: 2 pumps operate, the third pump is standby

Pump Data

Manufacturer: Mather + Platt

Year Installed: 1985

Model Number: 12/14 BLE

Serial Number: 861314/M/2 *

Flow rate: 1498.8 m³/hour

Head: 30 meters

RPM: 1480

Impeller size: NA

*Typical of three units. Flow parameters are design figures.

Motor Data

Manufacturer: NGEF

Year Installed: 1985

Model Number: AJ 315 M4

Serial Number: 17613100

Frame type: NA

Horsepower: 250

kW: 185

Volts: 415

Amps: 346

RPM: NA

NA - Not available

System Data

Location: Higher Grounds Cauvery Pump House (North)

Number of Pumps: 4

Hours of Operation: 24

Operating scheme: 3 pumps operate, the fourth is standby

Pump Data

Manufacturer: Kirloskar

Year Installed: 1984

Model Number: 10UPH2 250 x 300

Serial Number: NA

Flow rate: 195 LPs

Head: 30 meters

RPM: NA

Impeller size: NA

Motor Data

Manufacturer: Kirloskar (Bangalore)

Year Installed: 1984

Model Number: 2770540

Serial Number:

Frame type: LC2503

Horsepower: 100

kW: 75

Volts: 415

Amps: 127

RPM: 1460

System Data

Location: Lower Level Reservoir (100 HP Pump House)
City distribution

Number of Pumps: 3

Hours of Operation:

Operating scheme: supply alternate days to district

Pump Data

Manufacturer: Kirloskar

Year Installed: 1983

Model Number: 8UP2M 250 x 2

Serial Number: 8286016

Flow rate: 155 LPS

Head: 30 meters

RPM:

Impeller size:

Motor Data

Manufacturer: NGEF

Year Installed: 1983

Model Number: AJ250S4

Serial Number: 16401404

Frame type:

Horsepower: 100

kW: 75

Volts: 416

Amps: 136

RPM: 1445

System Data

Location: Lower Level Reservoir 50 HP Pump House

Number of Pumps: 2

Hours of Operation:

Operating scheme: both pumps operate, no standby

Pump Data

Manufacturer: Kirloskar

Year Installed: 1974 (obsolete, cannot get parts)

Model Number: 8UPI 8 x 10

Serial Number:

Flow rate: 1550 gpm

Head: 75 feet

RPM: 1450

Impeller size: NA

Motor Data

Manufacturer: Kirloskar

Year Installed: 1974

Model Number:

Serial Number:

Frame type:

Horsepower: 50

kW:

Volts: 420

Amps: 63

RPM: 1450

System Data

Location: Combined Jewel Fitters Pump Station

Number of Pumps:

Hours of Operation:

Operating scheme:

Pump Data

Manufacturer: Worthington

Year Installed: 1945

Model Number:

Serial Number:

	<u>Pump #1</u>	<u>Pump #2</u>	<u>Pump #3</u>	<u>Pump #4</u>
Flow rate:	2785	2780	2780	2780
Head:	80'	125'	125'	100'

RPM: 1460

Impeller size:

Motor Data

Manufacturer: Metropolitan Vickers (England)

Year Installed: 1956

Model Number:

Serial Number: E477263/1/01

Frame type:

Horsepower: 150

kW:

Volts: 400/440

Amps: 182

RPM: 1460

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System Data

Location: Combined Jewel Fitters

Number of Pumps: 1

Hours of Operation:

Operating scheme:

Pump Data

Manufacturer: Worthington Simpson Ltd

Year Installed: 1938

Model Number:

Serial Number:

Flow rate: 1380 gpm

Head: 90'

RPM: 1450

Impeller size:

(75 HP recommended)

Motor Data

Manufacturer: Lawrence Scot (Narrick & Manchester)

Year Installed: 1956

Model Number:

Serial Number:

Frame type:

Horsepower: 85

kW:

Volts: 400

Amps: 110

RPM: 1485

System Data

Location: Combined Jewel Fitters

Number of Pumps: 1

Hours of Operation:

Operating scheme:

Pump Data

Manufacturer: Pulsometer Engineering Company Ltd (London)

Year Installed: 1957

Model Number:

Serial Number: 89295/SZA

Flow rate: 1400 gpm

Head: 100'

RPM: 1475

Impeller size:

Motor Data

Manufacturer: Metropolitan Vickers

Year Installed: 1957

Model Number:

Serial Number: 481561/1/01

Frame type:

Horsepower: 60

kW:

Volts:

Amps: 75

RPM: 1475

System Data

Location: Combined Jewel Fitters

Number of Pumps:

Hours of Operation:

Operating scheme:

Pump Data

Manufacturer: Mather & Platt Ltd

Year Installed:

Model Number: 12/14 ALE-SPL

Serial Number: 861315/M/1

Flow rate: 1458 m³/hour

Head: 17 meters

RPM: 1480

Impeller size: NA

Motor Data

Manufacturer: NGEF India

Year Installed: 1988

Model Number: AJ280/UP

Serial Number: 16450403

Frame type:

Horsepower: 150

kW: 110

Volts: 415

Amps: 208

RPM: 1460

Appendix C
U.S. Motor Efficiency Table

1996 MOTOR EFFICIENCY LEVELS

RPM Qualified
Responsible Power Management

RPM Qualified Plus
Responsible Power Management

HP	Open Drip Proof Motors - Minimum Efficiencies				Open Drip Proof Motors - Minimum Efficiencies				Motor HP	Explosion Proof Motors - Minimum Efficiencies				Open Drip Proof Motors - Minimum Efficiencies			
	RPM				RPM					RPM				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

There are many motors with higher efficiencies than the minimums listed above that can increase your annual savings for many years to come. Our representatives can help you calculate the value of choosing a high efficiency motor.



For more information call
1-800-55-WI-RPM
1-800-559-4776

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.

Ultrasonic 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 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

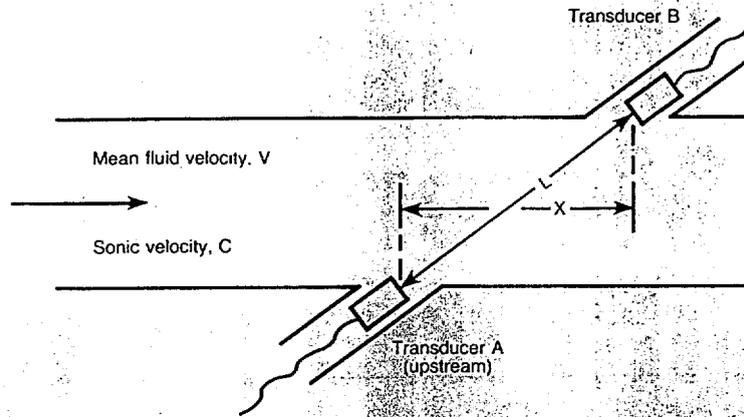
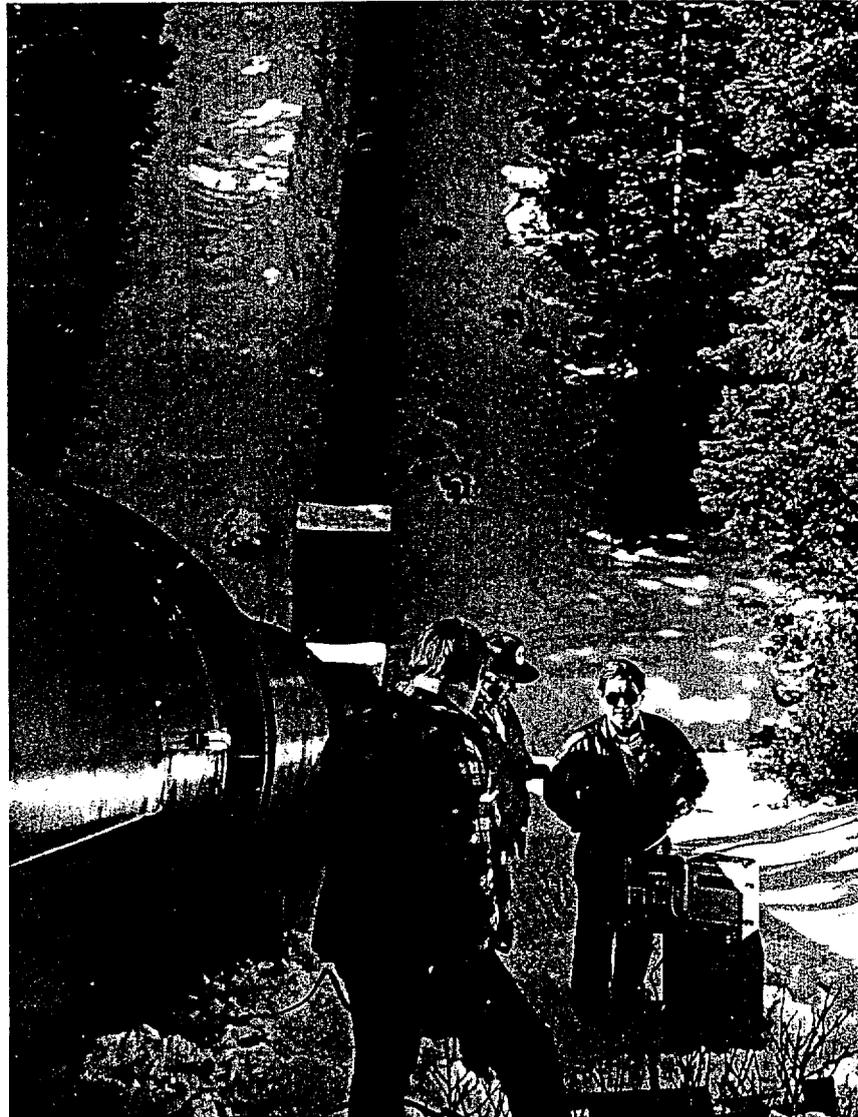


Figure 1. Transit-time technique with wetted transducer. This technique measures the difference between upstream and downstream times to determine flow velocity. It is the only flow-measuring technique that actively measures zero flow. The technique works well with clamp-on devices.



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

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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

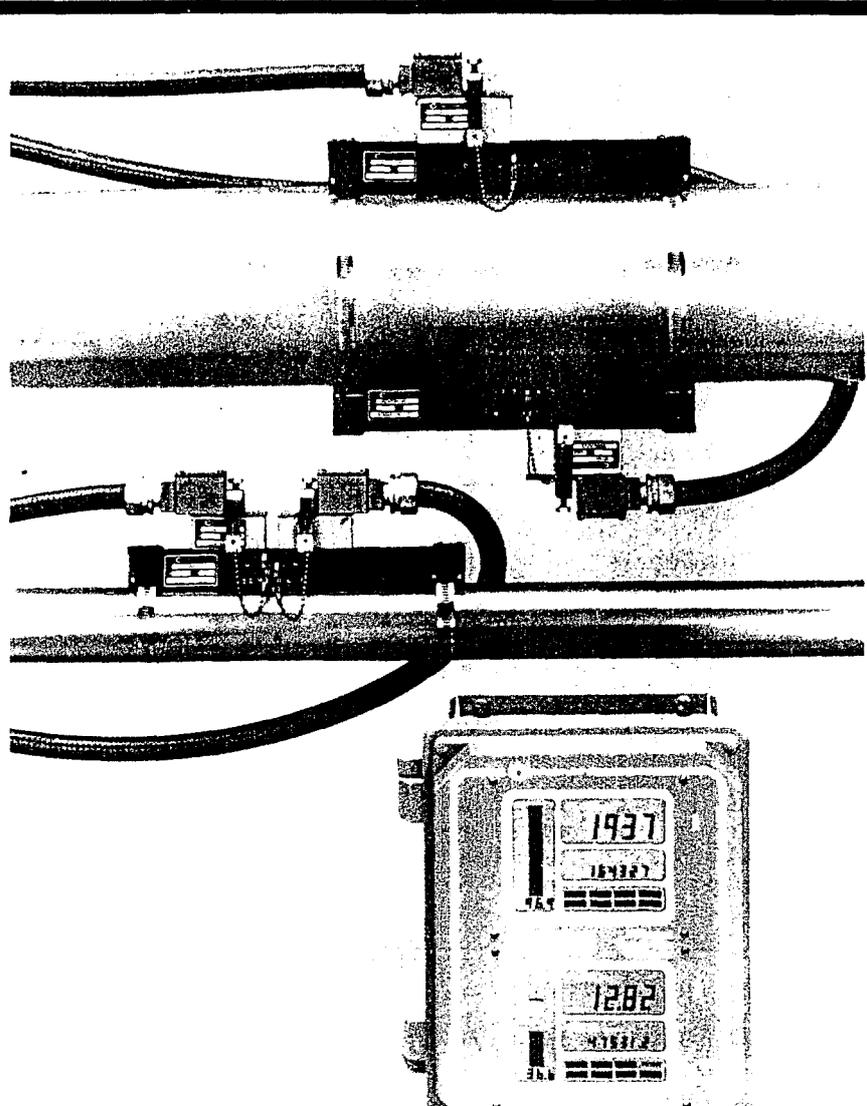
and the stronger the reflections from tiny particles. Unfortunately, short-length waves also reflect better from swirls, eddies, and other disturbances in the flow stream. Polysones has found that, by boosting power levels and sticking with frequencies on the order of 0.5 to 1.0 MHz, it can extend the 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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CONTROLTRON

SYSTEM 990 UNIFLOW

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



*An Extraordinary New
Standard of Flowmeter
Function and Performance*

DESIGNED AND MANUFACTURED IN USA

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

Uniflow cover holds Field Manual for ready availability.

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

Hybrid Direct Reflect Mode 992MT PinS Mounting Transducer assures fast, accurate and versatile Transducer installation. No tools needed for Track or Transducer installation.

Select the flow format of your choice on Graphics

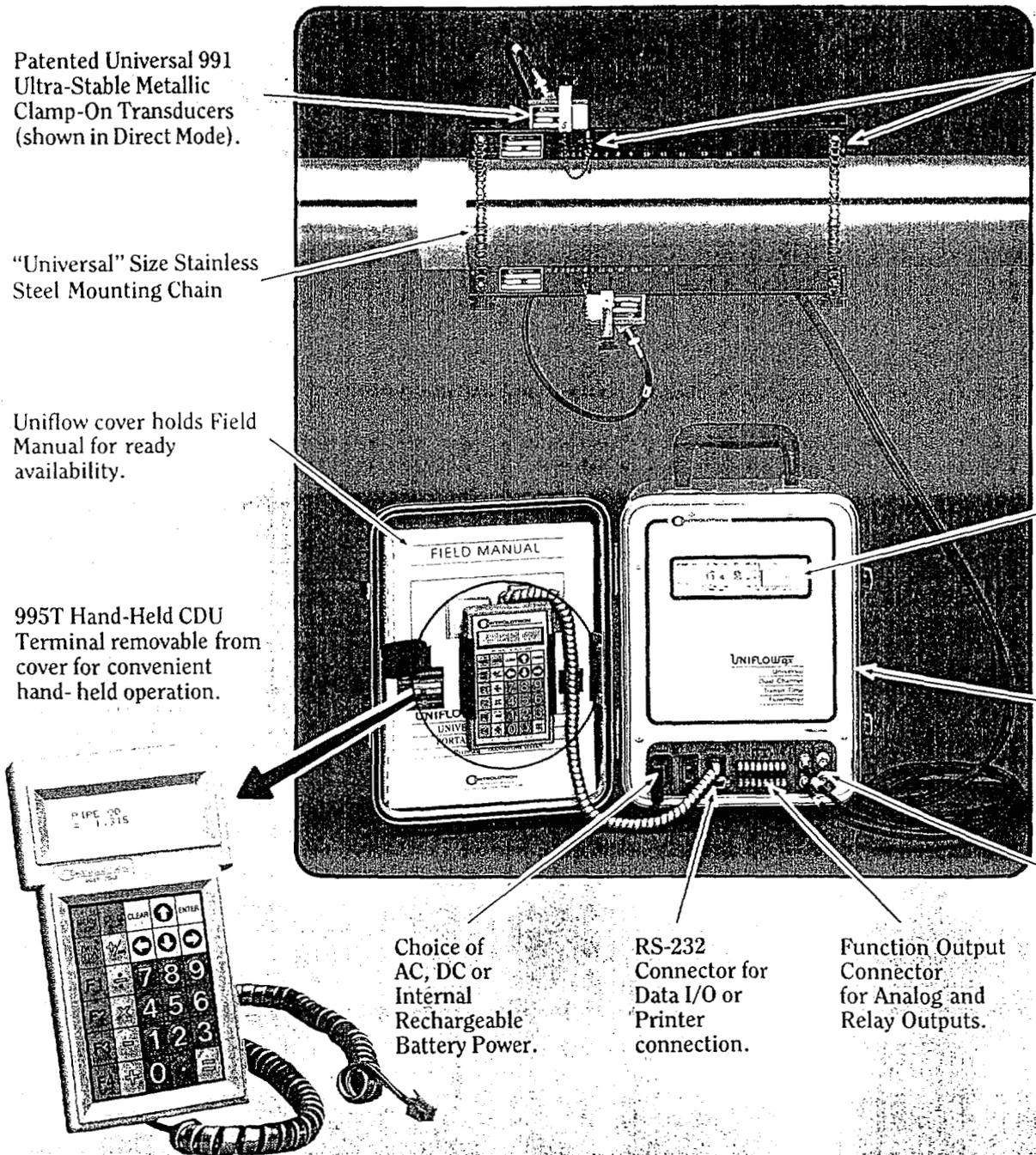
Sealed cable available for inclement weather

Dual Channel shown in single channel operation

Choice of AC, DC or Internal Rechargeable Battery Power.

RS-232 Connector for Data I/O or Printer connection.

Function Output Connector for Analog and Relay Outputs.



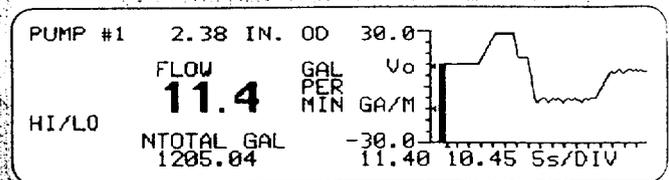
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o Carry - Simple to Use - Widely Applicable Flow System Maintenance, , and Flow Balancing.

GRAPHICS DISPLAY SCREENS

1. Digital Display with Stripchart

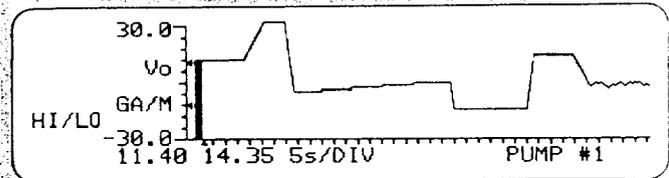
On one screen see your Flow Rate and Total in digital units of your choice, plus an Analog Stripchart with user selected data, span and timebase. Flow and operating condition alarms are brought to your attention by on-screen indicators. Site name and pipe OD shown on screen.



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.

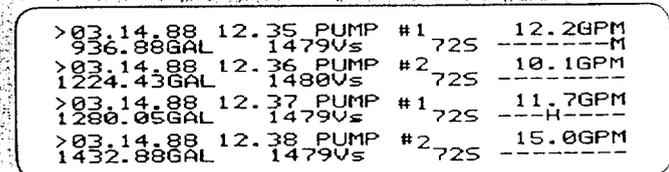
1. Digital Display with Stripchart



3. Dual Channel Datalogger

Use the 995 CDU to tell Uniflow what data you want it 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.

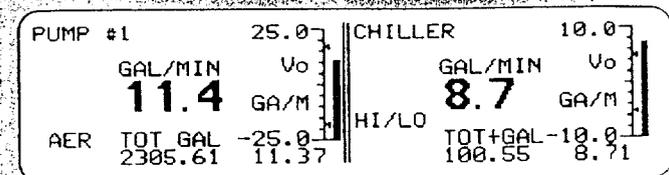
2. Stripchart



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.

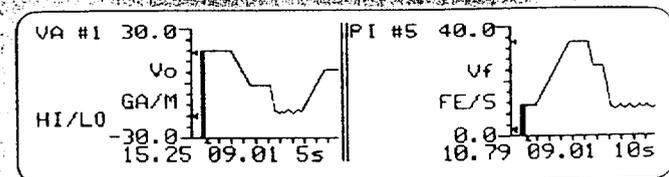
3. Dual Channel Datalogger



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.

4. Dual Channel Digital and Analog Barchart



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.

5. Dual Channel Stripchart

Controlotron's SYSTEM 990 UNIFLOW

Performance - Function - Applicability - Economy

Superior to Conventional Intrusive Flowmeters!

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
Barchart and Status
Display for each
Channel.
Dual Channel
Graphics Display
Optionally Available.

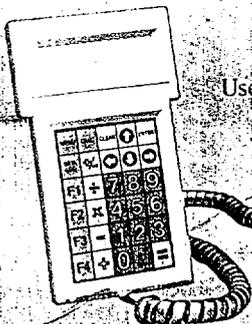
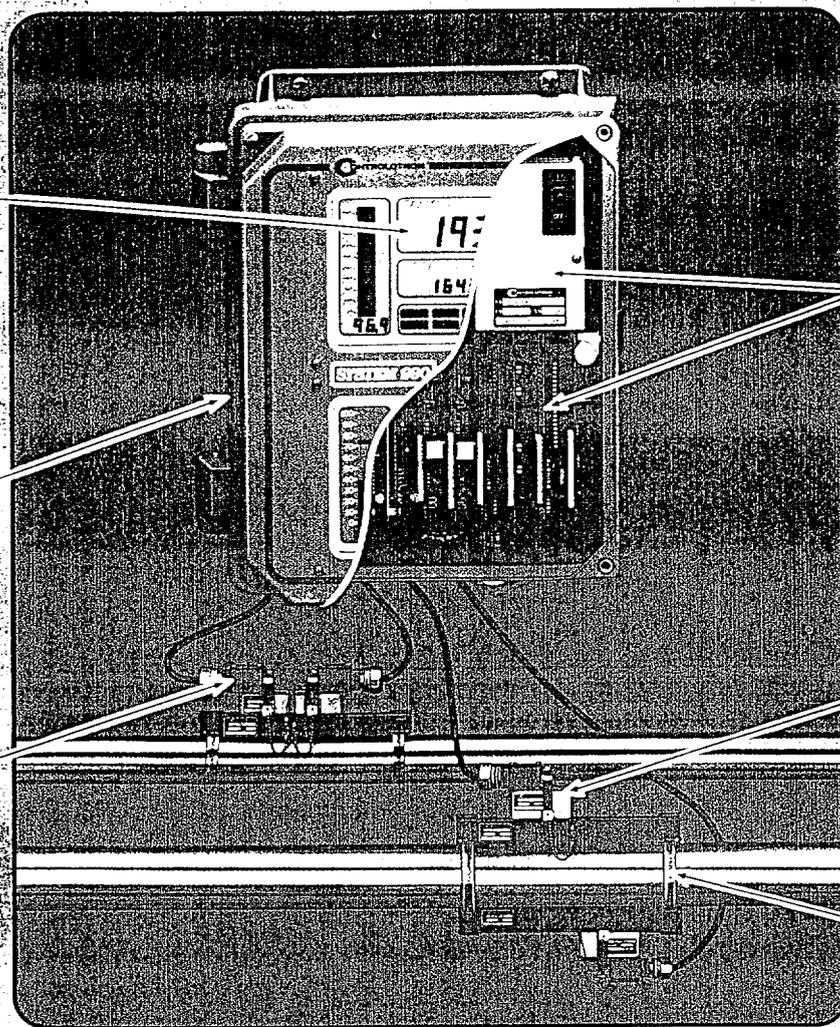
NEMA 4X Case,
suitable for
essentially all field
environments.
Intrinsically safe
models available.

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.

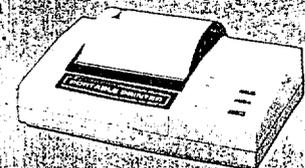
Weatherproof,
submersible, NEMA 4
Transducers are
intrinsically safe
(shown in
Direct Mode).

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

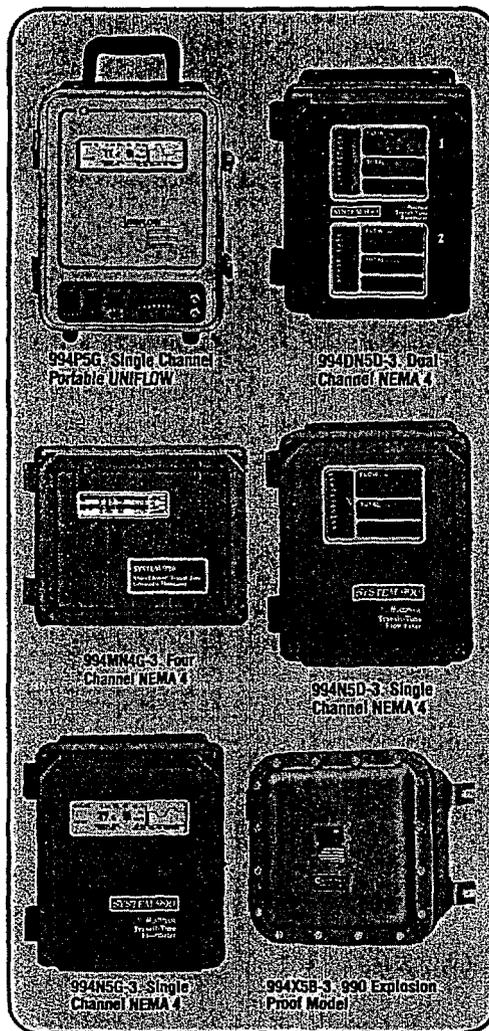
Dual Channel Portable 990DP Uniflow (shown on page 3) has all the functions of the Single Channel Portable, but with the added benefits of simple flow balancing, flow tracing and leak detection. 990DP operates both channels simultaneously so that interactive manifold effects can be observed.

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 990SLECT 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 ± 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°F to +250°F (-40°C to +120°C) Standard
-80°F to +450°F (-60°C to +230°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: ± 40 fps (± 12.2 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: Intrinsically 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, 16-40 VA
9 to 36 VDC, 20W, portable systems available with internal battery
- **TEMPERATURE:** -5°F to +115°F (-20°C to +45°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:** Intrinsically 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 (0.03 to 12.2 m/sec/sec) (settable)
- **FLOW PROFILE COMPENSATION:** Reynolds Number 0 to 10⁷
- **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.

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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 * See 991XA for guidelines in selecting "A" Series Transducers.	
992MTABC-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	
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 OS = Size OS 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	
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
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 990SLECT and 990 Application Information Form.

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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 x 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

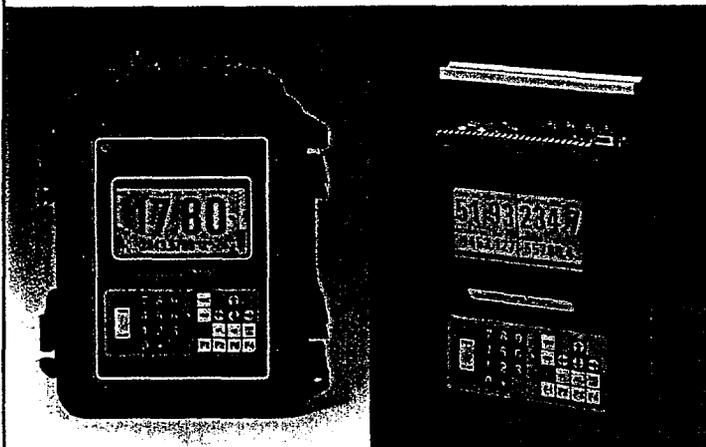
Users of Controlotron instruments enjoy the benefit of worldwide customer service organizations, available on short notice for training, application, installation, demonstration, and maintenance services. Contact us or your local representative for details on these services.

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.

FUNCTIONS AND FEATURES

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/Flow 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	?
	Analog Input (4), 2x4>20 mA+2x0>10 V	√	√	?
Computer Accessories	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	?	?	?
	Optional Training Video	?	?	?
Transducers	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

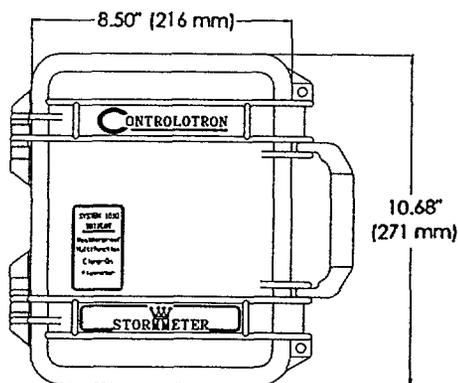
SLEW RATE: 80 f/s/s (24 m/s/s)

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

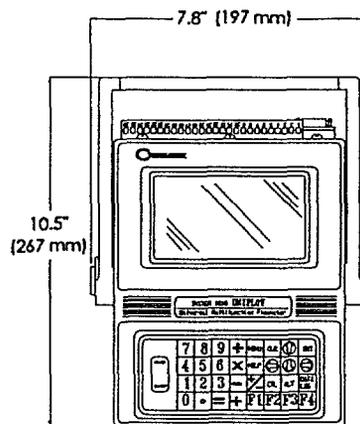
Model 1010WDP Outline Dimensions



Net Weight: 8.0 lbs. (3.64 Kg)

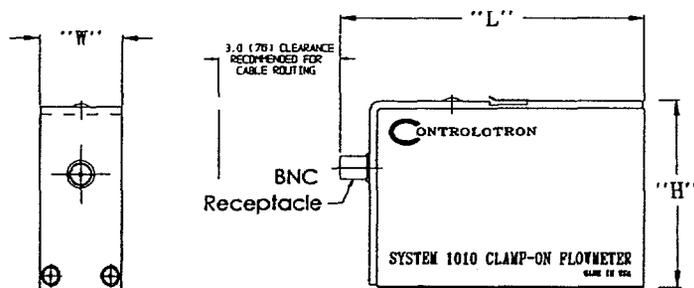
Depth: 6.97" (177 mm)

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)
1011P1PS-B1 1011P1PS-B2 1011P1PS-B3	2.3 (58)	1.4 (36)	1.0 (25)	0.4 # (0.2kg)
1011P1PS-C1 1011P1PS-C2 1011P1PS-C3	3.6 (91)	2.1 (53)	1.4 (36)	1.0 # (0.5kg)
1011P1PS-D1 1011P1PS-D2 1011P1PS-D3	5.0 (127)	3.0 (76)	1.4 (36)	2.1 # (1.0kg)

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

PORTABLE 1010 APPLICATIONS

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

LIQUID APPLICABILITY

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

PIPE APPLICABILITY

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.

OTHER PRODUCTS

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:

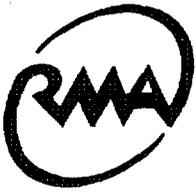
1010N Permanent Mount Flowmeter
1010SX Clamp-On Spool Flowmeter
1010FT In-Line Volumetric/Mass Flowmeter
1010FL In-Line Flare Gas Flowmeter
1010LDV Pipe Line Leak Detection/Mgt
1010E Energy Management Flowmeter

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 handhold receiving device including software.

BRONZE VERSUS PLASTIC CASINGS

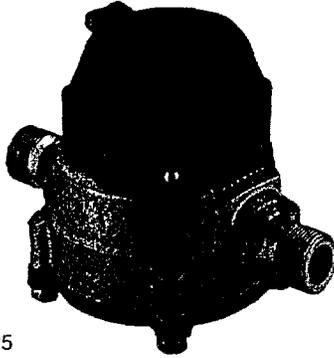
The plastic meters are chosen in areas where thieves are likely to take the meter for the scrap value of the bronze casing.

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



BadgerMeter
Utility Division

TECHNICAL BRIEF



Model 25

SPECIFICATIONS

Typical Operating Range (100% ± 1.5%)	1/2 - 25GPM (1.9 to 95 l/m)
Low Flow (Min. 98.5%)	1/4 GPM (1.0 l/m)
Maximum Continuous Operation	15 GPM (57 l/m)
Pressure Loss at Maximum Continuous Operation	3.5 PSI at 15 GPM (0.24 bar at 57 l/m)
Maximum Operating Temperature	80°F (26°C)
Maximum Operating Pressure	150 PSI (10 Bar)
Measuring Element	Nutating disc, positive displacement
Register Type	Straight reading, permanently sealed magnetic drive standard. Remote reading or Automatic Meter Reading units optional.
Register Capacity	10,000,000 Gallons, 1,000,000 Cubic Feet, 100,000 m ³ . 6 odometer wheels.
Meter Connections	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

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

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.

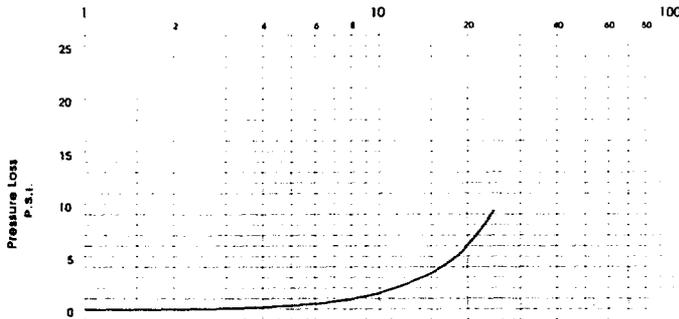
AMR

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.

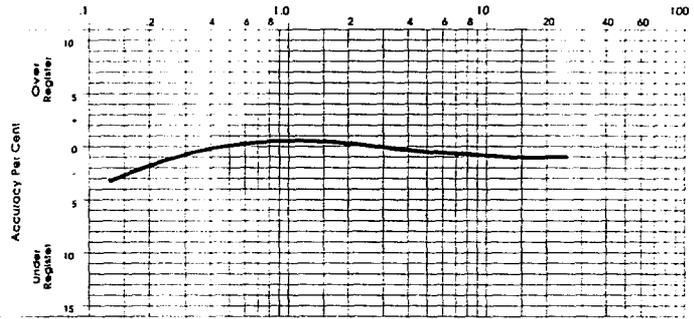
PRESSURE LOSS CHART

Rate of Flow, in Gallons per Minute



ACCURACY CHART

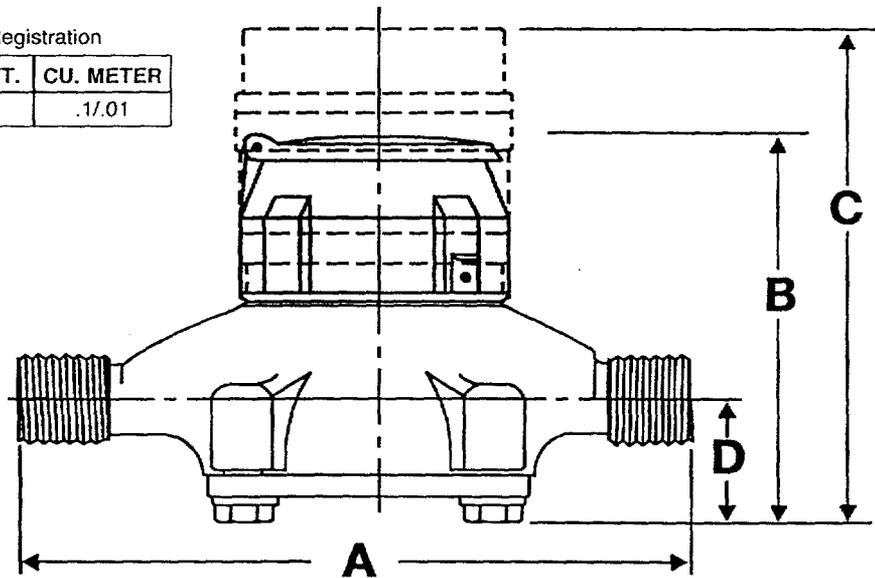
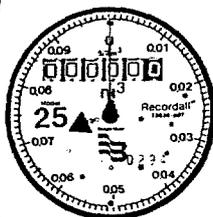
Rate of Flow, in Gallons per Minute



METER SIZE	METER MODEL	A LAYING LENGTH	B HEIGHT REG.	C HEIGHT GEN./HRT	D CENTERLINE BASE	WIDTH	APPROX. SHIPPING WEIGHT
5/8" (15mm)	25	7 1/2" (190mm)	4 15/16" (125mm)	6 5/16" (160mm)	1 11/16" (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
Dallas, TX 75381-4149
(214) 416-3525 / (800) 616-3837
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.

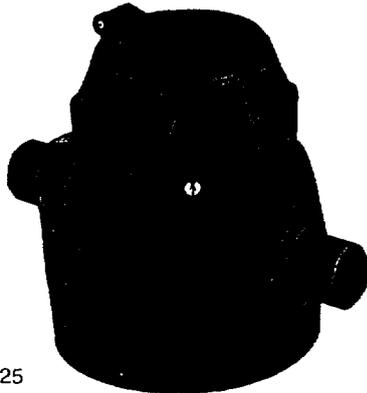


Size 5/8" (DN 15mm)
 Recordall® Cold Water
 Thermoplastic Disc Meter



BadgerMeter
 Utility Division

TECHNICAL BRIEF



Model 25

SPECIFICATIONS

Typical Operating Range (100% ± 1.5%)	1/2 - 25 GPM (1.9 to 95 l/m)
Low Flow (Min. 98.5%)	1/4 GPM (1.0 l/m)
Maximum Continuous Operation	15 GPM (57 l/m)
Pressure Loss at Maximum Continuous Operation	4.2 PSI at 15 GPM (0.29 bar at 57 l/m)
Maximum Operating Temperature	80°F (26°C)
Maximum Operating Pressure	150 PSI (10 bar)
Measuring Element	Nutating disc, positive displacement
Register Type	Straight reading, permanently sealed magnetic drive standard. Remote reading or Automatic Meter Reading units optional.
Register Capacity	10,000,000 Gallons, 1,000,000 Cubic Feet, 100,000 m ³ . 6 odometer wheels.
Meter Connections	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

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

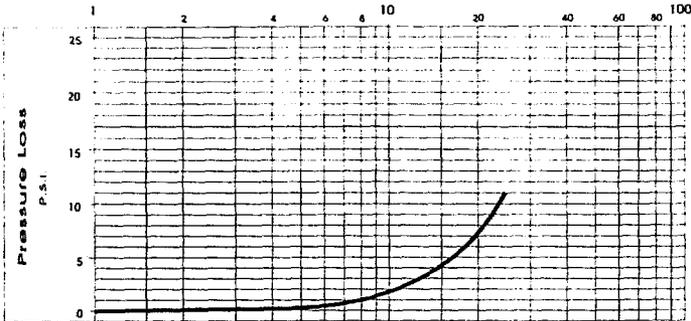
The Badger ROM system generates and transmits an electrical pulse up to 5000 feet from the meter to a remote totalizer register without use of external power. See reference chart ROM-I-3. The generator which incorporates test circle and odometer-type totalizer is submersible. The remote register design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

AMR

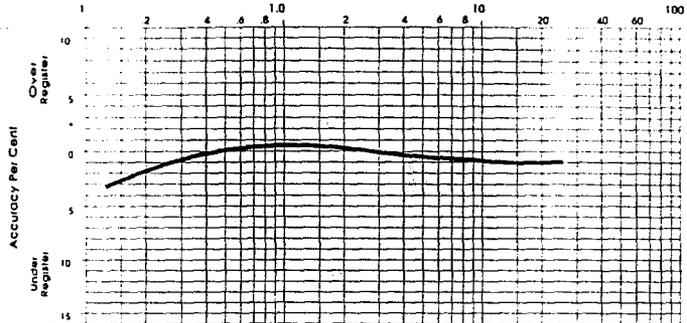
The TRACE® radio frequency system or the ACCESSplus® telephone system easily integrate with all Recordall Disc meters. Both technologies provide an efficient meter data retrieval and information management system. The TRACE Transponder and ACCESSplus Remote Module connect to the High Resolution Transmitter 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



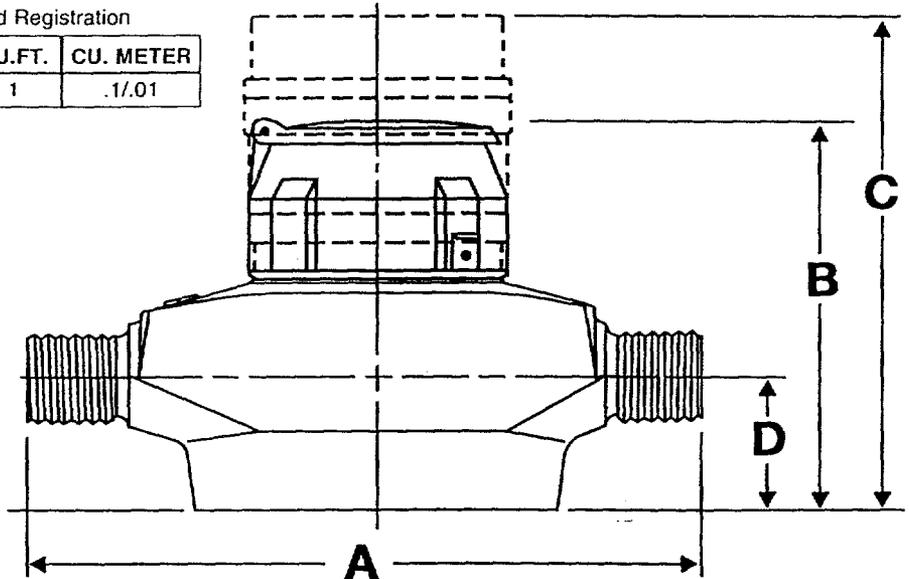
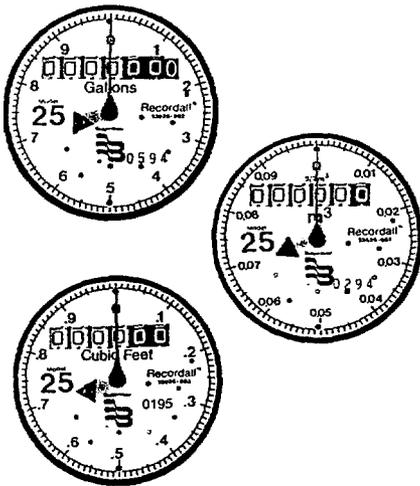
ACCURACY CHART
Rate of Flow, in Gallons per Minute



METER SIZE	METER MODEL	A LAYING LENGTH	B HEIGHT REG.	C HEIGHT GEN./HRT	D CENTERLINE BASE	WIDTH	APPROX. SHIPPING WEIGHT
5/8" (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



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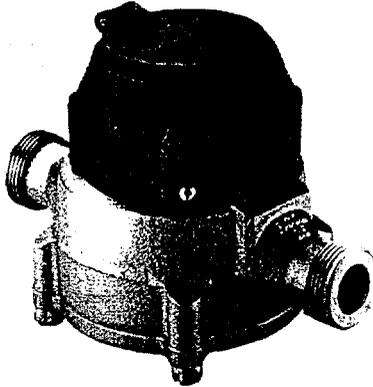
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Size 5/8 x 3/4" (DN 15mm)
Recordall® Cold Water
Bronze Disc Meter



BadgerMeter
Utility Division

TECHNICAL BRIEF



Model 25

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.

SPECIFICATIONS

Typical Operating Range (100% ± 1.5%)	1/2 - 25 GPM (1.9 to 95 l/m)
Low Flow (Min. 98.5%)	1/4 GPM (1.0 l/m)
Maximum Continuous Operation	15 GPM (57 l/m)
Pressure Loss at Maximum Continuous Operation	2.8 PSI at 15 GPM (0.19 bar at 57 l/m)
Maximum Operating Temperature	80°F (26°C)
Maximum Operating Pressure	150 PSI (10 bar)
Measuring Element	Nutating disc, positive displacement
Register Type	Straight reading, permanently sealed magnetic drive standard. Remote reading or Automatic Meter Reading units optional.
Register Capacity	10,000,000 Gallons, 1,000,000 Cubic Feet, 100,000 m³. 6 odometer wheels.
Meter Connections	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" x	7 1/2"	5/8", 3/4"	1" (3/4")	3/4"

MATERIALS

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

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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.

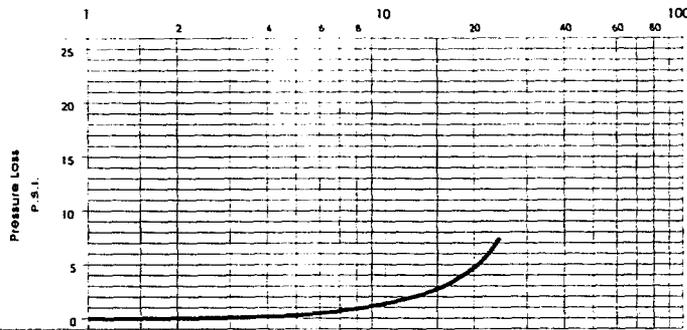
AMR

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.

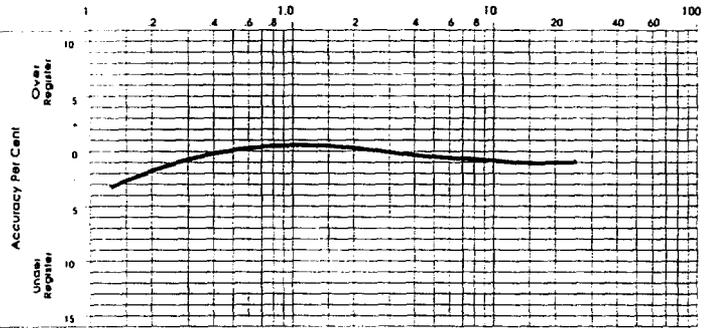
PRESSURE LOSS CHART

Rate of Flow, in Gallons per Minute



ACCURACY CHART

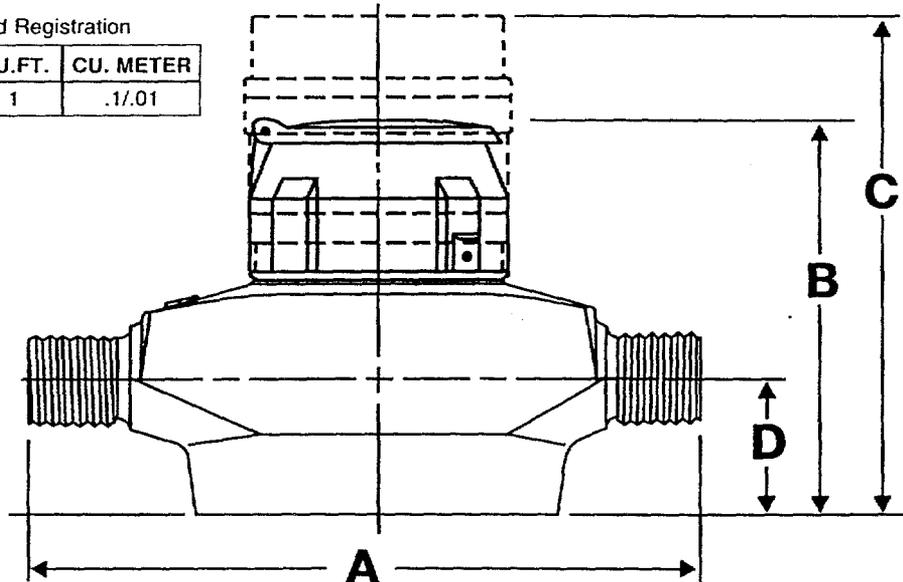
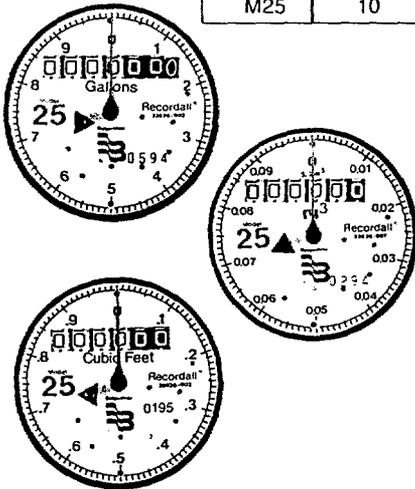
Rate of Flow, in Gallons per Minute



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



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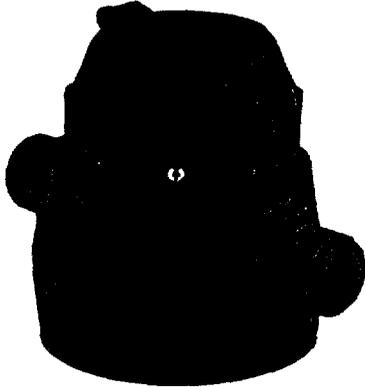


Size 5/8 x 3/4" (DN 15mm)
 Recordall® Cold Water
 Thermoplastic Disc Meter



BadgerMeter
 Utility Division

TECHNICAL BRIEF



Model 25

SPECIFICATIONS

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

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

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.

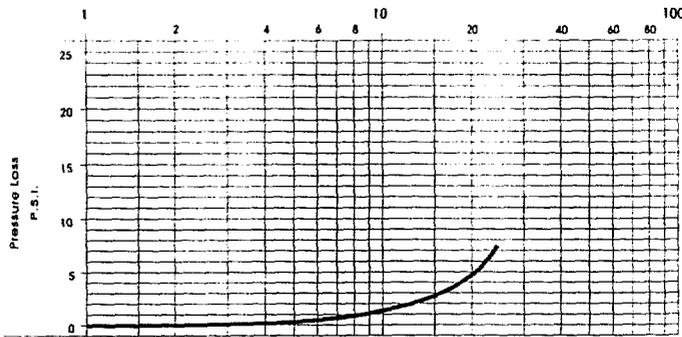
AMR

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.

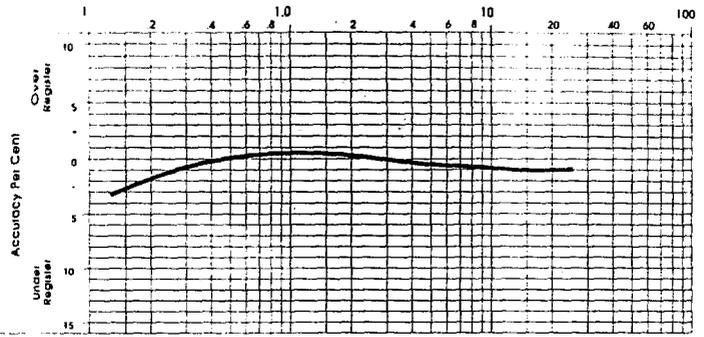
PRESSURE LOSS CHART

Rate of Flow, in Gallons per Minute



ACCURACY CHART

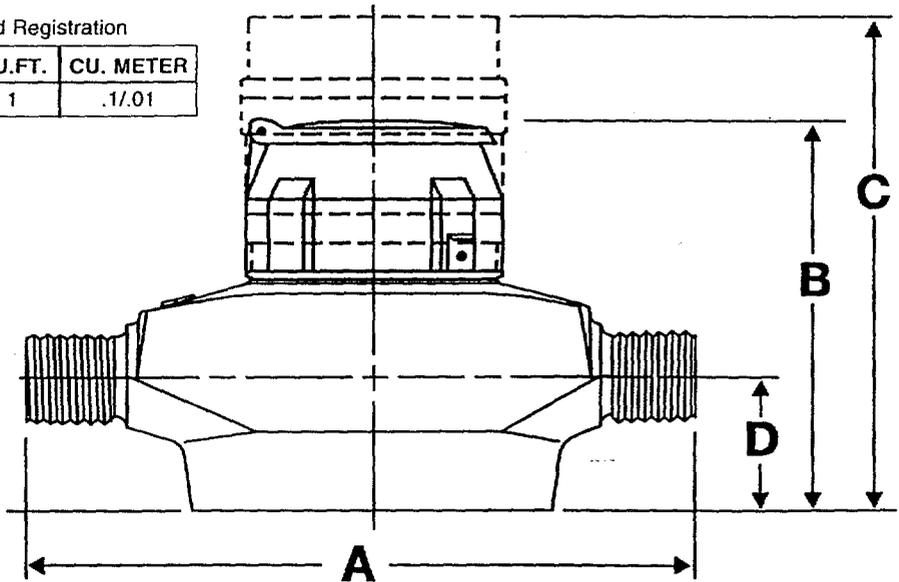
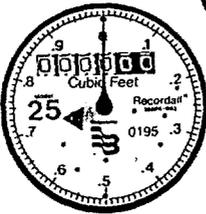
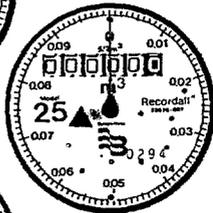
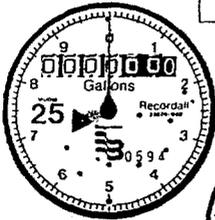
Rate of Flow, in Gallons per Minute



METER SIZE	METER MODEL	A LAYING LENGTH	B HEIGHT REG.	C HEIGHT GEN./HRT	D CENTERLINE BASE	WIDTH	APPROX. SHIPPING WEIGHT
5/8 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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An independently owned American company.



South/East Region

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Fax: (214) 416-7993

Western Region

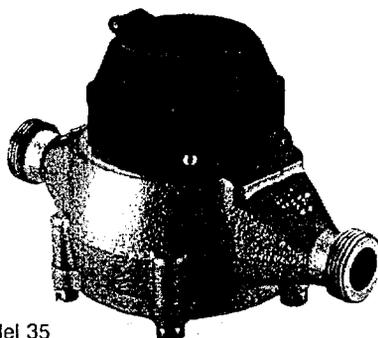
1318 Redwood Way, Suite 125
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(707) 664-8740 / (800) 656-3837
Fax: (707) 664-8264

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



BadgerMeter
 Utility Division

TECHNICAL BRIEF



Model 35

SPECIFICATIONS

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

Meter Housing	Cast Bronze
Housing Bottom Plates	Bronze, Cast Iron
Measuring Chamber	Thermoplastic
Disc	Thermoplastic
Trim	Stainless Steel, Bronze
Strainer	Thermoplastic
Disc Spindle	Stainless Steel
Magnet	Ceramic
Magnet Spindle	Stainless Steel
Register Lid and Shroud	Thermoplastic, Bronze
Generator Housing	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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RESOURCE MANAGEMENT SOCIETIES INC

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Remote/Automatic Meter Reading Systems

Remote Reading

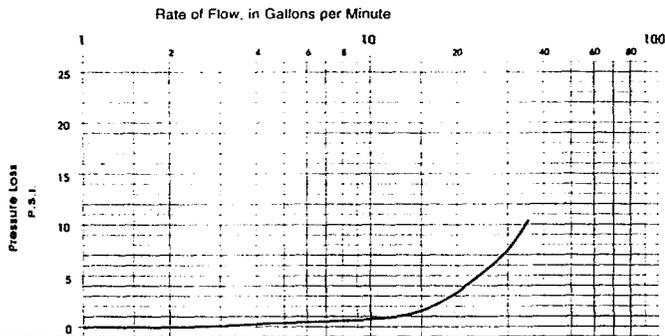
The Badger ROM system generates and transmits an electrical pulse up to 5000 feet from the meter to a remote totalizer register without use of external power. See reference chart ROM-I-3. The generator which incorporates a test circle and odometer-type totalizer is submersible. The remote register design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

AMR

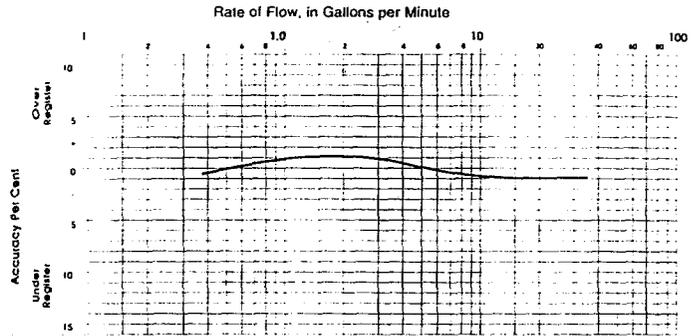
The TRACE® radio frequency system or the ACCESSplus® telephone system easily integrate with all Recordall Disc meters. Both technologies provide an efficient meter data retrieval and information management system. The TRACE Transponder and ACCESSplus Remote Module connect to the High Resolution Transmitter 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



ACCURACY CHART

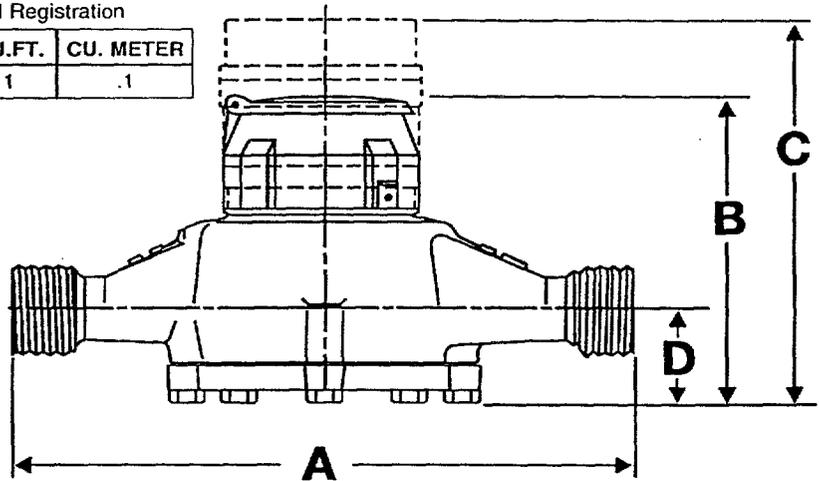


METER SIZE	METER MODEL	A LAYING LENGTH	B HEIGHT REG.	C HEIGHT GEN./HRT	D CENTERLINE BASE	WIDTH	APPROX. SHIPPING WEIGHT
3/4" (20mm)	35	7 1/2" (190mm)	5 1/4" (133mm)	6 5/8" (168mm)	1 5/8" (41mm)	5" (127mm)	5 1/2 lb. (2.5kg)
3/4" (20mm)	35	9" (229mm)	5 1/4" (133mm)	6 5/8" (168mm)	1 5/8" (41mm)	5" (127mm)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



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



BadgerMeter, Inc. Utility Division

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

An independently owned American company.



South/East Region

P.O. Box 814149
Dallas, TX 75381-4149
(214) 416-3525 / (800) 616-3837
Fax: (214) 416-7993

Western Region

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

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Appendix F
Centrifugal Pump Curves

65

1750 RPM PUMP CURVES

PERFORMANCE CHARACTERISTIC CURVE

SPEED 1770 R.P.M.

FOR 6BC CENTRIFUGAL PUMP FIG. NO. 1510

CURVES BASED ON SHOP TEST USING CLEAR COLD WATER AT A TEMPERATURE OF NOT OVER 85°F. PERFORMANCE IS GUARANTEED AT INDICATED OPERATING POINT ONLY.

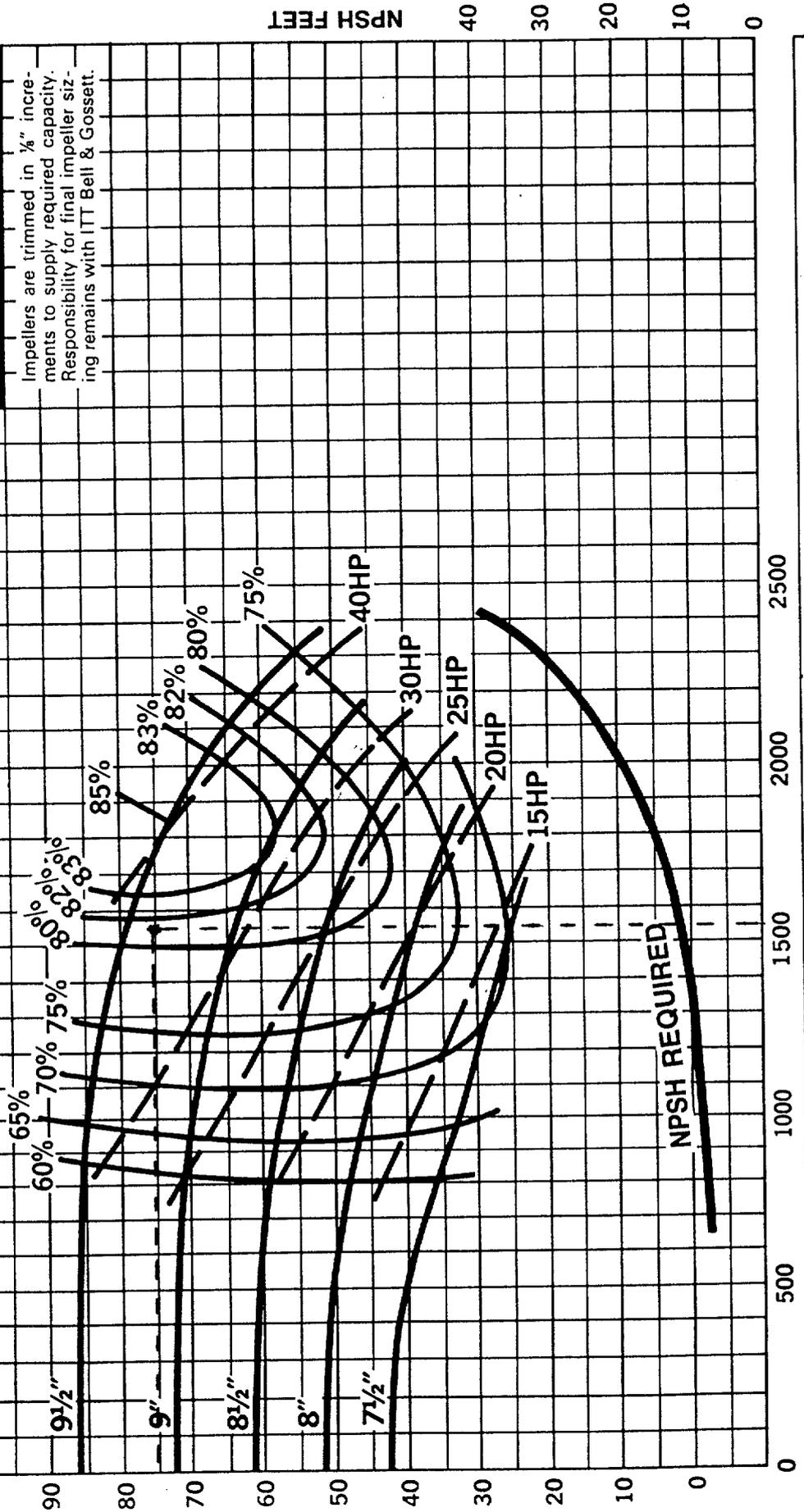
APPROVED *R.B.*

DATE 7-14-78

6BC

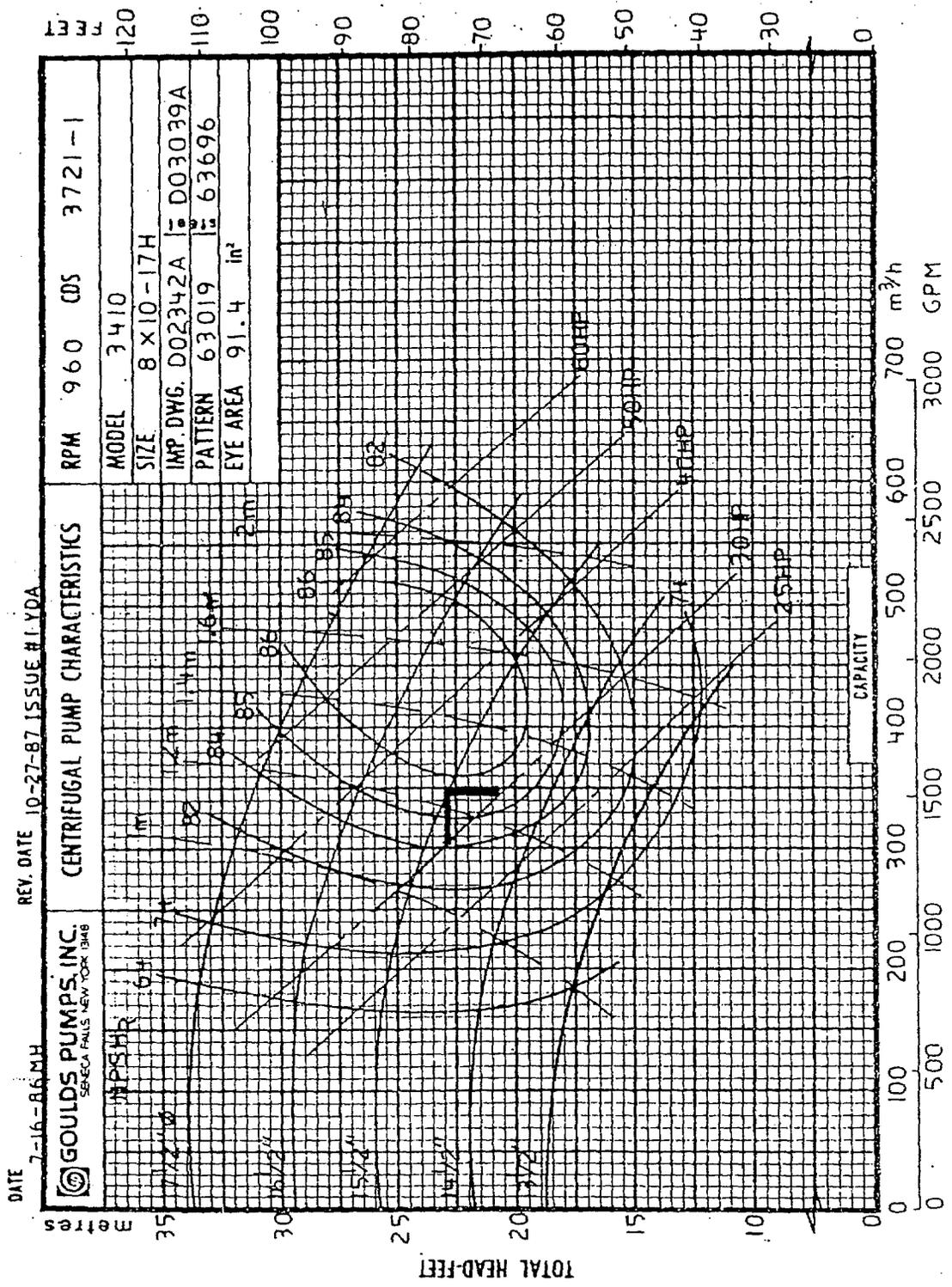
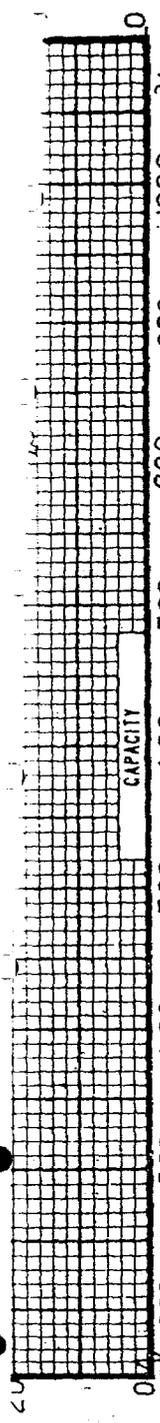
1770 R.P.M.

Impellers are trimmed in 1/8" increments to supply required capacity. Responsibility for final impeller sizing remains with ITT Bell & Gossett.



66

PRINTED



DATE	7-16-86 MH	REV. DATE	10-27-87 ISSUE #1 YDA
GOULDS PUMPS, INC. <small>SENECA FALLS, NEW YORK, USA</small>		CENTRIFUGAL PUMP CHARACTERISTICS	
NPSHR	6'	RPM	960 CDS 3721-1
SIZE	8 x 10 - 17H	MODEL	3410
IMP. DWG.	D02342A	IMP. DWG.	D03039A
PATTERN	63019	PATTERN	63696
EYE AREA	91.4 in²	EYE AREA	91.4 in²

condition
3

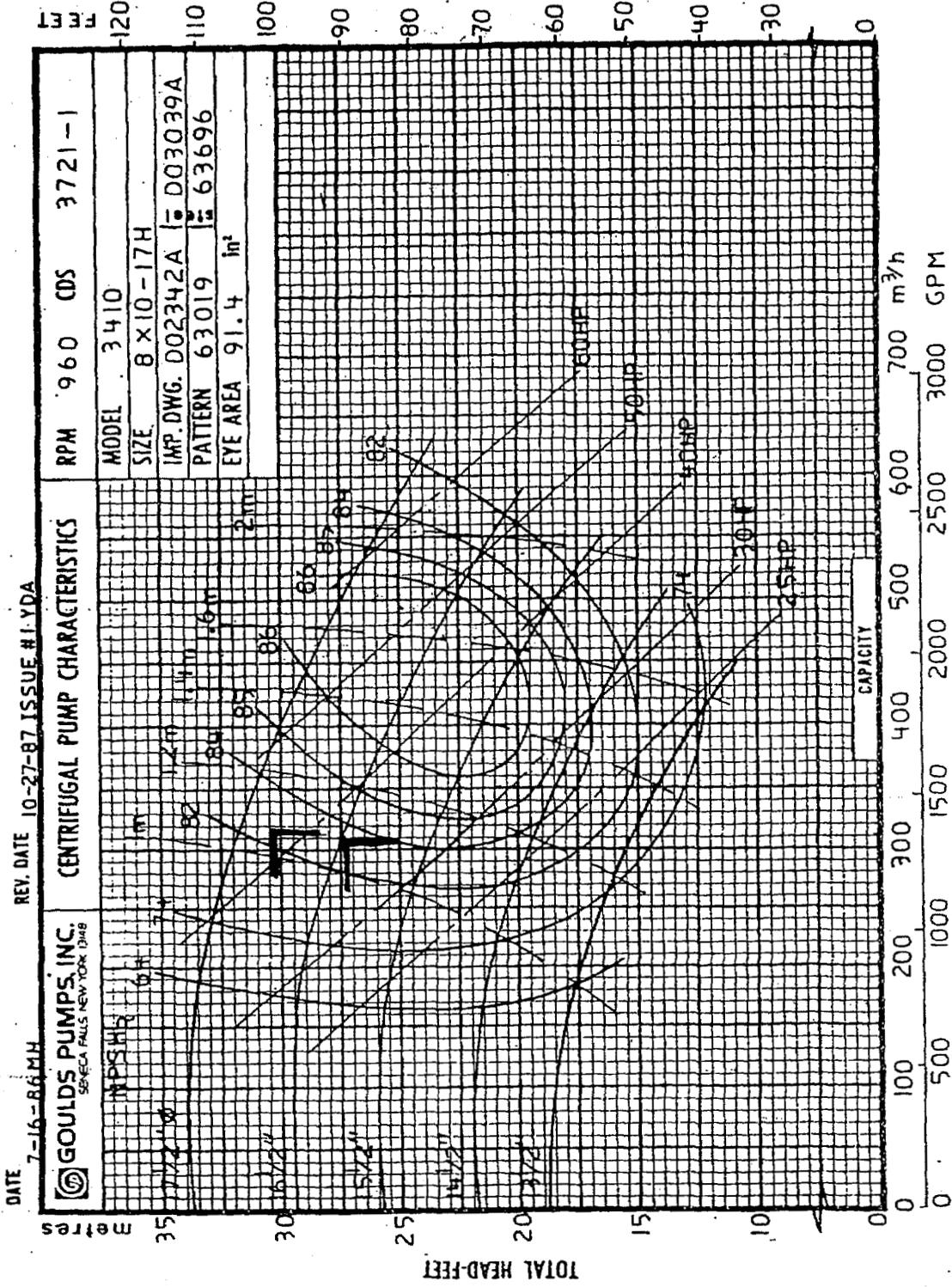
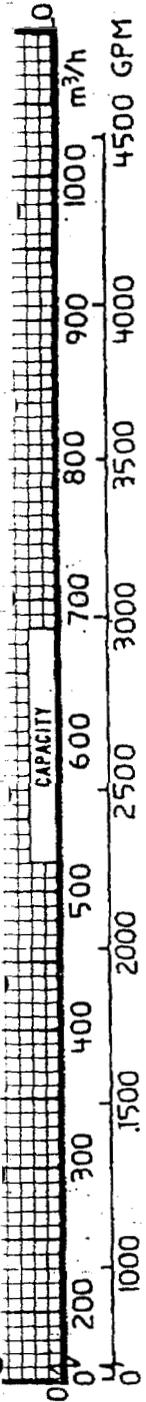
1550 spm
at 75' TDH

**960
R.P.M.**

© 1988 Goulds Pumps, Inc.

GOULDS PUMPS, INC.

57



DATE 7-16-86 MM
 GOULDS PUMPS, INC.
 SENECA FALLS, NEW YORK 13149

REV. DATE 10-27-87 ISSUE #1.YDA

CENTRIFUGAL PUMP CHARACTERISTICS

RPM 960 CDS 3721-1

MODEL 3410

SIZE 8 X 10 - 17H

IMP. DWG. D02342A D03039A

PATTERN 63019 63696

EYE AREA 91.4 in²

3 conditions
4 and 5
380 at 90'
400 at 100'
960
R.P.M.

PRINTED



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FAX COVER SHEET

Date: May 6, 1997

TO: Doug Presny

Company: RMA

Fax: 1-608-283-2881

FROM: Cheryl D. Bond

Crane Engineering Sales, Inc.

PH: 414-733-4425 FAX: 414-733-0050

RE: Asia Pumps

As I had mentioned, we have a better selection for the #2 selection of 8000 gpm at 520' TED. That curve is attached.

The following are rough budget prices for the selections requested.

#1	7000 gpm at 150'	Goulds 3420 16x18-30G	350 HP	\$67,000 ea ~12,390#
#3	1550 gpm at 75'	Goulds 3410L 8x10-17H	40 HP	\$14,500 ea ~3100#
#4	1380 gpm at 90'	Goulds 3410L 8x10-17H	50 HP	\$15,000 ea ~3200#
#5	1400 gpm at 100'	Goulds 3410L 8x10-17H	60 HP	\$16,000 ea. ~3300#

Just for your information, the #2 selection is approximately \$64,000 without the motor.

These prices do not include any allowance for freight to export packaging. These are quoted FOB factory, Seneca Falls, NY for standard shipment only.

We appreciate the opportunity to provide you with this information. Should you require additional information at this time, please feel free to call. If purchases will be made, all pricing will come from the factory.

Thank You!

BEST AVAILABLE DOCUMENT

69



Model 3620
50 Hz Performance Curve

724.6C575
September 29, 1995
(New)

Size: **14x16-17S-A** Group: **XL** s: **11,235** RPM: **2900**

Contract Data

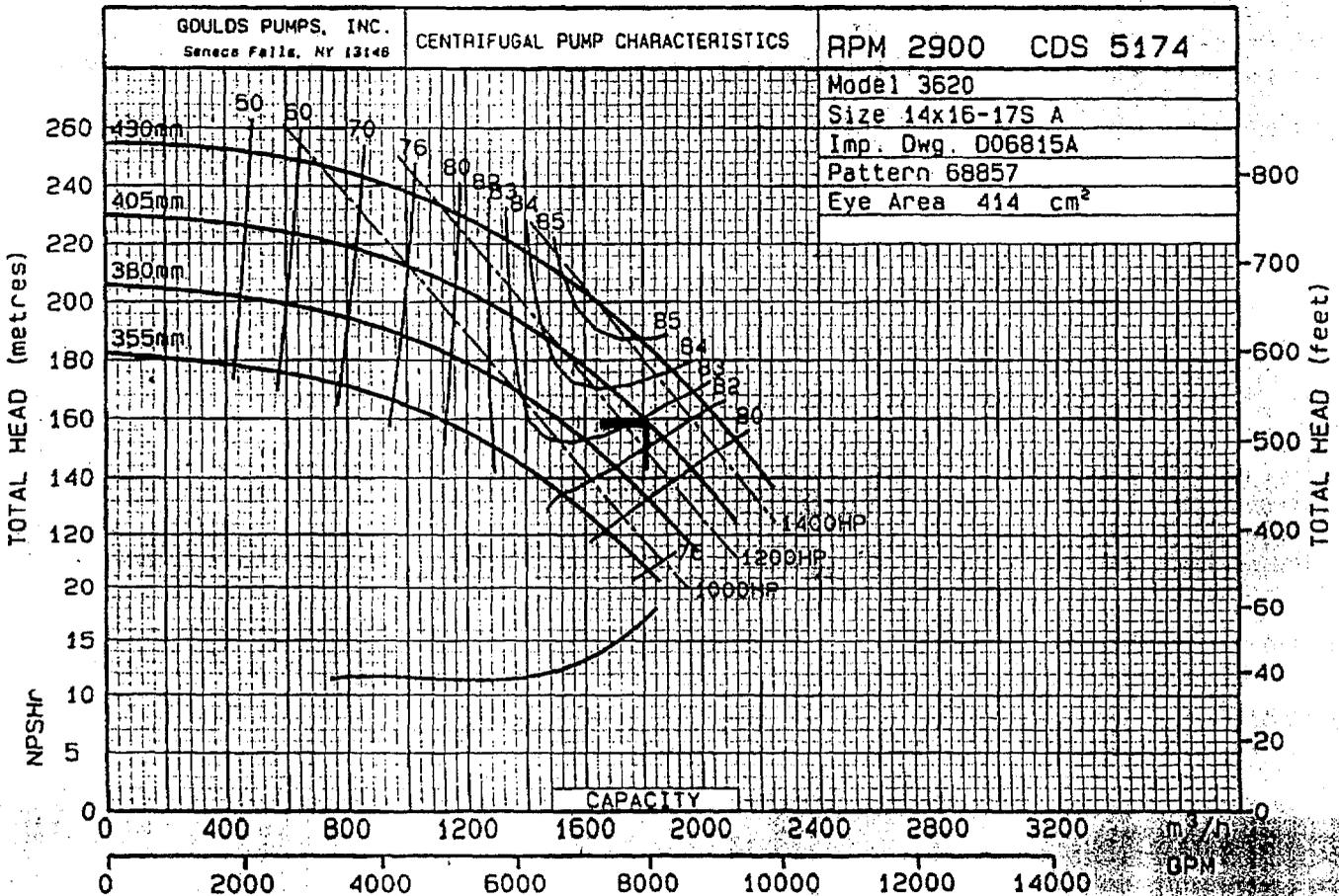
Purchaser: _____
 P.O. No.: _____
 User: _____
 Project: _____
 Unit: _____
 Location: _____
 Item No.: _____
 Service: _____
 F. O. No. _____
 Revision: _____ Date: _____
 Certified By: _____

Technical Data

Liquid: _____
 Temp:(°F) Nor. _____ Max. _____ Min. _____
 Specific Gravity _____ Specific Heat _____
 Viscosity (cP) _____ Vapor Pressure(psia) _____
Rated Operating Point
 Capacity (GPM) _____ Head (ft) _____
 Efficiency _____ %, (derated ___ points for high temp.)
 Pump power (BHP) _____
 Mechanical seal power (BHP) _____
 Total Rated Power (BHP) _____
 NPSHA (ft) _____ NPSHR (ft) _____
 Min. Cont. Stable Flow (GPM) _____
 Min. Cont. Thermal Flow (GPM) _____

Date 03-14-1995

Rev. Date



Appendix G

Newspaper Articles Regarding BWSSB and Water Supply

Sewage treated in 8 towns only in India

Unsound water strategy cause for alarm: Report

From N. C. Menon

WASHINGTON, March 9
Dangerously polluted water in Yamuna is just one example of the deleterious effects of unsound water strategies throughout the world, according to a new report by the International Food Policy Research Institute (IFPRI).

The report, "Water Resources in the 21st Century: Challenges and Implications for Action," by the Washington-based IFPRI, points out that only 8 of 3,119 towns in India fully treat their sewage and only 209 towns partially treat their sewage. The untreated sewage is carried away by India's rivers.

The Yamuna leaving New Delhi receives 200 million litres of

untreated sewage per day and has coliform counts of 25 million organism per 100 millilitres — the safe level for drinking water is 100 organisms per 100 millilitres.

Apart from contamination, depletion of the Earth's groundwater is a primary challenge. Heavy pumping in portions of Tamil Nadu have been estimated to reduce groundwater levels by as much as 25 to 30 metres in a decade. In the US alone, the equivalent of 10 million acres is watered by pumping groundwater faster than aquifers can recharge themselves.

Muammar Gaddafi's "man-made river" project to pump fossil water to the Libyan coastal region from the Nubian sandstone aquifer could deplete groundwater reserve not only in Libya, but in Egypt and

Sudan as well.

"New strategies are urgently needed to avert severe national, regional, and local water scarcities that will depress agricultural production, parch the household and industrial sectors, damage the environment, and escalate water-related health problems," according to the IFPRI report.

The report warns that water scarcity will become one of the main obstacles to feeding the world unless urgently needed policy reforms are made. The report also reveals that water supplies are dwindling in country after country because of wasteful water use, groundwater depletion and pollution, whereas demand for water has been increasing rapidly.

Between 1950 and 1990,

according to the report, water use increased by more than 100 per cent in North and South America, by 300 per cent in Africa and by almost 500 per cent in Europe.

According to Mark Rosegrant, research fellow at IFPRI and author of the report, the number of countries experiencing "water stress" will double in the next 30 years and the number of people affected by water scarcity will increase 10-fold.

"Water shortage are only going to get worse in the next 30 years," he says. "Unless better water policies are adopted internationally, we may see large-scale conflicts and catastrophes resulting from water shortage."

The report finds poor water policies to be the single most important cause of water scarcity.

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KEB thinks meters will show reading on the wall

BY OUR SPECIAL
CORRESPONDENT

Bangalore, March 18: Industrial consumers in the state consume around 40 per cent of the power supply but contribute 90 per cent of the revenue to the Karnataka Electricity Board. While the central ministries delay giving clearances and fuel linkages, industries have totally installed about 1400 MW of captive generation in the state, largely based on diesel. Private power is already a reality.

With the last tariff revision for industrial consumers, captive diesel power has become cheaper than grid power. This subverts the purpose of the central subsidy on diesel. And even though captive generation is capital cost-intensive and inconvenient for a variety of reasons, industries are forced to opt for diesel units because large additions to the state's installed capacity seem too remote.

As former chairman of the KEB, Mr B.G. Rudrappa says, "Independent power producers will invest the required Rs 30,000 crore in power generation only if they are convinced that the KEB will be able to pay for the energy they sell to it." In addition to the investment in generation, it is estimated that the board-itself will need to spend upto Rs 8,000 crore to transmit and distribute the power from the new generation stations. But, even if all this is

made possible by brilliant state negotiations with investors, litigation from environmentalists must be reckoned with. As mentioned earlier, the Karnataka Power Corporation has been completely sidelined by the government and prevented from exploiting all the state's hydroelectric potential, which is an estimated 8679 MW. For the government, hydro power is inexpensive, say energy experts; it is disastrous, say environmentalists. "A proper appreciation of the trade offs between economic benefits and environmental costs must emerge," says energy expert Dr V. Ranganathan.

The problem for the KPC, and now independent power producers

PRICE OF POWER: III

as well, is that environmentalists are also against nuclear and thermal power generation. Non-conventional energy schemes based on biomass gasification, wind power and solar power have not yet been worked out for largescale generation. So, the KPC frets over its experienced and idle engineers, waits for the KEB to pay up its monthly dues and watches with a sense of injury as the government looks for independent power generation.

The KEB is anyway frustrated because it has nothing to do with power generation, barring a few minor projects. As the decision makers and activists fight out, one way or the other, faced with the

■ Turn to Page 10 .

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KEB thinks electronic meters will show reading on the wall

Continued from Page 9

great of the very dismantling of the organisation. board employees have embarked on a public relations programme and pinned all their hopes on a new gadget — electronic meters.

According to KEB sources, it was the employees association which urged the board to announce the electronic meter scheme. Says association president T. Hanumanthappa: "It is due to the efforts of principal secretary to the chief minister S. Patil (former KEB chairman) that these electronic meters are being installed. This is the first step to solve all our problems."

It is typical of the board's irrational communication with its consumers, that it has roused so much wrath by insisting on installing these meters in all-electric homes which account for less than 10 per cent of total consumption and an even

lower percentage of revenue. The KEB employees association clearly explains the advantages of the electronic meters, as it sees it, in industries.

Since industries are big payers and consumers, accuracy of metering and billing, and control of usage in this sector are critical to improve the KEB's functioning, says Mr Hanumanthappa. With the connivance of KEB engineers, or otherwise, some industries tamper with the existing measuring devices to use more power than sanctioned, or more units of energy than recorded.

Explains Mr Hanumathappa, "The demand meter is reset every month by our employees. Now, it is possible for even a contractor to set it in such a way that more power is utilised than shown." For instance, if an industry is restricted to connect a given set of machinery for a given period, by recalibrating the meter, it is

possible to connect more machinery and during the forbidden peak load time without the possibility of detection. With overloading, as consumers discover everyday, the line trips or the transformer burns down.

The other major abuse of the service is power theft in which a phase is directly connected to the load and consumption in

PRICE OF POWER: III

units on that phase is not recorded by the energy meter. The new electronic meter for industries, priced at Rs 13,000, solves these problems, the employees claim. The electronic meter has a memory circuit which records over 10 parameters of consumption, including the critical aspects of power factor, connected load, phase and units. And, most importantly, on a time line.

"The meter can hold these records memory for 35 days and give us a print out which will show when and how much load was connected; when power failed or a phase was disconnected. And it is 100 per cent accurate," Mr Hanumanthappa says. At one shot, it would preempt any chance of tampering by anybody, charges and counter-charges of corruption and reduce the burden of inspection on the board, he says.

At present, the only way the KEB can check overloading is by a physical inspection. "There are 13,000 vacancies in the board today. For every 1000 consumers, 10 workers are necessary. In Karnataka we have five. Physical inspection is impossible," Mr Hanumanthappa pleads. The board has already introduced the electronic meters in a few areas, including 350 in the Peenya industrial estate in the city from January. "The trial meters are work-

ing well and we have no complaints from consumers. This is the best way to avoid litigation too," he says. The board is equipping its distribution stations with these meters to introduce energy audits.

Association general secretary D.R. Bhat agrees that it would be in the best interests to install the meters in 2,600 high tension and 2,80,000 low tension industries. "System improvement has to be step by step. We need to coordinate area-wise, so that we can get a better understanding of the performance of meters," he says.

They fervently appeal to the board to improve its public relations. "That is our main grouse. The board should both explain to the public why there is power shut down at least the day after office-bearer said.

■ Concluded

Five years to go before city gets adequate water supply

Staff Reporter

BANGALORE: Chairman of the Bangalore Water Supply and Sewerage Board (BWSSB) J.P. Sharma on Monday told the Bangalore City Corporation (BCC) council that it would take at least five years for the board to stabilise water supply in the city.

Replying to the discussion at a special meeting of the BCC, BWSSB and KEB organised to discuss water and electricity problems, Mr Sharma said that the board had drawn up a time-bound programme to tackle discrepancies.

He agreed that the board was able to meet just 50 per cent of the requirement since water had to be pumped from 100 kilometres outside the city and to a height of about 1,500 feet. "We are able to provide about 95 to 100 litres per day per person. This is way below international standards, which specifies a minimum of 200 litres per day per person," he said.

He said that instead of short-term measures, the board was interested in prioritising and devising a cost-effective method of streamlining the supply system.

Some of the measures taken was to entrust the Indian Institute of Science (IISc) with developing a computer graph of the pipes, overhead tanks and low-lying reservoirs. "It is already underway. Within three months, they will

All set to take on the heat

How the BWSSB plans to tackle the water problem during summer.

- All borewells to be repaired and maintained.
- All tankers to be repaired and kept on standby. Spare tankers to be borrowed from BCC, irrigation and health departments and PWD.
- Drivers will be recruited for these water trucks and two of them will be assigned to every truck so as to be on call all 24 hours.
- 10 large plastic tanks mounted on flat trucks will also be employed.
- To check outbreak of water-borne diseases, chlorination and other aspects will be standardised. All 16 chlorinators are in working condition and health officials will monitor the quality of water.
- BWSSB will sink 15 high water yielding borewells at places where a geological survey by ISRO through remote sensing had indicated a high percentage of water. These would be frequently tested.
- At least three heavy duty generators and capacitors worth Rs 3.5 crore have been installed.
- A 24-hour service control room with adequate telephone lines and hotlines will be set up in Malleswaram.

come up with the best way of laying pipes and locating tanks for maximum benefit," he said.

Mr Sharma said that leakages, which accounted for 30 per cent water loss, 15 per cent more than what is prescribed, was also being undertaken. Simultaneously, personnel were also being trained to control leakages. "We are also thinking of rain water harvesting, to get at least 10 per cent of total demand," he said.

The board has sent a plan to the government to replace corroded and narrow pipes in the old areas

where pipes were laid nearly 100 years ago. In the newly-added areas to the BCC, the BWSSB had constituted a special task force to repair and maintain all borewells since it would not be possible to provide these areas with Cauvery water at this stage, he said.

He said that the Tata Energy Research Institute had been entrusted with conducting an energy audit to devise means of reducing electricity consumption and increasing efficiency. A master plan for sewage lines was also being drawn up, he said.

K. Suresh

TIMES OF INDIA, MARCH 18, 1997

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THE BANGALORE

BANGALORE THURSDAY 20 MARCH 1997

Water sources run dry on bulging city

PRASHANTHSS HEBBAR

Bangalore, March 19: Even as the heat and dust settles over the garden city, 53 lakh people will be preoccupied in securing clean and hygienic water to wet their parched throats and beat the simmering summer in a few days:

With the Tippagondanahalli tank, one of the prime sources of drinking water to Bangalore city, drying up and the state suffering under acute power shortage, summer of 1997 is expected to be as dry as winter. Officials say the city's water situation is moderate. But they also throw up their hands at the pace at which Bangalore is drying.

The demand for water in the city is estimated at 700 million litre per day with every citizen entitled to 120 litres. However, the Bangalore Water Supply and Sewerage Board is supplying only 100 million litre per day to the city, out of which 540 million litres is from the

Cauvery and the rest 20 is from TG Halli. The demand supply gap is 140 million litres. Mr K.R. Narayana Iyengar, superintending engineer of BWSSB, described the situation best, "Water situation in Bangalore is similar to a patient kept on oxygen round the clock."

The BWSSB has come up with a solution to bridge this gap. Instead of pumping 120 litres per person per day it proposes to bring this down to 70 to 85 litres per person per day. The worrying point is that even in non-summer seasons many areas in the city is reported to have been getting supply of only 65 litres per person per day.

Water supply from TG Halli has dropped from 30 million gallons per day to a mere 4 million gallons per day. As a result, Cauvery is the only available resource to quench the city's thirst.

Hesaraghatta Lake which was another major source of water has also dried up.

Authorities have dug around 20 borewells around the lake which yields nearly 1 million gallons per day. This is just about enough for the Air Force station at Yelahanka, point out BWSSB officials.

As the summer progresses, the western and northern parts of Bangalore will be the worst hit areas since TG Halli is the prime source of water for these areas,

The southern and the eastern sections of the city is said to be comfortable with the supply situation. Mr Iyengar

assured that there will be no changes of water supply timings and dates in these areas.

The BWSSB authorities have geared up for crisis management, something which happens every summer. According to Mr Iyengar, the board has put in 22 lorries with water carrying capacity of 10,000 litres will be put into service. Twenty more lorries are being hired from private water suppliers to supplement the board-

's own fleet. Mr H.R. Mruthyunjaya, chief engineer (project), BWSSB, says that the water supply board will ensure that adequate water supply is maintained throughout the summer.

However, there's a catch in this situation. For BWSSB to pump water from the source, an uninterrupted power supply at 660 KV and a frequency of 66 cycles per seconds is essential. KEB, however, is supplying intermittent supply at 55 KV and a frequency of 47.75 cycles per second.

The reduction in number of cycles per second is resulting in almost 10 per cent reduction in water discharge every day. The BWSSB has been assured by the KEB that at any cost uninterrupted power will be supplied to the pumping stations. "We are sure they will stick to their commitment. In fact, last year KEB cooperated very well with us," says Mr Iyengar.

Availability of power is a vital factor

■ Turn to Page 10

WORST HIT AREAS

Rajajinagar, Vijayanagar Nandini Layout, Yeshwantpur, BEML, West of Cord Road, Mysore Road, Magadi Road, Subramanyanagara, Malleswaram, Srirampuram, Okalipuram

NOT AFFECTED

Jayanagar, JP Nagar, Indiranagar, BTM Layout, Basavanagudi, Hanumananagar BWSSB has set up a cell to monitor water supply in problem areas. Residents can contact the special cell at 3345170, 3342423

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Bangalore on oxygen

■Continued from Page 9

since BWSSB has to pump a bulk of the city's water requirement from Cauvery which is 100 km away with a height difference of 1,100 ft. Though water stored at TG Halli is expected to last till July, its share is a minute speck compared to the demand.

The water supply board is planning to prepare a comprehensive map of water supply network of Bangalore which is expected to help monitor the supply better. The project proposes to take assistance from Bangalore Metropolitan and Regional Development Authority, Bangalore Development Authority, Bangalore City Corporation and KEB. Isro is likely to be approached for implementing the project.

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THE BANGALORE

BANGALORE MONDAY 17 MARCH 1997

Burnt out KEB has only luck to offer students

Prakash Belawadi

Bangalore, March 16: An average 75 transformers of the Karnataka Electricity Board are burning out every day all over the state as its obsolete distribution system has been heavily overloaded, with over 750 connections added daily to the grid.

In an unusual gesture, the KEB took out an advertisement on Sunday to appeal to students who will be among the worst-affected with the coming annual examinations. In its appeal, the KEB requests students: "Please ensure that all the unnecessary lights and gadgets in your houses are switched off during study time. Or else, the lines will trip and load shedding will become inevitable. We wish you all the best in your examinations."

The KEB has also requested all categories of consumers to reduce their loads "as far as possible. Please remember, it is our sons and daughters who are

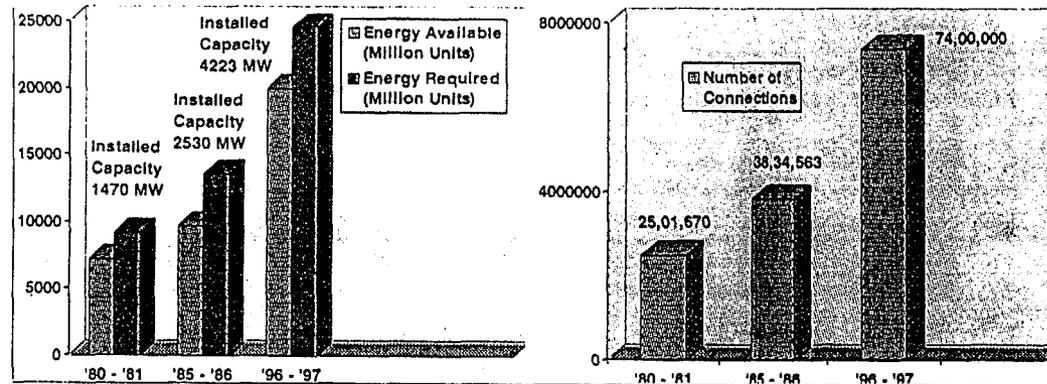
going to benefit by this," the appeal states.

With the expected summer increase in consumption by irrigation pumpsets, long and unscheduled power interruptions have become common either due to transformer breakdown or line tripping.

The board has a little more than one lakh transformers all over the state. According to official figures between April 1, 1995, and March 31, 1996, more than 20,000 transformers failed, mainly due to overloading of the system. What is particularly alarming to the board is that upto October 31, 1996, in just six months, 13,152 transformers broke down.

The KEB Employees Association, following attack on the board's offices and workers by angry consumers, has launched its own campaign to explain the helpless situation to the public. In a printed appeal, the association has pleaded that while the total connected load is over 10,000 MW, the available power

Turn to Page 10



The chart on the left shows the energy deficit and the right, the number of connections. Available energy includes power imports and required energy assumes 7 per cent annual growth (demand projections of the S.G. Ramachandra Committee 10 years ago is 36,600 million units)

bl

Burnt out KEB

■Continued from Page 9

including imports to the state, is only 3450 MW. "Even with this given shortage of supply, if more power is consumed the transformers come under pressure. If the board cuts supply, the consumers become angry. But if supply is continued under these conditions, the transformers burn out from overloading, or there is a fall in voltage," the association explains.

The simultaneous loads from irrigation pumpsets, industries and all-electric homes (those with heating appliances) are responsible for this situation, according to association office bearers.

It takes at least five hours to replace a transformer. In many cases, a transformer breakdown means an entire day, if not more, without power. All classes of consumers take out their anger on board employees, of late, even by physical means.

Says association president T. Hanumanthappa, who is also a member on the board: "The situation is desperate. We have to educate the public on the real problems of distribution since the KEB is not responsible for power generation. The board must improve its public relations before the situation becomes worse."

The KEB is adding an average three lakh new connects every year, but the last significant addition to the state's generation capacity was in September 1994 with the commissioning of the fourth unit of the Raichur Thermal Power Station. Successive governments have failed to take any initiative in closing the huge demand-supply gap as the table clearly shows.

■Tomorrow: The KEB suffers from a severe financial crunch, litigation and mindless political interference.

lol

Appendix H
TERI Work Order

TERMS AND CONDITIONS AND SCOPE OF WORK FOR COMPREHENSIVE ENERGY
AUDIT IN EWSSB INSTALLATION

EWSSB has contemplated a detailed comprehensive energy audit of all the installations which are dependent on power supply from KEB grid. EWSSB is paying nearly Rs.100.00 Crores towards power consumption every year and the purpose of the energy audit is to identify significant energy savings possibilities in all the pumphouses of water supply installations under the control of EWSSB and to suggest suitable measures or modifications in the installations to effect reduction in consumption of power.

The scope of study shall cover the following pumping stations and other installations of EWSSB.

- i) Cauvery pump houses I stage, II Stage and III stage located at T.K.Halli, Harohalli and Tataguni along the transmission main to the City vide Annexure I including substations at all places.:
- ii) Water purification plants taken up under CWSS I Stage, II Stage and III Stage located at T.K.Halli.
- iii) 3 pumps of 1675 HP are designed under CWSS I Stage to pump 135 MLD of water to the City, but on account of snag in the pumping system between T.K.Halli and Harohalli 4 pumps are run at a time at T.K.Halli. The scope shall include identification of snag and suggesting remedial measures to overcome the snag in the Transmission main, including the installations at J.K.Doddi.
- iv) Soldevanahalli pumphouse under the Hesaraghatta Scheme
- v) Arkavathy scheme pump houses located at T.B.Halli and Tavarekere.
- vi) Water Treatment plant at T.B.Halli
- vii) Various pump houses in the distribution system of EWSSB within the City-as per Annexure II.
- viii) Suggesting long term measures for new ventures to incorporate energy efficiency parameters.
- ix) To carryout the training workshop on practical energy Audit tailored to suit the needs of EWSSB to the operation and maintenance staff of EWSSB pumphouses.
- x) Preparation of maintenance manuals for electrical and pumping equipments in the EWSSB installations. The manuals shall be furnished in 10 sets.
- xi) EWSSB desires that Sri S.Govindappa, Retired Chief Engineer, KEB and an expert in Electrical Engineering and who has deep knowledge of the installations of the EWSSB shall be associated with the Energy Audit. Remuneration payable to Sri S.Govindappa,

shall be paid directly by Tata Energy Research Institute.

xii) The period of study shall be for a period of 10 weeks from the date of signing the agreement. Energy audit report shall be furnished in 10 copies.

xiii) TERI will identify the snags in the system and proposals for implementation shall be identified as short range and long range and also costs involved in implementing these proposal.

xiv) The total cost of remuneration payable to Tata Energy Research Institute shall be Rs.4.30 lakhs. 50% of the amount shall be paid in advance and the balance 50% of the amount shall be paid after completion of the energy Audit.