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TRACY FISH COLLECTION FACILITIES (TFCF)  
INSTRUMENTATION SELECTION RECOMMENDATIONS  
FINAL REPORT

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Date: 27 January 1993

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Memorandum

To: Regional Director, Sacramento CA  
Attention: MP-400

From: Chief, Hydraulics Branch

Subject: Tracy Fish Collection Facilities Instrumentation Selection  
Recommendations Final Report (Our Memorandum Dated November 6,  
1992 and Your Memorandum Dated December 23, 1992) (Hydraulic  
Research, Fish Screen)

As a followup to our memorandum dated November 6, 1992, enclosed is the final report on the instrumentation recommendations for the Tracy Fish Collection Facilities, entitled "Tracy Fish Collection Facilities (TFCF) Instrumentation Selection Recommendations Final Report." This report contains information regarding instrumentation upgrades at the facilities. These upgrades are required for monitoring hydraulic conditions and operating parameters during the upcoming efficiency evaluation. All preliminary reviews, as completed by MP-400, D-3423, D-3751, and D-3742, have been incorporated into this final report. Important modifications from the preliminary report are the inclusion of an executive summary and a cost estimate for the full instrumentation package option.

Please contact Perry Johnson, (303-236-6160) or Joe Kubitschek, (303-236-6155) if you have further questions.

*Philip H. Bung*

Enclosure

cc: Regional Director, Sacramento CA, Attention: MP-780 (Arthur),  
MP-400 (Sackett) (w/five copies of encl), MP-200 (Eaton)  
Project Superintendent, Byron CA, Attention: T-100 (Ing)  
(w/encl to each)

bc: D-3423 (Beard, Christensen)  
D-3742 (Liston)  
D-3420  
D-3740  
D-3750  
D-3751  
D-3751 (PAP file)  
(w/encl to each)

WBR:JKubitschek:flh:3/8/93:236-6155  
(c:\wp\d3751\TFCFrpt.1tr)

TABLE OF CONTENTS

1. Executive Summary.....	3
2. Scope.....	8
3. Introduction.....	8
4. Hydraulic Monitoring Plan.....	9
5. Evaluation of Existing Instrumentation.....	11
6. Required Additional Instrumentation.....	12
7. Final Recommendations - Conceptual Design.....	28
8. System Design, Purchase, and Installation.....	35
9. Manufacturers Listing (Sources).....	36
Appendix A: W.S.El. Instrumentation	
Appendix B: Velocity instrumentation	
Appendix C: Flow Rate Instrumentation	
Appendix D: Water Quality Instrumentation	
Appendix E: Data Acquisition System (DAS) Hardware	
Appendix F: Cost Data	
Appendix G: Tracy Projects Office Maintenance Schedule FY93	

## 1. Executive Summary

The following report identifies, evaluates, and provides recommendations for the instrumentation required to monitor the hydraulic operating parameters at the Tracy Fish Collection Facilities (TFCF). Monitoring of all hydraulic operating parameters is required for the upcoming efficiency evaluation of the facilities. The monitoring instrumentation could also be used as part of a future automation. Potential modification and temporary continued use of existing instrumentation is also discussed. Technical and cost information for all instrumentation identified for this application is included as appendices A-G.

1.1 Hydraulic Monitoring Requirements - The hydraulic monitoring requirements consist of monitoring those hydraulic parameters which potentially influence facilities efficiency and which must be considered with operation of the facilities. The hydraulic parameters are as follows:

1.1.1 Water surface elevation (W.S.El.) - W.S.El. monitoring is required throughout the TFCF to determine flow depths and losses exhibited by components of the facilities. Monitoring of losses in part indicates the degree of fouling at the trashrack and louvers, and thus could be used to automate cleaning procedures. The critical locations for monitoring W.S.El. are indicated by figure 1 - Basic Plan View of TFCF and are as follows:

- Upstream of the trashrack structure
- Upstream of the primary louver line in the primary louver forebay
- Downstream of the primary louver line
- Upstream of the first louver line in the secondary louver structure
- Between the first and second louver lines in the secondary louver structure
- Downstream of the second louver line in the secondary louver structure
- In each of the four fish holding tanks

Thus, a total of 10 locations require monitoring of W.S.El.

1.1.2 Flow velocity - Flow velocities strongly influence facilities efficiency and potential fish mortalities. Approach and louver line velocities are critical parameters which should be closely managed for effective louver operation. The critical locations for monitoring velocities are as follows:

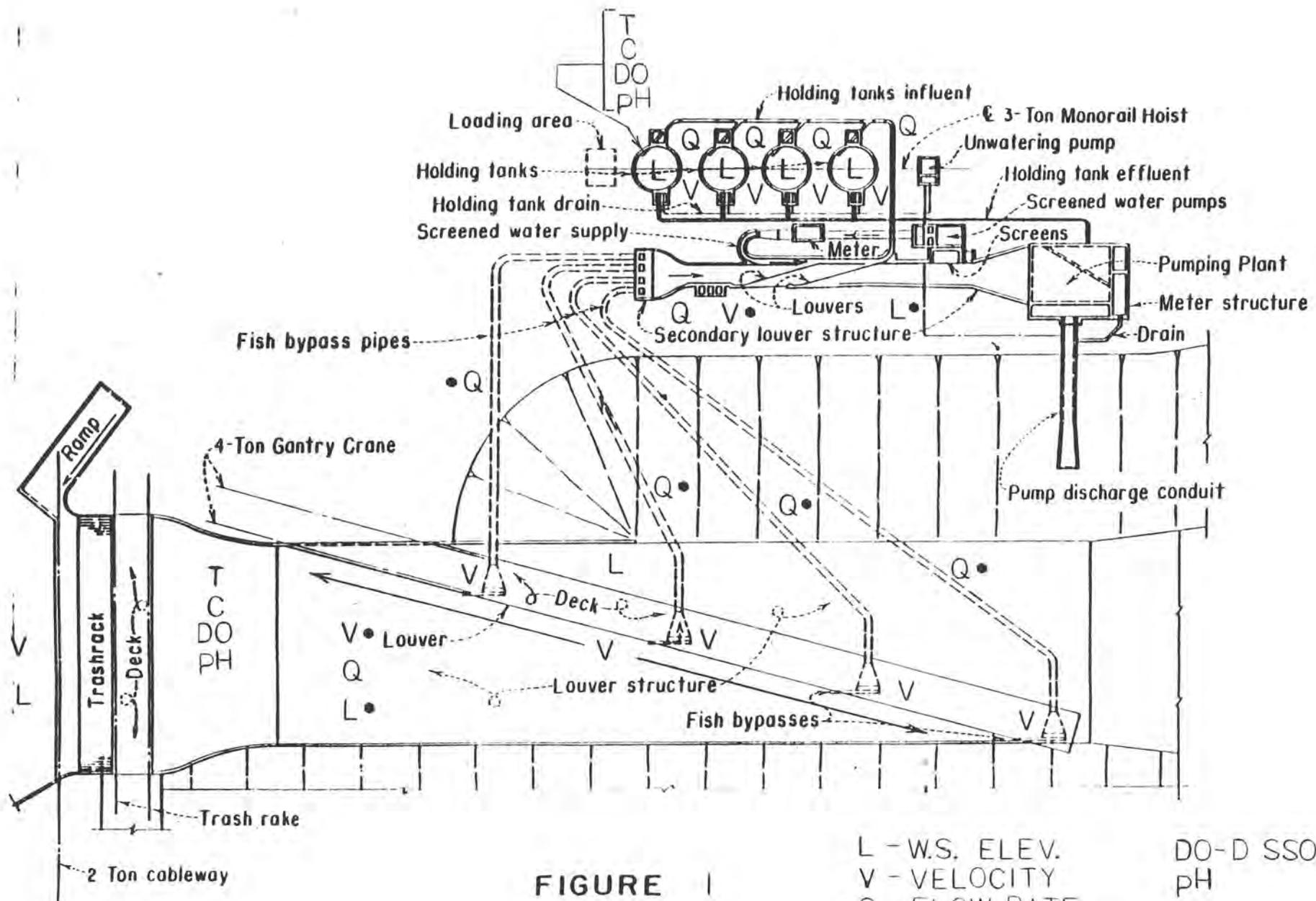


FIGURE 1

- L - W.S. ELEV.
- V - VELOCITY
- Q - FLOW RATE
- - EXISTING INST.
- T - TEMPERATURE
- C - CONDUCTIVITY
- DO - DISSOLVED OXYGEN
- pH

- Across the face of the trashrack structure
- Approach to the primary louver line in the primary louver forebay
- Across the face of the primary louver line
- In each of the four primary bypass intakes
- Upstream of the first louver line in the secondary louver structure
- Along each of the louver faces in the secondary louver structure
- In the secondary bypass intake
- In each of the four holding tanks

Thus, a total of 11 critical locations require monitoring of flow velocities.

1.1.3 Flowrate - In addition to velocities and W.S.El., flowrates must be monitored throughout the facilities. The critical locations for monitoring flowrates are as follows:

- Upstream of the primary louver line in the primary louver forebay
- Upstream of the secondary louver lines in the secondary louver structure
- In each of the four 36-in fish bypass pipes

Thus, a total of six locations require monitoring flowrates.

Monitoring of all the above hydraulic parameters will yield a complete understanding of the hydraulics at the TFCF, and consequently reveal the effects of various operating conditions on the overall efficiency of the facilities. In addition to the above monitoring requirements, water temperature, conductivity, dissolved oxygen (DO) levels, and pH in the holding tanks and the primary louver forebay should be monitored in that water quality will influence fish stress and consequently facilities efficiency. A complete data acquisition system (DAS) is recommended to expedite data acquisition, to provide continuous data collection, to provide data reduction tools for analysis, and to support potential automation of the facilities.

1.2 Instrumentation Selection Options - Three different packages have been developed to provide alternatives for instrumentation at the TFCF. These packages represent a varying degree of effort required for implementation as well as various cost options.

1.2.1 The basic instrumentation package meets the minimum requirements for monitoring hydraulic parameters within the scope of the efficiency evaluation. The instrumentation which has been identified for this package is summarized in the following table:

Table 1. - Basic Instrumentation Package: Includes instrumentation in addition to that which is existing.

Application	Instrumentation	Quantity required	Cost each	Total
Monitoring W.S.El.	Ultrasonic	3	\$1,207.00	\$ 3,621.00
Monitoring velocity	Velocity meters	1	1,865.00	1,865.00
Monitoring water quality	T, C, DO, pH sensor	2	3,450.00	6,900.00
Total Cost				\$12,386.00

1.2.2 The intermediate instrumentation package is essentially the basic package with some additional instrumentation which acts to improve hydraulic monitoring capabilities. The instrumentation which has been identified for this package is summarized in the following table:

Table 2. - Intermediate Instrumentation Package: Includes instrumentation in addition to that which is existing.

Application	Instrumentation	Quantity required	Cost each	Total
Monitoring W.S.El.	Ultrasonic	9	\$ 1,207.00	\$10,863.00
Monitoring velocity	Velocity meter	3	1,865.00	5,595.00
Monitoring open-channel flowrates	Magmeter	2	3,150.00	6,300.00
Monitoring water quality	T, C, DO, pH sensor	2	3,450.00	6,900.00
Total cost				\$29,658.00

1.2.3 The full instrumentation package represents the best available instrumentation and likely the best system for extended use. This is a step up from the intermediate package and includes a complete data acquisition (DAS) package. The instrumentation which has been identified for this package is summarized in the following table:

Table 3. - Full Instrumentation Package: Includes a complete upgrade of instrumentation at the TFCF.

Application	Instrumentation	Quantity required	Cost each	Total
Monitoring W.S.El.	Ultrasonic	8	\$ 1,207.00	\$ 9,656.00
Monitoring velocity	Velocity meter	12	1,865.00	22,380.00
Monitoring closed-conduit flowrates	Ultrasonic clamp-on	4	1,985.00	7,940.00
Monitoring open-channel flowrates	Ultrasonic	2	13,500.00	27,000.00
Monitoring water quality	T, C, DO, pH sensor	2	3,450.00	6,900.00
Data logging	DAS	1	6,745.00	6,745.00
Total cost				\$80,621.00

1.3 Recommendations - It is believed that the full package will prove to be the most cost effective option of the three discussed. This package includes the appropriate hardware necessary to fully understand the hydraulics of the facilities and to fully expedite data collection and reduction. The full package also offers the best option for support of future automation. This instrumentation would accurately document hydraulic conditions.

The basic package on the other hand was provided as an option of keeping cost as low as possible by using, where possible, existing instrumentation. For example, the primary and secondary forebay propeller meters which have limited accuracy would be used for the basic package. While the instruments could define approximate relationships between forebay velocities and structure performance, the accuracy of the relationships would suffer.

The full package includes 12 portable velocity meters instead of 3 proposed for the intermediate package. This will allow for quicker and more accurate documentation of the velocity distributions on the louver and trashrack faces.

In addition, the full instrumentation package supplies a complete DAS which will act to minimize labor requirements for both the TFCF staff and those working on the evaluation.

The full package is the option most compatible with future automation, the package could be directly used to control pumps and valves in an automated facility. Likewise, the instrumentation proposed is state of the art and suitable for extended operational use.

Thus, by expediting data collection and reduction, in the long run much of the initial expense would likely be offset by the reduction in labor required for collection of data during the efficiency evaluation. In other words, although the full package is expensive, it may be the least cost option in the long run.

1.4 Cost Summary - The cost of procurement for all instrumentation can be outlined as follows:

CONTAQ Technologies, Inc. Ultrasonic Level Sensor:	
8 units @ \$1,207.00 ea.....	\$9,656.00
Swoffer Instruments, Inc. Current Velocity Meter:	
12 units @ \$1,865.00 ea.....	\$22,380.00
Controlotron Ultrasonic Closed conduit Flowmeter:	
4 units @ \$1,985.00 ea.....	\$7,940.00
ORE Int'l, Accusonics Ultrasonic Open-channel Flowmeter:	
2 unit @ \$ 13,500.00 ea.....	\$27,000.00
HYDROLAB Corp., T, C, DO, pH monitor:	
2 unit @ \$3,450.00 ea.....	\$6,900.00
DIANACHART, Inc. SYSTEM-1 DAS:	
1 unit @ \$6,745.00 ea.....	<u>\$6,745.00</u>
TOTAL.....	\$80,621.00

Thus, instrumentation cost would be approximately \$82,000.00, including an additional \$1,500.00 for electrical conduit and additional instrumentation cable can be expected for purchase of instrumentation alone. An additional cost of \$40,500.00 will be incurred in the design and fabrication of installation hardware, installation of instrumentation, and any calibration which may be necessary. Thus, the total cost of the installed full package would be \$122,500.00. These costs have been included in the body of this report and a cost estimate has been prepared and included in appendix F.

1.5 System Design Purchase and Installation - To expedite system installation and to minimize design and installation cost, the Hydraulics Branch instrumentation staff can prepare "in-house" grade drawings. These drawings could then be reviewed by the Steel Pipe and Special Equipment Section of the Mechanical Branch, Denver Office; by the Region Engineers Office in the Mid-

Pacific Region; by the Office of the Regional Supervisor of Water and Power Resources Management in the Mid-Pacific Region; and by the staff at the Tracy Office. With completion of a reviewed design, the Hydraulics Branch instrumentation staff would prepare requisitions which could be processed through the Tracy Office, the MP Regional Office, or the Denver Office as deemed appropriate. The instrumentation staff could then work with the Tracy Office and the Denver Laboratory Shops to fabricate instrumentation mountings and to install the instrumentation. It is anticipated that staff from Denver would travel to the facility and work with the project in this effort. Involvement of project personnel has been discussed with the Tracy Office. Indications are that project personnel would be available if the work does not conflict with the annual equipment maintenance schedule (appendix G). The above process would maximize staffing continuity and hopefully minimize backtracking and familiarization.

Other options would include a similar process but with MP-200 or D-3423 conducting the design. Instrumentation purchase and installation could be contracted. This would require preparation of specification grade drawings and likely would be more expensive and require more time.

The Hydraulics Branch instrumentation staff also is experienced in developing automation systems. Their potential involvement with future fish facility automation should be considered.

Note: The procurement of this instrumentation will be specified as competitive. Therefore, all requisition items should be submitted for approval prior to award, to ensure that all specifications are met.

## 2. Scope

The following report identifies, evaluates, and provides recommendations for instrumentation to monitor the hydraulic operating parameters at the Tracy Fish Collection Facilities (TFCF) for the upcoming efficiency evaluation. Potential modifications of existing instrumentation at the TFCF is also discussed. Technical and cost information for all instrumentation identified in this report is included in appendices A through G.

## 3. Introduction

The purpose of the Tracy Fish Collection Facilities (TFCF) is to collect fish that would otherwise be entrained at the Tracy Pumping Plant and transport those fish back to the Delta away from the zone of pumping influence. Fish are removed from the intake flow by application of the fish louver concept, the

details of which are beyond the scope of this report. However, it is important to note that operating parameters directly affect the efficiency of the facilities, or the ability to collect fish with minimum injury. The intent of this report is not to evaluate the concept, but to identify those hydraulic parameters which may affect the efficiency of the TFCF and propose alternatives for monitoring these parameters. Currently, there exists virtually no automation or control scheme for the operation of the TFCF. Operators rely upon previously developed operating criteria, limited instrumentation, and experience to ensure proper operation of the facilities. Thus, automation may be pursued at the TFCF in the future. This will require selected instrumentation to have capabilities appropriate for future automation or control. All existing instrumentation at the TFCF has been evaluated and recommendations for use in the efficiency evaluation have been presented. Additional instrumentation will be required for evaluation of parameters not currently being monitored. Thus, the two primary features of the report are the evaluation and upgrade of the existing instrumentation and the selection of additional instrumentation to provide the appropriate hydraulic information for effectively evaluating the efficiency of the TFCF.

#### 4. Hydraulic Monitoring Plan

The monitoring plan for the TFCF consists of measuring water surface elevations (W.S.El.), open-channel and closed-conduit volumetric flowrates, flow velocities, and water quality parameters at various locations throughout the TFCF, as shown on figure 1.

4.1 W.S.El. instrumentation should be located upstream and downstream of the trashrack structure to acquire information regarding operation (i.e., head losses and trashrack fouling), which indicate excessive restriction and raking requirements. Similar instrumentation is required upstream and downstream of each of the louver lines in the primary louver forebay and the secondary louver structure. W.S.El. information is also required for each of the four holding tanks.

4.2 Velocities should be monitored approaching the trashrack and the primary and secondary louver lines, in the primary and secondary bypass intakes, and in each of the four holding tanks. Velocity distributions (vertical and horizontal) should be determined across each of the louver lines (primary and secondary), and across the face of the trashrack. It seems appropriate to select portable instrumentation to evaluate velocity distributions, because of the number of measurement locations and the fact that these measurements would be required only during the efficiency evaluation study. Each of the velocity instrumentation locations has been identified in

figure 1. Velocity information is a critical component in the efficiency evaluation, since proper louver operation is directly dependent upon louver line and bypass velocities.

4.3 Volumetric flowrates should be monitored in the primary louver forebay, the 36-in fish bypass lines, and the holding tank pump discharge line. Again these proposed locations are identified in figure 1. Also, water quality instrumentation is required in the primary louver forebay and the fish holding tanks. The water quality parameters to be monitored are: temperature, conductivity, dissolved oxygen (DO), and pH. The remainder of this report identifies and evaluates possible instrumentation required under this monitoring plan. All instrumentation was selected with standard 4-20 mA output as an overall requirement for future automation. All indicators should be remotely located at a central panel for display; or a complete data acquisition system should be specified, which will provide a basis for configuration of the telemetry.

The following monitoring techniques have been investigated in this report:

- Water surface elevation (W.S.EL) -
  - a. Continuous capacitance
  - b. Mechanical float
  - c. Pressure transducer
  - d. Ultrasonic
- Flowrate (open channel) -
  - a. Ultrasonic velocity and level
  - b. Electromagnetic velocity and level
- Flowrate (closed conduit) -
  - a. Ultrasonic, transit time
  - b. Electromagnetic
- Velocity -
  - a. Electromagnetic
  - b. Propeller type
- Temperature -
  - a. Thermocouple
  - b. Thermistor
  - c. RTD
- Conductivity -
  - a. Contact
  - b. Non-contact
- Dissolved oxygen monitor -
  - a. Submersible
  - b. Portable
- pH -
  - a. Submersible
  - b. Portable

## 5. Evaluation of Existing Instrumentation

The existing instrumentation monitors flow depth/water surface elevations, velocities, and flowrates at the TFCF. Although this instrumentation is outdated and in some cases operating poorly, it may be useful to temporarily retain some of this instrumentation as operational to maintain continuity between historical data and future data taken at the TFCF. If costs are to be minimized, much of the existing instrumentation could be rehabilitated, calibrated and utilized. The descriptions of this instrumentation is as follows:

5.1 Water surface elevations are monitored at three locations in the TFCF. Floatwells are located upstream of the primary louver structure, downstream of the primary louver structure, and upstream of the first secondary louver line. All of the existing water surface elevation instruments may be utilized. However, only the floatwell upstream of the primary louver structure is equipped with an indicator transmitter for remote monitoring at the recorder located near the electrical control panel. The remaining two floatwells are equipped with indicators only and must be monitored locally. Thus, if future automation is desired, the remaining two floatwells should be equipped with the appropriate indicator transmitter required for remote readout. It is important to note that each of these instrument locations provide critical hydraulic information which requires monitoring either with the existing floatwells or upgraded continuous level sensors.

5.2 Velocity information, other than calculations based on flowrates, is obtained via two propeller type velocity meters located in the primary louver forebay and upstream of the secondary louvers. Facilities staff have noted that these meters are direct readout (no time averaging capabilities) and show substantial velocity fluctuations. Visual averaging can be done to determine velocity; however, it would be difficult to maintain accuracy and repeatability. To utilize these instruments, a complete checkout would be required to determine operational accuracy and correct calibration. Consequently, a decision should be made to either service and equip the meters with the appropriate components for remote readout, or replace with new instrumentation. This decision may be based on cost. Once again, it is important to note that each of these instrument locations provides critical velocity information. An accurate assessment of velocities throughout the facilities is of strict importance to maintaining optimum efficiency of the TFCF.

5.3 Flowrates are currently monitored at each of the four 36-in primary fish bypass lines, at the holding tank pump discharge line, and at the screened water line. The flow rates at each of the four 36-in bypass lines are monitored by

ultrasonic flowmeters manufactured by Badger Meter, Inc., PO Box 581390, Tulsa, Oklahoma, 74158, 918-836-8411. The flowrates are remotely indicated at the electrical control panel located near the secondary louver structure. These meters are adequate for the TFCF evaluation and are capable of future incorporation into an automation or control scheme. However, these flowmeters will require a complete checkout (i.e., determination of correct mounting and coupling procedures and calibration checks) to ensure proper operation for the efficiency evaluation. A 16-in venturi meter is being used to monitor flow rates through the holding tank pump discharge line and a 24-in venturi meter is being used on the screened water line. Each of the venturi meters may be utilized as installed. Since the flowrates are controlled by operation of the respective butterfly valves, some additional components may be required in conjunction with these venturi meters for future automation or control.

A complete information package which identifies manufacturer's and specific technical information for much of the existing instrumentation is not available.

## 6. Required Additional Instrumentation

6.1 W.S.El. Instrumentation. - Should it be desirable to utilize existing floatwells, indicator transmitters should be selected. Again, transmitter upgrades are required only for the floatwells located downstream of the primary louver structure and upstream of the first secondary louver line. Continuous level sensors are recommended for the remaining locations. The remaining water surface monitoring locations are between the first and second louver lines in the secondary louver structure, downstream of the second louver line in the secondary louver structure, in each of the four holding tanks, and upstream of the trashrack structure. Technical information on the instrumentation identified for this application is included in appendix A. Information regarding other instruments can be obtained by contacting the manufacturer as given in section 9, Manufacturers' Listing. The existing floatwell instrumentation may be replaced by other water surface elevation instrumentation identified in this report. A description of the operation and options for this instrumentation is as follows:

### 6.1.1 Instrumentation options. -

1. Continuous Capacitance - Levels are monitored by sensing capacitance which changes with the amount of probe coverage.

Advantages:

- All electronics construction, no moving parts, requires minimal maintenance

- Monitors W.S.El. continuously
- Corrosion resistant
- Continuous 4-20 mA output options

Disadvantages:

- Shifting dielectric can cause signal shift
- Requires costly stilling well
- Conductive buildup on probe can affect accuracy and repeatability in some cases.

2. Mechanical Float - Levels are monitored by mechanical movement of a float to give indication.

Advantages:

- Good repeatability can be achieved
- Basic in design
- High accuracy

Disadvantages:

- Mechanical components are subject to wear
- May require more frequent servicing
- Requires costly stilling well

3. Pressure Transducer/Depth Transmitter - Levels are monitored based on hydrostatic pressure which is measured by a submersible pressure transducer.

Advantages:

- High accuracy
- Low cost

Disadvantages:

- Susceptible to corrosion
- Underwater installation is required leading to increased costs
- Signal drift may occur requiring re-calibration

4. Ultrasonic. - Levels are monitored by transit time of an ultrasonic signal reflected from liquid surface and related to fixed proximity of ultrasonic transducer.

Advantages:

- Non-contact technique allows for minimal maintenance
- Monitors levels continuously
- Unaffected by changing specific gravity, conductivity, or viscosity
- Does not require stilling well

Disadvantages:

- High cost

- Affected by changes in air temperature (Note: selected instrumentation has temperature compensation features.)

Sources - Manufacturer's and Monitoring Techniques. -

1. Endress + Hauser, Inc.
  - Continuous Capacitance:
  - Complete system cost = \$1,559.00 each
  - Requires stilling well, transmitter sensor probe, remote digital indicator
  - Telemetry: hardwired
2. Drexelbrook Engineering Co.
  - Continuous capacitance:
  - Complete system cost = \$1,220.00 each
  - Requires sensor probe, two-wire transmitter, electronic unit in NEMA 4 enclosure, telemetry cable, conduit and fittings
  - Telemetry: hardwired
3. Leopold & Stevens, Inc.
  - Pressure transducer:
    - Complete system cost = \$585.00
    - Requires depth transmitter, telemetry cable, remote indicator, and mounting hardware
    - Telemetry: hardwired
  - Mechanical float:
    - Complete system cost = \$1,891.00
    - Requires two-wire transmitter PAT aluminum enclosure, 18-inch float line pulley, 25-foot float line, 5-inch float including counterweight, and power supply
    - Telemetry: Hardwired
4. Druck, Inc.
  - Pressure transducer:
    - Complete system cost = \$1,037.00
    - Requires depth transmitter, telemetry cable, remote indicator, and mounting hardware
    - Telemetry: hardwired
5. Magnetrol, Inc.
  - Continuous capacitance:
    - Complete system cost = \$1,977.00

- Requires stilling well, transmitter, sensor probe, and remote indicator
- Telemetry: R.F.

- Ultrasonic:

- Complete system cost = \$1,515.00
- Requires ultrasonic sensor, transmitter, telemetry cable, and remote indicator
- Telemetry: hardwired

## 6. CONTAQ Technologies Corporation

- Ultrasonic:

- Complete system cost = \$1,207.00
- Requires ultrasonic sensor, transmitter, telemetry cable, and remote indicator
- Telemetry: hardwired.

6.1.2 Recommendations. - The CONTAQ Technologies Corporation LMU-1000-IS-STR ultrasonic, non-contact level sensor is the best selection for this application. This instrument can be mounted above the water surface, eliminating the need for underwater installation. Also, this non-contact technique minimizes susceptibility to corrosion. This unit is available for \$1,207.00.

6.2 Velocity instrumentation. - Velocity instrumentation will be required upstream of the trashrack, across (velocity distribution) the trashrack face, upstream of the primary louver structure, across (velocity distributions) the primary louver line face, at each of the four bypass intakes of the primary louver structure, upstream of the first louver line and between the first and second louver lines within the secondary louver structure, across (i.e., velocity distributions) the faces of each of the two louver lines within the secondary louver structure, and in each of the four holding tanks. Much of this information can be obtained by means of a directional velocity probe. This unit is portable, and thus best suited for the evaluation phase, but not for automation or control. The use of portable meters would require manual readings at selected depths and locations making data acquisition time consuming. However, these instruments would provide velocity distribution information which is required to relate operational characteristics with facilities efficiency. An option that might be pursued to expedite velocity measurements is to use multiple current velocity meters mounted at successive depths on the same probe or rod, or to procure a number of these assemblies. This would allow for complete velocity profiles to be obtained simultaneously along a louver line. This would improve evaluation accuracy in that velocities are constantly changing

due to tidal and pumping plant operation influences. Use of multiple meters would also expedite data collection and reduce labor requirements. The drawback is that these instruments are expensive thus, substantial cost may be incurred to achieve multiple meter installations.

The existing propeller type velocity meters may be utilized for continuous monitoring of the primary and secondary forebay velocities, contingent upon the results of a complete checkout to determine if the instruments are operating properly. Should these velocity meters be operating properly, additional components will be required to convert, condition, and transmit signals to a remote indicator location or DAS. If these meters are to be replaced, instrumentation may be selected based on this report. Note that continuous monitoring of the approach velocities is required to set bypass velocities and discharges. The technical information for the recommended continuous velocity monitoring instrumentation is described in appendix B. In the four holding tanks, a basic understanding of the velocity distributions may be obtained with this instrumentation. A description of the available velocity instrumentation is as follows:

#### 6.2.1 Instrumentation options. -

1. Fixed propeller velocity meter - Monitors directional fluid velocity based on the rotation rate of the fluid driven propeller assembly.

##### Advantages:

- High accuracy
- Low cost

##### Disadvantages:

- Susceptibility to fouling
- May require frequent servicing for permanent installations
- Gives velocity information at one location only

2. Portable propeller velocity meter - Monitors velocities based on the same concept as fixed propeller velocity meters.

##### Advantages:

- High accuracy
- Moderate cost
- Allows velocity evaluation at various locations

##### Disadvantages:

- Not applicable for future automation or control
- Maintenance requirements may be involved

3. Electromagnetic velocity meter - Monitors directional fluid velocity based on the Faraday Law, which states that a voltage will be induced in a conductor moving through a magnetic field. The magnitude of this voltage is directly proportional to the flowrate of the conductor.

Advantages:

- High accuracy at low velocities
- No moving parts
- Requires minimal maintenance

Disadvantages:

- High cost

Sources - Manufacturers and Monitoring Techniques:

1. Swoffer Instruments, Inc.
  - Portable Velocity Meter-Propeller:
  - Complete system cost = \$1,865.00
  - Requires rotor assy., digital readout indicator, 9-volt battery, probe extension, and accessories
2. ERDCO Engineering Corporation
  - Portable Velocity Meter-Propeller:
  - Complete system cost. = \$995.00
  - Requires sensor, probe extension, analog indicator, telemetry cable, and accessories
3. Marsh-McBirney, Inc.
  - Portable Velocity Meter-Electromagnetic:
  - Complete system cost = \$2,995.00
  - Requires sensor, telemetry cable, probe extension, digital indicator and accessories

6.2.2 Recommendations. - Based on cost considerations and salient features, such as digital display capability in engineering units, the model 2100 current velocity meter may be selected for all portable velocity measurement applications at the TFCF, as manufactured by Swoffer Instruments, Inc., 1048 Industry Dr., Seattle, Washington, 98188, 206-575-0160, or equal. This instrument is lower in price than the electromagnetic velocity meter manufactured by Marsh-McBirney and provides more versatility than the ERDCO, Inc., propeller velocity meter. Use of this portable instrumentation will provide much of the velocity information required at the TFCF.

It should be determined whether the existing velocity instrumentation should be used for continuous measurement of approach velocities in the primary forebay and the secondary louver structure. This would be the least cost option with the

only requirement being to equip the fixed propeller meters with signal transmitters. However, the best approach may be to add open-channel flowrate instrumentation (as discussed below). It is important to note that flowrate information will allow for future correlation between forebay velocities and louver line velocities. Thus, given approach flow conditions (i.e., flowrate and flow depth) at any time, trashrack and louver line velocity profiles may be estimated without direct measurement, but instead based on previously acquired data.

6.3 Flowrate Instrumentation. - Continuous flowrate monitoring should be considered for the primary louver forebay, the secondary louver structure, each of the four 36-in bypass lines, the screened water conduit, and the holding tank pump discharge line. The monitoring techniques described here include ultrasonic closed-conduit, ultrasonic open-channel, electromagnetic closed-conduit and electromagnetic open-channel flowrate instrumentation. As indicated in the evaluation of existing instrumentation, closed-conduit ultrasonic flowmeters are currently installed on each of the four 36-in bypass lines. Thus, no additional instrumentation would be required at these locations (assuming they pass a complete checkout to determine proper operation and accuracy). For the continuous operational monitoring of open-channel approach flows to each of the louver lines, there are several available flow monitoring techniques which utilize Manning's equation. However, this requires user defined channel slope or E.G.L. slope, and no velocity information is determined by these systems. For application at the TFCF, there is no channel bottom slope and the slope of the E.G.L. would be difficult to determine without velocity information. Thus, options considered were limited to monitoring techniques which accurately determine velocities and water surface elevations for the calculation of flow rates. This instrumentation, as described in appendix C, should be located in the primary louver forebay and the secondary louver structure.

Note: As described earlier, two venturi meters, 16 in and 24 in, currently exist to measure flowrates through the holding tank pump discharge line and the secondary louver screened water conduit. Thus, no additional instrumentation is required for these two locations. A description of the operation of this instrumentation is as follows:

#### 6.3.1 Instrumentation options. -

1. Open-channel ultrasonic flow monitoring - This technique is used to monitor open-channel flowrates and requires no primary flow measurement structure (i.e., flume or a weir). Velocities are measured based on the transit time of an ultrasonic pulse in the fluid. This information in

conjunction with channel geometry and flow depth is then used to calculate volumetric flowrates.

Advantages:

- Reasonably good accuracy
- Requires no primary flow structure
- Corrosion resistant
- No moving parts

Disadvantages:

- High cost
- Difficulty measuring large fluctuations in flow depth
- Requires underwater installation

2. Closed-conduit ultrasonic flowmeters - Monitors flow rates based on the same principles as open-channel monitoring techniques.

Advantages:

- Good accuracy
- Requires no modification to existing pipe
- No obstruction of flow
- No moving parts

Disadvantages:

- High cost

3. Open-channel electromagnetic flowmeter - Operation is based on Faraday's Law which states that a voltage is induced in a conductor moving through a magnetic field. The magnitude of which is directly proportional to the flowrate through the magnetic field.

Advantages:

- Low cost
- No moving parts
- Requires no primary flow structure

Disadvantages:

- Low accuracy
- Flow intrusive which may be susceptible to fouling.

4. Closed-conduit electromagnetic flowmeters - Operation is based on Faraday's Law which states that a voltage will be induced in a conductor moving through a magnetic field. The magnitude of the voltage is directly proportional to the flowrate through the magnetic field.

Advantages:

- No moving parts
- No obstruction of flow

- No pressure drop results
- Not affected by changes in temperature, pressure, density, viscosity or conductivity

Disadvantages:

- High cost
- Requires in-line installation (i.e., modification to existing pipe)

Sources - Manufacturers and Monitoring Techniques. -

1. Accusonic Division, ORE International, Inc.
  - Open-channel ultrasonic flowmeter
  - Complete system cost = \$13,500 each
  - Requires model no. 7612 transducer assy., and accessories
  - Telemetry: hardwired
2. Nusonics, Inc.
  - Closed-conduit ultrasonic flowmeter
  - Complete system cost = \$4,950.00
  - Requires ultrasonic transducers (2 per path), mounting slide rack, transmitter, and accessories
  - Telemetry: hardwired
3. Badger Meter, Inc.
  - Closed-conduit ultrasonic flowmeter
  - Complete system cost = \$4,050.00
  - Requires acoustic transducers, telemetry cable, remote microprocessor based electronic transmitter and accessories
  - Telemetry: hardwired
4. Controlotron, Inc.
  - Closed-conduit ultrasonic flowmeter
  - Complete system cost = \$1,985.00
  - Requires NEMA 4 transducers, mounting slide rack, converter, and accessories
  - Telemetry: hardwired
5. EMCO
  - Closed-conduit electromagnetic flowmeter
  - Complete system cost = \$8,112.00
  - Requires integrally mounted transmitter, flange insertion pipe, telemetry cable and accessories
  - Telemetry: hardwired
6. Monitek, Inc.
  - Open-channel magmeter
  - Complete system cost = \$3,500.00

- Requires Model 63b Flo-Probe, telemetry cable and accessories
- Telemetry: hardwired

6.3.2 Recommendations. - As previously mentioned, the open-channel flow monitoring application requires instrumentation which acquires velocity information as well as flow depth information to make an accurate assessment of volumetric flowrates. Thus, the best choice for this application is the Accusonics open-channel flowmeter model No. 7612 transducer assembly. This system would replace the existing propeller velocity meter and floatwell instrumentation in the primary louver forebay. This flowmeter provides the ability to flush-mount transducers in the channel, resulting in little or no flow obstruction and debris fouling. This system has no moving parts which will minimize maintenance requirements. Water surface elevations are monitored by this system, eliminating the need for a depth transmitter at this location. In addition, mean velocities are determined eliminating the need for the existing propeller meter. This system is available at a cost of \$13,500.00. Although the cost is high, it provides the most versatility and accuracy for this application. For future automation, it is recommended that an additional open-channel flowmeter of this type be selected for the secondary louver structure. Monitek, Inc., manufactures electromagnetic open-channel flowrate instrumentation that is less costly than the ultrasonic; however, this system measures velocity at one location, is flow intrusive, and requires separate measurement of water surface elevation, and would have lower measurement accuracy.

For the closed-conduit applications, ultrasonic clamp-on transducer assemblies as manufactured by Controlotron, Inc., or equal, should be selected. This is recommended over the electromagnetic monitoring technique because of installation requirements. The electromagnetic instrumentation would require modification to existing pipe, where as the clamp-on ultrasonic instrumentation would not (i.e., instrumentation can be externally mounted).

6.4 Water Quality Instrumentation. - Water quality parameters of interest for the efficiency evaluation consist of temperature, conductivity, DO, and pH. There are several options for monitoring each of these parameters. One option is to locate a different instrument for each of these parameters in the required locations, or to select an instrument that is capable of monitoring all of these parameters. The available instrumentation for these options are as follows:

6.4.1 Temperature Instrumentation. - Water temperatures would be monitored in the primary louver forebay and the fish

holding tanks. This instrumentation consists of a single sensor. This instrumentation would give temperature readings which may provide valuable information regarding temperature fluctuations throughout tidal or seasonal cycles. Three basic temperature monitoring techniques are available. The first is the thermocouple sensor which measures temperature based on a thermoelectric voltage which is induced when the junction of two dissimilar materials changes in temperature. The second is the thermistor sensor which is a temperature sensitive resistor. Thermistors provide accuracy to 1.0 degree fahrenheit, and thermocouples typically provide accuracy between 1 to 10 degrees fahrenheit, depending on the operating temperature. The third is the resistance temperature detector (RTD) which employs the use of a wheatstone bridge circuit to measure resistance changes with temperature. These sensors would need to be equipped with standard 4-20 mA transmitters to telemeter signals to either a remote indicator or data acquisition system (DAS). A description of the operation of these instruments are as follows:

#### 6.4.1.1 Instrumentation options. -

1. Thermocouple - Measures temperature based on the thermoelectric voltage induced when the junction of two dissimilar materials changes in temperature.

##### Advantages:

- Low cost
- Versatile and remote mounting
- Responsive

##### Disadvantages:

- Low output signal subject to noise
- Calibration is nonlinear over span
- Moderate accuracy

2. Thermistor - Measures resistance which varies with temperature (i.e., temperature sensitive resistor)

##### Advantages:

- High sensitivity
- Moderate cost
- Good accuracy over small range

##### Disadvantages:

- Nonlinear resistance change with temperature

3. RTD - This device is a resistance temperature detector which measures resistance changes with temperature.

Advantages:

- High accuracy

Disadvantages:

- High cost
- Limited sensitivity
- Current source required

Sources - Manufacturers and Monitoring Techniques

1. Omega Engineering, Inc.
  - Thermocouple:
  - Complete system cost = \$412.00
  - Requires NB1TX-T2 thermocouple probe, 304SS sheath, TX91 transmitter, NBN-0 nylon head, unregulated power supply, process loop powered indicator (optional @ \$165.00), and telemetry wire.
  - Telemetry: hardwired
2. Cole-Parmer Instrument Company
  - Thermocouple:
  - Complete system cost = \$365.00
  - Requires L-93826 thermocouple, 304SS probe sheath, mounting bushing, 4-20 mA transmitter, power supply, head, and telemetry wire
  - Telemetry: hardwired
3. Davis Instruments Company
  - Thermocouple
  - Complete system cost = \$413.00
  - Requires EM22 Type K underwater thermocouple probe, model 10-2, 2-wire, 4-20 mA, thermocouple transmitter, telemetry wire, and accessories.
  - Telemetry: hardwired
4. McHaney Engineering, Inc.
  - RTD:
  - Complete system cost = \$858.00
  - Requires RTD assembly, two wire RTD converter, 24
  - Telemetry: hardwired

6.4.2 Conductivity Instrumentation. - Water conductivity, a measure of salinity, would be monitored for the flow passing through the TFCF. Instruments located in the primary louver forebay and the fish holding tanks are required. Many types of conductivity monitoring techniques are available; however, this report has identified two types as follows: The first is a

standard electrode type which is submersible. The second is a non-contact type which is electrode-less and submersible. Both these sensors accompanied with the appropriate transmitter deliver a standard 4-20 mA output. A description of each of these instruments including operation is as follows:

#### 6.4.2.1 Instrumentation options. -

1. Standard submersible - Measures conductivity by setting up a known cell constant via two electrodes submerged in the fluid. Conductance is measured between the electrodes, which may then be related to water quality.

##### Advantages:

- Temperature compensation capability
- Submersible
- Low cost

##### Disadvantages:

- Contacting technique is susceptible to corrosion

2. Electrode-less - Measures conductance by inducing an alternating current in fluid and measuring its magnitude which changes with conductivity.

##### Advantages:

- Electrode-less, non-contacting
- Submersible
- Temperature compensation capability

##### Disadvantages:

- Higher cost

#### Sources - Manufacturers and Monitoring Techniques

1. Omega Engineering, Inc.

- Standard submersible:
  - Complete system cost = \$ 565.00.
  - Requires CTDX-101 transmitter, CDCN-106 sensor, telemetry cable, mounting hardware, and accessories.
  - Telemetry: Hardwired
- Non-contact:
  - Complete system cost = \$ 825.00.
  - Requires CTDX-102 transmitter, CDCN-108 sensor, telemetry cable, mounting hardware, and accessories.
  - Telemetry: Hardwired.

6.4.3 Dissolved Oxygen (DO) Monitoring. - Dissolved oxygen levels would be monitored in the primary louver forebay and within the fish holding tanks. In some cases it is necessary to hold fish in a fish holding tank for an extended period of time without exchange of water due to tidal and pumping conditions. It is possible that the DO levels may become unacceptable for fish during these periods. Thus, close monitoring of dissolved oxygen levels is required. Since, one or possibly two of the four holding tanks is to be operated at one time, portable DO monitoring equipment is more suitable than permanent instrumentation for this application. This unit shall be submersible and capable of being incorporated into a data acquisition system (DAS). A description of this instrument is as follows:

6.4.3.1 Instrumentation options. -

1. Portable and submersible - Measures temperature, conductivity, and DO levels housed in one unit.

Advantages:

- Good accuracy
- No moving parts
- Monitors temperature, conductivity, and DO in one unit
- DAS capabilities in a portable unit

Disadvantages:

- High cost
- Contacting type sensor

Sources - Manufacturers and Monitoring Techniques:

1. HYDROLAB, Inc.
  - Model 2040-DS submersible T, C, DO, pH data logger
  - Complete system cost = \$3,450.00 each
  - Requires submersible data logger, Data Management Unit DMU, and PC interface kit
  - Telemetry: Hardwired
2. Monitek Tech. Corp.
  - Model 8500 portable DO meter
  - Complete system cost = \$1,875 each
  - Requires a digital meter and submersible probe
  - Telemetry: Hardwired

6.4.4 Recommendations. - Realizing that temperature, conductivity, DO, and pH are all water quality parameters important in this application, the water quality monitor as manufactured by HYDROLAB, Inc. is best suited for this

application. Technical information is included in appendix D. Information for other types of instrumentation can be obtained by contacting the appropriate manufacturer. This instrument monitors all of the above parameters simultaneously. Thus, less instrumentation and consequently a smaller degree of effort is required for installation. This instrument should be located in the primary louver forebay and in the fish holding tanks. This instrument also has capabilities for DAS interfacing as required for future automation.

6.5 Data Acquisition System (DAS). - A complete DAS may be utilized to manipulate and store all data acquired during facilities operation for the efficiency evaluation. This approach is more logical than manual data acquisition from remote indicators for reasons of expediency. A complete DAS offers the use of data reduction packages that can be configured to virtually any specifications. Two types of PC DAS systems are available. The first, an interface board based DAS typically features 16 single-ended or 8 differential analog input channels (expandable in most cases). These systems offer continuous data collection at a choice of 12, 14, or 16 bit A/D resolution. In addition to the interface board, other required components are DAS driver software, analog expansion board, A/D multiplexor conversion, and connectors/cables. The second basic DAS available is the box based system which is similar in function to the board based system, but different in configuration. The box based system hardware is external to the PC allowing sensitive circuitry to be isolated. This system typically includes expandable channel data acquisition box, menu driven software, A/D converter, printer drive, and multi-tasking capabilities. This type of DAS is suited for the application at the TFCF because it offers the most versatility for incorporation into a future automation or control scheme. Technical information for these systems is included in appendix E. The basic description of operation of these systems are as follows:

#### 6.5.1 Instrumentation options. -

1. Interface board based system - 4-20 mA instrumentation signals are individually brought to the workstation. Each signal is converted to a voltage via a properly sized resistor. This data then passes through a multiplexor to an A-D converter and is stored to a data memory. The driver software is used to save, display and/or print data as desired.

##### Advantages:

- User programmable software
- No external mounting required
- Unlimited configuration capability

Disadvantages:

- High cost incurred for software packages
- Requires third-party software
- PC interchangeability difficult

2. Box based system - 4-20 mA signals are individually transmitted to the external DAS module or box. Signal conditioning and A/D conversion are achieved within this module. The digital signals are then brought to the PC via standard communication cable. Data is stored, displayed and or printed by means of menu driven software.

Advantages:

- Low cost
- PC interchangeability simple

Disadvantages:

- Requires mounting of external module
- Configuration capability somewhat limited

Sources - Manufacturers and Monitoring Techniques:

Board based systems:

1. Keithley Metrabyte
  - Complete system cost = \$5,749.00
  - Requires DAS-40 analog and digital interface board, PC and accessories and DAS software
2. DATEL, Inc.
  - Complete system cost = \$5,900.00
  - Requires PC-411 16-channel analog I/O board, PC and accessories, and DAS software

Box based system:

1. DIANACHART
  - Complete system cost = \$6,645.00
  - Requires SYSTEM-1 48-channel process ACQ with menu-driven software, signal conditioner, and printer driver
2. Keithley Metrabyte
  - Complete system cost = \$6,800.00
  - Requires 575 measurement and control system, interface board, PC and accessories and DAS software

6.5.2 Recommendations. - The box based SYSTEM-1 as manufactured by DIANACHART is recommended for the TFCF application. A box based system requires less effort for

modifications. Hardware is mounted externally allowing for isolation from sensitive PC circuitry. This system is available for \$6,645.00. The Keithley Metrabyte series 575 system is comparable to the DIANACHART system and may also be selected for this application. This system is available for approximately \$6,800.00; however, it does not include a PC or accessories.

## 7. Final Recommendations - Conceptual Design

Although an unlimited number of options exist for the configuration of the hydraulics monitoring system, this report has been developed to identify the most feasible and cost effective options that are available. These final recommendations have been broken down into three conceptual designs and a summary of instrumentation and hardware costs has been presented for each. The first, or basic package consists of the least cost option and is intended to meet the minimum requirements for the efficiency evaluation. The second, or intermediate package consists of the basic package with additional instrumentation that will give improved hydraulic information and in some cases expedite data collection. The third and final package includes all instrumentation that is required to give a complete understanding of the hydraulics at the TFCF. In addition to this instrumentation, a complete DAS is included to eliminate time consuming data logging, allow continuous data logging and provide data reduction and analysis tools with capabilities for future automation of the facilities. Note: In light of these three instrumentation packages, the greatest consideration should be given to the full package which will suit the needs of the efficiency evaluation as well as any future automation which may be incorporated into the facilities. However, the basic and intermediate packages have been developed to provide adequate alternatives.

7.1 The basic package or least cost option is comprised of instrumentation which meets the minimum requirements of the efficiency evaluation. All existing instrumentation is to be utilized as installed. Additional instrumentation will be required for monitoring water surface elevations at the following locations:

- Upstream of the trashrack
- In the primary louver forebay
- Downstream of the primary louver line
- Upstream of the first louver line in the secondary louver structure
- Downstream of the second louver line in the secondary louver structure
- In one of four holding tanks being operated

As indicated in the water surface elevation instrumentation recommendations, use of the LMU-1000-IS-STR non-contact ultrasonic level sensor as manufactured by CONTAQ Technologies Corporation, 15 Main Street, Bristol, Vermont, 05443, 802-453-3332, or equal is recommended. This unit is available for \$1,207.00 and a total of three units are required under this concept (assuming existing floatwells are operational).

Velocity instrumentation, including the two existing propeller meters are required to monitor velocities at the following locations:

- Upstream face of the trashrack structure
- In primary louver forebay
- Along primary louver line
- In each of the four 36-in bypass intakes
- Along each of the two secondary louver lines
- In the secondary bypass intake
- In each of the four holding tanks
- In the secondary louver forebay

As indicated in the velocity instrumentation recommendations, much of this monitoring can be achieved using the portable model 2100 current velocity meter as manufactured by Swoffer Instruments, Inc., 1048 Industry Drive, Seattle, Washington, 98188, 206-575-0160, or equal. This instrument is available for \$1,560.00. One unit is included under the requirements of this basic concept. Velocity profiles are obtained by measurement of point velocities at various depths and locations. In addition to the portable velocity meters, the two existing propeller meters must be equipped with indicators and transmitters for remote readout.

No additional flowrate instrumentation is required under this conceptual design. Flowrates can be calculated based on flow velocities and flow depths being monitored at various locations throughout the facilities. Flowrates are currently being monitored at each of the four 36-in fish bypass pipes by means of four Badger Meter ultrasonic clamp-on flowmeters. Output from these instruments can be used to compute bypass velocities. Monitored flowrates will be related to previously evaluated velocity profiles to obtain a complete overview of hydraulic conditions at the facilities.

Water quality information will be provided using the HYDROLAB water quality monitor. This instrument monitors temperature, conductivity, DO, and pH, and should be located in the primary louver forebay and the fish holding tanks. This unit is available for \$3,450.00 and has DAS capabilities.

All instrumentation under this concept will deliver a standard 4-20 mA output signal to a remote indicator. Consequently, telemetry wire and indicators would be required in addition to the instrumentation identified above. The model 558A 2-wire, loop-powered process indicator as manufactured by Newport Electronics, Inc., 2229 S. Yale Street, Santa Ana, California, 92704-4426, 714-540-4914, or equal may be selected for this application. This unit is available for \$149.00 and a total of eight units is required. The costs identified above are itemized as follows:

- CONTAQ Technologies, Inc., ultrasonic level, transmitter, telemetry wire, and accessories - required number, 3 units, cost \$1,207 each
- Swoffer Instruments, Inc., 2100 current velocity, meter, TSR-KIT, required number, 1 unit, cost \$1,865 each
- HYDROLAB, Inc. water quality monitor, T/C/DO/pH, required number, 2 units, cost \$3,450 each

Thus, a total cost on the order of \$12,386.00 can be expected for procurement of all instrumentation and hardware required for this basic concept. Additional cost will be incurred for design of installation hardware installation and calibration of this instrumentation, as well as for any fabrication of installation hardware that may be necessary. The requirements for this can be estimated as approximately two staff-days per instrument. This would require a total of 20 staff-days for design, fabrication, installation, and calibration of the proposed instrumentation for this basic package.

The advantages of this package are primarily related to cost. Although this represents the least cost option for instrumentation at the TFCF, it will yield limited hydraulic information. This system will require extensive data reduction and analysis time due to the absence of a data acquisition system. Calculation of flowrates will require velocity and W.S.El. information and will have to be done manually. Measurement of velocity profiles will be time consuming with the use of a single current velocity meter. Thus, with considerations for data collection and analysis, the cost of this option will rise.

7.2 The intermediate package consists of the basic package with some additional instrumentation required to obtain more hydraulic information and, in some cases, expedite data acquisition. Water surface elevations will be monitored under this intermediate concept at the following locations:

- Upstream of the trashrack structure
- In the primary louver forebay
- Downstream of the primary louver line
- Upstream of the first louver line in the secondary louver structure
- Between the first and second louver lines in the secondary louver structure
- Downstream of the second louver line in the secondary louver structure
- In each of the four holding tanks

As indicated in the water surface elevation instrumentation recommendations, these parameters may be monitored using the ultrasonic level sensor, as manufactured by CONTAQ Technologies Corporation, or equal. Existing water surface elevation instrumentation (floatwells) may be utilized under this concept or replaced entirely.

Velocity instrumentation is required to determine velocity profiles in the following locations:

- Along the upstream face of the trashrack structure
- Along the primary louver line
- In each of the four bypass intakes
- Along each of the two secondary louver lines
- In each of the four holding tanks
- Approach velocity to the primary louver line in the primary louver forebay
- Approach velocity to the secondary louver lines in the secondary louver structure

Use of three portable current velocity meters may be used to expedite profile data collection (this would allow for vertical velocity profiles to be obtained simultaneously at each horizontal location). Continuous monitoring of approach velocities to the primary and secondary louver lines is required under this package. This may be accomplished using the model 66 open-channel electromagnetic flowmeter as manufactured by Monitek, Inc., 1495 Zephyr Avenue, Hayward, California, 94544, 415-471-8300, or equal. This instrument would be mounted permanently in both the primary louver forebay and secondary louver structure and would replace the existing propeller velocity meters. This concept will allow for the elimination of additional open-channel flowmeters since flowrates can be calculated from velocities and flow depths.

Additional flowrate instrumentation is not required under this concept. Flowrates as currently being monitored in each of the four 36-in fish bypass pipes and in the holding tank discharge line are suitable for this package.

Water quality instrumentation will also be required under this package and will be identical to that specified for the basic package.

All instrumentation under this design shall deliver a standard 4-20 mA signal to the appropriate remote indicator. Consequently, telemetry wire and remote indicators would be required under this concept. The two-wire, loop process indicators as selected in the basic package is suitable for this intermediate package. Nine units are required for the instruments identified above. The instrumentation costs for this intermediated package are itemized as follows:

- CONTAQ Technologies, Inc., ultrasonic level sensor, transmitter, telemetry wire, and accessories, required number, 9 units, cost \$1,207 each
- Swoffer Inst., In.c, 2100 Current Velocity Meter TSW-KIT, required number, 3 units, cost \$1,865 each
- Monitek, Inc., model 66 open-channel magmeter, Model 88L flow probe, and accessories, required number, 2 units, cost \$3,150 each
- HYDROLAB Inc., water quality monitor, T/C/DO/pH, required number, 2 units, cost \$3,450 each

Thus, a total cost on the order of \$29,658.00 can be expected for procurement of this instrumentation. Additional cost will be incurred for the installation and calibration as well as for any fabrication of additional installation hardware that might be required. Three staff-days per instrument is the estimated requirement for design, fabrication, installation, and calibration. Thus, approximately 45 staff-days may be required for this entire package.

A DAS system could be added to this package which would allow for data acquisition and reduction with a minimum of effort. However, this would increase package cost by approximately \$7000.00.

Although the intermediate package will yield much improved hydraulic information, there still exists the problem of data logging requirements, which will not be alleviated under this intermediate package. A complete data acquisition system is certainly the solution to this problem, and has been included in the full package option.

7.3 Finally, the full package includes the best available instrumentation and likely is the best system for extended use.

This is a step up from the intermediate packages and includes a complete DAS.

The water surface elevation instrumentation monitoring concept is the same as specified for the intermediate package. Thus, identical costs will be incurred as indicated in the intermediate package.

The portable velocity instrumentation is of the same type as that specified in the intermediate package. However, four separate 3-meter assemblies as identified in the preceding package are required. This will allow for the acquisition of both vertical and horizontal velocity profiles simultaneously, and accurate documentation of velocity profiles as a function of tidal and pumping influences, further expediting this time consuming data acquisition process.

The major component of upgrade from the intermediate package exists with the open-channel flowrate instrumentation. The Monitek Model 66 open-channel velocity meter, specified in the intermediate package, is used in conjunction with water surface elevation instrumentation to estimate approach flowrates in the primary louver forebay and the secondary louver structure. In contrast, the Accusonic open-channel flowmeter applies ultrasonic technology to determine flow velocities at four different depths for a single cross section. The result is a more accurate assessment of average flow velocity and flowrate. In addition this meter is non-intrusive and thus is less susceptible to debris fouling. However, this meter is more expensive as indicated in the open-channel flow rate instrumentation recommendations. For the closed-conduit applications, the four existing Badger Meter ultrasonic flowmeters may be used as installed or should be replaced contingent upon the results of a complete checkout.

In addition to the above instrumentation, a temperature sensor such as the RTD assembly as manufactured by McHaney Engineering Company, or equal, would be included in this full package, and is available for \$858.00. Also included is a conductivity sensor as manufactured by Omega Engineering Corp., or equal. Finally, the DO monitor model 2040-DS as manufactured by Hydrolab Corp., P.O. Box 50116, Austin, Texas 78763, is required to evaluate oxygen levels within the holding tanks during operation, as previously discussed.

Note: This instrument has the capability of monitoring other water quality parameters such as temperature, conductivity, DO, and pH. Thus, it seems more appropriate to substitute this instrument for the temperature and conductivity instrumentation previously discussed. This would reduce the amount of

instrumentation and effort required to address water quality monitoring requirements.

All monitored data would be input into a data acquisition system (DAS). This would require a PC or laptop, the appropriate interface card, and other associated equipment (printer, modem, etc.). This DAS equipment could be acquired at a cost of approximately \$6,500.00 as manufactured by DIANACHART, 101 Roundhill Dr., Rockaway, New Jersey, 07866, 201-725-2299. Technical information is included in appendix G. The costs outlined above are itemized as follows:

- CONTAQ Technologies, Inc., Ultrasonic level sensor, transmitter, telemetry cable and accessories, required number, 8 units, cost \$1,207 each
- Swoffer, 2100 current velocity meter, rotor assembly, digital readout indicator, 4 ft.-19.5 ft. extension, telemetry cable, required number 12 units, cost \$1,865 each
- Controlotron, ultrasonic transducer, mounting hardware, telemetry cable, required number 4 units, cost \$1,985 each
- Accusonic, open-channel flowmeter and all accessories, required number 2 units, cost \$13,500 each
- Hydrolab Corp., Model 2040-DS Dissolved oxygen monitor, DMU, and interface kit, required number 2 units, cost \$3,450.00 each
- DIANACHART, Inc. SYSTEM-1 DAS, required number 1 unit, cost \$6,745 each

Thus, a total minimum cost of upgrade of instrumentation for the TFCF that can be expected is \$82,000.00 based on the above information. Installation of the instrumentation identified in this report will increase this cost. Forty staff-days can be expected to complete engineering requirements for design of installation hardware, a complete system layout, some DAS programming and all calibration of instrumentation. An additional 80 staff-days can be expected for fabrication of installation hardware and installation of all instrumentation. A detailed cost estimate prepared by Perry Johnson and Joe Kubitschek, D-3751 has been included in appendix F. This is a copy of the memorandum correspondence conveyed to Gary Sackett, MP-400 on January 27, 1993.

Although the full package has a high initial capital cost, it will certainly minimize future costs and efforts required for data acquisition, reduction, and analysis, as well as the effort required to fully automate the facilities in the future. Thus in

the long run it is felt that this full package will prove to be the most cost effective option for instrumentation at the TFCF, and thus is recommended above all other options.

A manufacturer's listing has been included, identifying several sources for the instrumentation discussed in this report.

#### 8. System Design, Purchase and Installation

To expedite system installation and to minimize design and installation cost, the Hydraulics Branch instrumentation staff can prepare "in house" grade drawings. These drawings could then be reviewed by the Steel Pipe and Special Equipment Section of the Mechanical Branch, Denver Office; by the Region Engineers Office in the Mid-Pacific Region; by the Office of the Regional Supervisor of Water and Power Resources Management in the Mid-Pacific Region; and by the staff at the Tracy Office. With completion of a reviewed design, the Hydraulics Branch instrumentation staff can prepare requisitions which could be processed through the Tracy Office, the MP Regional Office, or the Denver Office as deemed appropriate. The instrumentation staff could then work with the Tracy Office and the Denver Laboratory Shops to fabricate any special instrumentation mountings and to install the instrumentation. It is anticipated that staff from Denver would travel to the facility and work with the project in this effort. Involvement of project personnel has been discussed with the Tracy Office. Indications are that project personnel would be available if the work does not conflict with the annual equipment maintenance schedule (appendix G). The above process would maximize staffing continuity and hopefully minimize backtracking and familiarization.

Other options would include a similar process but with MP-200 or D-3423 conducting the design. Instrumentation purchase and installation could be contracted. This would require preparation of specification grade drawings and likely would be more expensive and require more time.

Also, the Hydraulics Branch instrumentation staff also is experienced in developing automation systems. Their potential involvement with future fish facility automation should be considered.

Note: Procurement of this instrumentation will be specified as competitive. Therefore, all requisition items should be submitted for approval prior to award, to ensure that all specifications are met.

## 9. Manufacturers Listing

1. Accusonic Div., ORE International, Inc., PO Box 709, Falmouth Heights Rd., Falmouth, MA 02541, 508-548-5800
2. Badger Meter, Inc., Box 581390, 6116 E. 15th St., Tulsa, OK 74158-1009, 918-836-8411
3. Nusonic, Inc., 11391 E. Tecumseh St., Tulsa, OK 74116 -1602, 918-438-1010
4. Endress + Hauser, Inc., 2350 Endress Pl., Box 246-1, Greenwood, IN 46143, 800-428-4344
5. ISCO, Inc., PO Box 82531, Lincoln, NE 68501-2531, 800-228-4373
6. Leopold and Stevens, Inc., 600 NW Meadow Dr., Box 688, Beaverton, OR 97075-0688, 503-646-9171
9. Marsh-McBirney, Inc., 4539 Metropolitan Ct., Frederick, MD 21701, 201-874-5599
10. Swoffer Instruments, Inc., 1048 Industry Dr., Seattle, WA 98188, 206-575-0160
11. Drexelbrook Engineering Co., 205 Keith Valley Rd., Horsham, PA 19044, 215-674-1234
12. Controlotron Corp., 155 Plant Ave., Hauppauge, NY 11787, 516-231-3600
13. Druck, Inc., 4 Dunham Dr., New Fairfield, CT 06812, 203-746 -0400
14. Water Specialties Corp., 191 W. Poplar Ave., Porterville, CA 93257, 209-784-3544
15. Newport Electronics Inc., 2229 S. Yale St., Santa Ana, CA 92704-4426, 714-540-4914
16. ERDCO Engineering Corp., 721 Custer Ave., PO Box 6318, Evanston, IL 60202-6218, 708-328-0550
17. Magnetrol Inc., 5300 Belmont Rd., Downers Rd., IL 60515-4499, 708-969-4000
18. EMCO, 600 Diagonal Hwy., Longmont, CO 80501- 6396, 303-651-0551

19. Monitek, Inc., 1495 Zephyr Ave., Hayward, CA 94544, 415-471-8300
20. DIANACHART, 101 Roundhill Rd., Rockaway, NJ 07866, 201-625-2299
21. DATEL, Inc., 11 Cabot Blvd., Mansfield, MA 02048-1194, 508-339-3000
22. Keithley Metrabyte/Asyst/DAC, 440 Myles Standish Blvd., Taunton, MA 02780, 508-880-3000
23. Omega Engineering, Inc., PO Box 2669, Stamford, CT 06907, 800-826-6342
24. Cole Parmer Instrument Co., 7425 N. Oak Park Ave., Niles, IL 60714, 800-323-4340
25. Davis Instrument Co., 4701 Mt. Hope Dr., Baltimore, MD 21215, 800-368-2516
26. CONTAQ Technologies, Inc., 15 Main St., Bristol, VT 05443, 802-453-3332
27. Hydrolab Corp., P.O. Box 50116, Austin, TX 78763, 512-255-8841
28. Hach Co., P.O. Box 389, Loveland CO, 80539

APPENDIX A: WATER SURFACE ELEVATION INSTRUMENTATION

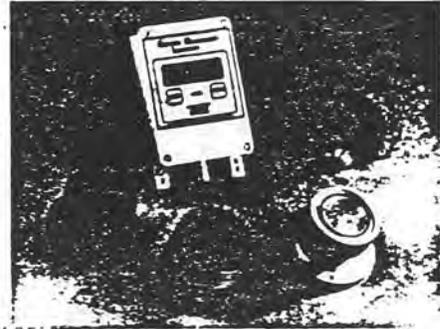
# ULTRASONIC DISTANCE MEASUREMENT PRODUCTS

**CONTAQ**  
SENSE THE FUTURE

## Model DMI

### DMI Distance Measurement Instrument

The CONTAQ Technologies Distance Measurement Instruments are a line of self contained measurement units intended for industrial and commercial applications. The DMI performs distance measurement from 2" to 60 feet and reports data continuously.



### APPLICATIONS

Non-contact distance measurements on targets which can include liquid levels, and transparent materials. With this ultrasonic technology a user can perform level detection, material dimensioning, and position and proximity determination.

### FEATURES

- Manual or Computer Programmable.
- Relay Output.
- Analog Outputs.
- Serial ASCII, 9600 Baud Communications.
- 4 Digit LED Display.
- NEMA 2 Enclosure.
- Remote Transducer Option.

### SPECIFICATIONS

- Size: 2.14" x 3.14" x 4.72"
- Power: 12VDC/600ma.
- Range: 2" to 60 feet
- Accuracy:  $\pm 1\%$
- Resolution: .007"
- Beamwidth: 12°
- Temp.: 0-70°C
- Humidity: 5-95%RH, non-condensing

## DMI

### Distance Measurement Instrument

#### PRODUCT SPECIFICATION

#### 1. Description

DMI is a device that measures distances, allows the setting of limits and, based on the measurement and setpoint values, controls a relay. DMI is available with analog outputs and RS-422/RS-232 communication options. With these options, DMI can be used in discrete, continuous and digital industrial controls transmitting either analog or digital data. DMI may also be controlled via its serial port from a remote computer or terminal. In this configuration data and status may be read, setpoints may be set, and the relay may be controlled remotely.

#### 2. Performance

- 2.1 Resolution: 0.18mm (.007") Internal  
2.54 mm (.10") Displayed
- 2.2 Report Rate: 13 measurements per second
- 2.3 Range: 2" to 60 feet

#### 3. Physical

- 3.1 Weight: 11 oz.
- 3.2 Dimensions: 2.14" X 3.14" X 4.72"
- 3.3 Cable: 24" Length, 12 Conductor

#### 4. Communication

- 4.1 Electrical: RS-422 or RS-232, 9600 baud, 8 bit data, no parity, 2 stop bit.
- 4.2 Protocol: All communications are initiated by the host computer or terminal. Commands are sent to and interpreted by DMI and data is returned.
- 4.3 Commands: DMI commands are ASCII characters:
  - "L" "L123.4" - sets the LOW limit to 123.4 inches
  - "R" "R234.5" - sets the HIGH limit to 234.5 inches
  - "E" "E" - enables DMI control of the relay.
  - "D" "D" - disables DMI control of the relay.

- "O" "O" - opens relay if control has been disabled.
- "C" "C" - closes relay if control has been disabled.
- "S" "S" - DMI transmits status.

(ex. terminal sends "S", DMI returns "123.4,234.5,EN,CL": LOW limit is set at 123.4 inches, HIGH limit is set at 234.5 inches, relay control is enabled, relay is closed).

- "U" "U" - DMI returns the current measurement.

(ex. terminal sends "U", DMI returns "2345" which is a raw data count indicating the current distance measurement . Scale factor is .007324218 for conversion to inches.

## 5. Outputs:

- 5.1 Relay: .25 amp @ 120VAC resistive.
- 5.2 Current Sink: 4 - 20 ma, 256 steps within setpoints.
- 5.3 Voltage: 0 to 3 VDC, 256 steps within setpoints.  
0 to 10 VDC, 256 steps within setpoints.

## 6. Power:

- 6.1 Nominal: 12 VDC @ 500 ma.
- 6.2 Continuous: 500 ma @ 9 VDC.
- 6.3 Pulse: 1.3 amp @ 9 VDC.

## 7. Installation:

The DMI enclosure is provided with mounting features for easy installation. DMI is provided with an electrical pigtail for wiring into existing applications.

## 8. Documentation:

Installation and operating instructions are supplied with each unit.

## 9. Service:

A one year warranty applies to properly installed and operated units. Warranty claims will be handled on a repair or replacement basis at the discretion of Contaq Technologies Corporation.

Custom configurations are available on request. Consult the factory for information and pricing.

DMISP  
8/89

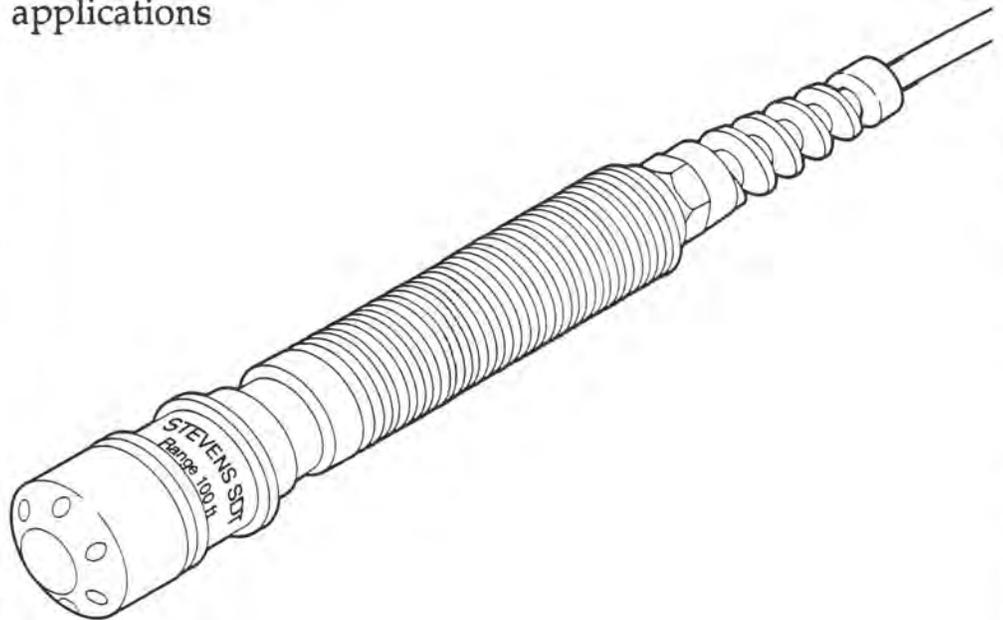


**STEVENS®**  
**Submersible**  
**Depth**  
**Transmitter II**

**Bulletin 75**  
**7th Edition**

## STEVENS Submersible Depth Transmitter II

A superior sensing device for water level measurement applications



---

**Totally submersible**

---

**Industry standard**  
**4-20 mA output**

---

**Stainless steel transducer**  
**in a PVC housing**

---

**Compact, easily mounted**  
**or inserted in**  
**small diameter wells**

---

The Stevens Submersible Depth Transmitter II (SDT-II) is a sensing device designed for water level measurement applications. It is totally sealed for direct insertion into the media to be monitored, and offers multiple applications. Low range units are ideal for open-channel flow applications. Higher range units may be used for ground water, storage tank, or other suitable applications.

A stainless steel pressure transducer is used as the primary sensing element, and measures the water depth by pressure above the unit. Internal electronics within the PVC housing convert the signal to a 4-20 mA output, with 4 mA corresponding to zero depth (atmospheric pressure) and 20 mA to rated depth for the selected range.

The SDT-II is equalized for atmospheric pressure changes, and is insensitive to cable parameters. The unit offers low electrical noise pickup.

On standard flumes or other monitoring wells or chambers, the SDT-II can be bracket mounted, bulkhead mounted, pipe mounted, suspended, or T-mounted; optional down hole and tank mounting kits are available. Custom cable lengths are available. Each SDT-II comes complete with a junction box for making connection to the receiving equipment, and for holding desiccant.

# STEVENS Submersible Depth Transmitter II

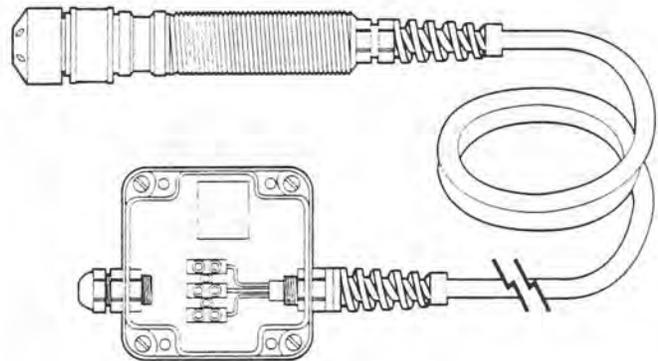
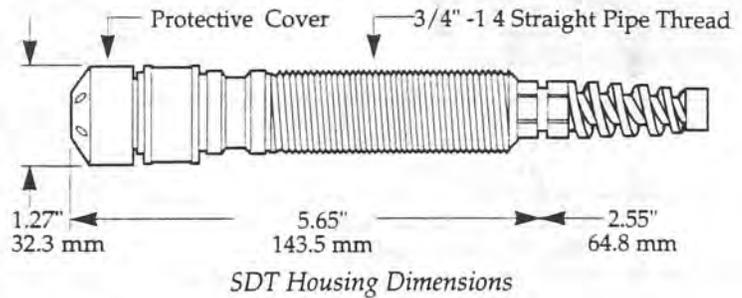
## Submersible Depth Transmitter II Specifications

<b>Power:</b>	12.5-35 VDC
<b>Output:</b>	4-20 mA current signal, linearly corresponding to range
<b>Operating temperature:</b>	+1 to 50° C (33 to 122° F) NOTE: SDT-II should not be subjected to freezing water conditions
<b>Media:</b>	Any media compatible with 316 stainless steel, PVC, nylon, and polyurethane
<b>Accuracy:</b>	Linearity: 1%, typically .25% of full scale Zero: 4.0 ± 0.2 mA at 22° C Span: 20.0 ± 0.5 mA at 22° C Thermal zero drift typical: 0.1% of span per degree Celsius
<b>Options:</b>	Down hole kit, tank mounting kit.

Model	Range (feet of water at sea level)	Max. Depth (feet)
SDT-II 2.5	0 to 2.5	5
SDT-II 5.0	0 to 5	10
SDT-II 10	0 to 10	20
SDT-II 25	0 to 25	50
SDT-II 35	0 to 35	70
SDT-II 50	0 to 50	100
SDT-II 60	0 to 60	120
SDT-II 75	0 to 75	150
SDT-II 100	0 to 100	150

Model	(meters at sea level)	(meters)
SDT-II 2.5	0 to .76	1.52
SDT-II 5.0	0 to 1.52	3.04
SDT-II 10	0 to 3.04	6.09
SDT-II 25	0 to 7.62	15.24
SDT-II 35	0 to 10.6	21.33
SDT-II 50	0 to 15.2	30.48
SDT-II 60	0 to 18.2	36.57
SDT-II 75	0 to 22.8	45.72
SDT-II 100	0 to 30.4	45.72



NOTE: Cable lengths are available up to 2000 ft.



### STEVENS® WATER RESOURCES PRODUCTS

Leupold & Stevens, Inc.

P.O. Box 688, Beaverton, Oregon 97075-0688 U.S.A.

Tel. 503-646-9171, Telex 15-1227, Cable LEUSTEV, FAX 503-526-1471

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Printed in U.S.A.

2M 7-92

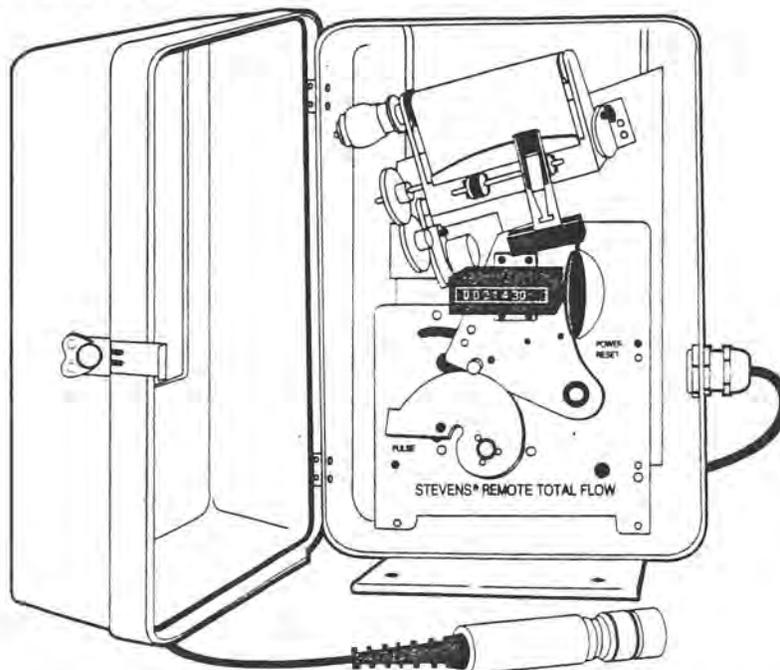


**STEVENS®**

## Model 88 Remote Total Flow Meter

Bulletin 28C  
3rd Edition

# STEVENS Model 88 Remote Total Flow Meter



---

Easy to understand, install,  
and operate

---

Reliable, accurate for remote  
total flow monitoring

---

Easy to convert for any  
weir or flume

---

Float- or pressure-operated  
input devices

---

The STEVENS Model 88 Remote Total Flow Meter (MODEL 88) is designed to allow for the recording instrument to be located remotely from the gaging site, which provides for more convenient monitoring of MODEL 88 data. The MODEL 88 should be used in environmentally controlled areas such as a control room or office, and receives transmitted data from the Stevens Position Analog Transmitter (PAT) or Stevens Submersible Depth Transmitter (SDT).

### Convenience

The MODEL 88 converts water level measurement to flow data for continuous indication (88M) or graphic record (88R), and uses a mechanical totalizer to continually indicate volume. The unit is housed in a compact case which can be mounted either on a shelf or wall, or is available for panel mounting. It is easy to install, service, maintain, or relocate.

### Flexibility

Interchangeable parts are available for simple field conversion to increase or decrease the instrument's flow range, change to another weir or flume, or change chart speed (four speeds available).

The MODEL 88 is designed for remote measuring of open channel flows when connected to a float-operated PAT or pressure-operated SDT. The unit operates on 24 VAC, 60 Hz. This is provided by a UL approved wall-mount power transformer from 110 VAC, 60 Hz standard wall socket.

The MODEL 88 is available in either English or metric units, and can be used with virtually any type and size of weir or flume. A full measuring range scale runs from 14,000 gallons per day (GPD) through a 22-1/2° V-notch weir to as much as several hundred million gallons per day (MGD) through large sizes of Parshall and other types of flumes.

The Model 88M provides a flow indication and 7-digit totalized volume. The indicator plate is graduated to show instantaneous flow rate as noted by the indicator pointer. A red clip on the indicator plate is positioned to indicate peak flow. Model 88R uses a strip chart to provide a permanent flow record and also has a 7-digit totalizer.

### Model 88R Recorder Chart

A standard 50-foot by 4-inch strip chart is printed on tracing quality paper which has been specially selected to minimize the effects of humidity. Curvilinear graduations compensate for the marking pen's arc swing. There are six minor time divisions between major divisions.

Charts are overprinted every 2, 3, 6, or 12 hours, depending on the time scale. The chart has uniform divisions for flow, and consists of seven major and five minor divisions.

Available time scales are 3 - 1/3, 5, 10, or 20 inches of chart travel per day, which yields 180, 120, 60, or 30 days, respectively, of continuous records. For most applications, a scale of 10 inches per day is satisfactory to provide a clear, easily read record. If the flows fluctuate rapidly, a scale of 20 inches per day is recommended. In cases where flows are relatively uniform, a slower scale of 5 inches per day is suggested, and will provide longer chart life. Scales may be changed easily in the field by interchanging gears.

# STEVENS Model 88 Remote Total Flow Meter

## Model 88R Marking Pen

The chart marking pen is a disposable cartridge-type with a typical life of 3 months. Replacement frequency depends upon the chart speed of the recorder and the characteristics of the flow being recorded.

## Accessories

### The Flow Transmitter

provides a choice of a transmitting potentiometer alone or a potentiometer combined with a 4-20 mA transmitter. It is available from the factory as a complete instrument or as a kit for installation in the field.

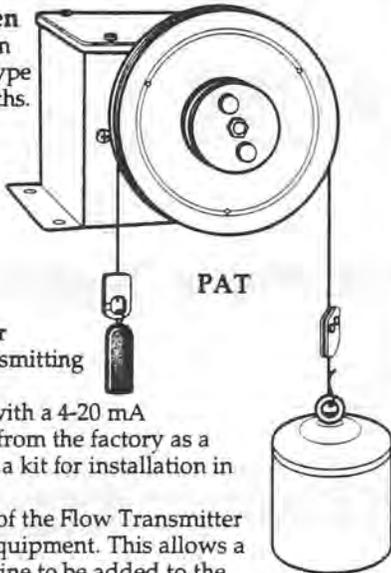
A typical application of the Flow Transmitter is to "pace" chlorination equipment. This allows a measured amount of chlorine to be added to the water in direct proportion to the flow determined by the MODEL 88. Another application of this potentiometer is for retransmission to provide an output signal for remote registration or control purposes. (NOTE: Sampling or chlorinating equipment is not furnished by Leupold & Stevens, Inc.)

The Sampling Switch accessory can be used for totalizing volume on a remote indicator, flow sampling, or dosage control. The switch can be installed at the factory or added in the field, and will provide a contact closure signal proportionate to flow. The switch can actuate a sewage sampler or other device through an external electric circuit. Contact closures of 25-50 ms duration are typical. Switching capacity is 1/4 A, 32 VAC/VDC. Three standard actuating cams (10, 20, and 25 lobe) can provide various sampling intervals. These are tabulated by instrument catalog number in Technical Data Sheet 100. Cams can be easily changed in the field.

The Adjustable Flow Switch is available for operating auxiliary equipment at one preselected flow. For example, an alarm may be required when a specific flow is reached or it may be desired to turn on a chlorinator or pump at some particular flow. The control switch actuates the auxiliary equipment when the MODEL 88 indicates the preselected flow has been reached. The actuation point is adjustable over the full range of the meter.

## Basic Instrument Specifications:

**MODEL 88R** - Open channel remote flow recorder with 7-digit totalizer for use with Position Analog Transmitter or Submersible Depth Transmitter for specific type and size of flume or weir; linear strip chart 4 inches wide by 50 feet long; flow scale; cartridge-type pen with spare cartridge; high-impact ABS plastic case and cover with viewing port; mounting bracket.



**MODEL 88M** - Same as 88R except without chart; includes linear scale and pointer for indicating instantaneous flow.

## Application Options:

**Time Scale (Model 88R only):**

- 3 - 1/3 in./day
- 5 in./day
- 10 in./day
- 20 in./day

**Input Devices:**

- Position Analog Transmitter
- Submersible Depth Transmitter

## Accessories:

- Stevens Flow Transmitter (4-20 mA)
- Stevens Flow Potentiometer (0-1k)
- Sampling Switch
- Adjustable Flow Switch providing contact closure output at preselected flow rate



## Technical Specifications:

- **Chart Speeds:** 3 - 1/3, 5, 10, or 20 inches per day
- **Chart paper:** 50 foot by 4 inch curvilinear paper
- **Mounting:** Wall or shelf mount standard  
Panel mount optional
- **Power requirements:** 24 VAC, 750 mA. Supplied by UL listed 110 VAC, 60 Hz transformer, 20 VA, wall mount
- **Input:** Water level (head). Absolute value current signal from Stevens Position Analog Transmitter (PAT) or from Stevens Submersible Depth Transmitter (SDT).
- **Head input range:** For PAT: 0 to 2 inches, minimum  
0 to 105 feet, maximum  
For SDT: 0 to 6 inches, minimum  
0 to 30 inches, maximum
- **Size (Inches):** MODEL 88: 14-3/4 x 10-1/8 x 6-3/8 (H x W x D)  
PAT: 5 x 7 x 7-3/4 (H x W x D)  
SDT: 1-1/8 diameter, 4-1/4 length
- **Operating Temperature:** MODEL 88: 31 to 122 ° F  
(-1 to 50 ° C)  
PAT: -40 to 160 ° F  
(-40 to 70 ° C)  
SDT: 33 to 122 ° F  
(1 to 50 ° C)
- **Accuracy:** ±2% of full scale for head ranges 0-1 foot or greater; ±5% of full scale for head ranges less than 1 foot (exclusive of input error)
- **Flow/volume Indication:** Flow and peak flow, total volume for meter version; continuous flow chart record, total volume for recording version



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2M 7-92



# STEVENS PRICE LIST

PL 75

MARCH 1992

## STEVENS Submersible Depth Transmitter II (SDT-II)

Bulletin 75

**Note: MINIMUM ORDER CHARGE \$50.00**

Compact, self-contained water level sensor consisting of stainless steel pressure transducer and electronics, packaged in a PVC housing. Produces standard 4-20 mA, non-adjustable 2-wire current signal, with 4 mA corresponding to zero level and 20 mA corresponding to maximum. Specify length of vented cable and order separately.

**Base Price \$585.00**

The following models are available:

P/N #	Model #	Range
45551	SDT-II 2.5	2.5 ft. water
45552	SDT-II 5.0	5.0 ft. water
45553	SDT-II 10	10 ft. water
45554	SDT-II 25	25 ft. water
45555	SDT-II 35	35 ft. water
45556	SDT-II 50	50 ft. water
45557	SDT-II 60	60 ft. water
45558	SDT-II 75	75 ft. water
45559	SDT-II 100	100 ft. water

[ ] Vented cable (P/N 44049) \$1.45 per foot (specify length)

### ACCESSORIES

Downhole Kit (P/N 45694)

Price \$95.00

Tank Adapter Kit (P/N 45695)

Price \$70.00

### NOTE

Prices F.O.B. factory Beaverton, Oregon. Insurance is buyer's responsibility. *Standard packing is provided. Additional charge for export packing.* When ordering replacement parts include serial number of instrument. Authorization number required prior to return of goods to factory (call or write for this number).

**PRICES SUBJECT TO CHANGE WITHOUT NOTICE**

LEUPOLD & STEVENS, INC. P.O. BOX 888 BEAVERTON, OREGON 97075-0888

TELEPHONE: (503) 846-9171 TELEX: 15-1227 FAX: (503) 526-1471





# D



## SMALL BORE DEPTH TRANSMITTER

### High accuracy

$\pm 0.1\%$  BSL for ranges to 2000 ft. water

### Totally submersible

With molded integral cable

### Excellent overpressure acceptance

$< 2$  times rated pressure

### Good thermal stability

$\pm 0.3\%$  total error band  $30^\circ$  to  $85^\circ F$

### Titanium construction

### Two wire, 4-20mA

The PTX 161/D transmitter has been specifically designed for depth measurement in small bore holes, reservoirs, the sea and many other applications. The 4-20mA operation permits extremely long cable lengths and Druck can supply up to 4500 ft. cable in a single length. The titanium body is electron beam welded, and a polyurethane sheathed cable is molded to the body completing a high integrity waterproof assembly.

The cable is tough, and complete with an integral vent tube and Kevlar strain cord.

The standard accuracy is 0.1% FS (0.06% FS is available) and the new electronic circuit gives very good thermal stability.

### Operating pressure ranges

Standard pressure ranges are expressed in psi, gauge or sealed gauge as follows. (Approximate equivalents are also shown for feet of ground water.)

1 psi (2-3 ft. water),  
2.5 psi (5.8 ft. water),  
5 psi (11.5 ft. water),  
10 psi (23.1 ft. water),  
15 psi (34.6 ft. water),  
20 psi (46.2 ft. water),  
30 psi (69.2 ft. water),  
50 psi (115 ft. water),  
75 psi (173 ft. water),  
100 psi (231 ft. water),  
150 psi (346 ft. water),  
200 psi (462 ft. water),  
300 psi (692 ft. water),  
500 psi (1154 ft. water),  
900 psi (2077 ft. water).

For other pressure ranges, please contact the manufacturer.

### Overpressure

The rated pressure can be exceeded by the following multiples causing negligible calibration change:

4 x for 1 psi to 5 psi ranges  
2 x for 10 psi range and above.

### Pressure media

Fluids compatible with quartz and titanium

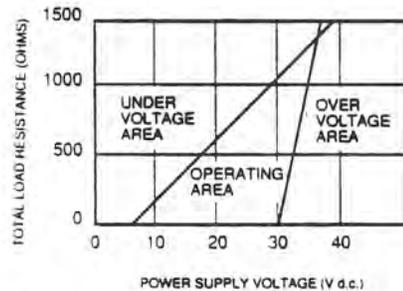
### Transduction principle

Integrated silicon strain gauge bridge.

### Transmitter supply voltage

9-30V d.c.

This voltage must appear across the transmitter terminals and the positive supply must be grounded.



For other supply voltages please refer to manufacturer.

### Supply sensitivity

0.003% FSO/Volt and excellent 50Hz and 100Hz supply rejection.

### Output current

4mA at zero pressure  
20mA at full range pressure.

### Resolution

Infinite.

### Combined non-linearity and hysteresis

$\pm 0.1\%$  BSL for 1 psi to 900 psi ranges  
 $\pm 0.2\%$  BSL for 1000 to 2000 psi ranges  
 $\pm 0.06\%$  BSL available for ranges to 300 psi on request.

Please refer to manufacturer.

### Zero offset

$\pm 0.5\%$  FSO set @ 68°F (20°C)

### Sensitivity setting

$\pm 0.5\%$  of reading, set @ 68°F (20°C)

### Operating temperature range

-5° to +140°F (-20° to +60°C)

### Temperature effects

$\pm 0.3\%$  total error band 30° to 86°F (-2° to +30°C)

1 psi range  $\pm 0.5\%$  total error band 30° to 86°F (-2° to +30°C).

For special applications it is possible to give improved temperature compensation over a wider temperature range.

### Mechanical shock

1000g for 1ms in each of three mutually perpendicular axes will not affect calibration.

### Dimensions

0.69 inches diameter x 8.66 inches length.

### Weight

4 oz. nominal

### Electrical Connection/Cable

3 ft. cable supplied as standard. This is molded to transmitter body with polyurethane to provide watertight connection. Continuous lengths up to 4500 ft. can be supplied.

### Cable specification:

2 conductor (24 AWG) shielded

- Red Supply positive

- Black Supply negative

- Shield To transmitter body.

Polyurethane outer jacket - 0.285 ins. dia.

Kevlar strength member #29/15000 Denier.

Nylon vent tube

Weight in air, 34 lbs. per 1000 ft.

Weight in water, 6 lbs. per 1000 ft.

Breaking strength, 200 pounds.

### Pressure connection

Illustrated front end delrin cone fitted as standard. This incorporates a hydraulic damper to protect the device from high pressure pulses caused by underwater impact.

### Pressure connections (optional)

1/4" NPT flat end.

7/16" UNF as MS 33656-4 (1/4 A.N)

Others available on request.

### Options available

Pressure transducers type PDCR 830

PDCR 35/D (see separate data sheets).

Pressure connections (see above).

### Ordering information

Please state the following

- (1) Type number
- (2) Pressure range
- (3) Temperature range
- (4) Cable length
- (5) Pressure media

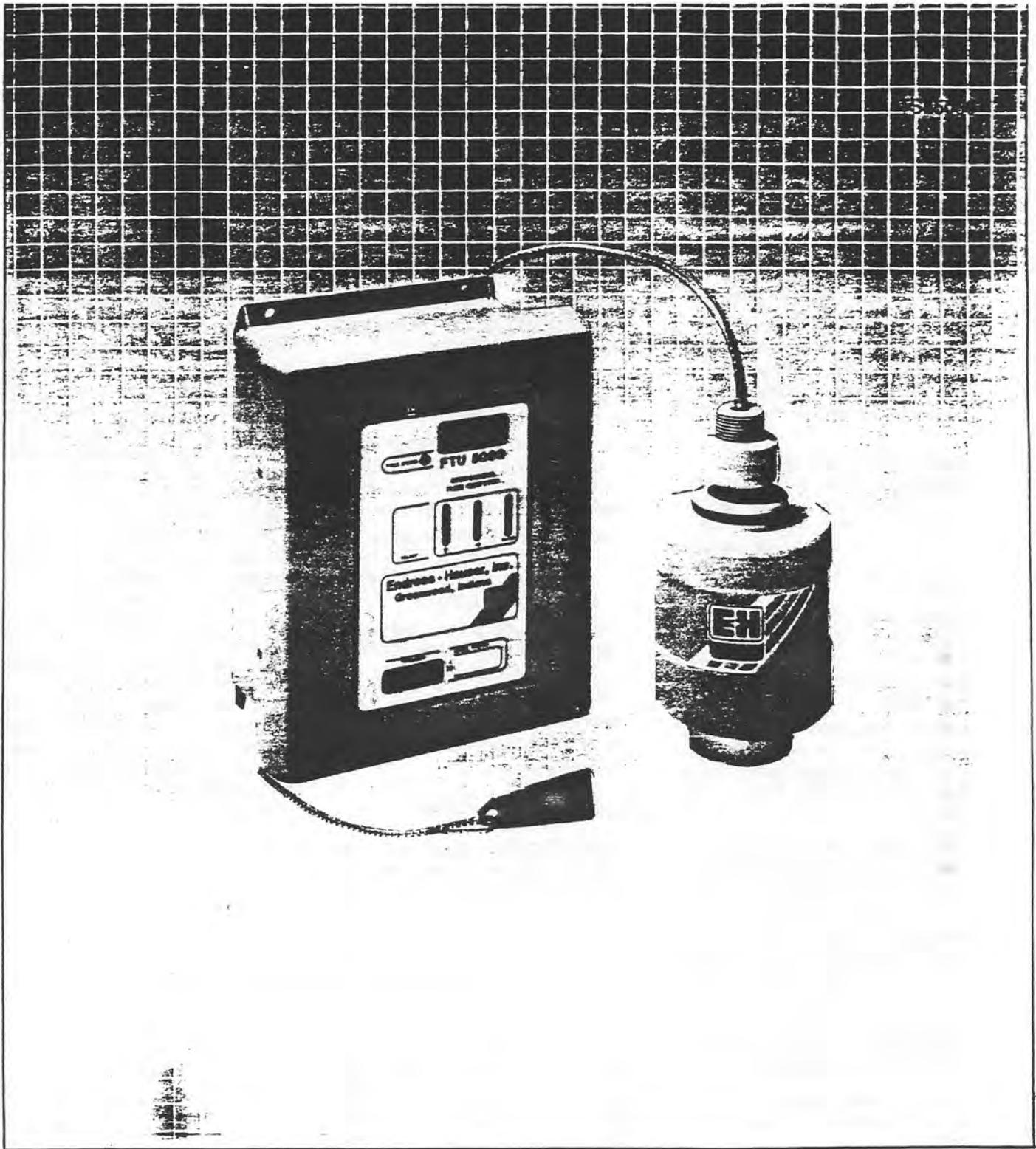
For non-standard requirements please specify in detail.

Continuing development sometimes necessitates specification changes without notice.

## Druck Incorporated

4 Dunham Drive  
New Fairfield, CT 06812  
Telephone: (203) 746-0400  
FAX: (203) 746-2494  
Telex: 643118

### Representative:



Technical Specifications – Level Measurement

## FTU 5060

Ultrasonic Open Channel Flow  
Transmitter With DU 200 Series Sensors

**THE BEABOUT COMPANY, INC.**  
5500 S. SYCAMORE ST. • SUITE 204  
LITTLETON, CO 80120  
TEL. (303) 795-1000  
FAX (303) 795-2274



More than just measurement

Endress+Hauser

## System Features

- **Submersible Sensors:** Both the DU 217 and DU 218 sensor are rated NEMA 6, submersible.
  - **Remote Mount Capability:** Transmitter can be placed in desired location or environment up to 1000 feet from the sensor, utilizing standard two conductor shielded interconnection cable.
  - **Display Toggle:** Simultaneous monitoring of two parameters, (flow rate and total flow), without manually addressing the system.
  - **Standard Built-in Flow Conversion Equations:** Converts the level measurement according to the 3/2 or 5/2 laws, or in combination.
  - **Custom Flow Conversion Equations:** The user can linearize the level measurement to any flow curve shape. The user may elect to modify one of the standard laws or enter a complete custom table.
  - **Factory Calibration:** With information supplied before shipment of the system, Endress + Hauser will factory calibrate all applicable parameters at no additional charge.
  - **Microprocessor Controlled:** Can be put into service with as few as two calibration steps, yet sophisticated enough to offer special user functions.
  - **Self Diagnostics:** Constantly monitors operation of the sensor input signals to assure optimum system performance.
  - **Magnetic Key Calibration:** No need to open the enclosure and expose the internal components to the environment.
  - **Weatherproof Enclosure for the Transmitter:** Suitable for indoor and outdoor installations.
  - **Liquid Crystal Display (LCD):** Easy to read even in bright sunlight.
  - **Output Simulation:** The user can manually activate 4 mA, 20 mA, and any of the relay or open collector outputs to verify proper operation.
  - **Fault Alarm Relay:** Gives local and remote indication of alarm.
  - **Password Protected:** Prevents unauthorized entry into any of the calibration parameters.
- **Scalable Units of Flow:** Selectable to indicate desired volume per time measurement unit (Engineering units, million gallons per day, GPM, etc.).
  - **Output Linearization:** Galvanically isolated 4 to 20 mA DC output proportional to flow.
  - **Sensor Powered Directly by FTU 5060:** No separate field power wiring needed.
  - **Standard Sampler Output:** Easily programmed for frequency and duration of output.
  - **Standard Totalizer Output:** Easily programmed for frequency and duration of output
  - **Output Filtering:** Programmable statistical and time delay based filtering functions to eliminate the effects of turbulence, foam, etc.
  - **Temperature Compensation:** Automatically compensates for the change in the speed of sound due to temperature changes.
  - **Failsafe Protection:** Selectable failsafe protection for all relay outputs and the open collector totalizer output.
  - **Alarm Relay:** Alarm output for low flow or submerged flow conditions.

## Application Versatility

The FTU 5060 is designed to handle any type of primary element or flow curve the user may have. The

microprocessor controlled transmitter can be factory or field calibrated to measure flow in flumes, weirs, open pipes, nozzles or any other device. This allows the user to use one instrument to monitor the flow in any type of primary device.

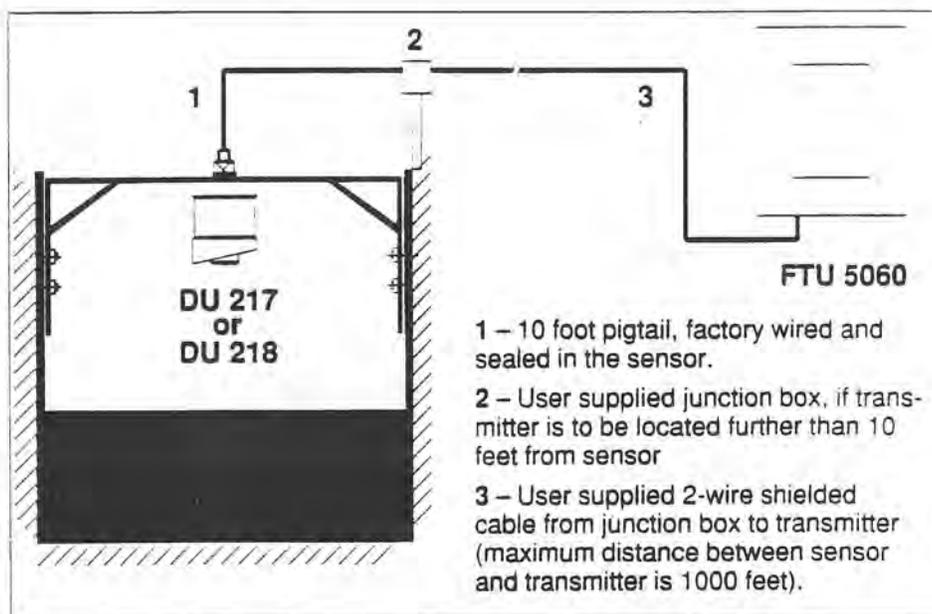
## Basic System Description

Together, the FTU 5060 Open Channel Flow transmitter and the DU 217 or DU 218 Ultrasonic sensor comprise a complete open channel flow measurement system. The selected sensor is mounted over the primary element to sense and communicate information about the channel level to the FTU 5060 transmitter. The transmitter, typically located in a convenient area some distance from the primary element, converts the sensor level signal to a flow rate.

Both the transmitter and sensor are designed to be used in indoor or outdoor environments.

The factory calibrated FTU 5060 is put into service by mounting the sensor and transmitter components, wiring signal and power, and performing two brief calibration steps.

Complete keyboard calibration offers the user a simplified approach to programming the system. There are no potentiometers to adjust, nor does calibration require the use of an oscilloscope.



## How The Ultrasonic Flow Measurement System Works

The ultrasonic open channel flow measurement system utilizes a remote mounted transmitter and a sensor mounted over a primary flow element. Their task is to perform a non-contact level measurement and convert this measurement to a usable and accurate measure of flow based on the incoming flow operating under free flow conditions.

The FTU 5060 provides power to the sensor's electronics which excite the piezoelectric crystals located behind the sensor's membrane. These crystals emit an inaudible ultrasonic pulse.

The sound pulses (or waves) travel to the surface of the incoming flow and are reflected back to the sensor membrane. The sensor receives the returned pulses by sensing the movement in the membrane caused by the reflected sound waves.

Then electrical transmit and receive signals are sent to the FTU 5060 transmitter, along with temperature information, to determine the time (or distance) traveled between the pulses. At this point, the system circuitry compensates for errors induced by temperature changes which affect the speed at which the sound waves travel between the membrane and the flowing surface.

Once the FTU 5060 has determined the temperature compensated level, it then calculates what this distance represents as a percentage of the overall level span. This becomes the input value for the subsequent flow calculation.

The system will then look up the corresponding flow output value at the appropriate location on the flow curve and convert it to an engineering value, i.e. volumetric flow rate. The entire measurement process is updated two to four times per second.

### System Accuracy

The FTU 5060 has a level measurement accuracy of  $\pm 0.08$  inch ( $\pm 2$  mm). This translates into an overall accuracy of better than  $\pm 1\%$  of the flow span.

The user should employ good engineering practices along with fabrication instructions when installing or building the primary element. Factors such as longitudinal and transverse level, surface roughness, elevation,

approach distance, flow velocity, and anticipated maximum flow rates can have a significant impact on the accuracy of the primary element's flow-to-level relationship.

The primary element, even when properly installed, will introduce an uncertainty or inaccuracy that is greater than the stated accuracy for any commercially available open channel flow metering system. For example, the uncertainty of a properly constructed and installed Parshall or Palmer Bowlus type flume is about  $\pm 3\%$  (even though the FTU 5060 has a 1% accuracy capability).

If the flume related errors are not acceptable to the user, then a field evaluation of the primary element must be made. Once the correct flow curve is determined, then the standard flow table can be modified to fit the new curve. The FTU 5060 can be easily programmed to accommodate the new curve and provide the accuracy required.

### Your Key to Environmental Integrity

A harsh environment is a standard feature of most open channel measurement applications. Opening the transmitter and exposing it to these conditions, to calibrate or to adjust the programming, has always been a major cause of system deterioration or failure. The FTU 5060 has been designed to eliminate this problem.

Programming the transmitter is a simple, nonintrusive action, accomplished by actuating the keypad through the sealed door with a magnetic key which is permanently attached to the unit. Thus, once the power and input connections have been installed the user will never need to open the unit again! Even functions such as relay and current output simulation can be performed via programming entries at the front panel.

Additionally, the FTU 5060 sensor design will free the user from the traditional concerns associated with high humidity and/or submerged conditions. The sensor is sealed to prevent the intrusion of moisture, and protect the sensor even if it should become submerged during a flood.

These features, coupled with the FTU 5060's accuracy and operating

simplicity, produce total system reliability that is unsurpassed.

### Sensor Location Guide

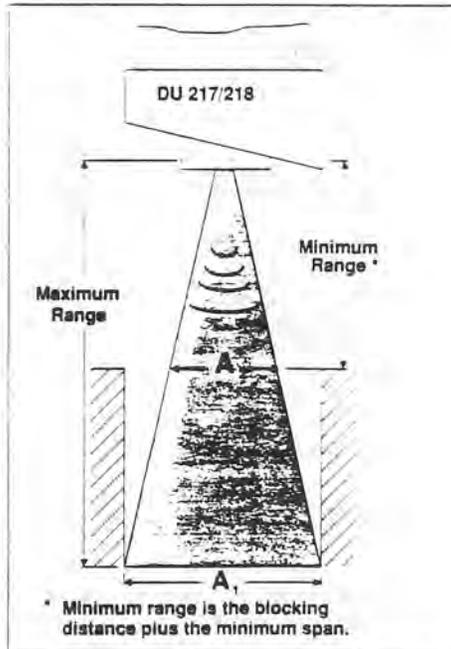
For best performance and maximum range, the sensor should be positioned vertically at the proper distance above the primary element as described in the examples below.

**Example 1:** Weir (rectangular or V notch plate). The sensor should be located upstream from the weir plate, a minimum of four times the maximum head height, and centered over the channel.

**Example 2:** Parshall flume. The sensor should be located 2/3 of the convergence length upstream from the flume throat opening, and centered over the channel.

The mounting height above the flow is determined by the range of the sensor, blocking distance (not adjustable), and the required measuring span. For small width flumes, the beam angle must be taken into consideration when determining the mounting height, as shown in the chart and diagram below.

	MINIMUM		MAXIMUM	
	Min Range	Beam Spread (A <sub>2</sub> )	Max Range	Beam Spread (A <sub>1</sub> )
DU217	30"	3.5"	96"	9.0"
DU218	36"	4.5"	192"	23.5"



## FTU 5060 Specifications

**Enclosure:** NEMA 4X and 12 plastic housing (FRP), wall mount, with plexi-glass window and hinged door (nominal size is 12 x 10 x 6 inches).

**Power:** 120 VAC, + 10% - 20%, 50/60 Hz, 15 VA maximum, standard (heated version, 55 VA). Optional 240 VAC, 50/60 Hz.

**Operating Temperature:** 15°F to 120°F. Heated version, down to -40°F.

**Storage Temperature:** 5°F to 170°F.

**Input:** Ultrasonic sensor, DU 217 or DU 218 (refer to sensor data chart below).

**Display:** 8 digit Alphanumeric liquid crystal display, 0.25" nominal character height.

**Output Signal:** Galvanically isolated 4 to 20 mA DC into a maximum of 700 ohms. Programmable for output dampening and failsafe protection.

**Linearization:** User selectable pre-programmed tables: 3/2 law, 5/2 law, and mixed. User programmable custom table or user modification of preprogrammed curves. Factory calibration to any curve.

**Accuracy:**  $\pm 0.08"$  ( $\pm 2$  mm) of level.  $\pm 1\%$  of flow.

**Fault Alarm:** Standard SPST contact 5 amp at 240 VAC resistive.

**Fault Indication:** LED indicator for echo viability.

**Flow Alarm:** Standard SPST contact 5 amp at 240 VAC resistive rating, with programmable deadband (hysteresis/differential).

**Sampler Output:** Standard SPST contact, 5 amp at 240 VAC resistive. Programmable for frequency and duration.

**Totalizer Output:** Standard SPST contact, 5 amp at 240 VAC resistive. Programmable scale factor.

**Totalizer:** Standard 8-digit resettable LCD, programmable scale factor, with 8 year lithium battery backup.

**Minimum Span:** 10 inches to maintain the accuracy of  $\pm 1\%$  of flow. A span of less than 10" can be programmed. (refer to the diagram below, h distance).

**Maximum Span:** Refer to sensor specifications.

**Maximum Range:** Refer to the sensor specifications.

**Minimum Range:** Minimum span setting plus minimum blocking distance for the selected sensor (refer to the diagram below, E distance).

**Recommended Remoting Cable:** 2-conductor shielded cable, up to 1000 feet (resistance not greater than 22.5 ohms per conductor).

**User Options:** Selectable via 3-key, magnetically operated, sealed keyboard.

**User Programming:** Pass number (code) protected entry into the programming locations.

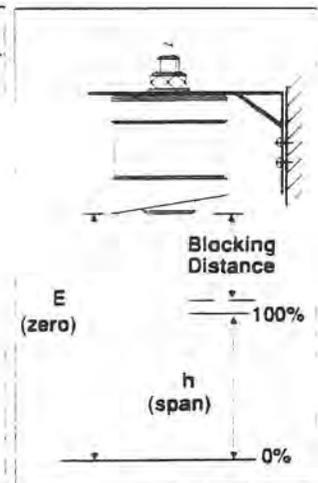
**Magnetic Key:** Plastic coated magnet for programming entries. Two supplied with each unit.

**Optional Totalizer:** 8-digit, nonresettable, mechanical. Installed and wired at factory.

**Optional Heater:** 40 watt thermostatically controlled, 40°F on to 60°F off. Installed and wired at factory.

**Optional Totalizer Output:** Optically isolated open collector transistor, 80 mA at 24 V maximum. Programmable scale factor.

Sensor Specifications	DU 217	DU 218
Maximum Range, Liquids:	8 feet	16 feet
Maximum span	6.3 feet	13.8 feet
Beam Angle:	7°	7°
Operating Frequency:	46.6 kHz	46.6 kHz
Sample Rate: (temp. dependent)	2 Hz at 60°C 4 Hz at -20°C	2 Hz at 60°C 4 Hz at -20°C
Blocking Distance:	20"	26"
Mounting:	1" BSP straight thread with mounting nut for clearance hole mounting.	1" BSP straight thread with mounting nut for clearance hole mounting.
Electronics Housing:	Heavy polypropylene and polycarbonate	Heavy polypropylene and polycarbonate
Operating Pressure:	7 psig maximum	7 psig maximum
Standard Operating Temperature *:	-4°F to +140°F (-20°C to +60°C)	-4°F to +140°F (-20°C to +60°C)
Temp. Compensation:	100 Ohm platinum RTD	100 Ohm platinum RTD
Weight:	3.2 lbs.	3.0 lbs.
Enclosure Rating:	NEMA 4X and NEMA 6 submersible	NEMA 4X and NEMA 6 submersible
Sensor Cable:	10 foot pigtail standard, 2-conductor cable, sealed in sensor.	10 foot pigtail standard, 2-conductor cable, sealed in sensor.



\* To maintain an accuracy of  $\pm 1\%$  of flow, the DU sensor standard temperature operating range should be maintained. The DU sensor is designed to operate at and withstand temperatures of -35°F.



# Magnetrol

## Echotel® III Series 350/351 Ultrasonic Non-Contact Level Transmitter

Echotel III Series 350/351, an ultrasonic, non-contact level transmitter, offers a 4-20 mA output current loop, providing the monitored level data to external control devices. The non-contact sensor is mounted integrally on the Series 350, while the Series 351 features a remote mounted sensor which can be mounted up to 100 feet (30 M) from the microprocessor based electronics. Unaffected by shifting specific gravity, viscosity, or conductivity, it is ideal for use in many control applications.

### Features

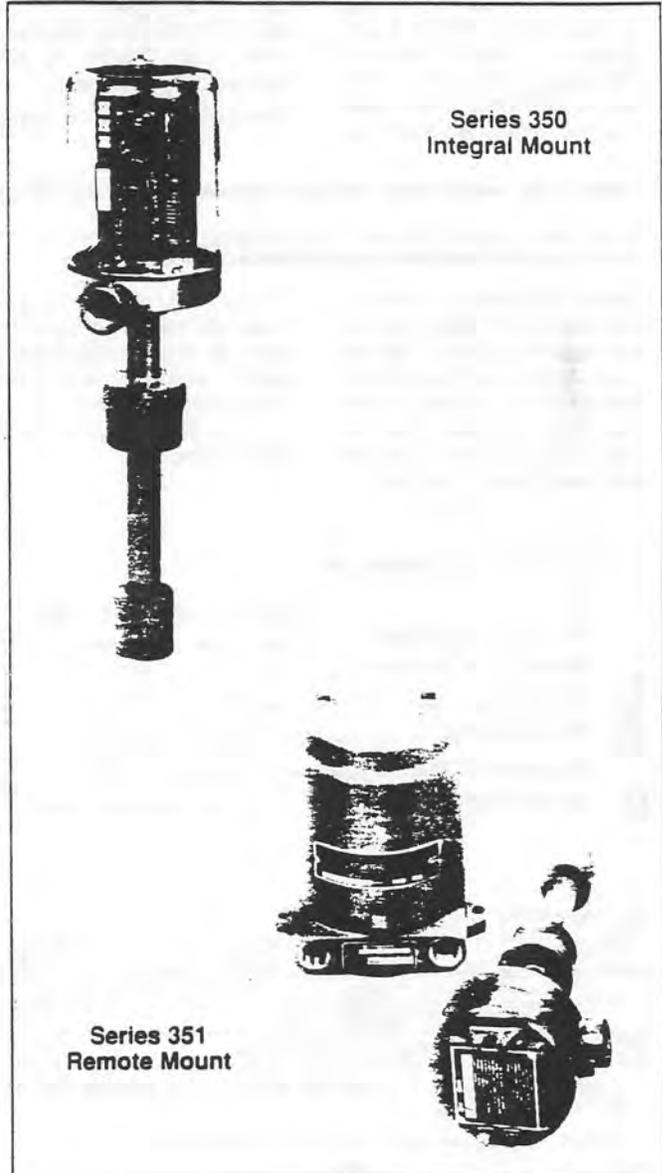
- Microprocessor-based electronics allow user selection of operating parameters including:
  - Range
  - Span
  - Set Points
  - Failsafe
  - Units of Distance
- Calibration mode allows selection of set point distance from tank bottom up or from sensor face down.
- Adjustable span of 2 in. (51 mm) to 24 ft. (7.3 M).
- Non-volatile memory; battery backup not required.
- Available in integral or remote sensor mounting.
- 4-20 mA output current loop for external control devices.
- Four digit LED alphanumeric display gives visual readout of distance, span, signal strength or current output.
- User selectable failsafe; 4 mA, 20 mA, or last value.
- Automatic temperature compensation ensures high accuracy over entire operating range.
- Choice of enclosures including NEMA 4 with Lexan® see-thru cover, NEMA 4 with black painted steel cover, or NEMA 7/9 epoxy coated cast aluminum cover. (For use in non-hazardous environments only).

### Applications

- Water & Wastewater
- Slurries
- Viscous Fluids
- Dry Bulk Materials
- Creams & Lotions
- Oils
- Chemicals
- Acids
- Caustics
- Adhesives

Lexan® is a registered trademark of General Electric

### Series 350/351 Level Transmitter



The complete level specialist

## Principle of operation - Series 350/351

Pulses generated by the microprocessor-based electronics are directed via the sensor to the surface level. The returning echo/signal is detected by the sensor. The microprocessor amplifies and

### 4-20 mA Current output

The Series 350/351 transmitter is equipped with a 4-20 mA current output loop, providing level data to external control devices. A unique calibration mode allows the user to select either a distance or height mode of operation. The height mode will provide 4 mA output when the monitored fluid level is at

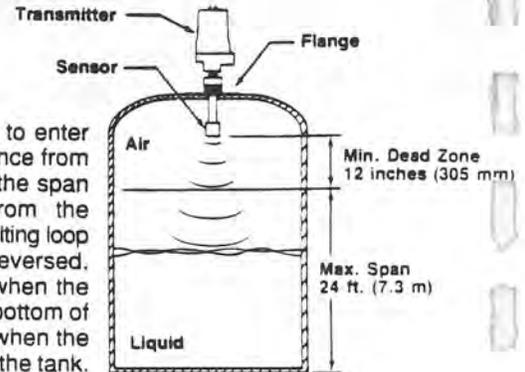
converts the signal into a digital representation of the distance from the reflecting surface. The Series 350/351 transmitter provides a 4-20 mA output current loop for external devices. All operating parame-

ters are entered via three tactile-feedback pushbuttons and displayed on a four digit LED display located under the NEMA cover.

the "bottom" of the tank, as defined by the range setting. The current output at the "top" of the tank, defined by the entered span, is 20 mA. An 8-bit D/A converter divides the span distance into 256 equal steps, each having its own defined output current.

The distance mode of opera-

tion allows the user to enter the range as a distance from the transducer and the span as the distance from the transducer. The resulting loop current output is reversed, providing a 20 mA when the liquid level is at the bottom of the tank, and 4 mA when the liquid is at the top of the tank.

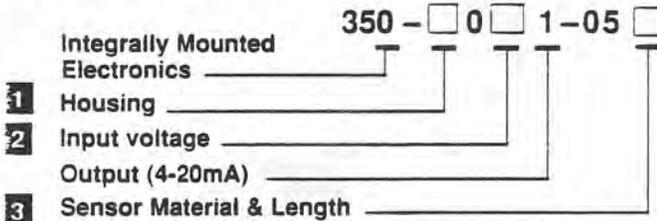


## Selection data - Series 350 integrally mounted

Series 350 transmitters are identified by an alphanumeric part number system. The part number provides exact specification of unit configuration, materials and other options vital to the performance and function of the instrument.

The system is comprised of three distinct components, each of which describes a specific part or feature of the instrument. A definition of each of the components is given below.

### Part number construction



### 1 Housing

Class	Cover Description	Code
NEMA 4	Black Painted Steel	5
	Transparent Lexan®	6
NEMA 7/9*	Epoxy Coated Cast Aluminum	8

\* Housing is NEMA 7/9 design. For use in non-hazardous environments only.

Lexan® is a registered trademark of General Electric.

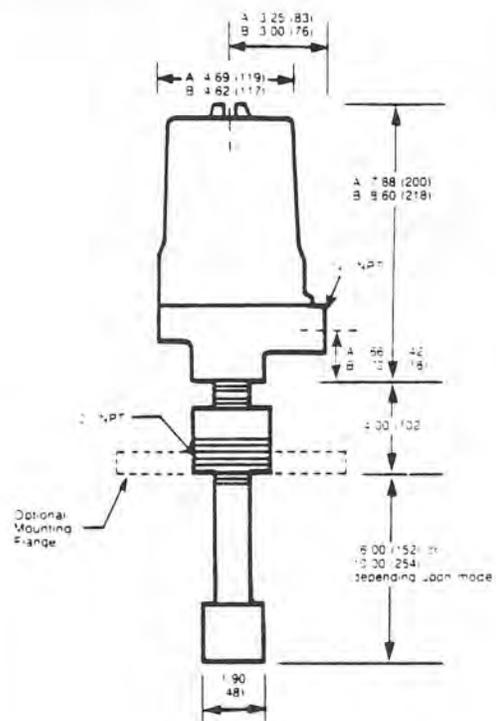
### 2 Input voltage

Description	Code
120 VAC	0
240 VAC	1

### 3 Sensor material & length

Description	Code
CPVC w/6" (152 mm) length	A
CPVC w/10" (254 mm) length	B

## Dimensional specifications inches (mm)



### HOUSING LEGEND

A. = NEMA 4  
B. = NEMA 7/9

### NOTES

- Allow 8.00 (203) overhead clearance for removal of cover
- Do not attempt to disassemble transducer

## Selection data - Series 351 remote mounted

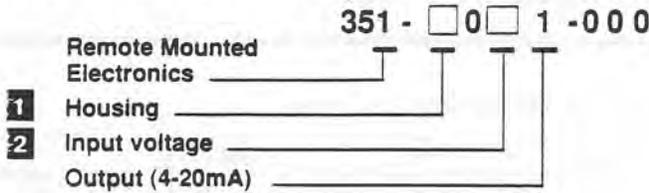
Series 351 transmitters are identified by an alphanumeric part number system. The part number provides exact specification of unit configuration, materials and other options vital to the performance and function of the instrument.

Materials and other options vital to the performance and function of the instrument.

The system is comprised of an electronics part number, a sensor part number and a connecting cable. (Connecting cable is used with sensor w/sensor housing only). A definition of each of the components is given below.

ing cable is used with sensor w/sensor housing only). A definition of each of the components is given below.

### Electronics part number construction



### 1 Housing

Class	Cover Description	Code
NEMA 4	Black Painted Steel	5
	Transparent Lexan®	6
NEMA 7/9	Epoxy Coated Cast Aluminum	8

\* Housing is NEMA 7/9 design. For use in non-hazardous environments only.  
Lexan® is a registered trademark of General Electric.

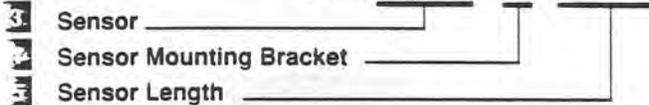
### 2 Input voltage

Description	Code
120 VAC	0
240 VAC	1

### Sensor part number construction

Example:

395 -    -  -



### 3 Sensor

Sensor Description	Code
CPVC with 3/4" NPT, 20 Ft. of cable (6 M)	1C0
CPVC with 3/4" NPT w/Sensor Housing ①	1C1
CPVC with 2" NPT, 20 Ft. of cable (6 M)	5C0
CPVC with 2" NPT w/Sensor Housing ①	5C1

① For sensor w/sensor housing, (1C1, 5C1), order connecting cable below.

### 4 Sensor mounting bracket

Description	Use with Sensor Code	Code
None	1C0, 1C1, 5C0, or 5C1	0
Wall Mount 3/4" NPT	1C0 or 1C1	1
Floor Mount 3/4" NPT	1C0 or 1C1	2
Wall Mount 2" NPT	5C0 or 5C1	3
Floor Mount 2" NPT	5C0 or 5C1	4

NOTE: See Bulletin 51-616.0 (Instruction Manual) for dimensional information on sensor mounting brackets.

### 5 Sensor length

Description	Code
6" length (152 mm)	006
10" length (254 mm)	010

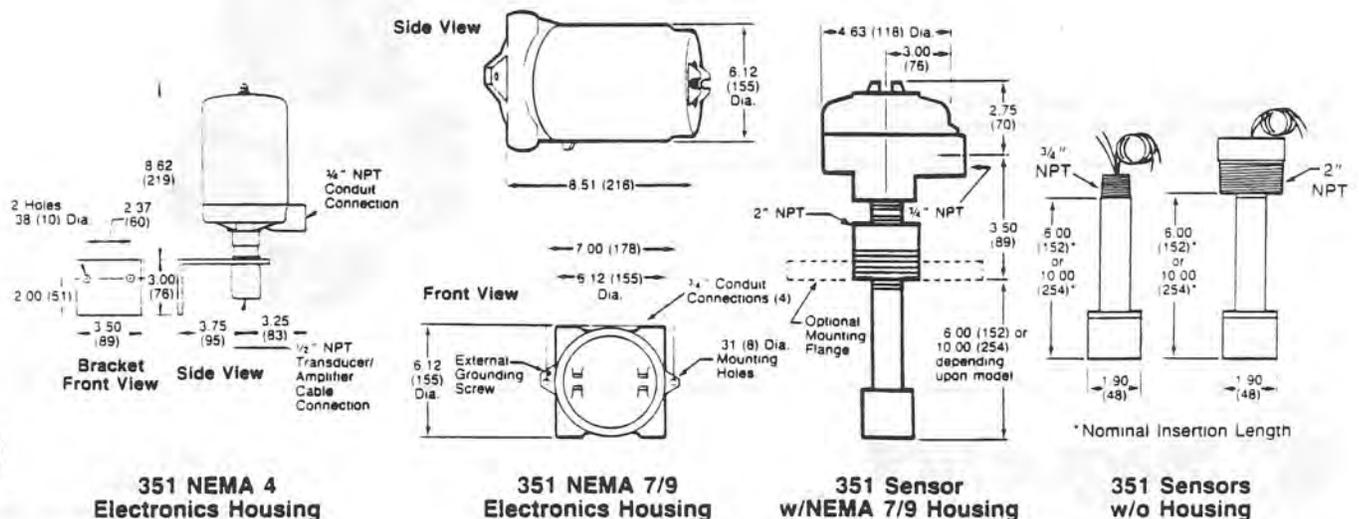
### Connecting Cable part number construction

037-3170 -

### Cable length in feet

10 Ft. (3 Meters) minimum, 100 Ft. (30 Meters) maximum length  
Example: 12 Ft. cable length = 037-3170-012.

## Dimensional specifications inches (mm)



## Product warranty

All Magnetrol electronic and ultrasonic level controls are warranted free of defects in materials or workmanship for one full year from the date of original factory shipment.

If returned within the warranty period, and upon factory inspection of the control, the

cause of the claim is determined to be covered under the warranty, then Magnetrol International will repair or replace the control at no cost to the purchaser (or owner) other than transportation.

Magnetrol shall not be liable for misapplication, labor

claims, direct or consequential damage or expense arising from the installation or use of equipment. There are no other warranties expressed or implied, except special written warranties covering some Magnetrol products.

## Electrical specifications

Description	Specification
Supply Voltage	120 VAC, 50-60 Hz 240 VAC, 50-60 Hz
Power Consumption	5 Watts Maximum
Range	25 ft. (7.6 m) from sensor face (Consult factory for range greater than 25 ft. - 7.6 meters)
Span	24 ft. (7.3 meters) max.
Frequency	50 kHz
Dead Zone	12 in.. -20°F to +140° F (305 mm. -30°C to +60°C) 18 in.. +140°F to +160° F (457 mm. +60°C to +71°C)
Output Signal	4-20 mA., max. at 1000 ohms. (isolated)
Failsafe	User selectable, 4 mA, 20 mA, or Last
Response Time	1 second minimum
Repeatability	± 0.125" (± 3mm)
Accuracy	± 0.25% of full scale
Ambient Temperature (Electronics)	-40° F to +160° F (-40° C to +71° C)
Ambient Temperature (Sensor)	-20° F to +160° F (-30° C to +70° C)
Temperature Compensation	Automatic over range of sensor operating temperature
Operating Pressure	-10 to +50 psig. (-0.689 to +3.45 bar)
Beam Angle	conical 12° (Typical)
Humidity	95% Non-condensing (Electronics)

The Series 350/351 is also available in a variety of Non-Contact Dual Point Level Controllers with two SPDT relays. See Bulletin 51-111 for Series 350/351 Level Controllers.

## Series 350 Agency Approvals

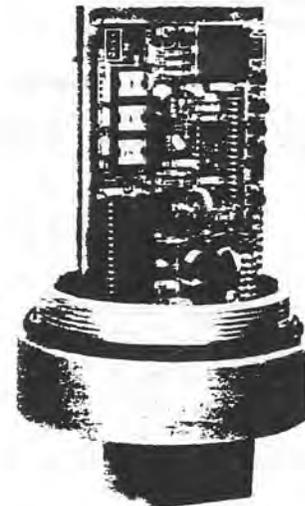
Agency	Model No.	Approval
CSA	350-50X1-05X	Non Hazardous environments w.CSA Enc. 4 exc. Lexan cover
	350-80X1-05X	
FM	350-60X1-05X	Non Hazardous environments w. NEMA 4 enclosures exc. blk steel cover
	350-80X1-05X	

## Series 351 Agency Approvals

Agency	Model No.	Approval
CSA	351-50X1-00X	Non Hazardous environments w. CSA Enc. 4 exc. Lexan cover
	351-80X1-00X with	
	395-1C11-XXX 395-1C12-XXX	
FM	351-60X1-00X	Non Hazardous environments w. NEMA 4 enclosures exc. blk steel cover
	351-80X1-00X with	
	395-1C11-XXX 395-1C12-XXX	

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## Printed circuit board/user keypad



BULLETIN: 51-112.1  
EFFECTIVE: March 1991  
SUPERSEDES: December 1990

5300 Belmont Road • Downers Grove, Illinois 60515-4499 • (708) 969-4000 • Fax 708-969-9489  
6291 Dorman Road • Mississauga, Ontario L4V-1H2 • Phone: (416) 678-2720 • Fax 416-678-7407  
Heikensstraat 6 • B 9240 Zele, Belgium • Tel. 052 45.11.11 • Telex 25944 • Fax 052 45.09.93  
Regent Business Ctr., Jubilee Rd. • Burgess Hill, Sussex RH15 9TL U.K. • Tel: 0444-871313 • Telex 87255 • Fax 0444-871317



**Drexelbrook**  
 Engineering Company

Factory phone # (215) 674-1234 Fax # (215) 674-2731

## Model # 508-25-9 Continuous Level Transmitter

### Important

*This UniversalLevel™ transmitter includes a 3/8-inch diameter, rigid sensor for ranges up to 20 feet.*

- For longer ranges, limited headroom, or agitated tanks, see page 8.5.
- In some situations, a lower-cost transmitter (See 12.5) is suitable for non-coating materials. Check with your Drexelbrook representative.



If this commonly used level transmitter does not fit your application, call your local Drexelbrook representative for an alternate recommendation.

## Performance Specifications

### Output

4 to 20 mA dc

### Load Regulation

0.1 for zero to max. load resistance

### Supply Voltage

24 Vdc nominal, 100 Vdc max.

### Max. Cable Length

100 feet (25 feet std.)

### Ambient Temperature

-40°F to 160°F

### Allowable Static Discharge to Sensor

2 amps max (Std.)  
 100 amps with optional protection circuit

### Max. Load Resistance

$\frac{*V_s - 13}{.02}$  (i.e. max 550 Ω @ 24 Vdc)

### Sensing Element Connection

3/4" NPT (Std.)  
 Flange mounting (optional)

### Span

2 inches to 20 feet

### Output Isolation

Min. 4000 V signal wires to sensor

### Electronics Housing

Weatherproof (std.) meets Nema 1-3, 5 and 12.

### Response Time

20 Milliseconds  
 0-30 seconds adjustable, (optional)

### Area Classifications

Cable and sensor are intrinsically-safe for all Groups, Div 1 and 2  
 Electronics are intrinsically-safe when used with approved barriers for Groups C, D, E, F, G, Div 1 Also non-incendive for all Groups, Div 2, without barriers

### Supply Voltage Error

± 0.2% max per 10V change

### Accuracy

± 1% nominal

\*Vs = Power Supply

### Approvals Available

FM (standard)  
 CSA, BASEEFA (optional)

### Typical Applications:

- Cooling Towers
- Water
- Organic Acids

### Do not use with:

- Hydrofluoric Acid
- Styrene Monomer
- Butydiene Monomer

## Process Specifications

### Pressure and Temperature Limits:

1000 psi @ 100°F

or

500 psi @ 300°F

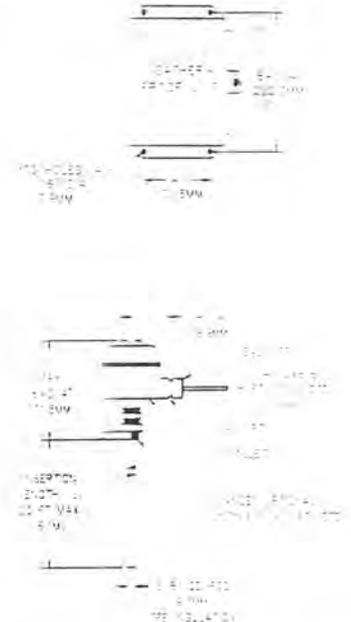
### Agitation:

Less than 1/2 horsepower

### Sensing Element

### Process-Wetted Parts:

304 SS and TFE (bonded)



For complete wiring details, request drawing #508-25-9-CD1

**8.1**  
 OVER →

## - HOW TO ORDER -

To ensure that your order can be processed, you *must* provide the following information. For your convenience, use a **copy** of the "508-2X Series Universal Order Worksheet" found at the end of this section, and fill in the appropriate information. (See form #440-112-918).

### Specify the following:

1. Process material
2. Max process pressure (PSI or Bar)
3. Max and min process temperature (°F or °C)
4. Agitation (if applicable) in horsepower
5. Vessel material
6. Connecting coaxial cable length (distance between sensing element and electronics)
  - 25 foot standard
  - Other lengths available, see options below
7. Electronic Unit Housing
  - Weatherproof Std.
  - Others optional, see below
8. Continuous level transmitter model number (#508-25-9)
9. Sensing element (#700-1-22) insertion length (max 20 ft.)

### Specify Common Options:

- Coax cable lengths (100 ft max):
  - 35, 50, 75 or 100 feet
- Electronic unit housing:
  - Nema 4
  - Nema 4X with digital meter
  - Explosionproof
- Flange mounting:
  - 1 1/2", 2", 3", 4" 150# RF 316 SS or CS threaded flanges
- Adjustable signal damping, 0-30 sec time delay
- CSA or BASEEFA approvals (if required)
- Heavy duty spark protection for insulating liquids and granulars (See Section 2.0, note (a) for your process material).
- Drexelcote™ sensing element conduit for corrosive atmospheres
- RFI filters for protection from radio frequency interference (mainly walkie talkies)
- Optional receivers, power supplies, current trips, meters, etc., see Section 14, Accessories

### Other Options Available: (Consult your local Drexelbrook representative)

- High sensitivity electronics
- Ruggedized electronics
- Tropicalized electronics
- Exotic metal wetted parts on sensing element
- 4-20 mA loop surge protection



# Magnetrol

## Kotron™ Series 82 R.F. Level Transmitter

REGISTERED  
ISO 9001 • Z299.1  
ASSURED QUALITY & SERVICE COST LESS

Magnetrol's Series 82 is a microprocessor-based R.F. capacitance level transmitter that offers precise level sensing to the industrial user. Calibration is made easy by the use of push button data entry. The Series 82 features advanced Pulsatel™ circuitry to provide effective level control with control room convenience. Kotron transmitters utilize extremely high radio frequency circuitry to minimize the effect of media buildup on the sensing probe.

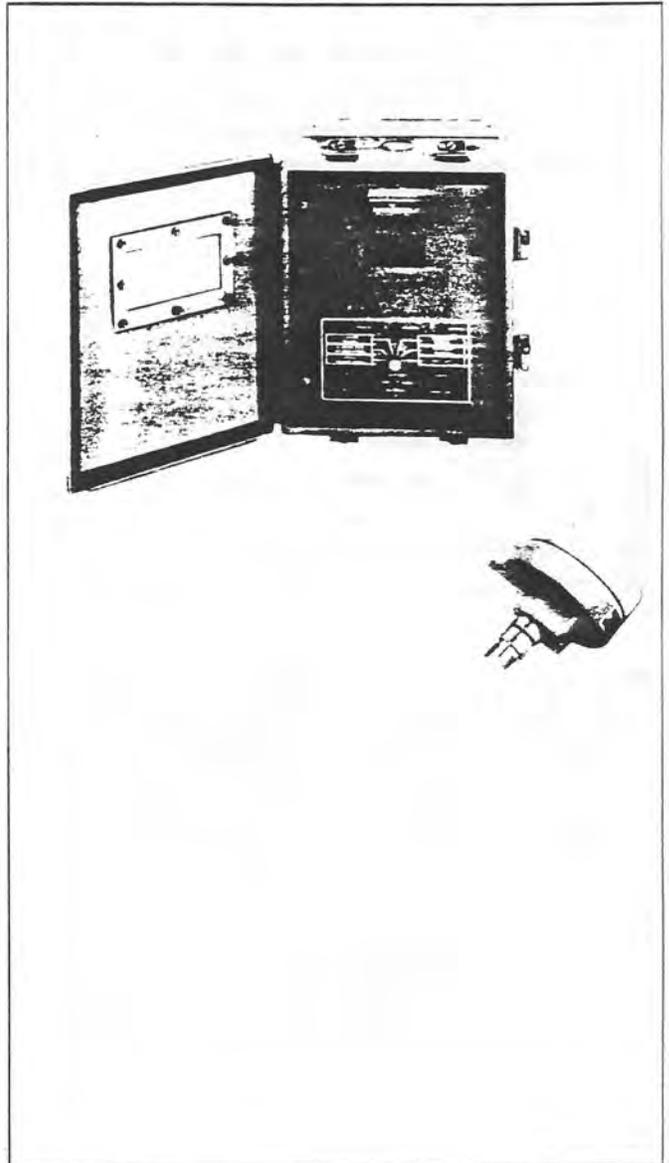
### Features

- Microprocessor-based electronics offer simplified push button calibration.
- Pulsatel circuitry allows up to 5000 feet (1524 M) between the sensing probe located in a hazardous environment, and the transmitter safely mounted in a control room.
- Wide span range of 10 to 15,000 pF allows use in almost any media.
- Rigid and flexible sensing probes to 1000°F (538°C) and 5000 psi (345 bar).
- Probe lengths from 6 inches (15.24 cm) to 150 feet (45 M).
- Up to three relays for sophisticated alarm/control requirements.
- 0 - 15 second adjustable time delay.
- Output options include:
  - 4-20 mA
  - 0-1 mA
  - 0 to -10 VDC
- RS-232C/422A output may be added to standard output.
- Blind, analog or digital meter scaled to read 0-100%.
- CSA and FM listed models for non-hazardous environments.

### Applications

- Clean or Dirty Liquids
- Light Slurries
- Viscous Liquids
- Food & Beverage
- Hydrocarbons & Solvents
- High Temperature/Pressure Liquids
- Chemicals
- Acids & Salts
- Powders & Granulars

### Kotron Series 82 R.F. Level Transmitter



The complete level specialist

## Principle of operation

The amount of capacitance developed in any vessel is determined by the surface area of the probe, the distance from the probe to its ground, and the dielectric of the medium it is measuring.

Considering that the probe's mounting position is fixed, and the dielectric value of the medium is constant, then the

amount of capacitance developed in any vessel becomes dependent upon the probe's total surface area. A probe's diameter and length determine its surface area. Adjusting the combination of the probe's diameter and length (and of course its proximity to ground) in any given application, can generate the necessary ca-

pacitance required by the electronic circuitry.

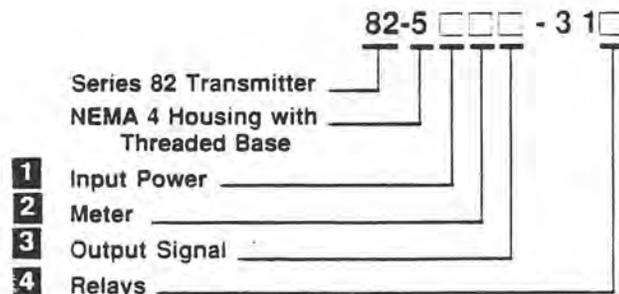
As medium rises and falls in the tank, the amount of capacitance developed between the sensing probe and the ground also rises and falls. This change in capacitance is sensed by the electronics which changes the capacitance signal to a variable fre-

quency. This signal can then be sent to the main electronics located up to 5000 feet (1500 M) away via standard shielded, twisted pair cable. This eliminates the 150 foot (45 M) maximum distance limitation using costly coaxial or triaxial cables utilized by other manufacturers.

## Selection data

Kotron System 82 capacitance level transmitters are identified by a numeric part numbering system. The part number provides exact specification of unit configuration, materials and other options vital to the performance and function of the instrument.

The system is comprised of a transmitter part number (shown below), and a probe assembly (ordered separately from Bulletin 50-125).



### 1 Input Power

Description	Code
120 VAC	0
240 VAC	1
24 VDC	2

### 2 Meter

Description	Code
Blind	0
Analog Meter	1
Digital Meter	2

### 3 Output Signal

Description	Code
4-20 mA, 0-1 mA, and 0 to -10 VDC	1
RS-232C/422A added to the outputs listed under Code 1	2

### 4 Relays

Description	Code
None	0
3 DPDT 10 amp relays	3

## Electrical specifications

Description	Specification
Supply Voltage	120 VAC, 50/60 Hz 240 VAC, 50/60 Hz 24 VDC
Power Consumption	15 Watts Maximum
Zero Range	0 pF (Minimum) 10,000 pF (Maximum)
Span Range	10 pF (Minimum) 15,000 pF (Maximum)
Relay Differential	Adjustable, 2% Minimum
Output Relays	AC (3) DPDT 120/240 VAC, 10 amp Non-Ind DC (3) DPDT 24 VDC, 0.50 Resistive
Output Signal	4-20 mA, 0-1 mA or 0 to -10 VDC 4-20 mA, 0-1 mA or 0 to -10 VDC with RS-232C/422A
Time Delay	0-15 seconds
Response Time	100 milliseconds
Repeatability	± 1%
Ambient Temp (Electronics)	Analog -40°F to +160°F (-40°C to +71°C) Digital -20°F to +160°F (-29°C to +71°C)
Operating Pressure	Dependent upon probe selection. Refer to Probe Bulletin 50-125.
Temperature Coefficient of Output	+0.02 pF per degree F (+0.036 pF per degree C)

## Agency approvals

Agency	Model No.	Approval
CSA	All Models	CSA Enc. 4 Non-Hazardous environments
FM	All Models	NEMA 4 Enc. Non-Hazardous environments

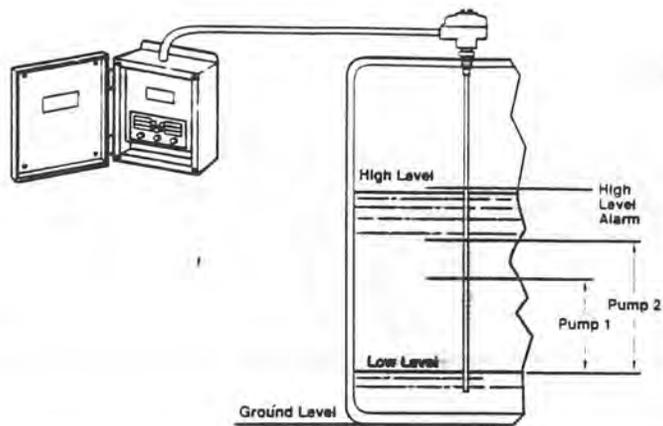
## Probe assemblies

A full range of rigid and flexible probes for conductive and non conductive materials is available in various lengths and materials of construction. For further information on probe assemblies, please refer to Bulletin 50-125. Be sure to

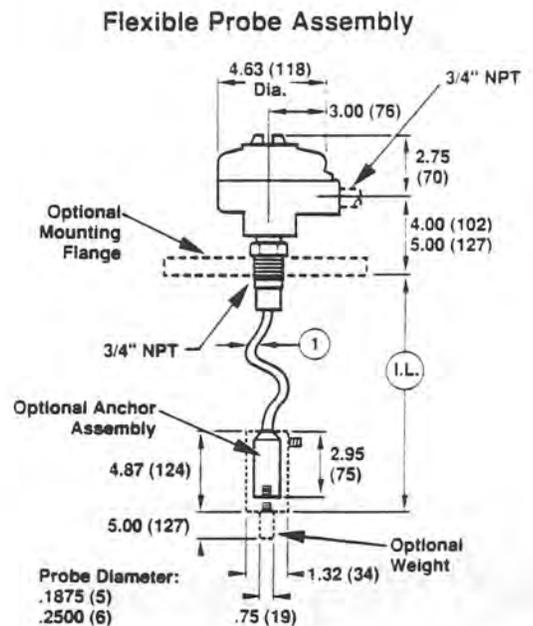
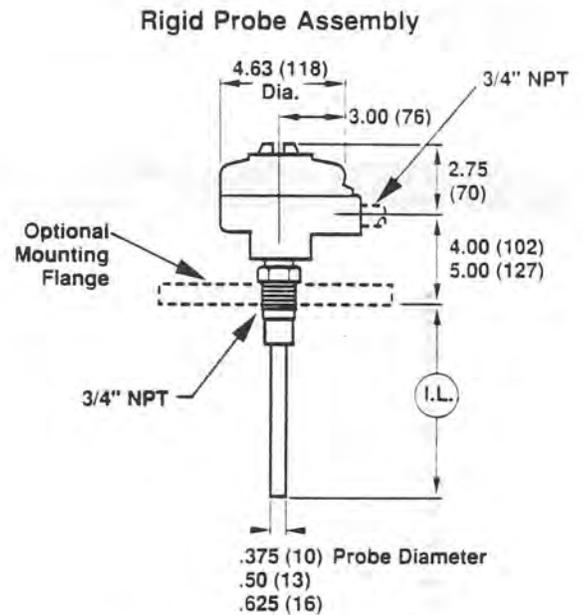
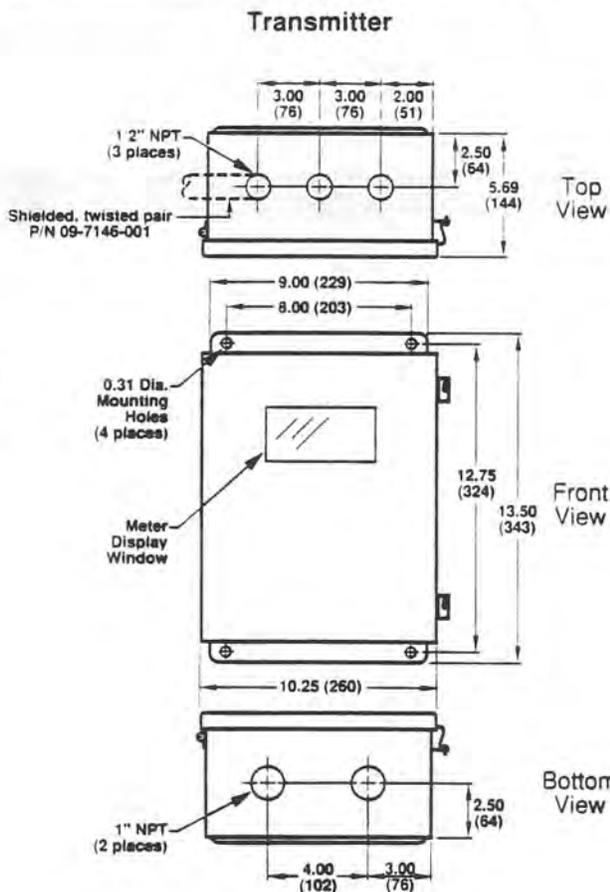
order a 41-5000 Series probe with a threaded housing connection. 41-1000 Series probes with a slip on housing connection are not compatible with this transmitter's probe assembly base.

## Typical application

The Series 82 offers a comprehensive level control approach by combining level readout (4 digit LCD), electronic output (4-20 mA, 0-1 mA, 0 to -10 VDC, and RS-232C/422A) and/or three 10 amp DPDT control relays. The illustration at right shows a typical application of a Series 82 utilizing a remote mounted rigid probe and calibrated for high level alarm and control of 2 pumps.



## Dimensional specifications Inches (mm)



### Notes:

1. All dimensions in ( ) are in millimeters.
2. Probes should be installed so that the probe end is at least 2.00 (51) below the desired level control point with conductive materials or 4.00 (102) below the control point with non-conductive materials.
3. Allow 4.00 (102) overhead clearance for removal of remote mount probe cover.

## Product warranty

All Magnetrol electronic and ultrasonic level controls are warranted free of defects in materials or workmanship for one full year from the date of original factory shipment.

If returned within the war-

ranty period, and upon factory inspection of the unit, the cause of the claim is determined to be covered under the warranty, then Magnetrol International will repair or replace the control at no cost to the purchaser (or owner)

other than transportation.

Magnetrol shall not be liable for misapplication, labor claims, direct or consequential damage or expense arising from the installation or use of the equipment. There

are no other warranties expressed or implied, except special written warranties covering some Magnetrol products.

## Quality assurance



The quality assurance system in place at Magnetrol guarantees the highest level of quality throughout the company. Magnetrol is committed to providing full customer

satisfaction both in quality products and quality service.

Magnetrol's quality assurance system is registered to ISO 9001 and Z299.1

affirming its commitment to known international quality standards providing the strongest assurance of product/service quality available.

**ASSURED QUALITY & SERVICE COST LESS**



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SUPERSEDES: April 1991

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# Magnetrol

## Kotron™ R.F. Sensing Probes

### Probe overview

Kotron R.F. sensing probes are available in over 45 standard configurations to handle a wide variety of application requirements. Probes may be combined with most Kotron R.F. level controls and transmitters.

Shown below is an overview of Kotron sensing probes. The first chart covers rigid probes; the second flexible probes. Major probe categories are listed down the left of the rigid probe matrix. Each column identifies the probe's

rod size and type of seal within a category. The numbers listed in each block identify specific probes.

Recommended applications and more detailed information on each probe can be

found in the charts shown in numeric order on Pages 2 through 4. The most commonly used probes are shaded in gray.

### Rigid probes Most commonly used probes

Probe Configuration	TFE Seal .250 Rod 316 SS Nut	ECTFE Seal .375 Rod 316 SS Nut	TFE Seal .500 Rod 316 SS Nut	Ceramic Seal		Specialty Probes
				.375 Rod 316 SS Nut	.500 Rod 316 SS Nut	
Bare ①		5070 5072 (.50 rod)		5038 5052 ③	5005 5051 ⑤	<b>Seal, Nut &amp; Insulation of the Same Material</b> 5021 — Kynar® 5023 — PVC 5076 — Halar® (ECTFE) <b>Specialty Metals ⑤</b> 5073 — Monel 5074 — Hastelloy B 5075 — Hastelloy C <b>Kynar® Faced Flanges ④</b> 5080, 5081, 5082, 5083, 5084, 5085 5041 — Polypropylene insulation w/316 SS nut & .500 rod, .625 O.D. 5087 — Enhanced gain 1.25" tube probe 5088 — same as 5087 w/integral stillwell 5089 — 500 rod with 4" dia. stillwell 5095 — Kynar insulation w/316 SS nut & 500 rod, .625 O.D.
Insulated	5001 (.375 O.D.)	5059 (.500 O.D.)	5017, 5093 (.625 O.D.)			
Stillwell (.75 I.D.)	5027	5067	5039 ①	5047 5054 ③	5090 5086 ③	
Inactive Sheath 6" Std.	5002	5066	5042			
Ground Wire	5030	5077	5029			
Bend	5032	5068 5069 ② 5071 ①	5035		5036	
Proximity Plate		5007		5045 5053 ③		
Reference Rod		5078				
Faced Flange ④		5060 1.5"/150# 5061 1.5"/300# 5062 2.0"/150# 5063 2.0"/300# 5064 3.0"/150# 5065 3.0"/300#				
Sanitary			5094, 5097 (.625 O.D.)			

① Bare rod.

② With inactive sheath.

③ With heat extension.

④ Plastic faced carbon steel flange.

⑤ Consult factory for horizontal mounting of bare probes.

⑥ Sectionalized probe.

### Flexible probes Most commonly used probes

Part No.	Seal	Nut	Insulation	Cable O.D.	Overall O.D.
5101	Halar® (ECTFE)	316 SS	Halar® (ECTFE)	.1250	.1875
5102					.2500

Part No.	Seal	Nut	Insulation	Cable O.D.	Overall O.D.
5103	PVC	CPVC	PVC	.1250	.2500
5105	Ceramic	316 SS	None	.1875	.1875

Halar® is a registered trademark of Ausimont.  
Kynar® is a registered trademark of Pennwalt.

## Selection data

Kotron probe part numbers are identified by a numeric part numbering system. The part number provides exact specification of the probe's configurations and insertion length. This system is com-

prised of three distinct components. The first two digits indicate Kotron probe, the next four digits describe the probe configuration and the last three digits detail the insertion length.

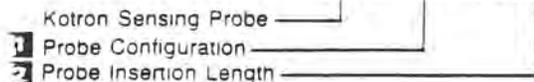
## Expedite ship plan

Several Kotron sensing probes are available for quick shipment, usually within two weeks after factory receipt of a purchase order. The models covered by "ESP"

service are conveniently color coded below. Contact your Magnetrol Representative for lead times on other selections.

## Part number construction

Example: 41-    -    



## 2 Probe insertion length

Insertion lengths for Kotron sensing probes are measured from the bottom of the threads of the mounting nut to the end of the probe. Rigid probe lengths from 6 to 234 inches, dependent upon model, are available in one inch increments. Standard flexible probe lengths from 10 to 150 feet are available in one foot increments. Custom lengths for both rigid and flexible probes are available by

consulting the factory. The last three digits of the probe part number equal the insertion length required. Rigid probes are measured in inches; flexible probes in feet.

### EXAMPLES:

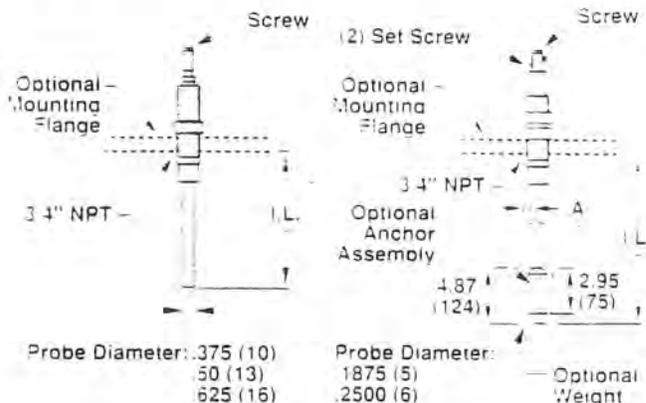
For Rigid Probe insertion length of 8 inches order 41-XXXX-008.

For Flexible Probe insertion length of 25 feet order 41-XXXX-025.

## 1 Probe configuration

Please refer to the charts on pages 2, 3 and 4. Should a flange be required to mount the probe, please refer to the flange chart on page 8 for the

sizes and part numbers available. 41-5000 series probes have a 3/4" NPT housing connection.



RIGID PROBE

FLEXIBLE PROBE

## 3 Rigid probe configurations

Probe Part No.	Application	Material		Probe Dia. Inches	Probe Pressure/Temperature Rating (1)	
		Probe	Nut		Integral Mount	Remote Mount
41-5001	Conductive or non-conductive liquids and bulk materials under 40 lb./cu. Ft., 48" max. length	TFE	316 SS	375	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F
41-5002	Conductive or non-conductive liquids and bulk materials under 40 lb./cu. ft., w/316 SS inactive sheath, 6" sheath standard, 48" max. length (7" min. insertion length)	TFE	316 SS	375	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F
41-5005 (3)	.5" bare rod, high temp./high pressure, ceramic seal	316 SS	316 SS	500	5000 PSI @ 100°F 800 PSI @ 350°F	500 PSI @ 1000°F 800 PSI @ 350°F
41-5007	6" dia. proximity plate for non-contacting applications, 48" max. length	316 SS	316 SS	375	5000 PSI @ 100°F 2100 PSI @ 160°F	5000 PSI @ 100°F 450 PSI @ 285°F
41-5017	Conductive or non-conductive liquids and bulk materials over 40 lb./cu. ft., "ESP" to 96"	TFE	316 SS	625	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F
41-5021	Corrosive liquids or Kynar (PVDF) reqmt., 120" max. lgth.	Kynar	Kynar	625	100 PSI @ 160°F	100 PSI @ 160°F
41-5023	Corrosive liquids or PVC reqmt., 60" max length	PVC	PVC	625	100 PSI @ 160°F	100 PSI @ 160°F
41-5027	For low dielectric fluids/signal compensation on horizontal tanks/turbulent surface/free flow liquid only w/stilling well	Rod—TFE Well—316 SS	316 SS	375 875	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F
41-5029	Clean, conductive, non-viscous liquids with 316 SS ground wire	TFE	316 SS	625	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F
41-5030	Clean, conductive, non-viscous liquids with 316 SS ground wire, 48" maximum length	TFE	316 SS	375	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F

(3) Consult the factory for horizontal mounting of bare probes.

Kynar is a registered trademark of Pennwalt.

(1) Temperature at electronics should not exceed +160°F. Probe pressure/temp. ratings limited to the lesser value of the probe or flange selected.

(2) Designed to mate with Triclover 16 AMP type fitting. For other sizes and configurations consult the factory.

**1 Rigid probe configurations cont.**

Probe Part No.	Application	Material		Probe Dia. Inches	Probe Pressure/Temperature Rating (7)	
		Probe	Nut		Integral Mount	Remote Mount
41-5032	Conductive or non-conductive liquids and bulk materials under 40 lb./cu. ft., w/90° bend, 1" radius, 48" maximum length	TFE	316 SS	.375	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F
41-5035	Conductive or non-conductive liquids and bulk materials over 40 lb./cu. ft., w/90° bend, 2.5" radius, 110" max. length	TFE	316 SS	.625	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F
41-5036 (5)	High temp./high pressure liquids w/90° bend, 2.5" radius, 110" max. length	316 SS	316 SS	500	5000 PSI @ 100°F 800 PSI @ 350°F	500 PSI @ 1000°F 800 PSI @ 350°F
41-5038 (5)	High temp./high pressure liquids	316 SS	316 SS	375	5000 PSI @ 100°F 800 PSI @ 350°F	500 PSI @ 1000°F 800 PSI @ 350°F
41-5039	For low dielectric fluids/signal compensation on horizontal tanks/turbulent surface/free flow liquid only with stilling well	Rod—304 SS Well—304 SS	316 SS	500 875	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F
41-5041	Corrosive liquids or polypropylene requirement	Polypropylene	316 SS	.625	100 PSI @ 160°F	100 PSI @ 250°F
41-5042	Conductive or non-conductive liquids and bulk materials over 40 lb./cu. ft., w/316 SS inactive sheath, 6" sheath standard (7" min. insertion length)	TFE	316 SS	.625	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F
41-5045 (5)	High temp./high pressure w/6" dia. proximity plate, 48" max. length	316 SS	316 SS	.375	5000 PSI @ 100°F 800 PSI @ 350°F	500 PSI @ 1000°F
41-5047 (5)	High temp./high pressure low dielectric liquids w/stilling well	Rod—316 SS Well—316 SS		.375 875	5000 PSI @ 100°F 800 PSI @ 350°F	500 PSI @ 1000°F
41-5051	High temp./high press., sectionalized 5' lengths, 31-5045-001, sections may be made to specific order, 15 ft. max.	316 SS	316 SS	500	5000 PSI @ 100°F 800 PSI @ 350°F	500 PSI @ 1000°F 800 PSI @ 350°F
41-5052 (5)	High temp./high pressure liquids w/10" heat extension	316 SS	316 SS	.375	5000 PSI @ 100°F 800 PSI @ 350°F	500 PSI @ 1000°F
41-5053 (5)	High temp./high pressure w/6" dia. proximity plate and w/10" heat extension, 48" max. length	316 SS	316 SS	.375	5000 PSI @ 100°F 800 PSI @ 350°F	500 PSI @ 1000°F
41-5054 (5)	High temp./high pressure low dielectric liquids w/10" heat extension & stilling well	Rod—316 SS Well—316 SS	316 SS	.375 875	5000 PSI @ 100°F 800 PSI @ 350°F	500 PSI @ 1000°F
41-5059	Liquids or low density media	ECTFE	316 SS	500	5000 PSI @ 100°F 2100 PSI @ 160°F	5000 PSI @ 100°F 450 PSI @ 285°F
41-5060	Corrosive liquids or ECTFE requirement w/ECTFE faced 1.5" 150 lb. carbon steel flange	ECTFE	ECTFE Faced Flange	500	260 PSI @ 160°F	250 PSI @ 285°F
41-5061	Corrosive liquids or ECTFE requirement w/ECTFE faced 1.5" 300 lb. carbon steel flange	ECTFE	ECTFE Faced Flange	500	700 PSI @ 160°F	300 PSI @ 285°F
41-5062	Corrosive liquids or ECTFE requirement w/ECTFE faced 2" 150 lb. carbon steel flange	ECTFE	ECTFE Faced Flange	500	260 PSI @ 160°F	250 PSI @ 285°F
41-5063	Corrosive liquids or ECTFE requirement w/ECTFE faced 2" 300 lb. carbon steel flange	ECTFE	ECTFE Faced Flange	500	700 PSI @ 160°F	300 PSI @ 285°F
41-5064	Corrosive liquids or ECTFE requirement w/ECTFE faced 3" 150 lb. carbon steel flange	ECTFE	ECTFE Faced Flange	500	260 PSI @ 160°F	250 PSI @ 285°F
41-5065	Corrosive liquids or ECTFE requirement w/ECTFE faced 3" 300 lb. carbon steel flange	ECTFE	ECTFE Faced Flange	500	700 PSI @ 160°F	300 PSI @ 285°F
41-5066	Liquids or low density media w/316 SS inactive sheath, 6" sheath standard (9" min. insertion length)	ECTFE	316 SS	500	5000 PSI @ 100°F 2100 PSI @ 160°F	5000 PSI @ 100°F 450 PSI @ 285°F
41-5067	For low dielectric fluids/signal compensation on horizontal tanks/turbulent surface/free flow liquid only w/stilling well	Rod—ECTFE Well—316 SS	316 SS	500 875	5000 PSI @ 100°F 2100 PSI @ 160°F	5000 PSI @ 100°F 450 PSI @ 285°F
41-5068	Liquids or low density media w/90° bend, 1.5" radius	ECTFE	316 SS	500	5000 PSI @ 100°F 2100 PSI @ 160°F	5000 PSI @ 100°F 450 PSI @ 285°F
41-5069	Liquids or low density media w/90° bend and inactive length, 1.5" radius, 110" max. length	ECTFE	316 SS	500	5000 PSI @ 100°F 2100 PSI @ 160°F	5000 PSI @ 100°F 450 PSI @ 285°F
41-5070 (5)	Fluids as point sensor, non-conductive fluids as transmitter, low density bulk media	316 SS	316 SS	.375	5000 PSI @ 100°F 2100 PSI @ 160°F	5000 PSI @ 100°F 450 PSI @ 285°F

(5) Consult factory for horizontal mounting of bare probes.

(7) Temperatures at electronics should not exceed +160°F. Probe pressure/temp. ratings limited to the lesser value of the probe or flange selected.

## 1 Rigid probe configurations cont.

Probe Part No.	Application	Material		Probe Dia. Inches	Probe Pressure/Temperature Rating ⑦	
		Probe	Nut		Integral Mount	Remote Mount
41-5071	Fluids as point sensor, non-conductive fluids as transmitter, low density bulk media w/90° bend, 1.5" radius, 120" max. length	316 SS	316 SS	.375	5000 PSI @ 100°F 2100 PSI @ 160°F	5000 PSI @ 100°F 450 PSI @ 285°F
41-5072 ⑤	High density bulk media, low dielectric fluids—ECTFE seal, 120" max. length	316 SS	316 SS	.500	5000 PSI @ 100°F 2100 PSI @ 160°F	5000 PSI @ 100°F 450 PSI @ 285°F
41-5073	Liquids requiring Monel, 120" max. length	Monel	Monel	.375	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F
41-5074	Liquids requiring Hastelloy B, 120" max. length	Hastelloy B	Hast. B	.375	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F
41-5075	Liquids requiring Hastelloy C, 120" max. length	Hastelloy C	Hast. C	.375	1000 PSI @ 70°F 500 PSI @ 180°F	1000 PSI @ 70°F 500 PSI @ 300°F
41-5076	Corrosive liquids and vapors	ECTFE	ECTFE	.500	500 PSI @ 100°F	150 PSI @ 285°F
41-5077	Clean, conductive, non-viscous liquids with 316 SS ground wire	ECTFE	316 SS	.500	5000 PSI @ 100°F 2100 PSI @ 160°F	5000 PSI @ 100°F 450 PSI @ 285°F
41-5078	Conductive fluids in non-metal tanks w/insulated reference rod and 3" 150 lb. faced flange	ECTFE	C/S Flange	.500	285 PSI @ 70°F 260 PSI @ 180°F	1000 PSI @ 70°F 230 PSI @ 285°F
41-5080	Corrosive liquids or Kynar requirement w/Kynar faced 1.5" 150 lb. carbon steel flange	Kynar	Kynar Faced Flange	.625	260 PSI @ 160°F	260 PSI @ 160°F
41-5081	Corrosive liquids or Kynar requirement w/Kynar faced 1.5" 300 lb. carbon steel flange	Kynar	Kynar Faced Flange	.625	700 PSI @ 160°F	700 PSI @ 160°F
41-5082	Corrosive liquids or Kynar requirement w/Kynar faced 2" 150 lb. carbon steel flange	Kynar	Kynar Faced Flange	.625	260 PSI @ 160°F	260 PSI @ 160°F
41-5083	Corrosive liquids or Kynar requirement w/Kynar faced 2" 300 lb. carbon steel flange	Kynar	Kynar Faced Flange	.625	700 PSI @ 160°F	700 PSI @ 160°F
41-5084	Corrosive liquids or Kynar requirement w/Kynar faced 3" 150 lb. carbon steel flange	Kynar	Kynar Faced Flange	.625	260 PSI @ 160°F	260 PSI @ 160°F
41-5085	Corrosive liquids or Kynar requirement w/Kynar faced 3" 300 lb. carbon steel flange	Kynar	Kynar Faced Flange	.625	700 PSI @ 160°F	700 PSI @ 160°F
41-5086 ③	High temp./high pressure low dielectric liquids w/10" heat extension & stilling well	Rod—316 SS Well—316 SS	316 SS	.500 .875	5000 PSI @ 100°F 800 PSI @ 350°F	500 PSI @ 1000°F
41-5087	1.25" tube probe for short spans in low dielectric materials w/1.5" NPT conn., 120" max. length	316 SS	316 SS	1.25	5000 PSI @ 100°F 2100 PSI @ 160°F	5000 PSI @ 100°F 450 PSI @ 285°F
41-5088	1.25" tube probe, same as 41-5087 w/integral 2" C.S. stillwell and 2" NPT conn., 120" max. length	316 SS	316 SS	1.25 1.60	5000 PSI @ 100°F 2100 PSI @ 160°F	5000 PSI @ 100°F 450 PSI @ 285°F
41-5089 ③	High temp./high pressure probe with 4" carbon steel stillwell and 4" 150 lb. flange for use in viscous, low dielectric material	316 SS	316 SS	.500 4.26	285 PSI @ 100°F	230 PSI @ 350°F
41-5090 ③	High temp./high pressure low dielectric liquid w/stilling well	Rod—316 SS Well—316 SS	316 SS	.500 .875	5000 PSI @ 100°F 800 PSI @ 350°F	500 PSI @ 1000°F
41-5093	High temp./high pressure requiring an insulated probe, 180" max. length	TFE	316 SS	.625	3000 PSI @ 70°F 2000 PSI @ 180°F	3000 PSI @ 70°F 200 PSI @ 400°F
41-5094 ③	Sanitary probe w/3A authorization and 1" or 1.5" sanitary fitting standard, 180" max. length	TFE	316LSS	.625	Ratings determined by clamp type chosen. Probe exceeds all clamp ratings.	
41-5095	For conductive media requiring high capacitance gain/inch	Kynar	316 SS	.625	3000 PSI @ 70°F 1000 PSI @ 180°F	3000 PSI @ 70°F 500 PSI @ 250°F
41-5097 ③	Sanitary probe w/3A authorization and 2" sanitary fitting standard, 180" max. length	TFE	316LSS	.625	Ratings determined by clamp type chosen. Probe exceeds all clamp ratings.	

⑤ Consult the factory for horizontal mounting of bare probes.

Kynar® is a registered trademark of Pennwalt.

⑦ Temperature at electronics should not exceed + 160°F. Probe pressure/temp. ratings limited to the lesser value of the probe or flange selected.

③ Designed to mate with Triclover 16 AMP type fitting. For other sizes and configurations consult the factory.

## 1 Flexible probe configurations

Probe Part No.	Application	Material		Probe Dia. Inches	Probe Pressure/Temperature Rating ⑦	
		Probe	Nut		Integral Mount	Remote Mount
41-5101	All media	ECTFE	316 SS	.1875	100 PSI @ 160°F	50 PSI @ 285°F
41-5102	Conductive media w/span over 40 feet	ECTFE	316 SS	.2500	100 PSI @ 160°F	50 PSI @ 285°F
41-5103	Conductive media requiring PVC	PVC	CPVC	.2500	5 PSI @ 140°F	5 PSI @ 140°F
41-5105	High temp./high pressure w/spans over 10 feet	316 SS	316 SS	.1875	5000 PSI @ 100°F	800 PSI @ 350°F 500 PSI @ 650°F

## Product warranty

All Magnetrol electronic level controls are warranted free of defects in materials or workmanship for one full year from the date of original factory shipment.

If returned within the warranty period, and upon factory inspection of the unit, the

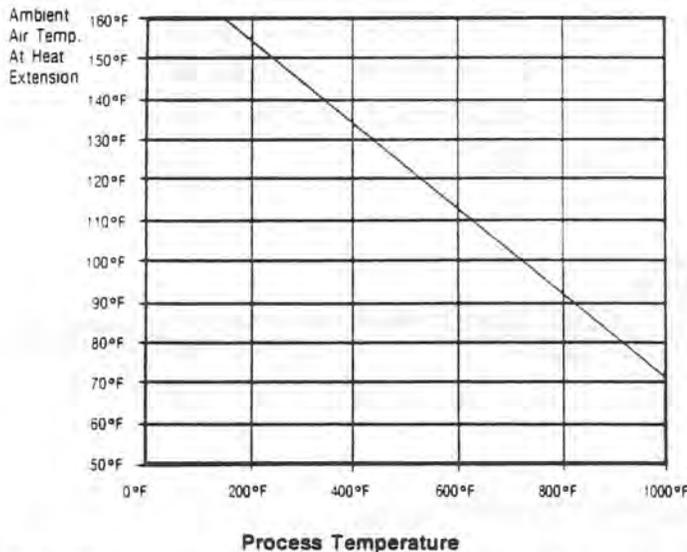
cause of the claim is determined to be covered under the warranty, then Magnetrol International will repair or replace the control at no cost to the purchaser (or owner) other than transportation.

Magnetrol shall not be liable for misapplication, labor

claims, direct or consequential damage or expense arising from the installation or use of the equipment. There are no other warranties expressed or implied, except special written warranties covering some Magnetrol products.

## Heat dissipation graph

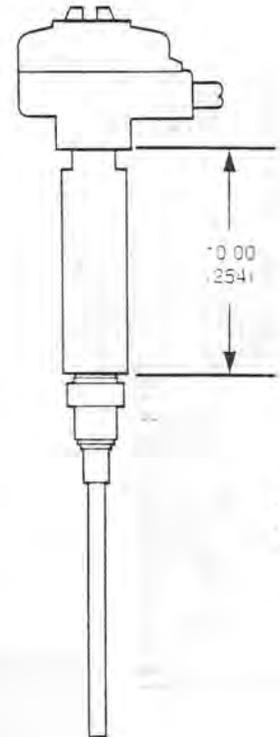
For use with Heat Extension (89-6593-001)



The heat dissipation graph at left depicts the maximum temperatures at which the heat extension, P/N 89-6593-001, can be used effectively.

1. Determine the maximum process temperature in the application and locate on the X axis.
2. Determine the maximum ambient temperature surrounding the heat extension and locate on the Y axis.
3. If the intersecting point on the graph is within the shaded area the heat extension will dissipate enough heat to keep the electronics temperature below +160°F (+71°C).

**NOTE:** The heat extension can be used with all rigid probe configurations and flexible probe configuration 41-5105.



**Note:** Do not exceed maximums for each probe rod and nut insulation or value of the selected flange.

## Probe mounting flanges

Raised face mounting flanges are available in the sizes and materials shown at right. Specify the part number as an additional line item when placing an order. Consult factory for additional flanges.

## Probe accessories

The probe accessories listed may be ordered as additional line items when placing an order.

**Heat extension** ..... 89-6593-001

## Flexible probes

Anchor assembly ..... 32-8814-001  
Weight ..... 04-4355-001

**Adaptors to convert 41-5000 Series 3/4" NPT probes to fit slip-on housing connections**

For rigid probes ..... 89-6591-001  
For flexible probes ..... 89-6591-002

Flange		Part Number			
Size	Rating	316 SS	304 SS	Carbon Steel	Hastelloy C
1 1/2"	150 lb.	04-5867-001	04-5867-011	04-5867-021	04-5867-031
2"		04-5867-002	04-5867-012	04-5867-022	04-5867-032
3"		04-5867-003	04-5867-013	04-5867-023	C/F
4"		04-5867-004	04-5867-014	04-5867-024	C/F
6"	300 lb.	04-5867-005	04-5867-015	04-5867-025	C/F
1 1/2"		04-5867-006	04-5867-016	04-5867-026	04-5867-036
2"		04-5867-007	04-5867-017	04-5867-027	04-5867-037
3"		04-5867-008	04-5867-018	04-5867-028	C/F
4"		04-5867-009	04-5867-019	04-5867-029	C/F
6"		04-5867-010	04-5867-020	04-5867-030	C/F
1 1/2"	600 lb.	04-5867-045	C/F	04-5867-046	C/F



5300 Belmont Road • Downers Grove, Illinois 60515-4499 • (708) 969-4000 • Fax 708-969-9489  
8291 Dorman Road • Mississauga, Ontario L4V-1H2 • Phone: (416) 678-2720 • Fax 416-678-7407  
Heikenstraat 6 • B 9240 Zele, Belgium • Tel. 052 45.11.11 • Telex 25944 • Fax 052 45.09.93  
Regent Business Ctr., Jubilee Rd., Burgess Hill, Sussex RH15 9TL U.K. • Tel: 0444-871313 • Telex 87255 • Fax 044-871317

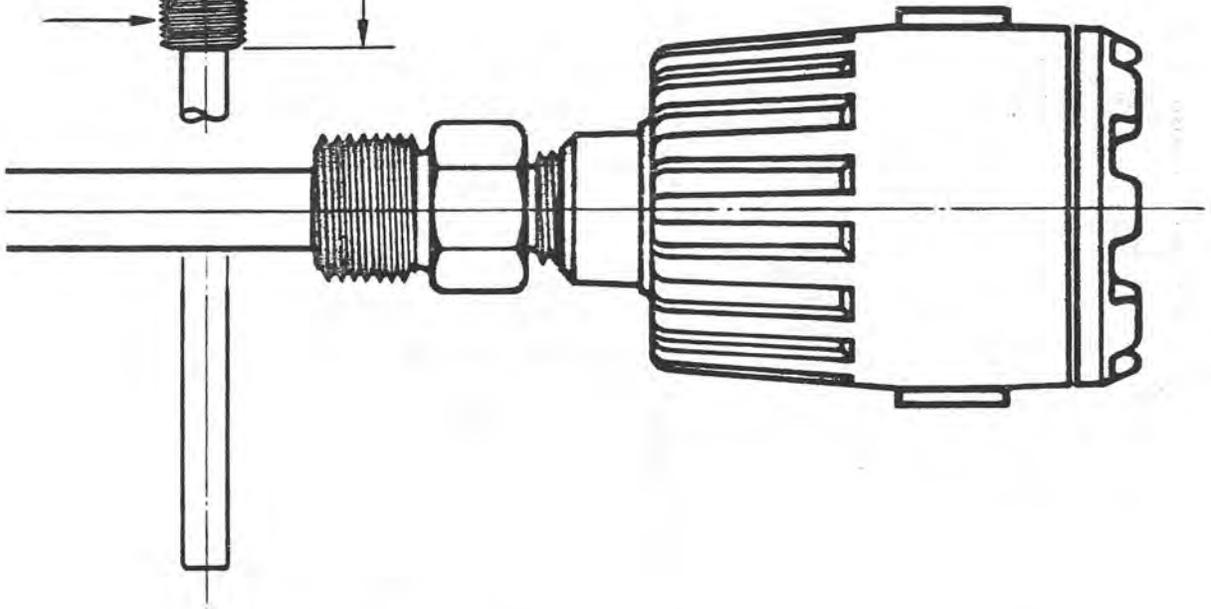
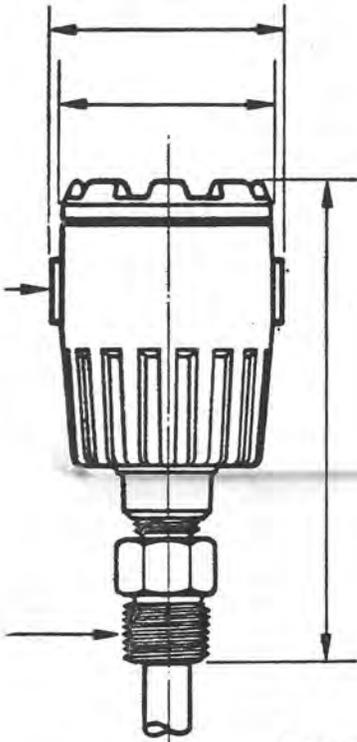
BULLETIN: 50-125.3  
EFFECTIVE: January 1992  
SUPERSEDES: February 1991



# Endress + Hauser, Inc. LTC 1210

Two-wire capacitance  
level transmitter

Isolated two-wire transmitter  
4-20 mA loop current  
13-55 VDC supply range  
END-A-COAT™ circuitry  
Independent zero and span  
State-of-the-art electronics  
Safety-designed probe circuit  
Low cost



### The advantages are obvious: ECONOMICS, SAFETY, ACCURACY AND FLEXIBILITY

The LTC 1210 is an advanced two-wire capacitance transmitter designed for all continuous level measurement applications. Expensive installation and maintenance costs are eliminated; the same two wires which power the LTC 1210 also transmit its output signal. Isolated, two-wire design eliminates ground loop errors to insure accuracy. With End-A-

Coat™ circuitry, the LTC 1210 is immune to conductive buildup. Sludge, slurries, industrial waste and other sticky applications are no challenge for the LTC 1210. Independent and non-interacting zero and span adjustments make calibration simple. Totally self-contained, the LTC 1210 features a probe circuit designed with safety in mind and is housed in an explosion-proof enclosure.

## PRINCIPLE OF OPERATION

The LTC 1210 works on a field-proven electronic capacitance principle. The transmitter utilizes low voltage, high frequency (RF) signal from probe to ground. Changes in the level of material generate

a 4-20 milliampere signal which is directly proportional to the actual level of the material being monitored. Transmission distance is limited only by loop resistance.

## DIMENSIONS

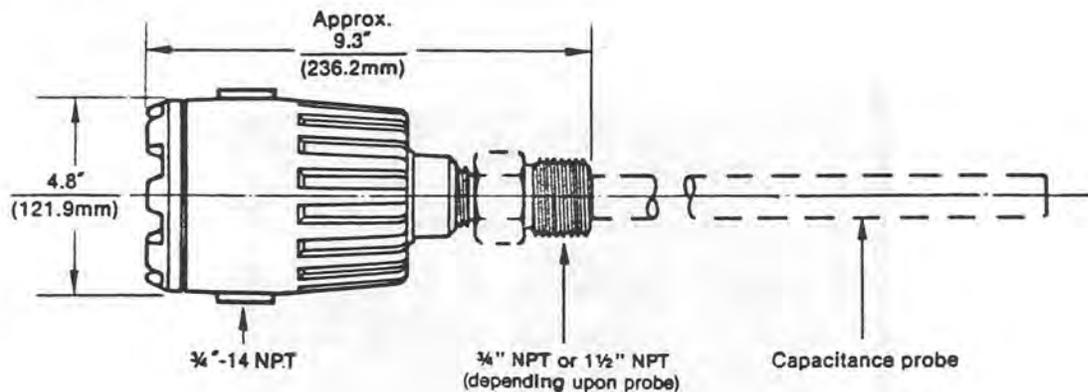


Figure 1

## SPECIFICATIONS

**Housing:** Die cast aluminum, NEMA 4x, 7, 9, 12.

**Probe:** All Endress + Hauser capacitance probes.

**Operating principle:** High frequency (RF) capacitance.

**Operating temperature range for electronics:** 0°F to 140°F (-20°C to +60°C).

**DC Power Supply range:** 13-55 VDC.

**Output:** 4-20 mA representing 0 to 100% of measuring span; output current is independent of the supply voltage but superimposed on the supply voltage line.

**Isolation:** 500 Vrms, approximately 50 pF coupling capacitance between probe and transmitter.

**Initial capacitance-zeroing capability:** up to 500 pF (maximum conductivity:  $2.13 \times 10^{-3}$  mhos).

**Maximum span:** 2000 pF. (May typically be estimated as 90 pF per foot of span in conductive materials.)

**Minimum span:** 50 pF. (May be typically estimated as 3 pF per foot of span in oils.)

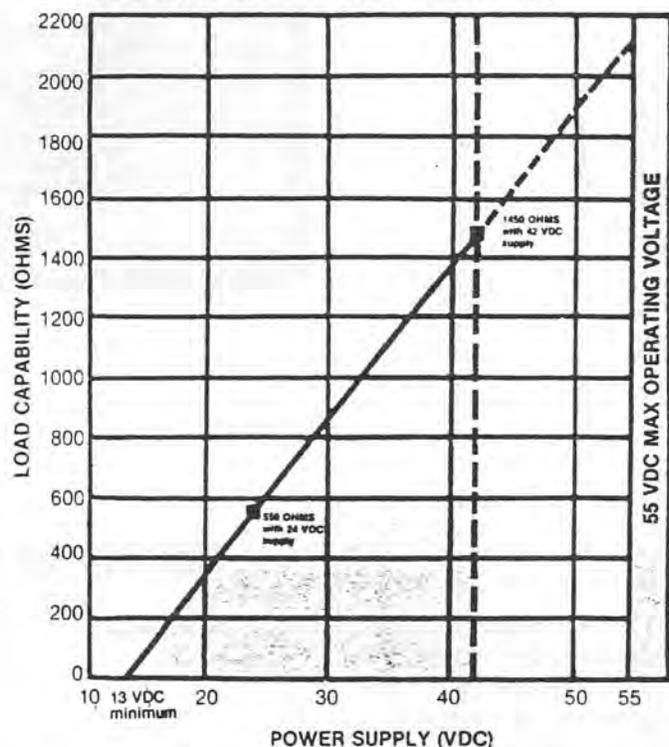
**Maximum transmission distance:** limited only by loop resistance.  $R \text{ (ohms)} = [\text{input voltage (volts)} - 13] / .02$

**% Accuracy over temperature:** as low as  $\pm 1\%$  F.S. (%accuracy =  $0.7 + (160 \div \text{"Span in pF"})$ ) Examples: 0.8% at 2000 pF; 3.9% at 50 pF

**Repeatability:** 0.5%

The LTC 1210 two-wire transmitter is available from stock with probes to meet any application requirements. For further information contact your Endress + Hauser representative or call us direct.

## LOAD CAPABILITY (loop resistance)



## Endress + Hauser, Inc.

2350 Endress Place  
P.O. Box 246 Greenwood, IN 46142  
Phone: 317/535-7138

Telex: 27-2195 (Level Grwd)  
Cable: LEVEL Greenwood

**TOLL FREE 800-428-4344**



Endress + Hauser, Inc.

# LTC 1230 CONTINUOUS CAPACITANCE LEVEL MEASUREMENT SYSTEM



## SYSTEM FEATURES

- Reliably monitors changing levels of conductive or non-conductive materials
- Microprocessor controlled
- System accuracy better than 1%
- Repeatability of 0.1%
- Linearity is 1% of full scale
- Digital readout in % or engineering units
- LCD display of individual setpoint values
- LED display of alarm relay status
- Simple pushbutton calibration
- Program sentry to prevent unauthorized access
- Isolated 4-20 mA DC output, user-configurable, hi and lo end
- Field programmable failsafe
- Maintenance free design, no moving parts
- Probe designs for virtually all applications
- Optional extended span up to 4000 pF
- Optional LINEARIZER
- Optional **Acculevel™** for liquids with varying dielectric constant plus dielectric constant alarm
- Holds programmed data over 5 years during power failure

## SPECIFICATIONS: LTC 1230

Enclosure:	NEMA 4, 4X, 12
Power:	115 VAC 60 Hz (+10%, -15%) 15 VA maximum 230 VAC 50/60 Hz Optional 24 VDC (22.5 to 32 VDC) optional
Display:	4 Digit LCD, 0.5" character height, 0-100% standard, user- programmable engr. units
Output:	Isolated 4-20 mA DC into 1 K ohm, user-programmable from 0.00 mA to 8 mA and 12 mA to 20 mA, selectable inverted 20-4 mA DC
Ambient Temperature Limits:	-20°F to +140°F
Linearity:	1% of full scale
Repeatability:	0.1%
Accuracy:	1% or better
Measuring Range Maximum:	2000 pF, optional extended span to 4000 pF
Minimum Span:	10 pF
Zero Offset:	0-500 pF
Dielectric Constant:	1.5 to infinity
Setpoint Alarms:	4 maximum, SPDT 10A at 250 VAC or 28 VDC
Diagnostic Relay Output:	SPST 5A at 250 VAC or 28 VDC
Fault Delay:	Signal failure delay, 0.5 to 60 seconds, programmable
Speed of Response:	0-60 seconds, programmable
Signal Failsafe:	User-programmable, output drives upscale to 100%, downscale to 0% or holds last value if a system fault should occur.
User Options:	Selectable via pushbutton pro- gramming and rotary selection switch
Alarm Time Delay:	0 to 100 seconds, programmable
Alarm Deadband:	0% to 100%, programmable
Options:	<b>Acculevel™</b> with dielectric constant alarm  Programmable LINEARIZER

## ELECTRONIC PREAMPLIFIER (End-A-Coat™)

Enclosure:	Die cast aluminum, Model E-1 FM approved Explosion-proof CLI, DIV 1, 2; GRP A, B, C, D; Dust Ignition-proof CL II, DIV 1, 2; GRP E, G; NEMA 4X
Power:	From LTC 1230 via 2-conductor twisted pair un- shielded cable, up to 1 mile
Output: Frequency:	Pulse Frequency Modulation 1 MHz
Operating Range:	10 to 2000 pF
Operating Temperature:	-40°F to +212°F, remote ver- sion for high temperature available, consult factory
Temperature Stability:	0.01% per °F
Adjustments:	Not required

## OPTIONAL ELECTRONIC PREAMPLIFIER (for extended span) - limited build-up capability

Enclosure:	Die cast aluminum, Model E-1, FM approved Explosion-proof CLI, DIV 1, 2; GRP A, B, C, D; Dust Ignition-proof CLII, DIV 1, 2; GRP E, G; NEMA 4X
Power:	From LTC 1230 via 2-conductor twisted pair un- shielded cable, up to 1 mile
Output: Frequency:	Pulse Frequency Modulation 33 KHz
Operating Range:	10 to 4000 pF
Operating Temperature:	-40°F to +212°F, remote version for high temperature available, consult factory
Temperature Stability:	0.01% per °F
Adjustments:	Not required

## MICROPROCESSOR RELIABILITY

The LTC 1230 continuous level system utilizes microprocessor technology to control virtually any process application. Modular design and user-programmable options insure ease of installation and low maintenance requirements.

One major benefit for your process control is zero suppression. This feature permits you to add an offset to

the display that indicates the remaining level in the vessel where the probe is normally shorter than the actual vessel bottom. Other user systems will indicate zero when the material reaches the bottom of the sensor — your vessel may still contain, for example, 8 inches of material, 200 gallons of liquid or a 10% level. Zero suppression lets you program the system to indicate actual levels.

The microprocessor provides a self-diagnostic feature that continually checks certain aspects of its operation while in use. Self-checking includes:

- Sensor connection and operation
- Calibration data
- Electronics failure

Should the fault alarm LED flash on and off, the operator simply turns the rotary switch to "DIAGNOSTIC" and an error code is displayed on the digital LCD.

Other system features which provide ultimate control of the process level include:

- Programmable isolated current output
- Programmable speed response to delay output signal when liquid surface motion is a problem
- Programmable fault delay to set time between a fault occurrence and a fault alarm
- Programmable level display, 0% to 100%, or engineering units from 0 to 9999

## PROGRAMMING MADE SIMPLE

The LTC 1230 sets a new standard for calibration simplicity. Custom tailoring to your exact process requirements is quickly and easily accomplished. Changes in your process requirements can be easily programmed without using external calibration equipment or interrupting the process.

The LTC 1230 program panel (Figure 1) provides a rotary selector switch and five pushbuttons. In addition, a mode indicator (show units, %, or seconds depending on switch selection), four setpoint LED's, and the digital LCD interact to provide precise calibration data as entered. To prevent tampering or accidental program changes, the LTC 1230 features a "sentry" technique that requires a known entry code to access program modes. Entered data is stored in memory and protected from power outages for over five years.

## APPLICATION VERSATILITY

The LTC 1230 is a highly reliable system designed to handle nearly all your level measurement needs. The system is available with the industry's widest selection of probe sensors to meet virtually any application; liquid, solid, or slurry. The LTC 1230 provides maximum security against dangerous and costly overflows. Setpoint-alarm options are simple pushbutton entries and two plug-in alarm modules may be specified to achieve complete control and limit outputs. Each module includes two independent relays which may be programmed for time delay or deadband. The LTC 1230 may be specified without alarms, with dual alarms or with four alarms. Programmed setpoints are indicated on the panel even when alarm relays are not specified.

An optional programmable linearizer is available for applications where the volume or desired units are not linear with the fluid level. The output and display may be scaled to actual tank volume or flow volume proportional to level. Example: Horizontal cylindrical tanks.

In liquid applications where various dielectric constant fluids are mixed or stored, the **Acculevel™** option may be specified. The system automatically compensates for

LED DISPLAY  
(4 digit)

SETPOINT LEDS  
(4)

DISPLAY  
SELECTION



MODE INDICATOR  
(units, seconds, %)

ALARM LED

PROGRAM  
PUSHBUTTONS

LTC 1230 PROGRAM PANEL  
Figure 1

varying dielectrics resulting in accurate level measurements. The Acculevel™ option provides a minimum/maximum dielectric fault relay which allows you to enter the min/max dielectric of the material being measured.

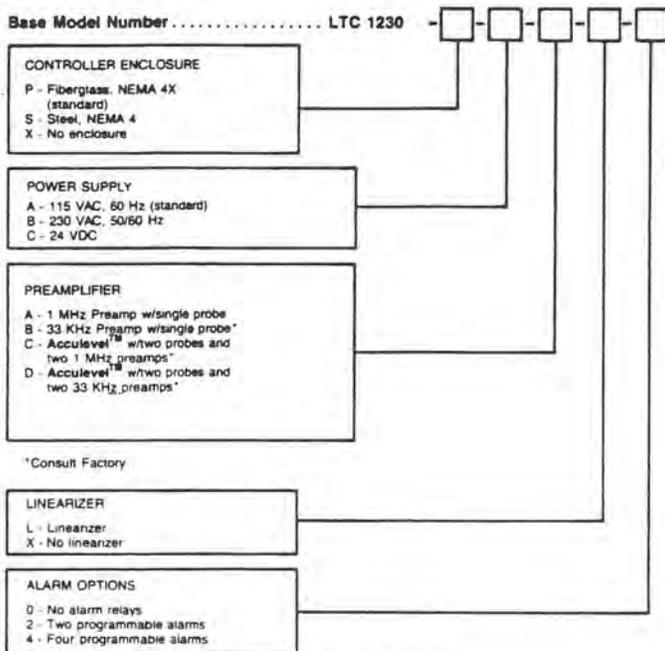
If the material dielectric exceeds or falls below set values,

the fault relay will trip.

The Acculevel™ option uses two independent probes; one as a reference, the other for level control. A dual segmented probe will soon be available (consult factory) which in most applications eliminates the reference probe unit.

## ORDERING INFORMATION

Construct Model Number by selecting one code from each category.



**NOTE:** Acculevel™ options require special probe/ground tube sensors and are designed for rod probes only. Consult factory for application and availability.

## PROBE SENSING ELEMENT (per application requirements)

Typical probes include:

Model 1320-2X001 — Fully Teflon insulated rod probe for conductive or corrosive environments.

Model 1330-2X001 — Partially Teflon insulated rod probe for non-conductive processes.

Model 2120-2X501 — Fully Teflon insulated cable probe (available with all wetted parts Teflon) for conducted processes.

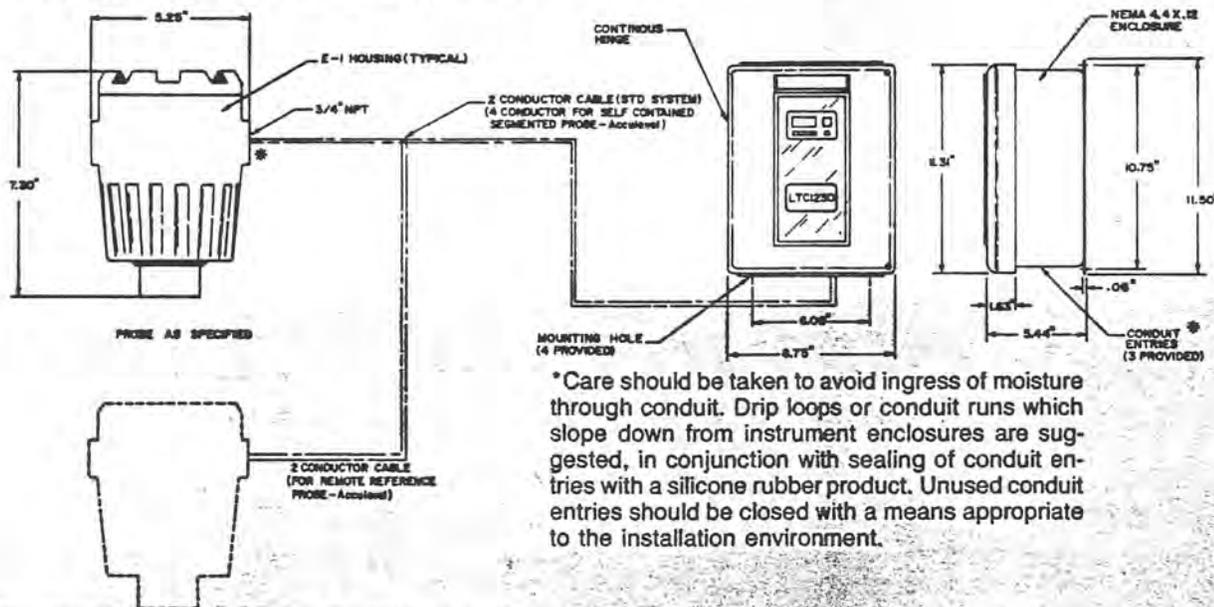
Model 2130-2X501 — Partially Teflon insulated cable probe for non-conductive processes.

Model 2800 Series — Heavy duty cable probe for harsh environments in solids.

Endress + Hauser technology is available for custom sensors as required, please consult factory.

Probes are priced and ordered separate from the LTC 1230 system.

## DIMENSIONS AND OUTLINE DETAILS



APPENDIX B: VELOCITY INSTRUMENTATION

# 2100

## CURRENT VELOCITY METER



SWOFFER INSTRUMENTS

2100

CLIPPING VELOCITY METER



# MODEL 2100

## 1992 PRICE LIST

SWOFFER INSTRUMENTS, INC.  
1048 Industry Drive  
Seattle, WA 98188  
U.S.A.  
(206) 575-0160  
FAX (206) 575-1329

MODEL NO.	DESCRIPTION	PRICE
2100-STDX	2' to 9½' telescoping extension wand with no graduations. Sensor is mounted on an 8" boom. A 2' depth probe is provided.	1,765.00
2100-LX	4' to 19½' extension. Same as the 2100-STDX except each telescoping section is 4'. Depth probe is 3' long.	1,865.00
2100-TSR-KIT	Includes the Digital Readout Indicator, Propeller Rotor Assembly, Sensor w/10' cable, and the 2100-TSR adapter. When coupled with your U.S.G.S. Top-Set Wading Rod, the 2100-TSR-KIT will make up a complete current meter. <small>NOTE: Swoffer does not supply the U.S.G.S. version of the Top-Set Wading Rod.</small>	1,560.00
2100-12	⅝ depth method. Wading rod measures to 2.7 feet.	1,695.00
2100-13	⅝ depth method. Wading rod measures to 3.7 feet.	1,745.00
2100-14	⅝ depth method. Wading rod measures to 4.7 feet.	1,810.00
2100-C80	⅝ depth method. Wading rod measures to 80cm.	1,765.00
2100-C140	⅝ depth method. Wading rod measures to 140cm.	1,870.00
2100-1514	12' total length. 1" diameter thick-walled aluminum tube graduated from bottom to top in feet and tenths. Wand breaks down via threaded fittings into four lengths of three feet each. Sensor cable length is 25'. This current meter is also supplied with the Top Cap, Slider, and Foot as described on back. Total wand length can be increased by use of the extra sections as shown on back.	2,125.00
2100-1518	4 M total length. Same as the 2100-1514 except has four 1" diameter sections of 1 meter each. Graduation marks are every 5cm.	2,230.00

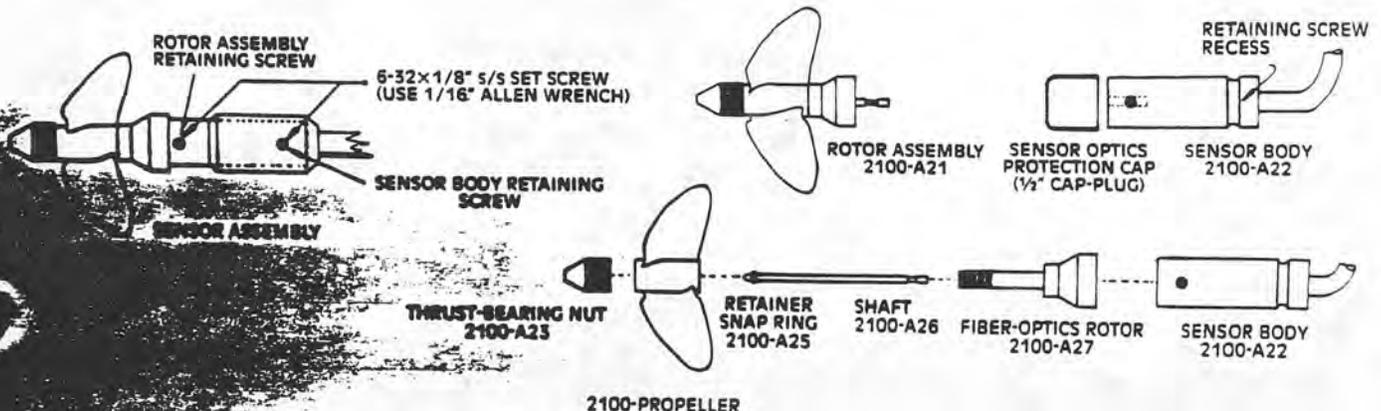
All Model 2100 instruments above are supplied with a 9-volt alkaline battery plus a spare, two complete Rotor Assemblies (2100-A21), a spare propeller, the Digital Readout Indicator with neck strap and the Model 2100 Sensor (2100-A22). Cable length equal to the sensor wand at its full extension plus five feet except where noted otherwise.

The sensor wands are shipped in a PVC tube which serves as a permanent carrying/storage case. **Not Supplied** but a very worthwhile option is the small Pelican Box® to protect the Model 2100 Indicator and Rotor Assembly during transport and storage.

Prices are in U.S. Dollars and are subject to change without notice. Prices are FOB Seattle, Washington ONLY. Shipping will be by United Parcel Service unless specified otherwise. Shipping charges will be pre-paid and added to invoice.

Terms of sale are 2% discount cash (15 days), Net 30 Days to those companies/organizations with approved credit.

All Swoffer Instruments products are warranted against defects in workmanship and materials for one year. For a copy of the complete warranty or if you have any questions about Swoffer products, please write or call.



Model 2100 Sensor

½ Actual Size

# OPTIONAL ACCESSORIES

MODEL NO.	DESCRIPTION	PRICE
2100-151G	Extra 1" dia. lengths for the 2100-1514 wands. Graduated in feet and tenths. Please specify starting number when ordering.	3' — \$185.00
		3' bottom section — 195.00
2100-151M	Extra 1" dia. lengths for the 2100-1518 wands. 5cm graduations. Please specify starting number when ordering.	1 meter — 210.00
		1 meter bottom section — 215.00
2100-151	Same as the above but with no graduations.	3' — 103.00
		3' bottom section — 113.00
		1 meter — 121.00
	1 meter bottom section — 131.00	
2100-151-Top Cap	Fits the top of any of the -151 rods.	90.00
2100-151-Slider	Supplied with the 2100-1514 and 2100-1518 but available separately if you wish to use your own 1" diameter rod.	95.00
2100-151-Foot	2½" diameter aluminum plate attached to the lower section of a -151 series wand. Comes with ¼-28 s/s bolt and lockwasher for installation.	75.00
2100-TSR	Acetal resin adapter for using the 2100 propeller sensor on a U.S.G.S. Top-Set Wading Rod. The 2100-TSR directly replaces the original "slider" of the wading rod and the propeller sensor is removed and replaced as needed. This part is supplied with the 2100-TSR-KIT as noted on the front.	65.00
2100-48	Stainless steel, brass, and fiberglass adapter for using the Model 2100 sensor with a cable suspension system. Swoffer does not supply the cable, reels, or weights.	310.00
Pelican Case®	Rugged, waterproof ABS case with pre-cut high density foam insert. Plenty of room inside for the Model 2100 Indicator, Sensor, and cable with room left over for other instruments you want to protect. I.D. is 17½ by 11¾ by 6½ inches.	109.50
Pellicase®	Smaller version of the Pelican Case above. I.D. is 12½ by 9¼ by 5¼ inches.	69.95
Pelican Box®	Waterproof ABS box which fits the Model 2100 Indicator. Provides extra protection for the Indicator and Rotor Assembly in transport and storage.	19.95



2100-151 SLIDER



2100-TSR  
INSTALLED ON  
TOP-SET WADING ROD

PELICAN CASE



PELICAN BOX

Pelican Case, Pellicase, and Pelican Box are registered trademarks of Pelican Products, Inc., Torrance, California.

# MODEL 2100 SPARE AND REPLACEMENT PARTS

MODEL NO.	DESCRIPTION	PRICE
2100-INDICATOR	Digital readout indicator only	\$1,200.00
2100-A21	Rotor Assembly with Rotor Shaft & Propeller	65.00
2100-A22	Sensor w/o Rotor Assembly. Cable length to 25'	225.00
2100-A23	Thrust Bearing Nut	7.00
2100-PROP	Propeller replacement	1.75
2100-A25	Retainer Snap Ring for Rotor Shaft	.60
2100-A26	Rotor Shaft (Includes 2100-A25)	21.00
2100-A27	Fiber-Optics Rotor	40.00
6-32 Set Screw	Stainless Steel socket hex head screw	.20
½" Cap Plug	Used to protect Sensor Optics when Rotor is removed	.10
EXTENSION CABLE Any length to 1000 feet. Twist lock connector at both ends. \$18.50 plus \$.95 per foot.		
Extra length continuous cable for any Model 2100 available on request when ordering. Price at \$.95 per foot on length beyond normal length supplied with wand.		

**SWOFFER INSTRUMENTS, INC.**  
1048 Industry Drive  
Seattle, WA 98188 U.S.A.  
(206) 575-0160  
FAX (206) 575-1329

## MODEL 90 CURRENT METER SPECIFICATIONS

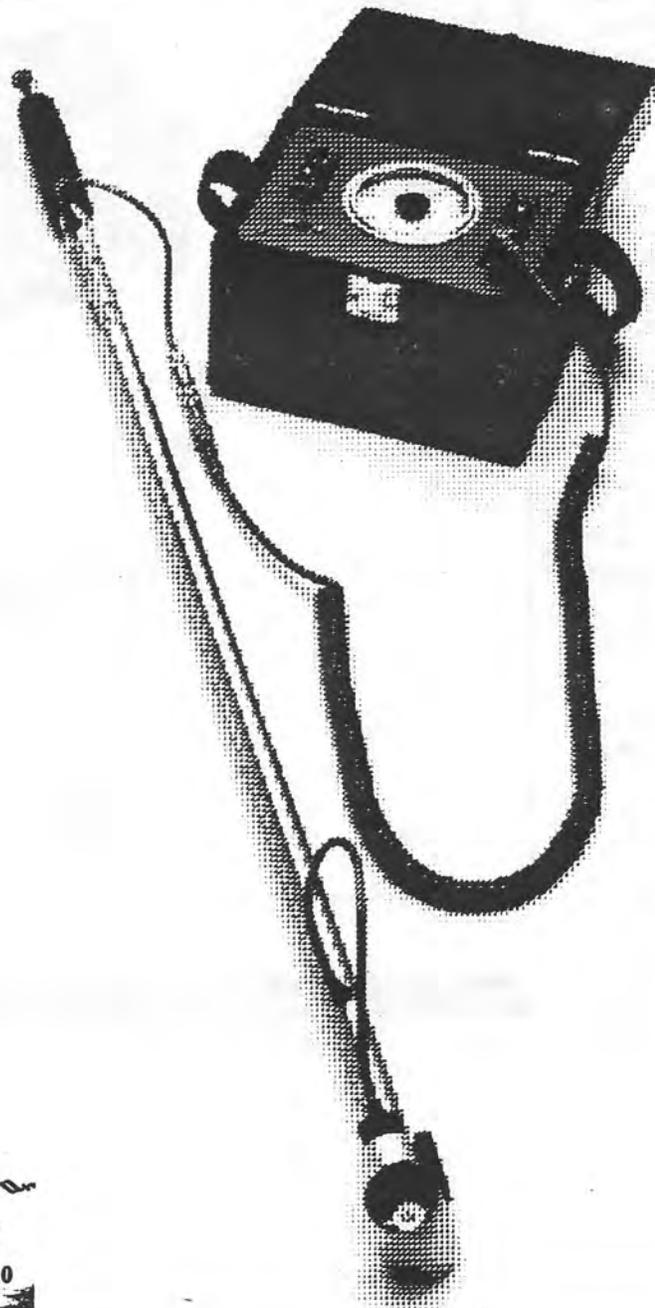
VELOCITY RANGE	0.1 to 25 Feet Per Second 0.03 to 7.5 Meters Per Second (Switch selectable)
DISPLAY	Liquid Crystal Digital, 0.7" Digit Height
RESOLUTION	To hundredths, both feet and meters
ACCURACY	Can be held to within 1% with periodic user required calibration tests and adjustments
DISPLAY AVERAGING	Three selectable averaging times: 5, 20, and 90 seconds—FPS mode 1.5, 6, and 30 seconds—MPS mode
OPERATING TEMPERATURE	Min. -14°F (-10°C) Max. 180°F (82°C) @ 15% relative humidity Max. 120°F (49°C) @ 95% relative humidity
POWER REQUIRED	A single standard 9-volt transistor battery. Alkaline type recommended.
INDICATOR SIZE	4 by 6 by 2 inches (15.2 by 10.2 by 5.1 cm)
INDICATOR WEIGHT	22 oz. (Including battery, spare battery, extra rotor assembly and rotor takedown wrench all stored in battery compartment)
INDICATOR MATERIAL	Vacuum-formed ABS with a clear acrylic viewing lens over the LCD. All switches sealed with threaded silicone rubber boots.
INDICATOR FACE PLATE	Back printed polycarbonate in four colors plus black.
FASTENERS	Stainless steel
SENSOR WAND MATERIALS	Aluminum = 6061-T6, Stainless steel = #303
SENSOR BODY AND ROTOR	Acetal-resin, machined from solid stock
SENSOR PROPELLER	Glass-filled, injection molded nylon. 2" diameter is supplied. Other sizes for special applications available.
ELECTRICAL CONNECTION	Flexible cable. Two-conductor signal system. Circular plastic connector with twist-lock operation. Water resistant with gold plated contacts.
CABLE LENGTH	Equal to wand at full extension plus five feet. Special lengths also available.
SENSOR TYPE	PHOTO-FIBER-OPTIC with all electronics permanently encapsulated in epoxy resin.

\*Specifications were correct at the time of publication; however, SWOFFER INSTRUMENTS, INC. reserves the right to change design and operating specifications to further improve the instruments at any time and without notice.

# Turbo-Flo™

ERDCO Engineering Corporation

Open stream velocity meter for  
measurement of liquid velocities



McCoy Sales Corp.  
2190 W. Bates Ave  
Englewood, CO 80110  
(303) 762-8012

ERDCO

# HP-302 Open Stream Velocity Meter

A hydrological instrument for the measurement of liquid velocities in sewers, pollution entering streams or rivers, stream velocity for flood control, flow patterns in filter beds, and flow out of large ducts.

ERDCO Engineering Corporation  
721 Custer Avenue  
Post Office Box 6318  
Evanston IL 60202-6318 USA

Telephone 708 328 0550  
Facsimile 708 328 3535

Form TF1016

Turbo-Flo™ probes consist of a low mass, high performance turbine mounted in a protective shroud at the end of a 3 foot long aluminum handle. The turbine, when immersed in a flowing stream, rotates at a speed in direct linear proportion to the fluid velocity. An electrical pulse is produced with each rotation of the turbine.

The patented design of the turbine and shroud offer unique capabilities. In combination, turbine and shroud are highly directional, enabling detection of stream patterns as well as measurement of velocity. By adjustment of a pivot, the turbine may be rotated over 90 degrees for vertical velocity measurement and insertion into pipe discharge ends. Small size permits measurement of streams as shallow as 1.5 inches. In addition to the basic 3 foot probe, extensions may be used for an overall reach of 21 feet enabling sewer surveys from street level.

Readings are direct and may be made by unscientific personnel. Selectable high and low meter ranges improve reading accuracy. Metric ranges are also available. Stable solid state electronics require no operational adjustments, counters, timers or trial runs. Functions include range selection and battery check. Power is supplied by eight "C" batteries. The splash proof enclosure has a removable lid and shoulder strap for easy carrying and one hand operation.



Model	Description	Characteristics	
HP-302	Open Stream Velocity Meter	Accuracy	±2%
		Range	0-5 & 0-10 ft/s
		Threshold	0.25 ft/s
		Max Temperature	140 F
		Weight:	
		Probe	1.1 lbs
		Indicator	5.5 lbs
M-21	Probe Extension Set (Three 6 ft sections for overall probe reach of 9, 15 or 21 ft.)	Weight	5 lbs



Distributed by:

**ERDCO**®



# Marsh-McBirney, Inc.

4539 Metropolitan Court, Frederick, Maryland 21701 USA

Phone: (301) 874-5599 • TWX: 710-828-0083

Toll Free: 1-800-368-2723 • FAX: (301) 874-2172

## Flowmeters . . . For Engineering The Future

Open Channel/Closed Conduit

(Portable/Permanent Models Available)

- Potable Water
  - Wastewater
  - Industrial Processes
- Pulp Stock
  - Slurries
  - Sludges
- Rivers
  - Streams
  - Sewers

### PORTABLE OPEN CHANNEL ELECTROMAGNETIC FLOWMETER

#### Flo-Mate™ Model 2000



- Rivers, Streams, Lakes
- Sewers - Open Channels
- Data Storage/Recall Capability
- Lightweight
- Rugged case of high impact molded plastic
- Direct replacement for USGS type mechanical meters
- Capable of accurately registering low flows
- Battery Powered - rechargeable or disposable
- Needs no primary device
- No installation hardware required
- Adapts to all channel shapes
- Adjustable filter modes: Time constant or fixed period averaging



### Model 2000 Specifications

#### VELOCITY MEASUREMENT

Method: Electromagnetic  
 Zero Stability:  $\pm 0.05$  ft/sec  
 Accuracy:  $\pm 2\%$  of reading + zero stability  
 Range:  $-0.5$  to  $+20$  ft/sec.  
 ( $-0.15$  m/sec to  $6$  m/sec)

#### OUTPUTS

Display:  $3\frac{1}{2}$  digit  
 Signal Output (Optional)  
 Analog:  $0.1v$  per  $1$  ft/sec or  $1$  m/sec

#### MATERIALS

Sensor: Polyurethane  
 Cable: Polyurethane jacket  
 Electronic Case: High impact molded plastic

#### ENVIRONMENTAL

Sensor:  $32^\circ F$  to  $160^\circ F$  ( $0^\circ C$  to  $65^\circ C$ )  
 Electronics:  $32^\circ F$  to  $122^\circ F$  ( $1^\circ C$  to  $50^\circ C$ )

#### POWER REQUIREMENTS

Batteries: Two D Cells

#### Battery Life:

Alkaline: 100 hours normal operation, 20 continuous hours (wet sensor)

Nicad: 13 continuous hours (wet sensor)

#### External Supply (Optional)

#### Supply Current:

Sensor Wet:  $300mA$ ,  $3V$

Sensor Dry:  $100mA$ ,  $3V$

#### WATER RESISTANCE

Submersible: One (1) foot for 30 seconds.

#### WEIGHT

With sensor and  $20'$  of cable:  $3\frac{1}{2}$  pounds

Without sensor:  $2\frac{1}{2}$  pounds

**Flo-Mate™ Model 2000** Flowmeter includes instrument incorporating electromagnetic sensor, 20 feet of interconnecting cable, universal sensor mount, and instruction manual. Standard velocity outputs include feet/second and meters/second.

Built-in options available include sensor disconnect, power in/signal out connector and additional sensor cable. Accessory options available include carrying case, wading rods, suspension cable kit and flow tables.

APPENDIX C: FLOW RATE INSTRUMENTATION

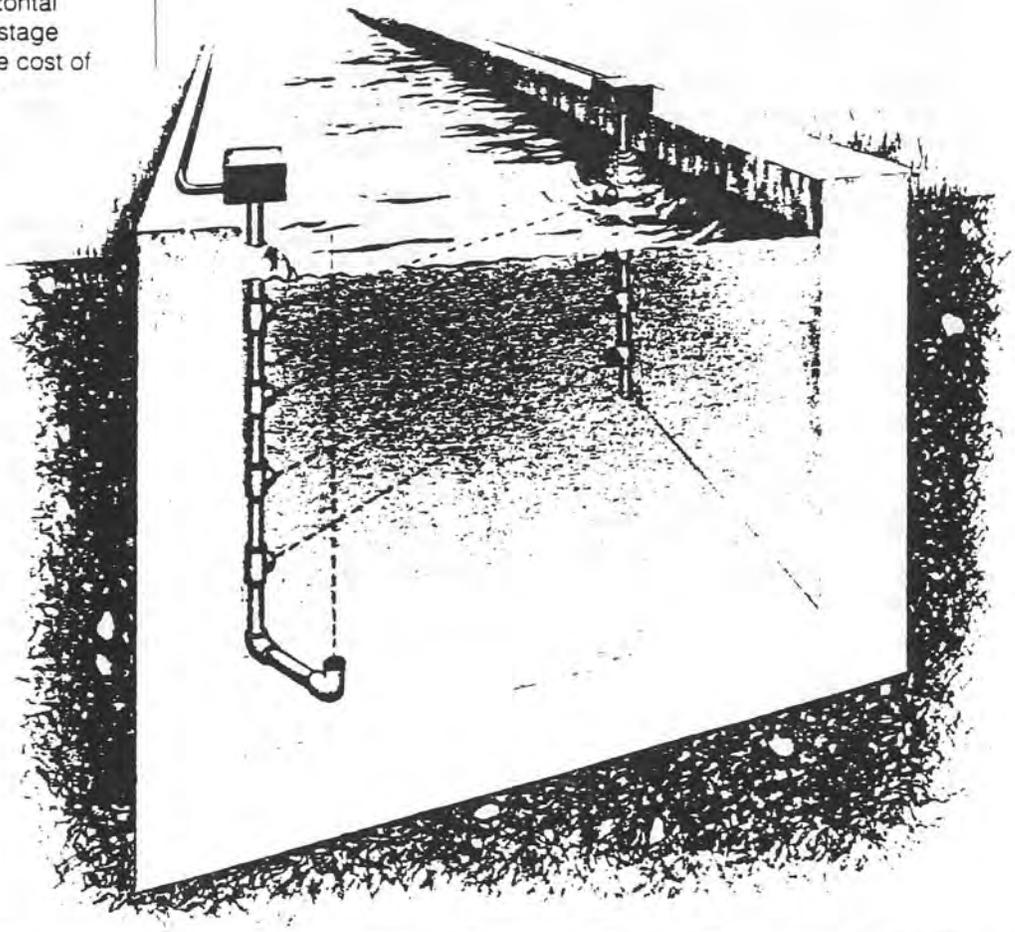
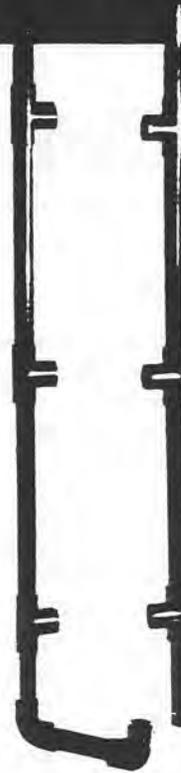
# ARRAY MOUNTED TRANSDUCER ASSEMBLY MODEL 7616

## ACCUSONIC<sup>®</sup>

Leaders in Acoustic Flow Measurement Systems

The Model 7616 Transducer Assembly is designed for installation in open channels and closed conduits. The Model 7616 is constructed such that all surfaces contacting the flow are of PVC, to resist the effects of chemicals, corrosives and similar agents normal to waste water and other hostile environments.

The Model 7616 is designed for permanent mounting in pre-fabricated array sections, configured for site-specific requirements. The mounting arrays, also of PVC, are constructed to provide a unitized section which is easily installed and aligned from within the channel. The arrays allow the utilization of up to 8 horizontal paths and an uplooking stage sensor at a fraction of the cost of conventional transducer installations.



# FLOWMETER CONSOLE MODEL 7410

## ACCUSONIC<sup>®</sup>

Leaders in Acoustic Flow Measurement Systems

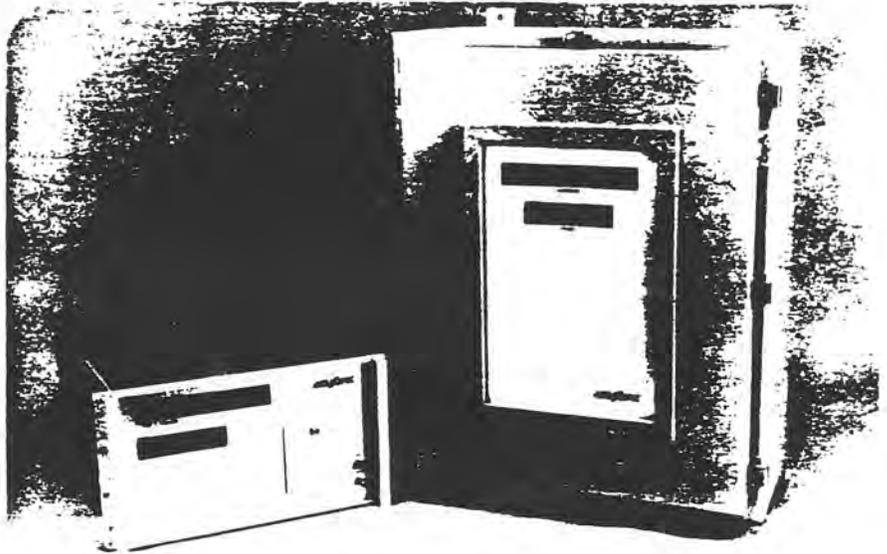
### System Accuracy

The accuracy of the rate indication and totalization of flow is specified to be plus or minus 0.5 percent of actual flow for all flows with velocity above 1 foot per second and up to maximum flow, provided the flowmeter is installed according to Accusonic specifications in a section of pipe with a minimum of ten diameters of upstream straight pipe. For installations having between four and ten diameters of straight pipe upstream of the meter section, four crossed paths (eight paths total) are required to maintain an accuracy of plus or minus 0.5 percent of flowrate.

To assure the specified accuracy, the flowmeter integrates the four velocities for each measurement plane (one for four path, two for four crossed paths) to calculate flowrate. Where crossed paths are used, the flowmeter software is designed to utilize velocity information from each plane of transducers to quantify and correct for crossflow.

### Two Path System

For a two path system installed with eight diameters of straight pipe upstream and two diameters of straight pipe downstream, the accuracy of the rate indication and totalization of flow is specified to be plus or minus 1.5% of actual flow for all flows with velocity above 1 foot per second.



### Power Requirement Options

115 VAC  $\pm 10\%$ , 50/60 Hz  
220 VAC  $\pm 10\%$ , 50/60 Hz  
100 VAC  $\pm 10\%$ , 50/60 Hz  
12 VDC +2.7V -1.8V

### Enclosure Options

NEMA 4 Wall Mount  
NEMA 4X Wall Mount  
Shock Mounted Portable  
Chassis (for 19" Rack)  
19" Rack Assembly

### Enclosure Dimensions

NEMA 4 30" h x 24" w x 12" d  
Shock Mounted Portable 24" h x 25" w x 27" d  
Chassis 10.5" h x 19" w x 22" d

### Measurement Options

Open Channel  
Pipe Flowing Full  
Pipe Flowing Partially Full

### Display Options

14 Digit LED  
8 Digit LED  
Flowrate  
Totalized Flow  
System Status  
Any Parameter or Variable

### Standard Output Options

4-20mA Flowrate  
RS-232 ASCII Ten Variable  
Report Format  
Pulsed Totalizer Output

### Parameter Entry Options

Keypad  
Keyboard  
Tape Cassette

### Number of Acoustic Paths

1 - 8

### Number of Pipes

1 or 2\*

### Environmental Requirements

Storage:  
0° - 140° F  
0% - 95% Relative Humidity  
Operation:  
35° - 140° F\*\*  
0% - 95% Relative Humidity

### Oscillator Frequency

80 MHz

### Power Consumption

35W maximum

\* With eight path, clamp-on systems or partially full pipes, only one pipe can be measured.

\*\* Heaters and air-conditioners can be added to certain enclosures to expand this range.

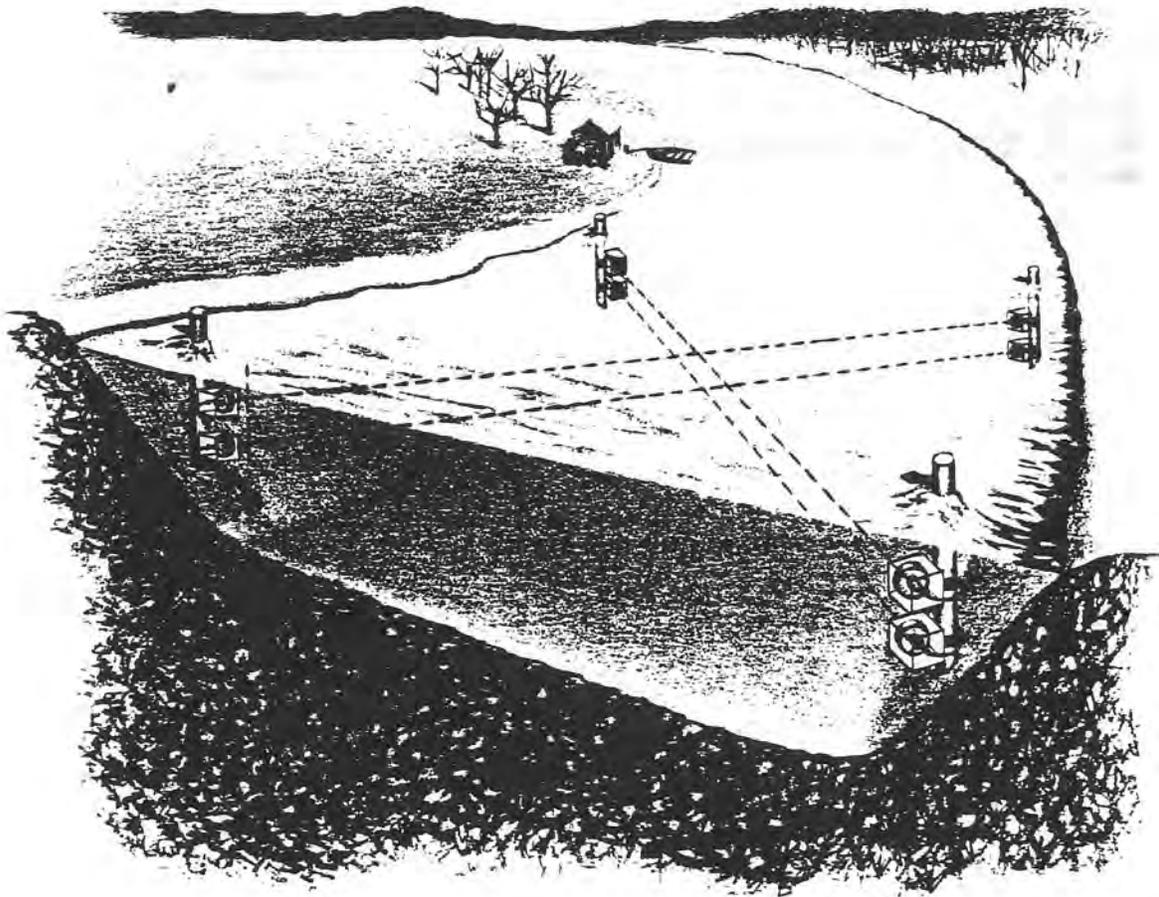
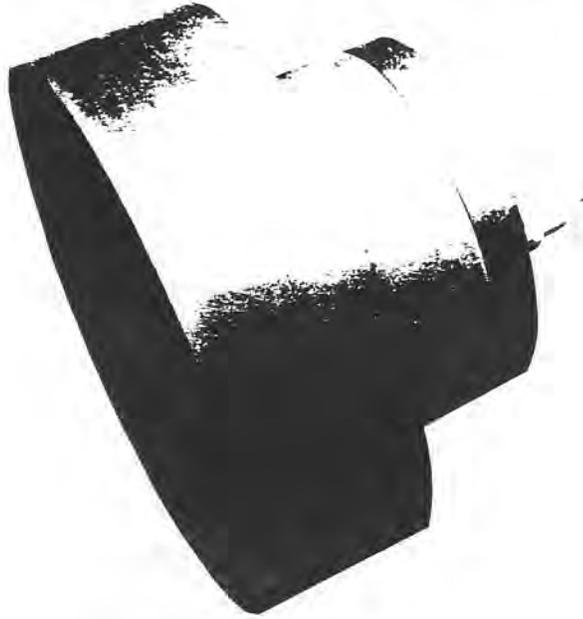
**Open Channel  
Transducer Assembly  
Model 7611**

**ACCUSONIC**

Leaders in Acoustic Flow Measurement Systems

The Model 7611 is designed for use in rivers and open channels where extremely long path lengths are required. The 7611 is constructed of durable and corrosion resistant material to provide long life and consistent operation. A self purging connector is provided with each transducer assembly.

Transducer mounting arrangements to meet site specific requirements can be designed upon request.



ORE INTERNATIONAL, INC.  
ACCUSONIC DIVISION  
G.S.A. PRICE LIST  
MAY 1, 1990



***ORE International Inc.***

**GENERAL SERVICES ADMINISTRATION  
Federal Supply Service  
Authorized Federal Supply Schedule Pricelist**

**Liquid or Gas Flow/Level and Water Velocity Measuring  
Instruments and Accessories  
PSC Group 66, Part II, Section R**

**FSC Class:** 6680

**Contract Number:** GS-00F-6200A

**Contract Period:** September 23, 1991 - January 31, 1994

**Contractor's Name:** O.R.E. International, Inc.  
Accusonic Division

**Contractor's Address:** Falmouth Heights Road  
Falmouth, MA 02541

**Contractor's Phone:** (508) 548-5800  
**Fax:** (508) 540-3835

**Contract Administration Source:** O.R.E. International, Inc.  
Accusonic Division  
Falmouth Heights Road  
Falmouth, MA 02541  
**Phone:** (508) 548-5800  
**Fax:** (508) 540-3835

**Business Size:** Small

## INFORMATION FOR ORDERING ACTIVITIES

1. AWARDED ITEMS--Special Item No. 505-17: Page
  - Flowmeter Systems--7410 4
  - Transducers 7
  - Rack Enclosures 9
  - Transducer Signal Cable 10
  - Peripheral Items for Flowmeter 11
  - Control Computer--7432 12
  - Spare Parts 13
  
2. Maximum Order Limitation: \$250,000.
  
3. Minimum Order: 250.
  
4. Geographic coverage: United States and Puerto Rico
  
5. Point of Production: Falmouth, Barnstable County,  
Massachusetts
  
6. Discount from List Prices: A 6% discount will be applied  
to all listed prices.
  
7. Quantity Discounts: None
  
8. Prompt Payment Terms: A 1% prompt payment discount  
will be applied to all invoices  
paid within 30 days.
  
- 9a. Government Commercial Credit Cards are not accepted.
- 9b. Government Commercial Credit Cards are not accepted.
  
10. Foreign items: None
  
11. Time of Delivery: 90 days after receipt of order.
  
12. F.O.B. Points: Destination by standard  
overland carrier.
  
13. Ordering Address: O.R.E. International, Inc.  
Accusonic Division  
P.O. Box 709  
Falmouth, MA 02541
  
14. Payment Address: O.R.E. International, Inc.  
Accusonic Division  
P.O. Box 709  
Falmouth, MA 02541

15. Warranty Provision:

O.R.E. International, Inc. warrants its products against defects in materials and workmanship for a period of one (1) year from the date of delivery. During this period, on satisfactory proof of such defects, any unit which becomes inoperative may be returned, prepaid, for repair or replacement at the option of O.R.E. International, Inc. FOR PARTS THAT ARE COVERED UNDER WARRANTY WHICH ARE RETURNED WITHIN THE FIRST 3 MONTHS OF THE WARRANTY PERIOD, O.R.E. INTERNATIONAL, INC., ACCUSONIC DIVISION, WILL PAY SHIPPING CHARGES BOTH WAYS. No returns will be accepted unless prior authorization has been received from Seller and an O.R.E. International, Inc. job number has been assigned.

This warranty applies only to the original purchaser and only if the equipment has been installed and operated in accordance with the published Operations and Service Manual, or in a manner approved by O.R.E. International, Inc. or its representatives.

No other warranty is express or implied and in no event shall O.R.E. International, Inc. be responsible for collateral or consequential damages.

16. Export Packing Charges: Standard commercial export packaging is included in prices listed herein.
17. Government Commercial Credit Cards are not accepted.
18. Rental, maintenance and repair of items are not included in this contract.
19. Installation services are not included in this contract.
20. Repair of items is not included in this contract.
21. Service and Distribution point: Not applicable.
22. There are no participating dealers.
23. Preventive Maintenance: Instructions contained in manuals provided with purchased equipment.

## ACCUSONIC PRICE LIST

### I. Model 7410 Flowmeter

1-4 Acoustic Paths, one 14-digit LED Display  
 one 8-digit LED Display, Keypad Parameter Entry,  
 Signal Quality Monitor, Self-test Feature. 13,500.

#### A. Enclosure

- |   |        |
|---|--------|
| 1. NEMA 4 Wall Mount Enclosure          | N/C    |
| 2. 19" Rack Mountable Chassis           | N/C    |
| 3. Portable Enclosure (Shock Resistant) | 2,500. |

#### B. Power Requirement

- |                                      |      |
|--------------------------------------|------|
| 1. 115 VAC $\pm 10\%$ 50/60 Hz Power | N/C  |
| 2. 220 VAC $\pm 10\%$ 50/60 Hz Power | N/C  |
| 3. 105 VAC $\pm 10\%$ 50/60 Hz Power | 200. |
| 4. 12 VDC Power                      | 750. |

#### C. Configuration

- |   |        |
|---|--------|
| 1. Dual Pipe Capability, includes 2 additional displays                                       | 3,500. |
| 2. 4-pipe (2 paths per pipe) capability, includes 2 additional displays (4 displays total)    | 5,000. |
| 3. 8-path Single Pipe Capability (cannot be ordered with Dual Pipe System)                    | 1,000. |
| 4. 4-path Open Channel Capability (includes acoustic stage capability--specify channel width) | 2,500. |
| 5. 8-path Open Channel Capability (includes acoustic stage capability--specify channel width) | 3,500. |
| 6. 4-path Compound Flowmeter (for pipes flowing partially to completely full)                 | 2,500. |
| 7. 8-path Compound Flowmeter (for pipes flowing partially to completely full)                 | 3,500. |
| 8. Multiplexing Capability (requires Model 7432 Control Computer)                             | 1,000. |
| 9. Specialized Software (e.g., dual direction totalizing, etc.)                               | TBQ*   |

#### D. Outputs

- |   |        |
|---|--------|
| 1. 2-channel RS-232 I/O   | 1,000. |
| 2. RS-232 Report Format Output (includes RS-232 output card and ports, calendar clock and software) | 2,500. |
| 3. 2-channel 4-20 mA Analog Output (outputs must be ordered in 2-channel increments)                | 750.   |
| 4. Alarm Contact Closure (each)   | 300.   |

- |  |        |
|--|--------|
| 5. Special Output (specialized outputs must be specified in detail prior to quotation) | TBQ*   |
| 6. Isolated 4-20mA output 2-channel  | 1,500. |

**E. Other**

- |  |      |
|--|------|
| 1. Additional 8-digit LED Display (each)                   | 500. |
| 2. Display Labeling  | 250. |
| 3. Thermostatically controlled Heater for NEMA 4 Enclosure | 500. |

\* Specialized Options may be available, but must be evaluated and quoted on an individual basis.

III. Transducers (All prices are each)--Specify number of paths and path angle when ordering.

A. Pipeline Transducers/Feedthroughs--Standard Installation

- |   |      |
|---|------|
| 1. Model 7625 Delrin /Lucite Fixed Window Transducer/Feedthrough Assembly (500 psi)         | 550. |
| 2. Model 7605 Stainless Steel/Lucite Fixed Window Transducer/Feedthrough Assembly (1000psi) | 850. |
| 3. Model 7601 Transducer  | 550. |
| 4. Model 7641 Feedthrough (450 psi)   | 550. |
| 5. Model 7642 Jacking Mechanism (1 required per site)                                       | 750. |
| 6. Model 7600 Transducer  | 800. |
| 7. Model 7660 Feedthrough (1500 psi)  | 950. |
| 8. Model 7661 Jacking Mechanism (1 required per site)                                       | 200. |

B. Pipeline Transducer/Feedthroughs--Outside access only (cold-tap) weld-on installation.

- |  |      |
|--|------|
| 1. Model 7600S Transducer  | 750. |
| 2. Model 7662 Weld-on Feedthrough (1500 psi) (Specify Pipe Wall Thickness) | 950. |
| 3. Model 7661 Jacking Mechanism (1 required per site)                      | 200. |

C. Pipeline Transducers--Hot-tap (150 psi maximum pressure\*\*)

- |  |        |
|--|--------|
| 1. Model 7600 Stainless Steel Hot-tap Transducer   | 800.   |
| 2. Model 7643 Stainless Steel Hot-tap Feedthrough (Specify Pipe Wall Thickness and Pressure) | 1,100. |
| 3. Model 7661 Jacking Mechanism (1 required per site)  | 200.   |
| 4. Hot-tap Tool Purchase   | 5,000. |

\*\* Higher pressures may be possible, but equipment must be quoted on an individual basis.

D. Pipeline Transducers for Spool Pieces (path angle not required)

- |  |      |
|--|------|
| 1. Model 7620 PVC Transducer (300 psi)   | 500. |
| 2. Model 7680 Stainless Steel Gate Valve | 500. |

E. Pipeline Transducers--Internal Mount

1. Model 7630 1 MHz Dual Element Internal Mount Transducer (for pipe less than 25-ft diameter)	800.
2. Model 7634 500 kHz Dual Element Internal Mount Transducer (for pipe over 25-ft diameter and dirty water applications)	800.
3. Model 7690 Base Plate Assembly	300.
4. Model 7691 4-wire Penetrator (1 required for every 2 transducers)	400.
5. 7691 8-wire Penetrator (1 required for every 4 transducers)	600.

F. Open Channel Transducers (path angle not required)

1. Model 7616 500 kHz Transducer--for Channels 3 to 30 feet wide* (Note: This type of transducer is sold in premanufactured arrays; channel dimensions must be specified when ordering).	250.
2. Model 7612 200 kHz Transducer--for Channels 10 to 300 feet wide* (includes 200-ft signal cable)	500.
3. Model 7611 100 kHz Transducer for Channels 100 to 1000 feet wide*	3,500.
4. Model 7652B 200 kHz Active Transducer (for use with Model 7300 AVM only)	750.
5. Model 7655B 500 kHz Active Transducer (for use with Model 7300 AVM only)	650.
6. Model 7651B 100 kHz Active Transducer (for use with Model 7300 AVM only)	3,750.
7. Model 7632 Up-looking Level Transducer	500.
8. Model 7692 Baseplate for Up-looking Level Transducer	500.

\* Width specifications are approximate; actual capabilities depend on specific installation characteristics.

IV. 19" Rack Enclosures for up to 4 Model 7410  
Flowmeter Chassis, 78" nominal height

A. Model 7440 AMCO Enclosure--for clean environments	3,500.
1. Fan and Filter	750.
2. Special Paint--Specify exact color, manufacturer and paint code (may increase delivery time)	900.
B. Model 7441 Hoffman NEMA 12 Enclosure--dust tight, with gasketed front and rear doors. Standard front door includes window for viewing displays or CRT	5,000.
1. Drop down compartment on front door for keyboard (used with 7432 controller)	1,000.
2. Fan and Filter	750.
3. Special Paint--Specify exact color, manufacturer and paint code (may increase delivery time)	900.

V. Transducer Signal Cable

- A. RG59 or RG62 without Connector--for Model 7605 and 7625 transducers or for other transducers when run between a junction box and the flowmeter console .30/ft
- B. RG59 or RG62 with E-O type Connector--for Model 7601 and 7600 Transducers .60/ft
- C. HDPE Jacketed RG59 with E-O type Connector--for use inside the pipe with Model 7630 and 7634 Transducers .85/ft
- D. HDPE Jacketed RG108--for use underwater with Model 7612 Transducers .75/ft
- E. RG108 for use out of the water with Model 7612 Transducers .50/ft
- F. RG111 A/U Armored Cable with Connector--for use with Model 7611 Transducer 3.50/ft

VI. Peripheral Items for Flowmeter

A.	4-digit LED Remote Display Unit--Panel Mount	700.
B.	4-digit LED Remote Display Unit--Wall Mount	1,200.
C.	Down Looker Level Transducer--for open channel systems	3,500.

VII.	Model 7432 Control Computer with 20 MB Hard Disk Drive, CPU, Floppy Disk Drive (3 1/2" or 5 1/4"), Monitor, Keyboard, and Parallel Printer with stand	15,000.
A.	Multi-unit Flow Measurement Package-- includes: Software for Data Presentation, Data Storage, system parameter storage, and I/O capabilities	5,000.
B.	Multiplexing Package--includes: Software and I/O Capabilities for measuring flow in up to 16 pipes using 1 Model 7410 flowmeter	5,000.
1.	MUX Path Selector Unit--handles 8 paths each	2,500.
C.	Turbine Efficiency Measurement (TEM) Package-- includes: Site-specific Software and Required I/O Capability for Subsystem Interface	20,000.
1.	Heise Pressure Gage, Series 9	4,200.
2.	Druck Pressure Sensor	2,500.
3.	YEW Power Meter	12,000.
4.	Scientific Columbus Power Meter	3,200.
5.	Wicket Gate Position Indicator	1,100.
6.	Tubing, Cable, etc.	TBQ*
7.	Special Software (if required)	TBQ*

\* Quoted after review of project specifications

VIII. Model 7410 Flowmeter Spare Parts

<u>Part Name</u>	<u>Number</u>	<u>Price</u>
Transceiver	7400-10002	1,025.
Transmitter	7400-10003	700.
Dual Path Selector	7400-10004	1,325.
Path Selector Module	7400-10005	1,000.
Receiver	7400-10006	675.
Triple Power Supply	7400-10007	1,500.
Watchdog Timer	7400-10013	500.
16 Slot Cardfile	7400-10014	1,400.
CPU	7400-10015	1,350.
SIO	7400-10037	1,050.
TTL I/O	7400-10038	1,000.
8-digit Display	7400-10084	975.
Multitelle Driver	7400-10085	500.
14-digit Display	7400-10086	1,000.
Keypad Interrupt	7400-10094	700.
EPROM	7400-10096	975.
4K CMOS RAM	7400-10097	1,650.
Calendar Clock	7400-10101	1,250.
4 x 4 Keypad	7400-10103	500.
2 channel D/A, D/I	7400-10109	850.
Receiver Module	7400-10118	950.
Asblank	7400-10182	500.
DIAG 80	7400-10205	2,000.
Stage	7400-10209	550.

<u>Part Name</u>	<u>Number</u>	<u>Price</u>
NEMA Box Heater	7400-10241	975.
RTU-1	7400-10271	1,025.
Dual Contact Closure	7400-10367	500.

SUPPLEMENTAL TO GENERAL SERVICES ADMINISTRATION  
FEDERAL SUPPLY SERVICE  
AUTHORIZED FEDERAL SUPPLY SCHEDULE PRICELIST

Liquid or Gas Flow/Level and Water Velocity Measuring  
Instruments and Accessories  
FSC Group 66, Part II, Section R

FSC Class: 6680  
Contract Number: GS-00F-6200A  
Contractor's Name: O.R.E. International, Inc.  
Accusonic Division  
Special Item Number: 505-17  
Modification Number: Two (2)  
Effective Date of  
Modification: February 14, 1992

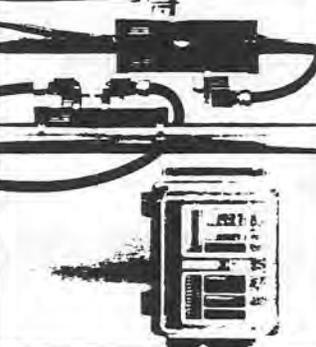
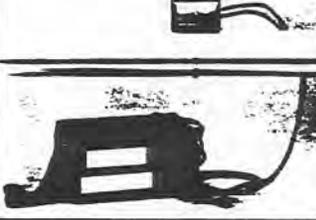
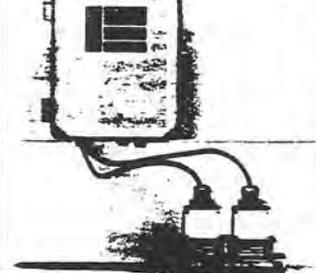
The above-referenced contract has been modified to add the following product:

Model Number	List Price	Discount
7300 Acoustic Velocity Meter (AVM) 1-2 Acoustic Paths, 12 VDC operation Periodic Sampling, NEMA 4X enclosure, active transducer capability	\$7,200.	6%

All other prices, terms, and conditions of this contract (except as previously modified, or heretofore changed) remain unchanged.

**ACCUSONIC**

## TRANSIT-TIME AND FOURIER FLOWMETERS

	<p align="center"><b>SYSTEM 990P UNIFLOW—Portable Transit-Time Flowmeter</b></p> <p><i>...easily programmable for any pipe size.</i> <i>...for "clean" to moderately "gritty/aerated" liquids.</i> <i>...clamp-on sensors, excellent for flow survey.</i></p> <p><b>Accuracy</b> ..... 1% to 3% of Actual Flow <b>Flow Range</b> ..... -40 to +40 ft/sec (including zero flow) <b>Flow Sensitivity</b> ..... 0.001 ft/sec (including zero flow) <b>Displays</b> ..... Multifunction Graphic LCD provides: Digital Rate and Total, Analog Stripchart, Status and Diagnostic info. <b>Outputs</b> ..... Programmable 4 to 20mA, 2 x 0-10V, Relay or RS-232 <b>Environment</b> ..... Liquid Temperatures to -425°F <i>...Ask for Bulletin 990SB-2.</i></p>
	<p align="center"><b>SYSTEM 990N UNIFLOW—Dedicated NEMA 4X Transit-Time Flowmeter</b></p> <p><i>...high accuracy, economical.</i> <i>...universally field programmable for operation on essentially any pipe &amp; most liquids.</i> <i>...an ideal "one type does all" stock replacement for Magmeters, Turbines, Vortex, Venturis &amp; Differential Pressure flowmeters.</i> <i>...optional built in Digital or Graphics displays with Datalogger &amp; Stripchart options, plus industry standard data outputs &amp; data printout.</i></p> <p><b>Accuracy</b> ..... 1% to 3% of Flow Rate, to 1.2% if calibrated <b>Applicability</b> ..... Any pipe from 1/4" to 240" OD, to 3" wall field programmable <b>Flow Range</b> ..... -40 to +40 ft/sec (including zero flow) <b>Flow Sensitivity</b> ..... 0.001 ft/sec at all flow velocities <b>Functions</b> ..... Flow Rate, Total, Status Alarms, Diagnostics, Datalogger, stripchart <b>Displays</b> ..... Optional Blind, LCD Digital or Graphics <b>Outputs</b> ..... 4 to 20mA (Iso.), Pulse Rate, Relay or RS-232 <b>Environment</b> ..... NEMA 4X, -40°F to +125°F <b>Models</b> ..... Single and Dual Channel, plus Dual Path <i>...Ask for Bulletin 990SB-2.</i></p>
	<p align="center"><b>SYSTEM 190P SPECTRA—Portable Fourier Flowmeter</b></p> <p><i>...easily programmable for any pipe size.</i> <i>...able to eliminate pipe noise &amp; vibration from flow signal.</i> <i>...for "gritty/aerated" to relatively "clean" liquids.</i></p> <p><b>Accuracy</b> ..... 1% to 5% of Actual Flow (application dependant). <b>Flow Range</b> ..... 0.2 to 40 ft/sec <b>Displays</b> ..... Multifunction Graphic LCD provides: Digital Rate and Total, Analog Stripchart, Status and Diagnostic info. <b>Outputs</b> ..... Programmable 0-10VDC, Relay or RS-232 <i>...Ask for Bulletin 190SB-2.</i></p>
	<p align="center"><b>SYSTEM 190N SPECTRA—Dedicated NEMA 4X Fourier Flowmeter</b></p> <p><i>...new Fourier flow detection principle provides low cost &amp; excellent accuracy in one field programmable universal flowmeter.</i> <i>...highly resistant to effects of pipe vibration &amp; liquid solids or aeration content.</i> <i>...all industry standard data outputs available, plus complete data printout.</i></p> <p><b>Accuracy</b> ..... 1% to 5% of Flow Rate <b>Flow Range</b> ..... 0.2 to 40 ft/sec <b>Functions</b> ..... Flow Rate, Total, Status Alarms, Datalogger and Stripchart <b>Displays</b> ..... Blind, Analog, LCD Digital or Graphics <b>Outputs</b> ..... 4 to 20mA, Pulse Rate, Relay or RS-232 <b>Environment</b> ..... NEMA 4X, -40°F to +125°F <i>...Ask for Bulletin 190SB-2.</i></p>
	<p align="center"><b>SYSTEM 990E—Thermal Energy (BTU) Flowmeter</b></p> <p><i>...high precision, field programmable, fully clamp-on thermal energy computer for use with both chilled, hot &amp; very hot water systems.</i> <i>...both BTU &amp; flow rate &amp; totals provided on optional Digital or Graphics displays, with printable Datalogger &amp; Stripchart trend recording.</i> <i>...industry standard data outputs provide computer control inputs.</i></p> <p><b>Accuracy</b> ..... To 0.5% with calibration <b>Flow Range</b> ..... -40 to +40 ft/sec (including zero flow) <b>Liquid Temp Range</b> ..... -40°F to +450°F <b>Applicability</b> ..... Any pipe from 1.25" to 48" OD, to 3" wall <b>BTU Range</b> ..... Field Programmable, 2000:1 Turndown Ratio <b>Flow Sensitivity</b> ..... 0.001 ft/sec at any Flow Rate <b>Functions</b> ..... BTU and Flow Rate, Total, Status Alarms, Diagnostics, Datalogger and Stripchart <b>Displays</b> ..... Optional Blind, LCD Digital or Graphics <b>Outputs</b> ..... 4 to 20mA, Pulse Rate, Relay or RS-232 <b>Environment</b> ..... NEMA 4X, -40°F to +125°F <b>Models</b> ..... Portable and NEMA 4X, Single and Dual Channel <i>...Ask for Bulletin 990E-1.</i></p>

# Model 4100 Compu-Sonic Transit Time Ultrasonic Flowmeter

# Technical Brief

## Description

The Model 4100 Compu-Sonic is a member of the Series 4000 industrial flowmeter family designed for accurate and reliable measurement of process water, influent/effluent, and industrial flows.

The transit time ultrasonic flowmeter can be supplied for measuring flow rates in 3 inch and larger pipes. Three styles of transducer configurations are available to suit the application: strap-on transducers for metal and plastic pipes which can support ultrasonic transmission; insertion transducers, which penetrate pipe walls; and internally mounted transducers for large pipes. It is also capable of measuring both forward and reverse flow.

The microprocessor-based meter is supplied with a 24-character, 2-line alphanumeric LCD display for rate of flow and totalized flow information. Front panel switches activate commands which allow functions such as zero/span, self test and rescaling to be selected.

## Piping Requirements

Model 4100 flowmeters may be either horizontally or vertically mounted. A well-developed velocity profile is needed. General practice requires the pipe to be full and the upstream piping run to be sufficient to assure predictable fluid velocity distribution.

## Operation

The Model 4100 Compu-Sonic flowmeter operates as a transit time flowmeter using Badger Meter's patented phase shift time multiplication detection system. This technique, exclusive to Badger Meter, improves time difference detectability to enhance accuracy and stable operation while substantially reducing noise effects.

Ultrasonic energy "bursts" are transmitted and received via well defined paths across the flow stream. The velocity of the flow is accurately measured by the difference in the arrival times of



signals from the upstream and downstream transducers. The overall "time of flight" is measured to accurately compensate for changes in the sonic velocity of the fluid. Sonic velocity variations in the fluid may result from changes in the amount of suspended and dissolved solids as well as temperature variations. The Model 4100 flowmeters also account for acoustic beam changes due to refraction and diffraction.

The electronics are microprocessor controlled, and signals are digitized for processing before any analog modifications are able to distort data or cause drift which can contaminate the signals. This technique allows more precise and accurate measurement of the flow, improves meter reliability, and minimizes meter drift normally associated with component instabilities. Early digitization also enhances interchangeability during maintenance. Digitized data is confirmed, stored and filtered by sophisticated mathematical algorithms to correct for signal distortions.



**Badger Meter, Inc.**

## Display Function

The front panel of the Model 4100 contains an enlarged 24-character alphanumeric LCD display and four individual switches for selection of operating modes. The function switches are:

**Menu-** This switch allows the user to review items for selection on the meter's operating menu. Each depression advances the menu and prompts the user. Among the menu items are span, zero, scale and self test.

**Select-Enter** This switch initiates the desired menu item and the microprocessor executes the program.

**▲/▼** These switches are used to raise or lower display items such as full scale flowrate, 4-20 mA, signal levels, etc. They are responsive only if the appropriate menu item is selected.

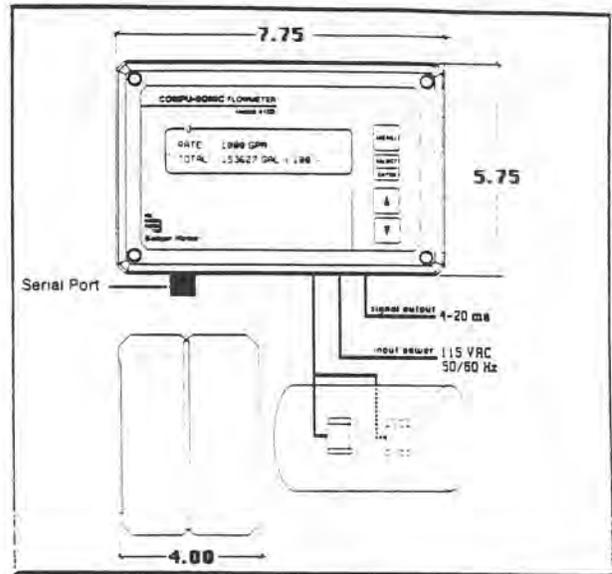
## External Communications

The Model 4100 is equipped with a bidirectional serial port which supports interactive communication with handheld microcomputers as well as mainframe machines. The port is accessed by a plug mounted on the electronics unit. Versatile communication protocols have been established to ensure reliability. Serial port communications can be used to change the meter application, to change the engineering units used for flow calculations, to ascertain signaling and operation quality of the meter, and to transmit data such as flow rate and flow totals.

## Mechanical Description

**Electronics Unit:** The standard unit is housed in a foam-molded polycarbonate enclosure suitable for wall or panel mounting. The enclosure is rated NEMA 4X for complete corrosion resistance and watertight integrity. Optional enclosure with heater and thermostat available for environments below 32° F.

**Transducers:** The transducers are constructed of corrosion-resistant material and sealed to provide sufficient protection from the environmental elements. Triax cable is used to provide shielding from external signal interference. The mounting hardware is designed to **make** the installation simple and easy. Three styles of **transducers** and mounting arrangements are available to meet the needs of the application.



## General Specifications

### Electronics

Microprocessor-based: Advanced single-chip microcomputer with 8k bytes of ROM, 512 bytes of EEROM and 256 bytes of RAM.

Linearity:	+/- 0.5%
Repeatability:	0.25%
Sensitivity:	+/- 0.005 ft./sec.
Accuracy:	+/- 1 to 3% above 1 fps velocity
Output signals:	LCD display, 4-20 mA DC isolated serial communication port (RS-232 opt.).
Operating temperature:	0° to 60° C
Operating humidity:	5 to 95% Relative
Power requirements:	117 VAC 50/60 Hz maximum 5 watts

### Transducers

Operating temperature: -30° to 150°  
Encapsulation: Able to withstand prolonged submergence or direct burial  
Interchangeability: Replacement without affecting meter accuracy  
Three mounting styles:  
Strap-on for metal or plastic pipes which can support ultrasonic transmission.  
Insertion for pipe walls that will not support ultrasonic transmission.  
Internally for large pipes to eliminate costly meter vaults.



Badger Meter, Inc.

# Ultrasonic Velocity Sensors Transit Time Mechanical and Dimensional Data

# Technical Specifications

## General

The Transit time flowmeters from Badger utilize acoustic signals transmitted from pipe-mounted sensors to accurately measure fluid velocities in both open channel and closed pipe conduits. Because of the diverse applications in fluid monitoring, as well as different pipe materials available, four distinct versions of the acoustic velocity sensor are provided.

## Description

Each sensor manufactured by Badger can both remotely transmit and receive acoustic pulses. These sensors can be mounted externally, clamp-on or welded; with "hot shot" wetted insert probes; or mounted on the inside of the conduit, fully submerged; or premounted on a factory made spool, windowed or external. This flexibility in sensor design provides custom tailoring to fit the user's application. Also, these sensors can be isolated from the electronic processor up to 1000 feet (250 ft. windowed sensors), requiring only signal cable to be run from the power source to the meter site.

## Standard Externally Mounted Velocity Sensor

The externally mounted sensor is the preferred design when acoustic signals can be transmitted through the pipe or conduit material. These sensors are fully potted, incorporating an intrinsic safety design concept; they can be directly buried and operate under water. The sensor holders and junction box are type 316 stainless steel. These sensors can operate over a

temperature range from  $-30^{\circ}\text{F}$  to  $150^{\circ}\text{F}$  ( $-30^{\circ}\text{F}$  to  $300^{\circ}\text{F}$  Opt.). They can be placed on all metallic and plastic piping, with the exception of pit cast iron and fiberglass pipe, and maintain pipe or conduit integrity.

## Instream Velocity Sensor

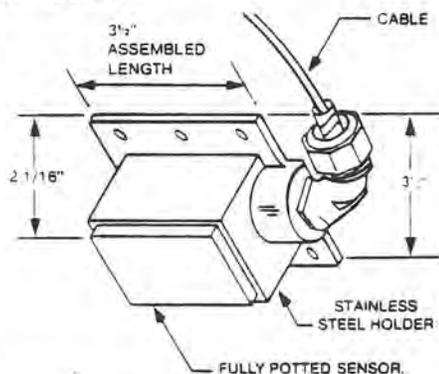
In open conduits over 12 inches in width or in large concrete pipes where the outside of the pipe is not accessible, the instream sensor is recommended for accurate fluid velocity measurement.

The unique design of the sensor facilitates simple installation. Mounting hardware supplied with each sensor allows flush mounting against the sidewall. After mechanical installation, the housing is grouted to the sidewall, producing a streamlined profile in the conduit. The sensor construction is of a hydraulic efficient design, watertight, and is intended for continuous submergence.

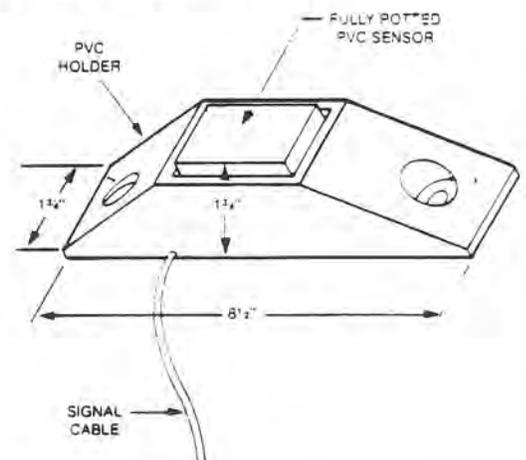
Also available is a unique internal strap design that comes with the instream sensor accurately positioned and mounted. This mounting arrangement makes installation fast and precise.

These sensors are constructed of PVC, are fully potted, and incorporate the same unique technology associated with the standard externally mounted sensor.

## STANDARD EXTERNALLY MOUNTED VELOCITY SENSOR



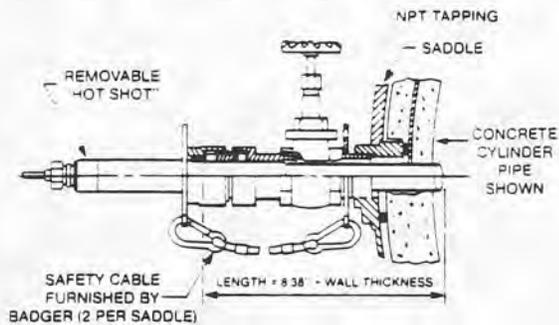
## INSTREAM VELOCITY SENSOR



### "Hot Shot" Wetted Sensor

Badger's "Hot Shot" sensors are used where the pipe or conduit material will not allow transmission of acoustic energy. A standard concrete saddle tap is utilized for penetration through the pipe wall. The sensor design allows for flush mounting with the conduit inside diameter, thereby eliminating solids buildup or turbulence around the measuring point. The sensors are used with an integral valve to allow sensor removal without process shutdown. Hot shot wetted sensors are recommended for concrete, asbestos cement, wood stave, fiberglass, and heavy mortar-lined pipe. They are constructed of PVC, fully potted, and incorporate the same unique technology associated with the standard externally mounted sensor.

#### HOT SHOT WETTED SENSOR



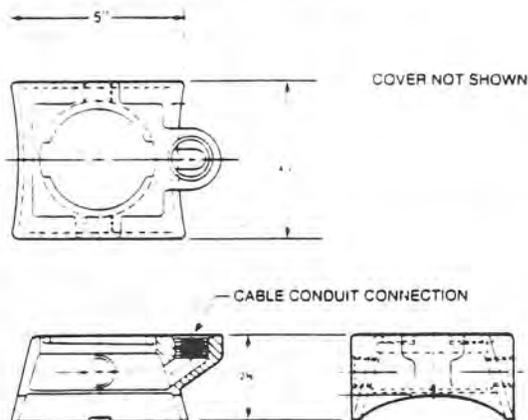
**NOTE:** VALVE PROVIDED TO ASSURE WATERTIGHT CONNECTION DURING PROBE REMOVAL

### Mounting Hardware

The acoustic sensors and the associated mounting hardware manufactured by Badger Meter, Inc., are constructed from materials that are resistant to corrosive environments. The 316 stainless steel junction box (as shown below) is utilized for sensor cable wiring.

It is welded on for those applications where factory spool fabrication is required or can be strapped on using stainless steel bands for the field-installed unit.

#### JUNCTION BOX FOR WIRING SPLICE



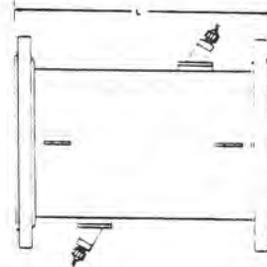
### Fabricated Spool

Fabricated spool pieces are available in windowed and external sensor designs, with a choice of end connections and materials of construction. Spool pieces come with the sensors mounted and calibrated with the electronics.

Windowed sensors transmit and receive the ultrasonic pulse through an acoustic window which is in contact with the flow stream. This design allows sensor removal without de-watering the line. The sensors and windows are constructed of Ultem thermoplastic and have temperature rating of 150°F

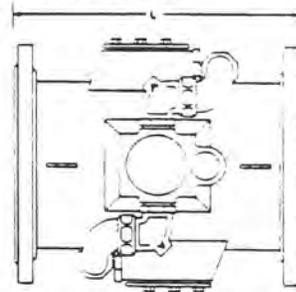
The windowed spool pieces are available in sizes 3" to 48" with stainless or carbon steel construction, with ANSI, AWWA and plain end connections being standard.

#### WINDOWED SPOOL



Externally mounted sensed spools utilize the standard velocity sensor and offer the advantage of higher temperature and pressure limits along with increased material selection. Typical pipe materials are stainless steel, PVC and carbon steel.

#### EXTERNAL MOUNT SPOOL



#### DIMENSIONS

Nominal Pipe Size (Inches)	1	2	3	4	6	8	10	12	14	16	18	20	24	30	36	42	48
3	12	12	18	24	36	42	48	60	72	84	96	108	120	144	168	192	216
4	12	14	21	30	42	54	66	78	90	102	114	126	150	180	210	240	270
6	12	16	24	36	48	60	72	84	96	108	120	132	156	192	228	264	300
8	14	18	27	42	54	66	78	90	102	114	126	138	162	198	234	270	306
10	14	18	27	42	54	66	78	90	102	114	126	138	162	198	234	270	306

#### APPLICATION GUIDE

PIPE MATERIAL	Field Installed Velocity Sensors		
	STANDARD EXTERNALLY MOUNTED	STREAM VELOCITY SENSORS	"HOT SHOT" WETTED SENSOR
CAST IRON Pig Cast			Yes
Centrifugal	Yes		Yes
DUCTILE IRON Flanged	Yes		Yes
Flanged	Yes		Yes
METALLIC Carbon Steel	Yes		Yes
Stainless	Yes		Yes
Exotic Metals	Yes		Yes
PLASTICS ABS			Yes
PVC	Yes		Yes
CONCRETE RCP		Yes	Yes
Asbestos Cement		Yes	Yes
OPEN CHANNEL CONDUIT		Yes	Yes
NON-FULL PIPE CONDITIONS	Yes	Yes	Yes

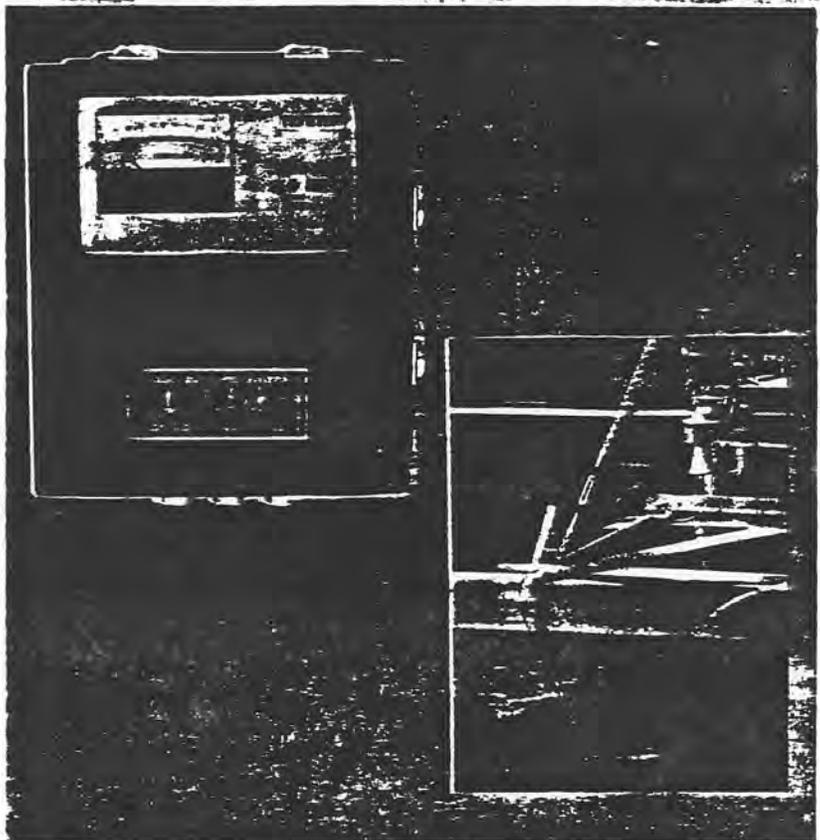


MONITEK  
MODEL 66

# OPEN-CHANNEL MAGMETER

## FEATURES

- No moving parts
- Unaffected by solids, air bubbles, or flotsam
- Linear display and output signals
- No need for flumes or weirs
- No backwater effects
- No head loss
- High accuracy
- Wide dynamic range
- Built-in self check
- Easily installed or removed for inspection without disruption of flow



## DESCRIPTION

The Monitek Model 66 Open-Channel Magmeter is a system that combines the Monitek Flo-Probe Magmeter for measuring velocity with a level sensing device to determine open channel flowrate by the Velocity X Area method. The velocity sensor generates a magnetic field which the fluid passes through, thereby inducing a voltage proportional to fluid velocity. This voltage is amplified and scaled by the electronic converter.

A separate level signal (e.g. ultrasonic level sensor) is accepted by the converter. The velocity and level signals are inputted to a programmed memory (PROM) that calculates flowrate by Velocity X Area. The PROM is available for handling linearization of the flowrate for circular, trapezoidal, and other irregular channel shapes.

The Model 66 is provided in a NEMA 4 enclosure with a meter readout of flowrate. An 8-digit non-resettable totalizer is available as an option. The totalizer is adjustable for setting any units of volume (e.g. gallons, cubic feet, cubic meters, etc.). Analog output signals are available for use with external recorders.

## APPLICATION

The Model 66 measures flows in open channels, partially-filled pipes, and troughs of virtually any size or shape. It is especially desirable in large channels where installation of a flume or weir is impractical.

# MODEL 66 OPEN-CHANNEL MAGMETER SPECIFICATIONS

## MODEL 88L (Series 80) Flo-Probe Magmeter Sensor

Operating Velocity: 0 to 30 feet (9 meters) per second  
 Probe Wetted Material: Epoxy and 316 Stainless Steel  
 Operating Temperature: 160°F (70°C) maximum  
 Operating Pressure: 0 to 300 PSIG (21 bars)  
 Minimum Fluid Conductivity: 2 micromhos per cm.  
 Cable Length: Standard 25 feet (7.5 meters)  
 Optional: Extension cable up to 500 feet (152 meters) maximum.  
 Cable Type: Submersible, polyurethane jacket  
 Probe Diameter: 7/8" (22 mm)  
 Sensor Length: 6" (152 mm)  
 Overall Probe Length: 36" (914 mm)  
 Weight: Approx. 12 lbs. (5.4 kg)

## Ambient Temperature:

Standard - +32°F to 135°F  
 (0 to 57°C)

Optional - -50°F to +135°F  
 (-45 to +57°C) with built  
 in thermostatically  
 controlled heater

## Power Supply:

100/120, or 200/220 volts switch  
 selectable, 50/60 HZ, 15 VA  
 (250 VA with optional heater)  
 Standard - Nema 4, water tight  
 and dust tight.

## Enclosure:

Optional - Class 1, Group D,  
 Division 1 explosion proof  
 case

## Dimensions:

12" (305 mm) high X 20"  
 (254 mm) wide X 5 1/2" (140 mm)  
 deep

## Weight:

Approx. 12 lbs. (5.5 kg)

## Shipping Weight:

Flo-Probe and converter package  
 approx. 30 lbs. (14 kg)

## MODEL 66 Converter (Indicator/Electronics)

Input: MONITEK Series 80 Flo-Probe  
 Magmeter Sensor and level  
 signal (0-10V dc)  
 Range: Continuously adjustable 0.3 to  
 30 feet per second Full Scale  
 Range Adjustment Controls: Multiplier switch, X3 and X30.  
 Continuous digital divider dial  
 calibrated 1.00 to 9.99.  
 Display: Standard 3" meter, calibrated  
 0 - 100 Linear Scale  
 Response Time: 10 seconds  
 Accuracy: ± 1% of Full Scale or ± 0.02  
 feet/sec, whichever is greater  
 Linearity: ± 0.5% of Full Scale  
 Repeatability: 0.01 feet/second or ± 0.2% of  
 Full Scale, whichever is greater  
 Flow Output Signal: Isolated - 4 to 20mA or 0 to  
 20mA, into 0 to 600 ohms,  
 or 10 to 50 mA into 0 to  
 400 ohms

## OPTIONAL BUILT-IN TOTALIZER

### Display:

8 digit, non-resettable counter  
 Relay contact, isolated SPDT  
 (Form C), rated at 5 amperes  
 120 VAC

### Output Signal:

### Measurement Range:

Adjustable 0.0001 to 10 counts  
 per second at full scale flow  
 Range Adjustment Controls: X0.1, X1, X10, X100 multiplier  
 switch and binary switch  
 divider selects any integer from  
 2 through 1024.

### Accuracy:

± 1 count plus the integrated  
 measured flow error.

### Power Supply:

From Model 66 converter

Level Monitoring System - refer to specifications on ultrasonic level system.

To order, specify the following:

- (1) Model 88L Flo-Probe Magmeter Sensor with 25 ft. of standard weatherproof cable.

#### Mounting Options

- ( ) None  
 ( ) Bridge Mount  
 ( ) Side Mount  
 ( ) Bottom Mount

#### Interconnecting Cable

- ( ) Std. cable length - 25 ft.  
 ( ) Additional cable (specify)  
 ( ) NEMA 4 junction box for extension cable  
 ( ) Submersible submarine cable

(2) MODEL 66 - 1  - 2  - 3  - 4 \_\_\_\_\_  
 Enclosure Totalizer Output Signal options

#### 1 - Enclosure (Select One)

- ( ) A = Nema 4  
 ( ) C = Nema 1 - "Panel Mount"  
 ( ) D = Explosion Proof Housing  
 Class 1, Group D, Division 1

#### 3 - Output Signal (Select One)

- ( ) E = Isolated 4 to 20 mA  
 ( ) F = Isolated 10 to 50 mA  
 ( ) G = Isolated 0 to 20 mA

#### 2 - Totalizer (Select One)

- ( ) O = No Totalizer  
 ( ) D = Totalizer with built-in 8 digit  
 non-resettable counter and SPDT  
 output contact

#### 4 - \_\_\_\_\_ List Options

- ( ) 00- None  
 ( ) 04- Non-standard scale (specify)  
 ( ) 05- Built-in heater and thermostat  
 ( ) 16- Stainless Steel Tags  
 ( ) 19- 1/8" (3mm) ID Tubing fittings for  
 enclosure air purge

#### (3) Level Monitoring System

- ( ) None (Customer supplied 0-10V DC level signal)  
 ( ) Ultrasonic Level Monitoring System - supplied in  
 NEMA 4 enclosure with level indicator, transducer,  
 and 25 ft. of cable.  
 Heater w/Thermostat (optional)  
 Additional lengths of cable (specify)

## MONITEK, INC.

1495 Zephyr Ave./Hayward, California 94544  
 (415) 471-8300

EUROPE  
 Monitek GMBH  
 Oberrather Str. 2  
 4000 Düsseldorf 30  
 West Germany

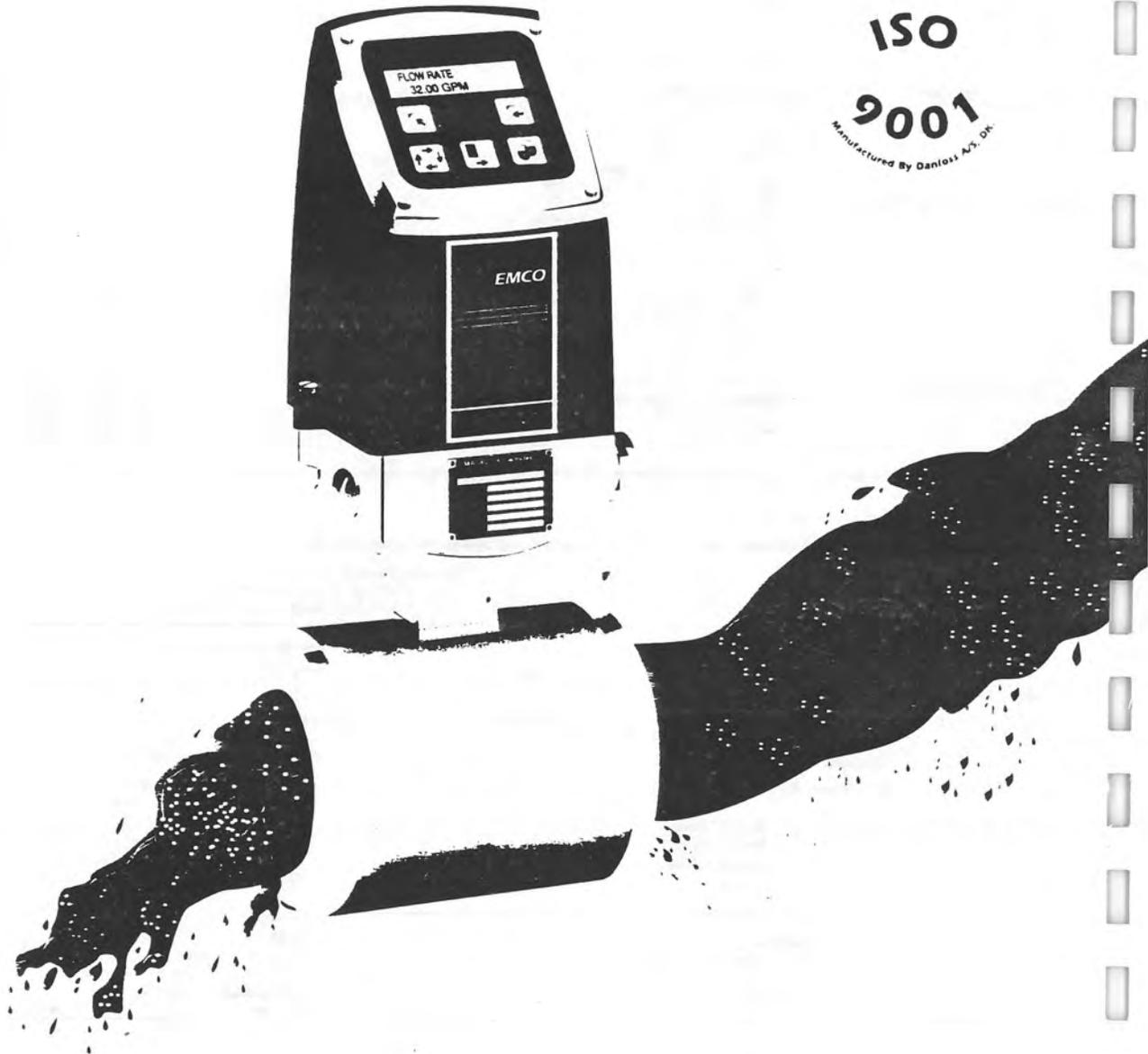
Telephone 02 11 / 65 20 06

Monitek reserves the right to  
 improve specifications without notice.

FLO - 104 - A 84

# MAGFLO™

MAGFLO™ is a trademark of Danfoss A/S. DK.



ISO  
9001  
Manufactured By Danfoss A/S. DK



# MAGFLO™

# Electromagnetic Flowmeter

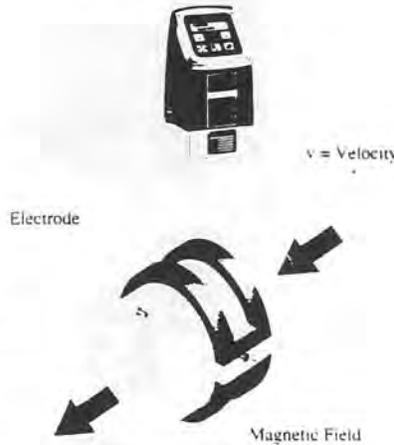
**The Concept:** *The ideal solution for the flow measurement of electrically conductive liquids such as water, chemicals, slurries, pulps, food and beverages.*

## General Theory

The measurement is based on Faraday's Law:

$$E = B \times D \times v$$

which states that a voltage will be induced in a conductor moving through a magnetic field B. The magnitude of the induced voltage E is directly proportional to the flow through the meter.



## Benefits

- No obstruction of flow
- No moving parts
- No pressure drop
- No maintenance
- Not affected by changes in temperature, pressure, density, viscosity or conductivity

## MAG 3000 Features

FLOW RATE 150.00 GPM	■	FLOW RATE 75.0 %	■
TOTALIZER-REV 00015230 GAL	■	TOTALIZER-FW RESET	■

Automatic zero adjustment

### Configuration

6 push buttons for specific performances

- Engineering units and flow rate
- Outputs
- Response time, cut off
- Flow direction ( → ← → )
- User code/password
- Display readout
- User application setup
- Counter reset

### Diagnostics

- Continuously monitors application, sensor, electronics, connections, cables and outputs
- Service mode can be used for location of Errors

Qmax. 200.00 GPM	■	TOTALIZER-FW 00006782 GAL	■
ERROR PENDING No. 010 00:02 h	■	ERROR LOG No. 010 00:10 h	■

Automatically adjusts measuring frequency

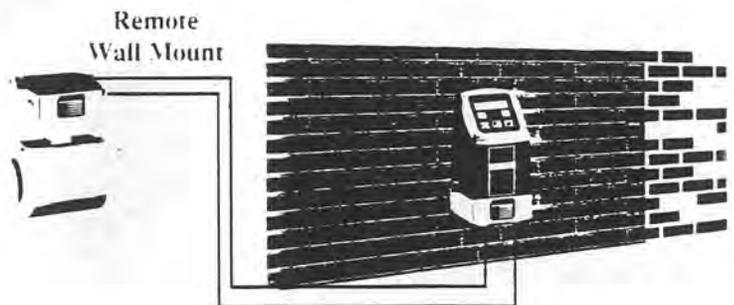
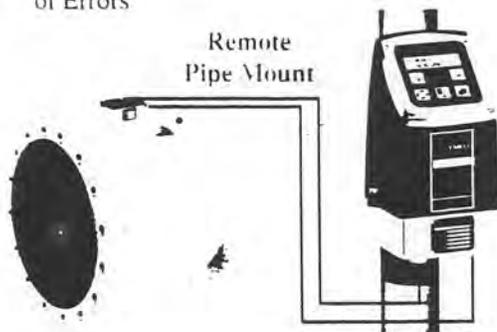
### Front Plate

- Weather proof push button operation
- Adjustable rotating display and terminal box



### Standard Outputs

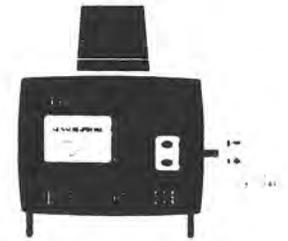
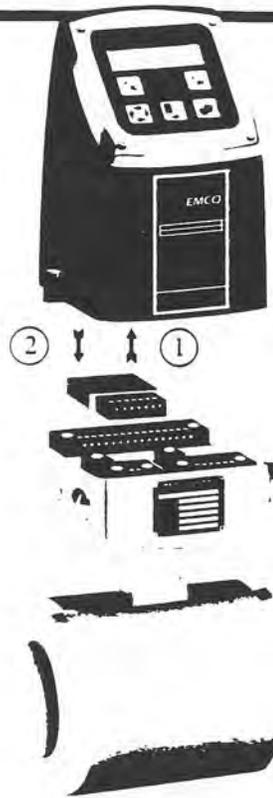
- Analog 4-20 mA
- Frequency/Pulse (Scaled in engineering units)
- Relay for flow direction or error



## SENSOR - PROM

for easy startup and use

- Automatic setup of all sensor characteristics
- The flowmeter will read out the flow rate, flow direction, etc. without making any settings
- Special application settings will download to the SENSOR-PROM
- Replacement of electronics can be done by non-technical personnel without rewiring, and any previous settings will automatically be loaded into the new electronics
- Critical settings are always in the SENSOR-PROM and can only be changed by a security code



Setup of data can be done at your desk with a 9-Volt battery

- 1 ↓ Loads sensor information
- 2 ↓ Loads application settings

## MAG 1100

Wafer Style (shown as remote)

Line Sizes: 1/2" to 4"  
 Accuracy: Class 0.25% of rate  
 Housing: ASTM 316  
 Liner: Ceramic Al<sub>2</sub>O<sub>3</sub>  
 Electrodes: Platinum  
 Temperature: up to 390°F  
 Cleaning: CIP (cleaning in place)  
 cleanable by steam or chemical



Remote and Integral Rating:  
 NEMA 6 submersible in accident

## MAG 3100

Flange Style (shown as integral)

Line sizes: 4" to 48"  
 Accuracy: Class 0.25% of rate  
 Liner: Neoprene, N-Rubber, Ebonite, EPDM, Teflon and Polyurethane PU  
 Electrodes: ASTM 316 Ti, Monel, Hastelloy C, Platinum and Titanium  
 Temperature: up to 355°F



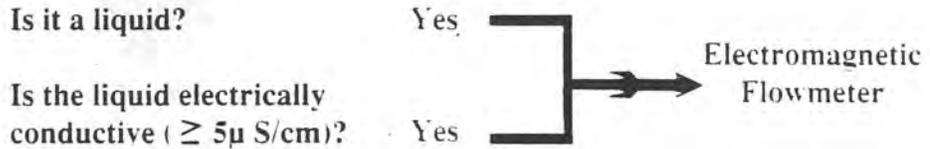
Remote Rating:  
 NEMA 6 submersible

Integral Rating:  
 NEMA 6 submersible in accident

# Applications



MAGFLO™ electromagnetic flowmeter is the most widely used flowmeter in the industrial market.



MAGFLO™ is the solution to your flowmetering application.

Process Industry • Food and Beverage • Energy • Pulp and Paper  
Chemical and Others

## Raw Material

Pulp  
Water  
Slurries  
Additives  
etc.

## Energy and Refrigeration

Hot Water  
Chilled Water  
Cooling Water

## Manufacturing Process

Food & Beverage  
Chemicals  
Pulps, Slurries, Water, etc.

## Water Treatment

Slurries  
Sewage Water  
Additive Chemicals  
etc.

## End Products

Chemicals  
Food & Beverage  
etc.

Saves Energy and Raw Materials  
Increases Productivity, Efficiency, and Quality

Input to Monitoring Systems  
Input to Regulation Loops  
Totalizing the Total Flow

Continuous Mixing Application  
Mixing of Two Components  
Accurate Dosing

Batching  
Batch times down to 1 sec.  
Custody Transfer Meters



Engineering  
Measurements  
Company

600 Diagonal Highway, Longmont, CO 80501  
Tel: (303)651-0550 FAX: (303)678-7152

## General Specifications

MAGFLO™ electromagnetic flowmeters, type MAG 1100/3000 and 3100/3000, are microprocessor-based flowmeters. Each will measure the flow of electrically conductive liquids having a conductivity of 5 micromho/cm or more.

Features of the MAG 1100/3000 and 3100/3000 include:

- **0.25% accuracy.** Better than 0.25% of rate value.
- **Compact and practical design.** The sensor and signal converter can be installed as either compact or remote units.
- **User-friendly.** Display indicates:
  - Instantaneous flow rate, selectable in any engineering units
  - Measurement of volume (totalization) forward & reverse with two built in counters and pulse outputs.
  - Error indication and Error log.
  - Configuring (max. flow rate, output units, etc.)
- **Simple start-up.** Automatic setup by SENSOR-PROM.
- **Battery operation.** The signal converter can be set simply by connecting to a 9 V standard battery.
- **Data bank.** With power failure or signal converter replacement, settings are retained.
- **Self-diagnostic.** Operating malfunctions are indicated by the display and an Error relay.
- **Robust Construction.** Acid-resistant ASTM 316 S.S. enclosures make the MAG 1100 especially suitable for hostile and sanitary environments. In addition, the signal converter, MAG 3000, is furnished in a high-tech polymeric material or ASTM 316 enclosure. The MAG 3100 sensor is designed for submersible use.
- **Reliability.** Meets ISO 9001 quality control standards.
- **Service.** Can be serviced by non-technical personnel. The signal converter is easily replaced with all settings automatically transferred from SENSOR-PROM into the new signal converter.
- **Bidirectional.** Meters can measure flow in both directions.

## MAGFLO™ Electromagnetic flowmeter Type MAG 1100/3000 and MAG 3100/3000

MAGFLO™  
MAGFLO™ is a trademark  
© Dunstons Ltd. UK



MAG 1100/3000

MAG 3100/3000

### Applications

MAGFLO™ electromagnetic flowmeters are commonly applied to diverse flowmetering applications using conductive type liquids. They offer important advantages such as: no pressure drop, high accuracy and a wide variety of materials of construction. They have been successfully used in most industries including food, beverage, drug, chemical, power, heat, pulp & paper and water treatment. Low maintenance and high reliability make MAGFLO™ the meter of choice in many flow measurement applications.

### Application examples

- Volume registration
- Measurement of flow in connection with
  - regulation
  - input to monitoring systems
  - input to main process control
- Liquid blending (proportional regulation)
- Measurement of predetermined volume (Batching)
- Filling liquid into packs, containers, etc.



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MAGFLO™

# Technical Data - Sensor MAG 1100 and 3100



**MAG 1100**



**MAG 3100**

Type	Wafer	Flange
Size	1/2", 1", 1-1/2", 2", 3", 4" (15 - 100 mm)	4" - 48" (100 - 1200mm)
Measuring Range	0-0.8 to 0-33 ft/s (0-0.25 to 0-10 m/s) with a min. turn down of 10:1	0-0.8 to 0-33 ft/s (0-0.25 to 0-10 m/s) with a turn down of min. 10:1
Measuring Methods	dc pulse flowmeter measuring frequency: 3 1/8 Hz, 6-1/4 Hz, 12-1/2 Hz automatically set depending on size.	dc pulse flowmeter measuring frequency: 3 1/8 Hz, 6-1/4 Hz, 12-1/2 Hz automatically set depending on size.
Process Pressure	580 psi (40 bar), fits ANSI Class 150/300#, 1/2" only 300#	ANSI Class 150#, 300# (contact factory for higher pressure rating) AWWA for sizes 28"-48"
Process Vacuum	Vacuum: $1.5 \times 10^{-2}$ psi (10 <sup>-2</sup> bar)	<b>Max. Vacuum per liner</b> Neoprene, Ebonite, EPDM and Natural rubber: 7.25 psia (500 mbar) Polyurethane: 5.8 psia (400 mbar) Teflon (PTFE): 3.7 psia (600 mbar)
Process Temperature	-5 F to 265 F (-20 to 130 C) optional 390 F (200 C) F > 200 F (95 C) use remote mount signal converter	<b>Max. Temperature per liner</b> Neoprene, Ebonite: 32 to 200 F (0 to 95 C) Natural rubber: 32 to 160 F (0 to 70 C) EPDM: 15 to 200 F (-10 to 95 C) Polyurethane: 32 to 120 F (0 to 50 C) Teflon (PTFE): -5 to 355 F (-20 to 180 C) T > 200 F (95 C) use remote mount signal converter
Temperature Shock	Temperature shock in less than 1 sec.: Positive change $\Delta T$ max. $\leq 210$ F (100 C) Negative change $\Delta T$ max. $\leq 140$ F (60 C) Higher $\Delta T$ requires heating/cooling time over 1 sec.	no limitation
Ambient Temperature	Operation: -40 to 390 F (-40 to 200 C) Storage: -40 to 165 F (-40 to 75 C)	Operation: -40 F to 300 F (-40 to 150 C) Storage: -40 F to 165 F (-40 to 75 C)
Liner	Aluminum oxide Al <sub>2</sub> O <sub>3</sub> (ceramic)	Neoprene (std), options: Ebonite, EPDM, Natural rubber, Polyurethane (PU), Teflon (PTFE), Linatex
Electrodes	Platinum	ASTM 316 Ti (w.no. 1.4571), Hastelloy C, Platinum/Iridium Titanium, Monel
Gaskets	Graphite (max. 390 F @ 580 psi), Teflon PTFE (max. 266 F @ 362 psi)	
Enclosure rating	NEMA 6 - IP 67 submersible in accident	NEMA 6 - IP 68 submersible
Cable Entries	1/2" NPT (Pg 13)	1/2" NPT (Pg 13)
Mechanical Load	1 G, 1-1000 Hz sinusoidal in all directions, to IEC 68-2-6	1 G, 1-1000Hz sinusoidal in all directions, to IEC 68-2-6
Test Pressure	2 x max. pressure: 1160 psi (80 bar)	1.5 x pressure rating
Conductivity	Compact type flowmeter: Electrically conductive liquids, conductivity $\geq 5$ micromho/cm.  Remote signal converter:  <div style="text-align: center;"> <p>Medium Conductivity micromho/cm</p> <p>Lmax (ft/m) Cable length</p> </div>	
Cable Type	Signal cable: 3 x 18 gauge (1.5 mm <sup>2</sup> ) PVC with common shielded cable Coil Current Cable: 2 x 18 gauge (1.5 mm <sup>2</sup> ) PVC with common shielded cable When ordering the wall mounting kit, 33 ft (10m) of 3 x 18 gauge (1.5 mm <sup>2</sup> ) cable and 5 x 1/2" NPT (Pg13) entry glands are supplied.	



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**MAGFLO™**

# Technical Data - Signal Converter MAG 3000



Measuring Method/ Magnetizing System	dc pulse flowmeter with following frequencies 3 1/8, 6 1/4 and 12 1/2 Hz (depending on sensor size)	
Measuring Range (F.S.)	Can be set from 0-0.8 ft/s to 0-33 ft/s (0-0.25 to 0-10 m/s)	
Enclosure Material	Acid resistant steel ASTM 316 High-tech polymer material type polyamide 66 70G35 HSL	
Ambient Temperature Operation	Polyamide enclosure: -4 to + 120 °F (-20 to +50°C) Stainless Steel enclosure: -4 to + 120 °F (-20 to +50°C)	
Storage	-40 to + 185 °F (-40 to 85 °C)	
Enclosure	NEMA 6 (IP 67), submersible (3 feet of water) in accident	
Supply Voltage	Standard versions: 110/240 Vac +10%/-15%, 50-60 Hz 24 Vdc +33%/-25%	
Basic Setup Of Output Characteristics	<p style="text-align: center;">Bidirectional flow Relay output indicates flow direction</p>	<p style="text-align: center;">Flow in one Direction Relay output indicates error</p>
Relays	Relay indicates flow direction or Error Maximum 42 Vac, 2A	
Analog Output	<p style="text-align: center;">0/4-20 mA galvanically isolated. Load: max. 800 ohm</p>	
Frequency/Pulse Output Can Be Scaled	Active: 200 mA, pulse ≤ 50 ms, f ≤ 2 Hz (for 24 V electromechanical counter) Active: 20 mA, 30 V, Fmax. = 10 kHz (for electronic counter) Passive: 200 mA, TTL - 50V, Ron < 5 ohm, Fmax. = 10kHz	
Time Constant	Analog output: 0.8-30 s adjustable Frequency/Pulse output: 0.1-30 s adjustable Reaction time relay: Error 1 s; flow direction 100 ms	
Outputs	Galvanic isolation min. 500 V, Short-circuit-proof	
Counter	Two internal counters for forward and reverse flow	
Low Flow Cut-off	Adjustable from 0%-9.9% of F.S.	
Display	Back lit with alphanumeric text, 2 x 16 digits for indicating flow, volume, settings, etc. Reverse flow shown with negative signs	
Zero Point	Automatic zero-point adjustment	
Power Consumption	8 VA	
Mechanical Load	1G, 1-1000 Hz sinusoidal in all directions, to IEC 68	



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**MAGFLO**™

### MODEL 1081 PORTABLE DOPPLER FLOWMETER

DFM-3002 ( 4 / 87 )

PAGE 1 of 2



The NUSONICS Model 1081 Doppler Flowmeter is designed for portable use in a wide range of applications. It is packaged in a small, durable, extruded-aluminum carrying case and operates off a rechargeable battery. The entire flowmeter weighs only 10 pounds, including carrying case, battery, electronics, clamp-on transducer with 10 feet of transducer-to-electronics cable, and ac adapter.

Bulletin DFM-3001 describes the operating principles and performance of NUSONICS' Doppler flowmeters and, specifically, the Model 1181. The Model 1181 is designed for permanent installation and provides a wider range of outputs and other options. However, both models use the

same operating principle and clamp-on transducers, and have the following characteristics:

- Thrive on bubbles and solids
  - No moving parts
  - Non-intrusive
  - Field installable on
    - pipes of 1-inch diameter or greater
    - metal or plastic pipes
  - Require less than 3.2 watts
  - Easy-to-read averaging panel meter
- The Model 1081 can be used for experimental purposes to qualify new applications for later permanent installation of the Model 1181. The Model 1081 can also be used for

# Specifications

**Flowrate Range:**

0-40 ft/sec (0-12.2 m/s), bidirectional

**Repeatability:**

±0.005 ft/sec

**Pipe Materials:**

Menu-selections – metal alloys, plastics, glass, etc.

**Line Sizes:**

Standard transducers fit all 4"-48" line sizes  
Transducer mounting rails: 15" rails fit 4"-12" lines  
36" rails fit 4"-48" lines

**Outputs:**

Analog: 4-20 mA into 800 ohms or less  
RS-232C: 9-pin connector; 300/1200/2400/4800/9600 baud  
Averaging: (Output Smoothing) 1-30 seconds

**Display:**

2-line × 16 character alphanumeric liquid crystal display,  
8.06 mm character height

**Power Supply:**

Standard: 115 VAC, ±10%, 50-60 Hz  
Ni-Cad battery operation, 8 hours at full charge  
Optional: 230 VAC, ±10%, 50-60 Hz

**Power Consumption:**

16 watts

**Battery-backup:**

10-year retention of data and calibration constants

**Liquid Temperature:**

-40°C to +150°C (-40°F to +302°F)

**Ambient Temperature:**

-10°C to +50°C (+14°F to +122°F)

**Size:**

Length: 11" (27.9 cm) Width: 7" (17.8 cm)  
Height: 8.3" (21.1 cm)

**Weight:**

11.6 lbs. (5.3 kg), excluding transducers/rails

**NUSONICS**  
INC.

11391 E. Tecumseh St. • Tulsa, OK 74116-1602  
Phone: (918) 438-1010 • Telex: 49-7592 • Fax: (918) 438-6420

# microFLOW 90:

- Portable, battery-powered
- Same pair of transducers fits all line sizes 4"-48"
- Self-zeroing
- Independent selections of rate and total units

- Latest 16-bit microcomputer technology
- Simple keypad setup
- Output smoothing, 1-30 seconds

*NUSONICS introduces the microFLOW 90, a strap-on transit-time flowmeter designed with the user in mind.*

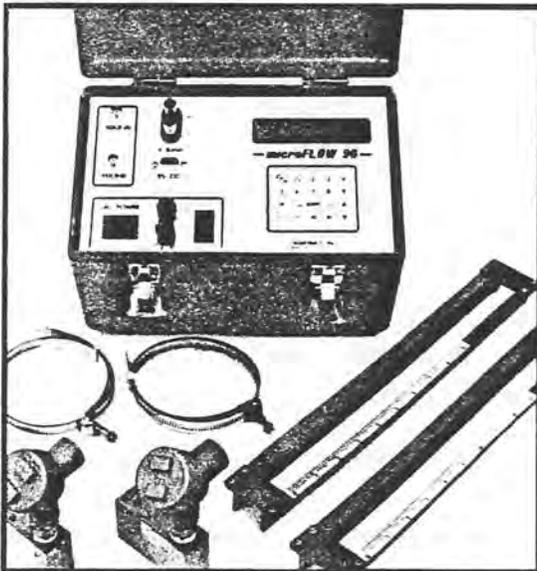
## The microFLOW Advantage

microFLOW 90 transducers are simply strapped to the outside of the pipe. This eliminates costly flowtubes and preserves the integrity of the pipe. The microFLOW 90 can be installed in minutes: no special skills or tools are required. Since the electronics are fully portable, the microFLOW 90 is ideal for flow surveys, and almost all closed-pipe liquid flow applications where non-intrusive measurement is desired.

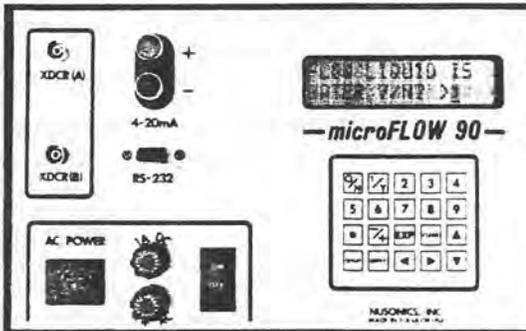
## Unmatched Versatility and Simplicity

Other transit-time flowmeters require different transducers for specific pipe size ranges, but the microFLOW 90 is equipped with a standard transducer set which allows the same flowmeter to be used on all pipe sizes from 4" to 48".

Its advanced, microcomputer-based design puts setup and operation steps literally at the user's fingertips: No switches, no pots, no manual adjustments. Step-by-step startup is as simple as answering questions which appear on the 2-line by 16-character liquid crystal display. The user selects operating ranges and specific application information from the microFLOW menu library, and the microFLOW conducts internal meter setup and output scaling automatically.



Portability was one of the primary microFLOW 90 design objectives. Its rugged carrying case measures only 11" x 7" x 8.3", and weighs less than 12 lbs. including electronics. In the field, it can be powered for up to eight hours by its self-contained rechargeable ni-cad battery, or through a conventional ac line.



## A Fully-Loaded Flowmeter

The standard microFLOW 90 comes equipped with many features that are offered as options with other flowmeters. The user can choose either unidirectional (forward) flow indication, or forward and reverse indication; the microFLOW scales the 4-20 mA output and LCD rate indication to the user-selected range and engineering units. The microFLOW 90's totalizer displays total flow in units selected from the menu library, and need not indicate the same units as the rate display. For instance, a user may select gallons per minute as the units of rate and cubic feet as totalization units. A variety of both English and metric units are available.

An RS-232C interface is included, allowing remote communication by computer or data logger. Rate and total may be continuously displayed, and engineering units and scaling values may be changed remotely via RS-232.

The microFLOW 90 RAM is non-volatile, so that setup data and totalized flow can be retained for as long as ten years, independent of external power or the microFLOW's main power ni-cad batteries.

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microFLOW  
90  
Transit-Time  
Flowmeter

PRODUCT BULLETIN

surveying flows for relatively short periods of time in a number of different locations.

Figure 1 shows the Model 1081 with its carrying case closed and illustrates its portability. Figure 2 shows the Model 1081 with its carrying case open and illustrates its various features. These features are described in greater detail below.

### TRANSDUCERS

The Model 1081 is always supplied with clamp-on transducers but will also work when connected to NUSONICS' wetted-type Doppler transducer. In either case, the transducer assembly includes a transmitting and receiving element. The electronics determine the frequency difference between the transmitted and received signals, and this Doppler-shift frequency (i.e. frequency difference) is proportional to flow rate. For more details of operation, performance, and transducer types, please refer to Bulletin DFM-3001.

As described in Bulletin DFM-3001, it is essential that the transducer assembly be properly coupled to the pipe wall. Model 1081's are supplied with a coupling kit consisting of a small acoustic pad and a tube of petroleum jelly. A hose clamp, for mounting the transducer on pipes up to 12 inches in diameter, and a nut driver also are included.

### OUTPUTS

The Doppler-shift frequency determined by the electronics is not suitable for common read-out devices and hence is not made available as an output to the user. Instead it is converted to a 4-20 mA (0-20 mA optional) output that is linear with flow rate and suitable for a wide range of rate indicators and recorders. This current output is provided at a pair of conveniently accessible binding posts for single or dual banana plugs, spade lugs, and for bare wire connections.

Two ranges, selected by means of a five-position switch, are provided for monitoring flow rates: 0-10 and 0-40 feet per second (0-3 and 0-12 meters per second optional). The lower range provides greater meter and current output resolution at low flow rates. At either range position, the electronics provide 20mA output at full-scale flow; i.e., 20 mA at 10 feet per second in the 0-10FPS switch position, and 20mA at 40 feet per second in the 0-40FPS switch position. However, in conjunction with flowmeter scaling and readout, the SPAN potentiometer can be adjusted so that outputs coincide precisely with customer's field data.

The five-position meter select switch also contains positions for checking the output voltage level of the battery and the strength of the received Doppler signals. Acceptable and unacceptable levels are indicated via the output meter.

### BATTERY OPERATION

The Model 1081 contains a 24-volt nickel-cadmium battery mounted inside its carrying case. When fully charged, this battery will operate the unit for about 8 hours without recharging. Controls are provided for testing the battery to make sure it is sufficiently charged to ensure proper flowmeter operation. The Model 1081 is supplied with an ac adapter for recharging the battery. Recharging

normally is performed overnight while the flowmeter is not in use. The ac adapter also can be used to operate the flowmeter and to trickle charge the battery simultaneously if a battery check produces an indication within the special test zone. When operated in this manner the battery will assume operation of the flowmeter in the event of ac power failure, but the flowmeter will not operate properly if the battery output falls below the test zone limit. The battery will be on trickle charge automatically when ac power is restored.

### SIGNAL LEVEL

Bulletin DFM-3001 describes how the strength of the received Doppler signal may vary with the nature of the liquid being metered. The sensitivity of the flowmeter is adjustable by means of a panel control and a special meter test zone. The signal level must be checked at each installation site. If the output meter indication is below the special test zone after sensitivity adjustment, indicating insufficient returned Doppler signals, another transducer location (perhaps where more bubbles or solids exist) must be tried.

### OPTIONS

A remote process indicator containing an LCD (liquid crystal display) is available for connection to the 4-20 mA output of the Model 1081. Separate power connections are not needed. Operating power is derived directly from the current output signal to drive the 3½-digit LCD. The display is field scalable to read common engineering units in ranges of 0-1.999, 0-19.99, 0-199.9, or 0-1999.

### OPERATING SPECIFICATIONS

Flow Rate Range	0 to 40 ft/s or 0 to 12 m/s
Flow Rate Outputs	
Analog Meter	Two selectable ranges: 0 to 10 and 0 to 40 ft/s, or 0 to 3 and 0 to 12 m/s
Analog Current	4 to 20 mA or 0 to 20 mA into 550 ohms or less
Output Averaging	5-second time constant
Power Requirement	24 V dc, 3.2 W maximum. Provided by built-in rechargeable battery. (Refer to battery specifications.)
AC Adapter	Input: 100, 115, or 230-V ac; 50 to 60 Hz Output: 29 V dc at 120 mA
Ambient Temperature	
Range (at transmitter)	0° C to 50° C (+32° F to +122° F)
Liquid Temperature	
Range	0° C to +150° C (+32° F to +302° F)
Liquid Pressure	Limited by users piping

### PHYSICAL SPECIFICATIONS

Overall Dimensions	Length: 11 in. (27.9 cm), Width: 7 in. (11.8 cm), Height (including feet & handle) 8.3 in. (21 cm)
Weight	10 pounds (4.5 kg)
Transducer Cable	
Length	10 ft (3.0 m)
AC Adapter Cable	
Length	6 ft (1.8 m)

### BATTERY SPECIFICATIONS

Type	Nickel-cadmium, rechargeable
Voltage-Current Rating (nominal)	24 V dc at 1.2 Ah
Continuous Operating Time Between Recharges (nominal)	8 hours at +25° C (+77° F), 7 hours at +40° C (+104° F)
Charge Time (nominal - from low end of BATTERY TEST scale)	10 hours at 10° C to 40° C (+50° F to +104° F)

# DOPPLER EFFECT

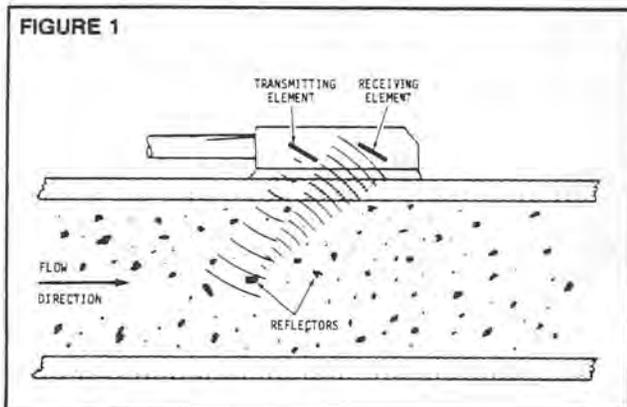
NUSONICS is already well-known as a manufacturer of instruments using "sound velocity" to measure flow rates, concentrations, and pipeline interfaces. With a pioneering position in acoustics dating back to the 1960s, NUSONICS is uniquely qualified to offer Doppler Flowmeters as logical companions to its sonic transit-time flowmeter line.

NUSONICS Doppler Flowmeters pick up where transit-time meters leave off. Transit-time models are for clean, bubble-free liquids; the Doppler Flowmeters thrive on suspended solids and bubbles.

The principle on which NUSONICS' Doppler line is based was proposed by Christian Doppler in 1843: namely, that there is a shift in apparent frequency or wave length when there is relative motion between the transmitter and receiver. Applied to sound, we hear this effect daily as the high-pitched whine of a car approaching on the highway is replaced by a lower-pitch roar after it has passed. Doppler radar is a more sophisticated application of this principle. Applied to light, the Doppler effect is used to measure the relative motion of the stars with respect to the earth. Now in flowmetering, the Doppler effect is an idea whose time has come!

## OPERATING PRINCIPLE

Two transducers are mounted to the wall of a pipe as illustrated in Figure 1. An ultrasonic wave of constant frequency is transmitted into the liquid by one of the transducer elements. Solids or bubbles in suspension in the liquid reflect the sound back to the receiving transducer element. The relative motion of the reflecting bodies tends to compress the sound into a shorter wave length, i.e. into a higher frequency. This higher frequency measured at the receiving transducer is electronically compared with the transmitted frequency to yield a frequency difference which is directly proportional to the flow velocity in the pipe.



## A TYPICAL NUSONICS® DOPPLER METER

Consists of a transducer, a transmitter, and an interconnecting cable. The transducer may be either a clamp-on or a wetted style, as described in this bulletin. The transmitter electronics may be mounted in a convenient carrying case for portability or in a NEMA enclosure for permanent or semipermanent installation as shown in Figure 2. Bulletin DFM-3002 contains a detailed description and performance specifications for NUSONICS' portable Doppler flowmeter.

FIGURE 3  
CLAMP-ON TRANSDUCER

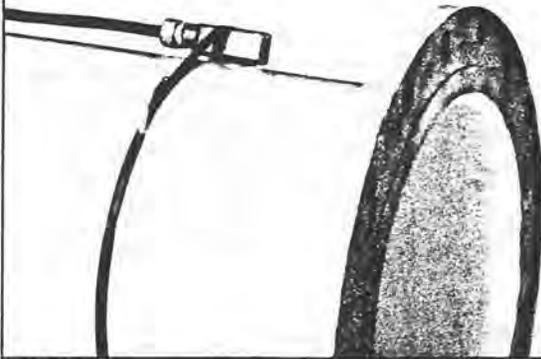
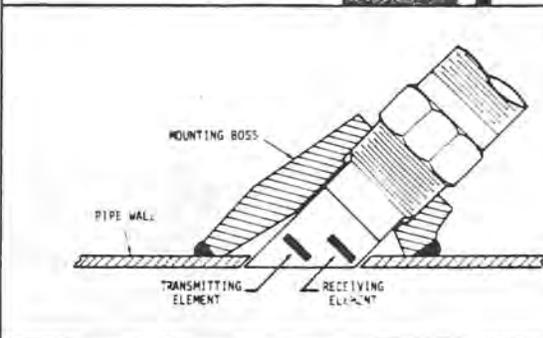
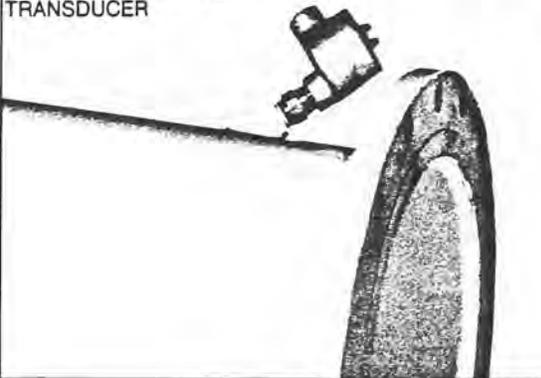


FIGURE 4  
PERMANENT WETTED  
TRANSDUCER



## TRANSDUCER TYPES

The clamp-on style transducer (Figures 1 and 3) is designed for convenient mounting to user's flowtube in the field. The epoxy plastic transducer assembly must be coupled to the pipe wall with one of the kits provided. For temporary installation, the transducer is clamped to the pipe wall using an elastomeric pad and a suitable grease as the signal coupling medium. For permanent installation, the transducer is usually epoxied to the pipe wall and held firmly by a mechanical clamp as shown in Figure 3.

The wetted style (Figure 4) is designed to be a permanent part of a fully assembled flowtube, supplied by NUSONICS. Such a flowtube can be pre-calibrated in NUSONICS' flow laboratory, under specific conditions. More important, there is only epoxy resin and no pipe-wall metal between the transducers and liquid to be metered. Since sound tends to "ring" in a metal, this style improves the signal-to-noise ratio of the instrument. The improved signal-to-noise ratio, in turn, extends the operating range of the Doppler Meter to cleaner liquids and may, in some cases, yield better accuracy.

Wetted transducers can also be applied to sonically opaque pipe walls such as concrete, which will not accommodate clamp-on transducers.

# MODEL 1181

The Model 1181 Doppler Flowmeter is intended primarily for permanent installation in industrial processes, power plants, and waste treatment facilities. In standard form it consists of the transmitter electronics contained in a NEMA 4X fiberglass enclosure, a clamp-on transducer assembly with 20 feet of transducer cable, and a transducer coupling and clamping kit. The standard and optional features of the Model 1181 are covered in greater detail on the following pages of this bulletin. Some of these features are illustrated in Figure 5.

## STANDARD FEATURES

### OUTPUTS

The Model 1181 converts the Doppler signal, which is directly proportional to the flow velocity in the pipe, to industry standard outputs of 0 to 10 VDC and 4 to 20 mA or 0 to 20 mA for driving peripheral equipment, and also provides a 0-10 VDC signal level output. The flow outputs are easily field rescalable to cover any full-scale flow from 3.5 up to 40 feet per second and/or to express the output in customer's preferred units, e.g., gallons per minute, liters per hour, etc.

Static calibration and scaling of the voltage and current outputs consists of injecting a built-in precision reference

frequency into the Doppler circuitry. Voltage and current "zero" and "span" potentiometers are then used to adjust the outputs to the appropriate calibration value. The "span" potentiometers also can be adjusted to make the outputs coincide precisely with prover runs or other field data.

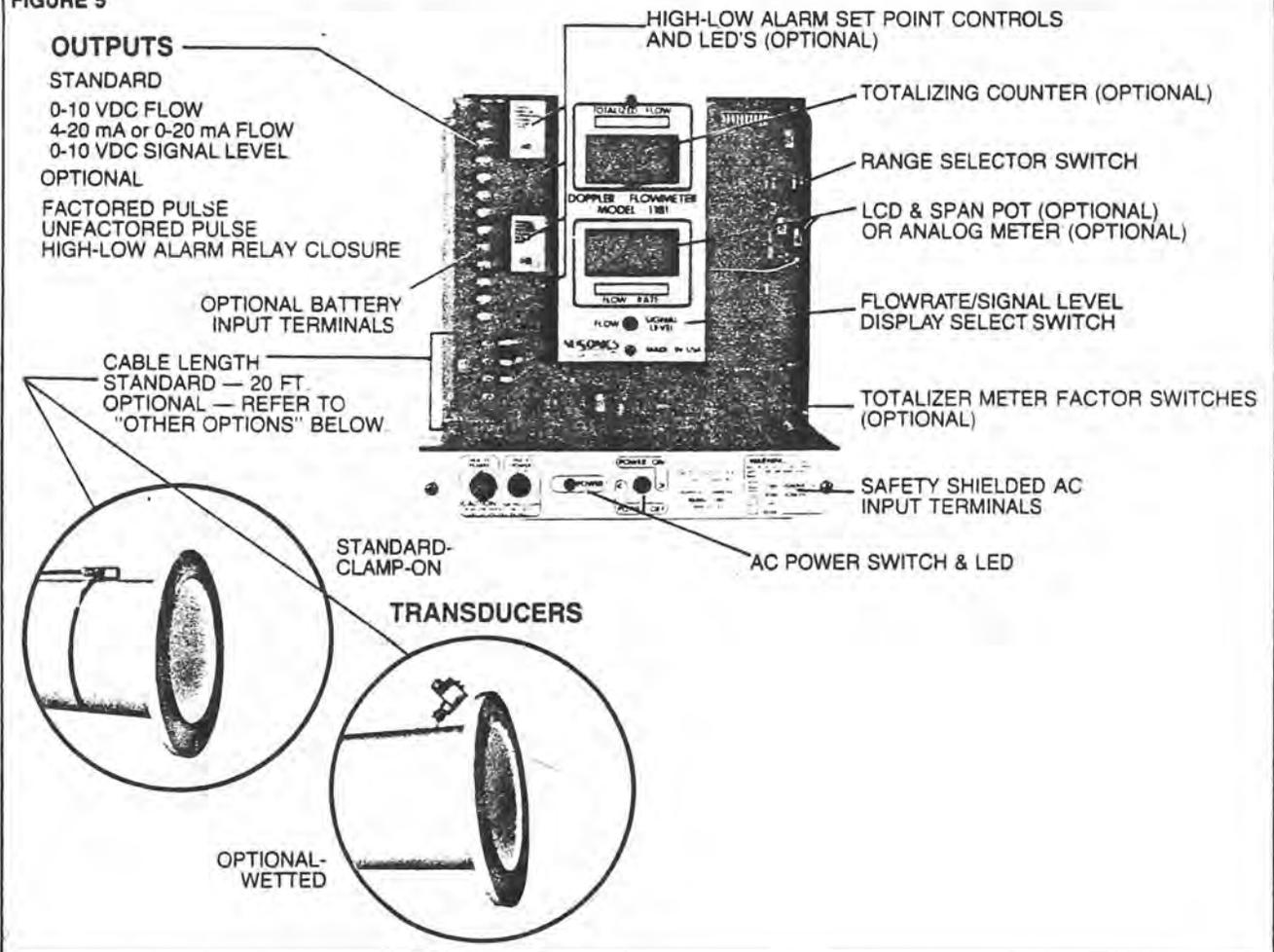
### SENSITIVITY

If a liquid is completely free of bubbles or solids, there will be no back-scattered Doppler signal and the meter will not function. If the bubble/solids content is small, the backscattered signal will be relatively weak and may disappear into background noise. This noise includes that created by other electrical equipment in the area and also that created by the instrument itself. The self-generated noise is especially great when clamp-on transducers are used, which are characterized by "ringing" in the pipe wall. NUSONICS Dopplers are relatively insensitive to all types of background noise compared to competitive Doppler meters and will thus handle cleaner liquids. Signal level can further be enhanced by specifying the optional wetted transducers.

### MAINTENANCE

Model 1181 is designed to operate indefinitely without maintenance. All standard electronics and clamp-on transducers are the same. Thus, one set of spare parts can serve a wide range of flowtube diameters and materials of construction.

FIGURE 5

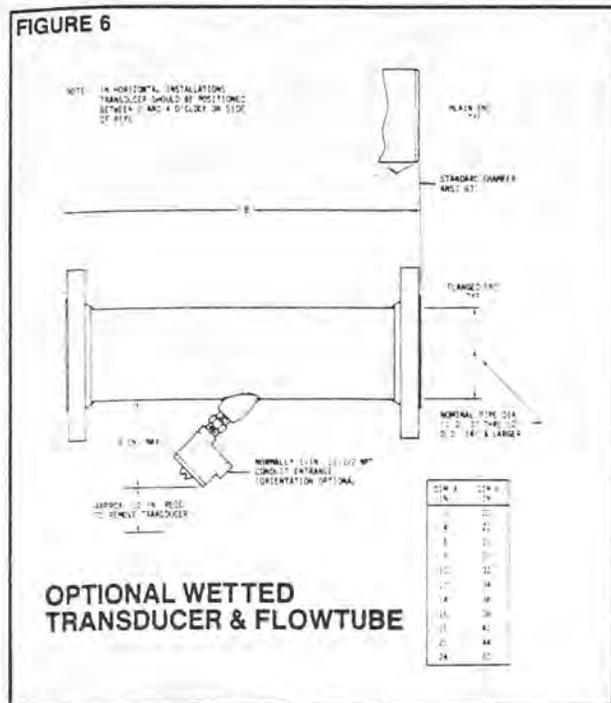


# OPTIONS

## TRANSDUCERS

For greater ruggedness and sensitivity, NUSONICS offers fully assembled flowtubes with wetted transducers, as an alternative to the standard clamp-on transducers. The wetted transducers have explosion-proof connection heads. Figure 6 shows the dimensions of NUSONICS' fully assembled Doppler flowtubes.

NUSONICS also offers wetted transducers in kit form for field installation in user's flowtube. In addition to weld-on kits for various types of metal piping; saddle-plate kits are available for concrete and other non-weldable materials.



## OUTPUT METERS

At time of purchase a LCD (liquid crystal display) or a needle-indicating (analog) meter can be installed as an integral part of the transmitter electronics assembly to provide a visual indication of flow rate. A transmitter enclosure with the optional window should be specified when either meter is ordered. A LCD and an analog meter are also available for remote mounting.

The transmitter-mounted (local) LCD and the remote LCD have a 3½-digit display. Each meter is factory-scaled in purchaser-specified units of flow to read out in ranges of 0 to 1.999, 0 to 19.99, 0 to 199.9, or 0 to 1999. These flow rate meters are conveniently rescalable by the user; however, when a local and a remote LCD are used at the same time, both meters must be adjusted for the same full-scale flow but different engineering units may be used. The remote LCD is designed to operate from the standard 4 to 20 mA output, without a separate AC power source. It can be supplied for mounting in user's control panel and is also available in a NEMA 12 enclosure.

The standard local or remote analog meter indicates the percent of full scale flow. As an extra option, either meter can be supplied with a face plate scaled in the desired units of flow. The remote analog meter connects to the voltage output terminals and is available for panel mounting or housed in a NEMA 4 or a NEMA 7 enclosure.

## TOTALIZER

At time of purchase, optional circuitry can be added to the electronics to provide a 5-volt, 0 to 1000-Hz frequency output which is suitable for driving a remote totalizer, and a 24-VDC factored pulse output for operation of a local and/or a remote totalizing counter. The frequency output may be specified independently of the factored pulse (totalizing counter) option, but the circuitry for both are required for the latter. However, a movable jumper permits feeding only one of the outputs at a time to the output terminal strip. For example, a remote totalizer and a remote totalizer counter cannot be connected to the Doppler meter at the same time.

The optional six-digit, lockable, resettable, totalizing counter mounts in a panel above the optional flow rate meter as shown in Figure 5. A transmitter enclosure which includes the optional window is necessary for viewing the totalizing counter. A five-digit set of rotary switches is used for dialing in a meter factor. Thus, the totalizing counter will read out in user-selected units of cumulative flow, e.g., gallons, 100's of gallons, liters, cubic meters, etc.

The totalizing counter also can be supplied for remote installation in user's own control panel.

## HIGH-LOW ALARM

At time of purchase, a high-low alarm option may be specified which provides two relay contact outputs. These relays activate when the output falls below or rises above preset limits.

Two 10-turn, dial-indicating potentiometers are provided for setting these limits. Movable jumpers permit user to select whether relay output contacts open or close when alarm is activated.

## ENCLOSURES

Instead of the standard NEMA 4X fiberglass electronics enclosure, purchaser may specify a NEMA 4 steel enclosure or a NEMA 7, Class I, Group D explosion-proof enclosure. Each enclosure is available with a window in the cover for viewing the flow rate meter and totalizing counter. If the NEMA 7 enclosure is required, user should also specify wetted transducers with explosion-proof connection heads and should provide explosion-proof conduit for the transducer-transmitter cable.

## BATTERY OPERATION

The standard Model 1181 operates off 115 VAC (or, at no extra cost, 230 VAC if specified at time of purchase). Optionally, NUSONICS can supply units for operation directly off user's 24 VDC battery. When AC power is applied to a unit with this option, the unit will operate off the AC power, and the battery will be on trickle charge, ready to maintain continuous operation automatically if AC power fails. If battery is low (in the absence of AC power), a "LO BAT" indication will appear on the local LCD, if installed.

## OTHER OPTIONS

A heater/thermostat is available to protect the electronics to -60°C (-76°F). It should be specified if ambient temperatures below -20°C (-4°F) are anticipated at the transmitter.

While the standard transducer-transmitter cable length is 20 feet, greater lengths up to a total of 60 feet (clamp-on transducer) and 70 feet (wetted transducer) are available at nominal extra cost.

Chart recorders and remote flow totalizers are also available from NUSONICS when required. The standard outputs from the Model 1181 are compatible with most recorders and totalizers on the market today.

# CHARACTERISTICS

## OF NUSONICS' DOPPLER METERS

- Simple electronically; requires less than 12 watts
- Same for all pipe sizes
- Thrives on solids and bubbles
- Non-intrusive
- Ruggedly portable or permanent
- No moving parts
- AC or DC powered
- Works on metal or plastic piping

## BENEFITS TO THE USER

- Low in cost
- High in reliability
- Especially economical for larger pipes
- Ideal for "those problem liquids"
- No energy cost due to pressure drop
- "Piggable"
- Sanitary (for foods)
- Withstand abrasive, corrosive liquids
- Meet short-term or long-term requirements under process conditions
- Require little maintenance
- Usable almost anywhere
- Usable almost anywhere

## TYPICAL APPLICATIONS

- Sewage and waste treatment streams
- Paper pulp slurries
- Drilling muds
- Rock, coal and mineral slurries
- Paints, pigment pastes and latices
- Sanitary liquids (e.g. foods and pharmaceuticals)
- Foams
- Mixed concretes and cements
- Fly-ash slurries
- Two-phase liquids (e.g. chemicals, rubber and glass)

the liquid and the meter may be calibratable to accuracies of 0.5 to 2 percent of full scale. For sonically opaque liquids, like mixed concrete, Doppler meters are useful indicators of flow but are not noted for their accuracy.

For best accuracy in clean liquids, NUSONICS' Model 8000A and 8400 transit-time meters should be considered.

## A FEW LIMITATIONS

Doppler meters apply only to liquids which have at least some suspended solids, gas bubbles or (in some cases) second-phase liquid bubbles. The outside pipe diameter must be at least 1 inch. The standard clamp-on Doppler meter is not applicable to concrete or piping lined with sonically opaque coatings; the pipe wall must be homogeneous. NUSONICS' Doppler meter is not recommended for flow velocities under about 1 foot/second. For best performance, the transducers should be located in straight piping per normal engineering practice.

## PERFORMANCE

When a flow-simulating sine-wave is fed to Doppler meter electronics, the electronic repeatability is better than  $\pm 0.005$  foot/second. In practical applications, repeatability is limited by background noise and the instability of the flow profile. These factors combine to give typical repeatability on the order of  $\pm 0.05$  foot/second.

The meter factor is independent of the sound velocity of the liquid flowing in the pipe. The principal unknown in estimating the meter factor of a Doppler is the depth to which the sonic beam penetrates the liquid. For relatively sonically transparent slurries such as primary and activated sludges in waste treatment, the sonic beam penetrates deeply into

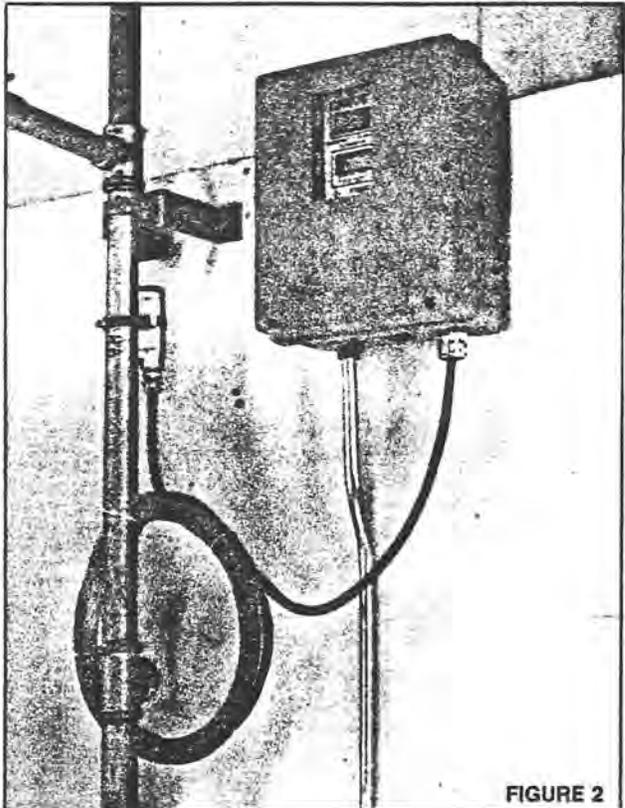


FIGURE 2

# SPECIFICATIONS

## MODEL 1181 OPERATIONAL SPECIFICATIONS

Flow rate range	User may set full scale from 3.5 to 40 feet/second.
Liquid temperature	0-150°C
Liquid pressure, maximum	
Clamp-on transducers	Limited by users piping
Wetted transducers	300 psig
Ambient temperature (at transmitter)	
Standard	-30°C to +60°C
With optional heater	-60°C to +60°C

## OUTPUT SPECIFICATIONS

Standard outputs	
Signal level	0-10 VDC into 1000 ohms or more
Current mode	4-20 mA or 0-20 mA into 550 ohms or less
Voltage mode	0-10 VDC into 2000 ohms or more
Optional Outputs	
Unfactored pulse (proportional to flow rate)	5-volt, 0.4-millisecond duration rectangular pulses, from 1100-Ohm source resistance, 1000 Hz full scale corresponds to 20 mA output.
Output averaging	5 seconds time constant.
Factored pulse	24-volt, 50-millisecond duration pulses at 150 mA maximum (capable of driving a remote counter).
High-low alarm	Two SPST relay contacts; 115 VAC or 28 VDC, 1.5A maximum resistance load. Relay energized at high or low flow set point. Jumper selectable normally open or normally closed relay contacts.

## PHYSICAL SPECIFICATIONS

Size	See outlines of flow tubes (Figure 6) and enclosures (this page)
Net weight	
Transmitter	
NEMA 4	25 pounds (11.4 kg.)
NEMA 4X	11 pounds (5.0 kg.)
NEMA 7	47 pounds (21.4 kg.)
Transducers	
Clamp-on	1 1/4 pounds (0.6 kg.)
Wetted, including flowtube	Refer to factory.

## POWER REQUIREMENTS

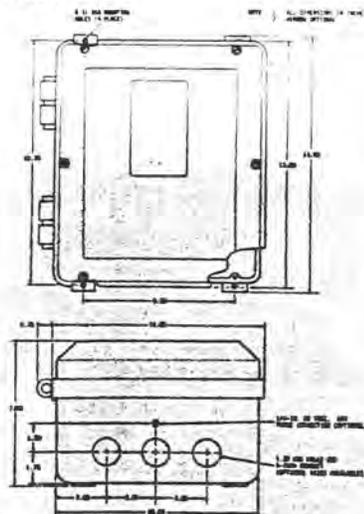
Flowtube	None (cabled to transmitter)
Transmitter	
AC, 50-60 Hz	
Standard	115 (±10%) VAC
Optional	230 (±10%) VAC
DC (user supplied battery)	24 VDC, 1.2 A.H.
Power consumption	
Standard	12 watts
With heater	212 watts
Optional remote flow rate meter	None (cabled to transmitter)
Optional totalizing counter	None (cabled to transmitter)

## OPTIONAL DISPLAYS

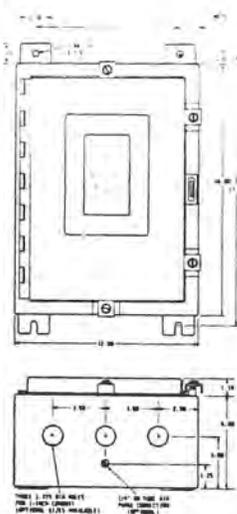
Liquid crystal display (LCD)	A 3 1/2-digit, field rescalable flow rate meter with ranges 0 to 1,999, 0 to 19.99, 0 to 199.9, 0 to 1999.
• Local	Factory mounted on front of electronics chassis. (Requires optional enclosure window.) Also displays LO BAT to denote low battery.
• Remote	Two-wire process LCD enclosed in separate NEMA 12 enclosure or for panel mounting by user. Connects to 4-20 mA output only and is rescalable independently of local LCD.
Analog meter	Indicates flow rate in percent of full-scale flow in increments of 5 percent. As an added option, the meter can be provided to readout in the desired units of measure.
• Local	Factory mounted on front of electronics chassis. (Requires optional enclosure window.)
• Remote	Enclosed in separate NEMA 4 or NEMA 7 enclosure or for panel mounting by user. Connects to voltage output.
Totalizing counter	Direct-reading, six-digit, electromechanical indicator with lockable reset lever. Scaled using five rotary factoring switches.
• Local	Factory mounted on front of electronics chassis. (Requires optional enclosure window.)
• Remote	To be panel mounted by user. Connects to pulse output.

**PERFORMANCE** Varies widely with flow conditions. Consult factory.  
**CONSULT FACTORY FOR SPECIAL REQUIREMENTS**

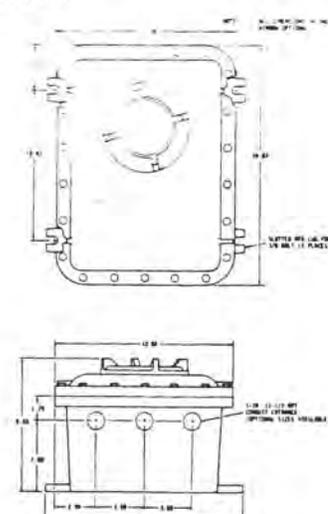
### STANDARD NEMA 4X FIBER GLASS ENCLOSURE



### OPTIONAL NEMA 4 ENCLOSURE



### OPTIONAL NEMA 7 EXPLOSION PROOF ENCLOSURE



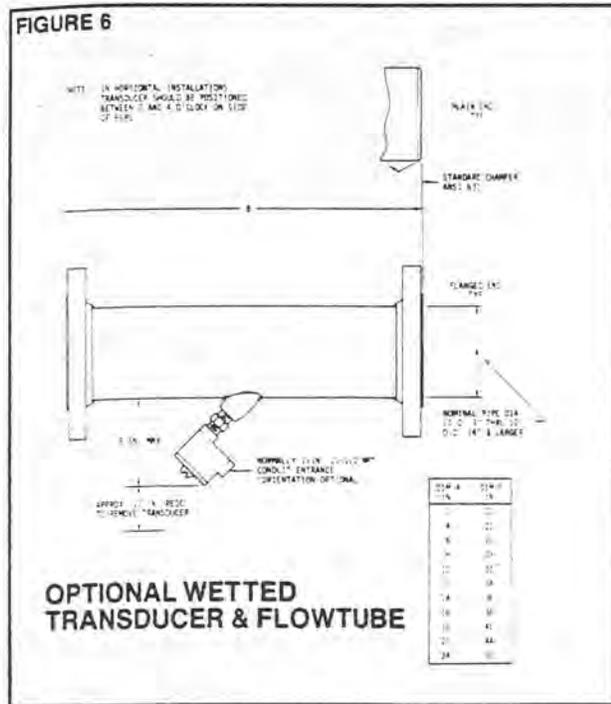


# OPTIONS

## TRANSDUCERS

For greater ruggedness and sensitivity, NUSONICS offers fully assembled flowtubes with wetted transducers, as an alternative to the standard clamp-on transducers. The wetted transducers have explosion-proof connection heads. Figure 6 shows the dimensions of NUSONICS' fully assembled Doppler flowtubes.

NUSONICS also offers wetted transducers in kit form for field installation in user's flowtube. In addition to weld-on kits for various types of metal piping; saddle-plate kits are available for concrete and other non-weldable materials.



## OUTPUT METERS

At time of purchase a LCD (liquid crystal display) or a needle-indicating (analog) meter can be installed as an integral part of the transmitter electronics assembly to provide a visual indication of flow rate. A transmitter enclosure with the optional window should be specified when either meter is ordered. A LCD and an analog meter are also available for remote mounting.

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At time of purchase, optional circuitry can be added to the electronics to provide a 5-volt, 0 to 1000-Hz frequency output which is suitable for driving a remote totalizer, and a 24-VDC factored pulse output for operation of a local and/or a remote totalizing counter. The frequency output may be specified independently of the factored pulse (totalizing counter) option, but the circuitry for both are required for the latter. However, a movable jumper permits feeding only one of the outputs at a time to the output terminal strip. For example, a remote totalizer and a remote totalizer counter cannot be connected to the Doppler meter at the same time.

The optional six-digit, lockable, resettable, totalizing counter mounts in a panel above the optional flow rate meter as shown in Figure 5. A transmitter enclosure which includes the optional window is necessary for viewing the totalizing counter. A five-digit set of rotary switches is used for dialing in a meter factor. Thus, the totalizing counter will read out in user-selected units of cumulative flow, e.g., gallons, 100's of gallons, liters, cubic meters, etc.

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## HIGH-LOW ALARM

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## ENCLOSURES

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## BATTERY OPERATION

The standard Model 1181 operates off 115 VAC (or, at no extra cost, 230 VAC if specified at time of purchase). Optionally, NUSONICS can supply units for operation directly off user's 24 VDC battery. When AC power is applied to a unit with this option, the unit will operate off the AC power, and the battery will be on trickle charge, ready to maintain continuous operation automatically if AC power fails. If battery is low (in the absence of AC power), a "LO BAT" indication will appear on the local LCD, if installed.

## OTHER OPTIONS

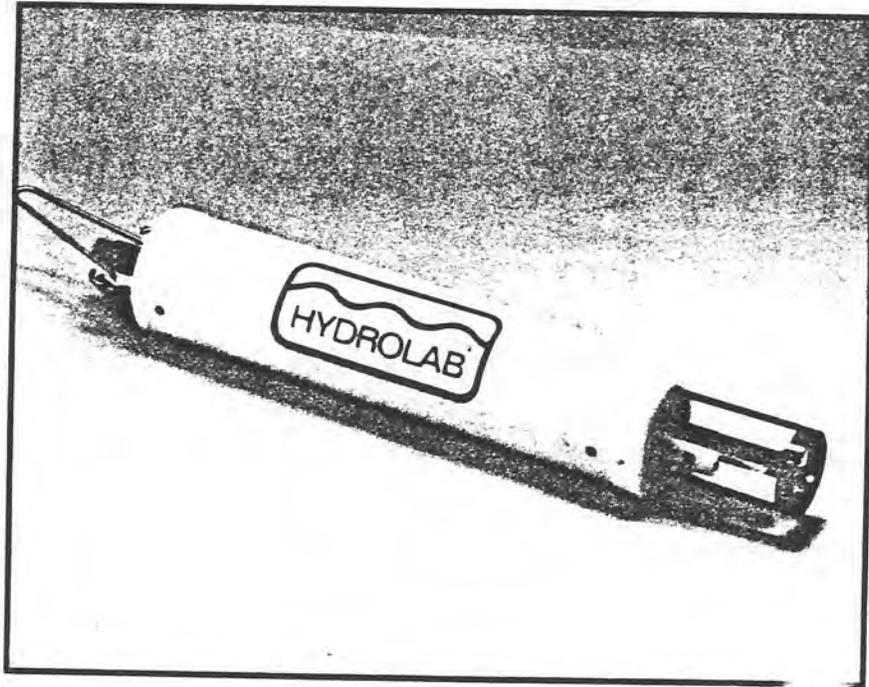
A heater/thermostat is available to protect the electronics to -60°C (-76°F). It should be specified if ambient temperatures below -20°C (-4°F) are anticipated at the transmitter.

While the standard transducer-transmitter cable length is 20 feet, greater lengths up to a total of 60 feet (clamp-on transducer) and 70 feet (wetted transducer) are available at nominal extra cost.

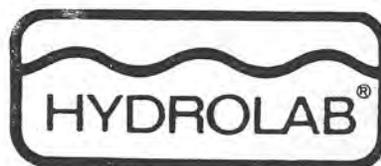
Chart recorders and remote flow totalizers are also available from NUSONICS when required. The standard outputs from the Model 1181 are compatible with most recorders and totalizers on the market today.

APPENDIX D: WATER QUALITY INSTRUMENTATION (T, C, DO, pH)

# DataSonde<sup>®</sup>



The Water Quality Datalogger  
With  
No Strings Attached



Fully submersible automated water quality data systems with totally self-contained solid-state "intelligence"—an exciting field-proven breakthrough in automated *in situ* datalogging technology.

## All-in-One Efficiency

What if you could have incredibly accurate water quality data, collected with the highest possible reliability, brilliantly organized, and transferred and/or typed with cybernetic precision?

With its new DataSonde 2000 series water quality data systems, Hydrolab Corporation has made such a dream a reality . . . once more earning its reputation as the leading edge of the microprocessor revolution within the water quality datalogging industry. Containing all necessary measuring circuits, processing, data storage and power supply batteries within one simple, portable, watertight housing, the DataSonde is a completely integral, completely solid-state, completely *self-dependent* submersible data system representing the achievement of a new plateau in water quality monitoring technology.

Unlike other water quality monitoring systems which require cumbersome cable hook-ups tying underwater sondes to expensive, vandal-prone, land-based equipment such as recording instruments and power supplies, the robot-like, submersible DataSonde system functions underwater automatically—without moving parts, without land-based instrumentation, without cable attachments . . . literally, *with no strings attached*.

Originally developed for Florida Power & Light Company to monitor cooling water intake and discharge temperatures, the DataSonde has been expanded in capability and made available to meet the needs of the entire community of water quality monitoring professionals . . . and has found immediate and enthusiastic acceptance by such agencies as the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, and the Utah State Department of Health in water quality investigation programs.

What appeals to agencies such as these is a spectrum of remarkable features which distinguishes the DataSonde as the leading technological advance in its field.

## Foolproof Accuracy

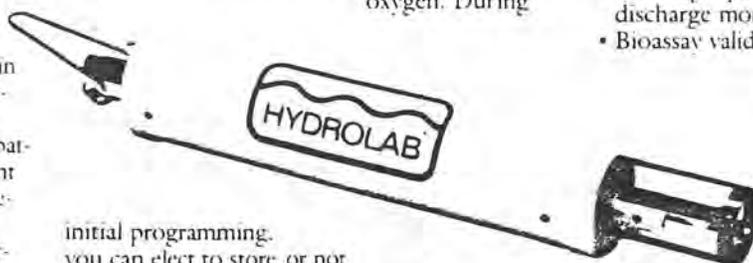
DataSonde's solid-state reliability and precision, plus automatic preprogrammed operation, result in a new level of confidence for the water quality monitoring professional. Precise parameter measurements are automatically temperature compensated (ATC) over a range of  $-2$  to  $50^{\circ}\text{C}$  (with temperature calibrated to an accuracy of  $\pm 0.1^{\circ}\text{C}$  with NBS traceability).

Moreover, once calibrated and programmed in the laboratory or office, the DataSonde needs only to be deployed at a desirable field location—preset to start collecting the data desired by lab personnel. All that field personnel do is anchor the DataSonde and later retrieve it—since all data transfer is handled electronically in the lab, data management professionals get machine-pure data they can fully trust . . . totally free of the errors possible through human transfer.

## Programmable Flexibility

Easily programmable via an external standard keyboard terminal, the DataSonde can be set to log only the parameters you wish, when you wish. The unit can even be set to turn itself on (delayed start) and shut itself off under control of an internal real time clock recording exact time and date. Sample intervals can be programmed in multiples of five minutes . . . to as long as 9 days!

An assortment of DataSonde versions are available providing various measurement capabilities, including temperature, conductivity/salinity, pH, ORP and dissolved oxygen. During



initial programming, you can elect to store or not store parameter data from any sensor system installed in the DataSonde, with the exception of temperature.

## Rugged Durability

Engineered and crafted with Hydrolab's renowned insistence on quality materials and superior workmanship, the DataSonde's hermetically sealed, watertight integrity and solid-state ruggedness ensure that each unit will withstand incredibly abusive environmental extremes. Built with a heavy-duty, nonmetallic pressure housing, each unit is at home in 3 feet or 1,000 feet of water, saline or fresh, from  $-2^{\circ}$  to  $50^{\circ}\text{C}$ . Weighing just 11 lbs. (5 kg.) and readily portable, the DataSonde can be toted anywhere—from the Arctic to the Amazon, the North Sea to the Everglades—by truck, boat, or plane . . . even by dog-sled, balloon, or canoe!

## Long-Life Endurance

Utilizing an energy-efficient CMOS RAM memory, the DataSonde can store over 3,600 parameter readings during each deployment period. With no energy-gulping moving parts, each unit is powered on-board by just eight long-life D-cell alkaline batteries, and can thus stay in the field as long as 6 months before retrieval.

## Versatile Applications

The potential water quality monitoring applications of the DataSonde are virtually limitless. Some of the more typical include:

### Analyses

- Biological
- Limnological
- Ichthyological
- Hydrological
- Petrological
- Benthological
- Oceanological

### Deployment

- Lakes, creeks, rivers, and other inland waterways
- Oceanic sites
- Salt marshes
- Sewerage and wastewater systems
- Industrial discharge sites
- Under ice

### Purposes

- Baseline surveys
- Water quality surveys, from tropical to arctic/antarctic
- Effluent detection
- Municipal power plant cooling water discharge monitoring
- Bioassay validation
- Municipal water quality monitoring
- Industrial water quality monitoring

## Simple, Easy Operation

Handled entirely in the lab, calibration and programming of the DataSonde are literally a snap—effected by simply snapping in the Hydrolab 5200-20XX DMU (Data Management Unit), itself connected to your EIA RS-232-C compatible keyboard terminal. Opening the DataSonde's heavy-duty housing isn't needed—and there's no need to fool with knobs, pots, etc. Moreover, once the unit leaves the lab, all your field personnel handle transportation and placement—the DataSonde functions automatically.

Back in the lab, the unit can be easily debriefed in virtually the same way—dumping its CMOS-stored water quality data, via the DMU, into your CRT or printer for immediate printout, or into your computer's mass-memory file storage . . . or both. Lab personnel will be pleasantly amazed by the system's sophistication—an "intelligence" which can even detect whether inputted calibration values are reasonable!

## Manpower and Deployment Savings

Since deployment of the DataSonde is so simple, field manpower needs are minimized and the unit can be left unattended for days, weeks, or months . . . until it's time for retrieval. Moreover, the system's automatic electronic data transfer means tremendous saving in dataprocessing manpower and a significant increase in personnel efficiency—together with a drastic increase in data recovery percentage and reliability!



In addition, since the DataSonde functions *in situ* with no strings attached, expensive vandal-proof shelters for housing land-based equipment aren't needed. And since the system's data management and data display/transfer functions are separate from the data collection and data storage unit, a single investment in just one DMU and display set up in the lab can service any number of DataSondes, which can be rotated between field and headquarters.

## Higher Quality at Lower Cost

Fully incorporating the spectacular benefits of state-of-the-art microprocessor technology, the DataSonde provides a major enhancement in water quality data systems performance together with a significant reduction in instrumentation cost—a fraction of the price of competitive systems. In effect, investment in the DataSonde system literally and immediately means greater quality and performance for the money.

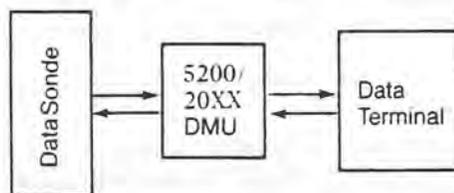
## An Invaluable Management Tool

Competent, dependable, electronically accurate, and centrally programmed, the DataSonde is a powerful, versatile management tool responding totally and reliably to your instructions—letting *you* know exactly *what* monitored environmental conditions it encountered and *when* . . . eliminating "go-between" human data reporting and transcription. Even equipment management is enhanced via convenient diagnostics which yield a complete lab record of every DataSonde in service.

In short, the submersible, self-contained, fully automatic DataSonde is a water quality data system you can have total confidence in . . .

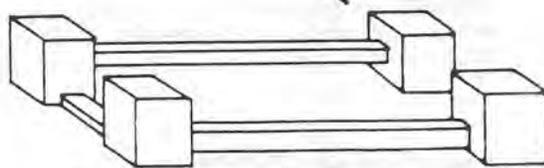
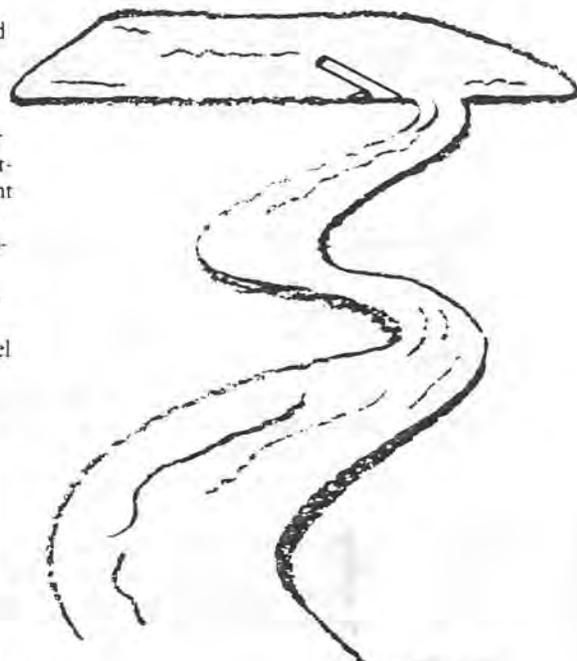
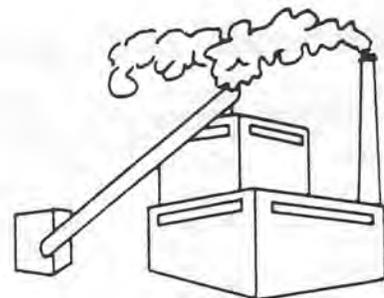
## Hydrolab 5200-20XX Data Management Unit

What enables each DataSonde to communicate with you—and, if desired, your computer and its mass-storage medium—is the Hydrolab 5200-20XX Data Management Unit (DMU), a solid-state, laboratory-based device which plugs into the DataSonde as well as your RS-232-C compatible keyboard terminal (e.g., CRT, TTY) and/or computer system. With the DMU, calibration, programming, diagnostics, and data read-out (i.e., outputting data from each DataSonde) can all be handled conveniently and efficiently in the laboratory via a dialogue with the keyboard operator. A series of questions and answers enables the operator to communicate pertinent parameter calibrations as well as test the DataSonde's battery, memory, and the ability of the instrument to perform in relation to the calibration standard. Further flexibility in data analysis is provided by the DMU's "intelligence," which allows for rudimentary conversions to be performed (e.g., conductivity to salinity and/or raw conductivity) as required by lab personnel and effected via keyboard command.

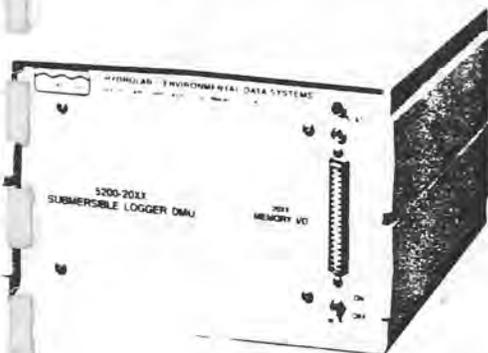


Operating via its own permanent internal software like each DataSonde, the DMU eliminates the need for expensive software packages (as well as tapes, disks, etc.) usually required to format data for understandability. Instead, output from the DataSonde's CMOS memory is automatically analyzed, organized, and formatted by the DMU, making it readable for your easy interpretation. Dual EIA RS-232-C ports on the unit allow this output to be printed out, transmitted via modem to a computer for permanent storage and/or further processing, or both.

The Hydrolab 5200-20XX DMU includes a plug-in power supply switchable for 120/240 VAC, 60/50 Hz.



## WITH NO STRINGS ATTACHED!



# DataSonde® 2000 Series Performance Specifications

Specification	Temperature	Conductivity	Salinity	pH	ORP	True D.O.
Range	-2° to 50°C	0-1.5, 15, 150 mS/cm (Selectable by keyboard)	0-60 ppt	0-14pH	-1,000 to +1,000 mv	0-20 mg/l (ppm)
Calibrated Accuracy	±0.1°C (NBS traceability)	±1% of range selected	See Conductivity	±0.1pH over 3-11pH range See Note (2)	Within ±10mv of platinum electrode potential	± 1% F.S.* *With Teflon™ membrane and sample velocities >25 cm/sec. See Note (1)
Resolution	±0.025°C	0.1% of range	0.1 ppt	0.01pH	1 mv	0.01 ppm
Sensor Type	Linear Thermistor	6-electrode cell	See Conductivity	Glass electrode, sealed reference with refillable flowing junction	Platinum electrode	Polarographic cell
Temperature Compensation (ATC)	N/A	Automatic 25°C reference	N/A	Automatic	N/A	Automatic
Salinity Correction	N/A	N/A	N/A	N/A	N/A	Automatic (True D.O.)
Calibration (By keyboard entry)	Factory (NBS traceability)	Quality KCl or seawater standard solutions.	See Conductivity	pH7 and 4 or 10 buffer	Quinhydrone standard	Air-saturated water, water-saturated air or Winkler titration

**Note (1):** For sample velocities <25 cm/sec, a calibrated accuracy of ± 5% (of reading) may be expected. For a discussion of the effect of low or varying sample velocity on the performance of industry-standard polarographic dissolved oxygen sensors and the methods employed in dealing with the "velocity effect" in DataSonde instruments, please request Hydrolab Application Notes concerning this subject.

**Note (2):** For measurements in solutions of low ionic strength (<0.2 mS/cm), pH accuracy may be affected. Sensor modification can be accomplished which will allow pH measurements in very low ionic strength solutions, i.e., those which might be encountered during acid-rain investigations. If applicable, please consult the Hydrolab Sales Office.

## DataSonde® 2000 Series Physical Specifications

Length Overall	26 in. (660 mm)
Diameter Overall	4.7 in. (120 mm)
Weight (Air)	11 lb. (5 kg)
Maximum Depth	660 ft. (200 m)
Temperature Tolerance Range	(-2 to 50)°C
Construction Materials	PVC, Delrin™, stainless steel, anodized aluminum

Teflon™ and Delrin™ are registered trademarks of E.I. DuPont Corporation.

## DataSonde® 2000 Series Operational Specifications

Data Storage	Solid-state CMOS RAM.
Data Capacity	3,600 parameter readings plus station identification, initial time and date, ending time and date, calibration standard values, sample time interval, and parameters selected.
Data Recovery	By means of any EIA RS-232-C compatible terminal or printer via Hydrolab 5200-20XX DMU.
Sampling Interval	Programmable by keyboard entry (1 min. to 9 days) for instruments which do not include pH or ORP as enabled parameters. If pH or ORP enabled, the minimum sample interval is (4) mins.
Clock	Quartz reference (accuracy: 2 min./month)
Power Supply	6 VDC with (8) internal "D"-cell alkaline batteries.
Operating Life	Up to (6) months, as affected by: parameters enabled, sample-interval selected, operating temperature and rate of sensor fouling.



P.O. Box 50116  
Austin, Texas 78763  
512-255-8841 Telex II 910-874-1335

# Type K or J Thermocouple Probes

## Precise Surface Probe

Ideal For Temperature Measurement of Motors, Engines, Pumps, etc.... Maximum Temp. 500°C. Accuracy  $\pm 0.2\%$  of Reading.

**\$148<sup>00</sup>**  
Cat. #EM16

## Right Angle Surface Probe

Maximum Temp. 500°C  
Accuracy  $\pm 0.2\%$  of Reading

**\$168<sup>00</sup>**  
Cat. #EM11

## Microsensing Probe

Ideal For Measuring Very Small Surfaces Like Transistors, IC, Transformers & Electronic Components. 400°C Max.,  $\pm 0.3\%$  of Reading Accuracy.

**\$178<sup>00</sup>**  
Cat. #EM12

## Moving Surface Probe

For Measuring Temp. of Moving or Stationary Smooth Flat Surface. Maximum Service Speed 800 m/min. Max. Temp. 250°C.  $\pm 0.3\%$  of Reading.

**\$193<sup>00</sup>**  
Cat. #EM13

## Roller Bearing Probe

Four Roller Bearings Supply Suitable Contact W Surface. Moving Surface Should Not Exceed 500 m/min. Max. Temp. 200°C.  $\pm 0.3\%$  Accuracy.

**\$242<sup>00</sup>**  
Cat. #EM14

## Moving Wire Probe

Max. Temp. 200°C  
Accuracy  $\pm 0.5\%$

Non-Steel Wires →

Steel Wires →

**\$218<sup>00</sup>**  
Cat. #EM15

**\$277<sup>00</sup>**  
Cat. #EM18

## Penetration Probe

Measures Most General Purpose Measurements of Internal Temperatures Such As Soft & Semi-Solid Materials. Max. Temp. 500°C.  $\pm 0.3\%$ .

**\$104<sup>00</sup>**  
Cat. #EM17

## Heavy-Duty Penetration Probe

This Probe Provides A Replaceable Needle Type Measuring The Temperature of Rugged Materials Like Frozen Meat, Tires, Rubber, etc.... Max. Temp. 300°C.  $\pm 0.3\%$  Accuracy.

**\$257<sup>00</sup>**  
Cat. #EM18

## Air Temperature Probe

Maximum Temperature 500°C  
 $\pm 0.3\%$  of Reading.  $\pm 1^\circ$

**\$99<sup>00</sup>**  
Cat. #EM19

## Metal Metal Probe

No Junction Thermocouple Is Measurement For The Melting Metal Surfaces. Ideal For Molten Solder & Other Electric Conductive Molten Materials. Max. Temp. 700°C.  $\pm 0.5\%$  Accuracy.

**\$89<sup>00</sup>**  
Cat. #EM20

## High Temperature Surface Probe

Right Angle & 45° Angle Probes Available

Long Reach Handle For Measuring 500°C to 800°C. Ideal For Boilers, Incinerators, Furnaces, etc.... Max. Temp. 800°C.  $\pm 0.3\%$  of Reading Accuracy.

**\$208<sup>00</sup>**  
Cat. #EM21

## Underwater Probe

Strong Lead Cable Allows This Probe To Be Thrown Into Sea, Bath & Tanks. Max. Temp. °C.  $\pm 0.3\%$  Accuracy.

**\$242<sup>00</sup>**  
Cat. #EM22

Cat. # EM25 NIST Certification **\$900**

# 2-Wire Thermocouple Transmitter

## Multiranging W/4-20 mA Output

The model 10/2 is a field configurable 2-wire transmitter module generating 402- mA output current. This current is related linearly to the output of a Thermocouple temperature sensor.

The connection of the thermocouple (type E, J, K, R, S, T and others) as well as the full-scale range of the transmitter is user configurable

by means of a resistor arrangement connected on a plug-in header. Any configuration change can be executed in a matter of minutes: only one Thermocouple transmitter type need be stocked for all Thermocouples, Zero and span are screw-driver adjustable. The multi-turn trimmers are readily accessible. Mounting

configuration is also user selectable to suit nearly any enclosure or housing. Model 10/2 two-wire transmitters offer an elegant and highly cost-effective solution to temperature-measurement problems in a multitude of industrial and commercial measurement, recording and control applications.



### SPECIFICATIONS

#### INPUT:

Types E, J, K, R, S, T, thermocouples and others.\*

#### INPUT SPAN:

minimum 5mV, protected to 2.5VDC input level

#### OUTPUT SPAN:

2-wire 4-20mA, 3.0mA min. Limiting at 27mA.

#### BURNOUT DETECTION:

upscale

#### INPUT IMPEDANCE:

minimum 20MΩ.

#### SUPPLY VOLTAGE:

8-40 VDC reverse polarity protected.

#### SUPPLY VOLTAGE

#### VARIATION EFFECT:

Less than 0.02% of span over 8-40V change.

#### MAXIMUM LOAD

#### RESISTANCE:

$R_{max} = (V_{supply} - 8V) / 20mA$ .

#### LINEARITY:

Better than 0.02% of span (referred to mV input).

#### INPUT ADJUSTABILITY:

Zero: ±40% of span \*  
Span: +50%, -35% of span \*

#### TEMPERATURE STABILITY:

Zero: Better than 2 μV/°C referred to input.

#### REFERENCE JUNCTION:

Better than 0.04°C/°C compensation.

#### MOUNTING:

Wall, panel and DIN rails mountings (complete mounting kit provided with each transmitter).

#### OPERATING TEMPERATURE:

0°C to 60°C

\* determined by plug-in header.

## ORDERING INFORMATION

Catalog No.	Model	Description	Price
ME888232	10/2	2-Wire Transmitter for Thermocouple	\$150.00

When ordering please specify thermocouple type required.

See our full line of thermocouple probes on pages 229-236.

# 2-Wire Platinum RTD Transmitter

The model 10/1 is a field-configurable 2-wire transmitter module, generating a 4-20 mA output current. This current is related linearly to the output of a resistance temperature detector (RTD).

The connection of the RTD (two-lead, three-lead, or differential probe) is user configurable by means of jumper connections on a plug-in header. The full-scale range of

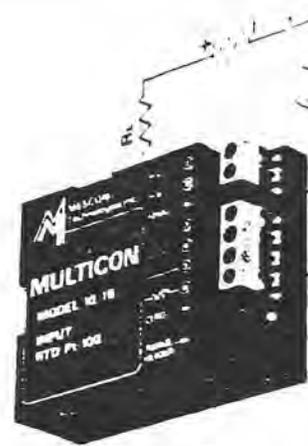
the transmitter is set by a resistor array connected on the same header.

Any configuration change can be executed in a matter of minutes: only one RTD transmitter type need be stocked.

Zero and span are screw-driver adjustable. The multi-turn trimmers are readily accessible. Mounting configuration is also user selectable to suit nearly

any enclosure or housing.

Model 10/1 two-wire transmitters offer an elegant and highly cost-effective solution to the multipoint temperature-measurement problem in heating, air-conditioning and refrigeration systems and in solar-energy, process-control, heat-exchange and energy-management applications



### MODEL DESIGNATION:

10/1A—NARROW RANGE

Scale from 10-100°C degrees

10/1B—WIDE RANGE

Scale from 100-800°C degrees

### SPECIFICATIONS

#### INPUT:

Platinum - 100 RTD  
2-wire, 3-wire, differential

#### INPUT RANGE:

minimum 10°C to maximum 120°C \* (model 10/1A)  
minimum 100°C to maximum 800°C \* (model 10/1B)

#### OUTPUT SPAN:

2-wire 4-20mA, 3.4mA min. Limiting at 27mA

#### SUPPLY VOLTAGE:

8-40 VDC, reverse polarity protected.

#### SUPPLY VOLTAGE

VARIATION EFFECT:  
Less than 0.02% of span over 8-40V change.

#### MAXIMUM LOAD

#### RESISTANCE:

$R_{max} = (V_{supply} - 8V) / 20mA$

#### SENSOR EXCITATION:

1mA constant current

#### LINEARITY:

(referred to sensor temperature)  
better than 0.05% of span for:  
100°C input range (model 10/1A)  
500°C input range (model 10/1B)

#### LEAD WIRE RESISTANCE

#### COMPENSATION:

(for 3-wire sensor)  
better than 400:1

#### INPUT ADJUSTABILITY:

Zero: ±40% of span \*  
Span: +50%, -35% of span \*

#### TEMPERATURE STABILITY:

Zero: better than 0.01% of span/°C for 100°C span and higher, better than 0.04% of span/°C for 10°C span and higher.

Span: better than 0.007% of span/°C

#### MOUNTING:

Wall, panel and DIN rails mountings (complete mounting kit provided with each transmitter)

#### OPERATING TEMPERATURE:

0°C to 60°C

\* determined by plug-in header

## ORDERING INFORMATION

Catalog No.	Model	Description	Price
ME88833	10/1A	Narrow Range RTD Transmitter	\$150.00
ME88834	10/1B	Wide Range RTD Transmitter	\$150.00

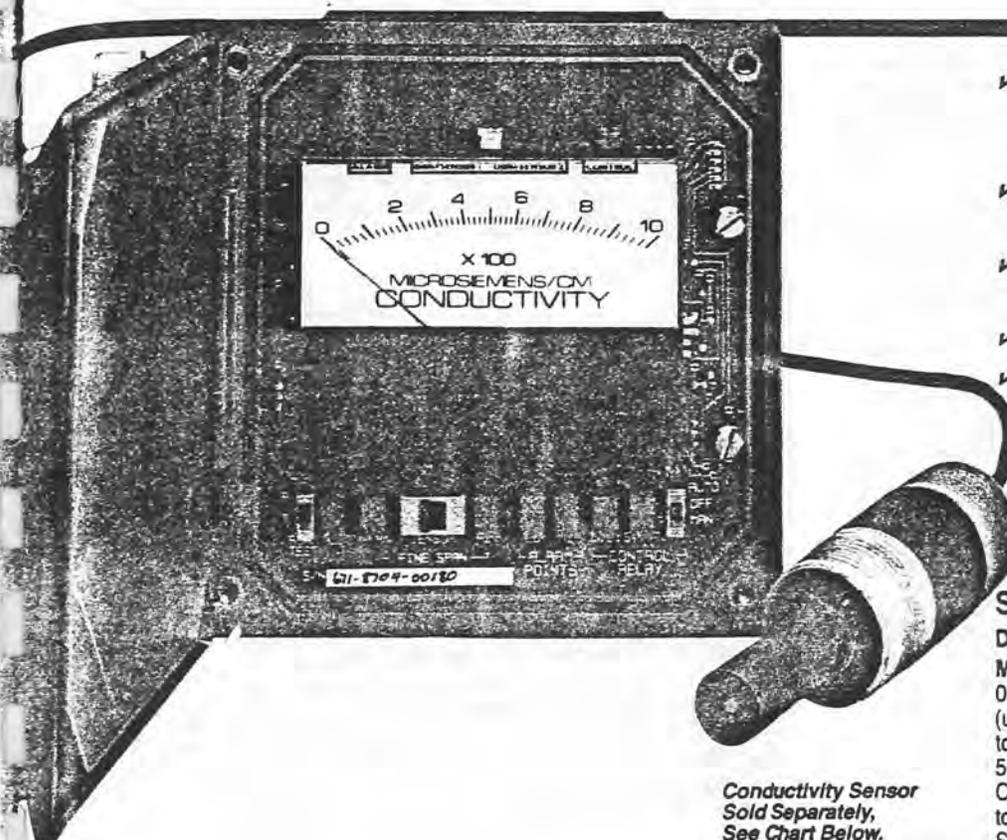
\* When ordering please specify input type: 2-Wire Sensor, 3-Wire Sensor or Differential and Measuring Range.

# CDCN-100 Series Conductivity Controllers

1 YEAR  
WARRANTY

MADE IN  
USA

CARE



Conductivity Sensor  
Sold Separately,  
See Chart Below.

- ✓ Accepts Two Conductivity Sensor Inputs
- ✓ Includes Control and Alarm Relays
- ✓ 1/2 DIN NEMA 4X Enclosure
- ✓ Universal Mounting
- ✓ 4 to 20 mA Output with Range Expand

**\$635**

## Specifications:

**Display:** 3 1/2" analog

**Measuring Ranges:** CDCN-101: 0 to 10, 0 to 50, 0 to 100 and 0 to 200  $\mu\text{S}/\text{cm}$  (using CDCN-102 Sensor) CDCN-103: 0 to 500, 0 to 1000, 0 to 2000, and 0 to 5000  $\mu\text{S}/\text{cm}$  (using CDCN-104 Sensor) CDCN-105: 0 to 10,000, 0 to 20,000 and 0 to 50,000  $\mu\text{S}/\text{cm}$  (using CDCN-106 Sensor)

## Relay Functions

**Control/Alarm Setpoints:** Continuously adjustable, 0 to 100% of full scale

**Control Deadband:** Continuously adjustable, 0 to 15% of full scale

**Alarm Deadband:** Fixed at 2% of measuring scale span

**Indicators:** LED lights when respective relay turns on

**Contact Rating:** SPDT, 5A 115/250 Vac, 5A at 30 Vdc resistive

Note: Control relay turns on in response to increasing or decreasing reading switch selectable

**Analog Outputs:** Non-expandable and non-isolated (isolated from ground and line power, but not from input or each other) 0 to 1 mA, 100 ohms max load or 0 to 5 Vdc, 50 K ohms min. load. 4 to 20 mA, 825 ohms max, range expandable and non-isolated

**Range Expand:** The 4 to 20 mA output can be made to represent a selected segment of the display scale. This segment cannot be smaller than 10% of the measuring scale span, but may be positioned anywhere within that span.

**Sensitivity:** 0.1% of span

**Repeatability:** 0.1% of span

**Temperature Compensation:** Automatic, 0 to 100°C

**Sensor to Analyzer Distance:** 100 ft max

**Connections:** Stripped leads

Designed to provide conductivity measurement and control versatility in minimal space, the CDCN-100 Series conductivity controller will accept two sensor inputs of the same cell constant and has a front panel switch to select the desired signal for measurement and control. A bi-color LED above the meter display indicates which sensor has been selected. Readings are displayed on a 3 1/2 inch analog meter, scaled in microSiemens/cm or milliSiemens/cm. For versatility, a range expand feature allows the 4 to 20 mA instrument output to represent a segment as small as 10% of the measuring span. The segment may be located anywhere

within the measuring scale. The control relay can be selected to operate in response to increasing or decreasing conductivity and for added control flexibility, an AUTO/OFF/MANUAL mode switch is provided. The "dual alarm" relay has two individually adjustable controls to establish high and low alarm points so that the alarm relay is energized whenever the conductivity value is outside of these points. The instrument may be panel, surface or pipe mounted with the two stainless steel brackets provided. Must be used with the CDCN-102, 104 or 106 conductivity sensors depending on range required.

## To Order

Controller Part No.	Price	Compatible Sensor Part No.	Price	Measuring Range, $\mu\text{S}/\text{cm}$
CDCN-101	\$635	CDCN-102	\$140	0-10, 0-50, 0-100, 0-200
CDCN-103	635	CDCN-104	130	0-500, 0-1000, 0-2000, 0-5000
CDCN-105	635	CDCN-106	170	0-10,000, 0-20,000, 0-50,000

# About Conductivity

All aqueous solutions conduct electricity to some degree. The measure of a solution's ability to conduct electricity is called "conductance" and is the reciprocal of resistivity (resistance). Adding electrolytes such as salts, acids or bases to pure water increases conductance (decreases resistivity).

A conductivity system measures conductance with electronics connected to a sensor immersed in a solution. The analyzer circuitry impresses an alternating voltage on the sensor and measures the size of the resulting signal which is linearly related to the conductivity. Because conductivity has a large temperature coefficient (as much as 4% per °C—see Fig. 1) an integral temperature sensor along with its circuitry adjusts the reading to a standard temperature, usually 25°C.

Historically, the standard unit of conductivity measurement has been "mhos/cm" (mho is the reciprocal of ohm). A resistivity of 100 ohms•cm is equivalent to a conductivity of 1/100 mhos/cm. The mhos/cm unit of measurement is now being replaced throughout industry by an equal and interchangeable international unit of measurement called the "Siemen/cm." Conductivity usually is expressed in millionths of a Siemen, that is, microSiemens/cm. Resistivity is still expressed as Megohm•cm for high purity water—usually from 0.1 to 20 Megohm•cm.

## RESISTIVITY

In high purity water, typically less than 1 microSiemen/cm, the measurement is referred to as resistivity with units of Megohm•cm. Pure water has a resistivity of about 18.3

Megohm•cm at 25°C. One consideration that must be made when measuring solutions is the temperature coefficient of the conductivity of the water itself. To compensate accurately, a second temperature sensor and compensation network is used. Specific sensors and analyzers are recommended for measurement in high purity water.

## About Conductivity Sensors . . .

The **Contacting-Type Sensor** usually consists of two electrodes, insulated from each other. The electrodes . . . typically 316 stainless-steel, titanium-palladium alloy or graphite . . . are specifically sized and spaced to provide a known "cell constant." Theoretically, a cell constant of 1.0 implies two electrodes, each one square centimeter in area, spaced one centimeter apart (Fig. 3).

Cell constants must be matched to the analyzer for a given range of operation. For instance, if a sensor with a cell constant of 1.0 were used in pure water with a conductivity of 1 microSiemen/cm, the cell would have a resistance of 1,000,000 ohms. Conversely, the same cell in seawater may have a resistance of 30 ohms. Since the resistances are so different, it is difficult for ordinary instruments to measure these extremes accurately with only one cell constant.

In measuring the 1 microSiemen/cm solution, the cell would be configured with large electrodes spaced a small distance apart. This results in a cell resistance of approximately 10,000 ohms which can be measured quite accurately. By using cells of different constants, the measuring instrument can operate over the same range of cell resistance for both ultra-pure water and high conductivity seawater.

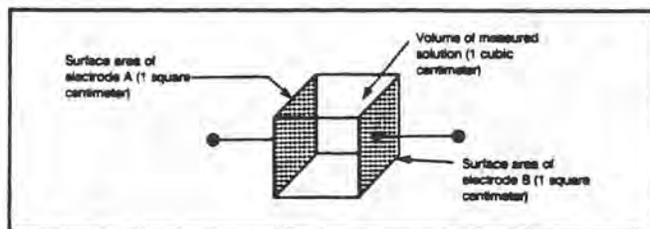


Figure 3.  
Theoretical Cell Constant of 1.0

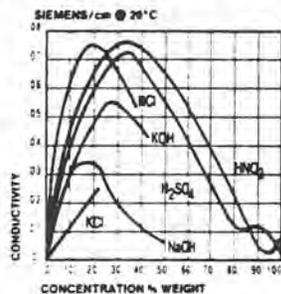


Figure 1.  
Conductivity vs. Concentration

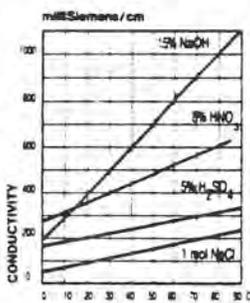


Figure 2.  
Conductivity vs. Temperature

The **Electrodeless-Type Sensor** operates by inducing an alternating current in a closed loop of solution and measuring its magnitude to determine the conductivity (Fig. 4). The conductivity analyzer drives Torroid A which induces the alternating current into the solution. This AC signal flows in a closed loop through the sensor bore and surrounding solution. Torroid B senses the magnitude of the induced current which is proportional to the conductance of the solution. This signal is processed in the analyzer to display the corresponding reading.

Since the electrodeless sensor has no electrodes, common problems facing contacting-type sensors are eliminated. Polarization, oily fouling, process coating or non-conducting electrochemical plating do not affect the performance of electrodeless sensors until gross fouling occurs.

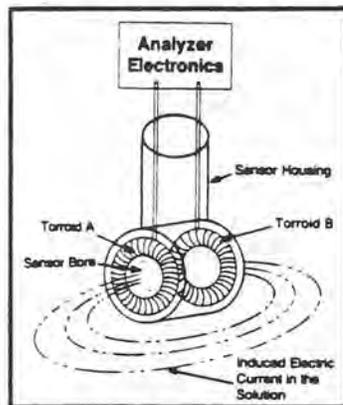


Figure 4.  
Electrodeless Sensor

## THE TEMPERATURE COMPENSATION

Conductivity measuring system accuracy can only be as good as its temperature compensation. Since common solution temperature coefficients vary on the order of 1-3% per °C, measuring instruments with adjustable temperature compensation should be utilized. Solution temperature coefficients are somewhat non-linear and usually vary with actual conductivity as well (Fig. 5). Thus, calibration at the actual measuring temperature will yield the best accuracy.

OMEGA ENGINEERING, INC. gratefully acknowledges Great Lakes Instruments, Inc. for permission to reprint the bulletin "About Conductivity"

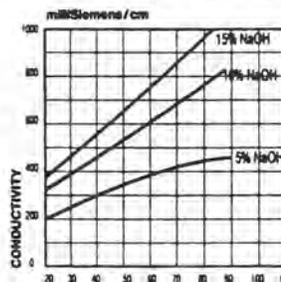


Figure 5.  
Conductivity vs. Temperature  
for Different Concentrations

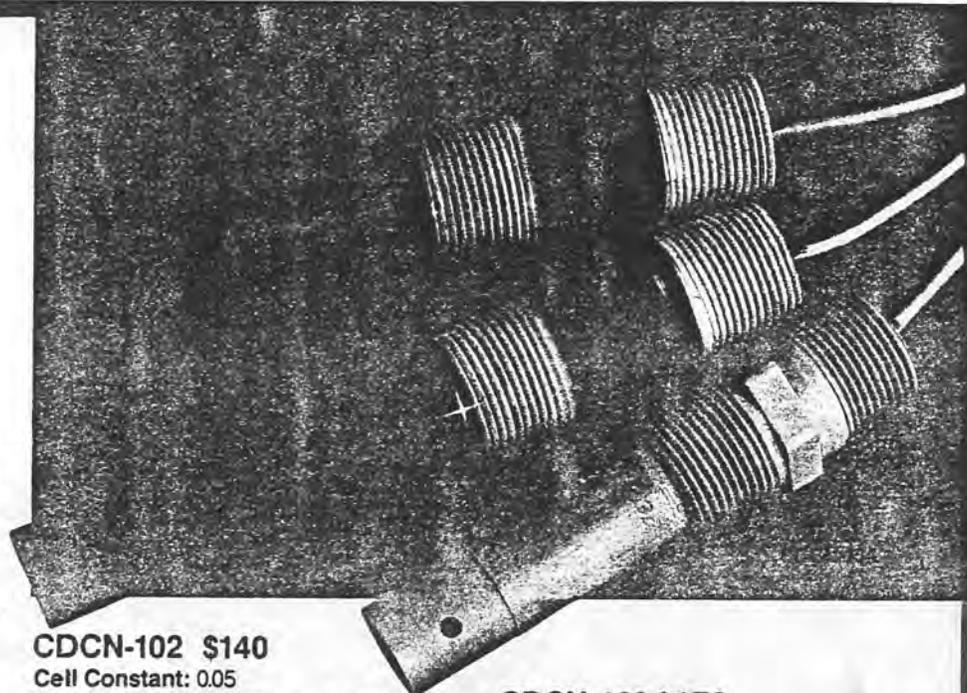
## Contacting Conductivity Sensors

- ✓ Convertible For Submersion Or Flow Through Applications
- ✓ Used with CDCN-100 Series Controllers and CDTX-101 Transmitter

Designed for convertible mounting in either submersion or flow-through applications, the CDCN-102, 104 and 106 conductivity sensors are the perfect match for the CDCN-100 Series conductivity controllers and the CDTX-101 conductivity transmitter. They are threaded on both ends for easy mounting.

### Specifications

**Cable Length:** 10 feet (all models)  
**Maximum Cable Length:** 100 feet  
**Maximum Pressure:** 100 PSI  
**Maximum Temperature:** 80°C  
**Mounting:** 1 Inch NPT, threaded on both ends



#### CDCN-102 \$140

**Cell Constant:** 0.05  
**Electrode Material:** Titanium palladium alloy  
**Body Material:** CPVC

#### CDCN-104 \$130

**Cell Constant:** 0.5  
**Electrode Material:** Graphite  
**Body Material:** Vinyl Ester

#### CDCN-106 \$170

**Cell Constant:** 10.0  
**Electrode Material:** Graphite  
**Body Material:** Vinyl Ester

All Cells Come With 10 Feet Cable, Additional Cable Available Up To 100 Feet Total. Add \$1.00 Per Additional Foot.

## Non-Contact Conductivity Sensor CDCN-108

- ✓ No Polarization, Electrode Coating or Ground Loop Problems
- ✓ Anti-clogging, Large Bore Design
- ✓ Used With the CDTX-102 Conductivity Transmitter

Designed for use in difficult environments, the CDCN-108 electrodeless conductivity sensor is a non-contacting design that prevents clogging. Since conventional electrodes are not used, polarization and electrode coating problems are eliminated. The large bore design greatly reduces fouling, so sensor maintenance is significantly reduced. The CDCN-108 is constructed so that only one material is wetted by the process to simplify chemical resistance problems. Because the wetted material (vinyl ester) is non-

conductive, the sensor is electrically isolated from the process fluid, eliminating ground loops which can affect accuracy. The sensor has an integral temperature compensator to automatically adjust the conductivity reading to a 25°C reference. This sensor must be used with the CDTX-102 conductivity transmitter.

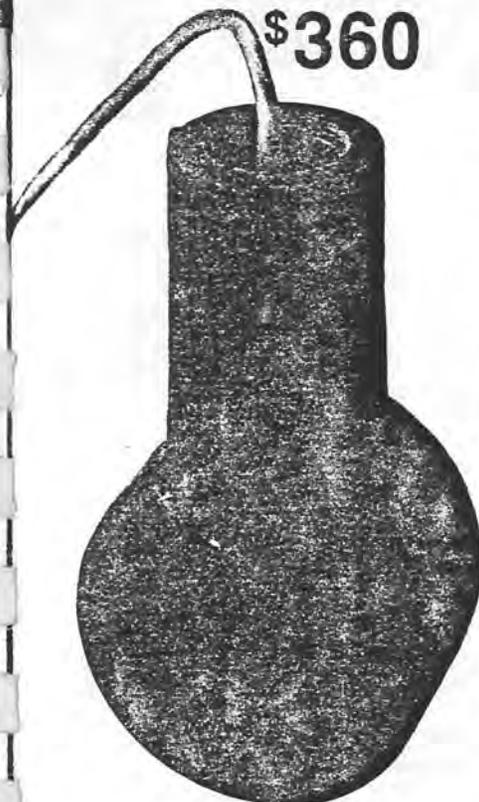
### Specifications

**Wetted Materials:** Vinyl Ester  
**Measuring Range:** 0 to 1,000,000  $\mu\text{S}/\text{cm}$   
**Temperature Range:** 0 to 95°C  
**Maximum Pressure:** 100 PSI  
**Temperature Compensation:** Automatic, 0 to 95°C  
**Mounting Connection:** 1" NPT female mates to 1" mounting pipe  
**Cable Length:** 4½ feet  
**Maximum Cable Length:** 100 feet

The CDCN-108 comes with 4½ feet of cable. Additional cable available up to 100 feet total. Add \$1.00 per additional foot.

CDCN-108

\$360



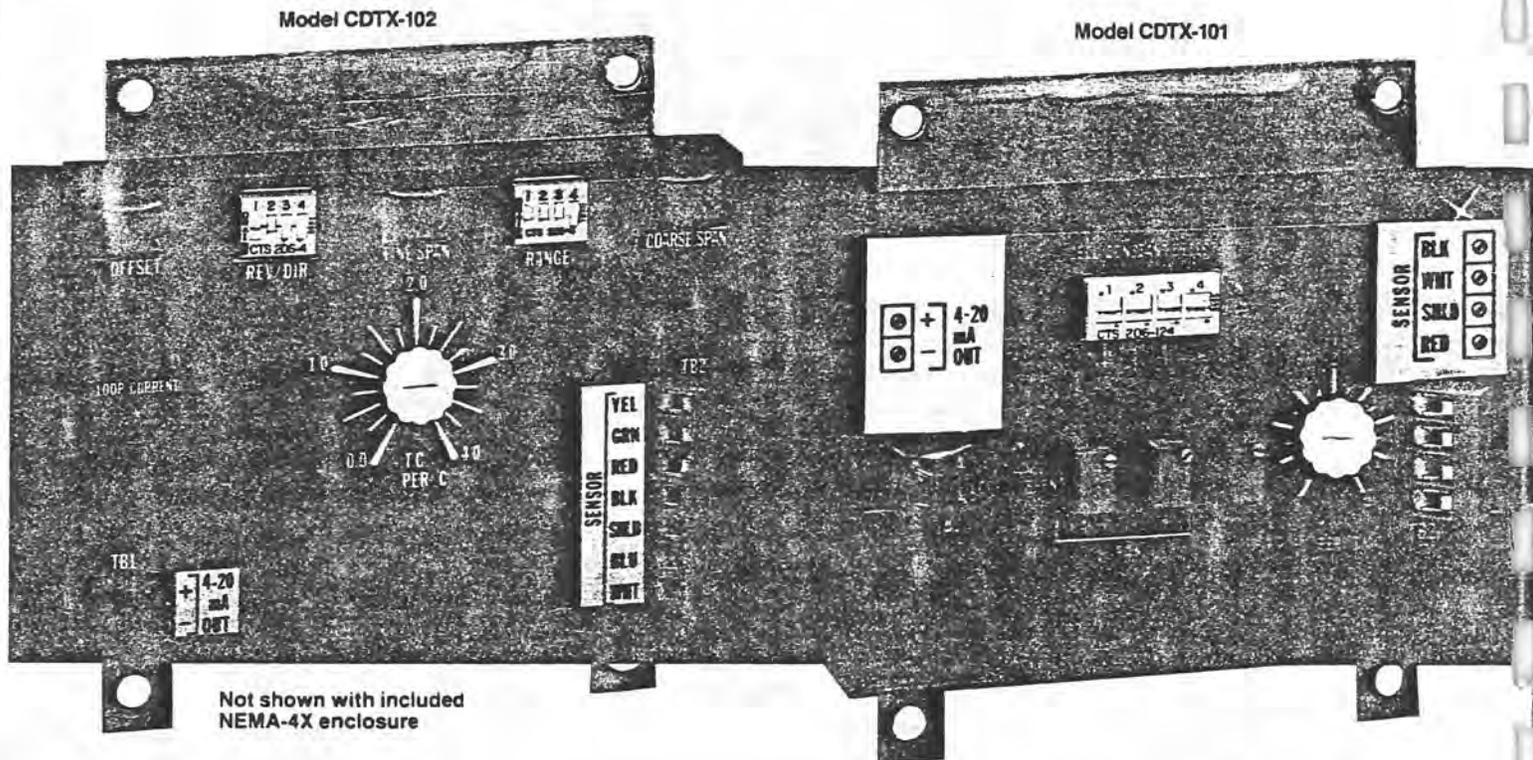
# Conductivity Transmitters and Sensors

MADE IN  
USA

## Two Wire Conductivity Transmitters CDTX-101, CDTX-102

- Model CDTX-101 for Contacting Conductivity Sensors and Model CDTX-102 for Electrodeless Conductivity Sensor

- Epoxy Encapsulated
- NEMA 4X Enclosure Surface Mounting



Not shown with included NEMA-4X enclosure

The CDTX-101 and 102 conductivity transmitters are designed to accept the signal from the model CDCN-100 Series conductivity sensors and provide an isolated 4 to 20 mA current output which is proportional to the conductivity being measured. The CDTX-101 will accept the CDCN-102, 104 and 106 contacting

conductivity sensors and the CDTX-102 accepts the input from the CDCN-108 electrodeless conductivity sensor. The transmitter electronics are fully encapsulated. Terminal strips are provided for field connections. For convenient and safe mounting, the CDTX-101 and

102 are provided with NEMA 4X enclosures that may be surface mounted in any position. These transmitters and sensors are a perfect match for a conductivity control system using the PHCN-105 conductivity controller.

## To Order

Model No.	Price	Compatible Sensor	Measuring Range, $\mu\text{S}$
CDTX-101	\$305	CDCN-102	0-10, 0-50, 0-100, 0-200
		CDCN-104	0-500, 0-1000, 0-2000, 0-5000
		CDCN-106	0-10,000, 0-20,000, 0-50,000
CDTX-102	375	CDCN-108	0-1,000,000

## Specifications

**Sensor to Transmitter Distance:** 100 feet maximum  
**Power Requirement:** 16 to 40 Vdc  
**Connections:** Stripped leads  
**Temperature Compensation:** Automatic 0 to 100°C  
**Enclosure:** NEMA 4X, polycarbonate, surface mount  
**Dimensions:** 4.8" x 4.7" x 2.2"  
**Weight:** 0.6 lb

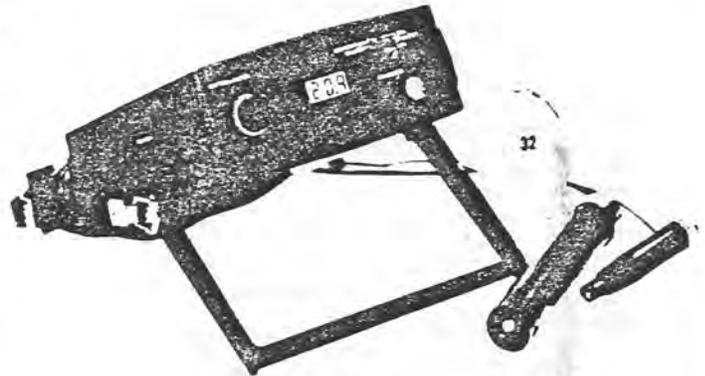
**MONITEK®**  
LIQUID MONITORING SPECIALISTS

# MONITEK MODEL 8500

## Portable Dissolved Oxygen/B.O.D. Meter

### FEATURES:

- Accurate monitoring of the true concentration of dissolved oxygen in wastewater and other liquids
- Unique patented probes operate independent of fouling, no stirring required
- Permanent membrane sensor requires no routine service, minimum maintenance
- No plating, etching or cleaning of electrodes; no contamination of electrolyte; no mechanical agitation required
- Design assures high reliability, long service
- Easy calibration against air or liquid
- Switch-selected digital meter display of 0-20 ppm O<sub>2</sub> range, temperature (0-50 C), or percent O<sub>2</sub> (for calibration)
- Millivolt output signal for recording



### DESCRIPTION:

The 8500 Dissolved-Oxygen Meter system, unique in both operation and configuration, comprises a meter housed in a weatherproof case for indoor or outdoor use, and a patented probe unaffected by fouling or changes in flow conditions.

#### METER

The Meter case is constructed of high-impact-resistant A.B.S. plastic, and joints are gasketed to resist water incursion. Power is supplied by two standard 9-V alkaline batteries, and the unit is designed to be in the "standby" mode, ready for operation at all times, eliminating any stabilization period (Battery life is up to 60 days on standby.) A low-battery indication is incorporated into the readout, and the circuitry is arranged so that the batteries can be replaced individually, without interrupting the operation.

A storage compartment and cable rack are provided on the Meter case to simplify storing or transporting the probe, and a special connector at the rear of the case to accept the probe cable.

#### PROBE

The submersible probe is permanently housed in a rugged, PVC enclosure which can be mounted on the end of an extension pipe. Calibration can be checked (using the Meter) by comparison with either an air or water sample (The diffusion independence of the probe also simplifies air calibration, since it eliminates drying requirements.) The sensor is covered with heavy-duty silicone rubber, a 20-foot waterproof cable, terminating in a waterproof plug-in connector, joins the probe to the Meter.

#### APPLICATIONS:

The 8500 Meter can be used in the field or laboratory to measure the concentration of dissolved oxygen in industrial or municipal wastewater lagoons and open water. Typical applications include:

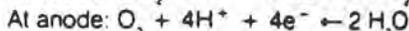
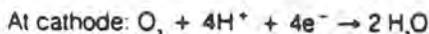
- Monitoring of aerated biological processes.
- Measuring wastewater effluent for compliance.
- Monitoring reservoir aeration systems.
- Profiling navigable water.
- Monitoring fish-hatchery conditions.
- Corrosion control.

## OPERATING PRINCIPLE

The probe consists of three electrodes: Two active electrodes are interspaced on a supporting substrate, and covered with an electrolyte. The third (reference) electrode also contacts the electrolyte to set the electrochemical potential. The two active electrodes are connected as cathode and anode, and perform oxygen reduction and generation functions. The electrolyte is retained around the electrodes by a gas-permeable membrane, which is covered in turn by silicone rubber.

When the probe is immersed in a sample stream, oxygen diffuses through the membrane and is reduced at the cathode; simultaneously, an equal amount of oxygen is generated at the anode. The diffusion continues until the oxygen tension on both sides of the membrane is equal and balanced. The current necessary to maintain this equilibrium is converted, by the electrical circuitry of the Meter, to a display of the concentration of dissolved oxygen in the solution.

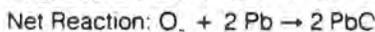
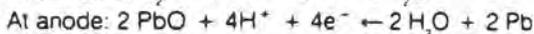
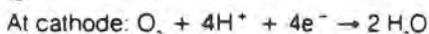
The chemical reactions are:



*No oxygen or acid is consumed; no water is produced; no net reaction occurs.*

In contrast, other probes work on either the galvanic principle—similar to a small fuel cell—or on the Clark polarographic principle. Both types require a continuous oxygen transfer through the membrane, in a one-way reaction.

The reaction for a Clark-type probe with a lead anode is:



*The lead anode is consumed, and a continual supply of oxygen is required. Any condition that impedes the flow of oxygen across the membrane into the sensor, such as fouling or insufficient flow, causes the signal to degenerate, resulting in erroneously low readings.*

## SPECIFICATIONS

### 8500 PORTABLE DISSOLVED-OXYGEN METER

**Concentration Range** 0-20.0 ppm dissolved oxygen

**Resolution** 0.1 ppm

**Accuracy Meter** 1% of full scale or least significant digit Meter and Probe. Overall accuracy (including compensation) is 0.2 ppm, over the normal operating range of the probe: 4 to 30 C (39 to 86 F)

**Indicator** Three-digit liquid crystal display (LCD), highly visible even in direct sunlight

**Ambient Temperature Limits** -10 to +40 C (14 to 104 F)

**Output** 0-100 mV proportional to concentration range, for recording

**Controls** (I) Four-position switch, for selection of (a) standby, (b) oxygen measurement (0-20.0 ppm), (c) air calibration (%O<sub>2</sub>), and (d) temperature measurement (0-50 C) from thermistor in probe. (II) Ten-turn calibration adjustment

**Power Requirement** Operates on two standard 9-V alkaline batteries. Battery life: 60 days on standby, 20 days on continuous operation. Low-battery indication is provided in display.

**Case** Suitable for field use, includes storage compartment for probe and rack for cable. Pivoted support stand elevates front of case to facilitate readings and adjustments.

**Dimensions** Overall 4" (h) x 10" (w) x 12" (d) (10.2 x 25.4 x 30.5 cm)

**Weight** 3.5 lb (1.5 kg)

### 8500-0002-00 SUBMERSIBLE DISSOLVED-OXYGEN PROBE

**Response Time** 40 seconds for a 90% response to a step-change, using a clean sensor

**Calibration** Oxygen calibration is against either liquid standard or air

**Temperature Range** For rated specifications, 4 to 30 C (39 to 86 F); maximum operating range, 2 to 80 C (36 to 176 F)

**Temperature Compensation** Automatic, over operating temperature range (4 to 30 C)

**Flow Requirement** No minimum flow requirement; no agitation or stirring required

**Oxygen Consumption** Regenerates 99% or more of all oxygen consumed

**Electrode Life** No theoretical limitation, since there is no plating or consumption of electrodes

**Electrolyte** Permanent electrolyte, sealed with an expansion chamber to compensate for pressure changes

**Internal Construction** Three electrodes (anode, cathode, reference electrode) and a thermistor for temperature compensation

**Electrical Connection** Integral waterproof cable, terminating in a waterproof 9-pin quick-disconnect plug

**Dimensions** 8 1/2" long x 1 1/4" OD (222 x 33 mm), with 20 ft. (6.1 m) integral cable

## HOW TO ORDER

Model 8500 Meter Only . . . . . Monitek #8500-0003-00

Wastewater D.O. Probe Only . . . . . Monitek #8500-0002-00

B.O.D. Probe Only . . . . . Monitek #8500-0004-00

R.C. Line Voltage Adapter . . . . . Monitek #8500-0006-00

## Represented by:

**MONITEK**  
LIQUID MONITORING SPECIALISTS

### U.S.A.

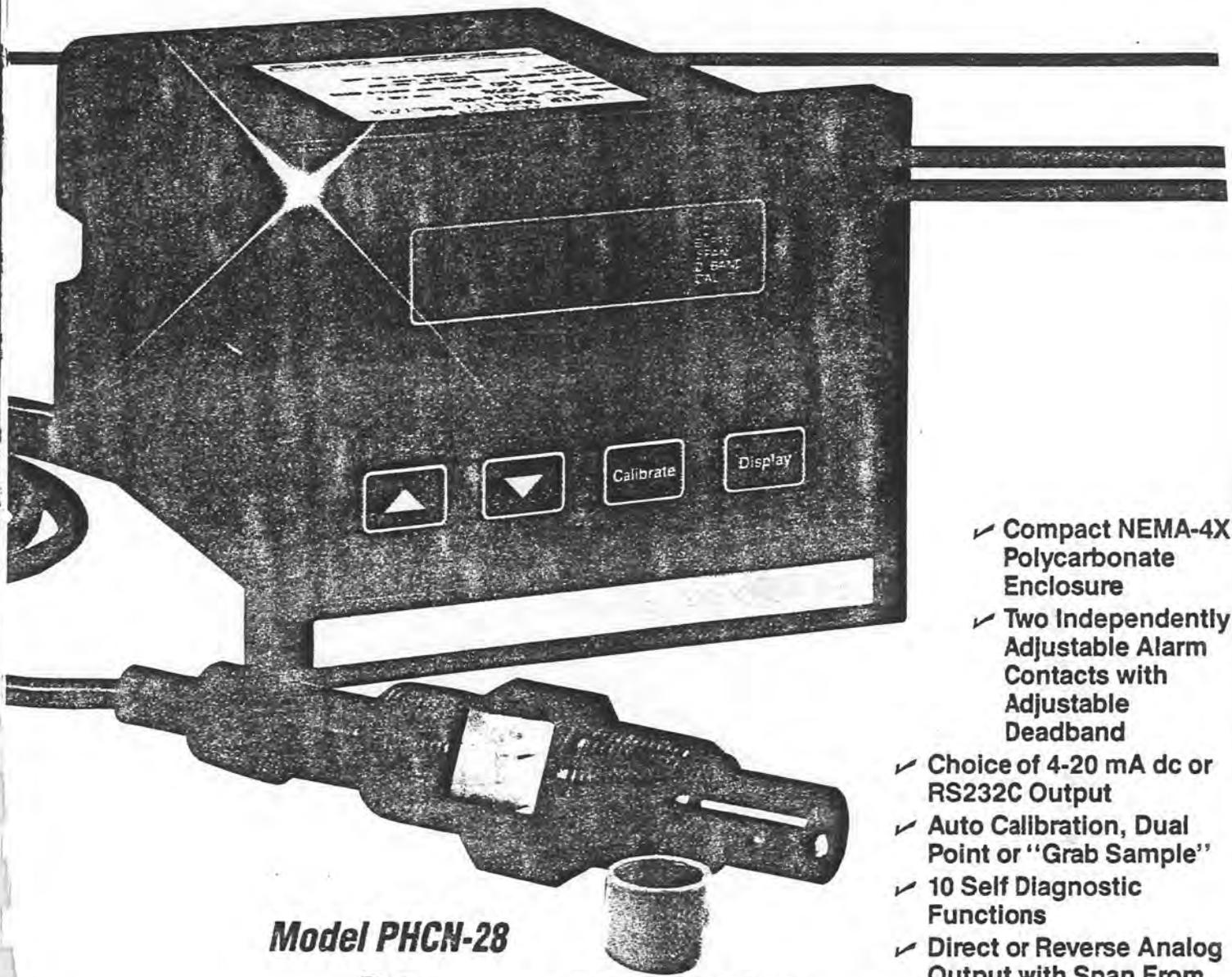
Monitek Technologies, Inc.  
1495 Zephyr Avenue, Hayward, CA 94544  
415/471-8300 TWX 910 383 2008 Ans. Back: Monitek HYWD  
FAX (415) 471-8647

Other Monitek products: •Turbidimeters •Nephelometers •Color Monitors •Suspended Solids, Density, Concentration/Consistency Monitors, Sludge Blanket Detectors/Controllers •Ultrasonic Level Flowmeters—Pipe Insertion Magmeter and Open Channel Ultrasonic •Dissolved Oxygen Analyzers •pH Controllers •Liquid Samplers

### Europe (Subsidiary)

Monitek GMBH, West Falenstrasse 8, 4000 Dusseldorf 30  
West Germany Telephone 02 11 / 65 20 06 TTX (17) 2114502  
FAX 0211/652009

# ... Omega microprocessor-Based pH Controller



## Model PHCN-28

From  
**\$675**

Electrode, Model PHE-2800,  
\$260, Sold Separately, See  
Chart on Opposite Page.

- ✓ Compact NEMA-4X Polycarbonate Enclosure
- ✓ Two Independently Adjustable Alarm Contacts with Adjustable Deadband
- ✓ Choice of 4-20 mA dc or RS232C Output
- ✓ Auto Calibration, Dual Point or "Grab Sample"
- ✓ 10 Self Diagnostic Functions
- ✓ Direct or Reverse Analog Output with Span From 0.1 to 20 pH Units
- ✓ CSA Approved

The OMEGA PHCN-28 microprocessor pH controller features auto buffering, solution temperature compensation, self-diagnostics and communication capabilities. Designed with the end-user in mind, this controller is user friendly and easy to operate. Four tactile membrane keypads allow for the selection and input of set-up parameters, input of calibration data and alarm setpoint adjustments. The two 5 A, 230 Vac relays can be configured as high/low, high/high or low/low.

The PHCN-28 is offered with a choice of an isolated 4-20 or 0-20 mA dc output (field selectable) or an RS232C interface with a non-isolated 0-5V analog output. The analog output is flexible enough to be used as either a proportional control output or recorder output. The self-diagnostics of the PHCN-28 can alert

the user to such conditions as internal circuitry malfunction, pH out of range, pH slope out of normal range, ATC short or open, or electrode failure to stabilize in buffer. The unit also employs a "watch-dog" timer which prevents memory loss in the event of a power surge.

The PHCN-28 has an integral pre-amplifier and is designed for use with the PHE-2800 gel filled, double junction combination electrode with ATC. For locations where the electrode and controller must be separated by more than 50 ft, the PHCN-28-PA external pre-amplifier should be considered. The unit features a rugged NEMA-4X polycarbonate enclosure. If an application requires an electrode other than the PHE-2800, then the PHCN-28-PA must be used. In this case a Pt100 is necessary for ATC (see page E-25).

APPENDIX E: DATA ACQUISITION SYSTEM (DAS) HARDWARE



# DIANACHART INC

101 ROUND HILL DRIVE • ROCKAWAY, N.J. 07866 • TELEPHONE (201) 825-2299 • FAX (201) 825-2449

Bureau of Reclamation  
P.O. Box 25007  
Denver Federal Center  
Denver, CO 80225-0007

MAIL STOP: D3751  
ATTN: Joe Kubitschek

DATE: September 14, 1992  
RE: Telephone Call

## QUOTATION

QTY	DESCRIPTION	ORDER CODE	UNIT PRICE
	<b>THE FOLLOWING PRODUCTS ARE RECOMMENDED TO SATISFY YOUR REQUIREMENTS:</b>		
1	<b>SYS-1, COMPLETE DATA ACQUISITION SYSTEM-</b> Includes a 14 channel PROCESS-ACQ Data acquisition system with menu driven software (-MS), signal conditioning (-SC), printer driver (-PD), real-time graphics (-RTG), and multi-tasking (-MT386). Features a 386SX with 2Mb memory, and 42 Mega Byte Hard Disk, complete with software (MS-DOS and Basic word processing) and a 120 CPS printer with near letter quality print.	SYS-1	\$6745

### Standard Terms:

Availability: 6-8 Weeks

For guaranteed 5 working day shipment, ARO, add 10% to order total. (Standard Products Only)

F.O.B. Rockaway, N.J.

Net 20 Days

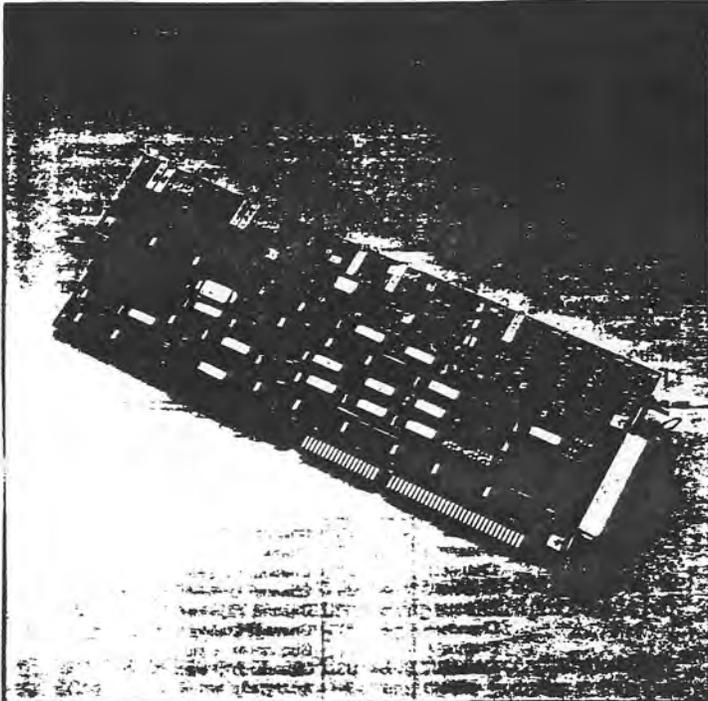
Quote is valid for 30 days.

Russ Graybill

# KEITHLEY

DATA ACQUISITION AND CONTROL  
FOR IBM PC/XT/AT AND COMPATIBLE  
COMPUTERS

## DAS-40 HIGH PERFORMANCE ANALOG & DIGITAL INTERFACE BOARD



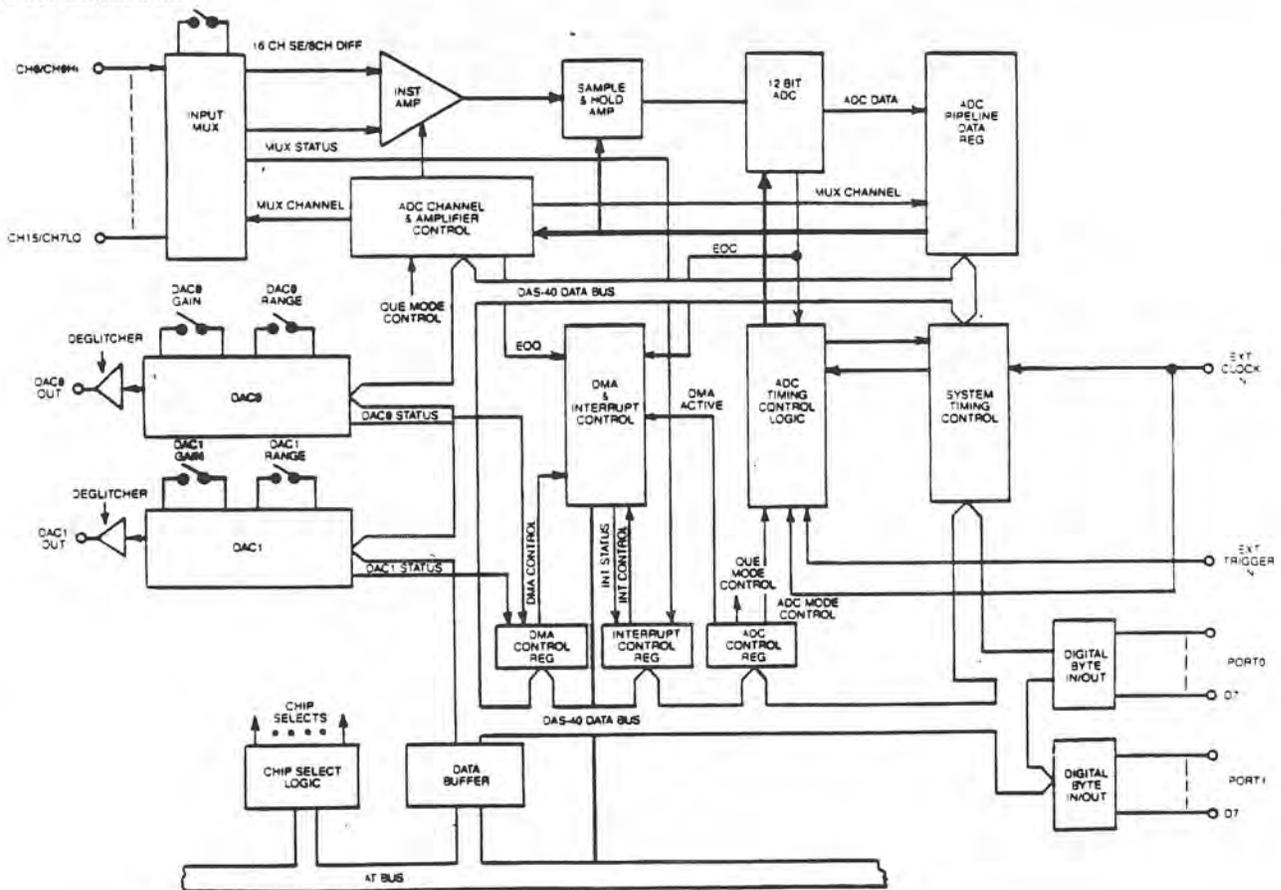
### FEATURES

- 250,000 Samples/Second
- DAS-40G1 provides gains of 1, 10, 100, 500
- DAS-40G2 provides gains of 1, 2, 4, 8
- 8 Differential/16 single ended analog inputs (User switch selectable)
- 2-Deglitched, 12-Bit Analog Outputs
- Internal & External Clocking and Triggering
- Fully protected analog input
- Short circuit protected outputs
- Unipolar and Bipolar operation
- 16 Bits of Digital I/O
- Interrupt support on one of five selectable levels
- Programmable Pacer Clock initiates A/D or D/A conversions
- Direct Memory Access (DMA)

### APPLICATIONS

- Vibration/Stress Analysis
- Event Transient Analysis
- FFT
- Waveform Analysis
- Laboratory Automation
- Process Monitoring & Control

### BLOCK DIAGRAM



16-bit Data Acquisition Boards

## CONFIGURATION SWITCHES

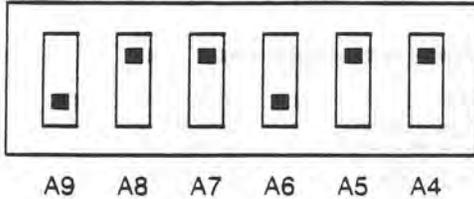
The DAS-40 employs easy to change DIP switches and jumper plugs to configure such things as the Base I/O Address, A/D Range and Coding, D/A ranges, DMA Channel(s) and the Interrupt Level.

The DAS-40 uses 16 consecutive locations in the I/O address space. The Base I/O Address can be set to any legal 16-byte boundary by a 6-position DIP switch; therefore, the DAS-40 can always be installed regardless of I/O address usage of other peripherals. No memory address space is used and there are no on-board embedded programs or microprocessors.

### Base Address—SW6

The Base Address switch is a 6-position DIP switch covering the range A9-A4. The switch function and operation is identical to the Base Address switches on all other MetraByte PC boards. The DAS-40 is shipped from the factory with the base address set at 240 (hex).

#### BASE ADDRESS (240H)



DMA Channels 5, 6 and 7 may be used by the DAS-40; these are assigned by the PC-AT as word transfer channels and a DAS-40 may be configured to use two channels for "gap-free" Data Acquisition of up to 128K Samples (words).

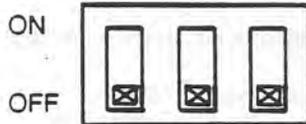
Interrupt Levels 3, 5, 7, 10 and 15 are available for use by the DAS-40. Select one (via jumper plug) to use, making sure that it is not used by any other device in your PC.

With the DAS-40 out of the PC, use the supplied configuration utility: CONFIG40.EXE for assistance in setting up the switches and jumpers on the DAS-40 board.

### Coding

Coding	S3
Straight Binary	On
Offset Binary (FC)	On
Two's Complement	Off

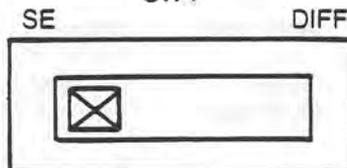
### SW3



### Input Configuration

Configuration	Position
16 Single-ended (FC)	Left
8 Differential	Right

### SW4

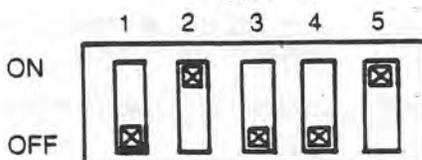


### D/A Functions

#### DAC 1 Output Range Selection—SW1

Output Range	S1	S2	S3	S4	S5
±10 Volts (FC)	Off	On	Off	Off	On
±5 Volts	Off	On	On	Off	On
±2.5 Volts	On	Off	On	Off	On
0 to 10 Volts	Off	On	On	On	Off
0 to 5 Volts	On	Off	On	On	Off

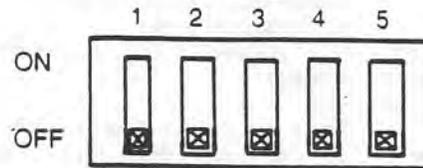
### SW1



#### DAC 0 Output Range Selection—SW2

Output Range	S1	S2	S3	S4	S5
±10 Volts (FC)	Off	On	Off	Off	On
±5 Volts	Off	On	On	Off	On
±2.5 Volts	On	Off	On	Off	On
0 to 10 Volts	Off	On	On	On	Off
0 to 5 Volts	On	Off	On	On	Off

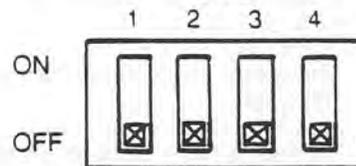
### SW2



### DMA Channel

Channel	First DMA Channel		Second DMA Channel	
	S1	S2	S3	S4
5	Off	On	Off	On
6	On	Off	On	Off
7	On	On	On	On
none	Off	Off	Off	Off

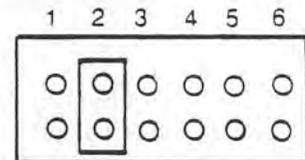
### SW5



The factory configuration has the first DMA channel set to Channel 5, and the second DMA channel set to Channel 6.

### Interrupt Level—J2

Interrupt Level	Jumper Position
10	1
15 (FC)	2
3	3
5	4
7	5
none	6

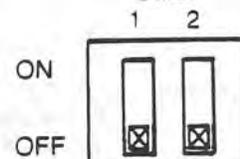


Note that the position numbers, 1 through 6, are specified from left to right, and are not labeled on the DAS-40. "FC" indicates the factory configuration.

### A/D Functions

Range	S1	S2
Bipolar ±10V (FC)	Off	Off
Bipolar ±5V	On	Off
Unipolar +10V	On	On

### SW6



## SPECIFICATIONS

### Analog Input

Speed: 575-1: 62,500 rdg/sec. 575-2: 50,000 rdg/sec  
Resolution: 575-1: 12 bits. 575-2: 16 bits.  
Full-scale Ranges:  $\pm 100\text{mV}$ ,  $\pm 200\text{mV}$ ,  $\pm 500\text{mV}$ ,  $\pm 1\text{V}$ ,  $\pm 2\text{V}$ ,  $\pm 5\text{V}$ ,  $\pm 10\text{V}$   
Channels: 8 differential, 16 single-ended plus 8 additional single-ended  
Maximum Input:  $\pm 30\text{V}$  (powered),  $\pm 15\text{V}$  (unpowered).  
Input Resistance:  $>100\text{M}\Omega$ .  
Input Bias Current:  $<1\text{nA}$ .  
Filter: Single-pole low-pass, 100kHz or 2kHz.  
Settling Time: AMM1A:  $12\mu\text{s}$  @ 100kHz, 0.6ms @ 2kHz (to 0.05% of final reading).  
AMM2:  $16\mu\text{s}$  @ 100kHz, 0.8ms @ 2kHz (to 0.003% of final reading).

Additional Inputs: Use AIM2-AIM9 in Expansion Slot for additional input channels, more gain, or transducer signal conditioning. A 26-pin ribbon cable mass-termination connector for up to 8 single-ended inputs is provided in the 575. Directly compatible with the 3B and MB subsystem for specialized signal conditioning.

### Analog Output

Channel Capacity: 2, single-ended, referenced to chassis.  
Output Ranges:  $\pm 10\text{V}$ ,  $\pm 5\text{V}$ ,  $\pm 2\text{V}$ ,  $\pm 1\text{V}$ .  
Resolution: 13-bits.  
Accuracy:  $\pm 10\text{V}$  Range,  $\pm 0.15\% \pm 5\text{mV}$ ; Other Ranges,  $\pm 0.2\% \pm 4\text{mV}$ .  
Output Load:  $2\text{k}\Omega$  (min),  $100\text{pF}$  (max).  
Settling Time:  $5\mu\text{s}$  (max) to 0.01%  $\pm 1$  LSB for any step size.  
Additional Outputs: Use AOM1-AOM5 in Expansion Slot for additional output channels, higher resolution, higher speed or sourcing.

### Digital Input/Output & Power Control

Channels: 32 non-isolated, programmable for input or output in groups of 8 channels. 16 channels can drive PCM3 power control rack.  
Input: TTL-level, high-true, 20mA source, 0.4mA sink.  
Output: 10 TTL loads, 24mA sink at 0.5V.  
Additional Input/Output: Use DIM1, DIO1A, DOM1 in Expansion slot for additional channels or isolation. Use PCM1 for 4 additional channels AC power control.

## ORDERING INFORMATION

**500-575-1** 575 with AMM1A 12-bit A/D; interface for IBM PC/XT/AT/386, PS/2 25 & 30 and compatibles; and KDAC500/I software for interpreted BASIC  
**500-575-2** 575 with AMM2 16-bit A/D; interface for IBM PC/XT/AT/386, PS/2 25 & 30 and compatibles; and KDAC500/I software for interpreted BASIC  
**500-575-1PS2** 575 with AMM1A 12-bit A/D; interface for IBM PS/2 Models 50, 60, 70, 80 and compatibles; and KDAC500/I software for interpreted BASIC  
**500-575-2PS2** 575 with AMM2 16-bit A/D; interface for IBM PS/2 Models 50, 60, 70, 80 and compatibles; and KDAC500/I software for interpreted BASIC  
**575-PWR** AC line adapter (120V) and automotive adapter (12v) for 575 external power.

## Trigger Function

Channels: 1, differential input.  
Trigger Source: Ext. input, any input channel, or software strobe.  
Ranges: 0 to +1V, 0 to -1V, 0 to +10V, 0 to -10V. 8-bit resolution.  
Level Accuracy:  $\pm 2\% + 1\text{LSB}$ .  
Input Impedance:  $10\text{M}\Omega$  (External Input).  
Input Protection:  $\pm 30\text{V}$  max (powered),  $\pm 15\text{V}$  max (unpowered).  
Input Coupling: AC or DC  
Trigger Slope: Rising or falling slope.  
Trigger Input Filter: Software selectable single-pole low-pass filter with cut-off frequencies of 1MHz, 300kHz, 100kHz, 30kHz, 10kHz, 3kHz, 1kHz, 300Hz.

## Other Functions from Expansion Slot:

Frequency: use PIM1  
Event/Pulse Counting: use PIM2  
Waveform Generation: use WAV1  
Custom Circuits: use PROTO

## General Chassis Specifications

**Host Computer:** IBM PC/XT/AT/386 using IBIN-A and PS/2 Micro-channel using IBIN-PS/2. DOS 3.0 or later, as recommended by computer manufacturer.

**Interface Requirements:** IBIN-A or IBIN-LP one half-length slot. IBIN-PS/2 one full-length PS/2 slot.

**Power Requirements:** May be powered from PC bus, requires 5V @ 2A. May also be powered from an external source of 8-18V AC or DC @ 3A. Optional wall-mount transformer and automotive power adapter (575-PWR).

**Initialization:** Automatic initialization of all outputs at power-up.

## Environmental Limits:

Operating Temperature: 0 to +40°C.  
Storage Temperature: -20 to +70°C.  
Humidity (Non-condensing): Up to 80% RH.

**Dimensions:** 85 cm (H) x 270 cm (W) x 302 cm (D) [3.5 in. x 10.5 in. x 12 in.].

**Weight:** Net: 3.0kg [6.5 lbs]. Shipping: 15kg [33 lbs].  
**Certification:** Meets FCC PART 15J, Class A.

**575-MAIN** 575 chassis, 5 ft. interface cable, KDAC500/I software and manuals.

**500-CABL15** System interface cable for 575 (15 feet), requires 575-PWR

**500-IBIN-A** Series 500 computer interface board for IBM PC/XT/AT, PS/2 Model 25 and 30, and 100% compatibles.

**500-IBIN-LP** Lower power interface for PC/XT/AT computers.

**500-IBIN-PS2** Series 500 computer interface board for IBM PS/2 Micro Channel models.

See Series 500 compatibility chart for available software.

**SPECIFICATIONS (1 year, 18°-28 °C):**

**Analog Input - Volts**

Full-scale Ranges: ±100mV, ±200mV, ±500mV, ±1V, ±2V, ±5V, ±10V  
 Channels: 8 differential, 16 single-ended plus 8 additional single-ended  
 Maximum Input: ±30V (powered), ±15V (unpowered).  
 Input Resistance: >100MΩ.  
 Input Bias Current: <1nA.  
 Input Noise: 576-1: <1 count; 576-2: greater of 6 counts or 50µV p-p.  
 Filter: Single-pole low-pass, 100kHz or 2kHz.  
 Settling Time: 576-1: 12µs @ 100kHz, 0.6ms @ 2kHz (to 0.05% of final reading).  
 576-2: 16µs @ 100kHz, 0.8ms @ 2kHz (to 0.003% of final reading).

**Model 576-1 (12-bits, 3½ digit)**

Range	Resolution	Accuracy (% of reading + mV)	
		Corrected	Uncorrected
±10V	4.9 mV	±0.04% + 4.9	±0.06% + 4.9
±1V	0.48mV	±0.09% + 0.98	±0.10% + 0.98
±100mV	49 µV	±0.09% + 0.67	±0.16% + 0.67

**Model 576-2 (16-bits, 4¼ digit)**

Range	Resolution	Accuracy (% of reading + mV)	
		Corrected*	Uncorrected
±10V	305µV	±0.035% + 0.66	±0.065% + 0.66
±1V	31µV	±0.040% + 0.19	±0.065% + 0.19
±100mV	3µV	±0.044% + 0.18	±0.065% + 0.18

\*Using average function (500 samples). Corrected readings use software gain & offset adjustment.

**Analog Input - Thermocouples** (Model 576-2 with AIM7 Thermocouple Input Module, excluding user thermocouple errors)

Channels: 16 differential  
 Maximum Input: ±30V (powered), ±15V (unpowered).  
 Resolution: 0.01°C at -100 and 25°C; 0.04°C at 700°C.

Type J	Accuracy (1 yr) 18° - 28° C	Type K	Accuracy (1 yr) 18° - 28° C
-200° to -100°	±1.5°C	-200° to 400°	±1.5°C
-100° to 100°	±0.9°C	400° to 750°	±2.0°C
100° to 400°	±1.5°C	750° to 1200°	±3.0°C
400° to 760°	±2.0°C	1200° to 1370°	±4.0°C

Type T	Accuracy (1 yr) 18° - 28° C	Type E	Accuracy (1 yr) 18° - 28° C
-170° to 0°	±1.5°C	-200° to 0°	±1.4°C
0° to 220°	±1.1°C	0° to 400°	±1.2°C
220° to 400°	±1.4°C	400° to 750°	±2.0°C
		750° to 1000°	±2.0°C

Also supports Type B, R, S transducers. Refer to the Manual for Specifications and extended temperature ranges for all thermocouple types.

**Analog Output**

Channel Capacity: 2, single-ended, referenced to chassis.  
 Output Ranges: ±10V, ±5V, ±2V, ±1V.  
 Resolution: 13-bits.  
 Accuracy: ±10V Range, ±0.15%±5mV; Other Ranges, ±0.2%±4mV  
 Output Load: 2kΩ (min), 100pF (max).  
 Settling Time: 5µs (max) to 0.01% ± 1 LSB for any step size.

**Digital Input/Output & Power Control**

Channels: 32 non-isolated, programmable for input or output in groups of 8 channels. 16 channels can drive PGM3 power control rack.  
 Input: TTL-level, high-true, 20µA source, 0.4mA sink.  
 Output: 10 TTL loads, 24mA sink at 0.5V.

**Trigger Function**

Channels: 1, differential input.  
 Trigger Source: Ext. input, any input channel, or software strobe.  
 Ranges: 0 to +1V, 0 to -1V, 0 to +10V or 0 to -10V, 8-bit resolution.  
 Level Accuracy: ±2% + 1LSB.  
 Input Impedance: 10 MΩ (External Input).  
 Input Protection: ±30V max (powered), ±15V max (unpowered).  
 Input Coupling: AC or DC  
 Trigger Slope: Rising or falling slope.  
 Trigger Input Filter: Software selectable single-pole low-pass filter with cut-off frequencies of 1MHz, 300kHz, 100kHz, 30kHz, 10kHz, 3kHz, 1kHz, 300Hz

**General**

Architecture: Plug-in A/D plus one expansion slot. Accepts one module for additional I/O channels or signal conditioning.  
 Program Storage: Up to 10,000 bytes plus 18,000 bytes for system parameters.  
 Data Storage: Up to 100,000 bytes available for use in up to twenty (20) user sized buffers. Expandable to 480,000 bytes with 576-MEM factory installed option.  
 Battery Life: Typically 2 years @ 25° C ambient.  
 Clock Accuracy: ±1 minute/month @ 25°C.  
 Initialization: Digital Outputs power-up in tri-state mode. Analog Output at 0V.  
 Front Panel: REMOTE, SRQ, TALK, RUN, POWER indicators. Power switch.  
 Rear Panel: Power input, IEEE-488 connector, and grounding posts.  
 Case: Aluminum.  
 Warm-up: 15 minutes to rated accuracy.  
 Environment: Operating: 0° to 50°C, 80% R.H. non-condensing at up to 35°C.  
 Storage: -20°C to +65°C.  
 Power: 12-18V 40VA (max) AC or DC. External power module supplied for 105-125VAC input. Order/E option for 210-250VAC mains operation.  
 Dimensions: 85 cm (H) x 270 cm (W) x 302 cm (D) [3.5 in. x 10.5 in. x 12 in.]  
 Weight: Net: 3.0kg (6.5 lbs). Shipping: 15kg (33 lbs).  
 Certification: Meets FCC PART 15J, Class A.

**IEEE-488 Bus Implementation**

Interface: IEEE-488-1978 standard.  
 Multiline Commands: DCL, SDC, GET, GTL, UNT, UNL, SPE, SPD  
 Uniline Commands: IFC, REN, EOI, SRQ, ATN.  
 Interface Functions: SH1, AH1, T6, TED, L4, LEO, SR1, RLO, PPO, DC1, DT1, E1  
 Progr. Parameters: Read, Write, Buffer size, Filter, Gain, Offset, Range, Units, Loop It., Else, While, Time, Time Stamp, Clock, Subroutine, On Interrupt, Trigger, Wait, Test, Peek/Poke, Reset, Halt, SRQ, ID, Terminator, Save, EOI, Cal, Real-time Average, Min/Max/Mean.

**Typical Rates**

Input/Output (channels/second)	Immediate Mode*		Buffered Mode†	
	1 channel	16 channels	1 channel	16 channels
DC Volt Input (576-1)	26	40	62,500	34,500
(576-2)	26	40	50,000	34,500
Thermocouple Input (all Types)	15	25	215	400
Analog Output (2 channels only)	55	85	40,500	54,000
Digital Input (Port Read)	55	790	90,100	125,000
Digital Output (Port Write)	49	860	72,750	108,000

\*Command sent from computer. Input data converted to ASCII and ready for transfer to computer.  
 †Aggregate channel rate for 1,000 scans executed from Model 576 program memory. Input data saved in internal memory.

Minimum Source-Delay-Measure Cycle Time: 250 µs

**Data Transfer Rate (to ideal listener from Model 576 memory):**

(in readings/second)	ASCII (no prefix)	IBM Binary	HP Binary
Raw A/D Counts	250	34,000	47,000
DC Volts	36	260	265
Thermocouple Input (all Types)	25	52	53

Maximum GPIB Transfer Rate: 112,500 bytes/second

### FEATURES

- 16S or 8D analog input channels
- 4 Analog output channels optional (PC-412) with simultaneous update
- Choice of 12 or 14 bit A/D resolution
- FIFO memory, DMA, and programmable interrupts for continuous, non-stop "streaming" data acquisition
- Programmable gain amplifier
- On-board programmable trigger clock
- Discrete digital I/O (8 input, 8 output)

### GENERAL DESCRIPTION

Offering non-stop continuous collection of up to 16 analog input signals in real time, the PC-411 is an analog input board for IBM-PC, PC/XT, PC/AT, and compatible computers. The PC-411 accepts 16 single-ended or 8 differential input signals, digitizes them up to 12- or 14-bit resolution and places them on the computer bus under software control. Data may then be stored in PC memory, saved on disk or displayed on the screen or printer.

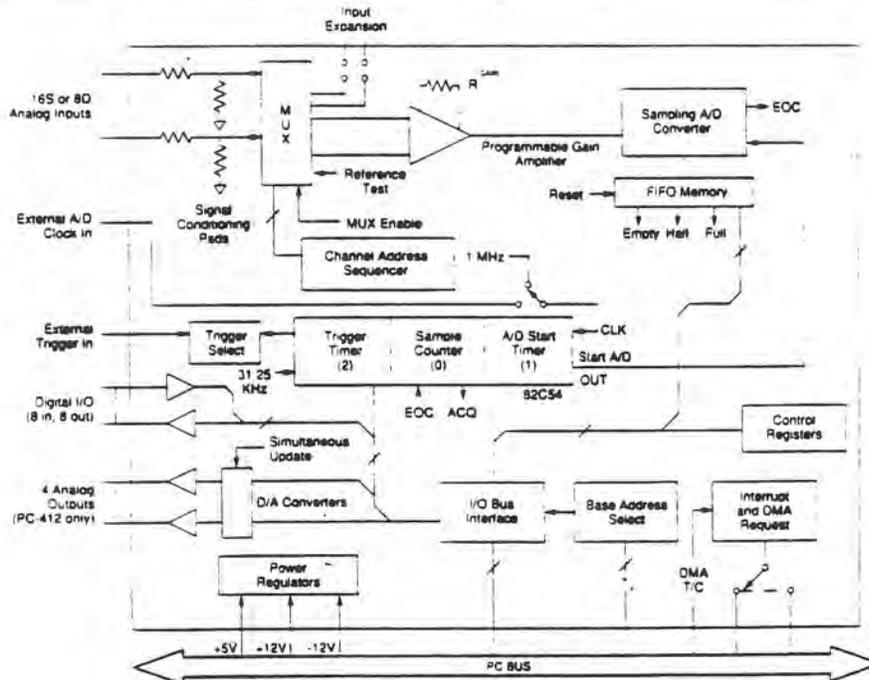
Model PC-412 is a combination analog input and output board using the same input section as the PC-411. The PC-412 adds four optional analog output channels to be used for chart recorders, actuator controllers or other output devices. Both the PC-411 and -412 accept external analog input expansion channels. On both the 411 and 412, sixteen discrete digital I/O lines are configured as 8 inputs and 8 outputs for external logic devices.

The digital outputs can control the channel addressing of an expansion input multiplexer. The differential analog inputs offer rejection of common mode noise while the on-board Pro-

grammable Gain Amplifier (PGA) offers higher gains (up to times 100) for low level sensors. On-board circuit pads may be configured for other input voltage or current ranges or input signal conditioning.

Analog to digital converter (A/D) data passes to an on-board First-In, First Out (FIFO) data memory. FIFO data is then transferred to the host computer bus interface under software control. Besides temporarily storing a block of samples, the FIFO acts to decouple the precise timing of the A/D section from the block-oriented data transfer burst on the bus.

Unlike many other analog input boards for the PC, the PC-411/412 can continuously collect analog data with non-stop converter triggering while data is simultaneously read by the PC from the FIFO. This allows the collection of "seamless" signals of millions of samples or greater. Another advantage of the FIFO is high speed disk recording of analog data with no loss of samples during disk writes.



**PC-411/412 Block Diagram**

<b>PC BUS INTERFACE</b>	
<b>Architecture</b>	Decodes 16 byte-wide I/O registers using address lines A9-A0. Highest base address is 3F0h.
<b>Data Bus Width</b>	8 bits.
<b>PC Bus Interrupt (software maskable)</b>	1 line. Software selectable IRQ 3, 5, 7.
<b>Bus Interrupt Sources</b>	Scan acquire flag (sample count), FIFO full, half full or not empty or DMA T/C.
<b>Bus Data Transfer Rate</b>	1 Megabyte/second or greater. Dependent on host PC CPU speed.
<b>Direct Memory Access</b>	1 line, software selectable, DRQ1 or DRQ3 from FIFO HF, FF, EF* or ACQ.
<b>PARALLEL PORT</b>	
<b>Parallel Output</b>	8 lines, TTL levels. 2 mA out
<b>Parallel Inport</b>	8 lines, TTL levels. 24 mA in plus pullup resistor to +5V
<b>CONNECTORS</b>	
<b>Analog Inputs, P1</b>	25-pin female DB-25S connector on rear mounting bracket for analog inputs and trigger.
<b>Analog Outputs, P2 (PC-412 only)</b>	9-pin female DB-9S connector on rear mounting bracket.
<b>Parallel Port</b>	Internal header connector. 0.025 inch pins on 0.100 inch spacing, suitable for flat cable.
<b>PC Bus Connector</b>	Edgeboard connector
<b>MISCELLANEOUS</b>	
<b>Power Required (PC-411)</b>	+5V dc, ±5% at 1.0 Amps max. and ±12V dc, ±5% at 100 mA max. all supplied from the bus.
<b>(PC-412)</b>	+5V: 2.0 Amps. max. ±12V: 250 mA max.
<b>Operating Temperature Range</b>	0 to +60 °C Forced cooling is recommended.
<b>Storage Temperature Range</b>	-20 to +80 °C
<b>Relative Humidity</b>	10% to 90%, non-condensing.
<b>Altitude</b>	0 to 10,000 feet.
<b>Outline Dimensions</b>	4.2" H x 13.31" L x 0.625" D (11.43 x 33.81 x 1.59 cm) compatible to PC bus.
<b>Weight</b>	10 ounces (290 grams)
<b>Analog Section Adjustments</b>	Inputs: offset and gain Outputs: offset and gain per channel.

**NOTES/DEFINITIONS**

**Input Settling Delays:**

The PC-411/412 will run faster in single channel operation than multichannel after the input is settled on the first channel. Total sample-to-sample throughput time must include input multiplexer settling time after changing the channel address, PGA settling time (depending on the gain), sampling A/D converter acquisition time, and A/D conversion time. The PC-411/412 sampling rate will not be delayed by FIFO-to-PC data transfers if the FIFO is not full.

For Immediate Assistance, Dial 1-800-233-2765

**Sampling Rate per Channel**

The rates shown for sequential sampling are the maximum A/D converter start rates and include MUX sequencing and settling delays. For example, if four channels were scanned, the maximum sample rate on any one channel of the PC-411/412 would be 20 microseconds times 4 channels, equalling 80 microseconds (12.5 KHz per channel). Observe Nyquist sample rate rules for inputs with unknown spectral content.

To avoid overload recovery delays, do not let the analog input exceed the input voltage range.

Highest total system speeds will be achieved if the FIFO is block transferred using DMA or the REP INS instruction in a loop with the CX register controlling the count of samples transferred.

**Scan:**

A group of channels sampled together with equal delays between each A/D sample, set by the A/D start clock. A scan is 16S or 8D channels or less. A scan uses sequential channel addressing.

**Frame:**

One or more channels sampled together at each trigger with equal delays between each A/D sample, set by the A/D start clock. Each frame is started by one trigger. Either single channel or autosequential scan addressing may be used. A frame may consist of several contiguous scans with wrap around addressing. Frames are stopped when the counter 0 Acquire bit is reset to zero.

**PROGRAMMING**

(Refer to the PC-411 user manual for detailed programming information.)

The BASE address may be selected anywhere up to 3F0h on 16-byte boundaries. At power up or PC bus reset, all registers contain zeroes except the FIFO HF and FF bits. When setting one bit in a write only register, remember to select all other bits according to the desired code. A shadow register should be considered to store the last value written. The registers may be programmed in any sequence as long as the command register is last. "x" bits are don't care or not used.

**I/O REGISTER MAPPING**

I/O Address (Hex)	Direction	Description
BASE + 0	Write	Command Register
BASE + 0	Read	Status Register
BASE + 1	Write	Channel Address Register
BASE + 1	Read	FIFO A/D Data Register
BASE + 2	Write	Interrupt/DMA Register
BASE + 2	Read	FIFO Reset Register
BASE + 3	Write	Digital Output Port
BASE + 3	Read	Digital Input Port
BASE + 4	Read/Write	Counter #0 (82C54)
BASE + 5	Read/Write	Counter #1 (82C54)
BASE + 6	Read/Write	Counter #2 (82C54)
BASE + 7	Read/Write	Control Word (82C54)
BASE + 8	Write	DAC 0 low byte
BASE + 9	Write	DAC 0 high byte
BASE + 10	Write	DAC 1 low byte
BASE + 11	Write	DAC 1 high byte
BASE + 12	Write	DAC 2 low byte
BASE + 13	Write	DAC 2 high byte
BASE + 14	Write	DAC 3 low byte
BASE + 15	Write	DAC 3 high byte

APPENDIX F: COST DATA

D-3751  
(Kubitschek)

D-3751

Memorandum

To: Regional Director, Sacramento CA  
Attention: MP-400

From: Chief, Hydraulics Branch

Subject: Cost Estimate for the Purchase, Design, Fabrication, Installation, and Calibration of all Instrumentation and Hardware for the Tracy Fish Collection Facilities (Hydraulic Research)

As a followup to our memorandum and report dated November 6, 1992, and recent discussions between Gary Sackett (MP-400) and Perry Johnson of my staff, we provide the following cost estimate for the full instrumentation package to be installed at the Tracy Fish Collection Facilities:

Instrumentation cost . . . . .	\$ 82,000.00
Installation development costs	
30 staff-days @ \$500/SD . . . . .	\$ 15,000.00
Travel costs . . . . .	\$ 2,500.00
Fabrication and installation costs	
80 staff-days @ \$250/SD . . . . .	\$ 20,000.00
Calibration costs	
10 staff-days @ \$300/SD . . . . .	<u>\$ 3,000.00</u>
Total cost . . . . .	\$122,500.00

This estimate is based on the full package option as discussed in the preliminary report "Tracy Fish Collection Facilities (TFCF) Instrumentation Selection Recommendations" by J. Kubitschek, D-3751, and is a conservative cost estimate. Please contact Perry Johnson (303-236-6160) or Joe Kubitschek (303-236-6155) if you have further questions.

*Philip A. Burg*

cc: Regional Director, Sacramento CA, Attention: MP-780  
(Arthur), MP-200 (Eaton), MP-400 (Sackett)  
Project Superintendent, Byron CA, Attention: T-100 (Ing)

bc: D-3420, D-3423 (Beard), D-3740, D-3742 (Liston), D-3750,  
D-3751, D-3751 (Johnson), D-3751 (Kubitschek),

WBR:JKubitschek:flh:1/28/93:236-6155  
(c:\wp\d3751\tfcf.est)

BUREC1.XLS

Sep/15/92



**QUOTE**

Federal T.I.N. 91-0937015 DUNS 07-926-2200

DATE  
Sep/15/92

Terms: 2% 15, Net 30 Days  
Date to Ship: Within three weeks of order

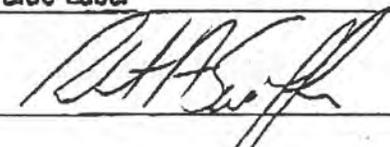
F.O.B.: Seattle

Bill To: Bureau of Reclamation  
P.O. Box 25007  
Denver Federal Center  
Denver, CO 80225-0002

Phone: (303) 236-7664  
Fax: (303) 236-6155

Ship To:  
Same

Quantity	Description	Price	Per	Extension
1	2100-LX, Open stream current velocity meter	1865.00	ea	\$1,865.00
	#1 of 2 @ 3 Lbs			
	#2 of 2 @ 9 Lbs			
1	SHIPPING	19.25		\$19.25
	UPS Blue Label			
			Sub Total:	\$1,884.25
			Total:	\$1,884.25

By: 

Date: 15 SEPT 92



ORE INTERNATIONAL, INC.  
ACCUSONIC DIVISION  
G.S.A. PRICE LIST  
MAY 1, 1990



***ORE International Inc.***

## INFORMATION FOR ORDERING ACTIVITIES

- |  |   |
|--|---|
| 1. AWARDED ITEMS--Special Item No. 505-17:               | Page  |
| Flowmeter Systems--7410                                  | 4   |
| Transducers  | 7   |
| Rack Enclosures  | 9   |
| Transducer Signal Cable                                  | 10  |
| Peripheral Items for Flowmeter                           | 11  |
| Control Computer--7432                                   | 12  |
| Spare Parts  | 13  |
|  |   |
| 2. Maximum Order Limitation:                             | \$250,000.  |
| 3. Minimum Order:  | 250.  |
| 4. Geographic coverage:                                  | United States and Puerto Rico   |
| 5. Point of Production:                                  | Falmouth, Barnstable County,<br>Massachusetts   |
| 6. Discount from List Prices:                            | A 6% discount will be applied<br>to all listed prices.                                  |
| 7. Quantity Discounts:                                   | None  |
| 8. Prompt Payment Terms:                                 | A 1% prompt payment discount<br>will be applied to all invoices<br>paid within 30 days. |
| 9a. Government Commercial Credit Cards are not accepted. |   |
| 9b. Government Commercial Credit Cards are not accepted. |   |
| 10. Foreign items:                                       | None  |
| 11. Time of Delivery:                                    | 90 days after receipt of order.   |
| 12. F.O.B. Points:                                       | Destination by standard<br>overland carrier.  |
| 13. Ordering Address:                                    | O.R.E. International, Inc.<br>Accusonic Division<br>P.O. Box 709<br>Falmouth, MA 02541  |
| 14. Payment Address:                                     | O.R.E. International, Inc.<br>Accusonic Division<br>P.O. Box 709<br>Falmouth, MA 02541  |

15. Warranty Provision:

O.R.E. International, Inc. warrants its products against defects in materials and workmanship for a period of one (1) year from the date of delivery. During this period, on satisfactory proof of such defects, any unit which becomes inoperative may be returned, prepaid, for repair or replacement at the option of O.R.E. International, Inc. FOR PARTS THAT ARE COVERED UNDER WARRANTY WHICH ARE RETURNED WITHIN THE FIRST 3 MONTHS OF THE WARRANTY PERIOD, O.R.E. INTERNATIONAL, INC., ACCUSONIC DIVISION, WILL PAY SHIPPING CHARGES BOTH WAYS. No returns will be accepted unless prior authorization has been received from Seller and an O.R.E. International, Inc. job number has been assigned.

This warranty applies only to the original purchaser and only if the equipment has been installed and operated in accordance with the published Operations and Service Manual, or in a manner approved by O.R.E. International, Inc. or its representatives.

No other warranty is express or implied and in no event shall O.R.E. International, Inc. be responsible for collateral or consequential damages.

16. Export Packing Charges: Standard commercial export packaging is included in prices listed herein.
17. Government Commercial Credit Cards are not accepted.
18. Rental, maintenance and repair of items are not included in this contract.
19. Installation services are not included in this contract.
20. Repair of items is not included in this contract.
21. Service and Distribution point: Not applicable.
22. There are no participating dealers.
23. Preventive Maintenance: Instructions contained in manuals provided with purchased equipment.

## ACCUSONIC PRICE LIST

### I. Model 7410 Flowmeter

1-4 Acoustic Paths, one 14-digit LED Display  
 one 8-digit LED Display, Keypad Parameter Entry,  
 Signal Quality Monitor, Self-test Feature. 13,500.

#### A. Enclosure

- |   |        |
|---|--------|
| 1. NEMA 4 Wall Mount Enclosure          | N/C    |
| 2. 19" Rack Mountable Chassis           | N/C    |
| 3. Portable Enclosure (Shock Resistant) | 2,500. |

#### B. Power Requirement

- |                                      |      |
|--------------------------------------|------|
| 1. 115 VAC $\pm 10\%$ 50/60 Hz Power | N/C  |
| 2. 220 VAC $\pm 10\%$ 50/60 Hz Power | N/C  |
| 3. 105 VAC $\pm 10\%$ 50/60 Hz Power | 200. |
| 4. 12 VDC Power                      | 750. |

#### C. Configuration

- |   |        |
|---|--------|
| 1. Dual Pipe Capability, includes 2 additional displays                                       | 3,500. |
| 2. 4-pipe (2 paths per pipe) capability, includes 2 additional displays (4 displays total)    | 5,000. |
| 3. 8-path Single Pipe Capability (cannot be ordered with Dual Pipe System)                    | 1,000. |
| 4. 4-path Open Channel Capability (includes acoustic stage capability--specify channel width) | 2,500. |
| 5. 8-path Open Channel Capability (includes acoustic stage capability--specify channel width) | 3,500. |
| 6. 4-path Compound Flowmeter (for pipes flowing partially to completely full)                 | 2,500. |
| 7. 8-path Compound Flowmeter (for pipes flowing partially to completely full)                 | 3,500. |
| 8. Multiplexing Capability (requires Model 7432 Control Computer)                             | 1,000. |
| 9. Specialized Software (e.g., dual direction totalizing, etc.)                               | TBQ*   |

#### D. Outputs

- |   |        |
|---|--------|
| 1. 2-channel RS-232 I/O   | 1,000. |
| 2. RS-232 Report Format Output (includes RS-232 output card and ports, calendar clock and software) | 2,500. |
| 3. 2-channel 4-20 mA Analog Output (outputs must be ordered in 2-channel increments)                | 750.   |
| 4. Alarm Contact Closure (each)   | 300.   |

- |  |        |
|--|--------|
| 5. Special Output (specialized outputs must be specified in detail prior to quotation) | TBQ*   |
| 6. Isolated 4-20mA output 2-channel  | 1,500. |

E. Other

- |  |      |
|--|------|
| 1. Additional 8-digit LED Display (each)                   | 500. |
| 2. Display Labeling  | 250. |
| 3. Thermostatically controlled Heater for NEMA 4 Enclosure | 500. |

\* Specialized Options may be available, but must be evaluated and quoted on an individual basis.

III. Transducers (All prices are each)--Specify number of paths and path angle when ordering.

A. Pipeline Transducers/Feedthroughs--Standard Installation

- |   |      |
|---|------|
| 1. Model 7625 Delrin /Lucite Fixed Window Transducer/Feedthrough Assembly (500 psi)         | 550. |
| 2. Model 7605 Stainless Steel/Lucite Fixed Window Transducer/Feedthrough Assembly (1000psi) | 850. |
| 3. Model 7601 Transducer  | 550. |
| 4. Model 7641 Feedthrough (450 psi)   | 550. |
| 5. Model 7642 Jacking Mechanism (1 required per site)                                       | 750. |
| 6. Model 7600 Transducer  | 800. |
| 7. Model 7660 Feedthrough (1500 psi)  | 950. |
| 8. Model 7661 Jacking Mechanism (1 required per site)                                       | 200. |

B. Pipeline Transducer/Feedthroughs--Outside access only (cold-tap) weld-on installation.

- |  |      |
|--|------|
| 1. Model 7600S Transducer  | 750. |
| 2. Model 7662 Weld-on Feedthrough (1500 psi) (Specify Pipe Wall Thickness) | 950. |
| 3. Model 7661 Jacking Mechanism (1 required per site)                      | 200. |

C. Pipeline Transducers--Hot-tap (150 psi maximum pressure\*\*)

- |  |        |
|--|--------|
| 1. Model 7600 Stainless Steel Hot-tap Transducer   | 800.   |
| 2. Model 7643 Stainless Steel Hot-tap Feedthrough (Specify Pipe Wall Thickness and Pressure) | 1,100. |
| 3. Model 7661 Jacking Mechanism (1 required per site)  | 200.   |
| 4. Hot-tap Tool Purchase   | 5,000. |

\*\* Higher pressures may be possible, but equipment must be quoted on an individual basis.

D. Pipeline Transducers for Spool Pieces (path angle not required)

- |  |      |
|--|------|
| 1. Model 7620 PVC Transducer (300 psi)   | 500. |
| 2. Model 7680 Stainless Steel Gate Valve | 500. |

E. Pipeline Transducers--Internal Mount

1. Model 7630 1 MHz Dual Element Internal Mount Transducer (for pipe less than 25-ft diameter)	800.
2. Model 7634 500 kHz Dual Element Internal Mount Transducer (for pipe over 25-ft diameter and dirty water applications)	800.
3. Model 7690 Base Plate Assembly	300.
4. Model 7691 4-wire Penetrator (1 required for every 2 transducers)	400.
5. 7691 8-wire Penetrator (1 required for every 4 transducers)	600.

F. Open Channel Transducers (path angle not required)

1. Model 7616 500 kHz Transducer--for Channels 3 to 30 feet wide* (Note: This type of transducer is sold in premanufactured arrays; channel dimensions must be specified when ordering).	250.
2. Model 7612 200 kHz Transducer--for Channels 10 to 300 feet wide* (includes 200-ft signal cable)	500.
3. Model 7611 100 kHz Transducer for Channels 100 to 1000 feet wide*	3,500.
4. Model 7652B 200 kHz Active Transducer (for use with Model 7300 AVM only)	750.
5. Model 7655B 500 kHz Active Transducer (for use with Model 7300 AVM only)	650.
6. Model 7651B 100 kHz Active Transducer (for use with Model 7300 AVM only)	3,750.
7. Model 7632 Up-looking Level Transducer	500.
8. Model 7692 Baseplate for Up-looking Level Transducer	500.

\* Width specifications are approximate; actual capabilities depend on specific installation characteristics.

IV. 19" Rack Enclosures for up to 4 Model 7410  
Flowmeter Chassis, 78" nominal height

- |  |        |
|--|--------|
| A. Model 7440 AMCO Enclosure--for clean environments   | 3,500. |
| 1. Fan and Filter  | 750.   |
| 2. Special Paint--Specify exact color, manufacturer and paint code (may increase delivery time)  | 900.   |
| B. Model 7441 Hoffman NEMA 12 Enclosure--dust tight, with gasketed front and rear doors. Standard front door includes window for viewing displays or CRT | 5,000. |
| 1. Drop down compartment on front door for keyboard (used with 7432 controller)  | 1,000. |
| 2. Fan and Filter  | 750.   |
| 3. Special Paint--Specify exact color, manufacturer and paint code (may increase delivery time)  | 900.   |

V. Transducer Signal Cable

- A. RG59 or RG62 without Connector--for Model 7605 and 7625 transducers or for other transducers when run between a junction box and the flowmeter console .30/ft
- B. RG59 or RG62 with E-O type Connector--for Model 7601 and 7600 Transducers .60/ft
- C. HDPE Jacketed RG59 with E-O type Connector--for use inside the pipe with Model 7630 and 7634 Transducers .85/ft
- D. HDPE Jacketed RG108--for use underwater with Model 7612 Transducers .75/ft
- E. RG108 for use out of the water with Model 7612 Transducers .50/ft
- F. RG111 A/U Armored Cable with Connector--for use with Model 7611 Transducer 3.50/ft

**VI. Peripheral Items for Flowmeter**

- |  |               |
|--|---------------|
| <b>A. 4-digit LED Remote Display Unit--Panel Mount</b>           | <b>700.</b>   |
| <b>B. 4-digit LED Remote Display Unit--Wall Mount</b>            | <b>1,200.</b> |
| <b>C. Down Looker Level Transducer--for open channel systems</b> | <b>3,500.</b> |

VII.	Model 7432 Control Computer with 20 MB Hard Disk Drive, CPU, Floppy Disk Drive (3 1/2" or 5 1/4"), Monitor, Keyboard, and Parallel Printer with stand	15,000.
A.	Multi-unit Flow Measurement Package-- includes: Software for Data Presentation, Data Storage, system parameter storage, and I/O capabilities	5,000.
B.	Multiplexing Package--includes: Software and I/O Capabilities for measuring flow in up to 16 pipes using 1 Model 7410 flowmeter	5,000.
	1. MUX Path Selector Unit--handles 8 paths each	2,500.
C.	Turbine Efficiency Measurement (TEM) Package-- includes: Site-specific Software and Required I/O Capability for Subsystem Interface	20,000.
	1. Heise Pressure Gage, Series 9	4,200.
	2. Druck Pressure Sensor	2,500.
	3. YEW Power Meter	12,000.
	4. Scientific Columbus Power Meter	3,200.
	5. Wicket Gate Position Indicator	1,100.
	6. Tubing, Cable, etc.	TBQ*
	7. Special Software (if required)	TBQ*

\* Quoted after review of project specifications

VIII. Model 7410 Flowmeter Spare Parts

<u>Part Name</u>	<u>Number</u>	<u>Price</u>
Transceiver	7400-10002	1,025.
Transmitter	7400-10003	700.
Dual Path Selector	7400-10004	1,325.
Path Selector Module	7400-10005	1,000.
Receiver	7400-10006	675.
Triple Power Supply	7400-10007	1,500.
Watchdog Timer	7400-10013	500.
16 Slot Cardfile	7400-10014	1,400.
CPU	7400-10015	1,350.
SIO	7400-10037	1,050.
TTL I/O	7400-10038	1,000.
8-digit Display	7400-10084	975.
Multilabel Driver	7400-10085	500.
14-digit Display	7400-10086	1,000.
Keypad Interrupt	7400-10094	700.
EPROM	7400-10096	975.
4K CMOS RAM	7400-10097	1,650.
Calendar Clock	7400-10101	1,250.
4 x 4 Keypad	7400-10103	500.
2 channel D/A, D/I	7400-10109	850.
Receiver Module	7400-10118	950.
Asblank	7400-10182	500.
DIAG 80	7400-10205	2,000.
Stage	7400-10209	550.

<u>Part Name</u>	<u>Number</u>	<u>Price</u>
NEMA Box Heater	7400-10241	975.
RTU-1	7400-10271	1,025.
Dual Contact Closure	7400-10367	500.

# DISCO ASSOCIATES, INC.

DIVERSIFIED INDUSTRIAL SALES

1476 Major Street  
Salt Lake City, Utah 84115  
(801) 487-7522  
FAX: (801) 466-3238

4105 East Florida Ave. #206  
Denver, Colorado 80222  
(303) 757-1366  
FAX: (303) 692-9049

SEP 15 9 41 AM '92

DISCO QUOTATION NO DAI#3246	
DATE 9-8-92	Page 1 of 1
TERMS Net 30 days	
EST. SHIP DATE 4-6 Weeks A.R.O.	
F.O.B.: Hauppauge NY	

TO: ATTN: JOE KUBITSCHKEK  
BUREAU OF RECLAMATION  
D3751  
PO BOX 25007  
DENVER CO 80225-0007

RE: SYSTEM 990 UNIFLOW  
CLAMP-ON ULTRASONIC FLOWMETER

### WE ARE PLEASED TO QUOTE THE FOLLOWING:

CONTROLOTRON -

- #994N5DS3 - SINGLE CHANNEL DIGITAL DISPLAY  
NEMA 4, FLOW COMPUTER.....\$3,075.00 EA.
- #991NMS3 - TRANSDUCER, NEMA 4.....\$ 880.00 EA.
- #992MTNHMA3 - MOUNTING TRACKS, NEMA 4 HYBRID.....\$ 365.00 EA.
- #992CNLSL - TRANSDUCER CABLE SET.....\$ 50.00 EA.  
OVER 20', ADD \$1.50/FT.
- #995T - HANDHELD CONTROL/DISPLAY UNIT.....\$ 395.00 EA.
- #994-7 - ANALOG DATA COMPUTER FOR 4-20MA OUTPUT.....\$ 225.00 EA.
- TOTAL PRICE.....\$4,990.00

Prices firm for thirty days. All stenographic or clerical errors or omissions are subject to corrections.

SUSAN BURTON/WILLIS BROOKS  
DISCO ASSOC. INC.

# ORDERING INFORMATION / USA DataSonde® I

**DataSonde 2000 Series** systems consist of **two** basic elements which, when combined with an **RS232 compatible** data terminal or printer, provide the user with a completely automated, **off-line**, submersible water quality datalogger.

- 1) **2000 Series DataSonde** (submersible water quality datalogger)
- 2) **5200-20XX DMU** (data management unit)

**DataSonde** Submersible Dataloggers should be selected according to a desired combination of water quality parameters which include: **temperature (T)**, **conductivity/salinity (C/S)**, **pH (pH)**, **true dissolved oxygen (TDO)**, and **REDOX (R)**. A **special** pH reference electrode (**LISREF**) should be specified for use in solutions with conductivities <0.2 mmho/cm. A **FLOW CELL** is available for **pumped-flow** applications. The **FLOW CELL** is a sealed chamber with inlet & outlet ports for

connecting pumped sample lines.

The instruments are tested, calibrated, and programmed in the office or laboratory, then deployed or installed at one or more remote locations. Please refer to the DataSonde brochure for information concerning data capacity and programming options.

The **5200-20XX DMU** is the means by which a DataSonde instrument is connected to a data terminal for programming or data retrieval. Dual **RS232-C** I/O ports allow connection also to a modem or computer for permanent data storage or additional processing. The DMU normally will remain in the laboratory or office but may, under certain circumstances, be used in the field. An **IBM PC INTERFACE KIT** is available to easily connect the DMU to any IBM PC, AT, XT or "Compatible." IBM PC, AT, XT are registered trademarks of International Business Machines.

MODEL	DESCRIPTION	QNTY.	PRICE	EXTENDED
2001-DS	DataSonde Submersible Datalogger (T) . . .		\$1,700.	
2010-DS	DataSonde Submersible Datalogger (T, C) . . .		2,350.	
2020-DS	DataSonde Submersible Datalogger (T, C, pH) . . .		2,950.	
2030-DS	DataSonde Submersible Datalogger (T, C, pH, TDO) . . .		3,450.	
2040-DS	DataSonde Submersible Datalogger (T, C, TDO) . . .		2,900.	
2070-DS	DataSonde Submersible Datalogger (T, C, TDO, pH, R) . . . (each includes calibration/maintenance kit)		3,600.	
LISREF	LOW IONIC STRENGTH REFERENCE ELECTRODE . . . (for solution conductivities <0.2 mmho/cm)		600.	
8400-020	FLOW CELL . . .		240.	
5200-20XX	DMU (Data Management Unit) . . . (with dual-RS232 I/O ports, includes: power supply, data-recovery cable, & operating/service manual)		2,100.	
IBMPCIK	IBM PC INTERFACE KIT . . . (includes RS232 I/O card, interface-cable & terminal emulator program)  <b>Note:</b> For connection to other Data-Terminals, Printers, or Computers, please consult the Hydrolab sales office.		340.	
			TOTAL	\$ _____

**Please note:** Prices and specifications are subject to change without notice. Prices are valid in U.S. only, F.O.B. Contiguous U.S. Destination.



**HYDROLAB® CORPORATION**  
P.O. Box 50116 / Austin, TX 78763  
Telephone (512) 255-8841  
Telex II 910-874-1335 Hydrolab Aus



# DIANACHART INC

101 ROUND HILL DRIVE • ROCKAWAY, N.J. 07866 • TELEPHONE (201) 625-2299 • FAX (201) 625-2449

Bureau of Reclamation  
P.O. Box 25007  
Denver Federal Center  
Denver, CO 80225-0007

MAIL STOP: D3751  
ATTN: Joe Kubitschek

DATE: September 14, 1992  
RE: Telephone Call

## QUOTATION

QTY	DESCRIPTION	ORDER CODE	UNIT PRICE
	THE FOLLOWING PRODUCTS ARE RECOMMENDED TO SATISFY YOUR REQUIREMENTS:		
1	SYS-1 COMPLETE DATA ACQUISITION SYSTEM- Includes a 14 channel PROCESS-ACQ Data acquisition system with menu driven software (-MS), signal conditioning (-SC), printer driver (-PD), real-time graphics (-RTG), and multi-tasking (-MT386). Features a 386SX with 2Mb memory, and 42 Mega Byte Hard Disk, complete with software (MS-DOS and Basic word processing) and a 120 CPS printer with near letter quality print.	SYS-1	\$6745

### Standard Terms:

Availability: 6-8 Weeks

For guaranteed 5 working day shipment, ARO, add 10% to order total. (Standard Products Only)

F.O.B. Rockaway, N.J.

Net 20 Days

Quote is valid for 30 days.

Russ Graybill

APPENDIX G: TRACY PROJECTS OFFICE MAINTENANCE SCHEDULE FY9322



# United States Department of the Interior

## BUREAU OF RECLAMATION

Mid-Pacific Region  
Tracy Office (CVP)  
Route 1 Box 35

Byron, California 94514-9614



IN REPLY  
REFER TO:

TO-600  
PRJ-20.00

JUL 24 1992

### Memorandum

To: Regional Director, Sacramento  
Attention: MP-2800

From: Project Superintendent, Tracy

Subject: Annual Equipment Maintenance Schedule -- Calendar Year 1993  
(Power Operation and Maintenance)

Enclosed is the Tracy Office (CVP) proposed schedule for calendar year 1993.

If you have any questions or additional information is desired, please contact  
Chuck Neese of my staff at (209) 836-6254.

### Enclosure

cc: MP-460

TO-100, TO-110, TO-400, TO-500, TO-510, TO-600, TO-660  
TO-661, TO-662, TO-663, TO-670, TO-671, TO-672

1993 Tracy Office Maintenance Outage Schedule

DATE	UNIT
1. May 3, 1993 - July 2, 1993	Tracy Pumping Plant. One unit impeller replacement, One additional unit out for annual maintenance of unit, breaker, and station service. A total of two units at a time out throughout the entire period.
2. March 15, 1993 - October 15, 1993	O'Neill Pumping/Generation Plant. Unit annual maintenance. One unit at a time unless manpower and/or pumping schedule permits an additional unit outage.
3. July 20, 1993 - July 22, 1993	O'Neill Pump/Generation Plant. Entire plant outage to perform annual maintenance on main transformers, station service and WAPA equipment.
4. October 4, 1993 - December 17, 1993	New Melones Generation Plant. One unit at a time to perform annual maintenance.

10-5-92

Perry :

Attached is our major maintenance projects for FY 1993. As discussed during our meeting of Sep. 30, 1992, our ability to install equipment will be dependent upon when you want it done.

Herb

