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

By: Joseph Kubitschek, D-3751
Mechanical Engineer
Date: 27 January 1993
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.

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)

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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.E1.) - W.S.E1. 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 louveres, and thus could be used to automate cleaning procedures. The critical locations for monitoring W.S.E1. 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.E1.

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:
• 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.

<table>
<thead>
<tr>
<th>Application</th>
<th>Instrumentation</th>
<th>Quantity required</th>
<th>Cost each</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring W.S.E1.</td>
<td>Ultrasonic</td>
<td>3</td>
<td>$1,207.00</td>
<td>$3,621.00</td>
</tr>
<tr>
<td>Monitoring velocity</td>
<td>Velocity meters</td>
<td>1</td>
<td>$1,865.00</td>
<td>$1,865.00</td>
</tr>
<tr>
<td>Monitoring water quality</td>
<td>T, C, DO, pH</td>
<td>2</td>
<td>$3,450.00</td>
<td>$6,900.00</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Application</th>
<th>Instrumentation</th>
<th>Quantity required</th>
<th>Cost each</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring W.S.E1.</td>
<td>Ultrasonic</td>
<td>9</td>
<td>$1,207.00</td>
<td>$10,863.00</td>
</tr>
<tr>
<td>Monitoring velocity</td>
<td>Velocity meter</td>
<td>3</td>
<td>$1,865.00</td>
<td>$5,595.00</td>
</tr>
<tr>
<td>Monitoring open-channel flowrates</td>
<td>Magmeter</td>
<td>2</td>
<td>$3,150.00</td>
<td>$6,300.00</td>
</tr>
<tr>
<td>Monitoring water quality</td>
<td>T, C, DO, pH sensor</td>
<td>2</td>
<td>$3,450.00</td>
<td>$6,900.00</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Application</th>
<th>Instrumentation</th>
<th>Quantity required</th>
<th>Cost each</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monitoring W.S.E1.</td>
<td>Ultrasonic</td>
<td>8</td>
<td>$1,207.00</td>
<td>$9,656.00</td>
</tr>
<tr>
<td>Monitoring velocity</td>
<td>Velocity meter</td>
<td>12</td>
<td>$1,865.00</td>
<td>$22,380.00</td>
</tr>
<tr>
<td>Monitoring closed-conduit flowrates</td>
<td>Ultrasonic clamp-on</td>
<td>4</td>
<td>$1,985.00</td>
<td>$7,940.00</td>
</tr>
<tr>
<td>Monitoring open-channel flowrates</td>
<td>Ultrasonic</td>
<td>2</td>
<td>$13,500.00</td>
<td>$27,000.00</td>
</tr>
<tr>
<td>Monitoring water quality</td>
<td>T, C, DO, pH sensor</td>
<td>2</td>
<td>$3,450.00</td>
<td>$6,900.00</td>
</tr>
<tr>
<td>Data logging</td>
<td>DAS</td>
<td>1</td>
<td>$6,745.00</td>
<td>$6,745.00</td>
</tr>
</tbody>
</table>

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:

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

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
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.E1. 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

   - 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
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, whereas 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

   • 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

   - 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 flow rates will require velocity and W.S.E.1. 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
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


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


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


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 Belmount 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


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


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

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: ±1%
- Resolution: .007"
- Beamwidth: 12°
- Temp.: 0-70°C
- Humidity: 5-95%RH, non-condensing

CONTAQ TECHNOLOGIES CORPORATION 15 MAIN STREET BRISTOL, VERMONT 05443 (802) 453-3332
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" - opens relay if control has been disabled.
"C" - closes relay if control has been disabled.
"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" - 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.
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

CONTAQ TECHNOLOGIES CORPORATION 15 MAIN STREET BRISTOL, VERMONT 05443 (802) 453-3332
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.
**Submersible Depth Transmitter II Specifications**

**Power:**
12.5-35 VDC

**Output:**
4-20 mA current signal, linearly corresponding to range

**Operating temperature:**
+1 to 50° C (33 to 122° F)
NOTE: SDT-II should not be subjected to freezing water conditions

**Media:**
Any media compatible with 316 stainless steel, PVC, nylon, and polyurethane

**Accuracy:**
- 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

**Options:**
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** | **Range (meters at sea level)** | **Max. Depth (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.

---

**STEVEN'S 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

STEVEN'S is a Registered Trademark of Leupold & Stevens, Inc.
Leupold & Stevens reserves the right to alter specifications and features of the products shown in this bulletin without prior notice.

SDT-II - Page 2
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.
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 a position 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 totaling 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 proportional 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.

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

STEVENS is a Registered Trademark of Leupold & Stevens, Inc.
Leupold & Stevens reserves the right to alter specifications and features of the products shown in this bulletin without prior notice.

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 (0 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

STEVENS Remote Total Flow Meter - Page 2
STEVENS Submersible Depth Transmitter II (SDT-II)

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:

<table>
<thead>
<tr>
<th>P/N #</th>
<th>Model #</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>45551</td>
<td>SDT-II 2.5</td>
<td>2.5 ft. water</td>
</tr>
<tr>
<td>45552</td>
<td>SDT-II 5.0</td>
<td>5.0 ft. water</td>
</tr>
<tr>
<td>45553</td>
<td>SDT-II 10</td>
<td>10 ft. water</td>
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<td>45558</td>
<td>SDT-II 75</td>
<td>75 ft. water</td>
</tr>
<tr>
<td>45559</td>
<td>SDT-II 100</td>
<td>100 ft. water</td>
</tr>
</tbody>
</table>

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

ACCESSORIES

- Downhole Kit (P/N 45694) $95.00
- Tank Adapter Kit (P/N 45695) $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
SMALL BORE DEPTH TRANSMITTER

- High accuracy
  ±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
  ±0.3% total error band 30° to 85°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 (34.8 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.

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

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

Please refer to manufacturer.

Zero offset

±0.5% FSO set @ 68°F (20°C)

Sensitivity setting

±0.5% of reading, set @ 68°F (20°C)

Operating temperature range

-5° to +140°F (-20° to +60°C)

Temperature effects

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

±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

For other supply voltages please refer to manufacturer.

Electrical Connection - Cable

3 ft. cable supplied as standard. This is molded to transmitter body with polyurethane to provide water tight 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 #29/12500 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 (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

PTX 161/D
Technical Specifications — Level Measurement

FTU 5060
Ultrasonic Open Channel Flow Transmitter With DU 200 Series Sensors
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.
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 ± 0.08 inch (± 2 mm). This translates into an overall accuracy of better than ± 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 measuring system. For example, the uncertainty of a properly constructed and installed Parshall or Palmer Bowlus type flume is about ± 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.

<table>
<thead>
<tr>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min Range</td>
<td>Beam Spread (A2)</td>
</tr>
<tr>
<td>DU217</td>
<td>36°</td>
</tr>
<tr>
<td>DU218</td>
<td>36°</td>
</tr>
</tbody>
</table>

* Minimum range is the blocking distance plus the minimum span.
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: ± 0.08" (± 2 mm) of level. ± 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 retable LCD, programmable scale factor, with 8 year lithium battery backup.

Minimum Span: 10 inches to maintain the accuracy of ±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.

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.

<table>
<thead>
<tr>
<th>Sensor Specifications</th>
<th>DU 217</th>
<th>DU 218</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum Range, Liquids:</td>
<td>8 feet</td>
<td>16 feet</td>
</tr>
<tr>
<td>Maximum span</td>
<td>6.3 feet</td>
<td>13.8 feet</td>
</tr>
<tr>
<td>Beam Angle:</td>
<td>7&quot;</td>
<td>7&quot;</td>
</tr>
<tr>
<td>Operating Frequency:</td>
<td>46.6 kHz</td>
<td>46.6 kHz</td>
</tr>
<tr>
<td>Sample Rate:</td>
<td>2 Hz at 60°C</td>
<td>2 Hz at 60°C</td>
</tr>
<tr>
<td>(temp. dependent)</td>
<td>4 Hz at -20°C</td>
<td>4 Hz at -20°C</td>
</tr>
<tr>
<td>Blocking Distance:</td>
<td>20&quot;</td>
<td>26&quot;</td>
</tr>
<tr>
<td>Mounting:</td>
<td>1&quot; BSP straight thread with mounting nut for clearance hole mounting.</td>
<td>1&quot; BSP straight thread with mounting nut for clearance hole mounting.</td>
</tr>
<tr>
<td>Electronics Housing:</td>
<td>Heavy polypropylene and polycarbonate</td>
<td>Heavy polypropylene and polycarbonate</td>
</tr>
<tr>
<td>Operating Pressure:</td>
<td>7 psig maximum</td>
<td>7 psig maximum</td>
</tr>
<tr>
<td>Standard Operating Temperature:</td>
<td>-4°F to +140°F (-20°C to +60°C)</td>
<td>-4°F to +140°F (-20°C to +60°C)</td>
</tr>
<tr>
<td>Temp. Compensation:</td>
<td>100 Ohm platinum RTD</td>
<td>100 Ohm platinum RTD</td>
</tr>
<tr>
<td>Weight:</td>
<td>3.2 lbs.</td>
<td>3 lbs.</td>
</tr>
<tr>
<td>Enclosure Rating:</td>
<td>NEMA 4X and NEMA 6 submersible</td>
<td>NEMA 4X and NEMA 6 submersible</td>
</tr>
<tr>
<td>Sensor Cable:</td>
<td>10 foot pigtail standard, 2-conductor cable, sealed in sensor.</td>
<td>10 foot pigtail standard, 2-conductor cable, sealed in sensor.</td>
</tr>
</tbody>
</table>

*To maintain an accuracy of ±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.
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

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

**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 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 operation 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.

**Part number construction**

- **Integrally Mounted Electronics**
- **Housing**
- **Input Voltage**
- **Output (4-20mA)**
- **Sensor Material & Length**

**Part number construction**

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.

**Part number construction**

1. **Housing**
   - **Cover Description**: NEMA 4
   - **Code**: 5
   - **Cover Description**: Transparent Lexan®
   - **Code**: 6
   - **Cover Description**: NEMA 7/9 Epoxy Coated Cast Aluminum
   - **Code**: 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**: 120 VAC
   - **Code**: 0
   - **Description**: 240 VAC
   - **Code**: 1

3. **Sensor material & length**
   - **Description**: CPVC w/6" (152 mm) length
   - **Code**: A
   - **Description**: CPVC w/10" (254 mm) length
   - **Code**: B

**Dimensional specifications - Inches (mm)**

![Dimensional specifications diagram](image)
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.

Electronics part number construction

Remote Mounted Electronics

Housing

Input voltage

Output (4-20mA)

1 Housing

<table>
<thead>
<tr>
<th>Class</th>
<th>Cover Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEMA 4</td>
<td>Black Painted Steel</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Transparent Lexan®</td>
<td>6</td>
</tr>
<tr>
<td>NEMA 7/9</td>
<td>Epoxy Coated Cast Aluminum</td>
<td>8</td>
</tr>
</tbody>
</table>

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

Lexan® is a registered trademark of General Electric.

2 Input voltage

<table>
<thead>
<tr>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>120 VAC</td>
<td>0</td>
</tr>
<tr>
<td>240 VAC</td>
<td>1</td>
</tr>
</tbody>
</table>

Sensor part number construction

Example:

395 - [Sensor] [Sensor Mounting Bracket] [Sensor Length]

3 Sensor

<table>
<thead>
<tr>
<th>Sensor Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPVC with 3/4&quot; NPT, 20 ft. of cable (6 M)</td>
<td>1CO</td>
</tr>
<tr>
<td>CPVC with 3/4&quot; NPT w/Sensor Housing</td>
<td>1C1</td>
</tr>
<tr>
<td>CPVC with 2&quot; NPT, 20 ft. of cable (6 M)</td>
<td>5CO</td>
</tr>
<tr>
<td>CPVC with 2&quot; NPT w/Sensor Housing</td>
<td>5C1</td>
</tr>
</tbody>
</table>

1 Sensor with sensor housing (1C1, 5C1), order connecting cable below.

4 Sensor mounting bracket

<table>
<thead>
<tr>
<th>Description</th>
<th>Use with Sensor Code</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>1CO, 1C1, 5CO, or 5C1</td>
<td>3</td>
</tr>
<tr>
<td>Wall Mount 3/4&quot; NPT</td>
<td>1C1 or 1C1</td>
<td>1</td>
</tr>
<tr>
<td>Floor Mount 3/4&quot; NPT</td>
<td>1C1 or 1C1</td>
<td>2</td>
</tr>
<tr>
<td>Wall Mount 2&quot; NPT</td>
<td>5C1 or 5C1</td>
<td>3</td>
</tr>
<tr>
<td>Floor Mount 2&quot; NPT</td>
<td>5C1 or 5C1</td>
<td>4</td>
</tr>
</tbody>
</table>

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

5 Sensor length

<table>
<thead>
<tr>
<th>Description</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>6&quot; length (152 mm)</td>
<td>006</td>
</tr>
<tr>
<td>10&quot; length (254 mm)</td>
<td>010</td>
</tr>
</tbody>
</table>

Connecting Cable part number construction

037-3170 - [Sensor Code]

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)

351 NEMA 4 Electronics Housing

351 NEMA 7/9 Electronics Housing

351 Sensor w/NEMA 7/9 Housing

351 Sensors w/o Housing

Cable length in feet

10 ft. (3 Meters) minimum, 100 ft. (30 Meters) maximum length

Example: 12 ft. cable length = 037-3170-012.
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

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

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

<table>
<thead>
<tr>
<th>Agency</th>
<th>Model No.</th>
<th>Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSA</td>
<td>350-50X1-05X</td>
<td>Non Hazardous environments w/ CAN 350-80X1-05X Enc. 4 exc. Lexan cover</td>
</tr>
<tr>
<td></td>
<td>350-80X1-05X</td>
<td></td>
</tr>
</tbody>
</table>

Series 351 Agency Approvals

<table>
<thead>
<tr>
<th>Agency</th>
<th>Model No.</th>
<th>Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSA</td>
<td>351-50X1-00X</td>
<td>Non Hazardous environments w/ CAN 351-80X1-00X Enc. 4 exc. Lexan cover</td>
</tr>
<tr>
<td></td>
<td>351-80X1-00X</td>
<td></td>
</tr>
<tr>
<td>FM</td>
<td>351-60X1-00X</td>
<td>Non Hazardous environments w/ CAN 351-80X1-00X NEMA 4 enclosures exc. blk steel cover</td>
</tr>
<tr>
<td></td>
<td>351-80X1-00X</td>
<td></td>
</tr>
</tbody>
</table>

Lexan is a registered trademark of General Electric

Printed circuit board/user keypad

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

Performance Specifications

Output
4 to 20 mAac

Supply Voltage
24 Vdc nominal, 100 Vdc max.

Ambient Temperature
-40°F to 160°F

Max. Load Resistance
*Vs - 13 (i.e. max 550 Ω @ 24 Vdc) .02

Span
2 inches to 20 feet

Output Isolation
Min. 4000 V signal wires to sensor

Response Time
20 Milliseconds

0-30 seconds adjustable, (optional)

Supply Voltage Error
± 0.2% max per 10 V change

Accuracy
± 1% nominal

Load Regulation
0.1% for zero to max load resistance

Max. Cable Length
100 feet (25 feet std)

Allowable Static Discharge to Sensor
2 amper max (Std)

0.00 amps with optional protection circuit

Sensing Element Connection
3/4” NPT (Std)

Flange mounting (optional)

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

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

Approvals Available
FM (standard)

CSA, BASEEFA (optional)

Model # 508-25-9
Continuous Level Transmitter

Typical Applications:
- Cooling Towers
- Water
- Organic Acids

Do not use with:
- Hydrofluoric Acid
- Styrene Monomer
- Butylylene Monomer

Pressure and Temperature Limits:
1000 psi @ 100°F
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

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.

Performance Specifications

Output
4 to 20 mAac

Supply Voltage
24 Vdc nominal, 100 Vdc max.

Ambient Temperature
-40°F to 160°F

Max. Load Resistance
*Vs - 13 (i.e. max 550 Ω @ 24 Vdc) .02

Span
2 inches to 20 feet

Output Isolation
Min. 4000 V signal wires to sensor

Response Time
20 Milliseconds

0-30 seconds adjustable, (optional)

Supply Voltage Error
± 0.2% max per 10 V change

Accuracy
± 1% nominal

Load Regulation
0.1% for zero to max load resistance

Max. Cable Length
100 feet (25 feet std)

Allowable Static Discharge to Sensor
2 amper max (Std)

0.00 amps with optional protection circuit

Sensing Element Connection
3/4” NPT (Std)

Flange mounting (optional)

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

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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

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1000 psi @ 100°F
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
- 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 Level 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'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.
- Pulsatell 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).

Applications

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

- 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.

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 capacitance 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 frequency. 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).

```
82-5 000 - 3 1
```

1. Input Power
   - Description: 120 VAC
   - Code: 0
   - Description: 240 VAC
   - Code: 1
   - Description: 24 VDC
   - Code: 2

2. Meter
   - Description: Analog Meter
   - Code: 1
   - Description: Digital Meter
   - Code: 2

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

4. Relays
   - Description: None
   - Code: 0
   - Description: 3 DPDT 10 amp relays
   - Code: 3

Electrical specifications

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

Agency approvals

<table>
<thead>
<tr>
<th>Agency</th>
<th>Model No.</th>
<th>Approval</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSA</td>
<td>All Models</td>
<td>CSA Enc. 4 Non-Hazardous environments</td>
</tr>
<tr>
<td>FM</td>
<td>All Models</td>
<td>NEMA 4 Enc. Non-Hazardous environments</td>
</tr>
</tbody>
</table>

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 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.

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.
**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**

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Seal</th>
<th>Nut</th>
<th>Insulation</th>
<th>Cable O.D.</th>
<th>Overall O.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5101</td>
<td>Halar® (ECTFE)</td>
<td>316 SS Nut</td>
<td>Halar® (ECTFE)</td>
<td>.1250</td>
<td>.1875</td>
</tr>
<tr>
<td>5102</td>
<td>Halar® (ECTFE)</td>
<td>316 SS Nut</td>
<td>Halar® (ECTFE)</td>
<td>.1250</td>
<td>.2500</td>
</tr>
</tbody>
</table>

**Flexible probes**

<table>
<thead>
<tr>
<th>Part No.</th>
<th>Seal</th>
<th>Nut</th>
<th>Insulation</th>
<th>Cable O.D.</th>
<th>Overall O.D.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5103</td>
<td>PVC</td>
<td>CPVC</td>
<td>PVC</td>
<td>.1250</td>
<td>2500</td>
</tr>
<tr>
<td>5105</td>
<td>Ceramic</td>
<td>316 SS</td>
<td>None</td>
<td>.1875</td>
<td>.1875</td>
</tr>
</tbody>
</table>

Halar® is a registered trademark of Ausimont. Kynar® is a registered trademark of Pennwalt. The complete level specialist
**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 comprised 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.

**Part number construction**

**Example:** 41- XXXXX-025

1. Kotron Sensing Probe
2. Probe Configuration
3. Probe Insertion Length

**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 6 inches order 41-XXXX-006.

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

**Rigid Probe configurations**

<table>
<thead>
<tr>
<th>Probe Part No.</th>
<th>Application</th>
<th>Material</th>
<th>Probe Dia.</th>
<th>Probe Pressure/Temperature Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>41-5001</td>
<td>Conductive or non-conductive liquids and bulk materials under 40 lb/cu. ft., 48” max. length</td>
<td>TFE</td>
<td>316 SS</td>
<td>375</td>
</tr>
<tr>
<td>41-5002</td>
<td>Conductive or non-conductive liquids and bulk materials under 40 lb/cu. ft., 1/2” 316 SS inactive sheath, 6” sheath standard, 48” max. length (7” min. insertion length)</td>
<td>TFE</td>
<td>316 SS</td>
<td>375</td>
</tr>
<tr>
<td>41-5005</td>
<td>6” bare rod, high temp./high pressure, ceramic seal</td>
<td>316 SS</td>
<td>316 SS</td>
<td>375</td>
</tr>
<tr>
<td>41-5017</td>
<td>Conductive or non-conductive liquids and bulk materials over 40 lb/cu. ft., ESP to 98”</td>
<td>TFE</td>
<td>316 SS</td>
<td>625</td>
</tr>
<tr>
<td>41-5021</td>
<td>Corrosive liquids or Kynar/PVDF reqmt., 120” max. gpm</td>
<td>Kynar</td>
<td>625</td>
<td>100 PSI @ 160°F</td>
</tr>
<tr>
<td>41-5023</td>
<td>Corrosive liquids or PVDF, 60” max. length</td>
<td>PVC</td>
<td>625</td>
<td>100 PSI @ 160°F</td>
</tr>
<tr>
<td>41-5027</td>
<td>For low dielectric fluids/signal compensation on horizontal tanks/turbulent surface/free flow liquid only, stainless steel</td>
<td>Red—TFE Well—316 SS</td>
<td>316 SS</td>
<td>375</td>
</tr>
<tr>
<td>41-5029</td>
<td>Clean, conductive, non-viscous liquids with 316 SS ground wire</td>
<td>TFE</td>
<td>625</td>
<td>1000 PSI @ 70°F</td>
</tr>
<tr>
<td>41-5030</td>
<td>Clean, conductive, non-viscous liquids with 316 SS ground wire, 48” maximum length</td>
<td>TFE</td>
<td>375</td>
<td>1000 PSI @ 70°F</td>
</tr>
</tbody>
</table>

1. Consult the factory for horizontal mounting of bare probes.
2. Temperature at electronics should not exceed +160°F. Probe pressure/temperature 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.

**Expedite shipment**

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.

**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.
<table>
<thead>
<tr>
<th>Probe Part No.</th>
<th>Application</th>
<th>Material</th>
<th>Nut</th>
<th>Probe Dia.</th>
<th>Inches</th>
<th>Probe Pressure/Temperature Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>41-5032</td>
<td>Conductive or non-conductive liquids and bulk materials under 40 lb/cu. ft., w/90° bend, 1&quot; radius, 46&quot; max. length</td>
<td>TFE</td>
<td>316 SS</td>
<td>375</td>
<td>1000 PSI @ 70°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5035</td>
<td>Conductive or non-conductive liquids and bulk materials over 40 lb/cu. ft., w/90° bend, 2.5&quot; radius, 110&quot; max. length</td>
<td>TFE</td>
<td>316 SS</td>
<td>625</td>
<td>1000 PSI @ 70°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5036</td>
<td>High temp./high pressure liquids w/90° bend, 2.5&quot; radius, 110&quot; max. length</td>
<td>316 SS</td>
<td>316 SS</td>
<td>500</td>
<td>5000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5038</td>
<td>High temp./high pressure liquids</td>
<td>316 SS</td>
<td>316 SS</td>
<td>375</td>
<td>1000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5039</td>
<td>For low dielectric fluids/signal compensation on horizontal tanks/turbulent surface/free flow liquid only with stilling well</td>
<td>Rod—304 SS Well—304 SS</td>
<td>316 SS</td>
<td>875</td>
<td>5000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5041</td>
<td>Corrosive liquids or polypropylene requirement</td>
<td>Polypropylene</td>
<td>316 SS</td>
<td>625</td>
<td>1000 PSI @ 160°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5042</td>
<td>Conductive or non-conductive liquids and bulk materials over 40 lb/cu. ft. w/316 SS inactive sheath, 6&quot; sheath standard (7&quot; min. insertion length)</td>
<td>TFE</td>
<td>316 SS</td>
<td>375</td>
<td>1000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5045</td>
<td>High temp./high pressure w/6&quot; dia. proximity plate, 48&quot; max. length</td>
<td>316 SS</td>
<td>316 SS</td>
<td>375</td>
<td>1000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5047</td>
<td>High temp./high pressure low dielectric liquids w/stilling well</td>
<td>Rod—316 SS Well—316 SS</td>
<td>316 SS</td>
<td>875</td>
<td>5000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5051</td>
<td>High temp./high pressure liquids w/10&quot; heat extension</td>
<td>316 SS</td>
<td>316 SS</td>
<td>500</td>
<td>5000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5052</td>
<td>High temp./high pressure liquids w/10&quot; heat extension, 48&quot; max. length</td>
<td>316 SS</td>
<td>316 SS</td>
<td>375</td>
<td>1000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5053</td>
<td>High temp./high pressure w/6&quot; dia. proximity plate and w/10&quot; heat extension, 48&quot; max. length</td>
<td>316 SS</td>
<td>316 SS</td>
<td>375</td>
<td>1000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5054</td>
<td>High temp./high pressure low dielectric liquids w/10&quot; heat extension &amp; stilling well</td>
<td>Rod—316 SS Well—316 SS</td>
<td>316 SS</td>
<td>875</td>
<td>5000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5059</td>
<td>Liquids or low density media</td>
<td>ECTFE</td>
<td>316 SS</td>
<td>500</td>
<td>5000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5060</td>
<td>Corrosive liquids or ECTFE requirement w/ECTFE faced 1.5&quot; 150 lb. carbon steel flange</td>
<td>ECTFE</td>
<td>ECTFE</td>
<td>500</td>
<td>280 PSI @ 160°F</td>
<td>250 PSI @ 285°F</td>
</tr>
<tr>
<td>41-5062</td>
<td>Corrosive liquids or ECTFE requirement w/ECTFE faced 2&quot; 300 lb. carbon steel flange</td>
<td>ECTFE</td>
<td>ECTFE</td>
<td>500</td>
<td>700 PSI @ 160°F</td>
<td>300 PSI @ 285°F</td>
</tr>
<tr>
<td>41-5063</td>
<td>Corrosive liquids or ECTFE requirement w/ECTFE faced 2&quot; 150 lb. carbon steel flange</td>
<td>ECTFE</td>
<td>ECTFE</td>
<td>500</td>
<td>280 PSI @ 160°F</td>
<td>250 PSI @ 285°F</td>
</tr>
<tr>
<td>41-5064</td>
<td>Corrosive liquids or ECTFE requirement w/ECTFE faced 3&quot; 150 lb. carbon steel flange</td>
<td>ECTFE</td>
<td>ECTFE</td>
<td>500</td>
<td>700 PSI @ 160°F</td>
<td>300 PSI @ 285°F</td>
</tr>
<tr>
<td>41-5065</td>
<td>Corrosive liquids or ECTFE requirement w/ECTFE faced 3&quot; 300 lb. carbon steel flange</td>
<td>ECTFE</td>
<td>ECTFE</td>
<td>500</td>
<td>700 PSI @ 160°F</td>
<td>300 PSI @ 285°F</td>
</tr>
<tr>
<td>41-5066</td>
<td>Liquids or low density media w/316 SS inactive sheath, 6&quot; sheath standard (9&quot; min. insertion length)</td>
<td>ECTFE</td>
<td>316 SS</td>
<td>500</td>
<td>5000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5067</td>
<td>For low dielectric fluids/signal compensation on horizontal tanks/turbulent surface/free flow liquid only w/stilling well</td>
<td>Rod—ECTFE Well—316 SS</td>
<td>316 SS</td>
<td>875</td>
<td>5000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5068</td>
<td>Liquids or low density media w/90° bend, 1.5&quot; radius</td>
<td>ECTFE</td>
<td>316 SS</td>
<td>500</td>
<td>5000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5069</td>
<td>Liquids or low density media w/90° bend and inactive length, 1.5&quot; radius, 110&quot; max. length</td>
<td>ECTFE</td>
<td>316 SS</td>
<td>500</td>
<td>5000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
<tr>
<td>41-5070</td>
<td>Liquids or low density media</td>
<td>ECTFE</td>
<td>316 SS</td>
<td>875</td>
<td>5000 PSI @ 100°F</td>
<td>Remote Mount</td>
</tr>
</tbody>
</table>

*Consult factory for horizontal mounting of bare probes.
*Temperatures at electronics should not exceed +160°F. Probe pressure/temperature ratings limited to the lesser value of the probe or flange selected.
### Rigid probe configurations cont.

<table>
<thead>
<tr>
<th>Probe Part No.</th>
<th>Application</th>
<th>Material</th>
<th>Probe Nut</th>
<th>Probe Dia. Inches</th>
<th>Probe Pressure/Temperature-Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>41-5071</td>
<td>Fluids as point sensor, non-conductive fluids as transmitter, low density bulk media w/90° bend, 1.5&quot; radius, 120° max. length</td>
<td>316 SS</td>
<td>316 SS</td>
<td>0.375</td>
<td>Integral Mount @ Remote Mount</td>
</tr>
<tr>
<td>41-5072</td>
<td>High density bulk media, low dielectric fluids—ECTFE seal, 120° max. length</td>
<td>316 SS</td>
<td>316 SS</td>
<td>0.500</td>
<td>-</td>
</tr>
<tr>
<td>41-5073</td>
<td>Liquids requiring Monel, 120° max. length</td>
<td>Monel</td>
<td>Monel</td>
<td>0.375</td>
<td>-</td>
</tr>
<tr>
<td>41-5074</td>
<td>Liquids requiring Hastelloy B, 120° max. length</td>
<td>Hastelloy B</td>
<td>Hast. B</td>
<td>0.375</td>
<td>-</td>
</tr>
<tr>
<td>41-5075</td>
<td>Liquids requiring Hastelloy C, 120° max. length</td>
<td>Hastelloy C</td>
<td>Hast. C</td>
<td>0.375</td>
<td>-</td>
</tr>
<tr>
<td>41-5076</td>
<td>Corrosive liquids and vapors</td>
<td>ECTFE</td>
<td>ECTFE</td>
<td>0.500</td>
<td>-</td>
</tr>
<tr>
<td>41-5077</td>
<td>Clean, conductive, non-viscous liquids with 316 SS ground wire</td>
<td>ECTFE</td>
<td>C/S Flange</td>
<td>0.500</td>
<td>-</td>
</tr>
<tr>
<td>41-5078</td>
<td>Conductive fluids in non-metal tanks, uninsulated reference rod and 3&quot; 150 lb. faced flange</td>
<td>Kynar 1</td>
<td>Kynar Face</td>
<td>0.625</td>
<td>-</td>
</tr>
<tr>
<td>41-5080</td>
<td>Corrosive liquids or Kynar requirement w/Kynar faced 1.5&quot; 150 lb. carbon steel flange</td>
<td>Kynar 1</td>
<td>Kynar Face</td>
<td>0.625</td>
<td>-</td>
</tr>
<tr>
<td>41-5081</td>
<td>Corrosive liquids or Kynar requirement w/Kynar faced 2&quot; 300 lb. carbon steel flange</td>
<td>Kynar 1</td>
<td>Kynar Face</td>
<td>0.625</td>
<td>-</td>
</tr>
<tr>
<td>41-5082</td>
<td>Corrosive liquids or Kynar requirement w/Kynar faced 2&quot; 300 lb. carbon steel flange</td>
<td>Kynar 1</td>
<td>Kynar Face</td>
<td>0.625</td>
<td>-</td>
</tr>
<tr>
<td>41-5083</td>
<td>Corrosive liquids or Kynar requirement w/Kynar faced 3&quot; 150 lb. carbon steel flange</td>
<td>Kynar 1</td>
<td>Kynar Face</td>
<td>0.625</td>
<td>-</td>
</tr>
<tr>
<td>41-5084</td>
<td>Corrosive liquids or Kynar requirement w/Kynar faced 3&quot; 300 lb. carbon steel flange</td>
<td>Kynar 1</td>
<td>Kynar Face</td>
<td>0.625</td>
<td>-</td>
</tr>
<tr>
<td>41-5085</td>
<td>Corrosive liquids or Kynar requirement w/Kynar faced 4&quot; 150 lb. carbon steel flange</td>
<td>Kynar 1</td>
<td>Kynar Face</td>
<td>0.625</td>
<td>-</td>
</tr>
<tr>
<td>41-5086</td>
<td>High temp./high pressure low dielectric liquids w/10&quot; heat extension &amp; stilling well</td>
<td>Rod—316 SS</td>
<td>316 SS</td>
<td>0.500</td>
<td>-</td>
</tr>
<tr>
<td>41-5087</td>
<td>1.25&quot; tube probe for short spans in low dielectric materials w/1.5 NPT conn., 120° max. length</td>
<td>316 SS</td>
<td>316 SS</td>
<td>0.250</td>
<td>-</td>
</tr>
<tr>
<td>41-5088</td>
<td>1.25&quot; tube probe, same as 41-5087 w/integral 2&quot; C.S. stillwell &amp; 2&quot; NPT conn., 120° max. length</td>
<td>316 SS</td>
<td>316 SS</td>
<td>0.125</td>
<td>-</td>
</tr>
<tr>
<td>41-5089</td>
<td>High temp./high pressure probe with 4&quot; carbon steel stillwell and 4&quot; 150 lb. flange for use in viscous, low dielectric material</td>
<td>316 SS</td>
<td>316 SS</td>
<td>0.426</td>
<td>-</td>
</tr>
<tr>
<td>41-5090</td>
<td>High temp./high pressure low dielectric liquid w/stilling well</td>
<td>TFE</td>
<td>TFE</td>
<td>0.625</td>
<td>-</td>
</tr>
<tr>
<td>41-5093</td>
<td>High temp./high pressure requiring an insulated probe, 180° max. length</td>
<td>TFE</td>
<td>TFE</td>
<td>0.625</td>
<td>-</td>
</tr>
<tr>
<td>41-5094</td>
<td>Sanitary probe w/3A authorization and 1° or 1.5° sanitary fitting standard, 180° max. length</td>
<td>316LSS</td>
<td>316LSS</td>
<td>0.625</td>
<td>-</td>
</tr>
<tr>
<td>41-5095</td>
<td>For conductive media requiring high capacitance gain/linch</td>
<td>Kynar</td>
<td>Kynar</td>
<td>0.625</td>
<td>-</td>
</tr>
<tr>
<td>41-5097</td>
<td>Sanitary probe w/3A authorization and 2° sanitary fitting standard, 180° max. length</td>
<td>TFE</td>
<td>TFE</td>
<td>0.625</td>
<td>-</td>
</tr>
</tbody>
</table>

1 Consult the factory for horizontal mounting of bare probes.
2 Temperature at electronics should not exceed +160°F. Probe pressure/temperature 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.

### Flexible probe configurations

<table>
<thead>
<tr>
<th>Probe Part No.</th>
<th>Application</th>
<th>Material</th>
<th>Probe Nut</th>
<th>Probe Dia. Inches</th>
<th>Probe Pressure/Temperature-Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>41-5101</td>
<td>All media</td>
<td>ECTFE</td>
<td>316 SS</td>
<td>1.375</td>
<td>Integral Mount @ Remote Mount</td>
</tr>
<tr>
<td>41-5102</td>
<td>Conductive media wp/width over 4 feet</td>
<td>ECTFE</td>
<td>316 SS</td>
<td>2.500</td>
<td>-</td>
</tr>
<tr>
<td>41-5103</td>
<td>Conductive media requiring PVC</td>
<td>PVC</td>
<td>CPVC</td>
<td>2.500</td>
<td>-</td>
</tr>
<tr>
<td>41-5105</td>
<td>High temp./high pressure wp/widths over 10 feet</td>
<td>316 SS</td>
<td>316 SS</td>
<td>0.1875</td>
<td>-</td>
</tr>
</tbody>
</table>

**Kynar** is a registered trademark of Pennwalt.
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)

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 ¾” NPT probes to fit slip-on housing connections

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

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.

<table>
<thead>
<tr>
<th>Flange</th>
<th>Part Number</th>
<th>Size</th>
<th>Rating</th>
<th>316 SS</th>
<th>304 SS</th>
<th>Carbon Steel</th>
<th>Hastelloy C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1½&quot;</td>
<td>04-5867-001</td>
<td></td>
<td></td>
<td>04-5867-011</td>
<td>04-5867-021</td>
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<tr>
<td>2&quot;</td>
<td>04-5867-002</td>
<td></td>
<td></td>
<td>04-5867-012</td>
<td>04-5867-022</td>
<td>04-5867-032</td>
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<td>3&quot;</td>
<td>04-5867-003</td>
<td></td>
<td></td>
<td>04-5867-013</td>
<td>04-5867-023</td>
<td>C/F</td>
<td></td>
</tr>
<tr>
<td>4&quot;</td>
<td>04-5867-004</td>
<td></td>
<td></td>
<td>04-5867-014</td>
<td>04-5867-024</td>
<td>C/F</td>
<td></td>
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<tr>
<td>6&quot;</td>
<td>04-5867-005</td>
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<td></td>
<td>04-5867-015</td>
<td>04-5867-025</td>
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<td>04-5867-016</td>
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<tr>
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<td>04-5867-037</td>
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<td></td>
<td>04-5867-020</td>
<td>04-5867-030</td>
<td>C/F</td>
<td></td>
</tr>
<tr>
<td>24&quot;</td>
<td>04-5867-045</td>
<td>1½&quot;</td>
<td>150 lb.</td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
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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.

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<td>04-5867-045</td>
<td>1½&quot;</td>
<td>150 lb.</td>
<td></td>
<td></td>
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</tbody>
</table>
Two-wire capacitance level transmitter

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

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 X 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 (ohms)= [input voltage (volts) — 13]/0.02
% Accuracy over temperature: as low as ±1% F.S. (%accuracy = 0.7 + (160 ÷ “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.

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
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%)
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
User Options: Acculevel™ with dielectric constant alarm
Programmable LINEARIZER

Alarm Time Delay: 0 to 100 seconds, programmable
Alarm Deadband: 0% to 100%, programmable

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 unshielded cable, up to 1 mile

Output: Pulse Frequency Modulation
Frequency: 1 MHz
Operating Range: 10 to 2000 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.

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.

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.
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.

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 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.

NOTE: Acculevel™ options require special probe/ground tube sensors and are designed for rod probes only. Consult factory for application and availability.
APPENDIX B: VELOCITY INSTRUMENTATION
# MODEL 2100 1992 PRICE LIST

## MODEL NO. | DESCRIPTION | PRICE
--- | --- | ---
2100-STDX | 2’ to 9 1/2’ 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 19 1/2’ 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. \*Swoffer does not supply the U.S.G.S. version of the Top-Set Wading Rod. | 1,560.00

<table>
<thead>
<tr>
<th>MODEL NO.</th>
<th>DESCRIPTION</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2100-12</td>
<td>90% depth method. Wading rod measures to 2.7 feet.</td>
<td>1,695.00</td>
</tr>
<tr>
<td>2100-13</td>
<td>90% depth method. Wading rod measures to 3.7 feet.</td>
<td>1,745.00</td>
</tr>
<tr>
<td>2100-14</td>
<td>90% depth method. Wading rod measures to 4.7 feet.</td>
<td>1,810.00</td>
</tr>
<tr>
<td>2100-C80</td>
<td>90% depth method. Wading rod measures to 80cm.</td>
<td>1,765.00</td>
</tr>
<tr>
<td>2100-C140</td>
<td>90% depth method. Wading rod measures to 140cm.</td>
<td>1,870.00</td>
</tr>
<tr>
<td>2100-1514</td>
<td>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.</td>
<td>2,125.00</td>
</tr>
<tr>
<td>2100-1518</td>
<td>4 M total length. Same as the 2100-1514 except has four 1” diameter sections of 1 meter each. Graduation marks are every 5cm.</td>
<td>2,230.00</td>
</tr>
</tbody>
</table>

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 90 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.
## OPTIONAL ACCESSORIES

<table>
<thead>
<tr>
<th>MODEL NO.</th>
<th>DESCRIPTION</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2100-151G</td>
<td>Extra 1' dia. lengths for the 2100-1514 wands. Graduated in feet and tenths. Please specify starting number when ordering.</td>
<td>3' bottom section — $185.00</td>
</tr>
<tr>
<td>2100-151M</td>
<td>Extra 1' dia. lengths for the 2100-1518 wands. 5cm graduations. Please specify starting number when ordering.</td>
<td>1 meter bottom section — $210.00</td>
</tr>
<tr>
<td>2100-151</td>
<td>Same as the above but with no graduations.</td>
<td>3' — $103.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3' bottom section — $115.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 meter — $121.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 meter bottom section — $131.00</td>
</tr>
<tr>
<td>2100-151-Top Cap</td>
<td>Fits the top of any of the -151 rods.</td>
<td>90.00</td>
</tr>
<tr>
<td>2100-151-Slider</td>
<td>Supplied with the 2100-1514 and 2100-1518 but available separately if you wish to use your own 1&quot; diameter rod.</td>
<td>95.00</td>
</tr>
<tr>
<td>2100-151-Foot</td>
<td>2¼&quot; diameter aluminum plate attached to the lower section of a -151 series wand. Comes with ¼-20 s/s bolt and lockwasher for installation.</td>
<td>75.00</td>
</tr>
<tr>
<td>2100-TSR</td>
<td>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 &quot;slider&quot; 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.</td>
<td>65.00</td>
</tr>
<tr>
<td>2100-48</td>
<td>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.</td>
<td>310.00</td>
</tr>
<tr>
<td>Pelican Case*</td>
<td>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 11½ by 6½ inches.</td>
<td>109.50</td>
</tr>
<tr>
<td>Pelican Case*</td>
<td>Smaller version of the Pelican Case above. I.D. is 12½ by 9¼ by 5¼ inches.</td>
<td>69.95</td>
</tr>
<tr>
<td>Pelican Box*</td>
<td>Waterproof ABS box which fits the Model 2100 Indicator. Provides extra protection for the Indicator and Rotor Assembly in transport and storage.</td>
<td>19.95</td>
</tr>
</tbody>
</table>

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

## MODEL 2100 SPARE AND REPLACEMENT PARTS

<table>
<thead>
<tr>
<th>MODEL NO.</th>
<th>DESCRIPTION</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2100-INDICATOR</td>
<td>Digital readout indicator only</td>
<td>$1,200.00</td>
</tr>
<tr>
<td>2100-A21</td>
<td>Rotor Assembly with Rotor Shaft &amp; Propeller</td>
<td>65.00</td>
</tr>
<tr>
<td>2100-A22</td>
<td>Sensor w/o Rotor Assembly. Cable length to 25'</td>
<td>225.00</td>
</tr>
<tr>
<td>2100-A23</td>
<td>Thrust Bearing Nut</td>
<td>7.00</td>
</tr>
<tr>
<td>2100-PROP</td>
<td>Propeller replacement</td>
<td>1.75</td>
</tr>
<tr>
<td>2100-A25</td>
<td>Retainer Snap Ring for Rotor Shaft</td>
<td>50.00</td>
</tr>
<tr>
<td>2100-A26</td>
<td>Rotor Shaft (includes 2100-A23)</td>
<td>21.00</td>
</tr>
<tr>
<td>2100-A27</td>
<td>Fiber-Optics Rotor</td>
<td>40.00</td>
</tr>
<tr>
<td>6-32 Set Screw</td>
<td>Stainless Steel socket hex head screw</td>
<td>.20</td>
</tr>
<tr>
<td>½&quot; Cap Plug</td>
<td>Used to protect Sensor Optics when Rotor is removed</td>
<td>.10</td>
</tr>
</tbody>
</table>

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.

Swoffers Instruments, Inc.
1048 Industry Drive
Seattle, WA 98188 U.S.A.
(206) 575-0160
FAX (206) 575-1329
<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OPERATING TEMPERATURE</strong></td>
<td>Min. $-14^\circ{}F (-10^\circ{}C)$</td>
</tr>
<tr>
<td></td>
<td>Max. $180^\circ{}F (82^\circ{}C)$ @ 15% relative humidity</td>
</tr>
<tr>
<td></td>
<td>Max. $120^\circ{}F (49^\circ{}C)$ @ 95% relative humidity</td>
</tr>
<tr>
<td><strong>POWER REQUIRED</strong></td>
<td>A single standard 9-volt transistor battery. Alkaline type recommended</td>
</tr>
<tr>
<td><strong>DISPLAY</strong></td>
<td>Liquid Crystal Digital, 0.7&quot; Digit Height</td>
</tr>
<tr>
<td><strong>RESOLUTION</strong></td>
<td>To six hundredths, both feet and meters</td>
</tr>
<tr>
<td><strong>ACCURACY</strong></td>
<td>Can be held to within 1% with periodic user required calibration tests and adjustments</td>
</tr>
<tr>
<td><strong>DISPLAY AVERAGING</strong></td>
<td>Three selectable averaging times:</td>
</tr>
<tr>
<td></td>
<td>5, 20, and 90 seconds—FPS mode</td>
</tr>
<tr>
<td></td>
<td>1.5, 6, and 30 seconds—MPS mode</td>
</tr>
<tr>
<td><strong>VELOCITY RANGE</strong></td>
<td>0.1 to 25 Feet Per Second, 0.1 to 7.5 Meters Per Second</td>
</tr>
<tr>
<td></td>
<td>(Switch selectable)</td>
</tr>
<tr>
<td><strong>INDICATOR SIZE</strong></td>
<td>4 by 6 by 2 inches (15.2 by 10.2 by 5.1 cm)</td>
</tr>
<tr>
<td><strong>INDICATOR WEIGHT</strong></td>
<td>22 oz. (Including battery, spare battery, extra rotor assembly and rotor takedown wrench all stored in battery compartment)</td>
</tr>
<tr>
<td><strong>INDICATOR MATERIAL</strong></td>
<td>Vacuum-formed ABS with a clear acrylic viewing lens over the LCD. All switches sealed with threaded silicone rubber boots.</td>
</tr>
<tr>
<td><strong>INDICATOR FACE PLATE</strong></td>
<td>Back printed polycarbonate in four colors plus black</td>
</tr>
<tr>
<td><strong>FASTENERS</strong></td>
<td>Stainless steel</td>
</tr>
<tr>
<td><strong>SENSOR WAND MATERIALS</strong></td>
<td>Aluminum = 6061-T6, Stainless steel = 303</td>
</tr>
<tr>
<td><strong>SENSOR BODY AND ROTOR</strong></td>
<td>Acetal-resin, machined from solid stock</td>
</tr>
<tr>
<td><strong>SENSOR PROPELLER</strong></td>
<td>Glass-filled, injection molded nylon, 2&quot; diameter is supplied. Other sizes for special applications available.</td>
</tr>
<tr>
<td><strong>ELECTRICAL CONNECTION</strong></td>
<td>Flexible cable, Two-conductor signal system, Circular plastic connector with twist-lock operation, Water resistant with gold plated contacts.</td>
</tr>
<tr>
<td><strong>CABLE LENGTH</strong></td>
<td>Equal to wand at full extension plus five feet. Special lengths also available.</td>
</tr>
<tr>
<td><strong>SENSOR TYPE</strong></td>
<td>PHOTO-FIBER-OPTIC with all electronics permanently encapsulated in epoxy resin.</td>
</tr>
</tbody>
</table>

*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.*
TurbTM o-Flo

Open stream velocity meter for
measurement of liquid velocities

McCoy Sales Corp.
2190 W. Bates Ave
Englewood, CO 80110
(303) 767-8012
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.

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.

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP-302</td>
<td>Open Stream Velocity Meter</td>
<td>Accuracy ±2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Range 0-5 &amp; 0-10 ft/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Threshold 0.25 ft/s</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Max Temperature 140°F</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weight:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Probe 1.1 lbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indicator 5.5 lbs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Weight 5 lbs</td>
</tr>
<tr>
<td>M-21</td>
<td>Probe Extension Set</td>
<td>(Three 6 ft sections for overall probe reach of 9, 15 or 21 ft.)</td>
</tr>
</tbody>
</table>
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: ±0.05 ft/sec
- Accuracy: ±2% of reading + zero stability
- Range: -0.5 to +20 ft/sec
  (-0.15 m/sec to 6 m/sec)

OUTPUTS
- Display: 3½ digit
- Signal Output (Optional)
  - Analog: 0.1 V per 1 ft/sec or 1 m/sec

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

ENVIRONMENTAL
- Sensor: 32°F to 180°F (0°C to 65°C)
- Electronics: 32°F to 122°F (1°C to 50°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)
  - Sensor Wet: 300mA, 3V
  - Sensor Dry: 100mA, 3V

WATER RESISTANCE
- Submersible: One (1) foot for 30 seconds.

WEIGHT
- With sensor and 20' of cable: 3½ pounds
- Without sensor: 2½ 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 meter/second. Built-in options available include sensor disconnect, power in/signal output connector and additional sensor cable. Accessory options available include carrying case, wading rods, suspension cable kit and flow tables.
APPENDIX C: FLOW RATE INSTRUMENTATION
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 prefabricated 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.
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 ±10%, 50/60 Hz
- 220 VAC ±10%, 50/60 Hz
- 100 VAC ±10%, 50/60 Hz
- 24 VDC ±70% -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.
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.
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
Contractor’s Address: Falmouth Heights Road
Falmouth, MA 02541
Contractor’s Phone: (508) 548-5800
Fax: (508) 540-3835
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:
   - Flowmeter Systems--7410
   - Transducers
   - Rack Enclosures
   - Transducer Signal Cable
   - Peripheral Items for Flowmeter
   - Control Computer--7432
   - Spare Parts

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.
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 ±10% 50/60 Hz Power  
   N/C
2. 220 VAC ±10% 50/60 Hz Power  
   N/C
3. 105 VAC ±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.
5. Model 7642 Jacking Mechanism (1 required
   per site) 750.
6. Model 7600 Transducer 800.
7. Model 7660 Feedthrough (1500 psi)
   (Specify Pipe Wall Thickness) 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.

* 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

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.
<table>
<thead>
<tr>
<th>Transducer Signal Cable</th>
<th>Price/ft</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. RG59 or RG62 without Connector</td>
<td>.30</td>
</tr>
<tr>
<td>B. RG59 or RG62 with E-O type Connector</td>
<td>.60</td>
</tr>
<tr>
<td>C. HDPE Jacketed RG59 with E-O type</td>
<td>.85</td>
</tr>
<tr>
<td>D. HDPE Jacketed RG108</td>
<td>.75</td>
</tr>
<tr>
<td>E. RG108 for use out of the water</td>
<td>.50</td>
</tr>
<tr>
<td>F. RC111 A/U Armored Cable</td>
<td>3.50</td>
</tr>
</tbody>
</table>
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 Locker 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.

2. Druck Pressure Sensor 2,500.
3. YEW Power Meter 12,000.
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

<table>
<thead>
<tr>
<th>Part Name</th>
<th>Number</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transceiver</td>
<td>7400-10002</td>
<td>1,025.</td>
</tr>
<tr>
<td>Transmitter</td>
<td>7400-10003</td>
<td>700.</td>
</tr>
<tr>
<td>Dual Path Selector</td>
<td>7400-10004</td>
<td>1,325.</td>
</tr>
<tr>
<td>Path Selector Module</td>
<td>7400-10005</td>
<td>1,000.</td>
</tr>
<tr>
<td>Receiver</td>
<td>7400-10006</td>
<td>675.</td>
</tr>
<tr>
<td>Triple Power Supply</td>
<td>7400-10007</td>
<td>1,500.</td>
</tr>
<tr>
<td>Watchdog Timer</td>
<td>7400-10013</td>
<td>500.</td>
</tr>
<tr>
<td>16 Slot Cardfile</td>
<td>7400-10014</td>
<td>1,400.</td>
</tr>
<tr>
<td>CPU</td>
<td>7400-10015</td>
<td>1,350.</td>
</tr>
<tr>
<td>SIO</td>
<td>7400-10037</td>
<td>1,050.</td>
</tr>
<tr>
<td>TTL I/O</td>
<td>7400-10038</td>
<td>1,000.</td>
</tr>
<tr>
<td>8-digit Display</td>
<td>7400-10084</td>
<td>975.</td>
</tr>
<tr>
<td>Multilevel Driver</td>
<td>7400-10085</td>
<td>500.</td>
</tr>
<tr>
<td>14-digit Display</td>
<td>7400-10086</td>
<td>1,000.</td>
</tr>
<tr>
<td>Keypad Interrupt</td>
<td>7400-10094</td>
<td>700.</td>
</tr>
<tr>
<td>EPROM</td>
<td>7400-10096</td>
<td>975.</td>
</tr>
<tr>
<td>4K CMOS RAM</td>
<td>7400-10097</td>
<td>1,650.</td>
</tr>
<tr>
<td>Calendar Clock</td>
<td>7400-10101</td>
<td>1,250.</td>
</tr>
<tr>
<td>4 x 4 Keypad</td>
<td>7400-10103</td>
<td>500.</td>
</tr>
<tr>
<td>2 channel D/A, D/I</td>
<td>7400-10109</td>
<td>850.</td>
</tr>
<tr>
<td>Receiver Module</td>
<td>7400-10118</td>
<td>950.</td>
</tr>
<tr>
<td>Asblank</td>
<td>7400-10182</td>
<td>500.</td>
</tr>
<tr>
<td>DIAG 80</td>
<td>7400-10205</td>
<td>2,000.</td>
</tr>
<tr>
<td>Stage</td>
<td>7400-10209</td>
<td>550.</td>
</tr>
<tr>
<td>Part Name</td>
<td>Number</td>
<td>Price</td>
</tr>
<tr>
<td>-----------------------</td>
<td>------------</td>
<td>--------</td>
</tr>
<tr>
<td>NEMA Box Heater</td>
<td>7400-10241</td>
<td>975.</td>
</tr>
<tr>
<td>RTU-1</td>
<td>7400-10271</td>
<td>1,025.</td>
</tr>
<tr>
<td>Dual Contact Closure</td>
<td>7400-10367</td>
<td>500.</td>
</tr>
</tbody>
</table>
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

-----------------------------------------------------------------------------
<table>
<thead>
<tr>
<th>Model Number</th>
<th>List Price</th>
<th>Discount</th>
</tr>
</thead>
<tbody>
<tr>
<td>7300 Acoustic Velocity Meter (AVM)</td>
<td>$7,200.</td>
<td>6%</td>
</tr>
<tr>
<td>1-2 Acoustic Paths, 12 VDC operation, Periodic Sampling, NEMA 4X enclosure, active transducer capability</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
-----------------------------------------------------------------------------

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

All other prices, terms, and conditions of this contract (except as previously modified, or heretofore changed) remain unchanged.
TRANSLIT-TIME AND FOURIER FLOWMETERS

SYSTEM 990P UNIFLOW—Portable Transit-Time Flowmeter
- Easily programmable for any pipe size.
- For "clean" to moderately "gritty/aerated" liquids.
- Clamp-on sensors, excellent for flow survey.

Accuracy 1% to 3% of actual flow
Flow Range -40 to +40 ft/sec (including zero flow)
Flow Sensitivity 0.001 ft/sec (including zero flow)
Displays Multifunction Graphic LCD provides: Digital Rate and Total, Analog Stripchart, Status and Diagnostic info.
Outputs Programmable 4 to 20mA, 2 x 0-10V, Relay or RS-232.
Environment Liquid Temperatures to -423°F
...Ask for Bulletin 990SB-2.

SYSTEM 990N UNIFLOW—Dedicated NEMA 4X Transit-Time Flowmeter
- High accuracy, economical
- Universally field programmable for operation on essentially any pipe & most liquids.
- An ideal one type does all stock replacement for Meters, Turbines, Vortex Venturis & Differential Pressure flowmeters.
- Optional built in Digital or Graphics displays with Data logger & Stripchart options, plus industry standard data outputs & data printout.

Accuracy 1% to 3% of Flow Rate, to 1, 2, 3 calibrated
Applicability Any pipe from 1/4" to 24" OD. to 3" wall
Flow Range -40 to +40 ft/sec including zero flow
Flow Sensitivity 0.001 ft/sec at all flow velocities
Functions Flow Rate, Total, Status Alarms, Diagnostics.
Displays Optional Blind, LCD Digital or Graphics
Outputs 4 to 20mA also, Pulse Rate, Relay or RS-232
Environment NEMA 4X, -40°F to +125°F
...Ask for Bulletin 990SB-2.

SYSTEM 190P SPECTRA—Portable Fourier Flowmeter
- New Fourier flow detection principle provides low cost & excellent accuracy in one field programmable universal flowmeter.
- Highly resistant to effects of pipe vibration & liquid solids or aeration content.
- All industry standard data outputs available, plus complete data printout.

Accuracy 1% to 5% of Flow Rate
Flow Rate & Total provided on optional Digital or Graphics displays.
Functions Flow Rate, Total, Status Alarms, Diagnostics.
Displays Blind, Analog, LCD Digital or Graphics
Outputs 4 to 20mA, Pulse Rate, Relay or RS-232
Environment NEMA 4X, -40°F to +125°F
...Ask for Bulletin 190SB-2.

SYSTEM 190N SPECTRA—Dedicated NEMA 4X Fourier Flowmeter
- New Fourier flow detection principle provides low cost & excellent accuracy in one field programmable universal flowmeter.
- Highly resistant to effects of pipe vibration & liquid solids or aeration content.
- All industry standard data outputs available, plus complete data printout.

Accuracy 1% to 5% of Flow Rate
Flow Rate & Total provided on optional Digital or Graphics displays.
Functions Flow Rate, Total, Status Alarms, Diagnostics.
Displays Blind, Analog, LCD Digital or Graphics
Outputs 4 to 20mA, Pulse Rate, Relay or RS-232
Environment NEMA 4X, -40°F to +125°F
...Ask for Bulletin 190SB-2.

SYSTEM 990E—Thermal Energy (BTU) Flowmeter
- High precision, field programmable, fully clamp-on thermal energy computer for use with both chilled, hot & very hot water systems.
- Both BTU & flow rate & totals provided on optional Digital or Graphics displays.
- With printable Datalogger & Stripchart trend recording.
- Industry standard data outputs provide computer control inputs.

Accuracy To 0.5% with calibration
Flow Rate -40 to +40 ft/sec (including zero flow)
Liquid Temp Range -40°F to +450°F
Applicability Any pipe from 1.25" to 48" OD. to 3" wall
BTU Range Field Programmable, 2000:1 Turndown Ratio
Flow Sensitivity 0.001 ft/sec at any flow rate
Functions BTU and Flow Rate, Total, Status Alarms, Diagnostics.
Displays Optional Blind, LCD Digital or Graphics
Outputs 4 to 20mA, Pulse Rate, Relay or RS-232
Environment NEMA 4X, -40°F to +125°F
Models Portable and NEMA 4X, Single and Dual Channel
...Ask for Bulletin 990E-1.

155 Plant Ave., Hauppauge, N.Y. 11788 Phone: (516) 231-3600 • Telex: 961-447 • Fax: (516) 231-3334
Model 4100 Compu-Sonic
Transit Time Ultrasonic Flowmeter

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.
P.O. Box 581390
Tulsa, Oklahoma 74158
(918) 838-6411
Telex: FICA 203605
Fax: (918) 832-9962

6/88-5M
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.
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°F to 150°F (-30°F to 300°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 submersion.

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.

---

**Technical Specifications**

- **General**
  - Temperature range from -30°F to 150°F (-30°F to 300°F Opt.).
  - Can be placed on all metallic and plastic piping, with the exception of pit cast iron and fiberglass pipe.
  - Maintain pipe or conduit integrity.

- **Instream Velocity Sensor**
  - Suitable for open conduits over 12 inches in width or in large concrete pipes where the outside of the pipe is not accessible.
  - Unique design facilitates simple installation.
  - Mounting hardware supplied with each sensor allows flush mounting against the sidewall.
  - Housing is grouted to the sidewall, producing a streamlined profile.
  - Constructed of PVC, fully potted, with similar technology as the standard externally mounted sensor.

---

**Badger Meter, Inc.**

3/88-1M
**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.

**JUNCTION BOX FOR WIRING SPLICE**

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.

**WINDOWED SPOOL**

Externally mounted sensor 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.

**APPLICATION GUIDE**

<table>
<thead>
<tr>
<th>PIPE MATERIAL</th>
<th>EXTERNAL MOUNTED</th>
<th>HOT SHOT WETTED SENSORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAST IRON</td>
<td>172</td>
<td>172</td>
</tr>
<tr>
<td>DUCTILE IRON</td>
<td>172</td>
<td>172</td>
</tr>
<tr>
<td>PLASTICS</td>
<td>172</td>
<td>172</td>
</tr>
<tr>
<td>CONCRETE</td>
<td>172</td>
<td>172</td>
</tr>
<tr>
<td>CONCRETE RCP</td>
<td>172</td>
<td>172</td>
</tr>
<tr>
<td>OPEN CHANNEL CONDUIT</td>
<td>172</td>
<td>172</td>
</tr>
<tr>
<td>NON-FULL PIPE CONDITIONS</td>
<td>172</td>
<td>172</td>
</tr>
</tbody>
</table>

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 a 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.
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 MAGNETOMETER SPECIFICATIONS

MODEL 88L (Series 80): Flo-Probe Magnetometer Sensor

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating Velocity:</td>
<td>0-1500 feet (6 meters) per second</td>
</tr>
<tr>
<td>Probes Wetted Material:</td>
<td>Epoxy and 316 Stainless Steel</td>
</tr>
<tr>
<td>Operating Temperature:</td>
<td>-32°F to 125°F (-30°C to 75°C)</td>
</tr>
<tr>
<td>Operating Pressure:</td>
<td>0 to 300 PSI (21 barg)</td>
</tr>
<tr>
<td>Minimum Fluid Conductivity:</td>
<td>2 micromhos per cm. (0.02 mS/cm)</td>
</tr>
<tr>
<td>Cable Length:</td>
<td>Standard 25 feet (7.5 meters)</td>
</tr>
<tr>
<td>Optional: Extension cable up to 500 feet (152 meters) maximum.</td>
<td></td>
</tr>
<tr>
<td>Cable Type:</td>
<td>Submersible, polyurethane jacket</td>
</tr>
<tr>
<td>Probe Diameter:</td>
<td>7/8&quot; (22 mm)</td>
</tr>
<tr>
<td>Sensor Length:</td>
<td>65&quot; (1652 mm)</td>
</tr>
<tr>
<td>Overall Probe Length:</td>
<td>36&quot; (914 mm)</td>
</tr>
<tr>
<td>Weight:</td>
<td>Approx. 12 lbs. (5.4 kg)</td>
</tr>
</tbody>
</table>

MODEL 66 Converter (Indicator/Electronics)

| Input: MONITEK Series 80 Flo-Probe Magnetometer 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 5" meter, calibrated 0 - 100 Linear Scale |
| Accuracy: ± 1% of Full Scale or ± 0.02 feet/sec, whichever is greater |
| Linearity: ± 0.5% of Full Scale |
| Repetitability: 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 |

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

To order, specify the following:

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

Mounting Options (1) None (2) Bridge Mount (3) Side Mount (4) Bottom Mount

(2) MODEL 66 — Enclosure (Select One)

1. Enclosure (Select One)
   ( ) A = Nema 4
   ( ) C = Nema 1 - "Panel Mount"
   ( ) D = explosion proof housing, Class 1, Group D, Division 1

2. Totalizer (Select One)

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

3. Level Monitoring System

   ( ) None (Customer supplied 0-10V DC level signal)
   ( ) Ultra sonic 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)

Model reserves the right to improve specifications without notice.
MAGFLO™

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

ISO 9001

EMCO
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

- 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

- FLOW RATE 150.00 GPM
- TOTALIZER-REV 00015230 GAL

- FLOW RATE 75.0%
- TOTALIZER-FW RESET

- 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**

- 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

**MAG 1100**

Wafer Style (shown as remote)

- Line Sizes: 1/2" to 4"
- Accuracy: Class 0.25% of rate
- Housing: ASTM 316
- Liner: Ceramic Al₂O₃
- Electrodes: Platinum
- Temperature: up to 390°F
- Cleaning: CIP (cleaning in place) cleanable by steam or chemical

**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 and Integral Rating:
NEMA 6 submersible in accident

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.

Is it a liquid?  Yes
Is the liquid electrically conductive (≥ 5 μS/cm)?  Yes

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)678-0550 FAX: (303)678-7152
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 micromhos 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 totalizations 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 316L 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.

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.
### Technical Data - Sensor MAG 1100 and 3100

#### MAG 1100

<table>
<thead>
<tr>
<th>Type</th>
<th>Wafer Size</th>
<th>Flange Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size</td>
<td>1/2&quot;, 1&quot;, 1-1/2&quot;, 2&quot;, 3&quot;, 4&quot; (15 - 100 mm)</td>
<td>4&quot; - 48&quot; (100 - 1200 mm)</td>
</tr>
<tr>
<td>Measuring Range</td>
<td>0 to 0.8 to 0-33 ft/s (0.25 to 0-10 m/s) with a max. turn down of 10:1</td>
<td>0 to 0.8 to 0-33 ft/s (0.25 to 0-10 m/s) with a turn down of 10:1</td>
</tr>
<tr>
<td>Measuring Methods</td>
<td>dc pulse flowmeter, measuring frequency: 3 to 1-1/2 Hz, automatically set depending on size.</td>
<td>dc pulse flowmeter, measuring frequency: 3 to 1-1/2 Hz, automatically set depending on size.</td>
</tr>
<tr>
<td>Process Pressure</td>
<td>580 psi (40 bars) ANSI Class 150# (150 mm)</td>
<td>ANSI Class 150#, 300# contact factors for higher pressure ratings AWWA for sizes 3&quot; - 48&quot;</td>
</tr>
<tr>
<td>Process Vacuum</td>
<td>Vacuum: 1.5 x 10⁻⁷ psig (10⁻⁰ bars)</td>
<td></td>
</tr>
<tr>
<td>Temperature Shock</td>
<td>Temperature shock is less than 1 sec.</td>
<td>no limitation</td>
</tr>
<tr>
<td>Ambient Temperature</td>
<td>Operation: -40°F to 300°F (-40°F to 150°C), Storage: -40°F to 165°F (-40°F to 75°C)</td>
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<tr>
<td>Liner</td>
<td>Aluminum oxide Al₂O₃ (ceramic)</td>
<td>Neoprene (std.), options: Ebonite, EPDM, Natural rubber, Polyurethane (PU), Teflon (PTFE), Liners</td>
</tr>
<tr>
<td>Electrodes</td>
<td>Platinum</td>
<td>ASTM 316 Ti (w. no. 1.4571), Hastelloy C, Platinum-Indium, Teflon, PTFE, Liners</td>
</tr>
<tr>
<td>Gaskets</td>
<td>Graphite (max. 300°F @ 500 psig), Teflon PTFE (max. 265°F @ 362 psig)</td>
<td></td>
</tr>
<tr>
<td>Cable Entries</td>
<td>1/2&quot; NPT (Pg 13)</td>
<td>1/2&quot; NPT (Pg 13)</td>
</tr>
<tr>
<td>Mechanical Load</td>
<td>1 G, 1,000 Hz sinusoidal in all directions, to IEC 608-2-6</td>
<td>1 G, 1,000 Hz sinusoidal in all directions, to IEC 608-2-6</td>
</tr>
<tr>
<td>Test Pressure</td>
<td>2 x max. pressure, 1100 psi (80 bars)</td>
<td>1.5 x pressure rating</td>
</tr>
<tr>
<td>Conductivity</td>
<td>Compact type flowmeter: Electrically conductive liquids, conductivity ≥ 5 micromhos/cm.</td>
<td>Remote signal converter:</td>
</tr>
</tbody>
</table>

#### MAG 3100

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<tr>
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<td>Remote signal converter:</td>
</tr>
</tbody>
</table>

---

**Cable Type**
- Signal cable: 3 x 18 gauge (1.5 mm²) PVC with common shielded cable
- Cable Entries: 2 x 18 gauge (1.5 mm²) PVC with common shielded cable
- When ordering the wall mounting kit, 33 ft (10 m) of 3 x 18 gauge (1.5 mm²) cable and 5 x 1/2" NPT (Pg 13) entry glands are supplied.

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**Engineering Measurements Company**

600 Diagonal Highway • Longmont, CO 80501-6396 U.S.A.
Tel: (303) 651-0550 • FAX: (303) 678-7152

MAGFLO™
## 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: -40 to +185°F (-40 to +85°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 +10%/-25%

## Output Characteristics

<table>
<thead>
<tr>
<th>Basic Setup Of</th>
<th>Bidirectional flow</th>
<th>Flow in one Direction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operation</td>
<td>Relay output indicates flow direction</td>
<td>Relay output indicates error</td>
</tr>
<tr>
<td>Ambience Temp.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stainless Steel: Operation</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stainless Steel: Enclosure VEMA 6 (IP 67)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Relays
- Relay indicates flow direction or Error
- Maximum 42 Vac, 2A

## Analog Output
- 0/4-20 mA galvanically isolated, Load: max. 500 ohm

## Frequency/Pulse Output

<table>
<thead>
<tr>
<th>Can Be Scalled</th>
<th>Active: 200 mA, pulse ≤ 50 ms, f ≤ 2 Hz (for 24 V electromechanical counter)</th>
<th>Passive: 200 mA, TTL - 50V, Ron ≤ 5 ohm, Fmax. = 10 kHz</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Active: 20 mA, 30 V, Fmax. = 10 kHz (for electronic counter)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Passive: 200 mA, TTL - 50V, Ron ≤ 5 ohm, Fmax. = 10 kHz</td>
<td></td>
</tr>
</tbody>
</table>

## Time Constant
- Analog output: 0.8-30 s adjustable
- Frequency/Pulse output: 0.1-20 s adjustable
- Reaction time relay: Error ≤ 1 s, flow direction 100 ms

## Output
- Galvanic isolation min. 500 V, Short-circuit-proof

## Counter
- Two internal counters for forward and reverse flow

## Low Flow Cut-off
- Adjustable from 0% to 99.9% of F.S.

## Display
- Backlit with alphanumeric text, 2 x 16 digits for indicating flow, volume, settings, etc. Reverse flow shown with negative sign

## Zero Point
- Automatic zero-point adjustment

## Power Consumption
- 8 VA

## Mechanical Load
- 1G, 1-1000 Hz sinusoidal in all directions, to IEC 68
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

<table>
<thead>
<tr>
<th>Flowrate Range:</th>
<th>0-40 ft/sec (0-12.2 m/s), bidirectional</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repeatability:</td>
<td>±0.005 ft/sec</td>
</tr>
<tr>
<td>Pipe Materials:</td>
<td>Menu-selections – metal alloys, plastics, glass, etc.</td>
</tr>
<tr>
<td>Line Sizes:</td>
<td>Standard transducers fit all 4&quot;-48&quot; line sizes</td>
</tr>
<tr>
<td></td>
<td>Transducer mounting rails: 15&quot; rails fit 4&quot;-12&quot; lines</td>
</tr>
<tr>
<td></td>
<td>36&quot; rails fit 4&quot;-48&quot; lines</td>
</tr>
<tr>
<td><strong>Outputs:</strong></td>
<td>Analog: 4-20 mA into 800 ohms or less</td>
</tr>
<tr>
<td></td>
<td>RS-232C: 9-pin connector; 300/1200/2400/4800/9600 baud</td>
</tr>
<tr>
<td></td>
<td>Averaging: (Output Smoothing) 1-30 seconds</td>
</tr>
<tr>
<td><strong>Display:</strong></td>
<td>2-line × 16 character alphanumeric liquid crystal display, 8.06 mm character height</td>
</tr>
<tr>
<td><strong>Power Supply:</strong></td>
<td>Standard: 115 VAC, ± 10%, 50-60 Hz</td>
</tr>
<tr>
<td></td>
<td>Ni-Cad battery operation, 8 hours at full charge</td>
</tr>
<tr>
<td></td>
<td>Optional: 230 VAC, ± 10%, 50-60 Hz</td>
</tr>
<tr>
<td><strong>Power Consumption:</strong></td>
<td>16 watts</td>
</tr>
<tr>
<td><strong>Battery-backup:</strong></td>
<td>10-year retention of data and calibration constants</td>
</tr>
<tr>
<td><strong>Liquid Temperature:</strong></td>
<td>−40°C to +150°C (−40°F to +302°F)</td>
</tr>
<tr>
<td><strong>Ambient Temperature:</strong></td>
<td>−10°C to +50°C (+14°F to +122°F)</td>
</tr>
<tr>
<td><strong>Size:</strong></td>
<td>Length: 11&quot; (27.9 cm) Width: 7&quot; (17.8 cm)</td>
</tr>
<tr>
<td></td>
<td>Height: 8.3&quot; (21.1 cm)</td>
</tr>
<tr>
<td><strong>Weight:</strong></td>
<td>11.6 lbs. (5.3 kg), excluding transducers/rails</td>
</tr>
</tbody>
</table>

**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

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

The microFLOW Advantage

Unmatched Versatility and Simplicity

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.

Portability was one of the primary microFLOW 90 design objectives. Its rugged carrying case measures only 11" × 7" × 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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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.

TRANSUCERS

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 20 mA output at full-scale flow; i.e., 20 mA at 10 feet per second in the 0-10FPS switch position, and 20 mA 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 readable to read common engineering units in ranges of 0-1,999, 0-199.9, 0-199.9, or 0-199.9.

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, 25 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: 24 V dc at 125 mA
Ambient Temperature
  Range (at transmitter) ........ 0°C to 50°C (+32°F to +122°F)
  Liquid Temperature ........... 0°C to +150°C (+32°F to +302°F)
  Liquid Pressure .............. Limited by user’s 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-Capacity Rating
  (nominal) ................. 24 V dc at 12 Ah
Continuous Operating
  Time Between Recharge (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)
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.

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.
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-specified 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 transmitter-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 50 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 "nois" problem liquids
- No energy loss due to pressure drop
- "Pig" able
- 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
- Sanitary liquids (e.g. foods and pharmaceuticals)
- Foams
- Mixed concretes and cements
- Fly-ash slurries
- Two-phase liquids (e.g. chemicals, rubber and glass)

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 ±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 ±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 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.

FIGURE 2
SPECIFICATIONS

MODEL 1161

OPERATIONAL SPECIFICATIONS

Flow rate range: User may set LL scale from 25 to 40 feet/second.

Liquid temperature: 0-150°C

Liquid pressure, maximum: Limited by user design

Wetted transducers: Limited by user design

Ambient temperature: -30°C to 50°C

Optional heater: -40°C to 80°C

OUTPUT SPECIFICATIONS

Standard outputs: 0-10 VDC into 1000 ohms or more

Current mode: 4-20 mA or 0-50 mA into 550 ohms or less

Voltage mode: 0-10 VDO into 2000 ohms or more

Optional Outputs: 4-20 mA into 200 ohms or more

Unfactored pulse: 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 130 mA maximum (capable of driving a remote counter)

High-low alarm: Two SPST relay contacts; 115 VAC or 29 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

Site: See outlines of flow tubes (Figure 6) and enclosures (this page)

Net weight: 0.4 pounds (11.4 kg)

Transmitter: 25 pounds (11.4 kg)

NEMA 4X: 11 pounds (5.0 kg)

NEMA 7: 47 pounds (21.4 kg)

Clamp-on: 11 pounds (4.8 kg)

Wetted, including flow tube: Refer to factory.

STANDARD

NEMA 4X RIBER GLASS ENCLOSES

OPTIONAL

NEMA 4 ENCLOSURE

OPTIONAL

NEMA 7 EXPLOSION PROOF ENCLOSURE

POWER REQUIREMENTS

Cable: 3/16" (5 mm) minimum trilaminate, propylene, or equivalent.

Model: 1161

Transmitter: AC, 50-60 Hz

Output: 115VAC (±10%) VAC

Power consumption: 12 watts

Optional heater: 250 watts

Optional remote power supply: None (cabled to transmitter)

Optional totalizing counter: None (cabled to transmitter)

OPTIONAL DISPLAYS

Liquid crystal display (LCD): A 4½-digit, field replaceable 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 for remote panel mounting by user. Connects to 4-20 mA output and is field replaceable 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 factor knobs.

• 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

PRINTED IN USA
OPTIONS

TRANSUCERS

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 flowtubes. In addition to weld-on kits for various types of metal piping; saddle-plate kits are available for concrete and other non-weldable materials.

FIGURE 6

OPTIONAL WETTED TRANSUDER & FLOWTUBE

OUTPUT METERS

At time of purchase a LCD (liquid crystal display) or a needle-indicating (analog) meter can be installed in 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-specified 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.

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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®

The Water Quality Datalogger
With
No Strings Attached
Fully submersible automated water quality data systems with totally self-contained solidstate “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, water-tight 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, the DataSonde is a completely self-dependent system. All that field personnel need is to deploy at a desirable field location—preset to start collecting the data desired by lab personnel. All 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 manual transfer.

Foolproof Accuracy

DataSonde’s solid-state reliability and precision, plus automatic preprogrammed operation, results 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°C (with temperature calibrated to an accuracy of ±0.1°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 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 manual 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 (delayed stop) under control of a real-time clock recording exact time and date. Sample intervals can be programmed in multiples of 5 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, water-tight housing and solid-state ruggedness ensure each unit will withstand incredibly abusive environmental extremes. Built with a heavy-duty, nonmetallic pressure housing, each unit is home in 3 feet or 1,000 feet of water, saline or fresh, from -2°C to 50°C. Weighing 11 lbs. (5 kg), and ready-to-go, the DataSonde can be moved anywhere—from the Arctic to the Amazon, the North Sea to the Everglades, by truck, boat, or plane...even by dog-sled, balloon, 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:

- Biological
- Limnological
- Ichthyological
- Hydrological
- Petrological
- Benthological
- Oceanological

Deployment

- Lakes, creeks, rivers, and other inland waterways
- Oceanic sites
- Salt marshes
- Sewage 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

Simple, Easy Operation

Handed entirely in the lab, calibration and programming of the DataSonde is literally a snap—eased by simply typing 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—uploading 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—and “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 savings in data processing 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 storage unit, a single investment in just one DMU and display setup 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 processing 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...

WITH NO STRINGS ATTACHED!

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.
### DataSonde ® 2000 Series Performance Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Temperature</th>
<th>Conductivity</th>
<th>Salinity</th>
<th>pH</th>
<th>ORP</th>
<th>True D.O.</th>
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<tbody>
<tr>
<td>Range</td>
<td>-2° to 50°C</td>
<td>0–1.5, 15, 150 mS/cm</td>
<td>0–60 ppt</td>
<td>0–14pH</td>
<td>-1,000 to</td>
<td>0–20 mg/l (ppm)</td>
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<td>(Selectable by keyboard)</td>
<td></td>
<td></td>
<td>+1,000 mv</td>
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<td>Calibrated Accuracy</td>
<td>±0.1°C</td>
<td>±1% of range selected</td>
<td>See Conductivity</td>
<td>±0.1pH over 3–11pH range</td>
<td>Within ±10mv of platinum electrode-potential</td>
<td>±1% F.S.* (With Teflon™ membrane and sample velocities &gt; 25 cm/sec. See Note (1))</td>
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<td>Resolution</td>
<td>±0.025°C</td>
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<td>0.01pH</td>
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<td>Sensor Type</td>
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<td>See Conductivity</td>
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<td>Platinum electrode</td>
<td>Polarographic cell</td>
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<td>Automatic (True D.O.)</td>
</tr>
<tr>
<td>Calibration (By keyboard entry)</td>
<td>Factory</td>
<td>Quality KCl or seawater standard solutions</td>
<td>See Conductivity</td>
<td>pH7 and 4 or 10 buffer</td>
<td>Quinhydrone standard</td>
<td>Air-saturated water, water-saturated air or Winkler titration</td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length Overall</td>
<td>26 in. (660 mm)</td>
</tr>
<tr>
<td>Diameter Overall</td>
<td>4.7 in. (120 mm)</td>
</tr>
<tr>
<td>Weight (Air)</td>
<td>11 lb. (5 kg)</td>
</tr>
<tr>
<td>Maximum Depth</td>
<td>660 ft. (200 m)</td>
</tr>
<tr>
<td>Temperature Tolerance Range</td>
<td>-2 to 50°C</td>
</tr>
<tr>
<td>Construction Materials</td>
<td>PVC, Delrin™, stainless steel, anodized aluminum</td>
</tr>
</tbody>
</table>

Teflon™ and Delrin™ are registered trademarks of E.I. DuPont Corporation.

### DataSonde ® 2000 Series Operational Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Storage</td>
<td>Solid-state CMOS RAM.</td>
</tr>
<tr>
<td>Data Capacity</td>
<td>3,600 parameter readings plus station identification, initial time and date, ending time and date, calibration standard values, sample time interval, and parameters selected.</td>
</tr>
<tr>
<td>Data Recovery</td>
<td>By means of any EIA RS-232-C compatible terminal or printer via Hydrolab 5200-20XX DMC.</td>
</tr>
<tr>
<td>Sampling Interval</td>
<td>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.</td>
</tr>
<tr>
<td>Clock</td>
<td>Quartz reference (accuracy: 2 min./month)</td>
</tr>
<tr>
<td>Power Supply</td>
<td>6 VDC with (8) internal “D”-cell alkaline batteries.</td>
</tr>
<tr>
<td>Operating Life</td>
<td>Up to (6) months, as affected by: parameters enabled, sample-interval selected, operating temperature and rate of sensor fouling.</td>
</tr>
</tbody>
</table>

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 ± 0.2% of Reading
- $148.00

**Right Angle Surface Probe**
- Maximum Temp. 500°C
- Accuracy ± 0.2% of Reading
- $168.00

**Roller Bearing Probe**
- Four roller bearings supply suitable contact with surface moving.
- Moving surface should not exceed 500 m/min.
- Max. Temp. 200°C
- Accuracy ± 0.3% of Reading
- $242.00

**Microsensing Probe**
- Ideal for measuring very small surfaces like transistors, ICs, transformers & electronic components.
- 400°C Max.
- ± 0.3% of Reading Accuracy
- $178.00

**Moving Surface Probe**
- For measuring temp. of moving or stationary smooth flat surface.
- Maximum Service Speed 600 m/min.
- Max. Temp. 250°C
- ± 0.3% of Reading
- $193.00

**Penetration Probe**
- Measures most general purpose measurements of internal temperatures such as soft & semi-solid materials.
- Max. Temp. 500°C
- ± 0.3% Accuracy
- $104.00

**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
- ± 0.3% Accuracy
- $257.00

**Air Temperature Probe**
- Maximum Temperature 500°C
- ± 0.3% of Reading
- $99.00

**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
- ± 0.5% Accuracy
- $89.00

**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
- ± 0.3% of Reading Accuracy
- $208.00

**Underwater Probe**
- Strong lead cable allows this probe to be thrown into sea, bath & tanks.
- Max. Temp. 300°C
- ± 0.3% Accuracy
- $242.00

Cat. # EM25 NIST Certification $9000

**CALL TOLL FREE 1-800-368-2516**
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.

**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:**
8-40VDC reverse polarity protected.

See our full line of thermocouple probes on pages 229-236.

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

**SUPPLY VOLTAGE VARIATION EFFECT:**
Less than 0.02% of span over 8-40V change.

**MAXIMUM LOAD RESISTANCE:**
R<sub>max</sub> = (V<sub>supply</sub> - 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.

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.

**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.

---

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 DESIGNATION:**
10/1A—NARROW RANGE
10/1B—WIDE RANGE
Scale from 10-100°C degrees
Scale from 10°C to 800°C degrees

**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, 3.0mA min. Limiting at 27mA.

**SUPPLY VOLTAGE:**
8-40VDC, reverse polarity protected.

**LEAD WIRE RESISTANCE COMPENSATION:**
(for 3-wire sensor) better than 400Ω

**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.

**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 68°C
* determined by plug-in header.

---

<table>
<thead>
<tr>
<th>Catalog No.</th>
<th>Model</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEBU232</td>
<td>10/2</td>
<td>2-Wire Transmitter for Thermocouple</td>
<td>$150.00</td>
</tr>
<tr>
<td>ME8833</td>
<td>10/1A</td>
<td>Narrow Range RTD Transmitter</td>
<td></td>
</tr>
<tr>
<td>ME8834</td>
<td>10/1B</td>
<td>Wide Range RTD Transmitter</td>
<td></td>
</tr>
</tbody>
</table>

* When ordering please specify input type: 2-Wire Sensor, 3-Wire Sensor or Differential Measurement Range.

---

270 DAVIS INSTRUMENTS

CALL TOLL FREE 1-800-368-2510
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 3½ 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

<table>
<thead>
<tr>
<th>Controller Part No.</th>
<th>Price</th>
<th>Compatible Sensor Part No.</th>
<th>Price</th>
<th>Measuring Range, µS/cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDCN-101</td>
<td>$635</td>
<td>CDCN-102</td>
<td>$140</td>
<td>0-10, 0-50, 0-100, 0-200</td>
</tr>
<tr>
<td>CDCN-103</td>
<td>635</td>
<td>CDCN-104</td>
<td>130</td>
<td>0-500, 0-1000, 0-2000, 0-5000</td>
</tr>
<tr>
<td>CDCN-105</td>
<td>635</td>
<td>CDCN-106</td>
<td>170</td>
<td>0-10,000, 0-20,000, 0-50,000</td>
</tr>
</tbody>
</table>

Specifications:
- Display: 3½” analog
- Measuring Ranges: CDCN-101: 0 to 10, 0 to 50, 0 to 100 and 0 to 200 µS/cm (using CDCN-102 Sensor) CDCN-103: 0 to 500, 0 to 1000, 0 to 2000, and 0 to 5000 µS/cm (using CDCN-104 Sensor) CDCN-105: 0 to 10,000, 0 to 20,000 and 0 to 50,000 µS/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 Vac resistive
- 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

$635
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 ºC—see Fig. 1) an integral temperature sensor along with its circuitry adjusts the reading to a standard temperature, usually 25 ºC.

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 internationally by an equal and interchangeable international unit of measurement called the “Siemens/cm.” Conductivity usually is expressed in millionths of a Siemens, that is, microSiemens/cm. Resistivity is still expressed as Megohms-cm for high purity water—usually from 0.1 to 20 Megohm-cm.

**RESISTIVITY**

In high purity water, typically less than 1 microSiemens/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 ºC. 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 microSiemens/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 microSiemens/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**

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.

**Figure 5. Conductivity vs. Temperature for Different Concentrations**

OMEGA ENGINEERING, INC. gratefully acknowledges Great Lakes Instruments, Inc. for permission to reprint the bulletin “About Conductivity”
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 µS/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.
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 CDTX-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.

### 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

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Price</th>
<th>Compatible Sensor</th>
<th>Measuring Range, μS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CDTX-101</td>
<td>$305</td>
<td>CDCN-102, CDCN-104, CDCN-106</td>
<td>0-10, 0-50, 0-100, 0-200, 0-500, 0-2000, 0-5000, 0-10,000, 0-20,000, 0-50,000</td>
</tr>
<tr>
<td>CDTX-102</td>
<td>$375</td>
<td>CDCN-108</td>
<td>0-1,000,000</td>
</tr>
</tbody>
</table>
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 O₂ range, temperature (0-50°C), or percent O₂ (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 ABS 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 a 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:

At cathode: \[ \text{O}_2 + 4\text{H}^+ + 4e^- \rightarrow 2\text{H}_2\text{O} \]
At anode: \[ 2\text{PbO} + 4\text{H}^+ + 4e^- \rightarrow 2\text{H}_2\text{O} + 2\text{Pb} \]

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:

At cathode: \[ \text{O}_2 + 4\text{H}^+ + 4e^- \rightarrow 2\text{H}_2\text{O} \]
At anode: \[ 2\text{PbO} + 4\text{H}^+ + 4e^- \rightarrow 2\text{H}_2\text{O} + 2\text{Pb} \]

Net Reaction: \[ \text{O}_2 + 2\text{Pb} \rightarrow 2\text{PbO} \]

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 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 Limit: -10°C to +40°C (-14°F to 104°F)
- Output 0-100 mV proportional to concentration range for recording
- Controls: (a) Calibration (\%0,) and (b) temperature measurement (0°C-50°C) from thermistor in probe (c) 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: Non-theoretical limitation, since there is no plating or consumption of electrodes
- Electrolyte: Permanent electrolyte, wasterless, which is replaced in a waterproof 9-pin quick-disconnect plug
- Internal Construction: Three electrodes: anode, cathode, reference electrode) and a thermistor for temperature compensation
- Electrical Connections: Integral waterproof cable, terminating in a waterproof 9-pin quick-disconnect plug
- Dimensions: 8" long x 1.5" OD (222 x 33 mm), with 20 ft. (6.1 m) integral cable

HOW TO ORDER

- Model 8500 Meter Only: Montek #8500-0003-00
- Wastewater D.O. Probe Only: Montek #8500-0002-00
- B.O.D. Probe Only: Montek #8500-0004-00
- R.C. Universal Voltage Adopter: Montek #8500-0006-00

Represented by:

MONITEK

U.S.A.
Montek Technologies, Inc.
1495 Zephyr Avenue, Hayward, CA 94544
FAX (415) 477-8847

Other Montek products: Turbidimeters, Nephelometers, Color Monitors, Suspended Solids, Density, Concentration/Consistency Monitors, Sludge Blanket Detectors/Controllers, Ultrasonic Level Flowmeters, Pipe Insertion Meters and Open Channel Ultrasonic, Dissolved Oxygen Analyzers, pH Controllers, Liquid Samplers

Specifications and descriptions subject to change without notice

D/D-102-G87
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 setup parameters, input of calibration data and alarm setpoint adjustments. The two 5 A, 230 Vac relays can be configured as high/high, high/low 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 0-5 V 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
Bureau of Reclamation  
P.O. Box 25007  
Denver Federal Center  
Denver, CO 80225-0007

MAIL STOP: DJ/751  
ATTN: Joe Kubitschek  
DATE: September 14, 1992  
RE: Telephone Call

**QUOTATION**

<table>
<thead>
<tr>
<th>QTY</th>
<th>DESCRIPTION</th>
<th>ORDER CODE</th>
<th>PRICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>SYS-1 COMP. 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.</td>
<td>SYS-1</td>
<td>$6745</td>
</tr>
</tbody>
</table>

**Standard Terms:**

Availability: 6-8 Weeks  
For guaranteed 5 working day shipment, AKO, add 10% to order total. (Standard Products Only)  
F.O.B. Rockaway, N.J.  
Net 20 Days  
Quote is valid for 30 days.

Rus Graybill
KEITHLEY
DATA ACQUISITION AND CONTROL
FOR IBM PC/XT/AT AND COMPATIBLE
COMPUTERS

KEITHLEY
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
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).

**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 SW3**

<table>
<thead>
<tr>
<th>Coding</th>
<th>SW3</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Straight Binary</td>
<td>On</td>
<td>Left</td>
</tr>
<tr>
<td>Offset Binary (FC)</td>
<td>On</td>
<td>Left</td>
</tr>
<tr>
<td>Two's Complement</td>
<td>Off</td>
<td>Right</td>
</tr>
</tbody>
</table>

**Input Configuration SW4**

<table>
<thead>
<tr>
<th>Configuration</th>
<th>Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-ended (FC)</td>
<td>Left</td>
</tr>
<tr>
<td>Differential</td>
<td>Right</td>
</tr>
</tbody>
</table>

**DAC Functions**

**DAC 0 Output Range Selection—SW2**

<table>
<thead>
<tr>
<th>Output Range</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
</tr>
</thead>
<tbody>
<tr>
<td>±10 Volts (FC)</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>±5 Volts</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>±2.5 Volts</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>0 to 10 Volts</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>0 to 5 Volts</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
</tbody>
</table>

**DAC 1 Output Range Selection—SW1**

<table>
<thead>
<tr>
<th>Output Range</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
</tr>
</thead>
<tbody>
<tr>
<td>±10 Volts (FC)</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>±5 Volts</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>±2.5 Volts</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>0 to 10 Volts</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>0 to 5 Volts</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
<td>Off</td>
</tr>
</tbody>
</table>

**DMA Channel Settings**

<table>
<thead>
<tr>
<th>Channel</th>
<th>First DMA Channel</th>
<th>Second DMA Channel</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>6</td>
<td>On</td>
<td>Off</td>
</tr>
<tr>
<td>7</td>
<td>On</td>
<td>On</td>
</tr>
<tr>
<td>10</td>
<td>Off</td>
<td>On</td>
</tr>
<tr>
<td>15 (FC)</td>
<td>Off</td>
<td>On</td>
</tr>
</tbody>
</table>

**Interrupt Level—J2**

<table>
<thead>
<tr>
<th>Interrupt Level</th>
<th>Jumper Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>15 (FC)</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>none</td>
<td>6</td>
</tr>
</tbody>
</table>

The factory configuration has the first DMA channel set to Channel 5, and the second DMA channel set to Channel 6.

**A/D Functions**

<table>
<thead>
<tr>
<th>Range</th>
<th>S1</th>
<th>S2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bipolar ±10V (FC)</td>
<td>Off</td>
<td>Off</td>
</tr>
<tr>
<td>Bipolar ±5V</td>
<td>On</td>
<td>Off</td>
</tr>
<tr>
<td>Unipolar +10V</td>
<td>On</td>
<td>On</td>
</tr>
</tbody>
</table>
**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:** ±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:** >100MQ
- **Input Bias Current:** <1nA
- **Filter:** Single-pole low-pass, 100kHz or 2kHz
- **Settling Time:** AMM1A: 124s @ 100kHz, 0.6ms @ 2kHz (to 0.05% of final reading)
  
  AMM2: 16µs @ 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 M8 subsystem for specialized signal conditioning.

**Analog Output**

- **Channel Capacity:** 2, single-ended, referenced to chassis.
- **Output Ranges:** ±10V, ±5V, ±2V, ±1V
- **Resolution:** 13-bits.
- **Output Load:** ±200mV, ±100mV, ±50mV, ±25mV, ±10mV
- **Settling Time:** 5µs (max) to 0.01% ±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 KDAC500/1 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 KDAC500/1 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 KDAC500/1 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 KDAC500/1 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:** ±2% + 1LSB
- **Input Impedance:** 10MQ (External Input)
- **Input Protection:** ±20V 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, 1kHz, 31kHz, 30Hz

**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 Microchannel 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.
- **Dimensions:** 85 cm (H) x 270 cm (W) x 30cm (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. KDAC500/1 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.
### 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: ≥1MΩ
- 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
- Setting Time: 576-1: 12us @ 100kHz, 0.6ms @ 2kHz (to 0.05% of final reading)
- 576-2: 16us @ 100kHz, 0.8ms @ 2kHz (to 0.003% of final reading)

#### Model 576-1 (12-bits, 3½ digits)

<table>
<thead>
<tr>
<th>Range</th>
<th>Resolution</th>
<th>Accuracy (% of reading + mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>±10V</td>
<td>4.9 mV</td>
<td>±0.04% + 4.9</td>
</tr>
<tr>
<td>±1V</td>
<td>48.4µV</td>
<td>±0.09% + 0.98</td>
</tr>
<tr>
<td>±100mV</td>
<td>49µV</td>
<td>±0.08% + 0.87</td>
</tr>
</tbody>
</table>

#### Model 576-2 (16-bits, 4½ digits)

<table>
<thead>
<tr>
<th>Range</th>
<th>Resolution</th>
<th>Accuracy (% of reading + mV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>±10V</td>
<td>305µV</td>
<td>±0.035% + 0.66</td>
</tr>
<tr>
<td>±1V</td>
<td>31µV</td>
<td>±0.040% + 0.19</td>
</tr>
<tr>
<td>±100mV</td>
<td>34µV</td>
<td>±0.044% + 0.18</td>
</tr>
</tbody>
</table>

*Using average function 100 samples. Corrected readings use software gain & offset adjustment.

### Analog Input - Thermocouples

**Model 576-2 with AIM7 Thermocouple Input Module, excluding user thermocouple errors**

<table>
<thead>
<tr>
<th>Type</th>
<th>Accuracy (1 yr)</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>J</td>
<td>±1°C</td>
<td>-200°C to 100°C</td>
</tr>
<tr>
<td>K</td>
<td>±1.5°C</td>
<td>-100°C to 100°C</td>
</tr>
<tr>
<td>T</td>
<td>±1°C</td>
<td>0°C to 100°C</td>
</tr>
</tbody>
</table>

*Also supports Type B, R, S transducers. Refer to the Manual for Specifications and extended temperature ranges for all thermocouple types.

### Analog Output

**Channels:**
- 16 single-ended, referenced to chassis
- 2, single-ended, referenced to chassis

**Output Ranges:**
- ±10V
- ±2V
- ±1V

**Resolution:**
- 13-bits

**Accuracy:**
- ±10V Range: ±0.15% ±5mV
- Other Ranges: ±0.2% ±4mV

**Output Load:**
- 2kΩ (min), 100µF (max)

**Settling Time:**
- 5us (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 16
- 16 channels can drive PC80 power control device

**Input:**
- TTL-level, high-true 2µA source, 0.4mA sink

**Output:**
- 10 TTL loads, 24mA sink at 0.3V

### Trigger Function

**Channels:**
- 1, differential input

**Trigger Source:**
- Ext. input, any input channel, or software strobe

**Ranges:**
- ±1V, 0 to 1V, 0 to ±10V, 0 to ±1V, 0 to ±10V, 0 to ±1V, 0 to ±10V, 0 to ±1V, 0 to ±10V

**Level Accuracy:**
- ±2% ±LSB

**Input Impedance:**
- 10MΩ (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, 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 10,000 bytes available for use in up to 20 secondary user defined buffers. Expandable to 400,000 bytes with AT80-VEM factory installed option.

**Battery Life:**
- Typically 2 years at 25°C ambient

**Clock Accuracy:**
- ±1 minute/month at 25°C

**Initialization:**
- Digital Outputs power-up in tri-state mode. Analog Output at 0V

**Front Panel:**
- REMOTE, SDS, TALK, RUN, +POWER indicators, Power switch

**Rear Panel:**
- Power input, IEEE-488 connector, and grounding options

**Case:**
- Aluminum

**Warm-up:**
- 15 minutes to rated accuracy

**Operating Environment:**
- 0°C to 50°C, 80% R.H. non-condensing at up to 35°C

**Storage:**
- -20°C to +65°C

**Power:**
- 12-18V 2.0A (max) AC or DC, External power module supplied for 100-260VAC input

**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:**
- OCL, SOC, GET, TALK, T, UNL, SPE, SPD

**Unline Commands:**
- PC, REN. EOI, SRQ, ATN

**Interface Functions:**
- SH1, AH1, T6, T6, L4, LEO, SR1, RLO, PPO, D1, DT1, E1

**Progr. Parameters:**
- Read, Write, Buffer size, Filter, Gain, Offset, Range, units, Loop 0

**Digital I/O Channels:**
- Immediate Mode, Suffered Mode

**Typical Rates:**
- Data Transfer Rate (to ideal listener from Model 576 memory):
  - ASCII Ind. Prefix I IBM Binary, HP Binary
  - 150 bytes/second

**Minimum Source-Delay-Measure Cycle Time:**
- 250 μs
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 Programmable 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
PC BUS INTERFACE

<table>
<thead>
<tr>
<th>Architecture</th>
<th>Decodes 16 byte-wide I/O registers using address lines A9-A0. Highest base address is 3F0h. 8 bits.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Bus Width</td>
<td>PC Bus interrupt (software maskable)</td>
</tr>
<tr>
<td>Bus Interrupt Sources</td>
<td>IRQ 3, 5, 7. Scan acquire flag (sample count), FIFO full, half full or not empty or DMA T/C.</td>
</tr>
<tr>
<td>Bus Data Transfer Rate</td>
<td>1 Megabyte/second or greater. Dependent on host PC CPU speed. 1 line, software selectable, DRQ1 or DRQ3 from FIFO HF, FF, EF* or ACQ.</td>
</tr>
<tr>
<td>Direct Memory Access</td>
<td>8 lines. TTL levels. 2 mA out in plus pullup resistor to +5V</td>
</tr>
</tbody>
</table>

PARALLEL PORT

| Parallel Outport | 8 lines. TTL levels. 2 mA out in plus pullup resistor to +5V |
| Parallel Inport | 8 lines. TTL levels. 24 mA in plus pullup resistor to +5V |

CONNECTORS

| Analog Inputs, P1 | 25-pin female DB-25S connector on rear mounting bracket for analog inputs and trigger. |
| Analog Outputs, P2 (PC-412 only) | 9-pin female DB-9S connector on rear mounting bracket. |
| Parallel Port | Internal header connector, 0.025 inch pins on 0.100 inch spacing, suitable for flat cable. Edgeboard connector |

PC BUS Connector

| PC Bus Connector | |

MISCELLANEOUS

| Power Required (PC-411) | +5V dc, ±5% at 1.0 Amps max. and ±12V dc, ±5% at 100 mA max. all supplied from the bus. +5V: 2.0 Amps. max. ±12V: 250 mA max. 0 to +60 °C Forced cooling is recommended. |
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APPENDIX F: COST DATA
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 ................ $ 3,000.00

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.

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),

     (c:wp\d3751\tfcf.est)
### Terms:
2% 15, Net 30 Days

### Date to Ship:
Within three weeks of order

### Bill To:
Bureau of Reclamation  
P.O. Box 25007  
Denver Federal Center  
Denver, CO 80225-0002

### Ship To:
Same

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
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<th>Extension</th>
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<td>2100-LX, Open stream current velocity meter</td>
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<td>$1,865.00</td>
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<td></td>
<td>#1 of 2 @ 3 Lbs</td>
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<td></td>
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<td></td>
<td>#2 of 2 @ 9 Lbs</td>
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<td><strong>19.25</strong></td>
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<td><strong>Sub Total</strong></td>
<td><strong>$1,884.25</strong></td>
<td><strong>$1,884.25</strong></td>
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**Total:** $1,884.25

By: [Signature]

Date: Sep/15/92

Federal T.I.N. 91-0837015  
DUNS 07-825-2200

Bureau of Reclamation  
P.O. Box 25007  
Denver Federal Center  
Denver, CO 80225-0002

### Phone:
(303) 236-7664

### Fax:
(303) 238-6155

1048 INDUSTRY DRIVE • SEATTLE, WASHINGTON 98188 • U.S.A. • (206) 575-0160 • FAX (206) 575-1329
Bill To: Bureau of Reclamation  
P.O. Box 25007  
Denver Federal Center  
Denver, CO 80225-0002

Ship To:  
Same

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<thead>
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<th>Per</th>
<th>Extension</th>
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</thead>
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<td>1</td>
<td>2100-TSR-KIT, Current velocity meter for use with USGS top-set wading rod (Rod not included)</td>
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<td>$1,560.00</td>
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<td>1 @ 3 Lbs</td>
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SHIPPING: $6.75  
Sub Total: $1,566.75  
Total: $1,566.75

 Terms: 2% 15, Net 30 Days  
Date to Ship: Within three weeks of order

By: [Signature]

Date: Sep/15/92  
F.O.B. Seattle  
Phone: (303) 236-7684  
Fax: (303) 236-6155
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

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.

Accusonic Division
P.O. Box 709
Falmouth, MA 02541

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  
2. 19" Rack Mountable Chassis  
3. Portable Enclosure (Shock Resistant)  2,500.

B. Power Requirement

1. 115 VAC ±10% 50/60 Hz Power  
2. 220 VAC ±10% 50/60 Hz Power  
3. 105 VAC ±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)  
6. Isolated 4-20mA output 2-channel  

E. Other  

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

* 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 (1000 psi) 850.
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. Model 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.

*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

1. Fan and Filter 3,500.
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.

B. RG59 or RG62 with E-O type Connector—for Model 7601 and 7600 Transducers.

C. HDPE Jacketed RG59 with E-O type Connector—for use inside the pipe with Model 7630 and 7634 Transducers.

D. HDPE Jacketed RG108—for use underwater with Model 7612 Transducers.

E. RG108 for use out of the water with Model 7612 Transducers.

F. RG111 A/U Armored Cable with Connector—for use with Model 7611 Transducer.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>RG59 or RG62 without Connector</td>
<td>$0.30/ft</td>
</tr>
<tr>
<td>RG59 or RG62 with E-O type Connector</td>
<td>$0.60/ft</td>
</tr>
<tr>
<td>HDPE Jacketed RG59 with E-O type Connector</td>
<td>$0.85/ft</td>
</tr>
<tr>
<td>HDPE Jacketed RG108</td>
<td>$0.75/ft</td>
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<tr>
<td>RG108 for use out of the water</td>
<td>$0.50/ft</td>
</tr>
<tr>
<td>RG111 A/U Armored Cable</td>
<td>$3.50/ft</td>
</tr>
</tbody>
</table>
VI. Peripheral Items for Flowmeter

A. 4-digit LED Remote Display Unit--Panel Mount
    Panel Kount 700.
B. 4-digit LED Remote Display Unit--Wall Mount
    Wall Kount 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.


2. Druck Pressure Sensor 2,500.
3. YEW Power Meter 12,000.
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

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<tr>
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<tbody>
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<td>Transmitter</td>
<td>7400-10003</td>
<td>700.</td>
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<tr>
<td>Dual Path Selector</td>
<td>7400-10004</td>
<td>1,325.</td>
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<tr>
<td>Path Selector Module</td>
<td>7400-10005</td>
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<td>Receiver</td>
<td>7400-10006</td>
<td>675.</td>
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<tr>
<td>Triple Power Supply</td>
<td>7400-10007</td>
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<tr>
<td>Watchdog Timer</td>
<td>7400-10013</td>
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<td>16 Slot Cardfile</td>
<td>7400-10014</td>
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<td>CPU</td>
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<td>SIO</td>
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<td>TTL I/O</td>
<td>7400-10038</td>
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<td>8-digit Display</td>
<td>7400-10084</td>
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<td>Multilevel Driver</td>
<td>7400-10085</td>
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<td>14-digit Display</td>
<td>7400-10086</td>
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<td>Keypad Interrupt</td>
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<td>EPROM</td>
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<td>4K CMOS RAM</td>
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<td>Calendar Clock</td>
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<td>4 x 4 Keypad</td>
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<td>2 channel D/A, D/I</td>
<td>7400-10109</td>
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<td>Receiver Module</td>
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<td>Asblank</td>
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<td>DIAG 80</td>
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<tr>
<td>NEMA Box Heater</td>
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<td>RTU-1</td>
<td>7400-10271</td>
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<tr>
<td>Dual Contact Closure</td>
<td>7400-10367</td>
<td>500</td>
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</table>
TO:                ATTN: JOE KUBITSCHEK
                   BUREAU OF RECLAMATION
                   D3751
                   PO BOX 25007
                   DENVER CO 80225-0007

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.

#992CNSL - TRANSDUCER CABLE SET..................$ 50.00 EA.

#995T - HANDHELD CONTROL/DISPLAY UNIT................$ 395.00 EA.

#994-7 - ANALOG DATA COMPUTER FOR 4-20MA OUTPUT....$ 225.00 EA.

OVER 20', ADD $1.50/FT.

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.
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.

<table>
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<td>2010-DS</td>
<td>DataSonde Submersible Datalogger (T, C)</td>
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<td>2020-DS</td>
<td>DataSonde Submersible Datalogger (T, C, pH)</td>
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<td>DataSonde Submersible Datalogger (T, C, pH, TDO)</td>
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<td>2070-DS</td>
<td>DataSonde Submersible Datalogger (T, C, TDO, pH, R)</td>
<td>(each includes calibration/maintenance kit)</td>
<td>3,800</td>
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<td>LISREF</td>
<td>LOW IONIC STRENGTH REFERENCE ELECTRODE (for solution conductivities &lt;0.2 mmho/cm)</td>
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<tr>
<td>8400-020</td>
<td>FLOW CELL</td>
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<td>240.</td>
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<td>5200-20XX</td>
<td>DMU (Data Management Unit) (with dual-RS232 I/O ports, includes: power supply, data-recovery cable, &amp; operating/service manual)</td>
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<td>2,100</td>
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<tr>
<td>IBMPCIK</td>
<td>IBM PC INTERFACE KIT (includes RS232 I/O card, interface-cable &amp; terminal emulator program)</td>
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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 11 910-874-1335 Hydrolab Aus
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**  

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<tr>
<td>1</td>
<td>SYS-1 COMPLETE DATA ACQUISITION SYSTEM- Includes a 16 channel PROCESS-ACQ Data acquisition system with menu driven software (-MS), signal conditioning (-SC), printer driver (-PD), real-time graphics (-RTG), and multi-tasking (-MT186). 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.</td>
<td>SYS-1</td>
<td>$6745</td>
</tr>
</tbody>
</table>

**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.  

[Signature]

Russ Graybill
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.

[Signature]

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

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.

   O'Neill Pumping/Generation Plant. Unit annual maintenance. One unit at a time unless manpower and/or pumping schedule permits an additional unit outage.

   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.