



**OPERATIONS AND
MAINTENANCE MANUAL REV. 1
MINE WATER DIVERSION DAM
NID ID# AK 00260
RED DOG MINE, ALASKA**

For

**TECK COMINCO ALASKA, INC.
URS JOB NO. 33757358
August 5, 2005**

**Original – May 31, 2002
Revision 1 – August 5, 2005**

August 5, 2005

Mr. Jim Swendseid
Teck Cominco Alaska, Inc.
Red Dog Operations
3105 Lakeshore Drive, Building A, Suite 101
Anchorage, Alaska 99517

Operations and Maintenance Manual
Mine Water Diversion Dam
NID ID# AK 00260
Red Dog Mine, Alaska
PO 1245255-S, Contract RD-2-06
URS Job No. 33757358

Dear Mr. Swendseid:

We are pleased to submit three copies of the Operations and Maintenance (O&M) Manual, Revision 2, for the Mine Water Diversion Dam at Red Dog Mine. Revision 2 supercedes all previous versions of the manual. The dam is also known as the Red Dog Creek Dam.

The scope of this work was authorized by Teck Cominco Alaska, Inc., in Purchase Order No. 1259053S, Contract No. RD-02-06.

We thank you for the opportunity to have been of service and we trust that the information provided will be useful in the operation of the mine water diversion system. Please call if you have questions or need additional information.

Yours truly,

URS CORPORATION



Cecil M. Ulrich, P.E.
Vice President

**OPERATIONS AND MAINTENANCE MANUAL
REVISION 1**

**MINE WATER DIVERSION DAM
NID ID# AK 00260**

RED DOG MINE, ALASKA

**Prepared by
URS Corporation
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**Prepared for
Teck Cominco Alaska Inc.
Red Dog Mine, 3105 Lakeshore Drive,
Building A, Suite 101, Anchorage, AK 99517**

August 5, 2005

APPENDICES

- Appendix A - Daily and Weekly/Quarterly Inspection Sheets
- Appendix B - Operation and Maintenance Procedures for Piezometer Data Collection
- Appendix C - Operation and Maintenance Procedures for Thermistor Data Collection
- Appendix D - Inspection, Calibration and Maintenance Procedures for Data Collection Devices
- Appendix E - Operators Manual for Dedicated Ultrasonic Flowmeter
- Appendix F - Pollution Prevention and Best Management Practices Plan

PROJECT DATA SHEET

A. GENERAL

| | | |
|-------------------------|---|-------------------|
| Dam Name: | Red Dog Mine Water Diversion Dam | |
| NID Number: | AK 00260 | |
| Hazard Potential Class: | Class III | |
| Purpose: | Diversion of mine water runoff to tailings pond | |
| Year Built: | 1991 | |
| Year Modified: | 1992 Pump system modified | |
| Location: | N 68-04-08 W 162-52-40 | lat/long (GPS) |
| Reservoir Name: | Mine Water Retention Basin | |
| River or Creek Name: | Red Dog Creek | |
| Owner: | Teck Cominco Alaska, Inc | |
| Owner Contact: | Jim Swendseid, P.E. | |

B. DAM

| | | |
|------------------------------|--|------|
| Type: | Rockfill Embankment | |
| Core Type: | Geomembrane and bentonitic clay liner system | |
| Crest Length: | 350 | feet |
| Crest Width: | 45 | feet |
| Crest Elevation: | 841 | feet |
| Crest Height (from d/s toe): | 25 | feet |
| Hydraulic Height: | 20 | feet |

C. PRIMARY SPILLWAY

| | | |
|----------------------------------|---|------|
| Type: | Open channel to Red Dog Creek diversion ditch | |
| Location: | Intersection of dam and diversion ditch dike | |
| Spillway Crest Elevation: | 841 | |
| Top Width: | 104 | feet |
| Bottom Width: | 100 | feet |
| Length: | 20 | feet |
| Discharge Capacity at Dam Crest: | >75 | cfs |

D. OUTLET WORKS

| | | |
|----------------------------------|---|--------|
| Type: | Eight submersible pumps (max) | |
| Location: | Timber dike retaining wall upstream of the dam | |
| Inlet Invert Elevation: | Varies from 800 to 830 | feet |
| Outlet Invert Elevation: | 950 | feet |
| Diameter: | Three 14-inch pipes. One insulated line regularly used. Two non-insulated lines available when eight pumps run. | inches |
| Length: | 2500 | feet |
| Outlet Type: | Open pipe | |
| Discharge Capacity at Dam Crest: | 23 | cfs |

E. RESERVOIR

| | | |
|------------------------------------|-----|-----------|
| Normal Water Surface Elevation: | 820 | feet |
| Normal Storage Capacity: | 0 | acre-feet |
| Maximum Water Surface Elevation: | 841 | feet |
| Maximum Storage Capacity: | 58 | acre-feet |
| Maximum Surface Area at Dam Crest: | 5 | acres |
| Surface Area at Spillway Crest: | 5 | acres |

F. HYDROLOGY

| | | |
|---------------------------------|----------------------------|-----------|
| Drainage Basin Area: | 0.34 | sq. miles |
| Average Annual Rainfall: | 17.5 | inches |
| 100 Year/24 Hour Rainfall: | 2.5 | inches |
| 100 Year Flood: | 75 (1" rain in 60 minutes) | cfs |
| Probable Maximum Precipitation: | 5.9 | inches |
| Probable Maximum Flood: | Not applicable | cfs |
| Flood of Record: | Not applicable | cfs |
| Inflow Design Flood: | 75 | cfs |

1.0 INTRODUCTION

This Operations and Maintenance (O&M) Manual, Revision 1, provides operation and maintenance guidelines for the mine water diversion dam at the Teck Cominco Alaska Inc. (TCAK) Red Dog Mine in Alaska. The dam is also known as the Red Dog Creek mine water diversion dam and Red Dog Creek dam.

The mine water diversion dam is classified by Alaska Department of Natural Resources (ADNR) as a Class III (low hazard) dam as defined in Title 11 of Alaska Administrative Code (AAC) 93.157. This classification is assigned to a dam if it is determined that the failure or improper operation of the dam will result in:

- (a) limited impacts to rural or undeveloped land, rural or secondary roads, and structures;*
- (b) property losses or damage limited to the owner of the barrier; or,*
- (c) insignificant danger to public health."*

The O&M program is defined by the U.S. Bureau of Reclamation as a *"systematic means of ensuring that a dam is operated and maintained adequately for ensuring the continued safe operation of the dam and the continued productive use of the reservoir."* The O&M Manual fulfills the requirements of "Guidelines for Cooperation with the Alaska Dam Safety Program," dated September 26, 2003.

The O&M Manual describes procedures for operating the mine water diversion dam under normal and extreme reservoir level and flow conditions. It also provides technical guidance and procedures for monitoring, inspection, and long-term maintenance programs. The following information is included in this O&M Manual:

- General information, including a description of the dam, its purpose and features, and identification of the parties responsible for its requirements.
- Project data sheet completed with information compiled during a Periodic Safety Inspection of the dam in October 2004.
- Operating guidelines such as valve opening and closing procedures and stage-storage-discharge curves.
- Schedule for routine maintenance of all aspects of the system that require routine attention, as well as maintenance instructions, if required.
- Schedule for routine inspection and monitoring, including a site-specific visual inspection checklist and data forms.
- Description of unusual conditions that could occur and operating procedures to be performed under those conditions, including special inspections and incident reporting.

This Revision 1 of the O&M Manual supercedes previous versions of the manual. The responsibility, location and distribution of the manual at the mine site are discussed in Section 3.0.

- Non-woven geotextile protection above and below the composite liner system
- One-inch minus crushed rock fill bedding material above and below the geotextile
- Riprap protection on the upstream slope of the dam
- Instrumentation consisting of piezometers and thermistors in and around the dam.

The diversion dam temporarily impounds mine water in the retaining basin during peak flows. During normal operations, excluding spring breakup and large storms, there is little to no water behind the dam. Water is only retained behind the dam when inflow to the basin exceeds the pump capacity. During years of heavy precipitation, this has occurred over two one-week periods.

2.2. SPILLWAY

The spillway crest is a low part of an access road that separates the retaining basin from the diversion channel. The crest discharges to the diversion channel, which discharges over a chute to Red Dog Creek. The spillway crest is at El. 841 which is one foot below the dam crest. The spillway consists of the following major components.

- Crest consisting of a 1.0-foot deep low part of the access road
- Crest width of 150 feet at the base and 250 feet at the top to facilitate vehicle access
- Channel that is the lowest part of the clean water diversion channel
- Chute in a relatively steep rock cut at the end of the diversion channel below the dam.

The purpose of the spillway is to discharge water from the retaining basin if the inflow to the basin exceeds the combined capacity of the basin and pumpback system. The basin has a capacity of about 45 acre-feet to the spillway crest, however, continuous pumping keeps the water level low. The access road provides access for maintenance vehicles to the retaining basin.

2.3. PUMPBACK SYSTEM

The pumpback system is located in the lower south part of the retaining basin upstream of the left abutment of the dam. The system operates using two to eight pumps to remove mine water from the retaining basin, and convey the water by means of up to three pipelines to the tailings facility. It consists of the following major components:

- Timber crib retaining wall used to hang up to eight pumps into the retaining basin.
- A 6-foot diameter corrugated metal pipe (CMP) extending down the wall to a sump.
- Two Flygt BS2400 submersible pumps in the CMP at lower sump levels for winter use.
- Four Flygt BS2400 submersible pumps and four Grundfos 1000s750-2 turbine well pumps.
- One insulated 14^ø-inch-diameter and 2,400-foot-long HDPE pipelines to the tailings facility

The location of the official O&M manual shall be in the office of the Responsible Party. In addition the "Responsible Party" shall distribute copies of the O&M manual to other mine staff with mine water diversion responsibilities.

3.2. REGULATORY REFERENCE DOCUMENTS

The Responsible Party should have available, and be familiar with, the following documents prepared by the Dam Safety and Construction Unit, Water Resources Section, Division of Mining, Land and Water, Alaska Department of Natural Resources (ADNR):

- "Revision 1 of the Guidelines for Cooperation with the Alaska Dam Safety Program", June 30, 2005, based on revisions to Alaska dam safety regulations articulated under Article 3 of 11 AAC 93.
- "Certificate of Approval to Operate a Dam" to Teck Cominco Alaska Inc., for Red Dog Mine Water Diversion Dam (NID ID#AK00260).

A new Certificate of Approval to Operate a Dam will be issued by ADNR after the most current PSI report and O&M manual are approved by ADNR.

3.3. PROJECT REFERENCE DOCUMENTS

The Responsible Party should have available, and be familiar with, the following project documents, or with any superceding updates of these documents:

- Cominco Engineering Services Ltd (CESL), "Red Dog Mine Drainage Project: Water Management. Volume I and II," January 1991.
- EBA Engineering, Inc. "Geotechnical Field Report: Mine Water Diversion Dam 0731-0175," for Cominco Engineering Services Ltd., January 1991.
- EBA Engineering, Inc. "Design of Mine Water Diversion Dam: Supporting Design Report," for Cominco Engineering Services Ltd., January 1991.
- EBA Engineering, Inc. "As-Built Report, Mine Water Diversion Dam 0731-0175/7," for Cominco Alaska Ltd., September 1991.
- Teck Cominco Alaska, Inc., "2004 Annual Instrumentation Report, Red Dog Creek Mine Water Diversion Dam, Red Dog Mine", to ADNR, January 10, 2005 (and all annual reports).
- URS Corporation "Minewater Pumpback Facility Retaining Wall (Crib)", Memorandum to Teck Cominco Alaska Inc., September 27, 2001.
- URS Corporation "Report, Red Dog Creek Pumpback Retaining Wall Stabilization Temporary Support System, Red Dog Mine, Alaska", May 8, 2002.
- URS Corporation "Periodic Safety Inspection Report, Mine Water Diversion Dam, Red Dog Mine Project," for Teck Cominco Alaska, Inc., August 5, 2005.

When signs of an impending break-up appear each spring, the daily inspection must increase attention at the spillway and pump sumps for any obstructions that might block flow, such as floating ice and other debris. Promptly remove any such materials, and increase the frequency of checking as necessary to prevent the spillway and sumps from becoming blocked.

4.2. WEEKLY INSPECTION

The mine water diversion dam and surrounding areas should be visually inspected weekly for any unusual behavior. This inspection is more detailed than the daily inspection, and is documented in the “Visual Mine Water Diversion Dam Inspection” sheet in Appendix A.

The duties of the mine staff responsible for the weekly inspection are to fill out the “Visual Mine Water Diversion Dam Inspection” sheet by completing the following:

- Identify the temperature range and general observations of the weather condition, wind, wave action and snow cover
- Visually scan the mine water diversion dam, spillway and surrounding areas for unusual behavior
- Visually scan the pump station retaining wall for bulges and settlement, and the pump station buildings and the three pipelines for unexpected behavior
- Inspect the crest, toe, east buttress, west buttress, upstream slope and downstream slope for signs of cracks, slumps and seepage
- Promptly report any unexpected behavior or unto the Responsible Party and describe in the “Other comments” section of the inspection sheet.

In the event of an unexpected behavior, the Responsible Party is to:

- Investigate and assess if the behavior is an unusual occurrence or emergency as defined later in this O&M Manual, and take appropriate action
- Keep a written log of the date, nature of the unexpected behavior, action taken, and other pertinent information

4.3. QUARTERLY INSPECTION AND MAINTENANCE

At quarterly intervals, the Responsible Party should walk over the diversion dam, spillway and pumpback system areas, closely view the retaining wall, and inspect all accessible parts of the system. This inspection is documented in the same “Visual Mine Water Dam Inspection” sheet in Appendix A that is used for the weekly inspections.

The spillway, dam toe and retaining wall base areas are inaccessible for close examination during the winter because of snow. Therefore, attempts should be made to complete two of the four

5.0 INSTRUMENTATION MONITORING

5.1. INSTRUMENTATION DESCRIPTION

Instrumentation for monitoring the dam and pump back facility include:

- Thermistors for collecting temperature data.
- Piezometers for collecting water level data
- Flowmeters for estimating the quantity of mine water pumped to the tailings pond.
- Water level detectors for maintaining operating levels in the retaining basin.
- Prism targets on the retaining wall for monitoring wall movements.

The approximate locations of these instruments are shown on Plate 1. Instrumentation results should be considered along with the inspection results and other data to evaluate if problems exist and there is a need for repair, maintenance or further study.

5.1.1 Thermistors

Three thermistors (T-1, T-2 and T-3) are located along the downstream edge of the dam crest. Their lengths are 70, 100 and 100 feet respectively. T-1 is located at the left abutment. T-2 is located in the south part of the dam over the creek channel. T-3 is located at the right abutment contact with the access road.

The thermistor strings are YSI 44034 equivalent and are manufactured by Dryden Instrumentation of Anchorage, Alaska. These instruments measure foundation temperatures to indicate the presence and extent of thawed zones through which seepage could occur.

5.1.2 Piezometers

Seven piezometers (P-1 to P-7) have been installed to characterize water levels and ground water flow in relation to the drainage system. The piezometers are vibrating wire type transducers manufactured by Geokon of Lebanon, New Hampshire.

Three piezometers (P-1, P-3 and P-6) are located along the downstream edge of the dam crest near thermistors T-1, T-2 and T-3, respectively. P-1 is at the left abutment. P-3 is in the south part of the dam over the creek channel. P-5 is at the right abutment contact with the access road. The transducers are located from 11 to 15 feet into the original ground.

Two piezometers (P-2 and P-5) are installed along the centerline of the dam crest, near the left and right abutments, respectively. P-2 is directly upstream of T-2 and P-3. P-5 is directly upstream of

T-3 and P-6. The transducers are located in the dam fill, approximately at the original stream bed elevation of 817 feet (El. 817).

Two piezometers (P-4 and P-7) are located in the creek channel at the downstream toe of the dam about 100 feet from the crest centerline. P-4 is in line with P-2 and P-3. P-7 is not lined up with any dam piezometers. The transducers are below the creek bed at El. 798.

5.1.3 Flow Meters

The Doppler flow meters installed in the three pipelines provide an estimate of the total volume of mine water pumped from the retaining basin to the tailings facility. The flow meters are manufactured by Polysonics of Houston, Texas. They are permanent, non-contact, ultrasonic flow meters that measure fluid flow from the outside of full pipes.

5.1.4 Water Level Detectors

Water levels in the retaining basin are controlled by a PLC (Programmable Logic Controller) tied into an ultrasonic level detector. It is programmed to track the minimum and maximum flows and calculate the average for the day. Every 24 hours, this file is saved and readings start being recorded for the next 24 hours.

5.1.5 Prism Targets

Six prism targets are located in a bulged area of the retaining wall to monitor the lateral and vertical displacement of the wall. The targets are placed in pairs in the upper and lower parts of the wall in three vertical planes.

5.2. DATA COLLECTION

5.2.1 Frequency of Data Collection

Thermistors are to be read:

- Quarterly under normal retaining basin operating conditions

Piezometers are to be read:

- Quarterly under normal retaining basin operating conditions
- Monthly if the water level behind the dam is rising at a rate faster than six inches per day
- Weekly if the water level behind the dam is rising at a rate faster than one foot per day
- Daily or more frequently if either:
 - flooding causes the water level in the basin to rise above El. 840
 - unusual seepage develops at or near the dam
 - any piezometer shows sudden changes in water level

Flow meter and water level indicator data are to be recorded and saved as follows:

- Record data by the automated PLC system.
- Save the file every 24 hours and start the new day's readings.

The retaining wall prism targets are to be read:

- Quarterly under the following situations:
 - normal retaining basin operating conditions
 - no visible wall movement
- Every two weeks or more frequently if either:
 - wall movement is visually observed
 - flooding causes the water level in the basin to rise above El. 829.5
- Some event may require that readings be taken more frequently than under normal operation conditions. Such readings must continue at the increased frequency until the event is over, and until either the readings have returned to the pre-event condition, or the situation has stabilized.

During the next PSI of the mine water diversion dam, the schedule of readings should be reviewed and the reading intervals should be modified as warranted.

5.2.2 Data Collection Methods

The elevation of water in the retaining basin and location of any unusual seeps should be noted when the instrumentation data are recorded.

The Responsible Party must be alert for erratic or unreasonable readings that may indicate instrument malfunctions or operator error. Instruments must be re-read or repaired as necessary.

5.2.2.1 Thermistor Data

Thermistor data can be read either manually or with automated data recording devices. Thermistor readings should include resistance values from each thermistor. Data from thermistors are read using either:

- The automated procedure using Hewlett Packard 200 collector and a T5KMUX analog to digital converter and multiplexer.
- Fluke multimeter and Dryden instrumentation switchbox.

Standard operating procedures for data collection, inspection, calibration, and maintenance procedures for the thermistors are summarized in the Appendix C.

5.2.2.2 Piezometer Data

Data from the vibrating wire piezometers are to be read using a GEOKON GK-403 data recording device. Readings should include resistance values from each piezometer. There may be occasional erratic and false readings due to:

- Atmospheric pressure changes because there is no head pressure on the upstream side of the dam and the piezometers are relatively shallow.
- Ice buildup in the well if the internal thermistor within the piezometer indicates frozen ground and the water level is elevated.

Standard operating procedures for data collection, inspection, calibration, and maintenance procedures for the piezometers are summarized in Appendix B.

5.2.2.3 Flow Meter Data

Flow meter data, along with water level measurements in the retaining basin, are to be displayed on a screen in the Mill control room including several alarms. The flow rates of mine water pumped from the retaining basin should be reviewed annually to estimate winter and summer quantities.

The operator manual for the flow meters is included in Appendix E.

5.2.2.4 Water Level Data

Water level data from the retaining basin, along with flow meter data, are to be displayed on a screen in the Mill control room including several alarms. Pump “turn on/shut off” indicators are set to maintain the water level at El. 820. Maximum water level data should be plotted annually against piezometer data to note any trends that may exist.

Appendix E describes the management of the pumpback system.

5.2.2.5 Prism Targets

Survey measurements of the two prism targets on the retaining wall are to be plotted as displacements from an assumed vertical plane against time. TCAK has defined a vertical plane that intersects the corners of the wall, and assumed that the wall was built vertical and the corners have not moved. The “y” axis of the plane is coincident with the wall. Positive changes along the “x” axis represent movement of the wall out from its original position.

The magnitude and rate of change of “x” is the most critical information to be obtained from the surveys. This should be monitored, especially during any visual observations of movement, during

drawdown of water through the wall backfill after the wall may have been partly inundated, and during the freeze thaw activity.

The magnitude and rate of change of “y” represents settlement of the wall and must be monitored. This is not as critical as the “x” movement, but excess vertical movement could cause differential settlement of the ground surface and possible damage to the surface pump and pipe systems, especially at pipe connections.

6.0 UNUSUAL OCCURENCES AND EMERGENCIES

6.1. UNUSUAL OCCURRENCE PROCEDURES

Unusual occurrences are events or conditions that are not normally encountered during routine operations and which may endanger the facility. Examples include:

- Storms and floods.
- Earthquakes.
- Increased seepage or changes in seepage character.
- Landslides around the reservoir perimeter and dam area.
- Fire or explosions.
- Human interference by terrorism, vandalism, or accidents.
- Incidents of potential environmental damage.
- Imminent rise of basin water level above the flood storage threshold.

The following steps are to be taken in the event of an unusual occurrence:

- Immediately report unusual occurrences to the Responsible Party and Mine Management.
- Promptly make a special inspection and evaluate the significance of the occurrence.
- Take protective or corrective actions as appropriate for the nature of the occurrence.
- Activate emergency procedures discussed below, if necessary.
- If emergency procedures are activated, inform State Dam Safety Engineer within 24 hours.

6.2. EMERGENCY PROCEDURES

Emergencies are serious situations which develop suddenly and unexpectedly, threaten the structural integrity of the dam, and demand immediate attention. Examples include:

- Impending or actual release of water caused by improper operation, accidental damage, sabotage, or general failure of the dam and its appurtenances.

- Impending flood conditions, even when the dam is not in danger of failure.
- Unusual increase in either seepage or turbidity of the seepage.
- Large or local earthquakes.

Emergencies should be handled by putting pre-existing contingency plans into action. If emergency procedures are activated, inform the State Dam Safety Engineer and the dam design engineer within 24 hours.

6.3. CONTINGENCY PLAN

The contingency plans should be periodically reviewed and updated. Contingency plans have been developed to address the potential for two types of failure:

- Hydrologic failure that results in water flow over the dam and spillway because of flooding of the retaining basin.
- Structural failure that would most likely occur as a result of catastrophic events such as an earthquake or human interference.

6.3.1 Hydrologic Failure

Three possible reasons for a hydrologic failure that could cause the retaining basin to fill faster than it can be pumped out are as follows:

- High precipitation or runoff collection from the mine and exploration areas
- Pump or power malfunction and higher than normal precipitation or runoff
- Failure of the retaining wall that would immobilize the pumpback system.

If the pond level reaches El. 829.5, one or more of the following measures are to be taken:

- Mobilize and use backup pumps and generators
 - Build impoundments to temporarily retain mine water on lower benches in the mine area
 - Use sandbags, riprap and other available materials for extra erosion control
- Check that the spillway in the access road is clear and graded to specifications

6.3.2 Structural Failure

Based upon the level of monitoring, inspection and maintenance conducted on the mine water diversion dam, it appears that any failure that might occur will most likely be the result of a major catastrophic event such as an earthquake or vandalism:

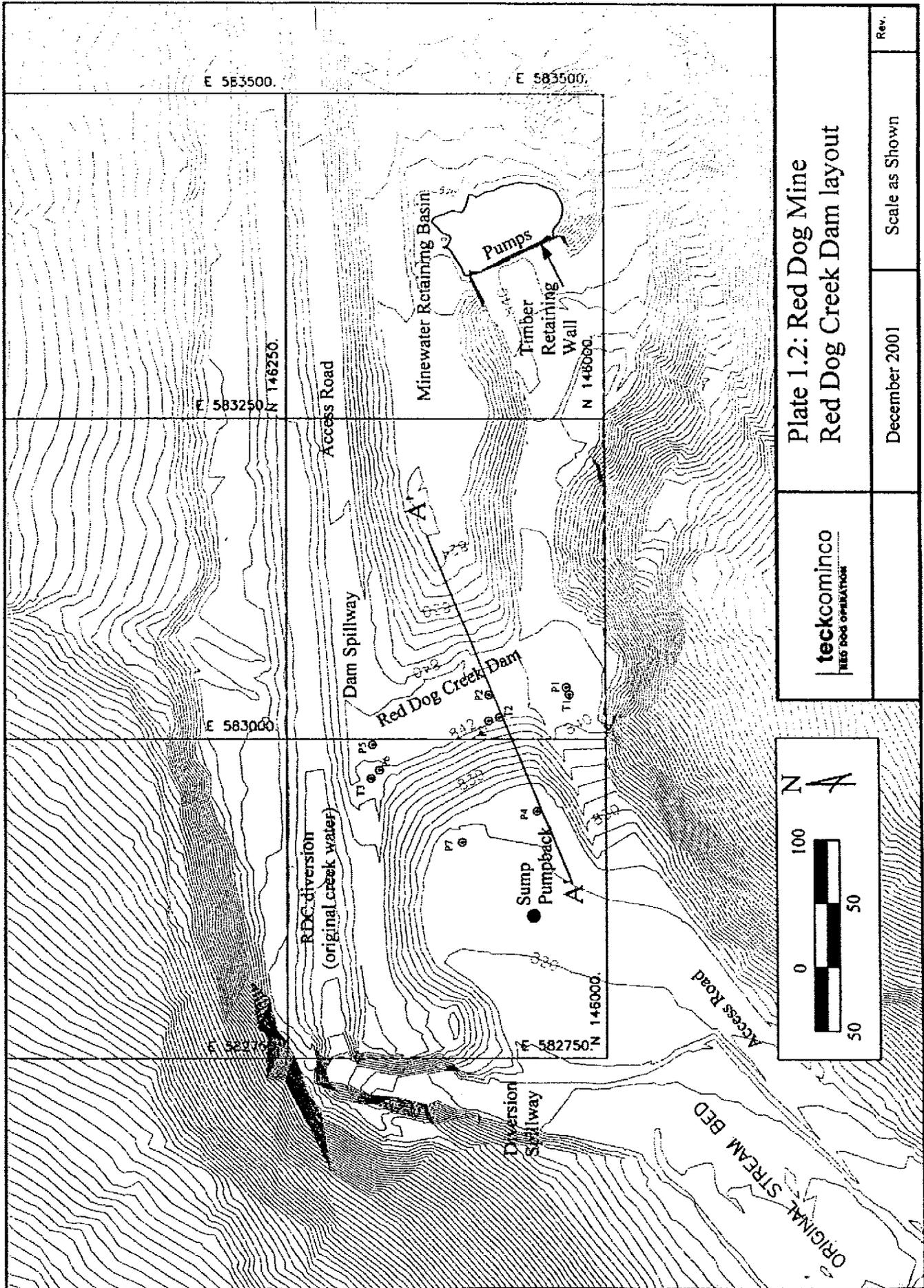
- If the pumpback system is intact, continue pumping the retaining basin to below El. 820. If the pumpback system was not intact, implement the contingencies in Section 6.3.1.

- If the retaining basin is full, downstream erosion damage will be minimal. Most sediment will likely not flow beyond the culverts at the confluence of Red Dog Creek and South Fork Red Dog Creek, and probably not beyond the fish weir.

Implement the following emergency action plan to the pumpback system retaining wall if the wall experiences any new movement that is sudden and rapid, which could indicate an accelerating condition that may not provide enough time to install the support system. The emergency plan could include:

- Dumping a rock fill buttress in front of the wall
- Installing a steel cable retention system across the face of the wall, with both ends of each cable attached to anchors drilled into the ground beside the walls.

DRAWINGS



| | | |
|---|---|----------------|
|  RED DOG OPERATION | Plate 1.2: Red Dog Mine Red Dog Creek Dam layout | |
| | December 2001 | Scale as Shown |
| | | Rev. |

APPENDIX A

DAILY AND WEEKLY/QUARTERLY INSPECTION SHEETS

EMS Daily Dam & Pumping Inspection Sheet

Visual Mine Water Diversion Dam and Seepage Pond Inspection

EMS DAILY DAM & PUMPING INSPECTION SHEET

Date: _____ Name: _____

Temperature _____
 General Weather _____
 Condition _____

Overburden Diversion System

| | | | | | | | | |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Check condition of all pumps & piping as well as roads | Operating | | Lines Intact | | Berms Intact | | Spills | |
| | Yes | No | Yes | No | Yes | No | Yes | No |
| | <input type="checkbox"/> |

Comment _____

RedDogCreekPumpback & Dam

| | | | | | | |
|--|--------------------------|--------------------------|---------------------------|--|--------------------------|--------------------------|
| Surfaces checked for; cracks, leaks and slumps | Crest | Toe | East Buttress | West Buttress | Downstream Slope | Upstream Slope |
| | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| Auxiliary pump operating | Yes No | | Water Level (high/low) | Number of Pumps Avail. Grunfos Bibo | | |
| | <input type="checkbox"/> | <input type="checkbox"/> | | | | |

Comment _____

Tailings Dam

| | | | | | | |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Surfaces checked for; cracks, leaks and slumps | Crest | Toe | East Buttress | West Buttress | Downstream Slope | Upstream Slope |
| | <input type="checkbox"/> |

Comment _____

Seepage Dam

| | | | | | | | |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|---------------------------|
| Surfaces checked for; cracks, leaks and slumps | Crest | Toe | East Buttress | West Buttress | Downstream Slope | Upstream Slope | Water level (high/low) |
| | <input type="checkbox"/> | |

Comment _____

Freshwater Dam

| | | | | | | |
|--|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| Surfaces checked for; cracks, leaks and slumps | Crest | Toe | East Buttress | West Buttress | Downstream Slope | Upstream Slope |
| | <input type="checkbox"/> |

Comment _____

**Cominco Alaska Incorporated - Red Dog Mine
Engineering Department
Visual Red Dog Creek Diversion Dam Inspection**

| | | | |
|--------------------------|----------------------|-------------|---------------------|
| <input type="checkbox"/> | Annual Inspection | Date: _____ | Mine Shifter: _____ |
| <input type="checkbox"/> | Quarterly Inspection | Time: _____ | Engineering: _____ |
| <input type="checkbox"/> | Weekly Inspection | | |

Temperature: 81 to above 21 to 40 -21 to -40
 61 to 80 0 to 20 -41 to -60
 41 to 60 -1 to -20 -61 to below

Circle observations:

Weather: (Clear, Scattered Clouds, Overcast, Rain, Snow)
 Winds: (none, light, medium, high) and (NE, NW, SE, SW)
 Snow cover on dam: (none, uniform, unexpected areas of melting, normal melting)
 Visibility due to snow cover: (good, moderate, poor)
 Retaining basin water level: (no change, rising, dropping) and (open, partially frozen, fully frozen)

RDC diversion dam: circle "yes" or "no" to the existing conditions:

| | Crest | Toe | Abutments | Upstream Slope | Downstream Slope |
|-----------------------------------|----------|---|---|----------------|---|
| Poor visibility due to snow cover | yes / no | yes / no | yes / no | yes / no | yes / no |
| Cracks | yes / no | yes / no | yes / no | yes / no | yes / no |
| Slumps | yes / no | yes / no | yes / no | yes / no | yes / no |
| Seepage | | yes / no | yes / no | | yes / no |
| Changes in seepage | | (circle one) no change increased flow decreased flow | (circle one) no change increased flow decreased flow | | (circle one) no change increased flow decreased flow |

Other comments: _____

Dam Spillway & Diversion Spillway: "X" or circle the existing conditions:

| | dam spillway | Diversion Spillway |
|--------------|--------------------------------------|--------------------------------------|
| Condition: | (good condition, requires attention) | (good condition, requires attention) |
| Water flow: | (none, low, medium, high) | (none, low, medium, high) |
| Ice buildup: | | (open, low, medium) |

Other comments: _____

MARK LOCATIONS ON MAP (REVERSE SIDE OF PAGE).

Report unexpected behavior promptly to the Mine Supt., Sr. Mine Engineer and Mine Ops. Coordinator.

APPENDIX B

**OPERATION AND MAINTENANCE PROCEDURES
FOR PIEZOMETER DATA COLLECTION**

PROCEDURE FOR READING PIEZOMETER AND ACTIVE LAYER PIEZOMETER DATA AND DOWNLOADING THE GEOKON GK-403 READOUT BOX

Collecting Piezometer Data

- Place the Geokon switch in position 'G'. In this position, the Geokon will store data into a 2D array that has 256 columns and 256 rows. Each piezometer is designated by its own column, with each row storing a different reading for that piezometer. In our case, the readings are grouped by week, so we store data in the row that corresponds to the week being read, for example Week #1 readings are stored in Row 1. This facilitates the downloading process and confines the data to the first 4 rows. The sequence of column numbers and piezometer names is shown at right.
- To take a reading for a specific piezometer, scroll to the row designated for that week and over to the column designated for that particular piezometer. Use the joystick to change columns (←→) and rows (↑↓). The piezometer name should show in the center of the Geokon display, for example "ID: P6". It is important that the row number stays the same for each piezometer in the weekly group being read. The Geokon displays the reading that is currently in the array for that setting under the heading "MEM" (the bottom part of the display) and the reading that it is receiving under the heading "NOW" (the top part of the display). When you are satisfied that you are at the correct piezometer and in the correct row, check to see that the value for 'NOW' is reasonable (magnitude 1000) then push the 'select/store' button to record the data. If the 'NOW' reading is 999999, try adjusting the cable connection to get better contact.
- For piezometers that require Packer pressure, record the pressure on the packer pressure gauge in the 'Pre-psi' space on the piezometer form. If the pressure is more than 10 psi below the pressure written on the inside of the well cap, it must be repressurized before the next month's reading is taken. Follow the 'Pressurizing the Packer' directions overleaf.
- Repeat this for all the piezometers for the week. Once you have read all of them, download the GK-403 in the office following the 'Transferring Data' directions overleaf.
- **NOTE:** You must read the T-Dam Baro on each day of data recording. If you can not finish all the week's piezometers in one day, transfer the Geokon data at the end of the day as per the directions overleaf. After the data is transferred into the

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database, clear the old data from the row in the Geokon box. Re-read the T-Dam Baro on the next day or whenever the remaining readings are taken. This way the T-Dam Baro data will relate to each day's data and no data will be duplicated in the database.

Collecting ALP data

- Place the M-Scope probe in the well and note the depth to conductance. The depth should be measured from the top of the steel casing. If the water is frozen, record the depth to the top of the ice, or if there is ice in the bottom of the hole with water sitting on top of it, record the depths to both the water and the ice.
- Write the depth(s) in the space provided for the ALPs on the weekly check list form.

Pressurizing the Packer

- Do not try repressurizing the packer if the temperature is below -25°F as the Schrader valve starts sticking, making it impossible to hold the packer pressure. You should wait until the temperature rises to at least -25°F before trying to repressurize the packer.
- Remove the cap from the compressed nitrogen cylinder and install the 400psi regulator, tightening lightly with a 1-1/8 inch wrench. (These are normal right hand threads.)
- Open the cylinder valve, the primary gauge should read 2200psi or less.
- Open the pressure regulator valve until the pressure reads at least the required packer pressure.
- Connect the fill hose to the Schrader valve on the wellhead and pressurize to the pressure written on the inside of the well cap. **Do not over pressurize!**
- Record the final pressure in the 'Now-psi' space on the piezometer form.

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APPENDIX C

**OPERATION AND MAINTENANCE PROCEDURES
FOR THERMISTOR DATA COLLECTION**

Reading/Downloading Thermistors with the HP200

- Turn on the HP200 and check the date and time at the HP Banner. The HP 200 should always open and be closed at this banner to save batteries.
- Connect 9 pin HP 200 cable to the Dryden electronic box.
- Press the '&' key to bring up the more applications menu.
- Press the menu key and 'A' for the Application menu.
- Press 'T' for terminate all and 'OK' to terminate system manager.
- You are now in DOS mode at A:\THERMS> (if you are not, get there by typing "A:", "enter", then "CD THERMS")
- Press 'T24' and 'enter' to start the program.

File Opening

1. Type O to open a file for data collection.
2. Type in the name of the file with the following naming convention, "TM followed by the reading date", for example TM102497 for readings on October 24, 1997, and hit enter. At this point, you will get a new screen; type A for append, then enter.
3. You should be back at the options screen. At the top of the screen a message will appear giving the data file name, for example "Writing A:\THERMS\TM1024". This message is your check to know that the data collector is ready to read thermistors.

Reading Thermistor Data

1. Type R, for Read, to go to the Red Dog thermistor list
2. Connect the data collector to a thermistor.
3. Scroll down the list using the PGUP and PGDN keys until the thermistor you want to read is highlighted. Thermistor names are listed in the first column, locations in the second column.
4. Once on the thermistor name, hit the enter key to read the thermistor.
5. After 4 seconds the thermistor data will come up on the screen. Typing O will Ok the reading, typing R will Reread the thermistor, and typing C will Cancel the reading.
6. Repeat steps 2 to 6 until all the thermistors you want to read have been read.
7. When you have finished reading thermistors for the day, you will be at the Red Dog thermistor list that step 1 refers to. Hit X to exit reading mode.

Closing Down the Data Collector

1. Hit 200 at the DOS prompt and you will go back to the HP banner and can shut off the HP200.

Transferring the downloaded files from HP200 to server

1. Connect HP200 to desktop serial port
2. Open transfile software executable: On the PC side, start the trwin200.exe program by clicking on the "Start" menu "Mine survey_engineering -> tfwin200". On the HP side, type "&", then "F".
3. Drag files from A drive of HP200 to: Y:\Minetech\Inter\Monitor\THERMIS\RAWDATA
4. To turn off The HP200, type "CTRL Menu", "menu F X", "menu A X" to get to the banner.

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Updating the Excel thermistor files

1. Start the Update Macro by clicking the “UpdateThermsXLS” icon in the “Mine survey_engineering” menu.
2. Type in the name of the thermistor rawdata file to be dumped, and enter.

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Standard Operating Procedure for Obtaining Thermistor String Readings “Fluke Multimeter”

Equipment:

- 1 Thermistor Well Data form
- 1 Pencil
- 1 Fluke multimeter with leads (Fluke model 23, Series II)
- 1 Dryden Instrumentation Switchbox
- 1 #2126 Master padlock key

Procedure:

- Drive to well.
- Unlock and remove the protective cap.
- Pull excess thermistor cable from well casing.
- Remove dust cover from the 50 pin male plug on cable end.
- Connect the leads to the multimeter by pushing the black lead into the port labeled ‘com’ and the red lead into the port labeled ‘ Ω ’ (ohms).
- Connect the red and black leads from the multimeter to the red and black terminal posts on the switchbox.
- Turn on multimeter by turning the main selector switch to ‘ Ω ’ DC.
- Meter should read 0.00.
- Push toggle switch on switchbox to “Test” position.
- Record the reading displayed on the multimeter on the Thermistor Well Data form. The reading should be very close to the number stamped on the faceplate of the Dryden switchbox (16325 Ω (Because the multimeter is an auto-ranging type it may read 16.32 or 16.33 K Ω). If the multimeter does not display something close

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to this reading then the multimeter is too cold. (See operating range for the multimeter in the owner's manual). Warm the multimeter and try again. You may wish to change the battery in the multimeter.

- Turn right toggle to "read" position.
- Turn left toggle to "1 - 12" position.
- Turn selector switch to "1" position and read and record the reading on the "Thermistor Well Data" form.
- Repeat process for switch positions 2 - 12.
- Turn toggle switch to "13 - 24" position.
- Continue to read and record data for positions 13 through 24.
- Take another reading in the test position and record. Again, this reading should be similar to the reading stamped on the faceplate of the switch box.
- Make sure the well number, date, time, outside air temperature and the name of the operator are on the form.
- Turn off the multimeter and disconnect leads.
- Install dust cover on the 50 pin connector plug.
- Carefully coil the excess cable back into the well casing.
- Lock the protective cap back into place.

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APPENDIX D

**INSPECTION, CALIBRATION, AND MAINTENANCE PROCEDURES FOR DATA
COLLECTION DEVICES**

**From Water Management Consultants “Quality Assurance Project Plan for
the Hydraulic Characterization of the Tailings Impoundment”, January 1998**

B.4 Instrument inspection, calibration, and maintenance

B.4.1 Dryden switchbox and Fluke multimeter

The Dryden switchbox and Fluke multimeter shall be inspected for damage and proper function prior to use. The switchbox is subject to significant mechanical wear, so a backup unit should be available in case of failure of the primary unit. A record of repairs for all equipment must be maintained in the log books.

Each thermistor string was tested in an icebath by Dryden Instrumentation prior shipment. The results of the icebath calibrations are presented in appendices of Phase I and subsequent reports. The calibration data are used in equations to reduce the data to temperatures. Each thermistor string is tested a second time prior to installation to confirm proper function of the string. No other calibrations are required. A calibration check is required immediately before and after each thermistor string reading. When the Fluke model 23, Series II meter is turned on, with the Dryden switch box in the off position, it should give a reading of 0.00. When the switch box is set to the "TEST" position it should give a reading matching the resistance shown on the switch box (16325 Ω or 16.32 or 16.33 K Ω). After reading all of the thermistor nodes, a "TEST" reading is taken again. If actual readings differ from these values, the thermistor data are invalid. Erroneous readings may be due to excessive cold or a low battery. It is the responsibility of mine personnel to correct the problem and take the readings again. Unstable thermistor readings must be noted in the log book. Unstable readings may be due to poor connections, a faulty switchbox, or shorting of the thermistor string. All corrective actions and repairs must be noted in the log book.

B.4.2 Electronic well sounder

Electronic well sounders must be inspected for function and damage prior to each usage and shall be periodically (at least annually) calibrated against a new sounder or tape. Calibration must include a zero and a span check. The correction factor (if any) must be applied to subsequent measurements and indicated as such in the log book. Field conditions that prevent measurement of water levels with the required degree of precision shall be noted in the log and appropriate corrective action taken and recorded in the log. A broken well sounder cable must be calibrated after repair, and the service recorded in the log. An example of a correction for a repaired well sounder with stretch using a linear regression is given below for the data in Table B-2.

Table B-2 Example of well sounder calibration data

| | New sounder or tape reading (X) | Old sounder reading (Y) |
|----------|---------------------------------|-------------------------|
| 1 (zero) | 0.00 | 2.6 |
| 2 (span) | 300.00 | 302.71 |

Corrected measurement = $(Y_3 - Y_1) / (Y_2 / (X_2 + Y_1))$, where Y_3 is a new reading

or

Corrected measurement = $(Y_3 - 2.6) / (302.71 / (300 + 2.6)) = (Y_3 - 2.6) / 1.000364$

B.4.3 Geokon GK-403 readout

The GK-403 readout instrument must be inspected for damage prior to each use. The face plate should be cleaned periodically with a soft cloth dampened with soap and water. Do not use solvents of any type. The connector sockets may be cleaned with a small stiff brush moistened with soapy water. Thoroughly dry the sockets after cleaning. When the unit is not used for a long period of time, it should be left connected to the battery charger. The GK-403 uses lead-acid type batteries and will not develop a memory as is typical of Ni-cad batteries.

The manufacturer recommends that the readout unit be periodically (every 12 months) returned for inspection, cleaning and calibration. Record all service in the log book.

B.5 Data acquisition from non-direct sources

Data collected prior to the date of entry of the Consent Decree that have been used in achieving compliance with Appendix B of the Consent Decree were acquired from several sources. These data and sources include:

- Historic thermistor data - Cominco Inc.,
- Surface water flow data - Cominco Inc.,
- Climate data - Design Report, Proposed Tailings Dam, Dames and Moore, Inc. 1987 and subsequent data by Cominco Inc.,
- Fish Monitoring Study - Ott et al, Alaska Department of Fish and Game, 1984, and
- A Water Balance Model for the Red Dog Mine - Hydrometrics Inc., 1996 and subsequent data by Cominco Inc.

These data were reviewed in detail during development of Phase I analyses. Data which were questionable or did not appear to be representative of actual conditions (such as high ground temperature measurements during winter months, or temperatures which were outside of observed or expected fluctuations in other areas of the site) were not used in the analyses. All data retained for use from Phase I are considered valid and usable.

B.6 Data management plan

This section describes the data management plan as required by Appendix B of the Consent Decree. The data management process for the groundwater investigation is outlined in Figure B-3.

B.6.1 Data recording

Prior to each routine data acquisition event (thermistor and piezometer measurements), a checklist is prepared by the designated Cominco team leader. The checklist indicates sites to be monitored, the date of measurement, and the team member that carried out the data collection. Data are recorded on the forms in Appendix A or in dedicated bound field books. If dedicated bound field books are used, all data shown on the forms must be recorded. When all of the data have been collected, the data sheets are copied and forwarded to the Cominco Project Manager or directly to the WMCI Project Manager for processing.

Data collected include the following:

- resistance measurements from site thermistors,
- manual measurements of depth to water within open screened wells,
- measurements of "digits" representing electrical impulses from vibrating wire transducers, and
- subpermafrost groundwater samples for age.

B.6.2 Data transformation

Both thermistor and vibrating wire transducer measurements require transformation prior to use in site analyses. Thermistor data consist of resistance measurement which are converted to representative temperatures by the following general equation:

$$T = 1/(A + B(\ln R) + C(\ln R)^2) - Y - 273.15$$

where:

- T = temperature (C°)
- A,B,C = empirical correction coefficients, (0.0012807, 0.000268, 9.073×10^{-6})
- R = measured resistance (Ω)
- Y = temperature bias correction based on icebath calibration

This equation has been programmed into spreadsheets for use by mine personnel, and in an Microsoft Access database kept by WMCI as the overall project database (Section B.6.4). Calibration sheets for each thermistor string installed are kept on file at WMCI, and will be reported in the various Groundwater Monitoring Program phase reports.

Vibrating wire transducers measure "digits" which represent the electronic signal in the wire. These readings are first converted to total pressure acting on the transducer, and then to head of water. The equation to convert "digits" to total pressure, including temperature and barometric corrections is:

$$P = ((R_0 - R_1) \times G) + ((T_1 - T_0) \times K) - ((S_1 - S_0) \times F)$$

where:

- P = total pressure acting on transducer (psi)
- R₀ = zero transducer digit reading (zero applied pressure reading at time of calibration)
- R₁ = transducer digit reading from measurement
- G = calibration factor from calibration (psi/digit)
- T₁ = temperature at time of measurement (°C)
- T₀ = temperature at calibration (°C)
- K = thermal factor (psi/°C rise)
- S₁ = barometric pressure at time of measurement (inches of mercury)
- S₀ = barometric pressure at calibration (inches of mercury)
- F = conversion factor between inches of mercury to psi

If a barometric correction is not available as part of transducer calibration, it can be estimated by a separate transducer measuring open air pressures.

The total estimated pressure in psi is then converted to feet of water by the following relationship:

$$1 \text{ psi} = 2.3108 \text{ ft of H}_2\text{O}$$

These equations have been programmed into spreadsheets for use by mine personnel, and in an Microsoft Access database kept by WMCI as the overall project database (Section B.6.4). Calibration sheets for each vibrating wire transducer installed are kept on file at WMCI, and will be reported in the various Groundwater Monitoring Phase reports.

B.6.3 Data transmittal

Raw data are collected by mine personnel and either noted in a field log book or in the thermistor datalogger. Copies of both field notes and raw electronic data are kept on file at the mine. Mine personnel either hand enter or electronically download raw data into spreadsheets for transformation of resistance and digit readings into temperatures and water levels, respectively. These spreadsheets are used at the mine as appropriate, but do not represent the overall site database used for technical analysis.

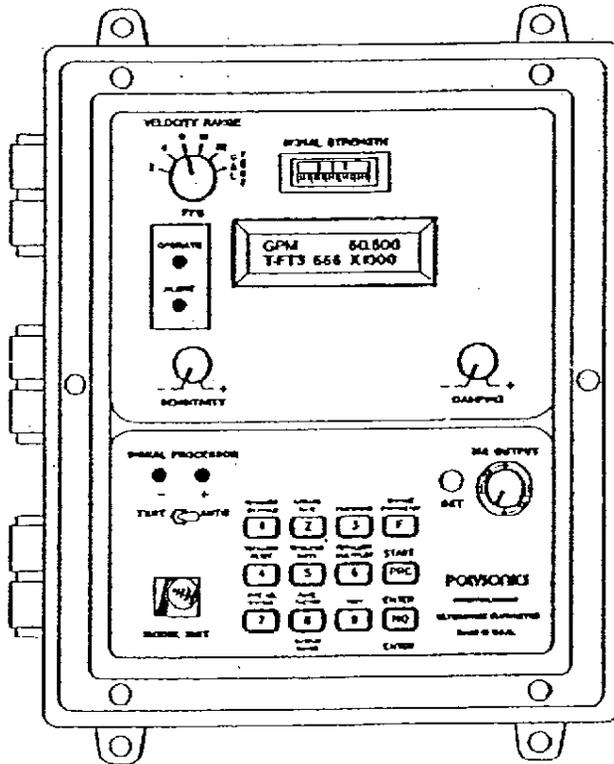
Copies of all raw data (hard copies or raw electronic versions) are also forwarded to WMCI for inclusion into the master site database. WMCI personnel either hand enter or electronically download all measurement data into the master site database. This database uses Microsoft Access software, and is controlled by a designated WMCI database manager.

APPENDIX E

OPERATORS MANUAL FOR DEDICATED ULTRASONIC FLOWMETER



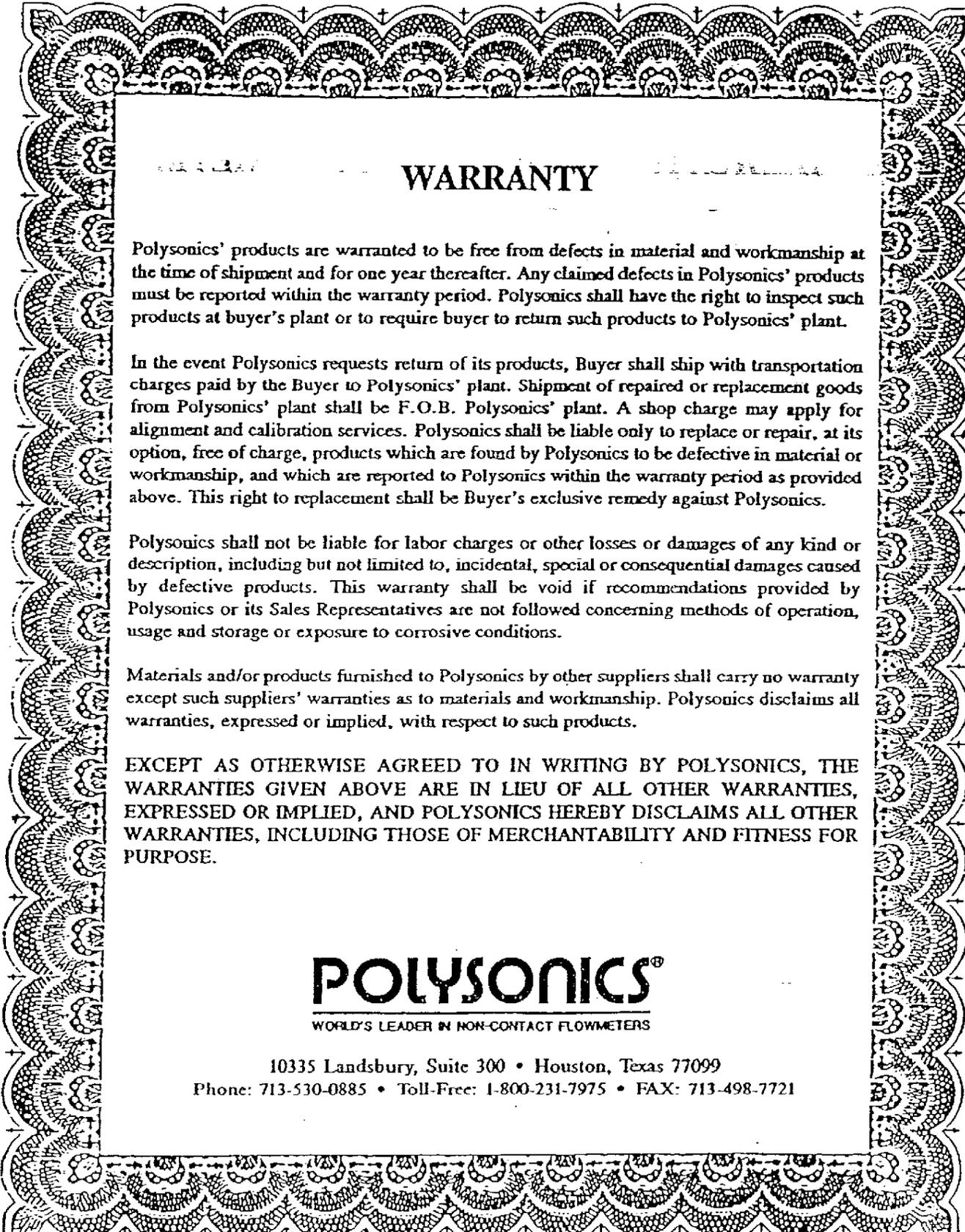
MODEL MST DEDICATED ULTRASONIC FLOWMETER OPERATORS MANUAL



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CHAPTER 1

EQUIPMENT DESCRIPTION

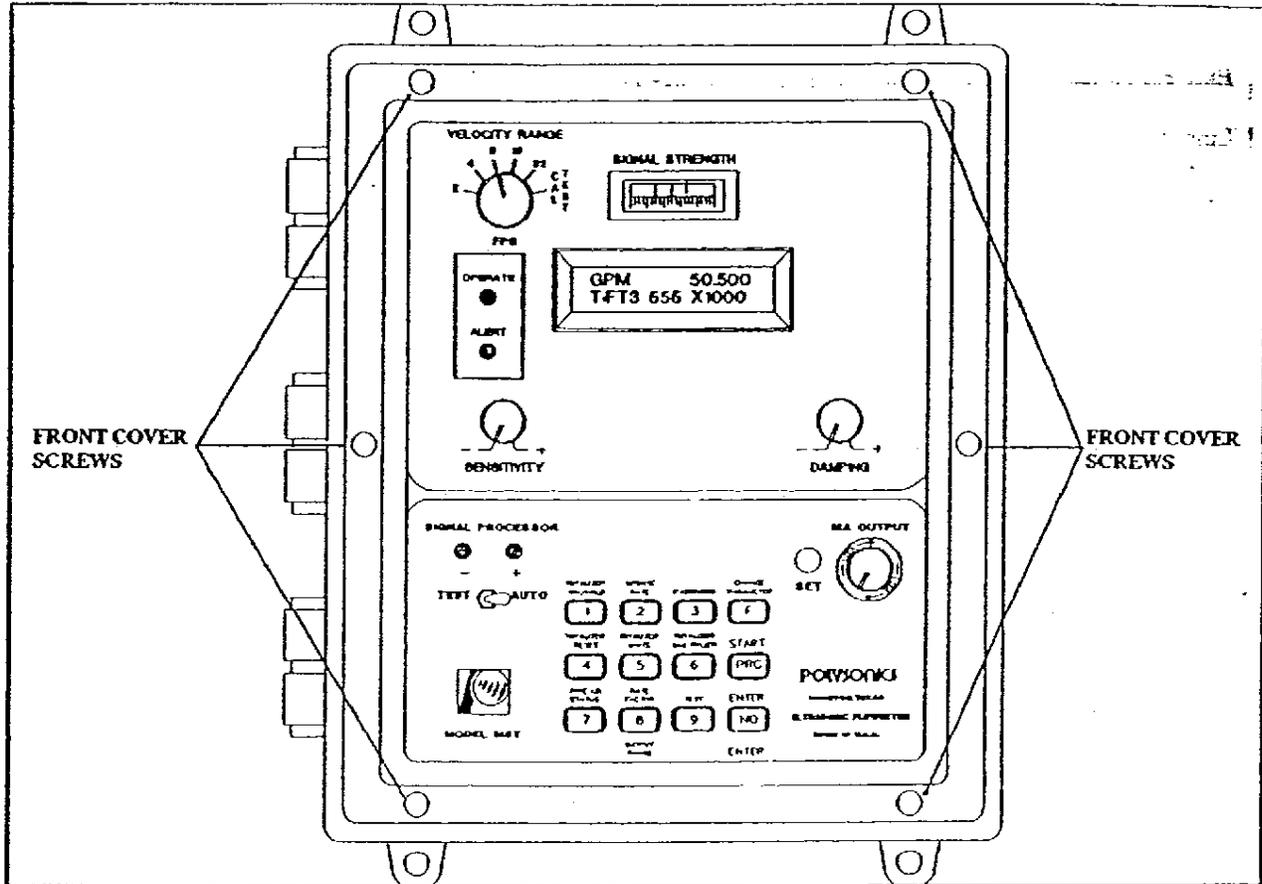


Figure 1-1
Model MST Flowmeter

BRIEF DESCRIPTION

The Polysonics Model MST flowmeter (Figure 1-1) is a permanent, non-contact, ultrasonic flowmeter that measures fluid flow from the outside of full pipes. Both english and metric versions of the flowmeter are available. The Model MST flowmeter is normally supplied with a NEMA 4X non-metallic housing. An optional NEMA 7 (explosion proof) housing can be supplied for hazardous environments. The transducers are designed to meet BASEFA requirements. Figure 1-2 contains technical specifications for the flowmeter.

Features of the Model MST include:

- Simultaneous digital display of flow rate and total flow.

- Visual over-range indication when fluid velocity has exceeded the full scale setting.
- Five-position velocity range switch with calibration test position to ensure accurate calibration and maximum resolution.
- Auto-range totalizer in selectable, volumetric units.
- 4-20 mA interface that can be connected to an external device, such as, a chart recorder.
- 0-10 VDC interface that can be connected to an external device, such as, a chart recorder.
- Positive zero interface that can be connected to an external device, such as, a pump controller, that causes a contact closure when a no flow condition exists. The contact closure will activate the low signal circuit that inhibits flow rate

CHAPTER 1 - EQUIPMENT DESCRIPTION

| | |
|-------------------------------|--|
| Flow Range | 5 switch selectable ranges plus CAL TEST position. For US flowmeters, ranges are 2, 4, 8, 16, and 32 feet per second. For metric flowmeters, ranges are .5, 1, 2, 4, and 8 meters per second. |
| Pipe Inside Diameter Range | For US flowmeters, .2-inches to 99.9-inches. For metric flowmeters, .5 mm to 2,499 mm. |
| Output | 4-20 mA DC into 750 ohms |
| External Adjustments | Range, sensitivity, damping and mA output |
| Linearity | +/- 0.5% full scale |
| Repeatability | +/- 0.1% full scale |
| Accuracy | +/- 2% full scale |
| Transmitter Temperature Range | -10°F to +160°F (-23°C to +71°C) |
| Transducer | Dual head type designed to meet BASEFA requirements with standard 20 foot armored cable. Custom length cables are available as an option. Dual head underwater/underground type is available as an option. |
| Transducer Temperature Range | -30°F to +300°F (-34°C to +149°C) |
| Signal Strength Indicator | Analog signal strength meter and LED signal condition indicator. |
| Power Requirements | 115 VAC or 220 VAC +/- 20%, switch selectable |
| Housing | NEMA 4X non-metallic housing |

Figure 1-2
Model MST Technical Specifications

- readings and totalizer counting during no flow conditions.
- Rate/total factor to allow for computation and indication of total flow in virtually any engineering unit.
 - Doppler signal strength indicator with operate and alert LEDs
 - Damping and Sensitivity adjustments for customized flow response.

LIST OF SUPPLIED ITEMS

Figure 1-3 is a list of standard and optional items supplied with the Model MST flowmeter.

DESCRIPTION OF FRONT PANEL INDICATORS

The front panel indicators described below are labeled in Figure 1-4.

Signal Strength Meter, A meter that provides an indication of the strength of the received Doppler signal. With no flow, provides an indication of background noise and is used to adjust the SENSITIVITY control.

Display, An LCD display that shows setup parameters and flow readings.

Operate Light, A green light that is lit when the Doppler signal strength is sufficient to measure fluid flow.

Alert Light, A red light that is lit when the Doppler signal strength is insufficient to measure fluid flow. A flashing ALERT light with a continuously lit OPERATE light indicates the presence of spurious high

| STANDARD ITEMS | | |
|----------------|--|----------------|
| QUANTITY | DESCRIPTION | POLYSONICS P/N |
| 1 | Flowmeter | 20772-0005 |
| 1 | Operator's Manual | 20807-0001 |
| 1 | Accessory Kit, Includes The Following Items: | 20806-0001 |
| 1 | • 2 Ounce Tube Ultrasonic Coupling Compound | 10823-0001 |
| 4 | • 3/2 Inch Stainless Steel Pipe Strap | 10605-0001 |
| 1 | Universal Mounting Kit | 20807-0001 |
| 2 | • Bracket | 20322-0001 |
| 2 | • U-Clamp | 10609-0001 |
| 4 | • 1/4-20 x 3/8-inch Flat Head Screws | 11016-0001 |

| OPTIONAL ITEMS | | |
|----------------|---|----------------|
| QUANTITY | DESCRIPTION | POLYSONICS P/N |
| 1 | Fuse 20 x 5 mm, 0.5 A/250 V Fast-blo (flowmeter without heater assembly and 115 VAC line voltage) | 10261-0003 |
| 1 | Fuse 20 x 5 mm, 0.2 A/250 V Fast-blo (flowmeter without heater assembly and 240 VAC line voltage) | 10261-0001 |
| 1 | Fuse 20 x 5 mm, 0.4 A/250 V Fast-blo (flowmeter with heater assembly and 115 VAC line voltage) | 10261-0002 |
| 1 | Fuse 20 x 5 mm, 0.6 A/250 V Fast-blo (flowmeter with heater assembly and 240 VAC line voltage) | 10261-0004 |
| 1 | Proportional Sampler Board | 20020-0032 |
| 1 | Dual Alarm Board (For Hi/Lo Alarms) | 20071-0002 |
| 1 | Counter Board (For Mechanical Totalizer) | 20095-0002 |
| 1 | Internal Heater Assembly (115 VAC line voltage) | 20761-0001 |
| 1 | Internal Heater Assembly (240 VAC line voltage) | 20761-0002 |
| 1 | Standard Transducer Set | 20804-0001 |
| 2 | Underwater/Underground Transducer (Single Transducer On An Individual Cable) | 20752-1020 |
| 1 | Underwater/Underground Transducer, Y-Configuration | 20753-1020 |

Figure 1-3
LIST OF ITEMS SUPPLIED WITH FLOWMETER

frequency noise signals that may cause erroneous flow rate readings.

Signal Processor - and + Lights, Lights that flash when the signal processor circuit is compensating for interfering signals above or below the correct flow rate. Fluctuation between the two conditions is expected. A continuously lit + lamp indicates an abnormality.

DESCRIPTION OF FRONT PANEL CONTROLS
The front panel controls described below are labeled in Figure 1-4.

Velocity Range Switch, A switch used to set the full-scale value of the flowmeter for fluid velocity. For english flowmeters, the velocity range is in feet per second (FPS). For metric flowmeters, the velocity range is in meters per second (MPS). The VELOCITY RANGE switch also has a CAL TEST position used for testing the calibration of the flowmeter.

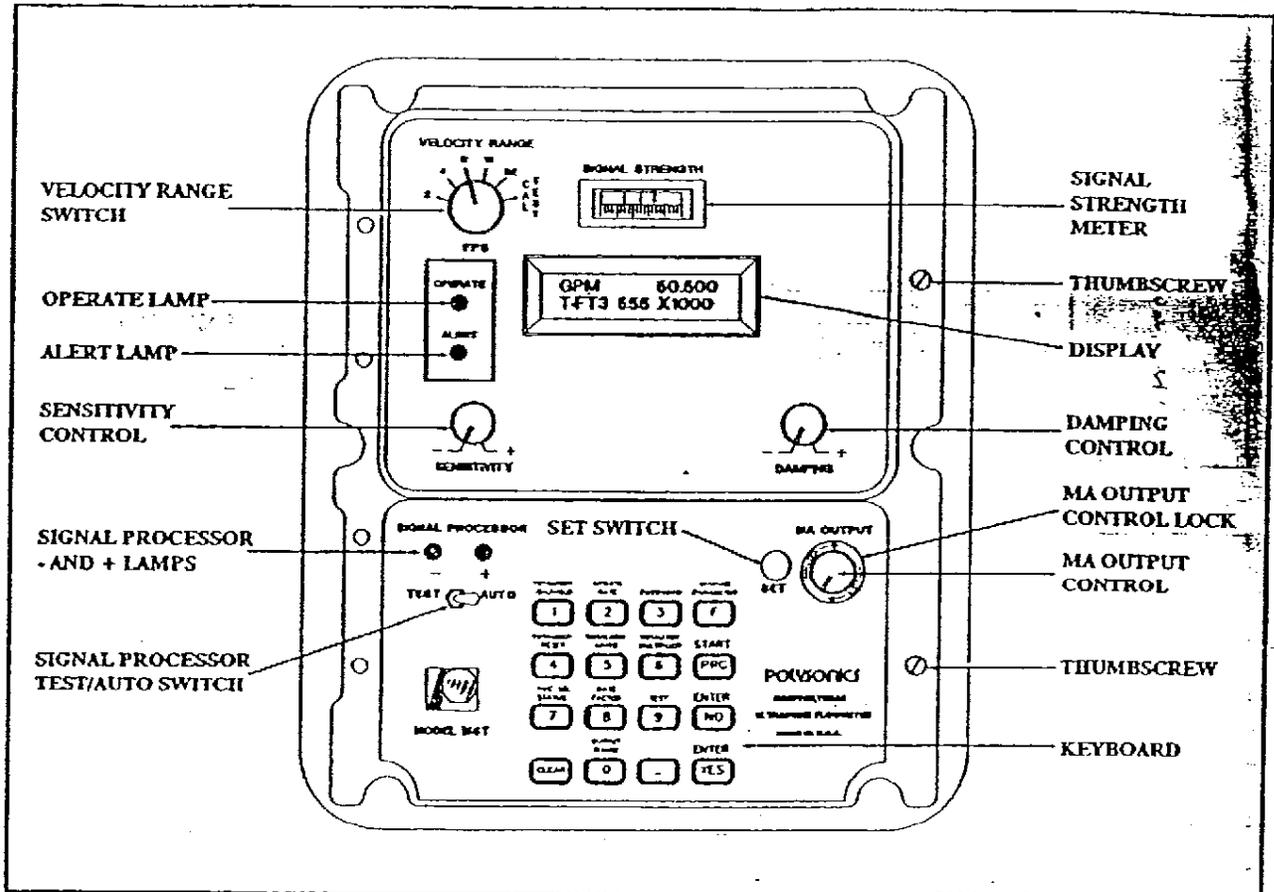


Figure I-4
Front Panel

, A control that sets the gain of the Doppler receiver circuit. The SENSITIVITY control is used to adjust the flowmeter to conditions at the transducer site, so that there is a sufficient signal for reliable readings while assuring low-signal cutoff under no-flow conditions.

Damping Control, A control that suppresses short-term fluctuations in the fluid velocity reading and adjusts response time to changes in fluid velocity. Response to changes will be slower as the DAMPING control is turned clockwise.

Signal Processor Test/Auto Switch, A switch that controls the signal processor circuit and is used to verify that the circuit is operating. The signal processor circuit compensates for flow conditions that cause low or high flow rate readings. The switch is normally in the AUTO position which enables the signal processor circuit. In the TEST position, the signal processor circuit is dis-

abled. With the switch in the TEST position, the SIGNAL PROCESSOR - and + lights will stop flashing and the flow rate reading will change, indicating that the signal processing circuit was operating when the switch was in the AUTO position.

MA Output Control, A control used to adjust the 4-20 mA interface and the 0-10 VDC interface to give 20 mA and 10 VDC output, respectively, at 50% to 100% of the selected velocity range.

Set Switch, A switch that is pressed when the MA OUTPUT control is used to adjust the 4-20 mA interface and the 0-10 VDC interface.

Keyboard, A key pad used to setup and control the flowmeter's microprocessor. The [CLEAR] key acts as a delete key.

CHAPTER 2 PROGRAMMING

GENERAL

Figure 1-4 is an illustration of the front panel of the Model MST Dedicated Ultrasonic Flowmeter. All switches, controls and the keyboard used to program the flowmeter are mounted on the front panel and have been labeled in Figure 1-4.

The steps to program the flowmeter are as follows:

- Set velocity range.
- Set flow rate units.
- Set the flow rate factor, if required.
- Set the 4-20 mA and 0-10 VDC interfaces, if required.
- Turn the totalizer on, if required.

To access the controls on the front panel of the flowmeter, unscrew the six front cover screws (Figure 1-1) using a straight slotted screwdriver and swing the front cover open. After completion of programming, close the front cover and tighten the six front cover screws.

SET VELOCITY RANGE *10.53 (16) set*

1. The velocity range is set to the next position above the fluid velocity, i.e., the velocity switch is set to 16 for a fluid velocity of 12 feet per second. This procedure should not have to be performed again unless the fluid velocity being measured exceeds the velocity range setting.

NOTE

Equations for calculating fluid velocity are included in Appendix B, Flow Conversion Data.

2. Turn on the electrical power to the flowmeter.
3. Rotate the VELOCITY RANGE switch to the appropriate position.

SET FLOW RATE UNITS *GPM*

1. The flow rate units are set at the time the flowmeter is placed in service. This procedure should not have to be performed again unless the flow rate units are to be changed or the flowmeter's transducer is moved to another pipe with a different inside diameter.

2. Turn the SENSITIVITY and DAMPING controls counter-clockwise to their minimum positions.

3. For english flowmeters, FPS XXXX VOLUME PROGRAM OFF will appear on the display. For metric flowmeters, MPS XXXX VOLUME PROGRAM OFF will appear on the display.

4. Initialize the flowmeter by pressing the [F] key followed by the [.] key followed by the [CLEAR] key. The display will momentarily flash signaling that the flowmeter has been initialized.

NOTE

Initializing the flowmeter erases all program parameters.

5. Press the [PRG] key. ENTER PASSWORD will appear on the display.

6. Key in the two character password and then press the [YES] key.

NOTE

The password for all new flowmeters is set at the factory to 00.

7. ENTER PIPE I.D. will appear on the display after the password has been entered.

8. Key in the pipe inside diameter and then press the [YES] key. Appendix C, Pipe Schedules, lists inside diameters for various nominal pipe sizes and materials. The accuracy of the flow rate measurements will be enhanced if an actual measured pipe inside diameter is used.

9. For english flowmeters, IS FLOW RATE UNIT IN GPM? will appear on the display. For metric flowmeters, IS FLOW RATE UNIT IN L/SEC? will appear on the display.

10. If this is the correct flow rate unit, press the [YES] key. Otherwise, press the [NO] key and the next available flow rate unit will appear on the display. Continue pressing the [NO] key until the desired flow

CHAPTER 2 - PROGRAMMING

| UNITS | DESCRIPTION |
|-------|-----------------------------|
| GPM | Gallons per minute |
| GPH | Gallons per hour |
| GPD | Gallons per day |
| MGD | Million gallons per day |
| IGPM | Imperial gallons per minute |
| CFS | Cubic feet per second |
| CFM | Cubic feet per minute |
| CFH | Cubic feet per hour |
| CFD | Cubic feet per day |
| LBM | Liquor barrels per minute |
| LBH | Liquor barrels per hour |
| LBD | Liquor barrels per day |
| OBS | Oil barrels per second |
| OBM | Oil barrels per minute |
| OBH | Oil barrels per hour |
| OBD | Oil barrels per day |

Figure 2-1
Flow Rate Units For US Flowmeters

rate unit appears on the display and then press the [YES] key.

NOTE

Flow rate units for english flowmeters are as shown in Figure 2-1. Flow rate units for metric flowmeters are shown in Figure 2-2. All kilogram units are based on a specific gravity of one. A specific gravity of one is defined as one U.S. gallon of water weighing 8.3283 pounds in air at a temperature of 60 degrees Fahrenheit. If a fluid with a specific gravity other than one is being measured, a flow rate factor must be applied as described in the Set Flow Rate Factor section.

11. The flow rate will appear on the top line of the display and the velocity rate will be appear on the bottom line of the display.

12. The flowmeter is now set to measure fluid flow.

SET FLOW RATE FACTOR

1. Flow rates in units other than those shown in Figures 2-1 and 2-2 can be shown on the display by selecting the available flow rate unit closest to the desired unit and applying a flow rate factor. Flow is measured in the selected unit and then multiplied by the flow rate factor (expressed as a percentage) and the result is shown on the display.

| UNITS | DESCRIPTION |
|---------|-----------------------------|
| L/SEC | Liters per second |
| L/MIN | Liters per minute |
| L/HR | Liters per hour |
| IGPS | Imperial gallons per second |
| IGPM | Imperial gallons per minute |
| IGPH | Imperial gallons per hour |
| M3/SEC | Cubic meters per second |
| M3/MIN | Cubic meters per minute |
| M3/HR | Cubic meters per hour |
| M3/DAY | Cubic meters per day |
| KG/SEC | Kilograms per second |
| KG/MIN | Kilograms per minute |
| KG/HOUR | Kilograms per hour |
| KG/DAY | Kilograms per day |
| OBS | Oil barrels per second |
| OBM | Oil barrels per minute |
| OBH | Oil barrels per hour |
| OBD | Oil barrels per day |

Figure 2-2
Flow Rate Units For Metric Flowmeters

Example

It is desired to measure the flow in a pipe in cubic yards per second.

To measure the flow in cubic yards per second, a flow rate multiplier must be used because cubic yards per second is not one of the available flow rate units for the flowmeter. Select cubic feet per second (the closest flow rate unit the flowmeter can be programmed to measure) and determine the flow rate multiplier required to convert cubic feet per second to cubic yards per second. Based upon one cubic yard equal nine cubic feet, cubic feet per second can be converted to cubic yards per second as follows:

$$\begin{aligned} \text{yds.}^3/\text{sec.} &= 1 \text{ yd.}^3/9 \text{ ft.}^3 \times \text{ft.}^3/\text{sec.} \\ &= 1/9 \times \text{ft.}^3/\text{sec.} \\ &= .111 \text{ ft.}^3/\text{sec.}; \text{ or,} \\ &= 11.1\% \text{ ft.}^3/\text{sec.} \end{aligned}$$

The flow rate factor to convert cubic feet per second to cubic yards per second is 11.1%.

CAUTION

The flow rate factor must be set before the totalizer is turned on. If the totalizer is on when the flow rate factor is set, the totalizer does not reset to zero and does not convert the existing reading to the new

units. The totalizer will start counting using the new units added to the existing reading which was based on the old units.

2. Press the [F] key followed by the [RATE FACTOR] key.

3. **%** will appear on the top line of the display with the percent sign blinking. Key in the flow rate factor expressed as a percentage and press the [YES] key. The flow rate factor can be any number between 1.001% and 199.9%.

4. The flow rate shown on the display is now based upon the selected flow rate unit multiplied by the flow rate factor. To indicate this, the flow rate factor followed by a blinking % is shown on the top line of the display.

5. To turn the flow rate factor off, press the [F] key followed by the [RATE FACTOR] key followed by the [CLEAR] key. The flow rate factor and the blinking % on the top line will disappear and the flow rate will again be displayed in the selected flow rate unit.

SET 4-20 mA AND 0-10 VDC INTERFACES

1. The flowmeter is equipped with a 4-20 mA interface and a 0-10 VDC interface that can each be connected to an external device, such as, a chart recorder. The full scale output of the 4-20 mA interface can be set from the keyboard. The 0-10 VDC interface is slaved to the 4-20 mA interface so that the 0-10 VDC interface full scale output is set at the same time as the 4-20 mA interface.

IMPORTANT

The 4-20 mA and the 0-10 VDC interfaces must be set before the totalizer is turned on. The SET switch is disabled when the totalizer is operating to prevent invalid totalizer counts. The flowmeter cannot process flow information when the SET switch is depressed.

2. Press the [F] key and then press the [OUTPUT RANGE] key.

3. ENTER 20 MA RANGE _____? XXX, where XXX is the current flow rate units, will appear on the display.

4. Key in the desired value for the full scale output of the interfaces and then press the [YES] key.

5. Turn the MA OUTPUT control lock (large knob at the bottom of the control) counter-clockwise to unlock the control.

6. Press and continue to hold the SET button located on the front panel. ##### ___XXX RANGE ADJUST ---> (or) <---, where ##### is the value keyed in for the full scale output and XXX is the current flow rate units, will appear on the display.

7. If ---> is displayed, turn the MA OUTPUT control clockwise until the arrow disappears and the word SET appears on the display. The SET button can now be released and the full scale output is now programmed. If the MA OUTPUT control is at the full clockwise position and SET has not appeared on the display, the VELOCITY RANGE switch must be rotated to a higher velocity range. Continue moving to a higher range until the <-- arrow appears on the display. Now the MA OUTPUT control can be turned counter-clockwise until the arrow disappears and SET appears on the display.

8. If <--- is displayed, turn the MA OUTPUT control counter-clockwise until the arrow disappears and the word SET appears on the display. The SET button can now be released and the full scale output is now programmed. If the MA OUTPUT control is at the full counter-clockwise position and SET has not appeared on the display, the VELOCITY RANGE switch must be rotated to a lower velocity range. Continue moving to a lower range until the --> arrow appears on the display. Now the MA OUTPUT control can be turned clockwise until the arrow disappears and SET appears on the display.

9. Turn the MA OUTPUT control lock (large knob at the bottom of the control) clockwise to lock the control.

10. If SET never appears on the display at any velocity range, the 4-20 mA and 0-10 VDC interfaces cannot be used with the current flow rate unit. To be able to use the interfaces, reprogram the flowmeter to use a flow rate unit with a larger time period, such as, changing GPM to MGD.

TURN TOTALIZER ON

1. The totalizer is used to measure the total volume of fluid that flows during a period of time. The totalizer starts counting at the time it is turned on and continues counting until it is turned off or reset. At the time the totalizer is turned on, the volume unit to be used by the

CHAPTER 2 - PROGRAMMING

| UNITS | DESCRIPTION |
|-------|------------------|
| GAL | Gallons |
| IGAL | Imperial gallons |
| FT3 | Cubic feet |
| LTR | Liters |
| M3 | Cubic Meters |
| LBL | Liquor Barrels |
| OBL | Oil Barrels |
| ACFT | Acre Feet |
| KG | Kilograms |

Figure 2-3
Totalizer Units

totalizer display reading and manual range mode or auto up-ranging mode are specified.

2. Press the [TOTALIZER ON/HOLD] key. The flow rate will appear on the top line of the display.
3. For english units, H:GAL? will appear on the left side of the bottom line of the display. For metric units, H:LTR? will appear on the left side of the bottom line of the display. The H: indicates that the totalizer is in the hold mode and not presently counting.
4. If this is the correct totalizer unit, press the [YES] key. Otherwise, press the [NO] key and the next available totalizer unit will appear on the display. Continue pressing the [NO] key until the desired totalizer unit appears on the display and then press the [YES] key.

NOTE

Totalizer units are as shown in Figure 2-3.

5. X1? will appear on right side of the bottom line of the display.
6. If this is the correct totalizer multiplier, press the [YES] key. Otherwise, press the [NO] key and the next available totalizer multiplier will appear on the display. Continue pressing the [NO] key until the desired totalizer multiplier appears on the display.
7. To select the displayed totalizer multiplier and place the flowmeter in the manual range mode, press the [CLEAR] key. When the totalizer reaches the largest number for the selected totalizer multiplier, the totalizer will reset and start counting again at 0000.

8. To select the displayed totalizer multiplier and place the flowmeter in the auto up-ranging mode, press the [YES] key. An H will be displayed at the end of the bottom line indicating that the auto up-ranging mode is activated. When the totalizer reaches the largest number for the selected totalizer multiplier, the totalizer will automatically increment to the next larger totalizer multiplier. This process will continue through all totalizer multipliers. When the totalizer reaches the largest number for the last totalizer multiplier, the totalizer will reset and start counting again at 0000; however, the X10000 multiplier will remain displayed indicating that the totalizer overflowed and reset.

9. The H: will disappear from the display and the totalizer will begin to count. The flow rate will be shown on the top line of the display and the totalizer count will be shown on the bottom line of the display.

10. If a flow rate factor is being used, the totalizer will count based on the calculated flow rate unit.

CAUTION

The totalizer does not convert the existing reading to the new units when the flow rate factor is set or turned off. If the flow rate factor is set to a new value or turned off with the totalizer turned on, reset the totalizer or make a notation of the new flow rate factor and the totalizer count at the time the flow rate factor was changed.

11. A non-blinking % will be displayed at the beginning of the bottom line to signal that the totalizer is counting in the factored mode. If the flow rate factor is turned off, the non-blinking % at the beginning of the bottom line will disappear and the totalizer will begin to count in the selected unit.

SET DISPLAY UPDATE RATE

1. The fluid flow rate shown on the display can be set to update every 2, 4, 6 or 8 seconds at any time when the flowmeter is operating.
2. To change the display update rate, press the [F] key followed by the [UPDATE RATE] key followed by the [2], [4], [6], or [8] key to specify the number of seconds between updates.
3. The display will momentarily flash, signaling that the new value was accepted. If an incorrect value was keyed in, the display will not flash and the display update rate will not be changed.

CHAPTER 3

OPERATION

GENERAL

Figure 1-4 is an illustration of the front panel of the Model MST Dedicated Ultrasonic Flowmeter. All switches, controls and indicators used to operate the flowmeter are mounted on the front panel and are labeled in Figure 1-4. To access the controls on the front panel of the flowmeter, unscrew the six front cover screws (Figure 1-1) using a straight slotted screwdriver and swing the front cover open. After the controls have been set, close the front cover and tighten the six front cover screws.

Before the flowmeter can be placed in operation, it must first be programmed as described in Chapter 2, Programming, and have the transducers installed as described in Chapter 5, Installation.

SET SENSITIVITY

1. The fluid in the pipe whose flow is to be measured must be in a steady state operating condition at the time the sensitivity is set.
2. Turn the SENSITIVITY and DAMPING control counter-clockwise to their minimum positions.
3. Turn the SENSITIVITY control clockwise until the SIGNAL STRENGTH meter reading is one-third of the way into the green area of the meter scale.
4. Allow the fluid flow rate reading time to stabilize and then verify that the SIGNAL STRENGTH meter reading is still one-third of the way into the green area of the meter scale.
5. Continue to perform steps 3 and 4 until the SIGNAL STRENGTH meter reading remains one-third of the way into the green area of the meter scale.

SET DAMPING

1. The fluid in the pipe whose flow is to be measured must be in a steady state operating condition at the time the damping is set.
2. If the fluid velocity reading is fluctuating, turn the DAMPING control clockwise until the fluid velocity reading becomes stable.

CHANGE DISPLAY UPDATE RATE

1. The fluid flow rate shown on the display can be set to update every 2, 4, 6 or 8 seconds at any time when the flowmeter is operating.
2. To change the display update rate, press the [F] key followed by the [UPDATE RATE] key followed by the [2], [4], [6], or [8] key to specify the number of seconds between updates.
3. The display will momentarily flash, signaling that the new value was accepted. If an incorrect value was keyed in, the display will not flash and the display update rate will not be changed.

CHANGE TOTALIZER UNITS

1. The totalizer units can be changed by pressing the [F] key immediately followed by the [TOTALIZER UNITS] key.
2. When this is done the totalizer will temporarily be put in the hold mode and an H: will be displayed at the beginning of the bottom line.
3. The operator can now select a new units by continually pressing the [NO] key.
4. When the desired units is displayed, press the [YES] key. At this time, the H: at the beginning of the bottom line will begin flashing signaling that the totalizer is still in the hold mode. Press the [TOTALIZER ON/HOLD] key to disengage the hold mode and start the totalizer counting.

CAUTION

The totalizer does not convert the existing reading to the new units when the totalizer units are changed. Reset the totalizer or make a notation of the new totalizer units and the totalizer count at the time the totalizer units were changed.

CHANGE TOTALIZER MULTIPLIER

1. The totalizer multiplier can be changed by pressing the [F] key immediately followed by the [TOTALIZER MULTIPLIER] key.

CHAPTER 3 - OPERATION

2. When this is done the totalizer will temporarily be put in the hold mode and an H: will be displayed at the beginning of the bottom line.
3. The operator can now select a new multiplier by continually pressing the [NO] key.
4. When the desired multiplier is displayed, the [YES] key is pressed.
5. At this time the H: at the beginning of the bottom line will begin flashing signaling that the totalizer is still in the hold mode.
6. Press the [TOTALIZER ON/HOLD] key to disengage the hold mode and start the totalizer counting.

CAUTION

The totalizer does not convert the existing reading to the new units when the totalizer multiplier is changed. Reset the totalizer or make a notation of the new totalizer multiplier and the totalizer count at the time the totalizer multiplier was changed.

RESET TOTALIZER

1. The totalizer can be reset to zero by pressing the [F] key followed by the [TOTALIZER RESET] key.
2. This will reset the counter to 0000.

NOTE

This will only reset the internal electronic totalizer, it has no effect on an optional internal mechanical totalizer or a remote totalizer.

PLACE TOTALIZER ON HOLD

1. The totalizer can be placed on hold by pressing the [TOTALIZER ON/HOLD] key.
2. When this is done, the totalizer will hold its count and indicate a flashing H: at the beginning of the bottom line to signal that the totalizer is in the hold mode.
3. Pressing the [TOTALIZER ON/HOLD] key again will cause the flashing H: to disappear and the totalizer will start counting again.

NOTE

The totalizer should be reset after being placed on hold. The current totalizer count is incorrect as it does not include the volume of fluid that flowed while the totalizer was on hold.

TURN TOTALIZER OFF

1. To turn the totalizer off, place the totalizer in the hold mode by pressing the [TOTALIZER ON/HOLD] key.
2. When this is done, the totalizer will hold its count and indicate a flashing H: at the beginning of the bottom line to signal that the totalizer is in the hold mode.
3. Press the [CLEAR] key.
4. The totalizer is turned off.
5. The bottom line of the display will now read TOT OFF and the fluid velocity will be shown on the right side.

CHECK PIPE ID STATUS

1. To view the pipe inside diameter for which the flowmeter is currently programmed, press the [F] key and then press the [PIPE ID STATUS] key.
2. For english units, CURRENT PIPE ID IS ###.## IN, where ###.## is the pipe inside diameter, will appear on the display. For metric units, CURRENT PIPE ID IS ###.## MM, where ###.## is the pipe inside diameter, will appear on the display. This message will appear for approximately 5 seconds and then return to the previous display screen.

CALIBRATION TEST

1. The flowmeter has an calibration test function that can be activated from the keyboard. This test routine checks the display and checks for correct calibration of the flowmeter.
2. Turn the DAMPING control to the minimum position (full counter-clockwise) position.
3. Rotate the VELOCITY RANGE switch to the CAL TEST position.
4. Press the [F] key and then press the [TEST] key.
5. TEST IN PROGRESS will appear on the top line of the display. Graphics characters will scroll across the bottom line of the display for approximately 18 seconds.

6. If the calibration test was successful, **TEST OK SELECT RANGE** will appear on the display.

7. If the calibration test was not successful, **TEST FAILED REFER TO MANUAL** will appear on the display.

NOTE

An unsuccessful calibration test is caused by the **DAMPING** control not being at the minimum position or the flowmeter being out of calibration. If the

DAMPING control was not at the minimum position repeat steps 1 through 7 above. If the **DAMPING** control was at the minimum position, have the flowmeter serviced.

8. Rotate the **VELOCITY RANGE** switch to the position it was in before the calibration test.

9. Set the **DAMPING** control as described in the Set Damping section.

CHAPTER 4 MAINTENANCE

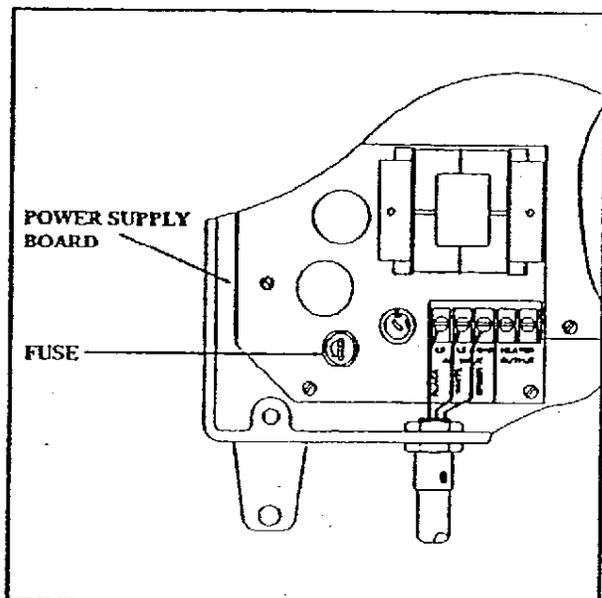


Figure 4-1
Power Supply Fuse

PRINTED CIRCUIT BOARD HANDLING

A reasonable degree of caution should be observed when handling printed circuit boards so that they are not contaminated or affected by static electricity. The following steps should be observed any time the flowmeter housing is opened:

- Turn off the electrical power to the flowmeter before the housing is opened.
- Wash any grease or dirt from your hands before handling any of the electronic parts in the flowmeter. Grease and dirt are a source of corrosion which could render the flowmeter inoperative.
- Never open the flowmeter housing in a hazardous environment or in the presence of rain, heavy fog or airborne chemicals.
- To remove a board from the flowmeter, pull straight out or by rocking very slightly. The board should be gripped by the fiberglass base material and not the components on the board.
- Do not disconnect any cables attached to the board because they can be easily damaged.
- Handle the board by the edges, being careful to avoid touching the gold plated contact fingers. If the board is to be moved to another location, place it in an anti-static bag. In the absence of

| FUSE RATINGS (AMPS) | | |
|----------------------|-------------------------|----------------------|
| NOMINAL LINE VOLTAGE | WITHOUT OPTIONAL HEATER | WITH OPTIONAL HEATER |
| 120 VAC | 0.5A | 0.6A |
| 220VAC | 0.2A | 0.4A |

Figure 4-2
Power Supply Fuse Ampere Ratings

an anti-static bag, the board can be wrapped with aluminum foil. If a replacement board is being installed it will be in an anti-static bag that can be used for the removed board.

- Switch settings on the board can be changed with a fingernail, small screw driver, or a dull pick. A ball point pen or pencil can also be used; however, a small ink or lead smudge will be left on the switch. Minimize the size of this smudge because a large build-up can get inside the switch and cause malfunctions.

POWER SUPPLY FUSE REPLACEMENT

1. Turn off the electrical power to the flowmeter.
2. Unscrew the six front cover screws (Figure 1-1) using a straight slotted screwdriver and swing the front cover open.
3. Unscrew the two thumbscrews on the right side of the front panel (Figure 1-4) and swing the hinged front panel open.
4. The fuse is located on the Power Supply board in the lower left corner of the flowmeter housing (Figure 4-1). Rotate the fuse extractor a quarter turn counter-clockwise with a straight slotted screwdriver. The fuse extractor along with the fuse will spring up above the top of the fuse holder. Lift the fuse extractor and fuse out of the flowmeter housing.
5. Remove the burned out fuse from the fuse extractor.

CHAPTER 4 - MAINTENANCE

6. Insert a new 20 x 5 mm, 250 V Fast-blo fuse with the appropriate ampere rating specified in Figure 4-2 into fuse extractor.
7. Place the fuse and fuse extractor into the fuse holder. Press the fuse extractor into the fuse holder and rotate the fuse extractor a quarter turn clockwise with a straight slotted screwdriver.
8. Swing the hinged front panel closed and tighten the two thumbscrews on the right side of the front panel.
9. Swing the front cover closed and tighten the six front cover screws.
10. Turn on the electrical power to the flowmeter.

REPLACE TRANSDUCER COUPLING COMPOUND

1. Loosen the transducer mounting strap and slide the transducers out from under the strap.
2. Wipe the old coupling compound from the pipe and transducer faces.
3. Apply a heavy coat of Polysonics' Ultrasonic Coupling Compound to each transducer face (Figure 5-3).
4. Lift the strap and slide the transducers underneath allowing the strap to engage the two indentations on either side of the transducers while keeping the transducers about 1/2-inch away from the pipe.
5. Position the transducers and strap to the predetermined location on the pipe and tighten the strap. The strap only needs to be tight enough to hold the transducers from sliding on the pipe. This can be tested by trying to rotate or slide the transducers slightly while tightening the strap.
6. After tightening the strap verify that the Ultrasonic Coupling Compound is squeezing out on all sides of the transducers forming a bead along the edge. Any voids or air gaps under the transducers will reduce the ultrasonic signal and can render the flowmeter inoperative.

CHANGE PASSWORD

1. The flowmeter is password protected to prevent unauthorized programming changes. Programming parameters can be viewed without entering the password; however, changes cannot be made. After the two character password has been correctly keyed in, program-

ming changes can be made. If more than one minute passes between keystrokes, the flowmeter will request reentry of the password before additional programming changes can be made.

2. Unscrew the six front cover screws (Figure 1-1) using a straight slotted screwdriver and swing the front cover open.
3. Press the [F] key and then press the [PASSWORD] key.
4. ENTER PASSWORD will appear on the display. Key in the current password and press the [YES] key.

NOTE

The password for all new flowmeters is set at the factory to 00.

5. NEW PASSWORD will appear on the display.
6. To change the password, key in a new two character password and press the [YES] key. The password has now been changed.
7. To leave the current password in effect, press the [NO] key.
8. Swing the front cover closed and tighten the six front cover screws.

PASSWORD OVERRIDE

1. If the current password has been forgotten, a password override switch located on the DC board inside the flowmeter can be used to view the current password and, optionally, assign a new password.
2. Turn off the electrical power to the flowmeter.
3. Unscrew the six front cover screws (Figure 1-1) using a straight slotted screwdriver and swing the front cover open.
4. Unscrew the two thumbscrews on the right side of the front panel (Figure 1-4) and swing the hinged front panel open.
5. Unscrew the printed circuit board hold down clamp thumbscrew and remove the printed circuit board hold down clamp (Figure 4-3).

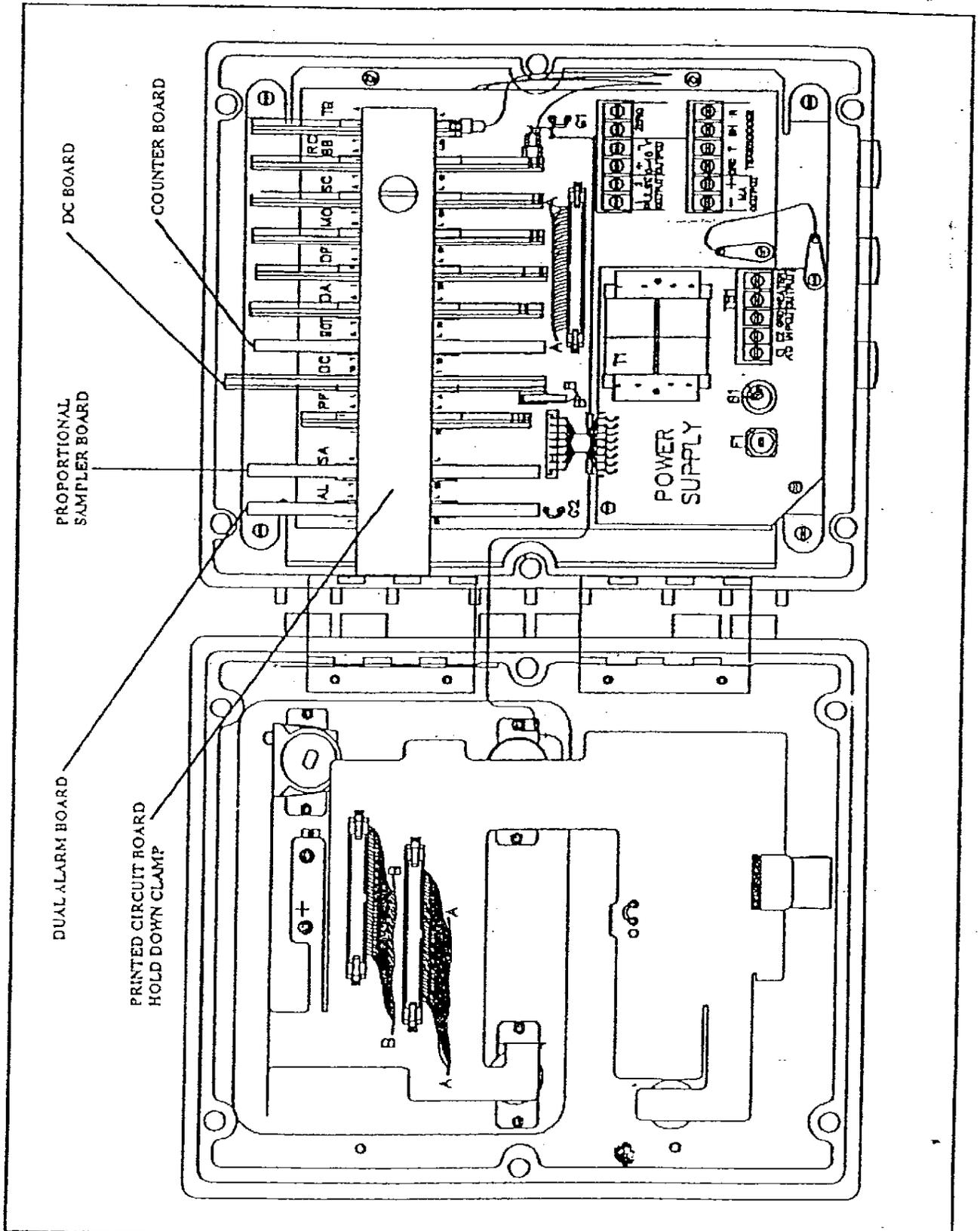


Figure 4-3
Inside Of Flowmeter Case

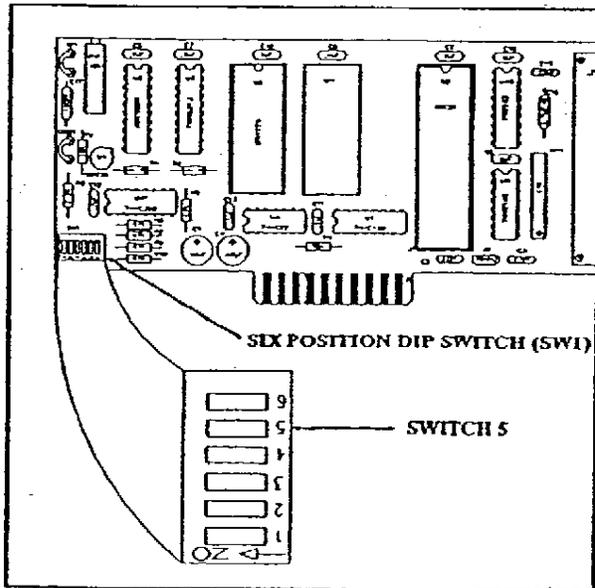


Figure 4-4
DC Board

6. Remove the DC board from the fourth slot from the left side of the flowmeter (Figure 4-3).

NOTE

Handle printed circuit boards as described in the Printed Circuit Board Handling section of Chapter 4, Maintenance.

7. Move switch five of the six position dip switch (SW1) mounted at the bottom left corner of the DC board to the ON position (Figure 4-4).

8. Replace the DC board in the fourth slot from the left side of the flowmeter (Figure 4-3). Turn on the electrical power to the flowmeter.

9. Initialize the flowmeter by pressing the [F] key followed by the [.] key followed by the [CLEAR] key. The display will momentarily flash signaling that the flowmeter has been initialized.

NOTE

The flowmeter must be initialized following any change to the six position dip switch (SW1) on the

DC board. Initializing the flowmeter erases all program parameters.

10. Press the [F] key and press the [PASSWORD] key.

11. CURRENT PASSWORD _____ ##, where ## is the password, will appear on the display for approximately 4 seconds then NEW PASSWORD _____ ? will appear on the display.

12. To leave the current password in effect, press the [NO] key. To change the password, key in the new password and press the [YES] key.

13. Turn off the electrical power to the flowmeter.

14. Remove the DC board from the fourth slot from the left side of the flowmeter (Figure 4-3).

15. Move switch five of the six position dip switch (SW1) mounted at the bottom left corner of the DC board to the OFF position (Figure 4-4).

16. Replace the DC board in the fourth slot from the left side of the flowmeter (Figure 4-3).

17. Replace the printed circuit board hold down clamp and thumbscrew.

18. Swing the hinged front panel closed and tighten the two thumbscrews on the right side of the front panel.

19. Swing the front cover closed and tighten the six front cover screws.

20. Turn on the electrical power to the flowmeter.

21. Reprogram the flowmeter as described in Chapter 2, Programming. The flowmeter must be reprogrammed following any change to the six position dip switch (SW1) on the DC board.

CHAPTER 5 INSTALLATION

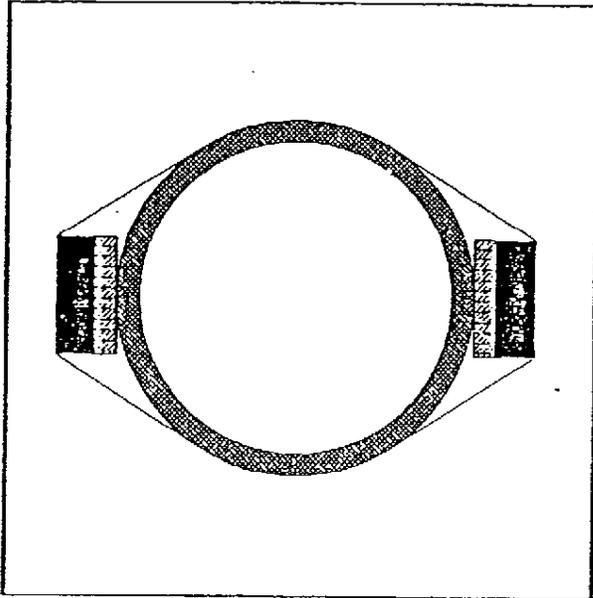


Figure 5-1
Transducer Mounting For Less Than
24-Inch Diameter Pipe

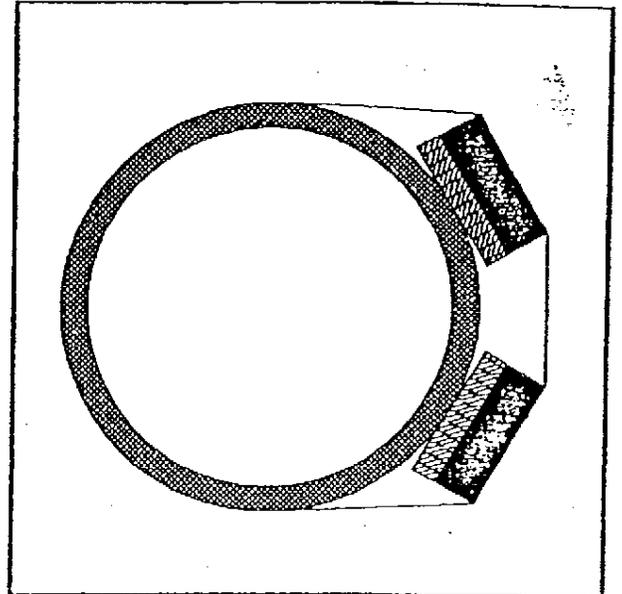


Figure 5-2
Transducer Mounting For 24-Inch And
Larger Diameter Pipe

TRANSDUCER MOUNTING

1. At the site where the transducers are going to be mounted (Figure 5-1 and 5-2), clean an area on the pipe slightly larger than the transducer to the bare metal.
2. Place the transducer mounting strap around the pipe (series two or more straps for large pipes) and snap the worm gear assembly in place with some slack in the straps.
3. Apply a heavy coat of Polysonics' Ultrasonic Coupling Compound to the face of each transducer (Figure 5-3).
4. Lift the strap and slide the transducers underneath allowing the strap to engage the two indentations on either side of the transducers while keeping the transducers about 1/2-inch away from the pipe.
5. Position the transducers and strap to the predetermined location on the pipe and tighten the strap. The strap only needs to be tight enough to hold the transducers from sliding on the pipe. This can be tested by

trying to rotate or slide the transducer(s) slightly while tightening the strap.

6. After tightening the strap verify that the Ultrasonic Coupling Compound is squeezing out on all sides of the transducers forming a bead along the edge. Any voids or air gaps under the transducers will reduce the ultrasonic signal and can render the flowmeter inoperative.

FLOWMETER HOUSING INSTALLATION

1. The flowmeter housing should be mounted on a vertical surface with the conduit holes located at the bottom of the housing. Mounting dimensions and conduit locations are shown in Figure 5-4.
2. If the flowmeter housing is to be mounted on a flat surface, attach the four mounting ears (Figure 5-4) to the back of the housing using the 1/4-20 x 3/8-inch flat head screws. Attach the flowmeter housing to the flat surface with screws through the mounting holes in the mounting ears.

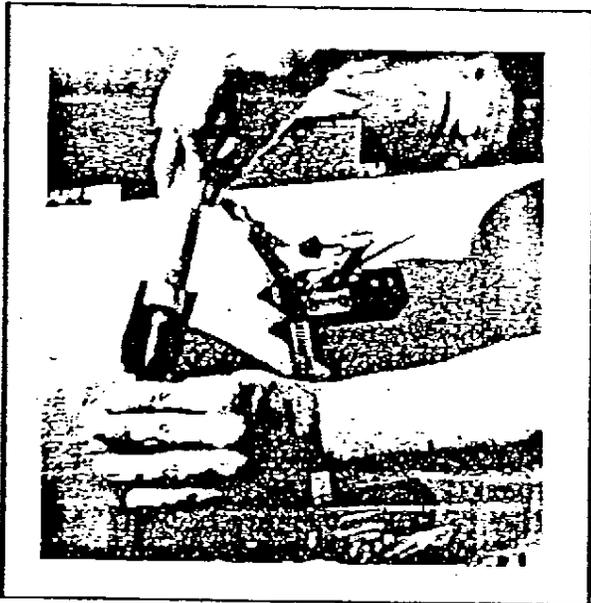


Figure 5-3
Application of Ultrasonic Coupling Compound

3. If the flowmeter housing is to be mounted to a unistrut or pipe, use the universal mounting kit (Fig 5-5). Attach the mounting brackets to the back of the housing using the 1/4-20 x 3/8-inch flat head screws. For a pipe, place the two clamps around the pipe, insert the threaded ends of the clamps through the clamp shackles and mounting holes in the mounting brackets, and screw the nuts onto the threaded ends of the clamps. Position the height of the flowmeter housing on the pipe and tighten the nuts on the clamps.

For a unistrut, place the two clamps or four bolts through holes in the unistrut at the proper height, insert the threaded ends of the clamps through the mounting holes in the mounting brackets, screw the nuts onto the threaded ends of the clamps, and tighten the nuts.

4. Install the required conduits and wiring for the flowmeter in accordance with applicable codes and standards.

CAUTION

Make sure power cables are not routed through the same conduit as the auxiliary input and output cables to reduce electrical noise. Auxiliary input and output cables that are lined voltage connections to external devices, should be routed through the power conduit.



This symbol indicated that the operator must refer to the instruction manual prior to making any connections to the equipment.

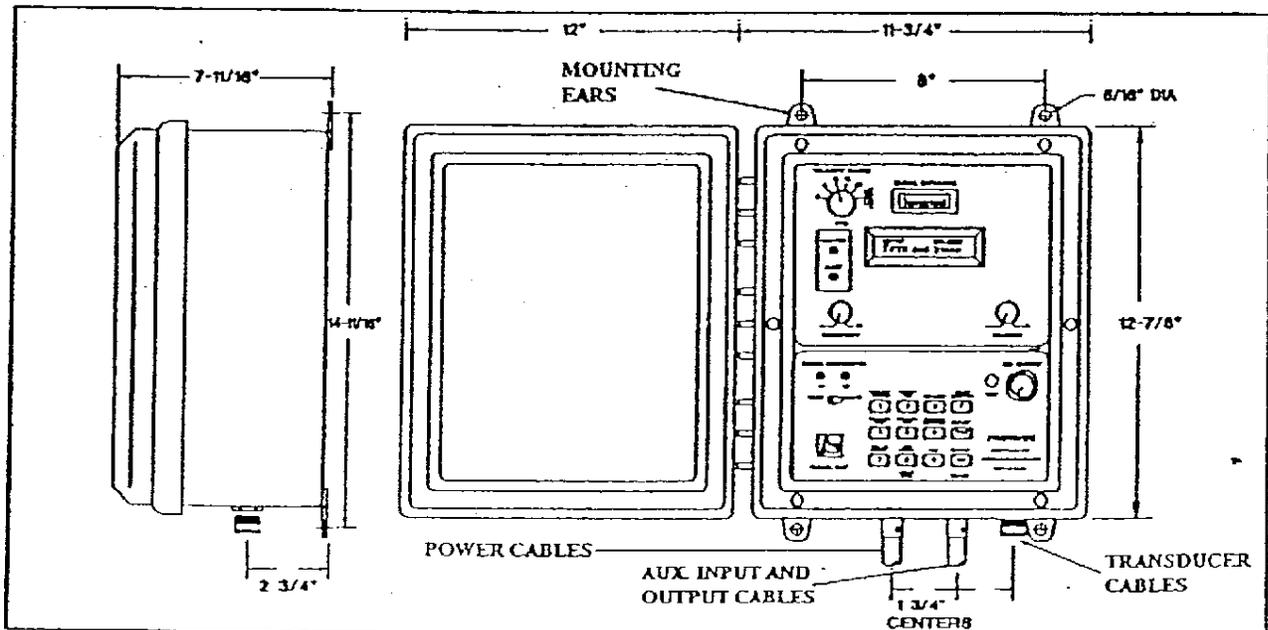
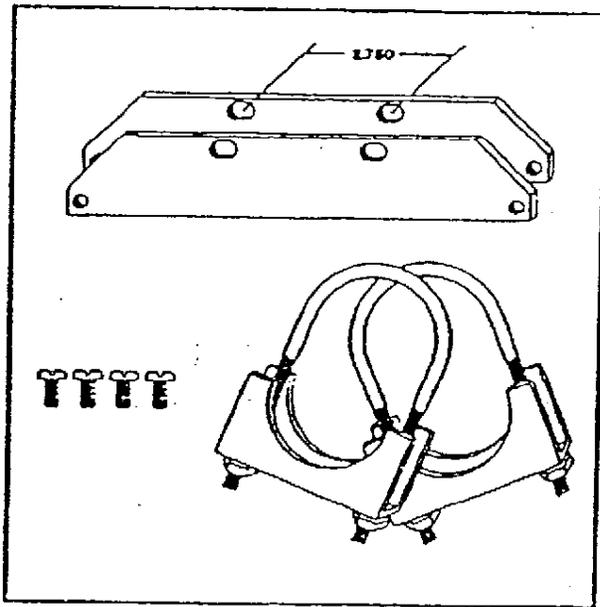


Figure 5-4
Mounting Dimensions and Conduit Locations



This symbol indicates a PROTECTIVE GROUND TERMINAL which must be connected to earth ground prior to making any other connection to the equipment.

WIRING CONNECTIONS AND VOLTAGE SELECTION

WARNING: Equipment must be grounded to an earth ground on the PROTECTIVE GROUNDING TERMINAL before any other connections are made.

120 VAC OPERATION

1. Unscrew the six front cover screws (Fig 1-1) using a straight slotted screwdriver and swing the front cover open.
2. Unscrew the two thumbscrews on the right side of the hinged front panel opening.
3. Unscrew the two screws that hold the protective cover in place over the power supply terminals and remove the cover.
4. Check to see that the LINE VOLTAGE SELECT switch is set in the 120 position. If it is not, use a straight slotted screw driver to carefully change it to that position.

5. Verify that the correct fuse for the selected line voltage is installed in flowmeter by following the instructions in the Fuse Replacement section of Chapter 4, Maintenance.

6. The power cable is connected to the terminals labeled AC INPUT on the Power supply board (Fig 5-4). Connect the hot wire to the L1 terminal, connect the neutral wire to the L2 terminal and connect the ground wire to the GND terminal.

7. Replace the protective cover over the power supply terminals and replace the two screws that hold it in place.

240 VAC OPERATION

1. Unscrew the six front cover screws (Fig 1-1) using straight slotted screwdriver and using the front cover open.

2. Unscrew the two thumbscrews on the right side of the hinged front panel opening.

3. Unscrew the two screws that hold the protective cover in place over the power supply terminals and remove the cover.

4. Check to see that the LINE VOLTAGE SELECT switch is set in the 240 position. If it is not, use a straight slotted screw driver to carefully change it to that position.

5. Verify that the correct fuse for the selected line voltage is installed in the flowmeter by following the instruction in the Fuse Replacement section of Chapter 4, Maintenance.

6. The power cable is connected to the terminals labeled AC INPUT on the Power Supply board (Fig 5-6). Connect one of the hot wires to the L1 terminal and the other hot wire to the L2 terminal and connect the ground wire to the GND terminal.

7. Replace the protective cover over the power supply terminals and replace the two screws that hold it in place.

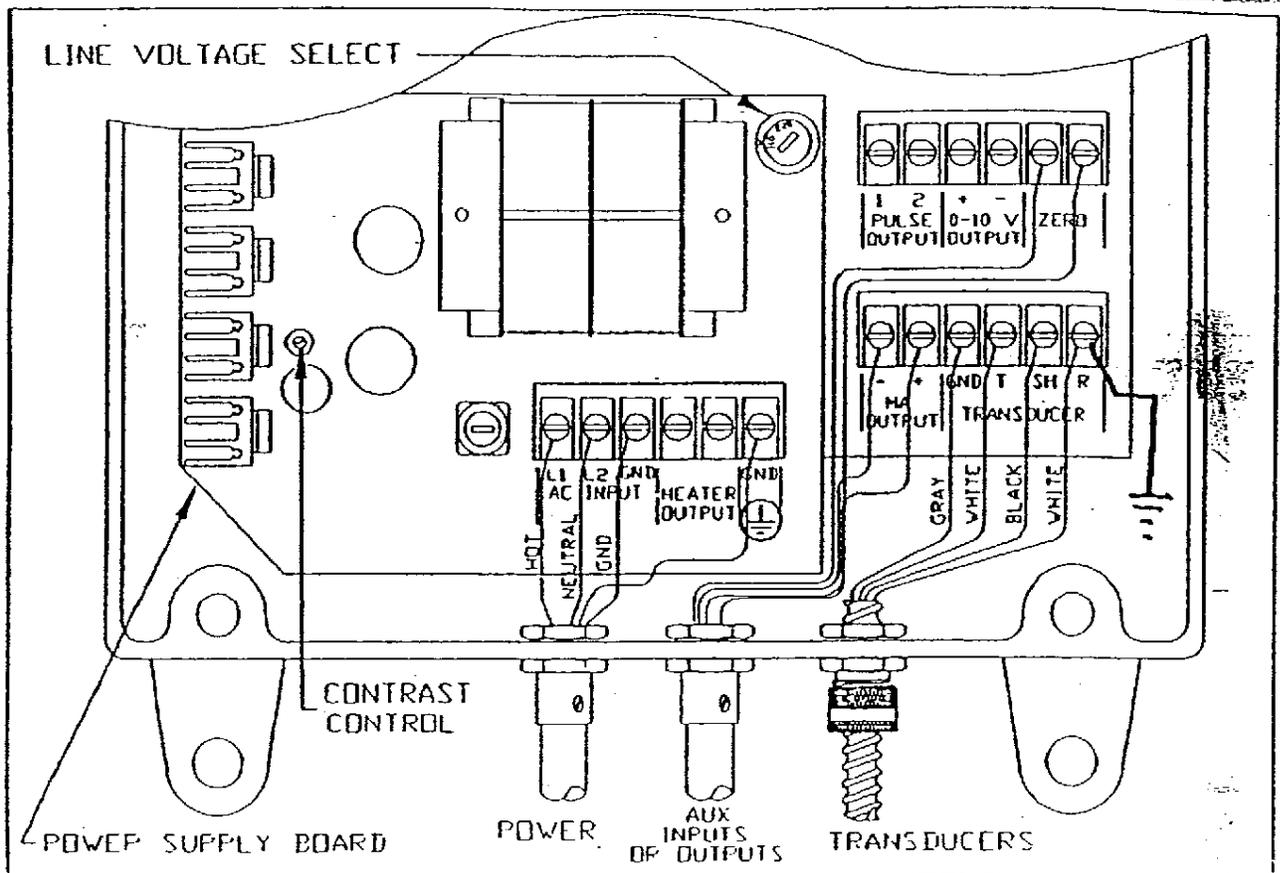


Figure 5-6
Line Voltage Selection and Wiring

TRANSDUCER AND AUXILIARY OUTPUT CABLE

1. The transducer cable is connected to the terminals labeled TRANSDUCER on the far right side of the flowmeter housing (Fig 5-6). Connect the gray wire to the GND terminal, connect one of the white wires to the T terminal and the other white wire to the R terminal, and connect the black wire to the SH terminal. The white wires and the T and R terminals are interchangeable allowing either white wire to be connected to either terminals.

2. The auxiliary output cable for the 4-20 mA interface for an external device, such as, a chart recorder, is connected to the terminals labeled MA OUTPUT immediately to the left of the transducer terminals (Fig 5-6). Connect the positive polarity wire to the + terminal and the negative polarity wire to the - terminal. The 4-20 mA interface output is rated for a loop resistance of up to 750 ohms and is isolated for 1500 volts.

3. The auxiliary output cable for the 0-10 VDC interface for an external device, such as, a chart recorder, is connected to the terminals labeled 0-10 V OUTPUT on the far right side of the flowmeter housing above the transducer terminals (Fig 5-6). Connect the positive polarity wire to the + terminal and the negative polarity wire to the - terminal.

NOTE

The source of the 0-10 VDC output voltage is not isolated and is returned to the internal ground of the flowmeter. Therefore, it must be connected to an isolated device.

4. The auxiliary input cable for the positive zero interface used to inhibit flow rate readings and totalizer counting during no flow conditions is connected to the terminals labeled ZERO on the far right side of the flowmeter housing above the transducer terminals (Fig 5-6). The terminals are interchangeable allowing either wire to be connected to either of the terminals.

5. Swing the hinged front panel closed and tighten the two thumbscrews on the right of the front panel.

6. Swing the front cover closed and tighten the six front cover screws.

SET DISPLAY CONTRAST

1. With electrical power to the flowmeter turned on, unscrew the six front cover screws (Fig 1-1) using a straight slotted screwdriver and swing the front cover open.

2. Unscrew the two thumbscrews on the right side of the front panel (Fig 1-4) and swing the hinged front panel open.

CAUTION

Avoid touching any components in the flowmeter to prevent electrical shock. Use an insulated screwdriver to adjust the CONTRAST control.

3. Adjust the display contrast by turning the CONTRAST control on the power supply board (Fig 5-6) using a phillips or small straight slotted screwdriver. To darken the characters on the display, turn the CONTRAST control clockwise. To lighten the characters on the display, turn the CONTRAST control counter-clockwise.

4. Swing the hinged front panel closed and tighten the two thumbscrews on the right side of the front panel.

5. Swing the front cover closed and tighten the six front cover screws.

TRANSDUCER SITE SELECTION

The following criteria should be considered when selecting the site for installation of the transducers:

- The site should be easily accessible for installation, later inspection, and servicing.
- A location for mounting the flowmeter housing must be within the reach of the transducer cable (20 to 100 ft. maximum).
- The pipe temperature must be within the transducer temperature rating.
- Do not mount transducers on severely vibrating pipes.

- The site should be as far away as possible from noise sources, such as, throttling valves, pump orifices, and reduced pipe sections. The transducer should be mounted so that the ultrasonic signal is directed away from noise sources. The transducer directs the ultrasonic signal in the direction of its own cable.
- If possible, the site should be upstream of noise sources.
- The site should be as far away as possible from fluid velocity increasing devices, such as, orifices, plates, partially closed valves, and venturis.
- Do not mount the transducers close to a turbine meter. The flowmeter will read the velocity of the fluid coming off the turbine blades.
- The section of piping where the transducers are to be mounted must always be full of fluid. A vertical pipe with upward flow or a full horizontal section is recommended.
- Do not mount the transducers on a vertical pipe with downward flow. The pipe may not be full of fluid.
- If a horizontal section of piping is selected, mount the transducer on the sides of the pipe. Do not mount the transducers on the top or bottom of pipe. Foaming at the top of the pipe or sediment at the bottom of the pipe may interfere with the ultrasonic signals.
- For less than 24-inch diameter pipe, mount the transducers opposite each other at the 3 o'clock and 9 o'clock position (Fig 5-1).
- For 24-inch and larger pipes, mount the transducers on the same side of the pipe at the 2 o'clock and 4 o'clock positions, two to six inches apart (Fig 5-6).

CHAPTER 6 TROUBLESHOOTING

| TROUBLESHOOTING CHART | | |
|---|---|--|
| PROBLEM | CAUSE | SOLUTION |
| Erratic flow rate readings or a drastic change in the flow rate readings. | The transducers were mounted downstream of a noise source, such as, a throttling valve, pump, orifice, or reduced pipe section. | Move the transducers upstream of the noise source. |
| Incorrect Flow Rate Readings. | <ol style="list-style-type: none"> 1. The transducers were mounted on the top and bottom of a horizontal pipe. Foaming at the top or sediment at the bottom of the pipe is interfering with the ultrasonic signal. 2. The transducers are mounted on a vertical pipe with flow in the downward direction. The pipe is not full of fluid. | <ol style="list-style-type: none"> 1. Move the transducers to the sides of the pipe. 2. Move the transducers to another location where the pipe is full. |
| Incorrect flow rate in clean fluids. | <ol style="list-style-type: none"> 1. A strong turbulence producing component, such as, a venturi, orifice plate or partially closed valve, is acoustically within range of the transducers. The flowmeter is reading the fluid velocity through the restricted opening. 2. The flowmeter is programmed for the wrong pipe inside diameter. | <ol style="list-style-type: none"> 1. Move the transducers to an acoustically isolated section of pipe, such as, between two elbows, which will confine the ultrasonic signal. 2. Reprogram the flowmeter for the correct pipe inside diameter. |
| Weak or erratic ultrasonic signal. | <ol style="list-style-type: none"> 1. The transducers are mounted on opposite sides of the pipe. 2. The fluid being measured is a clean fluid. 3. Low fluid velocity. | <ol style="list-style-type: none"> 1. Move the transducers to the same side of the pipe. 2. Move the transducers near a pump or discharge. In extreme cases, inject air or nitrogen into the fluid. 3. Move the transducers to a reduced diameter section of piping. If a reduced diameter section of piping does not exist, one may have to be installed to be able to measure fluid flow. |

CHAPTER 6 - TROUBLESHOOTING

| TROUBLESHOOTING CHART | | |
|---|--|---|
| PROBLEM | CAUSE | SOLUTION |
| Weak or erratic ultrasonic signal. | <ol style="list-style-type: none"> 4. The transducers are mounted on fiberglass pipe that attenuates the ultrasonic signal. 5. The transducers are mounted on lined pipe that attenuates the ultrasonic signal. 6. Voids or air gaps exist in the coupling compound under the transducers. | <ol style="list-style-type: none"> 4. Move the transducers to a section of piping that is not fiberglass. 5. Move the transducers to a section of piping that is not lined or is lined with another material. 6. Remove the transducers, clean the old coupling compound from the transducers and pipe, apply a heavy coat of coupling compound to the transducers, and remount the transducers. |
| The flow rate reading increases when a control valve is partially closed to reduce the fluid flow. | The transducers are mounted too close to the control valve. When the valve is partially closed, the flowmeter is measuring the increased fluid velocity as it goes through the restricted opening in the control valve. | Move the transducers further away from the control valve. |
| The flowmeter has been operating satisfactorily. Suddenly, the flowmeter can no longer measure the flow rate. | <ol style="list-style-type: none"> 1. Air bubbles have started to form in the fluid resulting in too many bubbles to allow the ultrasonic signal to penetrate the flow stream. 2. The sludge has become too dense to allow the ultrasonic signal to penetrate the flow stream. 3. A new ingredient was added to the fluid that is absorbing the ultrasonic signal. 4. The coupling compound under the transducers has washed away. | <ol style="list-style-type: none"> 1. Reset the SENSITIVITY control to correct for changes in the fluid. 2. Reset the SENSITIVITY control to correct for changes in the fluid. 3. Reset the SENSITIVITY control to correct for changes in the fluid. 4. Remove the transducers, clean the old coupling compound from the transducers and the pipe, apply a heavy coat of coupling compound to the transducers, and remount the transducers. |
| A flashing ALERT light and a continuously lit OPERATE light. | There are spurious high frequency noise signals that may cause incorrect flow rate readings. | Determine the cause of the spurious signals and take appropriate action to eliminate them. |

| TROUBLESHOOTING CHART | | |
|---|---|---|
| PROBLEM | CAUSE | SOLUTION |
| Continuously lit SIGNAL PROCESSOR + light. | The signal processor circuit cannot compensate for all of the spurious low frequency noise signals that are present. | Move the transducers to another location. |
| The SENSITIVITY control is rotated more than 75% of the way to the full clockwise position. | The strength of the reflected ultrasonic signal is weak and causes the flowmeter to be more susceptible to interfering frequencies. | Remove the transducers, clean the old coupling compound from the transducers and the pipe, apply a heavy coat of coupling compound to the transducers, remount the transducers, and reset the SENSITIVITY control. If the SENSITIVITY control is still more than 75% of the way to the full clockwise position, move the transducers to another location. |
| Calibration Test Failed. | <ol style="list-style-type: none"> 1. The DAMPING control was not at the minimum (full counter-clockwise) position. 2. The flowmeter is out of calibration. | <ol style="list-style-type: none"> 1. Turn the DAMPING control to the minimum position and perform the calibration test again. 2. Have the flowmeter serviced. |

CHAPTER 7 ACCESSORIES

ACCESSORY KIT

The accessory kit includes four transducer mounting straps and one tube of Ultrasonic Coupling Compound. The transducer mounting straps are 32-inch long stainless steel pipe straps with a worm screw tightening device. A 5/16-inch wrench fits the hex head of the worm screw. The Ultrasonic Coupling Compound is supplied in a two ounce tube and is good for temperatures up to 250°F. The compound is in grease form and is made from a mineral oil base.

UNIVERSAL MOUNTING KIT

The universal mounting kit includes two mounting brackets, two nickel plated U-bolt and shackle clamps and four screws. The mounting kit facilitates mounting the flowmeter housing to a unistrut or pipe. The mounting brackets are used to adapt the mounting pattern of the flowmeter housing to the clamps with the slotted holes in the bracket accepting the threaded portion of the clamps. The screws are standard 1/4-20 thread flat head screws 3/8-inch long.

CHAPTER 8

OPTIONS

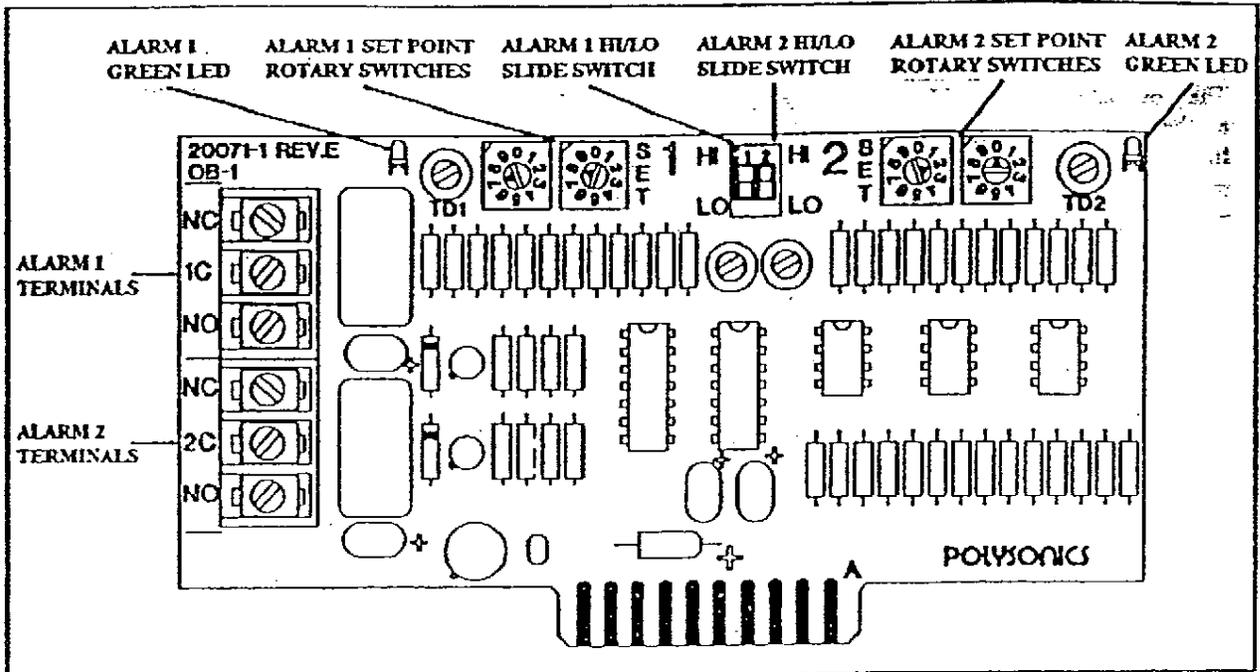


Figure 8-1
Dual Alarm Board

DUAL ALARM OPTION

DESCRIPTION

The Dual Alarm board (Figure 8-1) consists of two independently operating flow alarm monitors that can be connected to external annunciators. They may be used as a HI-LO alarm, dual HI or dual LO alarms. The set point of each alarm is a percentage of the flowmeter's full scale flow rate. Additionally, each alarm may be set for a high trip or a low trip. The green LEDs are lit when the relays are energized.

Both alarm monitors have an on-board terminal strip with SPDT contacts available for connection to an external annunciator. The relay contacts are rated at 1 A, 24 VDC or 115/240 VAC, non-inductive. The hysteresis (deadband) is fixed at 0.8% of span.

SET POINT

1. The set point of alarm 1 is set with the two rotary switches on the left side of the board and alarm 2 is set with the two rotary switches on the right side of the

board. Alarm 1 is set to be a high trip or low trip alarm using the left HI/LO slide switch and alarm 2 is set using the right HI/LO slide switch.

2. Calculate the flowmeter's full scale flow rate as described in Appendix B, Flow Conversion Data.

3. Calculate the set point for each alarm as a percentage of the flowmeter's full scale flow rate.

4. For each alarm, rotate the left rotary switch to the number that is in the 10 position of the set point number and rotate the right rotary switch to the number that is in the unit position of the set point number. In Figure 8-1 the left rotary switch of alarm 1 is set to 7 and the right rotary switch of alarm 1 is set to 8 for a set point of 78 percent.

CHAPTER 3 - OPTIONS

NOTE

Alarm set points must be recalculated and reset if the VELOCITY RANGE switch or the flow rate factor is changed.

5. For each alarm, move its HI/LO slide switch to the HI position if the alarm is to be a high trip alarm or to the LO position if the alarm is to be a low trip alarm.

Example

The flowmeter's VELOCITY RANGE switch is set at 8, the pipe inside diameter is 7.981-inches and the flowmeter's flow rate units are set to gallons per minute. A high alarm is desired for 973 gallons per minute and a low alarm is desired for 250 gallons per minute.

Calculate the flowmeter's full scale flow rate as described in Appendix B, Flow Conversion Data:

$$\begin{aligned}\text{Full Scale} &= \text{VR} \times \text{ID}^2 \times 2.45 \\ \text{Flow Rate} &= 8 \times 7.981^2 \times 2.45 \\ &= 1,248 \text{ gal./min.}\end{aligned}$$

Calculate the set points for the high and low alarms:

$$\begin{aligned}\text{High Alarm} &= \text{High Alarm Value} / \text{Full Scale} \\ \text{Set Point} &= \text{Flow Rate} \\ &= 973 \text{ gal./min.} / 1,248 \text{ gal./min.} \\ &= .78 \text{ or } 78\%\end{aligned}$$

$$\begin{aligned}\text{Low Alarm} &= \text{Low Alarm Value} / \text{Full Scale} \\ \text{Set Point} &= \text{Flow Rate} \\ &= 250 \text{ gal./min.} / 1,248 \text{ gal./min.} \\ &= .2 \text{ or } 20\%\end{aligned}$$

The alarms in Figure 8-1 are set as required by this example. The left alarm is set to 78% of the full scale fluid rate as a high alarm, and the right alarm is set to 20% of the full scale flow rate as a low alarm.

INSTALLATION

1. Turn off the electrical power to the flowmeter.

2. Unscrew the six front cover screws (Figure 1-1) using a straight slotted screwdriver and swing the hinged front cover open.

3. Unscrew the two thumbscrews on the right side of the front panel (Figure 1-4) and swing the hinged front panel open.

4. Unscrew the printed circuit board hold down clamp thumbscrew and remove the printed circuit board hold down clamp (Figure 4-3).

5. The external annunciator for each alarm is connected to the Dual Alarm board at the terminals on the left end of the board (Figure 8-1). The first three terminals on top are for alarm 1 and the last three terminals on bottom are for alarm 2.

NOTE

Handle printed circuit boards as described in the Printed Circuit Board Handling section of Chapter 4, Maintenance.

6. To connect the external annunciator as a normally closed circuit, connect one wire to the NC (top) terminal and connect the other wire to the C (middle) terminal.

7. To connect the annunciator as a normally open circuit, connect one wire to the NO (bottom) terminal and connect the other wire to the C (middle) terminal.

8. Place the Dual Alarm board in the first slot from the left side of the flowmeter (Figure 4-3).

9. Replace the printed circuit board hold down clamp and thumbscrew.

10. Swing the hinged front panel closed and tighten the two thumbscrews on the right side of the front panel.

11. Swing the front cover closed and tighten the six front cover screws.

12. Turn on the electrical power to the flowmeter.

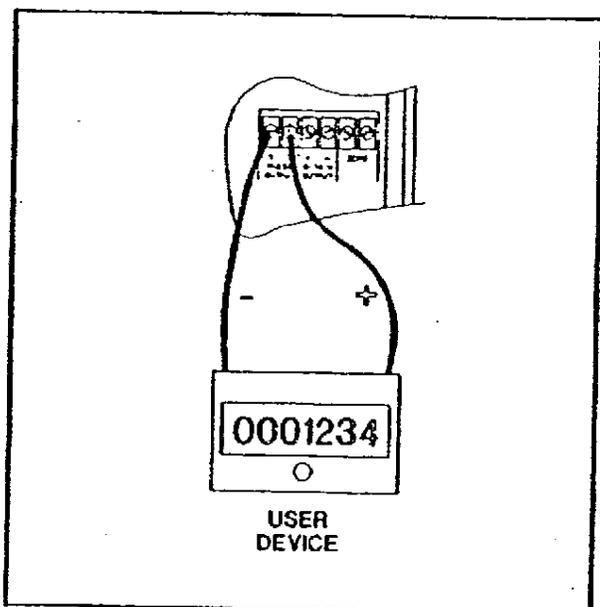


Figure 8-2
Remote Totalizer Powered By Flowmeter

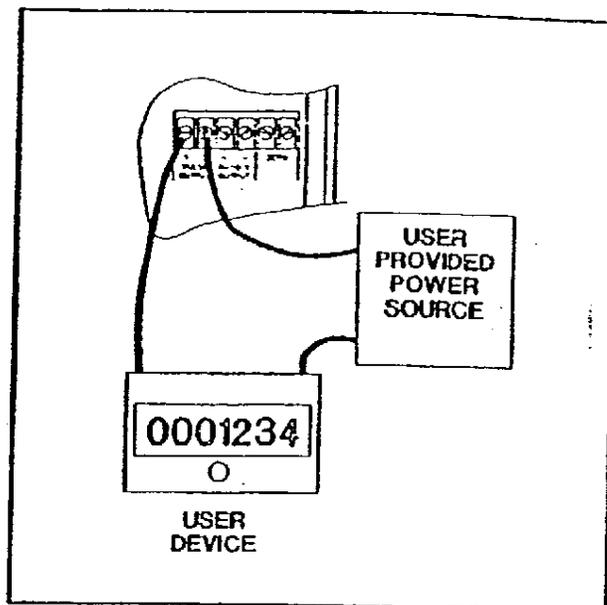


Figure 8-3
Remote Totalizer Powered By An
External Power Source (Dry Contact)

REMOTE TOTALIZER

DESCRIPTION

The remote totalizer is an external counter that replaces the totalizer count shown on the flowmeter display. The remote totalizer may be configured to be powered by the flowmeter (Figure 8-4) or by an external power source (Figure 8-5). This configuration is set at the factory.

When the remote totalizer is powered by the flowmeter, the output is 15 VDC and is limited to 2 W. A 50 millisecond pulse will be provided each time the fluid volume programmed into the totalizer occurs.

When the remote totalizer is powered by an external power source, the output is defined as a dry contact relay and is rated at 2 A DC resistive load or 0.5 A at 115 VAC at a normal temperature of 25°C. The contact closure can be configured at the factory to normally open or normally closed. The relay will activate each time the fluid volume programmed into the totalizer occurs.

SET POINT

There are no set points for this option.

MAINTENANCE

1. A fuse for the remote totalizer is located on the Counter board (Figure 8-4).

2. To replace the fuse, turn off the power to the flowmeter.

3. Unscrew the six front cover screws (Figure 1-1) using a straight slotted screwdriver and swing the hinged front cover open.

4. Unscrew the two thumbscrews on the right side of the front panel (Figure 1-4) and swing the hinged front panel open.

5. Unscrew the printed circuit board hold down clamp thumbscrew and remove the printed circuit board hold down clamp (Figure 4-3).

6. Remove the Counter board from the fifth slot from the left side of the flowmeter (Figure 4-3).

NOTE

Handle printed circuit boards as described in the Printed Circuit Board Handling section of Chapter 4, Maintenance.

7. Remove the burned out fuse from the fuse holder on the Counter board using a small straight slotted screwdriver (Figure 8-6).

NOTE

The output for a remote totalizer powered by the flowmeter is +15 V, maximum 3 watts, 50 millisecond, pulsed output.

6. If the remote totalizer is powered by an external power source, connect one wire to the 1 terminal and the other wire to the 2 terminal. Either wire can be connected to either terminal.

NOTE

The output for a remote totalizer powered by an external power source is dry contact closure.

7. Unscrew the printed circuit board hold down clamp thumbscrew and remove the printed circuit board hold down clamp (Figure 4-3).

8. Remove the DC board from the fourth slot from the left side of the flowmeter (Figure 4-3).

NOTE

Handle printed circuit boards as described in the Printed Circuit Board Handling section of Chapter 4, Maintenance.

9. Move switch four of the six position dip switch (SW1) mounted at the bottom left corner of the DC board to the ON position (Figure 4-4).

10. Replace the DC board in the fourth slot from the left side of the flowmeter (Figure 4-3).

11. Place the Counter board in the fifth slot from the left side of the flowmeter (Figure 4-3).

12. Replace the printed circuit board hold down clamp and thumbscrew.

13. Swing the hinged front panel closed and replace the two thumbscrews on the right side of the front panel.

14. Swing the front cover closed and tighten the six front cover screws.

15. Turn on the electrical power to the flowmeter.

16. Reprogram the flowmeter as described in Chapter 2, Programming. The flowmeter must be reprogrammed following any change to the six position dip switch (SW1) on the DC board.

APPENDIX A

GLOSSARY

Accuracy

A measure of the preciseness of an instrument's measurements when compared to a known standard. Accuracy is generally specified as the maximum error of the instrument's measurement expressed as a percentage.

Attenuation

The reduction in strength of an electrical or ultrasonic signal, i.e., the weakening of Doppler signal.

Clean Fluid

A fluid that has few suspended particles. Examples of clean fluids are distilled water, solvents, and alcoholic beverages.

Damping

The slowing of instantaneous signal changes to provide a more gradual or lower frequency response to the process measurement.

Dedicated

For permanent mounting; non-portable.

Dirty Fluids

Liquids containing suspended solids, contaminant, particles, or bubbles. Examples of dirty fluids are sewage, paper pulp, and coal slurry.

Doppler Theory

Developed by Christian Doppler, the effect wherein there is a measurable change of sound or light frequency as a function of the relative velocity of the source to the observer.

Doppler Shift

The measured difference between transmitted and received frequencies as a result of fluid motion.

English Flowmeter

A flowmeter that measures fluid flow using measurement units, i.e., feet, inches, gallons, etc., that are standard in the United States of America.

Full Scale Flow Rate

The highest fluid flow rate that can be measured by the flowmeter with its current settings. The full scale flow rate is dependant upon the setting of the VELOCITY RANGE switch, the pipe inside diameter and the setting of the flow rate factor. The full scale flow rate is calculated as described in Appendix B, Flow Conversion Data.

Internal Frequency Standard (IFS)

A standard feature on all Polysonics flowmeters, that is a built-in frequency source having a pre-assigned value of calibration checks in the field.

Intrinsically Safe

Conforming to standard set forth by a regulating agency which limits the voltage and current levels in a device so it is incapable of causing combustion through a spark or heat producing component in explosive or hazardous areas.

LCD

Liquid Crystal Display

APPENDIX A - GLOSSARY

LED

Light emitting diode.

Linearity

The ability of the flowmeter to establish a relationship between actual flow and its output, often called the characteristic curve of the flowmeter, to approximate a straight line relationship.

Metric Flowmeter

A flowmeter that measures fluid flow using measurement units, i.e., meters, millimeters, liters, etc., that are standard in the metric system.

NEMA-4X

An industry standard for instrument enclosures that are water tight and corrosion resistant with no exposed metal surfaces. The enclosure must pass a hose test, using a 1-inch nozzle, delivering 65 GPM at a 10 foot distance for 5 minutes.

NEMA-7

An industry standard for explosion proof instrument enclosures in hazardous environments, such as, an atmosphere of ethylether, ethylene, cyclopropane, gasoline, petroleum, alcohol or natural gas.

Noise

Any frequencies picked up by the Doppler flowmeter which are not Doppler shifted frequencies.

Password

A two character code that must be correctly keyed in before the user can access the programming functions of the flowmeter.

Positive Zero

The option added to Polysonics flowmeters which inhibits backflow indication or volume accumulation under no-flow conditions. This is accomplished by activating the low signal circuit under a no-flow condition. It requires a contact closure from an external device, such as, a pump, in order to initiate its function.

Repeatability

The ability of a flowmeter to reproduce a measurement each time a set condition is repeated.

Slurry

A mixture of a fluid with any insoluble material such as clay, cement, coal, etc. usually described in terms of percent solids content.

Totalizer

A feature of the flowmeter that counts the total volume of fluid that flows past the transducers from the time the totalizer is turned on until it is placed on hold or is turned off.

APPENDIX B FLOW CONVERSION DATA

FULL SCALE FLOW RATE

The flowmeter's full scale flow rate is dependant upon the setting of the VELOCITY RANGE switch, the pipe inside diameter and the setting of the flow rate factor. The following equations are used to calculate the full scale flow rate with units of gallons per minute or liters per minute:

$$\text{Full Scale Flow Rate For US Flowmeters} = \text{VR} \times \text{ID}^2 \times 2.45 \times \text{CF} \times \text{FRF}$$

$$\text{Full Scale Flow Rate For Metric Flowmeters} = \text{VR} \times \text{ID}^2 \times .04712 \times \text{FRF}$$

- Where: CF = Conversion factor to convert gallons per minute for US flowmeters; or, liters per minute for metric flowmeters, to the flow rate units currently set on the flowmeter
 FRF = Flow rate factor (use a value of 1 if the flowmeter does not currently have a flow rate factor)
 ID = Pipe inside diameter
 VR = VELOCITY RANGE switch setting (2, 4, 8, 16, or 32 ft./sec.)

CONVERSION FORMULAS

The following are conversion formulas that are useful when dealing with fluid flow:

FLUID VELOCITY

$$\text{FPS} = \text{GPM} / (\text{ID}^2 \times 2.45)$$

$$\text{MPS} = \text{LPM} / (\text{ID}^2 \times .04712)$$

Where: FPS = Feet per second

GPM = Gallons per minute

ID = Pipe inside diameter

LPM = Liters per minute

MPS = Meters per second

°F = Degrees Fahrenheit

°C = Degrees Centigrade

FLUID FLOW RATE

$$\text{GPM} = \text{FPS} \times \text{ID}^2 \times 2.45$$

$$\text{LPM} = \text{MPS} \times \text{ID}^2 \times .04712$$

TEMPERATURE

$$^{\circ}\text{F} = (^{\circ}\text{C} \times 1.8) + 32$$

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) / 1.8$$

| TO CONVERT | INTO | MULTIPLY BY |
|--------------|------------------|-------------|
| Cubic Meters | U.S. Gallons | 264.2 |
| Feet | Meters | 0.3048 |
| U.S. Gallons | Imperial Gallons | 0.83267 |
| Inches | Millimeters | 25.4 |
| Meters | Feet | 3.281 |
| Millimeters | Inches | 0.03937 |
| Liters | U.S. Gallons | 0.2642 |
| U.S. Gallons | Cubic Meters | 0.3785 |

APPENDIX B - FLOW CONVERSION DATA

| VELOCITY CONVERSION TABLE FPS to GPM | | | | | | | | | | |
|--------------------------------------|----------|---------|---------|---------|---------|---------|---------|---------|--------|--------|
| NOMINAL PIPE SIZE (SCH 40) | VELOCITY | | | | | | | | | |
| | 0.5 FPS | 1.0 FPS | 2.0 FPS | 3.0 FPS | 4.0 FPS | 5.0 FPS | 6.0 FPS | 8.0 FPS | 10 FPS | 15 FPS |
| 1" | 1.3 | 2.7 | 5.4 | 8 | 11 | 13 | 16 | 22 | 27 | 40 |
| 1.5" | 3.2 | 6.5 | 13 | 19 | 25 | 32 | 38 | 51 | 64 | 95 |
| 2" | 5.2 | 10.5 | 21 | 31 | 42 | 52 | 63 | 84 | 105 | 157 |
| 2.5" | 7.5 | 15 | 30 | 45 | 60 | 75 | 90 | 119 | 149 | 224 |
| 3" | 11.5 | 23 | 46 | 69 | 92 | 115 | 138 | 184 | 231 | 346 |
| 4" | 20 | 40 | 80 | 119 | 159 | 199 | 238 | 318 | 397 | 596 |
| 5" | 31 | 62 | 125 | 187 | 250 | 312 | 374 | 499 | 624 | 936 |
| 6" | 45 | 90 | 180 | 270 | 360 | 451 | 541 | 721 | 901 | 1352 |
| 8" | 78 | 156 | 312 | 468 | 624 | 780 | 936 | 1248 | 1561 | 2341 |
| 10" | 123 | 246 | 492 | 738 | 984 | 1230 | 1476 | 1968 | 2460 | 3690 |
| 12" | 175 | 349 | 698 | 1047 | 1397 | 1746 | 2095 | 2793 | 3492 | 5237 |
| 14" | 211 | 422 | 844 | 1266 | 1688 | 2110 | 2532 | 3376 | 4220 | 6330 |
| 16" | 276 | 551 | 1103 | 1654 | 2205 | 2756 | 3308 | 4410 | 5513 | 8269 |
| 18" | 349 | 698 | 1396 | 2093 | 2791 | 3489 | 4187 | 5582 | 6978 | 10466 |
| 20" | 434 | 867 | 1734 | 2602 | 3469 | 4336 | 5203 | 6938 | 8672 | 13008 |
| 24" | 627 | 1254 | 2508 | 3763 | 5017 | 6271 | 7525 | 10034 | 12542 | 18814 |
| 30" | 1048 | 2096 | 4192 | 6288 | 8385 | 10481 | 12577 | 16769 | 20961 | 31442 |
| 36" | 1522 | 3044 | 6089 | 9133 | 12177 | 15221 | 18266 | 24354 | 30443 | 45664 |
| 42" | 2048 | 4169 | 8338 | 12506 | 16675 | 20844 | 25013 | 33351 | 41688 | 62532 |
| 48" | 2735 | 5470 | 10940 | 16409 | 21879 | 27349 | 32819 | 43758 | 54698 | 82047 |
| 54" | 3441 | 6882 | 13764 | 20646 | 27528 | 34410 | 41292 | 55056 | 68821 | |
| 60" | 4192 | 8385 | 16769 | 25154 | 33538 | 41923 | 50307 | 67076 | 83845 | |

G
P
M

CONVERSION FORMULA
GPM = FPS x ID² x 2.45

$ID = 15.250$
 $GPM = 6,000$

$ID^2 = 232.5625$

Where: FPS = Feet per second = 10.53044
GPM = Gallons per minute - 6,000 (5999.69)
ID = Pipe inside diameter - 15.250"

$6,000 \times .01134 = FPS \quad 3.779882$

$15,000 \text{ Gals. AT } 45 \text{ min} = 333.333$

Aug 2, 1993 Re-ranged To 0-3,000 Gpm

FPS 5.26

AS PER JOHN SEYMOUR

APPENDIX C PIPE SCHEDULES

NOTE

The following tables are provided to assist in programming the flowmeter. The inside diameters shown in the tables were calculated based upon the outside diameter and minimum wall thickness specified in applicable standards. The actual pipe inside diameter may vary from the dimension in the tables by as much as 25% of the pipe minimum wall thickness. The accuracy of the flow rate measurements will be enhanced if an actual measured pipe inside diameter is used.

APPENDIX C - PIPE SCHEDULES

STEEL, STAINLESS STEEL AND PVC PIPE
STANDARD SCHEDULES
INSIDE AND OUTSIDE DIAMETERS IN INCHES

| NOMINAL PIPE SIZE | INSIDE DIAMETER | | | | | | | | | | | | | O.D. | | | |
|-------------------|-----------------|---------------------|--------|--------|-----------|--------|--------|-------|--------|---------|---------|---------|---------|------|--|--|--|
| | SCH 5 | SCH 10 (LIGHT WALL) | SCH 20 | SCH 30 | STD. WALL | SCH 40 | SCH 60 | X STG | SCH 80 | SCH 100 | SCH 120 | SCH 140 | SCH 180 | | | | |
| 1" | 1.185 | 1.097 | | | 1.049 | 1.049 | | 0.957 | 0.957 | | | | | | | | |
| 1.25" | 1.53 | 1.442 | | | 1.380 | 1.380 | | 1.278 | 1.278 | | | | | | | | |
| 1.5" | 1.77 | 1.682 | | | 1.610 | 1.610 | | 1.500 | 1.500 | | | | | | | | |
| 2" | 2.245 | 2.157 | | | 2.067 | 2.067 | | 1.939 | 1.939 | | | | | | | | |
| 2.5" | 2.709 | 2.635 | | | 2.469 | 2.469 | | 2.323 | 2.323 | | | | | | | | |
| 3" | 3.334 | 3.260 | | | 3.068 | 3.068 | | 2.900 | 2.900 | | | | | | | | |
| 3.5" | 3.834 | 3.760 | | | 3.548 | 3.548 | | 3.364 | 3.364 | | | | | | | | |
| 4" | 4.334 | 4.260 | | | 4.026 | 4.026 | | 3.826 | 3.826 | | | | | | | | |
| 5" | 5.345 | 5.295 | | | 5.047 | 5.047 | | 4.813 | 4.813 | | | | | | | | |
| 6" | 6.407 | 6.357 | | | 6.065 | 6.065 | | 5.761 | 5.761 | | | | | | | | |
| 8" | 8.407 | 8.329 | | | 7.981 | 7.981 | | 7.625 | 7.625 | | | | | | | | |
| 10" | 10.482 | 10.42 | | | 10.02 | 10.02 | | 9.750 | 9.750 | | | | | | | | |
| 12" | 12.420 | 12.39 | | | 12.00 | 11.938 | | 11.75 | 11.37 | | | | | | | | |
| 14" | | 13.50 | | | 13.25 | 13.124 | | 13.00 | 12.50 | | | | | | | | |
| 16" | | 15.50 | | | 15.25 | 15.000 | | 15.00 | 14.31 | | | | | | | | |
| 18" | | 17.50 | | | 17.25 | 16.876 | | 17.00 | 16.12 | | | | | | | | |
| 20" | | 19.50 | | | 19.25 | 18.814 | | 19.00 | 17.93 | | | | | | | | |
| 24" | | 23.50 | | | 23.25 | 22.626 | | 23.00 | 21.56 | | | | | | | | |
| 30" | | 29.37 | | | 29.00 | 29.250 | | 29.00 | | | | | | | | | |
| 36" | | 35.37 | | | 35.00 | 35.25 | | 35.00 | | | | | | | | | |
| 42" | | | | | 41.25 | 41.25 | | 41.00 | | | | | | | | | |
| 48" | | | | | 47.25 | 47.25 | | 47.00 | | | | | | | | | |

| CAST IRON PIPE STANDARD CLASSES INSIDE AND OUTSIDE DIAMETERS IN INCHES | | | | | | | | | | | | | | | | |
|--|---------|-------|---------|-------|---------|-------|---------|-------|---------|--------|---------|--------|---------|--------|---------|--------|
| NOMINAL PIPE SIZE | CLASS A | | CLASS B | | CLASS C | | CLASS D | | CLASS E | | CLASS F | | CLASS G | | CLASS H | |
| | O.D. | I.D. | O.D. | I.D. | O.D. | I.D. | O.D. | I.D. |
| 3" | 3.80 | 3.02 | 3.96 | 3.12 | 3.96 | 3.06 | 3.96 | 3.00 | 7.22 | 6.06 | 7.22 | 6.00 | 7.38 | 6.08 | 7.38 | 6.00 |
| 4" | 4.80 | 3.96 | 5.00 | 4.10 | 5.00 | 4.04 | 5.00 | 3.96 | 9.42 | 8.10 | 9.42 | 8.10 | 9.60 | 8.10 | 9.60 | 8.00 |
| 6" | 6.90 | 6.02 | 7.10 | 6.14 | 7.10 | 6.08 | 7.10 | 6.00 | 11.60 | 10.12 | 11.60 | 10.00 | 11.84 | 10.12 | 11.84 | 10.00 |
| 8" | 9.05 | 8.13 | 9.05 | 8.03 | 9.30 | 8.18 | 9.30 | 8.10 | 20.34 | 18.20 | 20.34 | 18.00 | 20.78 | 18.22 | 20.78 | 18.00 |
| 10" | 11.10 | 10.10 | 11.10 | 9.96 | 11.40 | 10.16 | 11.40 | 10.04 | 22.54 | 20.24 | 22.54 | 20.00 | 23.02 | 20.24 | 23.02 | 20.00 |
| 12" | 13.20 | 12.12 | 13.20 | 11.96 | 13.50 | 12.14 | 13.50 | 12.00 | 26.90 | 24.28 | 26.90 | 24.00 | 27.76 | 24.26 | 27.76 | 24.00 |
| 14" | 15.30 | 14.16 | 15.30 | 13.98 | 15.65 | 14.17 | 15.65 | 14.01 | 33.10 | 30.00 | 33.10 | 30.00 | 33.46 | 30.00 | 33.46 | 30.00 |
| 16" | 17.40 | 16.20 | 17.40 | 16.00 | 17.80 | 16.20 | 17.80 | 16.02 | 40.04 | 36.00 | 40.04 | 36.00 | 40.04 | 36.00 | 40.04 | 36.00 |
| 18" | 19.50 | 18.22 | 19.50 | 18.00 | 19.92 | 18.18 | 19.92 | 18.00 | 45.58 | 42.02 | 45.58 | 42.02 | 45.58 | 42.02 | 45.58 | 42.02 |
| 20" | 21.60 | 20.26 | 21.60 | 20.00 | 22.06 | 20.22 | 22.06 | 20.00 | 51.98 | 47.98 | 51.98 | 48.00 | 51.98 | 48.00 | 51.98 | 48.00 |
| 24" | 25.80 | 24.28 | 25.80 | 24.02 | 26.32 | 24.22 | 26.32 | 24.00 | 64.82 | 60.20 | 64.82 | 60.06 | 64.82 | 60.06 | 64.82 | 60.06 |
| 30" | 31.74 | 28.98 | 32.00 | 29.94 | 32.40 | 30.00 | 32.74 | 30.00 | 76.88 | 72.10 | 76.88 | 72.10 | 76.88 | 72.10 | 76.88 | 72.10 |
| 36" | 37.96 | 35.98 | 38.30 | 36.00 | 38.70 | 35.98 | 39.16 | 36.00 | 88.54 | 84.10 | 88.54 | 84.10 | 88.54 | 84.10 | 88.54 | 84.10 |
| 42" | 44.20 | 42.00 | 44.50 | 41.94 | 45.10 | 42.02 | 45.58 | 42.02 | 100.00 | 96.00 | 100.00 | 96.00 | 100.00 | 96.00 | 100.00 | 96.00 |
| 48" | 50.50 | 47.98 | 50.80 | 47.96 | 51.40 | 47.98 | 51.98 | 48.00 | 111.84 | 108.00 | 111.84 | 108.00 | 111.84 | 108.00 | 111.84 | 108.00 |
| 54" | 56.66 | 53.96 | 57.10 | 54.00 | 57.80 | 54.00 | 58.40 | 53.94 | 123.68 | 120.00 | 123.68 | 120.00 | 123.68 | 120.00 | 123.68 | 120.00 |
| 60" | 62.80 | 60.02 | 63.40 | 60.06 | 64.20 | 60.20 | 64.82 | 60.06 | 135.52 | 132.00 | 135.52 | 132.00 | 135.52 | 132.00 | 135.52 | 132.00 |
| 72" | 75.34 | 72.10 | 76.00 | 72.10 | 76.88 | 72.10 | 76.88 | 72.10 | 147.36 | 144.00 | 147.36 | 144.00 | 147.36 | 144.00 | 147.36 | 144.00 |
| 84" | 87.54 | 84.10 | 88.54 | 84.10 | 89.60 | 84.10 | 89.60 | 84.10 | 159.20 | 156.00 | 159.20 | 156.00 | 159.20 | 156.00 | 159.20 | 156.00 |

APPENDIX C - PIPE SCHEDULES

DUCTILE IRON PIPE
STANDARD CLASSES
INSIDE AND OUTSIDE DIAMETERS IN INCHES

| NOMINAL PIPE SIZE | OUTSIDE DIAMETER | INSIDE DIAMETER | | | | | | | | | | CEMENT LINING* | |
|-------------------|------------------|-----------------|----------|----------|----------|----------|----------|----------|---------------|------------------|-----|----------------|--|
| | | CLASS 50 | CLASS 51 | CLASS 52 | CLASS 53 | CLASS 54 | CLASS 55 | CLASS 56 | STD THICKNESS | DOUBLE THICKNESS | | | |
| 3" | 3.96 | | 3.46 | 3.40 | 3.34 | 3.28 | 3.22 | 3.16 | | | | | |
| 4" | 4.80 | | 4.28 | 4.22 | 4.16 | 4.10 | 4.04 | 3.98 | | | | | |
| 6" | 6.90 | 6.40 | 6.34 | 6.28 | 6.22 | 6.16 | 6.10 | 6.04 | .125 | | 250 | | |
| 8" | 9.05 | 8.51 | 8.45 | 8.39 | 8.33 | 8.27 | 8.21 | 8.15 | | | | | |
| 10" | 11.10 | 10.52 | 10.46 | 10.40 | 10.34 | 10.28 | 10.22 | 10.16 | | | | | |
| 12" | 13.20 | 12.58 | 12.52 | 12.46 | 12.40 | 12.34 | 12.28 | 12.22 | | | | | |
| 14" | 15.30 | 14.64 | 14.58 | 14.52 | 14.46 | 14.40 | 14.34 | 14.28 | | | | | |
| 16" | 17.40 | 16.72 | 16.66 | 16.60 | 16.54 | 16.48 | 16.42 | 16.36 | | | | | |
| 18" | 19.50 | 18.80 | 18.74 | 18.68 | 18.62 | 18.56 | 18.50 | 18.44 | .1875 | | 375 | | |
| 20" | 21.60 | 20.88 | 20.82 | 20.76 | 20.70 | 20.64 | 20.58 | 20.52 | | | | | |
| 24" | 25.80 | 25.04 | 24.98 | 24.92 | 24.86 | 24.80 | 24.74 | 24.68 | | | | | |
| 30" | 32.00 | 31.22 | 31.14 | 31.06 | 30.98 | 30.90 | 30.82 | 30.74 | | | | | |
| 36" | 38.30 | 37.44 | 37.34 | 37.06 | 37.14 | 37.04 | 36.94 | 36.84 | | | | | |
| 42" | 44.50 | 43.56 | 43.44 | 43.32 | 43.20 | 43.08 | 42.96 | 42.84 | .250 | | 500 | | |
| 48" | 50.80 | 49.78 | 49.64 | 49.50 | 49.36 | 49.22 | 49.08 | 48.94 | | | | | |
| 54" | 57.10 | 55.96 | 55.80 | 55.64 | 55.48 | 55.32 | 55.16 | 55.00 | | | | | |

* Reduce the pipe inside diameter by two times the dimension shown. These lining thicknesses also apply to cast iron pipe.

MODEL MST

DEDICATED ULTRASONIC FLOWMETER

ADDENDUM TO OPERATORS MANUAL

FEBRUARY 1992

DUAL ALARM OPTION

PAGE 8-1

Cross out the second paragraph on page 8-1 and substitute the following:

Both alarm monitors have an on-board terminal strip with SPDT contacts available for connection to an external annunciator. The relay contacts are rated at 1 A, 24 VDC. **WARNING: To reduce the risk of electrical shock do not connect voltages greater than 24 VDC or 24 VAC to the terminal strip on this printed circuit card.** The hysteresis (deadband) is fixed at 0.8% of span.

REMOTE TOTALIZER

PAGE 8-3

Cross out the third paragraph on page 8-3 and substitute the following:

When the remote totalizer is powered by an external power source, the output is defined as a dry contact relay and is rated at 2 A DC resistive load. **WARNING: To reduce the risk of electrical shock do not connect voltages greater than 24 VDC or 24 VAC to the terminal strip on this printed circuit card.** The contact closure can be configured at the factory to normally open or normally closed. The relay will activate each time the fluid volume programmed into the totalizer occurs.

CHAPTER 3 - OPERATION PAGE 3-2

Under the CALIBRATION TEST section, cross out paragraph 3, and replace it with the following:

3. Rotate the VELOCITY RANGE switch to the CAL TEST position. Wait for about one minute to allow the unit to finish responding before going on to the next step.

PROPORTIONAL SAMPLER

This section is an addition to the manual and was not previously included.

INSTALLATION

1. Turn off the electrical power to the flowmeter.

2. Unscrew the six front cover screws (Figure 1-1) using a screwdriver and swing the hinged front cover open.

3. Unscrew the two thumbscrews on the right side of the front panel (Figure 1-4) and swing the hinged front panel open.

4. Unscrew the printed circuit board hold down clamp thumbscrew and remove the printed circuit board hold down clamp (Figure 4-3).

5. The external fluid sampling device is connected to the board at the terminals on the left end of the board (Figure 8-2). The relay contacts are rated at 2 A, 24 VDC.

WARNING: To reduce the risk of electrical shock do not connect voltages greater than 24 VDC or 24 VAC to the terminal strip on this printed circuit card.

NOTE

Handle printed circuit boards as described in the Printed Circuit Board Handling section of Chapter 4, Maintenance.

6. To connect the external fluid sampling device as a normally closed circuit, connect one wire to the NC (bottom) terminal and connect the other wire to the C (middle) terminal.

7. To connect the external fluid sampling device as a normally open circuit, connect one wire to the NO (top) terminal and connect the other

wire to the C (middle) terminal.

8. Place the Proportional Sampler board in the second slot from the left side of the flowmeter.

9. Turn on the electrical power to the flowmeter.

CAUTION

Avoid touching any components in the flowmeter to prevent electrical shock. Use insulated tools to perform any necessary adjustments to the time control.

10. Verify that the duration of the output signal is correctly set by using a stopwatch to measure the time interval LED #3 remains lit. The amount of time LED #3 remains lit should equal the duration of the output signal required for the external fluid sampling device.

11. If LED #3 does not remain lit the correct amount of time, adjust the TIME control using a straight slotted screwdriver. Turn the TIME control clockwise to increase the duration of the output signal and counter-clockwise to decrease the duration of the output signal.

12. Re-perform steps 10 and 11 until the duration of the output signal is set correctly.

13. Replace the printed circuit board hold down clamp and thumb screw.

14. Swing the hinged front panel closed and tighten the two thumbscrews on the right side of the front panel.

15. Swing the front cover closed and tighten the six front cover screws.

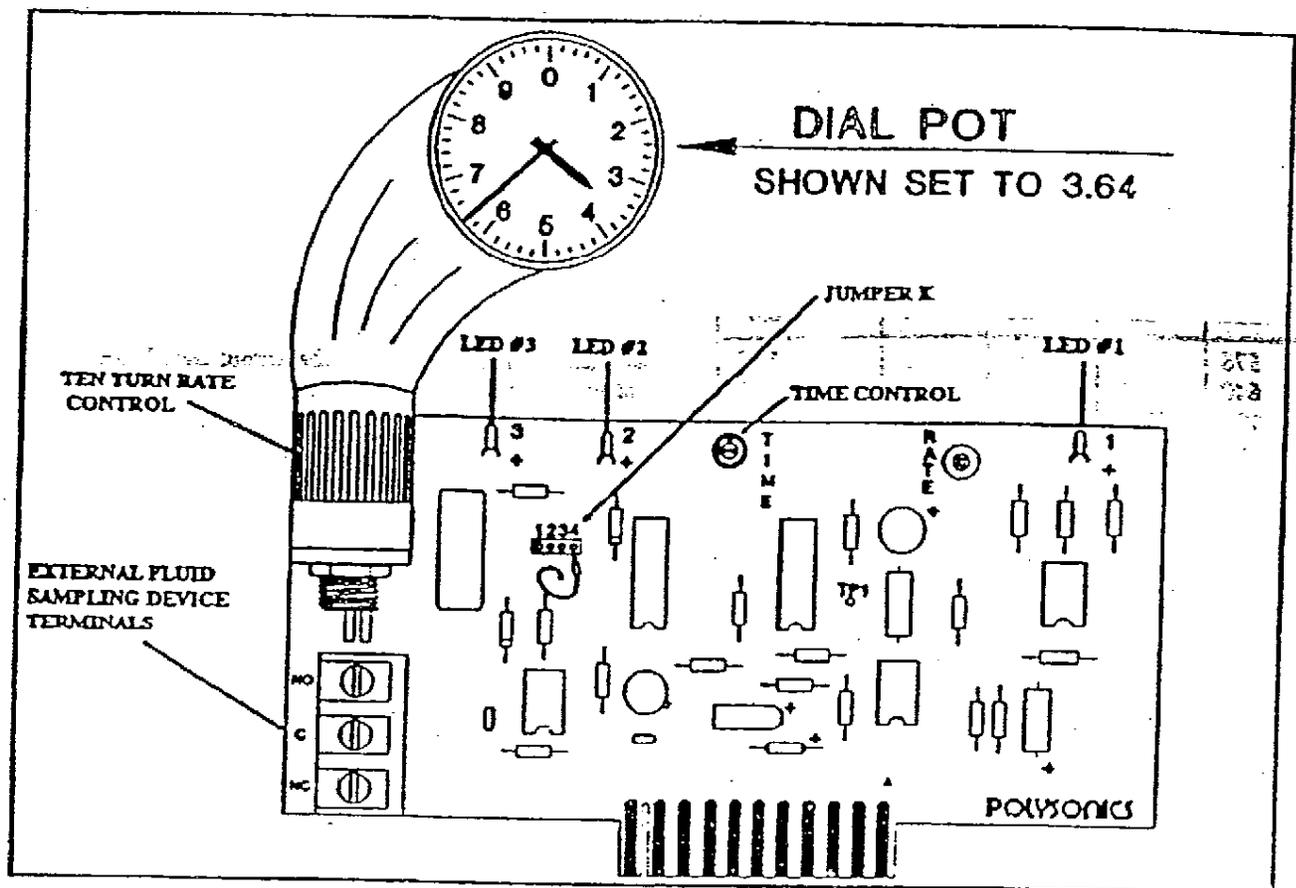


Figure 8-1
Proportional Sampler Board

PROPORTIONAL SAMPLER OPTION

DESCRIPTION

The Proportional Sampler board (Figure 8-2) provides an output signal at preset sample time intervals that represent a specified volume of fluid having flowed past the flowmeter's transducers. This output signal is used to activate an external fluid sampling device. The duration of the output signal can be set from 1 to 90 seconds to control the size of the sample.

CONTROLS AND INDICATORS

Ten Turn Rate Control, A control that sets the sample time interval. Figure 8-3 is a table of settings for the TEN TURN RATE control.

Jumper K, A four position movable jumper that creates a 4 to 1 multiplication factor in the sample time interval for each position moved. Position 1 is the longest sample time interval and position 4 is the shortest sample time interval. Figure 8-3 is a table of settings for JUMPER K.

Time Control, A control that sets the duration of the output signal used to activate an external fluid sampling device. This duration is adjustable from 1 to 90 seconds. Time increases as the control is turned clockwise.

LED #1, This green light flashes during low flow rates and is lit solid during high flow rates.

LED #2, This red light is lit when the duration of the output signal is longer than the sample time interval. When the sample time interval and the output signal duration are properly set, this light should never be lit.

LED #3, This yellow light is on for the duration of the output signal.

SET POINT

1. The sample time interval is set using a set point based upon a flow rate equal to the flowmeter's full scale flow rate. The sample time interval for the actual flow rate

| FULL SCALE FLOW RATE SAMPLE TIME INTERVAL (IN SECONDS) | | | | TEN TURN RATE CONTROL DIAL POT SETTING |
|--|-----|-----|----|---|
| JUMPER K POSITION | | | | |
| 1 | 2 | 3 | 4 | |
| 384 | 96 | 24 | 6 | 0 |
| 448 | 112 | 28 | 7 | 0.33 |
| 512 | 128 | 32 | 8 | 0.67 |
| 576 | 144 | 36 | 9 | 1.00 |
| 640 | 160 | 40 | 10 | 1.33 |
| 704 | 176 | 44 | 11 | 1.67 |
| 768 | 192 | 48 | 12 | 2.00 |
| 832 | 208 | 52 | 13 | 2.33 |
| 896 | 224 | 56 | 14 | 2.67 |
| 960 | 240 | 60 | 15 | 3.00 |
| 1024 | 256 | 64 | 16 | 3.33 |
| 1088 | 272 | 68 | 17 | 3.67 |
| 1152 | 288 | 72 | 18 | 4.00 |
| 1216 | 304 | 76 | 19 | 4.33 |
| 1280 | 320 | 80 | 20 | 4.67 |
| 1344 | 336 | 84 | 21 | 5.00 |
| 1408 | 352 | 88 | 22 | 5.33 |
| 1472 | 368 | 92 | 23 | 5.67 |
| 1536 | 384 | 96 | 24 | 6.00 |
| 1600 | 400 | 100 | 25 | 6.33 |
| 1664 | 416 | 104 | 26 | 6.67 |
| 1728 | 432 | 108 | 27 | 7.00 |
| 1792 | 448 | 112 | 28 | 7.33 |
| 1856 | 464 | 116 | 29 | 7.67 |
| 1920 | 480 | 120 | 30 | 8.00 |
| 1984 | 496 | 124 | 31 | 8.33 |
| 2048 | 512 | 128 | 32 | 8.67 |

Figure 8-2

Ten Turn Rate Control And Jumper K Settings

of the fluid in the pipe will be proportional to the full scale flow rate divided by the actual flow rate.

2. Calculate the flowmeter's full scale flow rate as described in Appendix B, Flow Conversion Data.

3. Calculate the full scale flow rate sample time interval by dividing the desired volume of fluid to flow between samples by the flowmeter's full scale flow rate. Convert the full scale flow rate sample time interval to seconds.

NOTE

The full scale flow rate sample time interval must be recalculated and reset if the VELOCITY RANGE switch or the flow rate factor is changed.

4. Look up the full scale flow rate sample time interval calculated in step 3 in Figure 8-3 to determine the set points for JUMPER K and the TEN TURN RATE control. Move JUMPER K to its set point and turn the TEN TURN RATE control dial pot to its set point (Figure 8-2).

5. Turn the TIME control to the output signal duration set point required for the external fluid sampling device. In the full counter-clockwise position, the duration of the output signal will be one second and in the full clockwise position the duration of the output signal will be 90 seconds. During installation of the Proportional Sampler board, this setting will be verified as described in the Installation section below.

Example

The flowmeter's VELOCITY RANGE switch is set at 8, the pipe inside diameter is 7.981-inches and the flowmeter's flow rate units are set to gallons per minute. A sample is desired after every 10,000 gallons of fluid flow.

Calculate the flowmeter's full scale flow rate as described in Appendix B, Flow Conversion Data:

$$\begin{aligned} \text{Full Scale Flow Rate} &= VR \times ID^2 \times 2.45 \\ &= 8 \times 7.981^2 \times 2.45 \\ &= 1,248 \text{ gal./min.} \end{aligned}$$

Calculate the full scale flow rate sample time interval:

$$\begin{aligned} \text{Full Scale Sample Time Interval} &= \text{Fluid Volume Between Samples} / \text{Full Scale Flow Rate} \\ &= 10,000 \text{ gal.} / 1,248 \text{ gal./min.} \\ &= 8.01 \text{ sec. rounded to 8 sec.} \end{aligned}$$

Look up the set points for JUMPER K and the TEN TURN RATE control dial pot in Figure 8-3 for the full scale flow rate sample time interval of 8 seconds:

JUMPER K = Position 4

TEN TURN RATE control dial pot setting = 0.67

APPENDIX F
POLLUTION PREVENTION AND
BEST MANAGEMENT PRACTICES PLAN

Red Dog Creek Pumpback Facility Pollution Prevention and Best Management Practices Plan

General Information: The Mine Water Diversion Dam diverts impacted water from two exploration areas and the open pit workings into a retaining basin behind the dam. A pumpback system conveys this water from the basin to the tailings facility for future treatment and discharge. Four TCAK operating groups share responsibility for operation of the pumpback facility:

- Mill Maintenance is responsible for mechanical maintenance (pumps, pipes, etc.)
- Electrical and Instrumentation (E&I) maintains the electrical components of the system
- Mill Operations monitors the flows and water levels on a daily basis
- Mine Operations is responsible for the dam, diversions, retaining wall and retaining basin.

The flows are monitored in the Mill Control Room by the control room operator. The levels are controlled by a Programmable Logic Controller (PLC) tied into an ultrasonic level detector. There are two ultrasonic detectors installed at the pumpback facility. One is located a metal culvert standpipe. The other is outside the culvert.

High level alarms in the Mill Control Room alert operators when the water level is approaching additional action levels.

Winter Operations: Winter operations typically encompass the period from October 1 to May 1. It is during this time that flows are the lowest, averaging about 310,000 gallons per day (gpd). This flow is handled by two pumps installed inside a corrugated metal pipe (CMP):

- One pump is set to start up when the water level rises to an elevation of 820 feet (El. 820) and shuts off when the water level drops to El. 816.
- The second pump is set to come on when the water level reaches El. 821 and off when the water level drops to El. 819.

These pumps are capable of pumping flows between 1200 and 1600 gpm. They discharge through a 14-inch outside diameter 2,400-foot long insulated pipeline to the tailings impoundment. An emergency generator is permanently stationed at this location to provide backup power to the pumps in the event the main mine power fails. In case a mechanical or electrical pump failure occurs, spares are available.

Summer Operations: Summer operations typically encompass the period from May 1 through October 1. A much wider range in flows occurs during the summer, averaging approximately 1.9

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million gpd. Up to eight pumps are used. This totals a maximum pumping capacity of 10,000 gpm. The two winter pumps are staged within the CMP. The remaining six pumps are hung outside over the retaining wall where they can be lowered into the sump when needed.

When flows approach 500,000 gpd, the summer operations start. The sump is cleaned out, timbers are installed in the log weir, additional pumps are added as needed, ultrasonic level indicators are set, and a seepage return pump is installed below the dam. Each additional pump is capable of pumping 1200 to 1600 gpm for a total summer pumping capacity of 9,600 to 10,200 gpm..

Good Housekeeping

Good housekeeping is accomplished on a weekly basis at the pumpback system to reduce the potential for pollution. Examples are:

- Keeping pump staging area free of extraneous material
- Keeping snow cleared in front of generator connex

Preventative Maintenance

Operational Practices: Periodic equipment maintenance is conducted to prevent mechanical failure. Specific preventative maintenance information is maintained on a computer inventory and maintenance software program by the Mill Maintenance Department. This program includes inventory records, maintenance logs, and maintenance schedules. The dam is inspected daily by a qualified person and the inspection sheet is kept in the Survey Office. A more detailed inspection is performed monthly and this inspection sheet is also kept in the Survey Office.

The dam is classed as Hazard Class III according to Alaska State Statutes (11 AAC 93.157). A permit is required for the operation of the dam "Certificate of Approval to Operate a Dam", Permit Number AK00260. Under this hazard classification, a certified engineer must perform a dam inspection at an interval not to exceed five years. These results must be forwarded to the State of Alaska, Department of Natural Resources for continued approval to operate. The records of these inspections are located in the Mine Engineering files.

Preventative maintenance inspections of the pumpback system are completed as follows:

- At the end of the summer season, the pumps outside the CMP are pulled and prepared for the next freshet. The pumps are rebuilt if there is a problem when they are removed.
- The emergency generator is started up and run once a month for approximately one-hour to insure that everything is operating properly.

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- The Mill Operations group checks the pumpback area four times during each shift.
- The E&I group checks the area daily to insure the proper operation of pumps in summer and winter and to insure the heat trace is functioning in the winter.
- During summer, the seepage high level alarm is checked by moving the float up and seeing if there is an alarm in the Mill Control Room.

The primary sump is cleaned by Mine Operations every spring. A record of this cleaning is maintained on file. It is cleaned as needed.

Visual Inspections: Visual inspections allow Mill Operations and Mill Maintenance personnel to detect equipment problems before an incident occurs.

- Walk Through Inspections are oversight inspections to ensure that all pumps are functioning properly. This is conducted during the shift.

Pollution Prevention and Response

Potential Sources of Pollution: Small fuel, glycol or oil spills are possible. Also possible is the potential for seepage to escape from the dam and impact Red Dog Creek directly, if the water levels in the pond become high enough.

Pollution Prevention Measures: A spill at the pumpback facility is possible where the generator or pumps are being serviced, repaired and cleaned. If this should occur, maintenance personnel would clean the spill using absorbent material and pads. The total amount of diesel fuel at the generator is 1000 gallons. Spill prevention measures include cleaning spills up immediately and maintaining a double walled tank at the emergency generator location.

Pollution Prevention Practices in Place: Mill Maintenance, Mill Operations and Mine Operations personnel have implemented the pollution prevention measures outlined below.

Training

Training: Mill Maintenance personnel typically handle used oil and non-hazardous solvents. Most Mill Maintenance, Mill Operations and Mine Operations personnel have had spill response training. See the C-Plan for specific details on spill response. Job performance observations are made by supervisors prior to allowing assumption of regular duties in that particular area.

Job specific training includes the following functional areas:

- Material handling

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- Proper vehicle operation use
- Safety training
- Chemical hazards
- First aid
- Incident reporting procedures
- HAZWOPER training
- On-the-job training
- Road system precautions
- Safety apparel
- Inspection of work area
- Proper lifting
- Radio communications
- Employee safety manual
- Location of eye wash stations
- Shop safety practices and procedures;
- Proper use of shop equipment and tools
- Proper chocking and parking of equipment;
- Guiding equipment in and out of shop.

A training program should be implemented to include visual inspections of embankment dams. A training module from the U.S. Bureau of Reclamation "Training Aids for dam safety" titled "Inspection of Embankment Dams" is recommended.

Sediment and Erosion Control: Management of Runoff

The pumpback system is built upon a gravel pad that is designed to slope sufficiently for good drainage of precipitation, but not steep enough to cause erosion problems.

Every spring, the sump is cleaned by Mine Operations personnel to insure adequate water depth and the additional pumps are installed by Mill Maintenance personnel to deal with the mine water inflows. The sump is cleaned as needed.

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