Quality Assurance Project Plan

HWU LTCP Post-Construction Monitoring

Grant No. N/A

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Date: 1 August 2013
Revision Date: 1 August 2014
Version No.: 1.1
**SECTION A – PROJECT MANAGEMENT**

**A1. Title and Approval Sheet**

Quality Assurance Project Plan  
For HWU LTCP Post-Construction Monitoring

Signatures:

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<tr>
<th>Name</th>
<th>Position</th>
<th>Date</th>
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Revision History

This page documents the revisions over time to the QAPP. The most recent iteration should be listed in the first space, with consecutive versions following. Signatures may be required for revised documents.

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<td>1/A-1, 7/A-3, 8 &amp; 9/A-4, 13/A-9, 18/C-1, 17 (B-6)</td>
<td>Personnel Changes and Title Changes</td>
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A3. Distribution List

Name: Lisa Hicks  
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Contact Information: bakerj@hkywater.org/270.869.6614
A4. Project / Task Organization

**Henderson Water Utility Director of Field Operations** will be the responsible official for this project, overseeing overall project operations and budget, as well as tasking individual HWU employees with work required to complete this project. He/she will communicate project needs to the HWU General Manager.

**Henderson Water Utility Projects and Compliance Manager** will be responsible for data management and analysis for CSO flow metering and reporting. He will also be the point person for all data used in the post-construction monitoring project, collating the information collected and preparing the data in annual reports for submission to KDOW. He will communicate project data analysis results to the HWU General Manager.

**Henderson Water Utility Automation Manager** will be responsible for data acquisition associated with the CSO flow metering devices and the rainfall gauges. He will communicate project data acquisition results to the Projects and Compliance Manager, and will communicate budget, equipment and repair needs to the Director of Utility Operations.

**Henderson Water Utility Director of Plant Operations** will be responsible for compiling and analyzing plant flow data, and for the acquisition and analysis of field water quality data. He will communicate project data acquisition results to the Projects and Compliance Manager, and will communicate budget, equipment and repair needs to the Director of Utility Operations.

**HWU North Wastewater Treatment - Chief Operator** will be responsible for acquisition of NWWTP plant flow data. He will communicate project data acquisition results to the Projects and Compliance Manager.

**HWU General Manager** will be responsible for writing and coordinating development of the QAPP. He will review and approve all data generated for the project, and may prepare QA reports as required by the project.
A5. Project Definition / Background

The Long-Term Control Plan (LTCP) for Combined Sewer Overflows (CSOs) for the Henderson Water Utility requires the submission of a Quality Assurance Project Plan (QAPP) for Post-Construction Monitoring. U.S. EPA guidance for a QAPP includes requirements to document the technical planning process for any project involving the acquisition of environmental data, in order to state clear objectives, provide a clear and concise plan, specify quality assurance procedures, and assign responsibility to personnel.

Henderson’s LTCP utilizes the presumptive approach to evaluate the collection system improvement alternatives. This approach presumes that water quality based requirements of the Clean Water Act will be met if no less than 85 percent of the volume of combined sewage collected in the CSS is eliminated or captured during the design storm precipitation events on a system wide annual average basis. The primary goal of a post-construction monitoring plan is to verify the approved LTCP is meeting the 85 percent CSO volume capture/elimination goal after completion of all LTCP projects.

In addition to meeting the 85 percent capture/elimination goal, LTCP guidance recommends a post-construction compliance monitoring program that evaluates the effectiveness of the CSO controls to protect water quality. HWU currently has a CSO monitoring plan in place and reports CSO discharge volume, duration, and flows.
A6. Project/Task Description

To evaluate the effectiveness of CSO controls under HWU’s LTCP, five types of monitoring activities are planned in the HWU combined sewer system area. The following types of data will be analyzed during preparation of the annual CSO discharge report:

1) Rainfall Monitoring: Data from rain gauges in our system is used to determine whether discharges from the CSOs occur during wet or dry weather, and to quantify the duration and strength of the rainfall events to determine if the design storm rainfall intensity is exceeded.

2) CSO Flow Monitoring: Flow monitoring at the CSO discharge locations has been installed to accurately determine the volume of all discharges.

3) Wastewater Treatment Plant Influent Water Quality Monitoring: Influent water quality samples collected during wet weather events will be recorded and reported as part of the LTCP post-construction monitoring program.

4) Water Quality Monitoring (Ohio River): ORSANCO regularly collects water quality information from the Ohio River as part of their yearly contact recreation sampling program. HWU will utilize this data to evaluate HWU’s impact to the water quality in the Ohio River.

5) Combined Sewer Discharge Effluent Water Quality Monitoring: HWU will install automatic samplers to take discharge samples at three locations under varying conditions, in order to quantify the impacts of CSO discharges to the Ohio River and Canoe Creek.

A7. Data Quality Objectives (DQOs) and Criteria for Measurement Data

Data collected under this plan will be used to evaluate the effectiveness of the CSO controls adopted in Henderson’s LTCP, which utilizes the presumptive approach to evaluate the collection system improvements. This approach presumes that water quality based requirements of the Clean Water Act will be met if no less than 85 percent of the volume of combined sewage collected in the CSS is eliminated or captured during the design storm precipitation events on a system wide annual average basis. The primary goal of our post-construction monitoring plan is to verify the approved LTCP is meeting the 85 percent CSO volume capture/elimination goal.

Data collected will include rainfall intensities, CSO discharge volumes, total system volume, and water quality data for the Ohio River and Canoe Creek discharges. Data will be collected during rainfall events that result in a CSO discharge. The LTCP is successful if the 85 percent capture criteria are maintained during the design storm precipitation events on a system wide annual average basis.
Uncertainty in the data may result from the following:

1) Failure of a rainfall gauge,
2) Failure or malfunction of a CSO discharge meter, either in the meter itself or in the data recording equipment associated with each meter,
3) Failure of a flow meter or recording device related to total system flow (plant influent flow meter),
4) Inconsistencies or unusable data in the ORSANCO Ohio River water quality monitoring, or
5) Failure of sampling equipment associated with an HWU combined sewer discharge monitoring point.

**Action Limits / Levels**

The action level for this plan is the 85 percent capture/elimination goal, which presumes that water quality based requirements of the Clean Water Act will be met if no less than 85 percent of the volume of combined sewage collected in the CSS is eliminated or captured during the design storm precipitation events on a system wide annual average basis.

**Acceptance Criteria**

If the 85 percent capture/elimination goal is obtained, the plan is acceptable.

Data Quality Indicators for this project are representativeness and completeness.

Representativeness: In order to accurately measure the 85 percent capture/elimination goal, rainfall and flow monitoring data must be correlated to determine capture during rainfall events at or below the design precipitation intensity/duration. Data must accurately and precisely represent environmental conditions.

Completeness: In order to measure the 85 percent capture/elimination goal, rainfall and flow monitoring data must be recorded during rainfall events at or below the design precipitation intensity/duration. Data must be collected during each such storm event.
A8. Special Training Requirements / Certification

Analysis of data-logger data requires familiarity with Microsoft Office products such as Access (database) and Excel (spreadsheet). Certification in use of these products is not required, but is desirable, and is a requirement of the job description for the position of data analyst (typically the Projects and Compliance Manager).

Installation and data-retrieval from remote sensing units (flow meters) requires training in correct procedures for installation, and in health and safety for retrieval of data in potentially hazardous conditions. Flow meters are installed by an outside contractor, and are serviced by HWU Automation Technicians.

Installation and retrieval and processing of samples from automatic samplers requires training in correct procedures for installation, and in health and safety for retrieval of samples in potentially hazardous conditions. Sampling devices are installed and serviced by an outside laboratory.

A9. Documentation and Records

Critical Records: Rainfall, overflow quantity and water quality samples are critical items of importance to this project. All these data points will be monitored and stored by electronic means in databases generated by the HWU SCADA system.

Updates and Distribution: This QAPP will be reviewed annually by HWU staff as appropriate. The most current version of the QAPP will be distributed to staff that have assigned duties under this plan. The plan will also be available in read-only format on the HWU intranet. As updates or changes are made, the revised QAPP will be distributed to all on the distribution list in Section A3.

Data Reports: Laboratory data reports for the post-construction monitoring of water quality include information on TSS and BOD 24 hour composite samples during an overflow event. These will consist of sample results for each location sampled, three times during a typical year. These tests are performed by an outside laboratory, and results will be reported by email.

Data Storage: Post-construction monitoring records that will be maintained through the end of the Consent Judgment include raw flow data records of overflows, annual reports which record the tabulation of those flows, and lab results from Combined Sewer Discharge Effluent Water Quality Monitoring. Electronic copies of these records will be maintained on HWU servers, with off-site backup of all records. For annual reports, paper copies are stored at several locations.
Annual Compliance Reports contain a detailed accounting of projects and activities completed in each fiscal year to comply with the requirements of the Consent Judgment, including an accounting of the current year and cumulative reductions in volume and number of discharges from HWU’s CSO locations. Annual Compliance reports submitted after all LTCP projects are complete will include a discussion of overflow data showing compliance with the requirements of the Consent Judgment.

Field Documentation and Records: Overflow data from the data loggers at each CSO location is downloaded every two weeks by an Automation Specialist. This data is contained in a zip file, which is “cumulative”, that is it contains data from the most recent period back to the data obtained for previous periods, up to the capacity of the memory unit of the data logger.

As the overflow events occur underground in a closed conduit, there can be no photographic or video evidence of the field conditions at the time of overflow events. Photographs are taken at least annually of the CSO outfalls to document their condition and the existence of required signage. These photos are complied and saved on the HWU servers.

Laboratory Documentation and Records: Standard operating procedures for the two lab methods included in this plan are attached as appendices to this QAPP. Electronic copies of lab reports will be stored on HWU servers. Paper copies will be stored in the office of the Director of Plant Operations.

QA Reports: Quality assurance reporting will be done on an informal basis during bi-weekly staff meetings at the HWU Systems Operation Center. QA reports will consist of discussion of any problems with obtaining bi-weekly downloads from data loggers. Also included as a QA item will be reporting on the annual set-up of automatic samplers at three locations to sample water quality of selected CSO discharges.

SECTION B. - DATA GENERATION AND ACQUISITION

B1. Sampling Process Design

The Long-Term Control Plan (LTCP) for Combined Sewer Overflows (CSOs) for the Henderson Water Utility requires the submission of a Quality Assurance Project Plan (QAPP) for Post-Construction Monitoring. U.S. EPA guidance for a QAPP includes requirements to document the technical planning process for any project involving the acquisition of environmental data, in order to state clear objectives, provide a clear and concise plan, specify quality assurance procedures, and assign responsibility to personnel.
Henderson’s LTCP utilizes the presumptive approach to evaluate the collection system improvement alternatives. This approach presumes that water quality based requirements of the Clean Water Act will be met if no less than 85 percent of the volume of combined sewage collected in the CSS is eliminated or captured during the design storm precipitation events on a system wide annual average basis. The primary goal of a post-construction monitoring plan is to verify the approved LTCP is meeting the 85 percent CSO volume capture/elimination goal.

In addition to meeting the 85 percent capture/elimination goal, LTCP guidance recommends a post-construction compliance monitoring program that evaluates the effectiveness of the CSO controls to protect water quality. HWU currently has a CSO monitoring plan in place and reports CSO discharge volume, duration, and flows. When the LTCP projects are completed, HWU will continue that monitoring plan to evaluate the effectiveness of control in meeting the 85 percent capture/elimination goal.

To meet the LTCP guidance for compliance monitoring of water quality, HWU will install automatic samplers to take discharge samples at three locations under varying conditions, in order to quantify the impacts of CSO discharges to the Ohio River and Canoe Creek.

Rationale for Selection of Sampling Locations: Data Collection of CSO discharge volumes has been ongoing for several years, and installation of flow monitoring equipment was a precursor activity to the Consent Judgment and submittal of the LTCP.

Since collection of Ohio River water quality data is problematic, HWU has chosen to rely on data collected by ORSANCO for characterization of water quality impacts on the river.

To supplement the ORSANCO data, HWU will install automatic samplers to take discharge samples at three locations under varying conditions, in order to quantify the impacts of CSO discharges to the Ohio River and Canoe Creek. These sample locations will include the Janalee Drive CSO discharge (KPDES 002), the Second Street CSO (KPDES 014) and the Third Street Basin overflow (KPDES 015). These three overflow points are the largest volume and most active CSO points historically. A map showing the three CSO sampling location is included as Appendix B. This map includes latitude and longitude for each site.

Water quality sampling of CSO discharges will consist of TSS and BOD 24 hour continuous samples during a typical storm. One composite sample will be collected at each location, three times during a typical year. The timing of the sample windows will include one early
spring storm, one mid-summer storm, and one late summer storm. With three storms and three locations, a total of nine sample periods will be tested.

Since the LTCP rests on the assumption that compliance is proved by meeting the requirements of the 85 percent capture rule, measurement of CSO discharge volume is the critical sampling paradigm of this plan. Analysis of ORSANCO data and the supplemental testing of CSO discharges in typical storms is non-critical to this plan.

**B2. Sampling Methods**

**NOTE:** Since the flow data collected to characterize the volume of CSO discharges is not actually a physical or chemical “Sample”, discussion in this section only applies to the supplemental discharge sampling to be performed at three CSO locations.

Automatic Samplers will be installed at three locations during three time periods, each year. Samples will be 24-hour composite samples, collected in aliquot containers that are part of the sample equipment. The samplers are refrigerated.

**B3. Sample Handling and Custody Requirements**

**NOTE:** Since the flow data collected to characterize the volume of CSO discharges is not actually a physical or chemical “Sample”, discussion in this section only applies to the supplemental discharge sampling to be performed at three CSO locations.

Sample handling and custody procedures are specified in Appendix B, Standard Operating Procedures for Installation and Sampling with Automatic Samplers. Appendix C contains samples of Custody Logs, chain-of-custody forms, and samples of labels for containers. A user instruction manual for the ISCO 9210 Autosampler we normally use is provided in Appendix D.

**B4. Analytical Methods Requirements**

**NOTE:** Since the flow data collected to characterize the volume of CSO discharges is not actually a physical or chemical “Sample”, discussion in this section only applies to the supplemental discharge sampling to be performed at three CSO locations.
Standard Method 5210 B (EPA Method 405.1):
Biochemical Oxygen Demand. Official Name: Biochemical Oxygen Demand (5 days, 20 deg C)

Summary:
The BOD test is an empirical bioassay-type test which measures the dissolved oxygen consumed by microbial life while assimilating and oxidizing organic matter in a sample. A waste sample (or dilution) is incubated for five days 20 deg C in the dark. Dissolved oxygen is measured before and after incubation using a modified Winkler or oxygen probe method (e.g., EPA Method 360.2 and 360.1). The reduction in dissolved oxygen during the incubation period yields a measure of BOD.

Scope:
This test for BOD is used to determine the relative oxygen requirements of municipal and industrial wastewaters.

Citation:
Methods for the Chemical Analysis of Water and Wastes (MCAWW) (EPA/600/4-79/020)

Standard Method SM2540D (EPA Method 160.2):
Non-filterable Residue by Drying Oven. Official Name: Residue, Non-Filterable (Gravimetric, Dried at 103-105 deg C)

Summary:
A well-mixed sample is filtered through a glass fiber filter, and the residue retained on the filter is dried to a constant weight at 103-105oC.

Scope:
This method determines non-filterable residue in drinking, surface, and saline waters; domestic and industrial wastes.

Citation:
Methods for the Chemical Analysis of Water and Wastes (MCAWW) (EPA/600/4-79/020)

B5. Quality Control Requirements

NOTE: Since the flow data collected to characterize the volume of CSO discharges is not actually a physical or chemical “Sample”, discussion in this section only applies to the supplemental discharge sampling to be performed at three CSO locations.

We do not utilize QC checks for field sampling and lab analysis measurement.
B6. Instrument / Equipment Testing, Inspecting and Maintenance Requirements

In order to collect flow data for the CSO discharges, each CSO point is equipped with a Teledyne-ISCO area velocity flow meter. These meters are maintained regularly, in accordance with procedures outlined in Appendix E.

Flow data from the meters is uploaded in real-time to our SCADA communication system and the data is maintained on the data historian along with all other automated process information.

B7. Instrument Calibration and Frequency

When the Teledyne-ISCO area velocity flow meters are installed in the flow stream, the flow stream properties must be defined in the AV module. This procedure is detailed in Section 2 of Appendix H.

Calibration of instruments for laboratory tests are discussed in Appendices F and G, for BOD and TSS analysis in the lab.

B8. Inspection / Acceptance Requirements for Supplies and Consumables

In general, the only supplies and consumables used for this project are sample bottles.

B9. Data Acquisition Requirements for Non-direct Measurements

There is no data required on this project that is available from non-direct sources.

B10. Data Management

Post-construction monitoring records that will be maintained through the end of the Consent Judgment include flow raw data records of overflows, annual reports which record the tabulation of those flows, and lab results from Combined Sewer Discharge Effluent Water Quality Monitoring. Electronic copies of these records will be maintained on HWU servers, with off-site backup of all records. For annual reports, paper copies are stored at several locations.
SECTION C – ASSESSMENT AND OVERSIGHT

C1. Assessments and Response Actions

Preparation of the Annual Compliance Report, where all the data for this activity is summarized and reported, is the responsibility of the Projects and Compliance Manager. Drafts of the report are prepared and circulated to upper-level management of HWU for comment and revision.

Data collected from the field-mounted flow meters is initially reviewed by the Automation Manager to insure data integrity. The data is downloaded every two weeks to insure that if a flow meter fails only a relatively short period of data will be lost.

Laboratory testing of the water quality samples taken at the CSO discharge locations is contracted to an outside lab. In the event that samples are destroyed, contaminated, or otherwise rendered useless, the Director of Plant Operations has budgetary authority to contract with a different lab (if necessary), and also has the authority to direct that the testing be repeated.

The Automation Manager and the Automation Specialists have budgetary authority to procure new meters or data loggers in the event of a data-acquisition problem due to equipment failure.

C2. Reports to Management

Monthly Operations Reports are prepared by the Director of Utility Operations, which highlight any issues with maintenance of equipment required for overflow monitoring or sampling. The Director of Utility Operations and other management staff attend weekly senior staff meetings, where issues with equipment are reported and discussed. Bi-weekly meetings are held with Systems Operation Center (SOC) personnel to discuss issues with automation and testing.

As the Annual Compliance Report is prepared, draft copies are distributed to HWU management for editing and revision. Several revisions and drafts are prepared, in a typical year, and comments are solicited and addressed by the report author.
SECTION D – DATA VALIDATION AND USABILITY

D1. Data Review, Validation and Verification

Appendix H includes detailed instructions on data download and handling to accurately show CSO discharge volumes. Data from the flow loggers is placed into a spreadsheet, where values for flow velocity and flow rate are analyzed. If velocity and rate are both positive, this indicates an actual overflow. Negative or zero values for velocity in the presence of a positive value for rate indicate water standing over the flow meter, or backflow into the system from a high river level.

The partially processed flow logger data from the spreadsheet is processed further by an Excel spreadsheet tool that aggregates the data into smaller pieces, allowing identification of discrete overflow events that fit the definition of an overflow event. Henderson Water Utility has defined an overflow “event” to be one or more permitted discharges that occur with no more than 72 hours between measured flows. If discharge flows start and stop multiple times, but the time between successive measured flows is less than 72 hours, the multiple flows are aggregated as a single overflow “event”.

D2. Validation and Verification Methods

Data from the flow loggers is placed into a spreadsheet, where values for flow velocity and flow rate are analyzed. If velocity and rate are both positive, this indicates an actual overflow. Negative or zero values for velocity in the presence of a positive value for rate indicate water standing over the flow meter, or backflow into the system from a high river level.

The partially processed flow logger data from the spreadsheet is processed further by an Excel spreadsheet tool that aggregates the data into smaller pieces, allowing identification of discrete overflow events that fit the definition of an overflow event. Henderson Water Utility has defined an overflow “event” to be one or more permitted discharges that occur with no more than 72 hours between measured flows. If discharge flows start and stop multiple times, but the time between successive measured flows is less than 72 hours, the multiple flows are aggregated as a single overflow “event”.

There have been instances when the flow meters used for CSO discharge monitoring have provided erroneous positive flow values, even though no overflow was taking place. Investigation of one particular instance led to the discovery that wind currents within the sewer pipe, and a small pool of standing water, led the metering device to interpret wave action on top of the pool as positive velocity, and a spurious overflow was recorded. These instances have been rare and were discovered when overflow indications were compared to precipitation records.
D3. Reconciliation with User Requirements and Data Quality Objectives

Data collected under this plan will be used to evaluate the effectiveness of the CSO controls adopted in Henderson’s LTCP, which utilizes the presumptive approach to evaluate the collection system improvements. This approach presumes that water quality based requirements of the Clean Water Act will be met if no less than 85 percent of the volume of combined sewage collected in the CSS is eliminated or captured during the design storm precipitation events on a system wide annual average basis. The primary goal of our post-construction monitoring plan is to verify the approved LTCP is meeting the 85 percent CSO volume capture/elimination goal.

Data collected will include rainfall intensities, CSO discharge volumes, total system volume, and water quality data for the Ohio River and Canoe Creek discharges. Data will be collected during rainfall events that result in a CSO discharge. The LTCP is successful if the 85 percent capture criteria are maintained during the design storm precipitation events on a system wide annual average basis.
SECTION E. - REFERENCES AND CITATIONS

References (for this QAPP Template Guidance)


### Table 1. Analytical Method, Containers, Preservation, and Holding Times Requirements

<table>
<thead>
<tr>
<th>Analytical Parameter and/or Field Measurements</th>
<th>Analytical Method Number</th>
<th>Containers (number, size/volume, type)</th>
<th>Preservation Requirements (chemical, temperature, light protection)</th>
<th>Maximum Holding Times</th>
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<tr>
<td>BOD</td>
<td>SM5210B</td>
<td>ANY</td>
<td>20 degrees C, dark</td>
<td>6 hours, or store at 4 deg C and report storage temp and time</td>
</tr>
<tr>
<td>TSS</td>
<td>SM2540D</td>
<td>ANY</td>
<td>None</td>
<td>7 Days</td>
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**FIELD MEASUREMENTS:**

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Quality Assurance Project Plan (QAPP) for Post-Construction Monitoring

Appendix A

CSO Sample Point Locations
Appendix A – CSO Sample Point Locations

Henderson Water Utility
Permit Number KY0020711
AI Number 1813

CSO Area in Henderson

- Permitted CSO Discharge Points
- Eliminated CSO Discharge Points

CSO Sample Point KPDES 002 – Janalee Drive P.S.
Latitude / Longitude
37º 49' 23" N / 87º 36' 49" W

CSO Sample Point KPDES 014 – Second Street P.S.
Latitude / Longitude
37º 50' 02" N / 87º 34' 26" W

CSO Sample Point KPDES 015 – Third Street Basin
Latitude / Longitude
37º 50' 18" N / 87º 34' 43" W
Quality Assurance Project Plan (QAPP)  
for Post-Construction Monitoring

Appendix B

Standard Operating Procedure for  
Installation and Maintenance of  
Autosampler
**Objective**

Collect & preserve a storm water or wastewater sample in a manner that maintains the integrity of the sample and offers an accurate representation of the flow being sampled.

**Equipment**

| Safety gloves | ISCO 2910 composite sampler |
| Pump Tubing 3/8” Silicone | Suction Line Tubing 3/8” Teflon/Vinyl |
| Debris strainer | Safety Vest |
| Safety glasses | 10 – 15L HPDE sample jug |
| Ice 20 – 40 lbs. cubed or crushed | Sampler battery ISCO 934 Ni-Cd |
| ISCO 2910 Sampler Instruction Manual | Padlocks |
| Steel wire if applicable | Weatherproofing wrap where applicable |
| Tube clamps | Flathead screwdriver |
| Hard hat where applicable | Blockades & signage where applicable |

**Safety Considerations**

Wear appropriate personal protective equipment during sampling tasks (safety glasses, protective gloves, boots, headwear & clothing etc.) Be aware of the following safety concerns:

- Storm water and/or wastewater may contain disease-causing microorganisms
- Be cognizant of the surrounding area and unsafe terrain.
- Be aware of harmful animal and plant life in undisturbed areas.
- Be aware of traffic and utility piping, electrical etc.
- Be aware of the effects of the storm/rain/wind while in the field especially concerning fall/slip hazards.

**Operational Considerations**

- The effluent auto sampler must be running properly to collect the composite sample.
- It is recommended that a pre-determined sampling point is chosen based upon historical observation of the storm water / wastewater flow path(s).
- The most accepted compositing scheme is that of a flow-proportionate sample, but without elaborate & costly equipment a rigid sample protocol of 100 mL aliquots every fifteen minutes is also well-accepted.
- Pump & suction line tubing should be changed or cleaned thoroughly before each sampling event even if sampling the same location.
- The sampler can be suspended if necessary, but ensure it is properly secured to prevent loss as a result of movement during pumping and actual flow conditions.
• Freezing conditions may require the sampler to be wrapped or enclosed to prevent freezing of the collected sample.
• Suction line should be oriented in a vertical sloping manner to allow it to drain fully after each sample aliquot and may need to be wrapped or enclosed in freezing weather.
• Suction line submerged in deep water may float and dislodge from the sampler or even pull the sampler into the flow stream. Do not submerge the suction beyond 10 ft. of depth.
• Pumping lift is limited to 26 ft. of head, the less head that is required results in greater reliability and accuracy.
• Some analytes for testing may require a grab sample therefore it is important to know precisely what parameters will be tested for on your sample stream. Other arrangements will need to be made for grab sampling.

Instructions

• Insert the clean sample jug into the base of the sampler.
• Using the Attached new or clean pump tubing in the pump cavity. Pump tubing length is factory set – DO NOT ALTER.
• Place the pump assembly onto the sampler base ensuring the discharge of the pump tubing is in the sample jug and is not compromised (pinched, etc.).
• Attach the battery to the sampler according to manufacturer instructions.
• Attach new or clean pump tubing in the pump cavity.
• Attach the suction line tubing which has been measured to the nearest whole foot measurement. This measurement is included in the programming of the sampler computer interface.
• Attach strainer to sample end of suction line using a tube clamp.
• Set up the sampler according to manufacturer’s instructions to collect 96 - 100 mL samples every 15 minutes resulting in 9,600 mL over 24-hrs.
• New pump tubing should be run a few cycles forward and in reverse to overcome initial rigidness and increase accuracy.
• Ensure proper calibration of the sampler by running it through the provided program on the unit itself.
• Position the sampler on solid footing and secure the unit to prevent tip-over, wind etc. scenarios.
• Add ice, if necessary, to maintain a sample temperature between 1 – 6 °C
• Position sample strainer on suction line inside of flow so that it will remain submerged during the entire event so as to not collect floating debris.
• Begin sampling by pressing the “Start” button on the computer interface. Observe the first sample event to ensure proper operation.
• Attach padlocks, if applicable, to secure the lid over the sample computer interface and sample jug.
• A temporary blockade device and sign indicating HWU Sampling point along with a contact name and/or number should be used for samplers left unattended.
• During very hot times of the year one will likely need to replenish the ice supply to maintain the desired preservative range of 1 - 6°C.
• Sample retrieval involves no additional special concerns that have not already been listed herein this SOP. Although attention to sample temperature during transport, mixing before and during sample division into individual bottles & chain of custody procedures must be followed.
Quality Assurance Project Plan (QAPP)
for Post-Construction Monitoring

Appendix C

Sample Chain-of-Custody forms
for BOD and TSS Samples
### Henderson Water Utility

**111 Fifth Street**  
Henderson, Ky. 42420  
(270) 827-9588

**Company:** Henderson Water Utility  
**Contact:**  
**Telephone #:** (270) 827-9588  
**Fax #:** (270) 826-2428

**Location:** Henderson NWWTP  
205 Drury Lane  
Henderson, KY 42420

### Chain of Custody

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<td>Telephone #</td>
<td>(270) 827-9588</td>
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Received by: Date/Time:
Model 2910
Instruction Manual
Foreword

This instruction manual is designed to help you gain a thorough understanding of the operation of the equipment. Isco recommends that you read this manual completely before placing the equipment in service.

Although Isco designs reliability into all equipment, there is always the possibility of a malfunction. This manual may help in diagnosing and repairing the malfunction.

If the problem persists, call or email the Isco Customer Service Department for assistance. Contact information is provided below. Simple difficulties can often be diagnosed over the phone. If it is necessary to return the equipment to the factory for service, please follow the shipping instructions provided by the Customer Service Department, including the use of the Return Authorization Number specified. Be sure to include a note describing the malfunction. This will aid in the prompt repair and return of the equipment.

Isco welcomes suggestions that would improve the information presented in this manual or enhance the operation of the equipment itself.

Contact Information

Phone: (800) 228-4373 (USA, Canada, Mexico)
        (402) 464-0231 (Outside North America)
Repair Service: (800) 775-2985 (Analytical and Process Monitoring Instruments)
               (800) 228-4373 (Samplers and Flow Meters)
Fax: (402) 465-3022
Email address: info@isco.com
Website: www.isco.com
Return equipment to: 4700 Superior Street, Lincoln, NE 68504-1398
Other correspondence: P.O. Box 82521, Lincoln, NE 68501-2531
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Model 2910 Sampler
Chapter 1  Product Description

INTRODUCTION

The first chapter of the Model 2910 Instruction Manual provides a general introduction to the sampler. It consists of a brief discussion of the organization of the manual, an overall description of the sampler, and a list of technical specifications.

MANUAL ORGANIZATION

The purpose of this manual is to provide the user, in a clear and concise manner, with the information necessary to operate, maintain, and service the Model 2910 Sampler. To accomplish this purpose, the manual is organized into six chapters they are as follows:

- Chapter 1 Product Description.
- Chapter 2 Setup and Operating Procedures.
- Chapter 3 Safety Procedures.
- Chapter 4 Programming.
- Chapter 5 Routine Maintenance.
- Chapter 6 Servicing and Troubleshooting.

DESCRIPTION OF THE 2910 SAMPLER

The Model 2910 Sampler (Figure 1, on page 2) is a portable device designed to collect a composite sample from a liquid source. The sampler pumps uniform, small sample increments into a single container at equal time intervals using the sampler's internal timing circuitry or at equal flow volume intervals using flow pulse inputs from an external Isco 3200 or 4200 Series Flow Meter, 4100 Series Flow Logger, or Non-Isco flow meter. These flow meters and flow loggers are collectively called "flow meters" throughout this manual.

In the time mode, the interval between samples may be set from 1 to 9999 minutes in one minute intervals, or, in the flow mode, the interval may be set from 1 to 9999 flow pulses in 1 pulse intervals. A sample collection may also be manually initiated at any time. Sample volumes of up to 990 milliliters at each sample initiation may be selected in 10 milliliter increments.

Sample Container

Samples may be collected in a 1 or 2-1/2 gallon high density polyethylene container or a 1 or 2-1/2 gallon glass container. The container drops into the insulated base section without attaching any tubes or spouts and has a mouth wide enough to insert an arm and brush for vigorous cleaning.

Programming

The Model 2910’s sampling program is set up using a keypad and a liquid crystal display. In the programming mode, the display "steps" the user through the sampler programming process by indicating the quantity (for example, sample volume) to be set. The desired quantity is then entered on the twenty-four position keypad and simultaneously shown on the display. In this way, all of the information necessary to set up the desired sampling program may be quickly and easily entered.

In operation, the display shows the status of the sampling program; for example, the time remaining until the next sample, the number of composite samples, etc. The volume of sample liquid delivered may be set on the keypad, or may be calibrated for special applications such as extra long suction lines or a suction line precondition by sample liquid. Volume, suction line lengths, and suction head measurements can be entered in either English or metric units of measure.

Composite sampling may be terminated either by a user programmed total number of composite samples or a float shut-off mechanism. A polypropylene float and stainless steel cage are provided to automatically shut the sampler off in the event of accidental overfilling of the sample container. The sampler also features a software program lock which prevents the sampler's program from being changed by unauthorized personnel.

Pumping System

The Model 2910 Sampler uses the Isco peristaltic pump system to transport the sample from the source to the sample container. The sample is under pumped flow at all times, there are no metering chambers or gravity-fed internal tubing. The only materials in contact with the sample are the vinyl or Teflon™ suction line, the polypropylene and stainless steel inlet strainer (use optional), the silicone rubber pump tubing and the polyethylene or glass sample container.

These features make the Model 2910 suitable for both "suspended solids" sampling and "toxic materials" sampling, by minimizing cross contamination between samples, by eliminating sites for sediment accumulation in the system, and by limiting the materials in contact with the sample to silicone rubber, Teflon (when a Teflon suction line is used), and glass.
Cleaning the system between sampling locations is uncomplicated and may be accomplished by simply replacing relatively inexpensive lengths of tubing. Each sampling cycle includes an air prepurge and postpurge to clear the suction line both before and after sampling.

**Figure 1 Model 2910 Sampler**

Optional Suspension Harness

**Construction**

The sampler is designed to operate over a temperature range of 0°C to 50°C (32°F to 120°F) in ambient conditions including high humidity, rain, or dust. The electronics and mechanisms are housed in the rugged, watertight, high impact strength, 0.64 cm (1/4 in.) thick structural foam control unit enclosure. The keypad and display used to set up and monitor the sampling program are contained on the sealed top panel of the control unit. The sampler may be powered by either a 12-volt DC battery or a “line” power source. Information on Isco’s power source is in the Isco Power Products Guide.

The Model 2910 is made up of three sections which are held together by a series of clasps. These three sections are shown in the exploded view of Figure 2 through Figure 4.

**Cover** - The cover encloses the mechanical and electrical components of the sampler, affording them additional protection. The top cover is required to protect the label from caustic solutions.

**Center Section** - This section pumps and meters the desired samples. The electronic circuitry, programming controls, and mechanisms are contained in this section.

**Base Section or Sample Container Tub** - This tub holds the composite sample container and insulates the collected samples from the outside environment.

**CONTROLS, INDICATORS, AND CONNECTORS**

The controls, indicators, and connectors of the Model 2910 Sampler are briefly described in Table 1, on page 3. Refer to Figure 15, on page 19 for a view of the controls and indicators, and Figure 14, on page 16 for a view of the connectors.

**Figure 2 Cover or Top Section**
Model 2910 Sampler

Figure 3 Center Section

Figure 4 Base Section

Rubber Draw Catch
Stainless Steel Latch

Table 1 Controls, Indicators, and Connectors

<table>
<thead>
<tr>
<th>Controls</th>
<th>Key Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Control keys</td>
<td>MANUAL SAMPLE PUMP JOG FWD, PUMP JOG REV, PUMP CONT. FWD, PUMP STOP</td>
<td>Initiates sampling cycle. Manually controls action of pump. Also used in sample volume calibration.</td>
</tr>
<tr>
<td>2. Numeric keys</td>
<td>OFF, ON 0 - 9</td>
<td>Turns sampler off and on. Used to enter values for the program quantity to be set.</td>
</tr>
<tr>
<td>3. Program keys</td>
<td>PROGRAM/STEP, ENTER VALUE, CLEAR ENTRY, START SAMPLING, HALT SAMPLING, RESUME SAMPLING</td>
<td>Used to control program entry and execution.</td>
</tr>
</tbody>
</table>

Indicator

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Reading</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Standby State</td>
<td>A. STNDBY legend on. Alternates between time or flow pulse interval to next sample and number of composite samples collected. If sampling previously completed, bottle numbers replaced with &quot;FULL.&quot;</td>
<td>A. Shows that the sampler is in standby state and indicates present status of the sampling program</td>
</tr>
<tr>
<td>B. Program State</td>
<td>B. PRGM legend on.</td>
<td>B. Shows the value of the program quantity step indicated as currently stored in memory or a new value as it is being entered.</td>
</tr>
<tr>
<td>C. Run State</td>
<td>C. RUN legend on. Alternates between time or flow pulse interval to next sample and number of samples collected.</td>
<td>C. Shows the current operational status of the sampler.</td>
</tr>
</tbody>
</table>
### Model 2910 Sampler

<table>
<thead>
<tr>
<th>D. Program Complete State</th>
<th>D. Alternates between &quot;FULL&quot; and the total number of composite samples collected.</th>
<th>D. Indicates that the sampling program has been completed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Internal Case Humidity Indicator Card</td>
<td>Blue = Safe. Pink or White = Replace desiccant.</td>
<td>Indicates the relative humidity inside the control unit case.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Connector</th>
<th>Type</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. 12 VDC</td>
<td>2 conductor plug</td>
<td>12 volt DC power input for sampler.</td>
</tr>
<tr>
<td>2. Flow meter</td>
<td>6 conductor plug</td>
<td>Connector for Isco's 3200 and 4200 Series Flow Meters, 4100 Series Flow Loggers, Non-Isco flow meters, or other accessory equipment.</td>
</tr>
</tbody>
</table>

#### Table 2 Technical Specifications

<table>
<thead>
<tr>
<th>Physical Size:</th>
<th><strong>Height:</strong> 64.1 cm (25-1/4 in.) <strong>Diameter:</strong> 41.3 cm (16-1/4 in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry Weight:</td>
<td>23-1/2 lbs. (10.7 kg)</td>
</tr>
<tr>
<td>Sampling Frequency:</td>
<td>1 to 9999 minutes between samples in 1 minute intervals, or flow proportional.</td>
</tr>
<tr>
<td>Sample Volume:</td>
<td>980 ml per sample, maximum, programmable in 10 ml steps.</td>
</tr>
<tr>
<td>Sample Volume Repeatability:</td>
<td>± 10 ml, typical.</td>
</tr>
<tr>
<td>Sample Collection Modes:</td>
<td>Composite time or flow.</td>
</tr>
<tr>
<td>Power Required:</td>
<td>1. 12 VDC 2. 120 V 60/60 Hz or 240 V 50/60 Hz.</td>
</tr>
<tr>
<td>External Nicad Battery Capacity:</td>
<td>Capacity of Nicad battery after 18 hr. charge: 140 samples of 600 ml each, 3 ft. head, typical.</td>
</tr>
<tr>
<td>Internal Lithium Battery Life:</td>
<td>5-10 years, typical (maintains sampling program settings).</td>
</tr>
<tr>
<td>Time Base Accuracy:</td>
<td>Better than 0.007% (quartz crystal controlled clock).</td>
</tr>
<tr>
<td>Suction (Intake) Tubing:</td>
<td>1. Vinyl-1/4&quot; ID x 10' long (0.64 cm x 3 m), 1/8&quot; ID x 25' line (0.95 cm x 7.8 m), 3/8&quot; ID x 10' long (0.95 cm x 3 m), or 3/8&quot; ID x 25' long (0.95 cm x 7.6 m). 2. Teflon, 3/8&quot; ID x 10' long (0.64 cm x 3 m) or 3/8&quot; ID x 25' long (0.64 cm x 7.6 m).</td>
</tr>
<tr>
<td>Suction Lift:</td>
<td>26 ft. (7.9 m), maximum.</td>
</tr>
<tr>
<td>Pump Flow Rate</td>
<td>1500 ml/min.</td>
</tr>
<tr>
<td>Line Transport Velocity (1 Ft. Head):</td>
<td>1. 0.5 ft./sec. (79 cm/sec.)</td>
</tr>
<tr>
<td>Sample Bottle Capacity:</td>
<td>Glass composite container: 1 gallon (3785 ml) or 2.0 gallon (9462 ml) Polyethylene composite container: 1 gallon (3785 ml) or 2.0 gallon (9462 ml)</td>
</tr>
<tr>
<td>Flow Meter Input Required to Initiate Sampler Flow Cycle:</td>
<td>12 volt DC pulse or isolated contact closure of at least 25 millisecond duration.</td>
</tr>
<tr>
<td>Cooling Capacity:</td>
<td>With the 2-1/2 gallon container installed in the tub, the void space filled with uncontaminated cubed ice (8 lb.), and the container then filled with 35°F liquid over a 24 hour sampling period, the following cooling can be typically expected: After 24 hours - 22°F lower than ambient. After 48 hours - 11°F lower than ambient. With the 1 gallon container installed in the tub, the void space filled with uncontaminated cubed ice (10 lb.), and the room temperature at 70°F, over a 24 hour sampling period, the following cooling can typically be expected: After 24 hours: 37°F lower than ambient. After 48 hours: 31°F lower than ambient.</td>
</tr>
</tbody>
</table>
Chapter 2  Setup and Operating Procedures

OPERATING PROCEDURES
This second chapter of the Model 2910 Instruction Manual provides the information necessary for the day-to-day operation of the sampler. Included are sections covering preparation for use, setting up a sampling program, placing the sampler into operation, and sample recovery.

PREPARATION FOR USE
The following sections detail the preparations required for the sampler before a sampling program is set up. They include descriptions of various preparational procedures, such as assembly and disassembly of the case, preparation of the sample container tub, attaching the suction line, connection to a power source, etc.

ASSEMBLY AND DISASSEMBLY OF THE CASE
In order to prepare the sampler for use, the case must be disassembled to gain access to the various sections of the sampler. Refer to Figure 1, on page 2 through Figure 4, on page 3. To gain access to the center section, unlash the three black rubber draw catches and lift the top cover off. The catches are unlashed by simply stretching them up and out of their mating receptacles in the top cover. To gain access to the sample tub, unlash the three lower stainless steel latches and lift the center section straight up.

PREPARATION OF THE SAMPLE CONTAINER TUB
The sample container tub will hold any of the four containers shown in Figure 5, on page 6. The 2-½ gallon containers are directly accommodated in the tub. The 1 gallon containers require the use of a locating deck, installed as shown in Figure 6, this deck may be ordered separately. The deck is necessary to assure that the container is properly located with respect to the float shut-off mechanism.

Tub Preparation
To prepare the sample container tub for use, first disassemble the case, as described in Assembly and Disassembly of the Case, to separate the tub from the rest of the sampler. The sampler is shipped from the factory with the specified sample container in place. For initial use, the only preparation necessary will be to assure that the desired sample container is in place. For subsequent uses, install the desired container as shown in Figure 6.

COOLING OF THE SAMPLES
For some applications, it may be necessary to keep the collected samples cooler than the ambient conditions at the site. This can be accomplished by placing cubed or crushed ice in the sample container tub. The capacity of the tub is approximately 8 pounds of cubed ice when a 2-½ gallon container is used and 14 pounds when a 1 gallon container is used. Refer to Table 2, on page 4 for cooling specifications.

Note
When cooling composite samples with ice, the melt water may cause the bottle to float when you remove the center section.

Insulation
To aid in cooling the samples, both the center section and the sample container tub have double-walled construction with polyurethane foam insulation.

ATTACHING THE SUCTION LINE
The suction line of the Model 2910 Sampler is the piece of tubing that extends from the sampler's pump to the liquid source. There are six standard suction lines available for use with the Model 2910. Four of the suction lines are made of plasticized vinyl tubing, and are available with two different inside diameters and two different lengths: ½ in. (0.64 cm) or ¾ in. (0.94 cm) inside diameter and 10 ft. (3 m) or 25 ft. (7.6 m) length. The other two suction lines are made of FEP Teflon with a polyethylene protective cover, and are available only in a ¾ in. inside diameter with lengths of 10 and 25 ft. The thin polyethylene cover over the 0.02 in. (0.051 cm) wall Teflon tubing is to prevent the Teflon liner from kinking or collapsing in service and to protect it from abrasion and damage.

Note
The minimum bend radius of the Teflon suction line is four inches.

Trace amounts of phenols (low ppm range) may be present in some polyvinylchloride (PVC) suction tubing as a by-product of the production process. (Phenols are necessary to provide thermal stability to the tubing during production.) If this phenol content is not acceptable in a sampling application, Isco recommends that the Teflon-lined polyethylene suction line be used with the samplers.
Model 2910 Sampler

Figure 5 Preparing the Sample Container Tub


Locating Deck

Tub

Shipment of Suction Lines
The ¼ and ¾ in. ID vinyl suction lines are shipped from the factory with a polypropylene bodied weighted inlet strainer installed on the end of the suction line. Optional all stainless steel strainers are also available for use with the vinyl or Teflon suction lines. If a stainless steel strainer was ordered with the Teflon suction line, it will be attached to the line at the factory. For sampling from highly acidic flow streams, an all plastic strainer is available. Bulk suction line can be purchased without strainers.

The suction lines, with strainer assembly attached, are shipped from the factory coiled in the center portion of the tub. The line-strainer assembly may be removed by disassembling the case as described in Assembly and Disassembly of the Case, on page 5.

Vinyl Suction Line
The first step in installing the ¼ in. ID vinyl suction line is to remove the pump cover. This is done by loosening the four captivated thumbscrews indicated in Figure 6 A and pulling the outer pump case straight away from the control box. Loosen the lower clamp and slide the pump tubing guide and clamp assembly up the pump tube. Insert the end of the suction tube in which the stainless steel ferrule is installed into the end of the pump tube approximately ½ in. (1.3 cm), as shown in Figure 6 A. Next, slide the pump tubing guide and clamp assembly down over this junction so that the clamp can be tightened on the stainless steel ferrule and tighten the clamp.

The purpose of the strainer is to prevent solid particles over a certain diameter from entering and clogging the suction line. The polypropylene strainer supplied with the ¼ in. ID suction line has 17/64 in. (.56 cm) diameter holes, preventing any particles larger than this from entering into the strainer, while the strainer supplied with the vinyl ¾ in. ID suction line has 23/64 in. (.91 cm) diameter holes in it for the same purpose. Strainers are recommended for bottom sampling or sampling from streams where large solid particles are present.

Now the pump tubing guide and clamp assembly can be replaced in the inner pump case half so that its groove mates with the semicircular opening in the pump case. Slip the pump tube under the rollers so that the pump tube does not interfere with the installation of the outer pump case half. Replace the outer pump case half so that the grooves of the pump tubing guide and clamp assembly fit properly into both halves of the pump, and tighten the four thumbscrews.
Model 2910 Sampler

Figure 6 Suction Line Assemblies

A. 1/4" Vinyl Suction Line

B. 3/8" Vinyl Suction Line

C. 3/8" Teflon Suction Line
The installation procedure for the % in. ID vinyl suction line is similar to that used for the % in. ID vinyl suction line, except that the suction line does not fit directly into the pump tubing. Instead, a longer % in. ID stainless steel ferrule is installed in the suction line to connect it to the pump tube.

To install the % in. ID vinyl suction line, follow the same procedure as for the % in. ID suction line. However, instead of inserting the entire suction line and ferrule, insert only the portion of the ferrule extending out of the end of the suction line into the pump tube until the ends of the two tubes are touching, as shown in Figure 6 B. The pump tubing guide and clamp assembly is then tightened to secure the pump tube to the stainless steel ferrule. The remainder of the installation is the same as for the % in. ID vinyl suction line. An additional clamp, as shown in Figure 6 B, is provided to secure the suction line to the ferrule.

For instructions pertaining to the removal of the suction line and replacement of the suction tubing, refer to Vinyl Suction Line, on page 47.

**TEFLON SUCTION LINE**

The installation procedure for the % in. ID Teflon suction line is similar to that for the % in. ID vinyl line. The Teflon suction line is simply slipped inside the silicone rubber pump tube, as shown in Figure 6 C. It is not necessary or desirable to strip the polyethylene cover off the Teflon tubing prior to inserting it into the pump tube. Wetting the outside of the suction line may aid the insertion.

**Removal**

For instructions pertaining to the removal of the suction line and replacement of the suction tubing, refer to Teflon Suction Line, on page 47.

**PlACEMENT OF THE SUCTION AND INTAKE LINE**

When placing the suction line from the sampler to the sampling point, it is important to route the line so that it is always sloped downhill. This will ensure that the suction line drains completely when the peristaltic pump reverses to purge the suction line of the liquid. Otherwise, cross-contamination of samples could occur. Also, when the sampler is used in weather near freezing, it is important to have maximum draining of the suction line to minimize the possibility of a clogged line due to freezing of any liquid in the line.

**Suction Line Length Recommendations**

As a general practice, it is advisable to use as short a line as is consistent with the sampling application. This will aid in the downhill routing mentioned and reduce the amount of liquid held in the suction line during the purge cycle caused by loops of coiled suction line. A shorter suction line will also conserve the battery. Refer to Overview of Calibration, on page 36 for instructions on the use of nonstandard length suction lines.

**Inlet Strainers**

The % and % in. ID vinyl suction lines are shipped from the factory with a polypropylene bodied weighted inlet strainer installed on the end of the suction line, as shown in Figure 6 A. Optional all stainless steel strainers are also available for use with the vinyl or Teflon suction lines. Figure 8, on page 9 shows the stainless steel strainer. For sampling from highly acidic flow streams, an all plastic strainer is available. Two stainless steel strainers are available for low flow conditions. The % in. low flow strainer can be used with both vinyl or Teflon suction line. The % in. low flow strainer can be used with vinyl suction line but is not recommended for use with Teflon line.

However, the use of the weighted strainer is optional. Some field investigation results indicate that, particularly when heavy suspended solids are involved and flow stream velocities are significant, more representative samples are obtained without the strainer. If the strainer is not used, it is recommended that a short piece of thin walled aluminum tubing be attached to the end of the suction line and the tubing anchored in the flow stream so that the inlet is oriented upstream. The thin wall will provide minimum disturbance of the flow stream during sampling, and aluminum ions are usually not of concern in subsequent analysis.

**Prepurge**

Whether the strainer is used or not, the prepurge cycle of the Model 2910 Sampler should be sufficient to remove any debris which may collect over the strainer or tubing entrance during periods between sampling cycles.

**Intake Placement**

In either case, the placement of the sampler intake is vital to assure the collection of representative samples. The intake (either the strainer or tubing only) should be placed in the main flow and not in an eddy or at the edge of flow. The vertical position of the intake in the flow is also important. An intake at the bottom may result in excess heavy solids and no floating materials, while placement at the top may result in the opposite. Judgment must be exercised in placing the intake according to the type of sample to be collected.
Model 2910 Sampler

The suction line tends to float in deep flow streams, dislodging the line and strainer. Table 3 shows the maximum depths you can submerge the lines and strainers without risks of flotation. At depths exceeding the safe limits shown in the table, anchor the line and strainer securely.

Table 3 Submersion Depths for Suction Line

<table>
<thead>
<tr>
<th>Strainer</th>
<th>1/4&quot; Vinyl Line</th>
<th>3/8&quot; Vinyl Line</th>
<th>3/8&quot; Teflon Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stainless Steel</td>
<td>22 feet</td>
<td>10 feet</td>
<td></td>
</tr>
<tr>
<td>Low Flow Stainless Steel</td>
<td>14 feet</td>
<td>7 feet</td>
<td></td>
</tr>
<tr>
<td>Polypropylene</td>
<td>22 feet</td>
<td>11 feet</td>
<td></td>
</tr>
<tr>
<td>CPVC</td>
<td>4 feet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 7 Polypropylene Strainer

Figure 8 Stainless Steel Strainer

SAMPLER LOCKING

If it is desired to lock the Model 2910 Sampler to prevent tampering with the controls and sample bottles, an optional sampler locking package is available. The locking package consists of three stainless steel cables and a padlock. To secure the sampler, place the large loop on the end of the cable over one of the latch tabs (with the loop up), and then feed the end of the cable with the small loop up from the bottom through the hole in the latch tab, as shown in Figure 9. Repeat this with the other two cables, and gather the ends of the cables with the small loops at the center of the top cover. Then, feed the padlock through the loops and lock, as shown in Figure 10.
Chapter 3 Safety Procedures

IMPORTANT INFORMATION

When installing the Isco Model 2910 Sampler, the safety of the personnel involved should be the foremost consideration. No project is so important or deadline so critical as to justify the risk of human life. The following present both general and specific safety procedures for working in and around manholes and sewers.

WARNING

The 2900 samplers have not been approved for use in hazardous locations as defined by the National Electrical Code.

CAUTION

Before you install any sampler, you must take the proper safety precautions. The following discussion of safety procedures offers only general guidelines. Each situation in which you install a sampler varies. You must take into account the individual circumstances of each installation.

Additional safety considerations, other than those discussed here may be required. Check applicable guidelines, codes, and regulations of federal state, city, and county agencies.

GENERAL SAFETY PROCEDURES

The following procedures are those used by Black & Veatch, a respected consulting firm. We have reprinted them here with their kind permission.

*Field personnel must keep safety uppermost in their minds at all times. When working above ground, rules of common sense and safety prevail. However, when entering manholes, strict safety procedures must be observed. Failure to do so could jeopardize not only your own life, but also the lives of other crew members.

1. Hazards. There are many hazards connected with entering manholes. Some of the most common hazards are:

   *Adverse Atmosphere. The manhole may contain flammable or poisonous gases or the atmosphere may be deficient in oxygen. Forced ventilation may be necessary.

   *Deteriorated Rungs. Manhole steps may be corroded and not strong enough to support a man. It may be difficult to inspect the rungs because of poor lighting.

   *Traffic. Whenever manholes are located in the traveled way, barricades and warning devices are essential to direct traffic away from an open manhole.

   *Falling Object. Items placed near the manhole opening may fall and injure a worker in the manhole.

   *Sharp Edges. Sharp edges of items in or near a manhole may cause cuts or bruises.

   *Lifting Injuries. Unless proper tools are used to remove manhole covers, back injuries or injuries to hands or feet may result.

   2. Planning. Advance planning should include arrangements for test equipment, tools, ventilating equipment, protective clothing, traffic warning devices, ladders, safety harness, and adequate number of personnel. Hasty actions may result in serious injuries. Time spent in the manhole should be kept to a minimum.

   3. Adverse Atmosphere. Before you enter a manhole, tests should be made for explosive atmosphere, presence of hydrogen sulfide, and oxygen deficiency. Since combustible or toxic vapors may be heavier than air, the tests on the atmosphere must be run at least ¾ of the way down the manhole.

   Whenever adverse atmosphere is encountered, forced ventilation must be used to create safe conditions. After the ventilating equipment has been operated for a few minutes, the atmosphere in the manhole should be retested before anyone enters the manhole.

   When explosive conditions are encountered, the ventilating blower should be placed upwind to prevent igniting any gas that is emerging from the opening. When a gasoline engine blower is used, it must be located so that exhaust fumes cannot enter the manhole.

   If testing equipment is not available, the manhole should be assumed to contain an unsafe atmosphere and forced ventilation must be provided. It should never be assumed that a manhole is safe just because there is no sign or the manhole has been entered previously.

   4. Entering Manholes. Since the top of the manhole is usually flush with the surrounding surface, there may not be anything for the person who is entering the manhole to grab on to steady himself. Persons who are entering manholes should not be permitted to carry anything in their hands as they enter the manhole, to ensure that their hands will be free to hold on or grab if they slip.
"A good method for entering a manhole is to sit on the surface facing the manhole steps or ladder, with the feet in the hole and the arms straddling the opening for support. As the body slides forward and downward, the feet can engage a rung, and the back can rest against the opposite side of the opening. If there is any doubt about the soundness of the manhole steps, a portable ladder should be used.

"A person should never enter a manhole unless he is wearing personal safety equipment, including a safety harness and a hard hat. Two persons should be stationed at the surface continuously while anyone is working inside a manhole, to lift him out if he is overcome or injured. One man cannot lift an unconscious man out of a manhole. The persons stationed at the surface should also function as guards to keep people and vehicles away from the manhole opening. To avoid a serious injury, a person should not be lifted out of a manhole by his arm unless it is a dire emergency.

"When more than one person must enter a manhole, the first person should reach the bottom and step off the ladder before the next one starts down. When two men climb at the same time, the upper one can cause the lower one to fall by slipping or stepping on his fingers.

5. Traffic Protection. In addition to traffic cones, markers, warning signs, and barricades, a vehicle or a heavy piece of equipment should be placed between the working area and oncoming traffic. Flashing warning signals should be used to alert drivers and pedestrians. Orange safety vests should be worn by personnel stationed at the surface when the manhole is located in a vehicular traffic area.

6. Falling Object. All loose items should be kept away from the manhole opening. This applies to hand tools as well as stones, gravel and other objects.

7. Removing the Covers. Manhole covers should be removed with a properly designed hook. Use of a pick ax, screwdriver, or small pry bar may result in injury. A suitable tool can be made from 3/4 inch round or hex stock. Two inches of one end should be bent at a right angle and the other end should be formed into a D-handle wide enough to accommodate both hands. Even with this tool, care must be exercised to prevent the cover from being dropped on the toes. The 2-inch projection should be inserted into one of the holes in the cover, the handle grasped with both hands, and the cover lifted by straightening the legs which have been slightly bent at the knees.

8. Other Precautions. Other precautions which should be taken when entering a manhole are:
   • Wear a hard hat.
   • Wear coveralls or removable outer garment which can be readily removed when the work is completed.
   • Wear boots or non-sparking safety shoes.
   • Wear rubberized or waterproof gloves.
   • Wear a safety harness with a stout rope attached.
   • Do not smoke.
   • Avoid touching yourself above the collar until you have cleaned your hands.

9. Emergencies. Every member of the crew should be instructed on procedures to be followed in an emergency. Each crew chief must have a list of emergency phone numbers, including the nearest hospital and ambulance service, police precinct, fire station, and rescue or general emergency number.

10. Field Equipment. The following equipment will be available for use:
   - Blowers
   - Breathing apparatus
   - Coveralls
   - First aid kits
   - Emergency flashers
   - Flashlights
   - Mirrors
   - Gas detectors
   - Gas masks
   - Gloves
   - Hard Hats
   - Harnesses
   - Manhole irons
   - Pick axes
   - Rain slickers
   - Ropes
   - Safety vests
   - Traffic cones
   - Waders

LETHAL ATMOSPHERES IN SEWERS

The following is an article written by Dr. Richard D. Pomeroy, and published in the October 1980 issue of Deeds & Data of the WPCA. Dr. Pomeroy is particularly well known for his studies, over a period of nearly 50 years, in the field of the control of hydrogen sulfide and other odors in sewers and treatment plants. He has personally worked in a great many functioning sewers. In the earlier years he did so, he admits, with little knowledge of the grave hazards to which he exposed himself. Dr. Pomeroy writes:

"It is gratifying that the subject of hazards to people working in sewers is receiving much more attention than in past years, and good safety procedures are prescribed in various publications on this subject. It is essential that people know and use correct procedures."
“It is less important to know just what the hazardous components of sewer atmospheres are, as safety precautions should in general be broadly applicable, but there should be a reasonable understanding of this subject. It is disturbing to see statements in print that do not reflect true conditions.

“Of the most common errors is the assumption that people have died from a lack of oxygen. The human body is able to function very well with substantially reduced oxygen concentrations. No one worries about going to Santa Fe, New Mexico, (elevation 2,100 meters), where the partial pressure of oxygen is equal to 56.4% (a normal atmosphere is about 21%) oxygen. When first going there, a person may experience a little “shortness of breath” following exercise. People in good health are not afraid to drive over the high passes in the Rocky Mountains. At Loveland Pass, oxygen pressure is 13.2% of a normal atmosphere. At the top of Mt. Whitney, oxygen is equal to 12.2%. Many hikers go there, and to higher peaks as well. After adequate acclimation, they may climb to the top of Mt. Everest, where oxygen is equal to only 6.7%.

“The lowest oxygen concentrations that I have observed in a sewer atmosphere was 13%. It was in a sealed chamber, near sea level, upstream from an inverted siphon on a metropolitan trunk. A man would be foolish to enter the chamber. Without ventilation, he might die, but not from lack of oxygen.

“It seems unlikely that anyone has ever died in a sewer from suffocation, that is, a lack of oxygen. Deaths have often been attributed to “asphyxiation.” This is a word which, according to the dictionary, is used to mean death from an atmosphere that does not support life. The word has sometimes been misinterpreted as meaning suffocation, which is only one kind of asphyxiation.

“In nearly all cases of death in sewers, the real killer is hydrogen sulfide. It is important that this fact be recognized. Many cities diligently test for explosive gases, which is very important, and they may measure the oxygen concentration which usually is unimportant, but they rarely measure H₂S. Death has occurred where it is unlikely that there was any measurable reduction in the oxygen concentration. Wastewater containing 2 mg/l of dissolved sulfide, and at a pH of 7.0, can produce, in a chamber with high turbulence, a concentration of 300 ppm H₂S, in the air. This is considered to be a lethal concentration. Many people have died from H₂S, not only in sewers and industries, but also from swamps and from hot springs. In one resort area, at least five persons died from H₂S poisoning before the people were ready to admit that H₂S is not a therapeutic agent. Hardly a year passes in the U.S. without a sewer fatality from H₂S as well as deaths elsewhere in the world.

“The presence of H₂S in a sewer atmosphere is easily determined. A bellows-and-ampoule type of tester is very satisfactory for the purpose, even though it is only crudely quantitative. When using a tester of this type, do not bring the air to the ampoule by way of a tube, as this may change the H₂S concentration. Hang the ampoule in the air to be tested, with a suction tube to the bulb or bellows.

“Lead acetate paper is very useful as a qualitative indicator. It cannot be used to estimate the amount of sulfide, but it will quickly turn black in an atmosphere containing only a tenth of a lethal concentration.

“Electrodes or other similar electrical indicating devices for H₂S in air have been marketed. Some of them are known to be unreliable, and we know of none that have proved dependable. Do not use one unless you check its at frequent intervals against air containing known H₂S concentrations. A supposed safety device that is unreliable is worse than none at all.

“Remember that the nose fails, too, when it comes to sensing dangerous concentrations of H₂S.

“Various other toxic gases have been mentioned in some publications. It is unlikely that any person has been asphyxiated in a sewer by any of those other gases, except possibly chlorine. The vapor of gasoline and other hydrocarbons is sometimes present in amounts that could cause discomfort and illness, but under that condition, the explosion hazard would be far more serious. The explosimeter tests, as well as the sense of smell, would warn of the danger. Pipelines in chemical plants might contain any number of harmful vapors. They, too, are sensed by smell and explosimeter tests if they get into the public sewer. Such occurrences are rare.

“The attempt to instill a sense of urgency about real hazards is diluted if a man is told to give attention to a long list of things that in fact are irrelevant.

“Be very careful to avoid high H₂S concentrations, flammable atmospheres, and hazards of physical injuries. Remember that much H₂S may be released by the stirring up of sludge in the bottom of a structure. Obey your senses in respect to irritating gases, such as chlorine (unconsciousness comes suddenly from breathing too much). Be cautious about strange odors. Do not determine percent oxygen in the air. There is a danger that the result will influence a man’s thinking about the seriousness of the real hazards. Most important, use ample ventilation, and do not enter a potentially hazardous structure except in a good safety harness with two men at the top who can lift you out.”
## Table 4 Hazardous Gas

<table>
<thead>
<tr>
<th>Gas</th>
<th>Chemical Formula</th>
<th>Common Properties</th>
<th>Specific Gravity or Vapor Density</th>
<th>Altitude</th>
<th>Physiological Effect*</th>
<th>Max Safe 60 Min Exposure ppm</th>
<th>Max Safe 8 Hour Exposure ppm</th>
<th>Explosive Lower Limit (% by vol.)</th>
<th>Upper Limit (% by vol.)</th>
<th>Lethal Location of Highest Concentration</th>
<th>MMI Common Sources</th>
<th>Recommended and Common Safe Method of Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonia</td>
<td>NH₃</td>
<td>Irritant and poisonous. Colorless with characteristic odor.</td>
<td>0.66</td>
<td>Causes throat and eye irritation at 0.05%, coughing at 0.5%, short exposure at 3.5% to 1% fatal.</td>
<td>360 to 590</td>
<td>85 to 165</td>
<td>25</td>
<td>Near top. Concentrations in closed upper spaces.</td>
<td>Savers, chemical feed rooms.</td>
<td>Detectable odor at low concentrations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benzene</td>
<td>C₆H₆</td>
<td>Irritant, colorless, smellless.</td>
<td>2.77</td>
<td>Slight symptoms after several hours exposure at 0.16% to 0.38%, 2% rapidly fatal.</td>
<td>5,000 to 5,000</td>
<td>25</td>
<td>1.3</td>
<td>7.1</td>
<td>At bottom.</td>
<td>Industrial wastes, varnish, solvents.</td>
<td>Combustible gas indicator.</td>
<td></td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>CO</td>
<td>Nearly colorless. Odors pungent, colorless, tasteless, phosphoric.</td>
<td>2.84</td>
<td>Very poisonous. Breathing, vomiting, convulsions, psychic disturbance.</td>
<td>—</td>
<td>15</td>
<td>44.0</td>
<td>At bottom.</td>
<td>An Insecticide</td>
<td>Combustible gas indicator.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>CO₂</td>
<td>Asphyxiating. Colorless, odorless, irritating, stinging, corrosive.</td>
<td>1.53</td>
<td>Cannot be endured at 10% volume. Causes slowly to death minutes, even if subject is well oxygen content is normal.</td>
<td>40,000 to 60,000</td>
<td>5,000</td>
<td>—</td>
<td>—</td>
<td>At bottom: {2}</td>
<td>Products of combustion, sewer gas, sludge.</td>
<td>CO₂ sensors.</td>
<td></td>
</tr>
<tr>
<td>Carbon tetrachloride</td>
<td>CCl₄</td>
<td>Heavy, flammable odor.</td>
<td>5.3</td>
<td>Intestinal upset, loss of consciousness, possibly central nervous system, respiratory failure.</td>
<td>1,000 to 1,000</td>
<td>100</td>
<td>—</td>
<td>—</td>
<td>At bottom.</td>
<td>Industrial wastes, solvents, cleaning.</td>
<td>Detectable odor at low concentrations.</td>
<td></td>
</tr>
<tr>
<td>Chlorine</td>
<td>Cl₂</td>
<td>Irritant, yellow-green color. Corrosive odor. Obstructs in very low concentrations. Non-flammable.</td>
<td>2.48</td>
<td>Irritates respiratory tract. Kills most animals in a very short time at 0.1%.</td>
<td>4</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>At bottom.</td>
<td>Chlorine cylinder and feed line leak.</td>
<td>Detectable odor at low concentrations.</td>
<td></td>
</tr>
<tr>
<td>Formaldehyde</td>
<td>CH₂O</td>
<td>Colorless, pungent sulfuric odor.</td>
<td>1.67</td>
<td>Irritating to the nose.</td>
<td>—</td>
<td>7.0</td>
<td>73.0</td>
<td>Near bottom.</td>
<td>Incomplete combustion of organic. Common air pollution.</td>
<td>Gaseous.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquefied</td>
<td>C₂H₅0H</td>
<td>Liquefied methanol. Colorless. Odor noticeable at 0.03%. Flammable.</td>
<td>3.0 to 4.0</td>
<td>Sunlight or heat when boiled. Rapidly fatal at 2.4%. Dangerous for short exposure at 1.1 to 2.2%.</td>
<td>4,000 to 7,000</td>
<td>1,000</td>
<td>1.0</td>
<td>6.0</td>
<td>At bottom.</td>
<td>Service stations, garages, storage tanks, houses.</td>
<td>1. Combustible gas indicator. 2. Oxygen deficiency indicator.</td>
<td></td>
</tr>
<tr>
<td>Hydrogen cyanide</td>
<td>HCN</td>
<td>Pungent odor of bitter almonds. Colorless gas</td>
<td>0.93</td>
<td>Slight symptoms appear upon exposure to 0.002% to 0.004%, 0.3% rapidly fatal.</td>
<td>—</td>
<td>10</td>
<td>40.0</td>
<td>Near top.</td>
<td>Insecticide and rodenticide.</td>
<td>Detector tube.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Percentages shown represent volume of gas in air.
**For concentration over 0.1%.

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13
### Model 2910 Sampler

**Hazardous Gas (continued)**

<table>
<thead>
<tr>
<th>Gas</th>
<th>Chemical Formula</th>
<th>General Properties</th>
<th>Specific Gravity or Vapor Density at 15°C</th>
<th>Physiological Effect</th>
<th>Max Safe 60 Min Exposure ppm</th>
<th>Max Safe 6 Hour Exposure ppm</th>
<th>Explosive Range (% by vol. in air)</th>
<th>Likely Location of Highest Concentration</th>
<th>Notes on Common Sources</th>
<th>Stopping and Clean-up, Safe Method of Testing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydrogen Sulfide</td>
<td>H₂S</td>
<td>Irritant and poisonous. Malodorous gas.</td>
<td>1.19</td>
<td>Impaired sense of smell.</td>
<td>200 to 300</td>
<td>45.0</td>
<td>Near bottom, but may be above bottom if area is heated and highly humid.</td>
<td>Coal gas, petroleum, sewer gas. Primary means of entry is by breathing under some conditions. Shudies gas.</td>
<td>1. H₂S Ammonia. 2.5% by weight in water.</td>
<td>1. Combustible gas indicator. 2. Oxygen deficiency indicator.</td>
</tr>
<tr>
<td>Methane</td>
<td>CH₄</td>
<td>Simple asphyxiant. Colorless, odourless, tasteless, flammable.</td>
<td>0.55</td>
<td>Acta mechanically to deplete tissues of oxygen. Does not support life.</td>
<td>—</td>
<td>15.0</td>
<td>Not toxic.</td>
<td>Natural gas, shude gas, manufactured gas, sewer gas. Symptoms of sedative origin in swamps or marshes.</td>
<td>Sewer gas may be found near bottom.</td>
<td>Oxygen deficiency indicator.</td>
</tr>
<tr>
<td>Nitrogen Oxides</td>
<td>NO₂</td>
<td>Colorless</td>
<td>1.04</td>
<td>600 to 1500 ppm causes irritation and coughing.</td>
<td>50</td>
<td>10</td>
<td>Near bottom.</td>
<td>Industrial waste, common air pollutant.</td>
<td>NO₂ detector tube.</td>
<td></td>
</tr>
<tr>
<td>Oxygen</td>
<td>O₂</td>
<td>Colorless, odourless, tasteless. Supports combustion.</td>
<td>1.11</td>
<td>Normal air contains 20.8% of O₂. Man can tolerate down to 12%. Minimum safe 6-hour exposure 16%. Below 16%. Amaugens to life. Below 5% to 7% probably fatal.</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>Variable or different levels.</td>
<td>Oxygen depletion from poor ventilation and absorption, or chemical consumption of oxygen.</td>
<td>Oxygen deficiency indicator.</td>
</tr>
<tr>
<td>Cyanide</td>
<td>CN</td>
<td>Irritant and poisons. Strongly acid to be colorless.</td>
<td>1.56</td>
<td>Max. normally occurring level is 0.0 ppm. 10 ppm causes irritation of eyes and nose. 10 to 300 ppm causes headache, nausea, can cause coma. Symptoms similar to radiation damage.</td>
<td>0.08</td>
<td>0.04</td>
<td>—</td>
<td>Near bottom.</td>
<td>Where cyanide is used for disinfection.</td>
<td>Detectable odor at 0.015 ppm.</td>
</tr>
<tr>
<td>Sulfur Dioxide</td>
<td>SO₂</td>
<td>Colorless, pungent odor. Sulfuric, corrosive, poisonous, non-flammable.</td>
<td>2.28</td>
<td>Inflammation of the eyes, 400 to 500 ppm immediately fatal.</td>
<td>50 to 100</td>
<td>10</td>
<td>—</td>
<td>At bottom, can combine with water to form sulfuric acid.</td>
<td>Industrial waste, combustions, common air pollutant.</td>
<td>Detectable taste and odor at low concentration.</td>
</tr>
<tr>
<td>Toluene</td>
<td>C₈H₁₀</td>
<td>Colorless, benzene-like odor.</td>
<td>3.14</td>
<td>As 200-500 ppm, headache, nausea, dizziness.</td>
<td>200</td>
<td>100</td>
<td>1.27</td>
<td>At bottom.</td>
<td>Solvent.</td>
<td>Combustible gas indicator.</td>
</tr>
<tr>
<td>Turpentine</td>
<td>C₅H₈</td>
<td>Colorless, characteristic odor.</td>
<td>4.06</td>
<td>Eye irritation. Headache, dizziness, nausea, irritation of the kidneys.</td>
<td>—</td>
<td>100</td>
<td>—</td>
<td>At bottom.</td>
<td>Solvent, used in paint.</td>
<td>1. Detectable odor at low concentrations. 2. Combustible gas indicator.</td>
</tr>
<tr>
<td>Xylene</td>
<td>C₈H₁₀</td>
<td>Colorless, flammable.</td>
<td>3.66</td>
<td>Narcotic in high concentrations. Less toxic than benzene.</td>
<td>—</td>
<td>100</td>
<td>1.1</td>
<td>At bottom.</td>
<td>Solvent.</td>
<td>Combustible gas indicator.</td>
</tr>
</tbody>
</table>

* For references, please refer to the source or additional documentation.

**Mostly methane and carbon dioxide with small amounts of hydrogen, nitrogen, hydrogen sulfide, and oxygen; occasionally traces of carbon monoxide.**
Chapter 4 Programming

CONNECTION TO POWER SOURCE
The Model 2910 can be supplied with power from a variety of Isco power sources or an external 12-volt DC source (such as an automotive or marine battery). For more information about power sources, see the Isco Power Products Guide.

Internal Battery
A lithium battery inside the sampler keeps the sampler’s circuitry operative when external power is interrupted. It also maintains the sampler’s program when the unit is off or power is disconnected so that the program is not lost. However, the internal battery will not operate the sampler’s pump. The lithium battery has an expected life of 5 to 10 years.

MOUNTING POWER SOURCES
To power the sampler, mount an Isco 12-volt battery or power pack on the sampler (Figure 12 through Figure 14). Then stretch the catches up and into the “U” shaped receptacles on the power source. Finally, attach the power source connector to the sampler’s “12 VDC” connector. If using a power pack, route the line cord through the notch in the center section.

EXTERNAL 12 VOLT DIRECT CURRENT SOURCE
The 2910 may also be powered from an external 12-volt DC source, such as an automotive or deep-cycle marine battery. An connect cable is available to connect the sampler to the battery. Plug the connector on the end of the battery connect cable into the sampler’s “12 VDC” connector. Then, connect the battery clips to the battery terminals. The positive lead of the cable has a “+” stamped in it. The cable should pass through the external line port shown in Figure 11.

CAUTION
Be sure of proper polarity when attaching the clips of the battery. The sampler is equipped with internal circuitry which is intended to protect the sampler in case of polarity reversal by sacrificing the externally mounted fuse. However, should the internal protection fail, a great deal of circuit damage may result from such a mistake.
**Model 2910 Sampler**

**Connection to a Flow Meter**

As discussed in Chapter 1 the Model 2910 can collect samples on a flow proportional basis using flow inputs from an external flow meter. Electronically, the Model 2910 requires a 12 volt DC pulse or an isolated contact closure of at least 25 millisecond duration to cause a sample to be taken and/or register a flow pulse. Connection of the sampler to Isco and non-Isco flow meters is discussed in the following sections. If a connect cable is not attached to the flow meter socket on the side of the sampler control box, be sure that the protective cover is tightly screwed in place to maintain the watertightness of the unit.

**ISCO Flow Meter**

Connect cables to connect the Model 2910 to an Isco flow meter are purchased with the flow meter. To make the connection, attach the appropriate cable connector to the flow meter per directions in the flow meter instruction manual, and attach the other connector to the FLOW METER socket on the side of the sampler control box, as shown in Figure 14. Refer to the flow meter instruction manual for further details.

![Figure 14 Sampler Connections](image)

**Non-ISCO Flow Meters**

Certain non-Isco flow meters can be directly interfaced with the Model 2910 Sampler. These are flow meters having an isolated contact closure type output of at least 25 millisecond duration, the frequency of the contact closures being directly proportional to total flow. A connector and cable clamp to connect a non-Isco flow meter to the Model 2910 are available from Isco, part number 68-1680-060. The isolated contact closure from the flow meter should be connected to pins A and C of the six pin connector. The connector prewired to a 22 ft. (6.7 m) cable is also available from Isco, part number 60-1394-077.

Attach the non-Isco flow meter connector to the FLOW METER socket on the side of the Model 2910 Sampler control box. The sampler will now accept flow pulse inputs from the flow meter. Refer to the instruction manual of the flow meter being used for further information.

**Interface Devices**

The 2910 Sampler can also be used with flow meters having other types of outputs, for example, a 4-20 mA output directly proportional to flow rate. However, these flow meters require a special interface device to convert their output signal into one compatible with the 2910 Sampler.

Two interfaces are available: the Type A Interface and the 4 - 20 mA Sampler Input Interface. Each interface connects to the flow meter connector on the rear of the sampler. Consult the factory for assistance in interfacing the sampler with non-Isco flow meters.

**Type A Interface** - Converts flow pulse duration output from non-Isco flow meters to acceptable flow pulses.

**4-20 mA Sampler Input Interface** - Converts 4 to 20 mA output signals from non-Isco flow meters to acceptable flow pulses.

**Setting Up a Sampling Program**

After the preparations described in Chapter 2 have been completed, the Model 2910 Sampler can be programmed for automatic sample collection in a number of different modes. The following sections describe the procedures for setting up an automatic sampling program. Included are sections discussing the types of samples which may be collected, describing the sampler controls and indicators in detail, explaining standard and advanced programming techniques, and describing sample recovery procedures.

**Typical Sampling Cycle**

For reference, the sequence of events in a typical sampling cycle follows:

1. The interval (either in minutes or flow pulses) since the previous sample reaches the preset value and an automatic sampling cycle is initiated.
2. The pump rotates in the reverse direction to air pre purge the suction line inlet of any accumulated debris.
3. The pump direction changes, pumping in the forward direction to fill the suction line.
4. After the suction line has been filled to the pump inlet, the sample volume measuring portion of the sampling cycle begins. The pump continues to rotate in the forward direction until the preset volume of sample has been delivered to the sample container.

5. The pump direction again changes, pumping in the reverse direction to air postpurg the suction line to avoid cross-contamination of samples. The pump then shuts off.

6. The sample interval is again being counted down from the preset value, until “zero” is reached and the cycle begins again at step 1.

This process continues until the programmed number of composite samples has been collected or the sample container fills to the point where the float shut-off is actuated, at which time the sampler automatically shuts off.

**Peristaltic Pump**

Also for general reference, following is a brief description of the method by which the sample volume is determined. As discussed in *Description of the 2910 Sampler*, on page 1, the Model 2910 uses a peristaltic pump to transport the sample from the source to the sample container. When compared with other suction lift sample gathering methods, a peristaltic pump has numerous advantages: simplicity, reliability, no metering chamber required, easily cleaned, etc. However, the determination of the volumetric delivery of a peristaltic pump presents significant design problems, especially when different suction head lifts are considered. The Model 2910 addresses these problems through the use of sophisticated, microprocessor-based control logic.

**Volumetric Determination**

The Model 2910 Sampler determines the volumetric delivery of its peristaltic pump by electronically counting revolutions of the pump rotor. Each revolution of the pump rotor corresponds to a certain volume of sample liquid; however, the volume of liquid delivered by one revolution of the pump rotor changes as the suction head of the pump changes and when the type of suction line being used is changed. The function of programming a suction head value into the sampler is to establish a relationship between the operating suction head and the volume delivered by one revolution of the pump rotor. The function of programming a suction line type into the sampler is to establish a relationship between the type of suction line being used and the volume delivered by one revolution of the pump rotor. Thus, for a given suction head and given type of suction line, one revolution of the pump rotor results in the delivery of a fixed, known amount of sample volume.

**Volume Counting**

As discussed above, the sample pumping portion of a sampling cycle consists of two parts: suction line fill and sample volume delivery. The sampler “knows” the volume of the suction line being used by the type of suction line programmed. To fill the suction line, the sampler “counts” a number of pump rotor revolutions corresponding to the volume of the suction line. After the suction line has been filled, the sample volume delivery is accomplished in a similar manner. The sampler “counts” a number of pump rotor revolutions corresponding to the programmed sample volume. Thus, based on a given operating suction head and a given type of suction line, the sampler fills the suction line and delivers the preselected volume to the sample container.

**Sample Volume Variation**

The sample delivery process is discussed at much greater length in *Programming Overview*, on page 18 and *Description of Controls and Indicators*, on page 18. However, it is very important to note that the volume delivered by a peristaltic pump can be influenced by a number of factors other than those discussed above. Thus, even with the sophistication of the sample volume measuring functions of the Model 2910, the volume of sample deposited in the sample container may vary from the programmed nominal sample volume. The repeatability of a sample volume from sample to sample (which normally is the most important consideration) will typically be within the ±10 ml specification stated in *Table 2*, on page 4. And the wide range of sample volumes which may be programmed will allow any sample volume to be repeatably placed in the sample container through a trial-and-error process or by calibrating the sample volume, as discussed in *Overview of Calibration*, on page 56. But, the inherent potential variation between the programmed sample volume and the volume of sample actually placed in the sample container should be kept in mind when reading the following sections.

**TYPES OF SAMPLES**

The Model 2910 Sampler is designed to collect composite samples. To provide a frame of reference for the following sections, the types of samples which may be collected using the Model 2910 are briefly discussed:
Model 2910 Sampler

Composite Time
In a composite time sample, the individual samples collected are combined ("composited") into a single container. Samples are collected at equal increments of time.

Composite Flow
In a composite flow sample, the individual samples collected are combined into a single container. Samples are collected at equal increments of flow volume, as measured by an associated flow meter.

Composite Samples
A composite time or flow sample represents an average of the characteristics of the flow stream over the total elapsed time of sampling.

PROGRAMMING OVERVIEW
To provide a general background for the discussion of the controls and indicators and sampler programming, following is an overview of the sampler’s programming techniques. The sampler is programmed through the use of a 24-position keypad and a 4-character liquid crystal display (LCD) with eight additional descriptive legends. The keypad is used to enter program quantities and to control certain sampler functions. The display is used to show the program quantities being set, to indicate the operational status of the sampler, and to “step” the user through the sampler programming process by indicating the quantity to be programmed.

Programming Terms
The “program quantities” are simply the quantities that define the sample and the sampling process: for example, the type of sample to be collected (time), the interval between samples (30 minutes), the sample volume (750 ml), type of suction line being used (¼” x 25’), etc. The sampler’s “program” consists of a stored collection of the program quantities that completely define the sampling process, and the act of “programming” the sampler consists of establishing and storing the desired settings of the program quantities. “Running” or “executing” the sampler’s program causes a series of samples to be collected according to the program quantities stored in the sampler’s program.

Sampler States
To fully understand the sampler’s programming techniques, it is necessary to realize that the sampler has five basic states: off, standby, program, run, and full (program complete). In the off state, the display is blanked and none of the controls (except ON) are functional. However, even in the off state, all the program quantities are retained by an internal battery. In the standby state, the sampler is waiting either to be programmed or to have the program run. In the program state the programming functions are enabled. The sampler’s pump can be operated manually only in the standby and program states. In the run state, the program is being executed and the pump can only be operated under program control. In the full state (program complete), the composite container has been filled according to the program and the sampler is dormant, waiting to be restarted.

Programming
From this overview, it can be seen that the Model 2910 Sampler is not “programmed” in the sense that a programmable calculator or home computer is programmed. The actual microprocessor-based program that controls the overall action of the sampler is built into the unit, and cannot be modified by the user. In the sense that it will be used in this manual, programming refers to the process of establishing and storing the desired settings of the program quantities. The sampler’s programming process is self-prompting in that the display steps the user through the programming sequence in a logical order, indicating the program quantity to be established. The sampler will accept only appropriate values for the program quantities, and will reject any unacceptable values. Thus, the sampler’s programming process is simple and straightforward.

DESCRIPTION OF CONTROLS
AND INDICATORS
The control panel of the Model 2910 Sampler is shown in Figure 18. The operation and use of the keypad, the liquid crystal display, and the humidity indicator are discussed in detail in the following sections.

Keypad
The twenty-four position keypad is used to program the sampler and to manually control certain functions of the sampler. The individual key switches that make up the keypad feature both tactile and audio feedback to assure that the key switch has been successfully actuated. When one of the key switches is pressed, the user will “feel” the resistance of the spring member in the switch, and should easily be able to note when the switch “peeks over center” into the actuation point. Also, when one of the key switches is successfully actuated, an audio indicator inside the sampler will “beep” once to confirm the successful actuation of the switches.
**Manual Controls**

The keypad switches are divided into three functional groups, which will be discussed individually in the following sections. The six keys of the left column of the keypad make up the manual controls. These keys allow some of the sampler's functions to be manually controlled, outside of program operation. The six Manual Control keys are:

1. Mode
   - 1 = time
   - 2 = flow

2. Interval between samples
   - Time: 1-9999 minutes
   - Flow: 1-9999 flow pulses

3. Delay to first/next sample
   - 1-9999 minutes

4. Nominal sample volume
   - 1-99 in 10% of ml
   - 0 = calibrate mode

5. Type of suction line
   - 1 = 1/4" x 10'
   - 2 = 1/4" x 25'
   - 3 = 3/8" x 10'
   - 4 = 3/8" x 25'

6. Option head
   - 1 - 20 ft.

7. Calibrate sample volume

8. Number of samples

---

**Manual Sample**

Pressing the Manual Sample key of a sampler in the standby state will cause a sample to be collected according to the sampler's present program. The collection of a manual sample does not alter any of the preset program quantities (for example, the interval to the next sample); a manual sample is simply an "extra" sample outside of the normal sampling program. The sampler's logic will prevent a manual sample from being collected in a sample container that the sampler believes to be "full." Note that the Manual Sample key is functional only when the sampler is in the standby state.

---

**Pump Jog Fwd**

Pressing the PUMP Jog FWD (forward) key will cause the sampler's pump to run in the forward direction as long as the key is held down. When the key is released, the pump will stop. Note that the PUMP Jog FWD key is functional only when the sampler is in the standby state or in the program state (for calibration of sample volume as discussed in Overview of Calibration, on page 36).

---

**Pump Jog Rev**

Pressing the PUMP Jog REV. (reverse) key will cause the sampler's pump to run in the reverse direction as long as the key is held down. When the key is released, the pump will stop. Note that the PUMP Jog REV. key is functional only when the sampler is in the standby state or in the program state (for calibration of sample volume, as discussed in Overview of Calibration, on page 36).

---

**Pump Cont. Fwd**

Pressing the PUMP CONT. FWD. (continuous forward) key will cause the sampler's pump to run continuously in the forward direction. The pump may be stopped by pressing the PUMP STOP key, as described below. Note that the PUMP CONT. FWD. key is functional only when the sampler is in the standby state.

---

**Pump Cont. Rev**

Pressing the PUMP CONT. REV. (continuous reverse) key will cause the sampler's pump to run continuously in the reverse direction. The pump may be stopped by pressing the PUMP STOP key, as described. Note that the PUMP CONT. REV. key is functional only when the sampler is in the standby state.

---

**Pump Stop**

Pressing the PUMP STOP key will cause the sampler's pump to immediately cease pumping. Note that the PUMP STOP key is functional any time that the sampler's pump is running, regardless of whether it is running under manual or program control.
NUMBER KEYPAD

The center two columns of twelve keys on the keypad make up the number keypad. These keys turn the sampler on and off, and allow program quantities to be entered. The twelve Numeric keys are:

Off

Pressing the Off key blanks the liquid crystal display, disables all keys except the On key, and immediately interrupts any action of the sampler (pumping). Note that an internal battery maintains the program quantities even when the unit is turned off.

On

Pressing the On key of a sampler which has been turned off will reactivate the display and place the sampler into the standby state.

Number keys

Pressing any of the number keys will cause the number entered to be shown on the display. They are used to enter program quantities into the sampler.

CONTROL KEYS

The right column of six keys on the keypad make up the Control keys. These keys are used to set up and control the execution of the sampler’s program. The six Control keys are:

Program/Step

Pressing the Program/Step key of a sampler in the standby state will cause the sampler to be transferred from the standby to the program state. Once the sampler is in the program state, depressing the Program/Step key will cause the quantity shown in the display to be loaded into memory and the unit to be stepped to the next program quantity. A depression of the Program/Step key after the last applicable program quantity step will cause the sampler to be returned to the standby state from the program state. Thus, the Program/Step key is used to place the sampler into the program state and to step through the program quantities to be set. The Program/Step key may also be used in place of the Enter Value key (discussed below), as the Program/Step key contains an implied enter value function. Pressing the Program/Step key of a sampler in the full (program complete) state will cause the sampler to be transferred to the program state.

Depressing the Program/Step key of a sampler in the run state will cause the sampler to be placed into a program scan mode, showing on the display the program quantity step number followed by the value of the program quantity set. This allows the settings of the program quantities to be checked without halting the sampler’s program by repeatedly press-
Start Sampling

Depressing the START SAMPLING key of a sampler in the standby or full (program complete) state will cause the sampling program to begin according to the program quantities previously set. Note that the START SAMPLING key is functional only for a sampler in the standby or full states.

Halt Sampling

Pressing the HALT SAMPLING key of a sampler in the run state will cause the sampling program which is in operation to be halted and will transfer the sampler to the standby mode. This allows the sampler's program to be modified, if desired. Time incrementing will continue even after the program has been halted; if the interval to the next sample reaches zero while the program is halted, no sample will be collected, the time interval to the next sample will be reset to the programmed interval, and time incrementing will continue. A missed sample will not be remembered and consequently will not be collected when the program is resumed by the RESUME SAMPLING key. Flow pulse incrementing will cease until the halted program is resumed. If the HALT SAMPLING key is pressed while the sampler's pump is running, the pump will immediately stop. The use of the HALT SAMPLING key is further discussed in Program Halt/Resume, on page 40.

The HALT SAMPLING key can also be used to access the special programming step used to select English or metric units of measure for the sampler. Refer to Selecting Units of Measure, on page 42 for more information.

Resume Sampling

Pressing the RESUME SAMPLING key of a sampler in the standby state will cause the sampling program as it currently exists to begin execution. The RESUME SAMPLING key is initially used to resume the program of a previously running sampler whose program has been interrupted by the HALT SAMPLING key. If, during the time while the program was halted, no program quantities or only the interval between samples and/or the interval to the first/next sample were changed, the sampling program will be resumed, upon depression of the RESUME SAMPLING key, at the point where it was halted, according to the program quantities currently set. If, on the other hand, any program quantities other than the interval between samples or the interval to the first/next sample were changed during the program halt, behavior of the sampler upon program resumption depends upon whether the pump was running. If the program was halted during a sample collection (while the pump is running), when the RESUME SAMPLING key is pressed the suction line will be purged. Note that the RESUME SAMPLING key is functional only for a sampler in the standby state. The use of the RESUME SAMPLING key is further discussed in Program Halt/Resume, on page 40.

DISPLAY

The four character liquid crystal display (LCD) with eight additional descriptive legends is used to display the program quantities being set, to display the operational status of the sampler, and to "step" the user through the programming process in a logical manner. The nature of the display depends upon which of the five possible states the sampler is in. Figure 16, on page 23 is provided as a reference for the following sections.

Off

For a sampler in the OFF state, the display is blanked (turned off).

Standby State

For a sampler in the standby state, the STNDBY (standby) legend on the display will always be on. The time or flow pulse interval to the next sample ("00XX") will alternate with the total number of composite samples collected ("XXX"), as shown in Figure 16 A. When the time or flow pulse interval is shown, either the TIME or FLOW legend (as appropriate) will be on, when the number of composite samples collected is shown, the COMP (composite) legend will be on. If a sampling program has been previously completed (the composite container filled), a third quantity will be added to the alternation of the display, the text "FULL", as shown in Figure 16 B.

Program State

For a sampler in the program state, the PRGM legend on the display will always be on, and the display will initially alternate between a number which indicates the program quantity to be set and the current value of the program quantity indicated, as shown in Figure 16 C. The program quantity step number refers to the eight numbered descriptions listed on the sampler's control panel directly below the display. When the program quantity step number is shown on the display, both the PRGM and STEP legends will be on. When the program quantity presently set is shown, the STEP legend will be turned off. As soon as a new program quantity is entered on the numeric keypad, the alternating nature of the display will be halted and the new value being entered will be shown on the display. The alternation of the display between the program quantity step number and the value of the program quantity indicated will be restored when the ENTER or PROGRAM/STEP key is pressed.
The TIME or FLOW legend (as appropriate for the mode selected) will be on when the sampler is in the program state. It should be noted that during the time when a new program quantity is being entered on the numeric keypad, if there is no further activity on the keypad for approximately five minutes, the alternation of the display will be restored with the previously established program quantity value being shown.

Run State
For a sampler in the run state, the RUN legend on the display will always be on, and the display will alternate between the time or flow pulse interval to the next sample ("00XX") and the total number of composite samples collected ("XXX"), as shown in Figure 16D. When the time or flow pulse interval is shown, either the TIME or FLOW legend (as appropriate) will be on; when the number of composite samples collected is shown, the COMP (composite) legend will be on. As described Control Keys, on page 20, a sampler in the run state may be placed into a special program scan mode. In this mode, both the RUN and PRGM legends will be on simultaneously. The display will alternate between the program quantity step number ("X") and the current value of the program quantity indicated ("XX"), as shown in Figure 16E. When the program quantity step number is shown on the display, the STEP legend will also be on.

Full State
For a sampler in the full (program complete) state, the display will alternate between the text “FULL” and the total number of samples collected before sampling was terminated ("XXX"), as shown in Figure 16F.

Error Messages
The display also indicates error conditions which may occur during operation of the sampler. If the sampler’s pump becomes jammed (for example, by the formation of ice in the pump tube), the display will indicate this condition with the word “HELP”. The “HELP” display will be shown when the sampler attempts to run a jammed pump, either under program control or responding to the manual pump controls. To prevent injury due to unexpected actuation of the pump during servicing, the sampler will be “locked-up” as long as the “HELP” error message is shown on the display. In other words, simply unjamming the pump will not cause the pump to resume action, nor will it cause the sampling program to be restarted or allow the pump to be operated manually. The display may be cleared of the “HELP” error message and normal operation restored by turning the sampler off and back on.

Diagnostic Messages
As discussed in Troubleshooting, on page 61, the Model 2910 automatically runs diagnostic checks on its internal RAM and PROM memory upon power up and during operation. If an error is detected during power up (refer to Power Up, on page 60), the display will become “stuck” on one of the following error messages: “PPPP” or “EEEE”. If an error is detected during operation (refer to Normal Operation, on page 60), other error messages will also be shown in the display. In this case, the error message consists of the letters EE (“EE-”) and in some instances a number. The display will also show other quantities and possibly error messages during the manually initiated diagnostic routine.

Low Battery Indication
Depending upon the circumstances, the sampler may indicate a low battery in any one of several ways. If the sampler’s battery is dead or extremely low, the sampler will be completely inoperable, the display will not light and the pump will not run. If the sampler’s battery is discharged, but not completely dead, the low battery condition will be indicated on the sampler’s display. In this case, the display may read either “HELP”, “PPPP”, or “EEEE”. Depending upon the state of discharge of the battery, the sampler’s pump may also repeatedly cycle on and off during a sampling cycle. If any of these indications are present, it should be assumed that the battery is low and the sampler’s battery should be replaced or recharged. However, it should be noted that the “HELP”, “PPPP”, or “EEEE” displays may also indicate other types of problems. If replacing or recharging the sampler’s battery does not restore the normal operation of the display, refer to Table 8, on page 62 for further troubleshooting instructions.

Program Quantity Steps
As mentioned, there are eight program quantity step descriptions listed on the sampler’s control panel, directly below the display. The program quantity step descriptions list the program quantity to be set and indicate the acceptable settings. They are numbered 1 through 8, and correspond to the program quantity step numbers (PRGM STEP) shown on the display when the sampler is in the program mode. Their purpose is to “step” the user through the sampler programming process by indicating the program quantity to be set.
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Figure 16 Display Modes

A. Standby State. Alternates between:

```
TIME 0015 STNDY

and

COMP 125 STNDY
```

Time or flow pulse interval to next sample

Total number of composite samples collected

B. Standby State (composite sampling previously completed). Alternates among:

```
TIME 0015 STNDY

and

COMP 125 STNDY

and

FULL
```

Time or flow pulse interval to next sample

Total number of composite samples collected

C. Program state. Alternates between:

```
TIME 2 PROM

and

STEP 60
```

Program quantity step number

Value of program quantity. (For example, time interval between samples).

D. Run state. Alternates between:

```
FLOW 0016 RUN

and

COMP 53
```

Time or flow pulse interval to next sample

Total number of composite samples collected

E. Run state (program scan mode). Alternates among:

```
TIME 2 PROM

and

STEP 0060 RUN
```

Program quantity step number

Value of program quantity. (For example, time interval between complec).

F. Full state. Alternates between:

```
FULL

and

COMP 100
```

Total number of composite samples collected
Table 5 Sampler Error Messages

<table>
<thead>
<tr>
<th>Error Message</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;HELP&quot;</td>
<td>Sampler's pump jammed.</td>
</tr>
<tr>
<td>Stuck on &quot;PPPP.&quot;</td>
<td>Failed PROM check during power up.</td>
</tr>
<tr>
<td>Stuck on &quot;EEEE.&quot;</td>
<td>Failed RAM check during power up.</td>
</tr>
<tr>
<td>Time or flow pulse interval to next sample replaced by &quot;EE&quot; in the normal rotation of the display</td>
<td>Failed PROM or RAM check while operating in the run state.</td>
</tr>
<tr>
<td>Alternates between &quot;EE&quot; and &quot;1.&quot;</td>
<td>Failed PROM check while operating in off or standby states, or in run state and subsequently placed into off or standby state.</td>
</tr>
<tr>
<td>Alternates between &quot;EE&quot; and &quot;2.&quot;</td>
<td>Failed RAM check while operating in off or standby states, or in run state and subsequently placed into off or standby state.</td>
</tr>
<tr>
<td>Alternates between &quot;EE&quot; and &quot;6.&quot;</td>
<td>Pump rotation counting optics error detected during pumping portion of manually initiated diagnostics.</td>
</tr>
</tbody>
</table>

When the sampler is placed into the program state by pressing the PRG/STEP key, PRG/STEP 1 will be shown on the display, indicating that the first program quantity (MODE) is to be set. Subsequent depressions of the PRG/STEP key will cause the unit to sequentially step through the program quantities to be set. Depending upon the type of sampling program being established, certain of the program quantity steps may be skipped, as described below.

When the PRG/STEP key is pressed after the last program quantity has been set, the sampler will be transferred from the program to the standby state. Note that for a sampler in the program state, if there is no activity on the keypad for five minutes, the sampler will automatically be transferred from the program to the standby state.

The program quantities associated with each of the eight program steps are discussed individually.

Mode

When PRG/STEP 1 (MODE) is shown on the display, the basic mode of sampler operation may be selected. The mode to be used is selected by entering on the keypad the number associated with the mode. The two modes available and the numbers used to select them are as follows:

1. = TIME (Composite Time)
2. = FLOW (Composite Flow)

These modes of operation were briefly described above. For example, to select a time mode of operation, the number 1 should be entered in the keypad. If MODE 1 (time) is selected, the TIME legend on the display will be on while the sampler is in the program state; if MODE 2 (flow) is selected, the FLOW legend on the display will be on.

Interval Between Samples

When PRG/STEP 2 (INTERVAL BETWEEN SAMPLES) is shown on the display, the time or flow pulse interval between samples may be selected. When the sampler is operating in the time mode (mode 1), the interval is set in minutes. The time interval between samples is selected by entering on the keypad any value between 1 and 9999 minutes. When the sampler is operating in the flow mode (mode 2), the interval is set in flow pulses (received from an external flow meter). A flow pulse is simply an electronic signal from the flow meter indicating that a certain fixed total volume of liquid has flowed past the flow meter, for example, 10,000 gallons. The flow interval between samples is selected by entering on the keypad any value between 1 and 9999 flow pulses.

Duration of Sampling Cycle

When setting the interval between samples, be sure that the interval selected is longer than the duration of the sampling cycle described in Setting Up a Sampling Program, on page 16. The duration of the sampling cycle will vary according to the program quantities selected, and if it is questionable, the duration may be determined by simply timing one complete cycle. For truly representative sampling, the interval between samples selected (either in minutes or the fastest anticipated flow pulse rate) should be longer than the duration of the sampling cycle established. Otherwise certain sample initiations will occur at improper times, although no sample initiations will be lost.

Delay To First/Next Sample

When PRG/STEP 3 (DELAY TO FIRST/NEXT SAMPLE) is shown on the FIRST/NEXT display, the time delay to the first (or the next) sample may be selected. The time delay to the first/next sample is selected by entering on the keypad any value between 1 and 9999 minutes.
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This allows the user to establish a time delay to the first sample independent of the normal interval between samples, permitting the synchronization of the sampling program with real clock time or any other external event. Since time continues to advance for a sampler in the program state, the state time delay to the first sample starts at the moment the delay is entered on the keypad. If the sampler is not placed into the run state before the delay to the first sample has counted down to zero, the delay to the first sample will be automatically reset to the normal interval between samples, and the counting down process restarted.

It is very important to realize that the program quantity set when PRGM STEP 3 (DELAY TO FIRST/NEXT SAMPLE) is shown on the display is different from all the other program quantities. The DELAY TO FIRST/NEXT SAMPLE step provides the user with access to the register in the sampler's memory which contains the time interval until the next sample is collected. When PRGM STEP 3 (DELAY TO FIRST/NEXT SAMPLE) is shown on the display, the time interval remaining until the next sample (which may be the first or a subsequent sample) will be shown on the display and may be changed by a keypad entry. Unlike the other program quantities, which remain constant until changed, the delay to the first sample is continuously being counted down, reflecting the decreasing amount of time remaining until the next sample is collected. Thus, the delay to the first sample program quantity is a dynamic quantity, which is counted down from the value entered on the keypad. As mentioned, this allows the user to establish a delay to the first sample which differs from the interval between the remainder of the samples. It also allows the user to modify the time interval to the next sample by halting the sampler's operation and changing the value of the delay to first sample as described in Program Halt/Resume, on page 40.

For a sampler operating in the flow mode (mode 2), PRGM STEP 3 (DELAY TO FIRST/NEXT SAMPLE) is skipped.

Nominal Sample Volume

When PRGM STEP 4 (NOMINAL SAMPLE VOLUME) is shown on the display, the nominal sample volume to be placed in the sample container may be selected. Sample volume is programmed in terms of 10s of milliliters (ml) of nominal delivered sample volume. The nominal sample volume is selected by entering on the keypad any volume between 1 and 99 "10s" of ml. For example, a keypad entry of 25 would result in a nominal 250 ml (25 × 10 = 250) sample. This assumes that the type of suction line and suction head program quantities have been correctly programmed, as described below.

Calibrate Mode

A keypad entry of 0 while PRGM STEP 4 (NOMINAL SAMPLE VOLUME) is shown on the display places the sampler into the calibrate sample volume mode. This mode allows the user to precisely calibrate the delivered sample volume for a given setup. The calibrate sample volume process is described later in this chapter and in Overview of Calibration, on page 30.

It is very important to note that the name of this program quantity refers to the nominal sample volume. The programmed delivery volume should be used only as a nominal indication of the volume of liquid which the sampler will actually deliver into the sample container. Depending upon the conditions of use (as discussed below), the actual delivered volume may be different than the programmed volume, although the repeatability of the delivered sample will typically be within the ±10 ml specification stated in Table 2, on page 4. Thus, while the volume of sample delivered into the sample container may vary from the programmed setting, the volume of each individual sample will be quite repeatable. It is essential to realize that the fact that the nominal sample volume is programmable to within 10 ml does not imply that the volume of sample actually delivered to the sample container will match the programmed volume within 10 ml; as with many digital controls, the nominal sample volume has greater setability than it has accuracy.

The volume delivered by a peristaltic pump (the type used in the Model 2910 Sampler) is affected by a number of factors: operating suction head, atmospheric pressure, installation and condition of pump tubing, length and inside diameter of the suction line, etc. The volumetric measuring functions programmed into the Model 2910 were determined by careful tests using the correct length of pump tubing and the standard suction lines, at precisely measured operating heads. Any deviation from these conditions will result in a delivered volume which may be different from the programmed volume. For example, improper installation of the pump tubing (too little or too much tubing in the pump housing) will cause a decrease in pumping efficiency and a resultant decrease in delivered volume.

In the case of sampling procedures where the actual delivered volume is critical, it may be advantageous to select the sample volume using the calibrate sample volume mode. This is described later in this section and in Overview of Calibration, on page 36.
Type of Suction Line

When **PRGM STEP 5 (TYPE OF SUCTION LINE)** is shown on the display, the type of suction line to be used with the sampler may be selected. The suction line to be used is selected by entering on the keypad the number associated with the suction line. The four suction lines available and the numbers used to select them are as follows:

1 = \(\frac{3}{4}'' \times 10'\) (\(\frac{3}{4}''\) ID \(\times 10\) long vinyl line)
(Metric: 6.35 mm \(\times\) 3 m)

2 = \(\frac{1}{4}'' \times 25'\) (\(\frac{1}{4}''\) ID \(\times 25\) long vinyl line)
(Metric: 3.18 mm \(\times\) 7.6 m)

3 = \(\frac{3}{8}'' \times 10'\) (\(\frac{3}{8}''\) ID \(\times 10\) long vinyl or Teflon lines)
(Metric: 9.53 mm \(\times\) 3 m)

4 = \(\frac{3}{8}'' \times 25'\) (\(\frac{3}{8}''\) ID \(\times 25\) long vinyl or Teflon lines)
(Metric: 9.53 mm \(\times\) 7.6 m)

These suction lines were briefly described in **Attaching the Suction Line**, on page 5. For example, to set the sampler up for use with a \(\frac{3}{4}'' \times 10'\) suction line, the number 1 should be entered on the keypad.

If suction line configurations other than the four listed above are used with the sampler, the calibrate sample volume mode of operation, described later in this section and in **Overview of Calibration**, on page 36 will have to be used to establish the sample volume. When the calibrate sample volume mode is used, it is not necessary to specify the type of suction line, and consequently, **PRGM STEP 5 (TYPE OF SUCTION LINE)** is skipped when this mode is selected.

Suction Head

When **PRGM STEP 6 (SUCTION HEAD)** is shown on the display, the actual operating suction head of the sampler may be selected. Suction head is the vertical distance the sample must be lifted from the liquid source to the sampler pump; it does not include any horizontal components, but rather is simply the vertical distance from the surface of the liquid source (not the suction line inlet) to the pump inlet. This should not be confused with the suction line length (the physical length of the suction line) which may include some horizontal components. The actual operating suction head is selected by entering on the keypad any value between 1 and 20 ft. or 4 to 60 decimeters of suction head. If a 10 ft. (3 m) suction line has been programmed, a suction head of greater than 10 ft. or 30 decimeters may not be selected.

Effect of Suction Head

The Model 2910 Sampler determines the delivered sample volume by counting revolutions of the peristaltic pump rotor. The volume of liquid delivered by one revolution of the pump rotor is a function of the suction head of the pump; as the suction head increases, the volume delivered by one revolution of the pump rotor decreases and vice versa. The programmed suction head value is used to compensate for these changes in delivered volume with operating suction head.

To properly program the suction head, first determine the actual suction head under which the sampler will be operating. Keep in mind that this is the vertical distance from the surface of the liquid source to the sampler pump inlet. Then, enter on the keypad the suction head from 1 to 20 ft. which is closest to the actual suction head. For example, if the actual operating suction head for a particular setup were 8-\(\frac{3}{4}\) ft., a suction head of 9 ft. should be entered on the keypad.

In some sampling applications, the operating suction head varies with time because the level of the liquid source is changing due to changing flow rates, the effect of intermittent pumps, etc. In this case, a suction head value should be programmed which is a time weighted average of the suction heads expected to be encountered. It should be recognized, though, that the volume of samples collected during periods of time when the actual suction head does not match the programmed suction head will vary from nominal values.

When the calibrate sample volume mode is used, it is not necessary to specify the suction head, and consequently, **PRGM STEP 6 (SUCTION HEAD)** is skipped when this mode is selected.

Calibrate

When **PRGM STEP 7 (CALIBRATE SAMPLE VOLUME)** is shown on the display, the delivered sample volume may be directly calibrated. This is an alternative to the normal method of sample volume selection (selecting the nominal sample volume, type of suction line, and suction head), and is used to precisely calibrate the delivered sample volume for a given setup. It is useful when very accurate sample volume determination is necessary or when non-standard sampling conditions are encountered. The calibrate sample volume mode is selected by entering a zero when **PRGM STEP 4 (NOMINAL SAMPLE VOLUME)** is shown on the display, as described above.

The calibrate sample volume procedure is fully described in **Overview of Calibration**, on page 36. Briefly, to calibrate the sample volume, the pump tubing is removed from the float and placed over a graduated cylinder. Then, using the **PUMP JOG FWD** and **PUMP JOG REV** keys, a suction line prepurge, line and bottle fill, and suction line postpurge are programmed by pumping the desired amount of sample volume into the graduated cylinder.
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The number of volume counts associated with each segment of the sampling cycle will be shown in the display as it is being programmed, along with a “P” (for purge) or “F” (for fill) designator to identify the segment being programmed. Up to five complete N2-purge cycles may be programmed, allowing for suction line preconditioning or other special sampling cycles. The end of the sampling cycle is marked by entering a volume count value of zero on the NUMERIC KEYPAD for either a purge or fill cycle as desired.

PRGM STEP 7 (CALIBRATE SAMPLE VOLUME) will be skipped unless a zero was entered when PRGM STEP 4 (NOMINAL SAMPLE VOLUME) was shown on the display.

Number of Samples

When PRGM STEP 8 (NUMBER OF SAMPLES) is shown on the display, the number of individual composite samples to be collected before the sampling process is terminated may be selected. The number of composite samples is selected by entering on the keypad any value between 1 and 999 samples. For example, programming a value of 250 for the number of composite samples will cause the sampler to place 250 individual samples into the composite container, and then shut off.

Note that a float shut-off mechanism is provided to prevent accidental over-flow of the composite sample container. This may be used in conjunction with a programmed number of composite samples as a fail-safe, or as an independent means of terminating the sampling process.

Humidity Indicator

A humidity indicator, labeled INTERNAL CASE HUMIDITY, is located in the lower right hand corner of the control panel. The humidity indicator, visible through a window in the panel, indicates the amount of moisture which is present inside the control box. The paper indicator is all blue in a dry state. If moisture begins to accumulate in the control box, the numbered areas on the indicator will turn light pink or white, starting with the area numbered “20”. This indicates that the relative humidity inside the control box exceeds 20%. As more moisture accumulates in the control box, the areas numbered “30” and “40” will turn light pink or white, indicating relative humidities of 30% and 40%.

Use of the Indicator

The control box is a completely sealed unit, which does not need to be opened during normal operation. It is shipped from the factory with a fresh bag of desiccant installed inside the control box. This desiccant should absorb any moisture which might leak into the control box. Thus, the humidity indicator should remain blue under normal conditions. If the 30% area of the humidity indicator turns light pink or white, the control unit should be opened, inspected to determine if there is a leak, and the desiccant renewed, as described in Renewing Desiccant Bags, on page 48.

General Programming Considerations

An overview of the sampler programming process was presented in Programming Overview, on page 18. The sections following this section will present detailed procedures on standard and advanced sampler programming. This section will introduce some general programming considerations and procedures that are common to all the sampler programming modes.

Learning to Program

The most effective way to learn how to program the Model 2910 Sampler is to read this and the following sections, get a sampler, and experiment. The sampler cannot be harmed by improper programming, so there is nothing to be lost by experimenting. The Model 2910 is basically a simple, straightforward, “user-friendly” unit. A few minutes in the office or laboratory spent in actually programming the sampler and observing its operation usually proves to be a worthwhile investment of time. Simply “playing” with the sampler is the best way to become familiar with programming, and may help avoid costly delays or problems when the sampler is used in the field.

Basic Programming

The basic programming sequence for the Model 2910 is listed on the control panel:

1. Press ON key.
2. Press PROGRAM/STEP key.
3. Enter on the Numeric Keypad the desired setting for the program step indicated.
4. Press ENTER VALUE key.
5. Press PROGRAM/STEP key.
6. Repeat steps 3, 4, and 5 for all program steps.
7. Press START SAMPLING key to start sampling program.

Programming Process

Pressing the ON key turns the sampler on and places it in the standby state. Pressing the PROGRAM/STEP key transfers the sampler into the program state (allowing it to be programmed). PRGM STEP 1 (MODE) will be shown in the display, indicating that the mode of sampler operation is to be programmed.
Note that the display alternates between PRGM STEP 1 and the mode (either 1 or 2) previously programmed. One of the two modes may then be selected by pressing a key on the Numeric Keypad corresponding to the desired mode. As soon as a number is entered on the keypad, the alternating nature of the display is stopped, and only the newly entered mode is shown on the display. The mode selected is then entered into the sampler's memory by pressing the ENTER VALUE key. After the ENTER VALUE key has been pressed, the alternation of the display between PRGM STEP 1 and the newly entered mode is restored. Pressing the PROGRAM/STEP key steps the unit to PRGM STEP 2 (INTERVAL BETWEEN SAMPLES). The interval between samples is then programmed in a similar manner, and the next program quantity is sequenced to. This process is repeated until all the program quantities have been programmed, at which time pressing the PROGRAM/STEP key will return the sampler to the standby state. If the sampler is left in the program state, and there is no activity on the keyboard for approximately five minutes, it will be automatically transferred to the standby state. Pressing the START SAMPLING key places the sampler into the run state and starts the sampling program.

Use of Program/Step

As mentioned in Control Keys, on page 20, the PROGRAM/STEP key contains an implied enter value function. Thus, if the key user desires, the PROGRAM/STEP key may be used alone both to enter into the sampler's memory the quantity being programmed and to simultaneously sequence to the next program quantity. This is one less keystroke than is used in the basic programming sequence listed above (press ENTER VALUE key, then press PROGRAM/STEP key). Functionally, the ENTER VALUE key is redundant, since its function is contained within the PROGRAM/STEP key. However, the ENTER VALUE key is provided because its use is thought to be more intuitively obvious to the beginning user. The programming procedures in the following sections utilize the two step method (ENTER VALUE and PROGRAM/STEP) of entering a program quantity into memory and sequencing to the next program quantity. However, the reader should recognize that this two step procedure can (and probably will by the experienced programmer) be replaced by a single depression of the PROGRAM/STEP key.

Clear Entry Key

Also as mentioned in Control Keys, on page 20, the CLEAR ENTRY key has additional uses beyond clearing a previously entered program quantity. Pressing the CLEAR ENTRY key will cause a newly entered program quantity shown on the display to be replaced with the previously entered program quantity. This allows keyboard entry errors to be corrected before the program quantity is loaded into the sampler's memory. A second depression of the CLEAR ENTRY key (without an intermediate depression of one of the numeric keys) will cause the sampler to be transferred from the program to the standby state. Likewise, if no new value has been entered before the CLEAR ENTRY key is pressed, the sampler will also be transferred from the program to the standby state. This is to provide the user with a means of getting out of the programming state without sequencing through all the program quantities. This is useful when it is necessary to change only one of the program quantities. The quantity to be changed may be sequenced to using the PROGRAM/STEP key, the new quantity entered, and the sampler transferred from the program to the standby state by pressing the CLEAR ENTRY key.

Keypad Feedback

As discussed in Keypad, on page 18 the sampler's keypad features both tactile and audio feedback to assure that the key switch has been successfully actuated during the programming process. When one of the keys is pressed, the user will both feel the switch as it is actuated and hear a "beep" generated by an audio indicator inside the sampler.

Invalid Keypad Entry

An audio indication is also provided should the user attempt to key in a value which is invalid for the program quantity being set. In the case of an invalid entry, the sampler will "beep" rapidly for a few moments, and then replace on the display the improper entry with the previously entered value. For example, when PRGM STEP 1 (MODE) is shown on the display, only the numbers 1 and 2 are valid entries. As soon as an invalid entry is keyed in on the numeric keypad, say a 3, the sampler will "beep" rapidly for a few moments, and then replace the 3 on the display with the previously entered value, say a 2.

Keys Functional only in Certain Sampler States

As discussed in Programming Overview, on page 18, the sampler has five basic states of operation. Depending on which state the sampler is in, only certain keys on the keypad will be functional. In the off state, only the ON key is functional. In the standby state, all keys are functional except the numeric keys 0 through 9. In the program state, the numeric keys 0 through 9 and the first three program control keys (PROGRAM/STEP, ENTER VALUE, and CLEAR ENTRY) are functional.
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When the calibrate sample volume mode is being used, the PUMP JOG FWD and PUMP JOG REV keys are also functional in the program state but only when PRGM STEP 7 (CALIBRATE SAMPLE VOLUME) is shown on the display. In the run state, only the PUMP STOP, PROGRAM/STEP, and HALT SAMPLING keys are functional. In the full state, the first four program control keys (PROGRAM/STEP, ENTER VALUE, CLEAR ENTRY, and START SAMPLING) are functional. Of course, in all states except off, the OFF key is also functional.

Program Scan
After the sampler has been programmed and placed into operation (sampler in the run state), the programmed values of the various program quantities may be reviewed at any time by pressing the PROGRAM/STEP key. This places the sampler into a program scan mode, whereby all the program quantities may be stepped through by repeatedly pressing the PROGRAM/STEP key, showing on the display the program quantity step number followed by the value of the program quantity. While the program is being scanned in this manner, the PRGM legend will be shown on the display in addition to the RUN legend. If, after a program scan has been initiated, the PROGRAM/STEP is not pressed again, the scan mode will be terminated after approximately 60 seconds. After the last applicable program quantity has been stepped through, the sampler will return to the normal run state. If a sample initiation occurs during a program scan, the sample will be delayed until after the scan has ended.

Continuous Memory
As mentioned in Connection to Power Source, on page 15, the Model 2910 Sampler has a small internal lithium battery which maintains the sampler’s program when external power is interrupted or the unit is turned off. Thus, the sampler has what is conventionally referred to as “continuous memory”. When the sampler is shipped from the factory, the unit will be programmed with a standard test program. The user should be aware that, because of the continuous memory, there will always be a program in existence in the sampler.

Synchronization With Real Time
As a final note to the general programming considerations, the timing and flow pulse counting logic of the sampler will be discussed. The timing logic of the sampler was established to allow the user to easily synchronize sample collections with real time. This is accomplished by continuously decrementing (counting down) the time interval to the next sample in all sampler states except off. In this way, synchronization with real clock time may be easily and directly established by the setting of the delay to the first/next sample. For example, if the time of day is 9:37 and it is desired to collect the first sample at 10:00, programming a delay to first/next sample of 23 minutes would accomplish this, since the delay to the first sample is decremented from the moment the delay is programmed. Also, synchronization is not lost when the program is interrupted by the use of the HALT key or when the program is completed. Time decrementing is stopped only when the sampler is turned off. The flow pulse interval to the next sample, on the other hand, is decremented only when the sampler is in the run state.

Delay to First Sample
Consistent with this is the manner in which the time or flow pulse delay to the first sample is handled upon program start (the depression of the START SAMPLING key) for the two basic modes of sampler operation:

Mode 1 (Time) - The delay is not affected by program start.

Mode 2 (Flow) - Upon program start, the flow pulse interval to the first sample will be reset to the programmed flow pulse interval between samples.

STANDARD PROGRAMMING
The following two sections describe in detail the methods of programming the Model 2910 Sampler for automatic sample collection in the time and flow modes. The procedures in the following sections define the “standard” programming techniques for the sampler. For the more advanced programming techniques, refer to Advanced Programming, on page 36.

To fully understand the programming methods discussed in the following two sections, the reader should be thoroughly familiar with the introductory material on programming and the sampler’s controls, presented in Types of Samples, on page 17 through General Programming Considerations, on page 27. The following sections will present a specific set of step-by-step instructions for programming the sampler in the two standard modes.

TIME
The object of time sampling using the Model 2910 is to collect a series of discrete, equal volume samples at a known regular time interval, and to place these samples into a single composite sample container. When programming the sampler in a composite time mode, two quantities must be calculated to allow the sampler to be programmed in a rational manner: the total number of samples to be collected and the volume of each individual sample.
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Calculation of Total Number of Samples
To calculate the total number of samples to be collected, two quantities must be known: the time increment between samples and the total time over which the composite sample is to be collected. The total number of samples to be collected is calculated by dividing the total time over which the composite sample is to be collected by the time increment between samples. For example, assume that the duration of the composite sampling is to be 24 hours and that it is desired to collect samples at 15 minute intervals. The total number of samples to be collected is calculated:

\[ 24 \text{ hours} \times 60 \text{ minutes/hour} = 1440 \text{ minutes} \]
\[ 1440 \text{ minutes} \div 15 \text{ minutes/sample} = 96 \text{ samples} \]

Thus 96 individual samples will be collected over the 24-hour period.

Calculation of Sample Volume
To calculate the volume of each individual sample, the size of the composite container being used and the total number of samples to be collected (calculated above) must be known. Isco provides a 1 gallon (3,785 ml) or 2½ gallons (9,462 ml) container for use with the Model 2910.

The individual sample volume is calculated by simply dividing the volume of the composite sample container by the total number of samples to be collected. For example, assume that a total of 96 samples are to be collected in the one gallon container. The individual sample volume is then calculated:

\[ 9.462 \text{ ml} \div 96 \text{ samples} = 98.5 \text{ ml/sample} \]

Thus, a sample volume of 90 ml (the next smaller volume which may be programmed on the Model 2910) will result in the desired composite sample. It is important to select an individual sample volume which will not result in an overfilled sample container under worst-case conditions. Because of the basic uncertainty of the delivered sample volume exactly matching the programmed nominal sample volume and the ± 10 ml sample repeatability, it is good practice to select a sample volume which is slightly smaller than the calculated sample volume. In the example, an individual sample volume of 80 ml might be a prudent example. For critical applications, it may be useful to use the calibrate sample volume mode, as described in Overview of Calibration, on page 30. A shut-off float prevents the composite sample container from overflowing, but may terminate the sampling program prematurely, degrading the quality of the sample. Thus, it is important to select an individual sample volume which will not result in an overfilled sample container under worst-case conditions.

Calculation of Total Sample Volume
The nominal total volume of the composite sample may be calculated by multiplying the programmed nominal sample volume by the total number of samples to be collected. In the example:

\[ 80 \text{ ml} \times 96 = 7,680 \text{ ml} \]

It should be kept in mind that this calculated nominal total volume may vary from the actual total volume because of variations in the actual volume of each individual sample from the programmed nominal sample volume.

Time Example
After the volume of each individual sample and the total number of samples to be collected have been determined, the sampler may be programmed for automatic operation in a composite time mode by the use of the following set of step-by-step instructions. These instructions assume that the sampler is off, and that a composite sample container has been installed, as described in Preparation of the Sample Container Tub, on page 5.

Table 6 Automatic Operation in a Composite Time Mode

<table>
<thead>
<tr>
<th>Step No.</th>
<th>Program Quantity To Be Set</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Press ON key. Places the sampler into the standby state.</td>
<td>None</td>
<td>STANDBY legend on. This alternates between time or flow pulse interval to next sample (&quot;0014&quot; - TIME or FLOW legend), and the number of composite samples collected (&quot;45&quot; - COMP legend); if sampling previously completed, text &quot;FULL&quot; will be added to the alternation of the display.</td>
</tr>
<tr>
<td>2. Press PROG/STEP key. This places the sampler into the program state.</td>
<td>MODE</td>
<td>Alternates between PROG STEP 1 and previously programmed mode (&quot;2&quot;) PRGM legend is on as long as sampler remains in program state. FLOW legend on.</td>
</tr>
</tbody>
</table>
## Model 2910 Sampler

<table>
<thead>
<tr>
<th>Step No.</th>
<th>Program Quantity To Be Set</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Enter mode 1 (Time) on the numeric keypad.</td>
<td>MODE</td>
<td>&quot;1&quot;</td>
</tr>
<tr>
<td>4. Press ENTER VALUE key.</td>
<td>MODE</td>
<td>Alternates between PRGM STEP 1 and newly entered mode (&quot;1&quot;). TIME legend is on as long as sampler remains in program state.</td>
</tr>
<tr>
<td>5. Press PROGRAM/STEP key.</td>
<td>Interval Between Samples</td>
<td>Alternates between PRGM STEP 2 and previously programmed interval in minutes (&quot;30&quot;)</td>
</tr>
<tr>
<td>6. Enter on the numeric keypad the desired interval between samples in minutes (up to 9999 minutes). For example, assume it is desired to collect samples at 15 minute intervals -- enter 15 on the numeric keypad.</td>
<td>Interval Between Samples</td>
<td>&quot;15&quot;</td>
</tr>
<tr>
<td>7. Press ENTER VALUE key.</td>
<td>Interval Between Samples</td>
<td>Alternates between PRGM STEP 2 and newly entered interval in minutes (&quot;15&quot;)</td>
</tr>
<tr>
<td>8. Press PROGRAM/STEP key</td>
<td>Delay To First/Next Sample</td>
<td>Alternates between PRGM STEP 3 and present interval to the next sample in minutes (&quot;11&quot;)</td>
</tr>
<tr>
<td>9. Enter on the numeric keypad the desired delay until the first sample is collected in minutes (up to 9999 minutes). Note that this is the time interval from the present time until the time when it is desired to collect the first sample. For example, assume that it is presently 7:15 a.m., and it is desired to collect the first sample at 8:00 a.m. -- enter 45 on the numeric keypad.</td>
<td>Delay To First/Next Sample</td>
<td>&quot;45&quot;</td>
</tr>
<tr>
<td>10. Press ENTER VALUE key.</td>
<td>Delay To First/Next Sample</td>
<td>Alternates between PRGM STEP 3 and present interval to the next sample in minutes (&quot;45&quot;)</td>
</tr>
<tr>
<td>11. Press PROGRAM/STEP key.</td>
<td>Nominal Sample Volume</td>
<td>Alternates between PRGM STEP 4 and previously programmed nominal sample volume in 10's of ml (&quot;50&quot;)</td>
</tr>
<tr>
<td>12. Enter on the numeric keypad the desired sample volume in 10's of milliliters (to a maximum of 50). For example, assume that it is desired to collect samples with a volume of 80 ml -- enter 8 on the numeric keypad.</td>
<td>Nominal Sample Volume</td>
<td>&quot;8&quot;</td>
</tr>
<tr>
<td>13. Press ENTER VALUE key.</td>
<td>Nominal Sample Volume</td>
<td>Alternates between PROGRAM STEP 4 and newly entered sample volume in 10's of ml (&quot;8&quot;)</td>
</tr>
<tr>
<td>14. Press PROGRAM/STEP key.</td>
<td>Type of Suction Line</td>
<td>Alternates between PRGM STEP 5 and previously programmed type of suction line (&quot;3&quot;)</td>
</tr>
<tr>
<td>15. Enter on the numeric keypad the number corresponding to the desired type of suction line. For example, assume that a % ID X 10' long suction line is being used -- enter type 3 (%&quot; ID X 10') on the numeric keypad.</td>
<td>Type of Suction Line</td>
<td>&quot;3&quot;</td>
</tr>
<tr>
<td>16. Press ENTER VALUE key.</td>
<td>Type of Suction Line</td>
<td>Alternates between PRGM STEP 5 and newly entered type of suction line (&quot;3&quot;)</td>
</tr>
</tbody>
</table>
### Model 2910 Sampler

<table>
<thead>
<tr>
<th>Step No.</th>
<th>Program Quantity To Be Set</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>17.</td>
<td>Press PROGRAM/STEP key.</td>
<td>Suction Head</td>
</tr>
<tr>
<td>18.</td>
<td>Enter on the numeric keypad the suction head in feet, to a maximum of 20 ft. The suction head is the vertical distance from the surface of the liquid source to the pump inlet. For example, assume that the suction head in 8 ft. enter 8 on the numeric keypad.</td>
<td>Suction Head</td>
</tr>
<tr>
<td>19.</td>
<td>Press Enter Value key.</td>
<td>Suction Head</td>
</tr>
<tr>
<td>20.</td>
<td>Press PROGRAM/STEP key.</td>
<td>Number of Samples</td>
</tr>
<tr>
<td>21.</td>
<td>Enter on the numeric keypad the desired total number of individual samples which make up the composite sample. For example, assume that it is desired to composite 96 individual samples -- enter 96 on the numeric keypad</td>
<td>Number of Samples</td>
</tr>
<tr>
<td>22.</td>
<td>Press ENTER VALUE key.</td>
<td>Number of Samples</td>
</tr>
<tr>
<td>23.</td>
<td>Press PROGRAM/STEP key. This returns the sampler to the standby state.</td>
<td>None</td>
</tr>
<tr>
<td>24.</td>
<td>Press START SAMPLING key. This places the sampler in the run state</td>
<td>None</td>
</tr>
</tbody>
</table>

* EXAMPLE - may be other value

### Operation in Composite Time Mode

This completes the programming of the Model 2910 Sampler in composite time mode. Following the example, after the initial delay of 45 minutes from the moment the 45 minute delay was entered in step 9, the sampler will place the first individual sample in the composite container at 8:00 am. The display will continue to alternate between the time in minutes remaining until the next sample is collected (for example, "0011" - TIME legend) and the total number of individual samples which have been placed in the composite container (for example, "36" - COMP legend). After the first sample has been collected, the time interval to the next sample will be reset to the programmed value of 15 and will continue decrementing. When it decrements to zero, a sample will be collected, the display will be reset to the programmed value of 15, and the decrementing process will be started again. The process of placing individual samples into the composite container will continue until the 96th and last sample is placed in the container (after a 24 hour period), at which time the sampler will shut-off and the display will alternate between the text "FULL" and the total number of samples collected ("96" - COMP legend).

### Composite Flow

The object of composite flow sampling using the Model 2910 is to collect a series of discrete, equal volume samples at a known, regular flow interval, and to place these samples into a single composite sample container. The Model 2910 will accept flow proportional inputs of a certain specific nature from an external flow meter. These electronic flow input signals are transmitted to the sampler at fixed increments of total flow, for example every 10,000 gallons.
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That is, each time 10,000 gallons of liquid has flowed past the flow meter, a signal is sent to the sampler, which registers it as a single flow pulse. The Model 2910 Sampler can be programmed to totalize any number of flow pulses from 1 to 9999 before a sampling cycle is initiated.

For example, if the sampler were programmed to totalize 5 flow pulses and each flow pulse represented 10,000 gallons of total flow, a sample would be collected each time 50,000 gallons (5 flow pulses of 10,000 gallons each) had flowed past the flow meter.

Programming Calculations

When programming the sampler in a composite flow mode, three quantities must be calculated to allow the sampler to be programmed in a rational manner: the flow volume increment between samples (number of flow pulses), the total number of samples to be collected, and the volume of each individual sample.

Calculation of Flow Increment Between Samples

To calculate the flow increment between samples, the average flow rate of the flow stream and either the desired average time interval between individual samples or the total desired number of individual samples to be collected over the sampling period must be known. If the desired average time interval known between individual samples is known, the flow increment between samples can be determined by calculating how much flow, based on the average flow rate) occurs during that time interval. For example, assume that the average flow is 2.5 MGD and it is desired to collect a sample every 30 minutes, based on this flow. The flow increment between samples is calculated:

\[
2.5 \text{ MGD} = 2,500,000 \text{ gallons/day} \\
2,500,000 \text{ gallons/day} \times \frac{1 \text{ day}}{24 \text{ hours}} \times \frac{1 \text{ hour}}{60 \text{ minutes}} = 1736.11 \text{ gallons/minute} \\
1736.11 \text{ gallons/minute} \times 30 \text{ minutes/sample} = 52,063 \text{ gallons/sample}
\]

Thus, the desired flow increment between samples is approximately 52,000 gallons.

Alternatively, if the total number of samples to be collected over the total sampling period is known, the flow increment known between samples can be determined by calculating how much total flow will occur during the sampling period, and dividing this by the total number of samples to be collected. For example, assume that the average flow is 1.75 MGD, that the composite sampling period is 2 days, and that it is desired to collect 100 individual samples. The flow increment between samples is calculated:

\[
1.75 \text{ MGD} = 1,750,000 \text{ gallons/day} \\
1,750,000 \text{ gallons/day} \times 2 \text{ days} = 3,500,000 \text{ gallons} \\
3,500,000 \text{ gallons} \div 100 \text{ samples} = 35,000 \text{ gallons/sample}
\]

Thus, the desired flow increment between samples is approximately 35,000 gallons.

Calculation of Number Flow Pulses

Once the desired flow increment between samples is known, the number of flow pulses to be flow pulses programmed into the sampler may be calculated, assuming that the volume of the flow pulses from the flow meter is known. The number of flow pulses is calculated by dividing the flow increment between samples by the volume of each flow pulse.

Using the first example, the flow increment between samples was calculated as 52,000 gallons; assume that each flow pulse represents 10,000 gallons of flow. The number of flow pulses to be programmed into the sampler is calculated:

\[
52,000 \text{ gallons} \div 10,000 \text{ gallons/flow pulse} = 5.2 \text{ flow pulses}
\]

Rounding this to an even number results in 5 flow pulses to be programmed into the sampler. This in turn results in a flow increment between samples of 50,000 gallons (5 flow pulses x 10,000 gallons/flow pulse).

Calculation of Total Number of Samples

To calculate the total number of samples to be collected, three quantities must be known: the average flow rate, the flow of samples increment between samples (calculated above), and the total time over which the composite sample is to be collected. The total number of samples to be collected is determined by first calculating the total flow volume over the sampling period, and then dividing this by the flow increment between samples. For example, assume that the average flow is 2.5 MGD, the flow increment between samples is 50,000 gallons, and the composite sample is to be collected over a 24 hour period. The total flow volume over a 24 hour period is:

\[
2.5 \text{ MGD} = 2,500,000 \text{ gallons/day} \\
2,500,000 \text{ gallons/day} \times 1 \text{ day} = 2,500,000 \text{ gallons}
\]

Thus, based on an average flow of 2.5 MGD, 50 samples will be collected.
Model 2910 Sampler

Calculation of Sample Volume
To calculate the volume of each individual sample, the volume of the composite sample container being used and the total number of samples to be collected (calculated above) must be known. Isco provides a 1 gallon (3,785 ml) container for use with the Model 2910.

The individual sample volume is calculated by simply dividing the volume of the composite sample container being used by the total number of samples to be collected. For example, assume that a total of 80 samples are to be collected in the one gallon container. The individual sample volume is then calculated:

\[
\frac{3785 \text{ ml}}{80 \text{ samples}} = 47.3 \text{ ml/sample}
\]

Thus, a sample volume of 70 ml (the next smaller volume which may be programmed on the Model 2910) will result in the desired composite sample. It is important to select an individual sample volume which will not result in an overfilled sample container under worst case conditions. Because of the basic uncertainty of the considerations delivered sample volume exactly matching the programmed nominal sample volume and the ± 10 ml sample repeatability, it is good practice to select a nominal sample volume which is slightly smaller than the calculated sample volume. This is to prevent overfilling of the sample container. In the example, an individual nominal sample volume of 60 ml is a prudent choice because it will not result in an overfilled container. For critical applications, it may be useful to use the calibrate sample volume mode, as described in Overview of Calibration, on page 36.

A shut-off float prevents the composite sample container from overflowing, but may terminate the sampling program prematurely, degrading the quality of the sample. Thus, it is important to select an individual sample volume which will not result in an overfilled sample container under worst-case conditions.

Calculation of Total Sample Volume
The nominal volume of the composite sample may be calculated by multiplying the programmed nominal sample volume by the total volume number of samples to be collected. In the example:

\[
60 \text{ ml/sample} \times 80 \text{ samples} = 3000 \text{ ml}
\]

It should be kept in mind that this calculated nominal total volume may vary from the actual total volume because of variations in the actual volume of each individual sample from the programmed nominal sample volume, and the total time to collect the 80 individual samples may vary from the desired time period because of variations in the average flow rate used for calculations.

Flow Example
After the flow volume increment between samples (number of flow example pulses), the total number of samples to be collected, and the volume of each individual sample have been determined, the sampler may be programmed for automatic operation in a composite flow mode by the use of the following set of step-by-step instructions. These instructions assume that the sampler is off and that the composite sample container has been installed, as described in Preparation of the Sample Container Tub, on page 5.

Table 7 Automatic Operation In a Composite Flow Mode

<table>
<thead>
<tr>
<th>Step No.</th>
<th>Program Quantity To Be Set</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Press On key. Places the sampler into the standby state</td>
<td>None</td>
<td>STANDBY legend on. This alternates between time or flow pulse interval to next sample (&quot;0014&quot; TIME or FLOW legend), and the number of composite samples collected (&quot;46&quot; - COMP legend); if sampling previously completed, text &quot;FULL&quot; will be added to the alternation of the display.</td>
</tr>
<tr>
<td>2. Press Program/Step key. This places the sampler into the program state.</td>
<td>MODE</td>
<td>Alternates between PRGM STEP 1 and previously programmed mode (&quot;2&quot;), PRGM legend is on as long as sampler remains in program state. FLOW legend off.</td>
</tr>
<tr>
<td>3. Enter mode 2 (FLOW) on the numeric keypad.</td>
<td>MODE</td>
<td>&quot;2&quot;</td>
</tr>
<tr>
<td>4. Press Enter Value key.</td>
<td>MODE</td>
<td>Alternates between PRGM STEP 1 and newly entered mode (&quot;2&quot;). FLOW legend is on as long as sampler remains in program state.</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Step No.</th>
<th>Program Quantity To Be Set</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.</td>
<td>Press PROGRAM/STEP key.</td>
<td>Interval Between Samples Alternates between PRGM STEP 2 and previously programmed interval in flow pulses (&quot;15\textsuperscript{m}&quot;&quot;).</td>
</tr>
<tr>
<td>6.</td>
<td>Enter on the numeric keypad the desired interval between samples in flow pulses (up to 9999 flow pulses). For example, assume it is desired to collect samples at 150,000 gallon intervals and each flow pulse represents 10,000 gallons -- enter 6 (150,000/10,000 = 6) on the numeric keypad.</td>
<td>Interval Between Samples &quot;5&quot;</td>
</tr>
<tr>
<td>7.</td>
<td>Press ENTER VALUE key.</td>
<td>Interval Between Samples Alternates between PRGM STEP 2 and newly entered interval in flow pulses (&quot;5\textsuperscript{m}&quot;&quot;).</td>
</tr>
<tr>
<td>8.</td>
<td>Press PROGRAM/STEP key.</td>
<td>Nominal Sample Volume Alternates between PRGM STEP 4 and previously programmed nominal sample volume in 10's of ml (&quot;50\textsuperscript{m}&quot;&quot;).</td>
</tr>
<tr>
<td>9.</td>
<td>Enter on the numeric keypad the desired sample volume in 10's of milliliters (to a maximum of 99). For example, assume that it is desired to collect samples with a volume of 60 ml -- enter 6 on the numeric keypad.</td>
<td>Nominal Sample Volume &quot;6&quot;</td>
</tr>
<tr>
<td>10.</td>
<td>Press ENTER VALUE key.</td>
<td>Nominal Sample Volume Alternates between PROGRAM STEP 4 and newly entered sample volume in 10's of ml (&quot;6\textsuperscript{m}&quot;&quot;).</td>
</tr>
<tr>
<td>11.</td>
<td>Press PROGRAM/STEP key.</td>
<td>Type of Suction Line Alternates between PRGM STEP 5 and previously programmed type of suction line (&quot;3\textsuperscript{m}&quot;&quot;).</td>
</tr>
<tr>
<td>12.</td>
<td>Enter on the numeric keypad the number corresponding to the desired type of suction line. For example, assume that a %\textsuperscript{m} ID x 26\textsuperscript{m} long suction line is being used -- enter type 4 (%\textsuperscript{m} ID x 26\textsuperscript{m}) on the numeric keypad.</td>
<td>Type of Suction Line &quot;4&quot;</td>
</tr>
<tr>
<td>13.</td>
<td>Press ENTER VALUE key.</td>
<td>Type of Suction Line Alternates between PRGM STEP 5 and newly entered type of suction line (&quot;4\textsuperscript{m}&quot;&quot;).</td>
</tr>
<tr>
<td>14.</td>
<td>Press PROGRAM/STEP key.</td>
<td>Suction Head Alternates between PRGM STEP 6 and previously programmed suction head in feet (&quot;10\textsuperscript{m}&quot;&quot;).</td>
</tr>
<tr>
<td>15.</td>
<td>Enter on the numeric keypad the suction head in feet, to a maximum of 20 ft. The suction head is the vertical distance from the surface of the liquid source to the pump inlet. For example, assume that the suction head is 18 ft. -- enter 18 on the numeric keypad.</td>
<td>Suction Head &quot;18&quot;</td>
</tr>
<tr>
<td>16.</td>
<td>Press ENTER VALUE key.</td>
<td>Suction Head Alternates between PRGM STEP 6 and newly entered suction head in feet (&quot;18\textsuperscript{m}&quot;&quot;).</td>
</tr>
<tr>
<td>17.</td>
<td>Press PROGRAM/STEP key.</td>
<td>Number of Samples Alternates between PRGM STEP 10 and previously programmed number of samples (&quot;15\textsuperscript{m}&quot;&quot;).</td>
</tr>
<tr>
<td>18.</td>
<td>Enter on the numeric keypad the desired total number of individual samples which make up the composite sample. For example, assume that it is desired to composite 60 individual samples -- enter 50 on the numeric keypad.</td>
<td>Number of Samples &quot;50&quot;</td>
</tr>
</tbody>
</table>
Model 2910 Sampler

<table>
<thead>
<tr>
<th>Step No.</th>
<th>Program Quantity To Be Set</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>19. Press ENTER VALUE key.</td>
<td>Number of Samples</td>
<td>Alternates between PRGM STEP 10 and newly entered number of samples (&quot;50&quot;).</td>
</tr>
<tr>
<td>20. Press PROGRAM/STEP key. This returns the sampler to the standby state.</td>
<td>None</td>
<td>STNDBY legend on. Alternates between time interval to next sample (&quot;0014&quot; - FLOW legend) and number of composite samples collected (&quot;45&quot; - COMP legend); if sampling previously completed, text &quot;FULL&quot; will be added to the alternation of the display.</td>
</tr>
<tr>
<td>21. Press the START SAMPLING key. This places the sampler in the run state.</td>
<td>None</td>
<td>RUN legend on. Alternates between flow pulse interval until the first next sample is collected (&quot;5&quot; - FLOW legend) and the total number of composite samples which have been collected (&quot;0&quot; - COMP legend).</td>
</tr>
</tbody>
</table>

*EXAMPLE* - may be other value

**Operation in Flow Mode**

This completes the programming of the Model 2910 Sampler in the composite flow mode. Following the example, the sampler will place the first individual 60 ml sample in the composite sample container after 5 flow pulses (50,000 gallons) have been received from the external flow meter. The display will continue to alternate between the interval in flow pulses remaining until the next sample is collected (for example, "0004" - FLOW legend) and the total number of individual samples which have been placed in the composite container (for example, "14" - COMP legend). The flow pulse interval to the next sample is reset to the programmed value of 5 when the START SAMPLING key is pressed in step 21. As flow pulses are received from the external flow meter, the flow pulse interval to the next sample shown in the display will decrement to zero, at which point a sample will be collected, the display will be reset to the programmed value of 5, and the decrementing process will begin again as flow pulses are received. The process of placing 60 ml samples into the composite container will continue until the 50th and last sample is placed in the container, at which time the sampler will shut off and the display will rotate between the text "FULL" and the total number of samples collected ("50" - COMP legend).

**ADVANCED PROGRAMMING**

The following five sections describe in detail some advanced programming techniques for the Model 2910 Sampler. As described in Standard Programming, on page 29 the composite time and flow modes typically account for the vast majority of sampling applications. However, special applications or situations may require the use of the "advanced" programming techniques described in the following sections.

These techniques are described separately from the "standard" programming techniques so as not to add unnecessary and potentially confusing material to the programming procedures normally used. Included are sections describing an alternate method of selecting the sample volume, the modes available in the sampler techniques for use with the Model 1640 Liquid Level Sampler Actuator, the use of the program HALT and RESUME keys, the program lock feature, and Selecting English or metric units of measure. To fully understand the advanced programming techniques discussed in the following sections, the reader should be thoroughly familiar with the introductory material on programming and the sampler's controls, presented in Types of Samples, on page 17 through General Programming Considerations, on page 27, and the standard programming techniques, presented in Standard Programming, on page 29.

**OVERVIEW OF CALIBRATION**

The normal method of selecting the sample volume, as described in Standard Programming, on page 29, is to program into the sampler the desired nominal sample volume, the type of suction line being used, and the applicable suction head. The calibrate sample volume mode offers an alternative method of selecting the sample volume. The calibrate sample volume mode is used to calibrate the delivered sample volume precisely for a given setup of the sampler. It is useful when very accurate sample volume determination is necessary or when nonstandard sampling conditions are encountered (typically, a nonstandard suction line length).
Model 2910 Sampler

Calibration Process

The calibrate sample volume mode is selected by entering a zero when PRGM STEP 4 (NOMINAL SAMPLE VOLUME) is shown on the display. Then, when PRGM STEP 7 (CALIBRATE SAMPLE VOLUME) is shown on the display in its expected order in the programming sequence, the delivered sample volume may be directly calibrated. Briefly, to calibrate the sample volume, the sampler is set up exactly as it will be used, and the pump tubing is removed from the float cage and placed in a graduated cylinder.

Then, using the PUMP JOG REV and PUMP JOG FWD keys, a suction line purge, a suction line and bottle fill, and a suction line postpurge are programmed by pumping the desired amount of sample volume into the graduated cylinder. The number of volume counts associated with each segment of the sampling cycle will be shown in the display as it is being programmed, along with a "P" (for Purge) or "F" (for Fill) and a numeric designator to identify the segment being programmed. Up to five complete purge-fill-purge cycles may be programmed, allowing for suction line preconditioning or other special sampling cycles. The end of the sampling cycle is marked by entering a volume count value of zero on the NUMERIC KEYPAD for either a purge or fill cycle as desired.

Preparation

In detail, the sample volume is calibrated as follows. If it is known that a calibrate sample volume mode of operation is to be used, the sampler should be physically prepared before the programming process is started. This is done by placing the sampler in the location in which it will be used, attaching the suction line which will be used to the pump, and placing the inlet end of the suction line in its final position in the flow stream. Then, remove the pump tube from the float cage (refer to Replacement of Pump Tubing, on page 45) by disconnecting power from the unit, removing the center section (see Assembly and Disassembly of the Case, on page 5), and turning the center section over as shown in Figure 17, on page 46.

The pump tube may then be pulled out of the float cage assembly. Next, turn the center section back over, pull the tube out of the pump tube port indicated in Figure 17, and replace the center section on the sample bottle tub. Finally, place the end of the tube over a graduated cylinder. A 1000 ml plastic graduated cylinder is optionally available for sample volume calibration; however, any cylinder of sufficient volume graduated in cc's or ml's may be used.

Sample Volume Calibration Mode Selection

After a sampler has been physically prepared for the sample volume calibration process, the sampler may be programmed. As noted, the sample volume calibrate mode of operation is selected by entering a zero when PRGM STEP 4 (NOMINAL SAMPLE VOLUME) is shown on the display. Then, when PRGM STEP 7 (CALIBRATE SAMPLE VOLUME) is shown on the display during programming, the volume calibration may be made. Before describing the calibration process, three items need to be discussed. First, during the calibration process, a number termed "volume counts" will be shown in the display. The number of volume counts is directly related to rotations of the peristaltic pump rotor. It is displayed to provide a frame of reference and to allow direct keyboard entry of volume counts for previously calibrated setup conditions. However, it is not practical to directly relate the number of volume counts to a number of milliliters of delivered volume.

It is best to consider the volume count as an arbitrary, dimensionless number. Second, it should be kept in mind that the sampler's pump constitutes the major source of sampler power consumption. If the sampler is being powered by a battery, some care should be exercised not to calibrate in unnecessarily long pre purge and post purge cycles. This could lead to an unnecessary current drain on the battery. Third, calibration should be completed with as little delay as possible between the various sampling cycles. This is to prevent draining of the tubing which would not occur during a normal sampling cycle.

Calibration of Sample Volume

When the calibrate sample volume mode of operation has been selected, the presence of the text PRGM STEP 7 (CALIBRATE SAMPLE VOLUME) on the display signifies that the volume calibration can be made. Initially, the display will alternate between a previously programmed number of volume counts (for example, "280") and a PO ("PO--"), indicating that the number of volume counts shown represents the number of volume counts for the initial purge cycle (the prepurge). The prepurge cycle is calibrated by turning the pump on using the PUMP JOG REV key. Holding the PUMP JOG REV key down causes the alternation of display to cease, the display to be reset to zero, and the pump to be turned on in reverse, providing an air prepurge of the line and intake. The number of volume counts registered for the prepurge will be shown on the display as they are accumulated. When the desired prepurge has been obtained, releasing the PUMP JOG REV key will cause the pump to stop.
The typical duration of a prepurge is only a few seconds, since its purpose is to clear any accumulated debris from the inlet of the suction line. However, a very heavily laden flow stream may require a longer prepurge. If a satisfactory prepurge is not obtained, press the CLEAR ENTRY key and repeat the calibration process. After a satisfactory prepurge has been obtained, pressing the ENTER VALUE key will cause the number of prepurge volume counts to be loaded into the sampler's memory, and restores the display's alternation between the newly calibrated number of prepurge counts and "PO-". Alternatively, if the number of volume counts for the prepurge is known from a previous calibration process, a prepurge value of 0 to 9999 volume counts may be entered on the numeric keypad. As soon as the first numeric key is pressed, the alternation of the display will stop and the prepurge number will be shown on the display as it is entered. Note that for the initial purge cycle only (the prepurge) a zero is a valid entry for the number of volume counts. Since the prepurge is not absolutely necessary, it may be left off in applications where battery life is critical. After the desired number of prepurge volume counts has been entered, pressing the ENTER VALUE key will load the new number of counts into the sampler's memory and restore the display's alternation between the newly entered number of counts and "PO-". After the correct number of prepurge volume counts has been obtained, either by keyboard entry or by using the PUMP JOG REV key, the display may be stepped to the next quantity to be calibrated by pressing the PROGRAM/STEP key. If the number of prepurge volume counts initially shown on the display is known to be correct, for example, from a previous calibration process, it may be retained by pressing the PROGRAM/STEP key. This also will cause the display to be stepped to the next quantity to be set. It should be noted that instead of using the sequence of loading the newly entered number of prepurge volume counts into the sampler's memory using the ENTER VALUE key and then stepping to the next quantity to be programmed, both functions may be accomplished by pressing the PROGRAM/STEP key, since it contains an implied ENTER VALUE function.

Line and Bottle Fill

After the prepurge has been loaded by pressing the PROGRAM/STEP key, the display will alternate between a previously programmed number of volume counts (example, "1000") and an F1 ("F1-"), indicating that the number of volume counts shown represents the number of volume counts for the first line and bottle fill cycle. The line and bottle fill cycle is calibrated by holding the outlet of the pump tube at the bottom of the graduated cylinder and turning the pump on using the PUMP JOG FWD key. Locating the end of the tube in the bottom of the cylinder reduces turbulence, allowing more accurate determination of the volume of liquid. Holding the PUMP JOG FWD. key down causes the alternation of the display to cease, the display to be reset to zero, and the pump to be turned on in the forward direction, causing the suction line to be filled with liquid and a sample to be placed in the graduated cylinder. The number of volume counts registered for the line and bottle fill will be shown on the display as they are accumulated. When the desired sample volume has been obtained in the graduated cylinder, releasing the PUMP JOG FWD. key will cause the pump to stop. If too much sample volume was obtained, the excess may be pumped out of the graduated cylinder using the PUMP JOG REV. key.

After a satisfactory line and bottle fill has been obtained, pressing the ENTER VALUE key will cause the number of fill volume counts to be loaded into the sampler's memory, and restores the display's alternation between the newly calibrated number of fill counts and "F1-". Alternatively, if the number of volume counts for the line and bottle fill is known from a previous calibration process, a fill value of 1 to 9999 volume counts may be entered on the numeric keypad, as described for the prepurge. The remainder of the procedure is also the same as for the prepurge.

Postpurge

After the first line and bottle fill has been loaded by pressing the PROGRAM/STEP key, the display will alternate between a previously programmed number of volume counts (for example, "500") and a P1 ("P1-"), indicating that the number of volume counts shown represents the number of volume counts for the first postpurge cycle. The postpurge cycle is calibrated by removing the pump tube from the graduated cylinder and turning the pump on using the PUMP JOG REV key. Holding the PUMP JOG REV key down causes the alternation of the display to cease, the display to be reset to zero, and the pump to be turned on in reverse, forcing the liquid out of the suction line. The number of volume counts registered for the postpurge will be shown on the display as they are accumulated. When the desired postpurge has been obtained, releasing the PUMP JOG REV key will cause the pump to stop. The typical duration of the postpurge is the number of volume counts sufficient to clear the suction line. This may be determined by watching for bubbles to flow from the inlet of the suction line.
Model 2910 Sampler

If a satisfactory postpurge is not obtained, press the CLEAR ENTRY key and repeat the calibration process. After a satisfactory postpurge has been obtained, pressing the ENTER VALUE key will cause the number of postpurge volume counts to be loaded into the sampler’s memory, and restores the display’s alternation between the newly calibrated number of postpurge counts and “P1--.” Alternatively, if the number of volume counts for the postpurge is known from a previous calibration process, a postpurge value of 1 to 9999 volume counts may be entered on the numeric keypad, as described for the prepurge. The remainder of the procedure is also the same as for the prepurge.

Marking the End of the Sampling Cycle

After the first postpurge has been loaded by pressing the PROGRAM/STEP key, the display will alternate between a previously programmed number of volume counts (for example, “0” and an F2 (“F2--”), indicating that the number of volume counts shown represents the number of volume counts for the second line and bottle fill cycle. At this point, a normal complete sampling cycle, consisting of a prepurge, a line and bottle fill of the desired volume, and a postpurge, has been programmed into the sampler. The end of the normal sampling cycle is marked by entering a volume count value of zero on the numeric keypad for the second fill cycle. After a zero has been entered, pressing the PROGRAM/STEP key will cause the sampler to be transferred to the standby state.

Up to Five Cycles

However, if desired, the first postpurge cycle may be followed by another fill cycle, followed by another postpurge cycle, etc., up to a total of five complete fill-postpurge cycles (F5, P5). These fill and postpurge cycles are calibrated or directly entered as described above. The end of a sampling cycle is always marked by entering a volume count value of zero on the numeric keypad for either a purge or fill cycle as desired. Additional cycles beyond the normal prepurge, line and bottle fill and postpurge are typically used to provide a suction line precondition mode of operation, although other uses are possible. Certain researchers have suggested that a suction line sample liquid flush prior to the actual sampling cycle may be desirable to eliminate cross-contamination due to residue in the suction line. A suction line precondition mode may be established using the calibrate sample volume functions by limiting the first fill cycle to filling the suction line just up to the inlet of the pump. This would then be followed by a normal postpurge, a normal line and bottle fill, and a final postpurge. If desired, the preconditioning suction line fill could be repeated several times. In operation, the suction line is actually flushed with the sample liquid one or more times, normalizing the concentration of pollutants in the suction line and eliminating the possibility of any cross-contamination from the previously collected sample.

Reassembly of Sampler

After the sample volume calibration has been completed, the pump tube needs to be reinstalled in the float cage (see Figure 17, page 46). Feed the free end of the tube down through the pump tube port in the center section. Then, turn the center section over again, and feed the end of the tube into the tube guide in the float cage assembly, as shown in Figure 17, page 46. As a final check, inspect the length of exposed tube under the center section; there should be no excessive slack in this tube.

Final Check

As a final confirmation of the calibrated sample volume, a test sample may be collected using the MANUAL SAMPLE key. The volume of this sample should then be measured. If the desired sample volume is not obtained, repeat the calibration process.

Operation of Clear Entry Key

In the calibrate sample volume mode, the behavior of the CLEAR ENTRY key is enhanced. CLEAR ENTRY key in that when the display is alternating between a number of volume counts and a P or F designator, a depression of the CLEAR ENTRY key will cause the display to “back-up” to show the number of volume counts and the P or F designator of the previous purge or fill cycle. This enhancement has been added as a programming convenience; it allows a previously entered purge or fill cycle to be modified without stepping through the entire programming sequence. Backing up past the initial prepurge cycle will cause the sampler to be transferred to the standby state. When the display is not alternating, the CLEAR ENTRY key works in its normal manner.

LIQUID LEVEL SAMPLER

ACTUATOR MODES

The Model 2910 Sampler may be used with an Isco Model 1640 Liquid Level Sampler Actuator. The Model 1640 Actuator causes the sampler to remain dormant until the liquid level in a flow stream rises to a predetermined level, at which time the sampling program is initiated. The Model 2910 has three selectable modes in which the sampling program may be initiated when liquid touches the Actuator’s probe.
Model 2910 Sampler

Mode 1
A sample is collected immediately when liquid touches the Actuator's probe, and the interval to the next sample is reset to the programmed INTERVAL BETWEEN SAMPLES.

Mode 2
A sample is not collected when liquid touches the Actuator's probe and the interval to the next sample is not reset. In this mode, when the sampler is operating in one of the time modes, sampler time is decremented even when sample collection is inhibited by the Actuator; this permits synchronization of the sampling with real clock time. When the sampler is operating in one of the flow modes, flow pulses are not accepted until after liquid touches the probe.

Mode 3
A sample is not collected when liquid touches the Actuator's probe and the interval to the next sample is not reset. In this mode, when the sampler is operating in one of the time modes, sampler time does not start decrementing until water touches the Actuator's probe; thus, the programmed time delay to the first sample and the time interval between samples are both operative. When the sampler is operating in one of the flow modes, flow pulses are not accepted until after liquid touches the probe and the interval to the next sample is reset to the programmed interval. This is significant only when the Model 1640 is operating in the toggle mode.

Mode 1 is used when it is desired to collect a sample immediately when liquid touches the Actuator's probe and collect the remainder of samples at the programmed time or flow pulse interval between samples. Mode 2 is typically used in time mode when it is desired to delay the start of sampling until liquid touches the Actuator's probe and to synchronize the collection of samples with real clock time. Mode 3 is typically used in a time mode when it is desired to delay the start of sampling until liquid touches the Actuator's probe, and to use the programmed delay to the first sample and the interval between samples. Modes 2 or 3 are used in the flow mode when it is not desired to collect a sample when liquid touches the probe, but to subsequently collect samples at the programmed flow pulse interval.

Programming of Actuator Mode
The mode of Liquid Level Sampler Actuator operation is selected by placing the sampler into a program state where the mode of Actuator operation maybe selected. This is indicated by PRGM STEP 88 being shown on the display. When PRGM STEP 88 is shown, the mode of Actuator operation previously programmed will be shown on the display. A number corresponding to the desired mode of Actuator operation (1, 2, or 3) may then be entered on the numeric keypad. The ENTER, VALUE, and CLEAR ENTRY keys work as in the normal program state. Pressing the PROGRAM/STEP key returns the sampler to the standby state.

PROGRAM HALT/RESUME
The HALT SAMPLING and RESUME SAMPLING keys are used to interrupt the program of a running sampler, allowing changes to be made to the program, and then permitting the program to be restarted, without resetting the number of composite samples which have been collected.

The program halt/resume sequence is typically used to modify the time interval between samples or time interval to the first sample collection. However, it may be used to modify any of the program quantities, if, for example, they were originally programmed incorrectly, sampling conditions change, etc.

General Halt/Resume Procedures
The general procedures for the use of the program halt/resume procedures are:
1. Halt the program by pressing the HALT SAMPLING key.
2. Using the PROGRAM/STEP key, step to the desired program quantity (or quantities) to be changed, and make the change (or changes).
3. Return the sampler to the standby state.
4. Restart the program by pressing the RESUME SAMPLING key.

Use of Halt Sampling key
Pressing the HALT SAMPLING key of a sampler in the run state will cause the sampling program which is in operation to be halted and will transfer the sampler to the standby state. This allows the sampler's program to be modified as desired using the standard programming techniques. If the sampler is operating in the time mode, time decrementing will continue even after the program has been halted. If the time interval to the next sample reaches zero while the program is halted, a sample will not be collected, the time interval to the next sample will be reset to the programmed interval, and time decrementing will continue.
A missed sample will not be remembered and consequently will not be collected when the program is resumed. If the sampler is operating in the flow mode, flow pulse decrementing will cease until the program is resumed. If the HALT SAMPLING key is pressed while the sampler’s pump is running, the pump will immediately stop.

**Use of Resume Sampling key**

Pressing the RESUME SAMPLING key of a sampler in the standby state will cause the sampling program as it currently exists to begin execution. The number of composite samples collected will not be reset to zero. (This is one of the differences between the RESUME SAMPLING and START SAMPLING keys.) The RESUME SAMPLING key is normally used to resume the program of a previously running sampler whose program has been interrupted by the HALT SAMPLING key. If, during the time while the program was halted, no program quantities or only the interval between samples and/or the delay to the first/next sample were changed, the sampling program will be resumed, upon depression of the RESUME SAMPLING key, at the point where it was halted, according to the program quantities currently set. The exception to this is that, as noted above, the time interval to the next sample will continue to decrement while the program is halted; thus, the time interval to the first/next sample will probably be a smaller value when the program is resumed. This allows the sampling to remain in synchronization with real clock time and the time interval between samples to remain constant, providing that the interval to the first/next samples does not decrement to zero while the program is halted. The flow interval to the next sample, however, does not change during the halt; thus, under these conditions, the flow interval will be resumed at exactly the point where it was when sampling was halted.

**Other Program Quantities**

If, on the other hand, any program quantities other than the interval between samples or the interval to the first/next sample were changed during the program halt, or if the program was halted during a sample collection (while the pump is running), when the RESUME SAMPLING key is pressed, the suction line will be purged before a sample is collected. Under these conditions, the time interval to the next sample behaves as described above. The flow interval to the next sample, though, will be reset to the programmed interval upon program resumption.

It should be noted that changing program quantities during a program halt/resume sequence quite possibly may result in subsequent samples which are not consistent with the previously collected samples. Thus, before changing program quantities during a program halt, the user should be aware of the consequences of such a change on subsequent samples, and the inconsistencies which may result.

**PROGRAM LOCK**

To prevent casual tampering with the program set in the Model 2910, a program lock feature has been included. When the sampler’s lock is engaged, the sampler cannot be placed into a program mode and hence the program cannot be changed. This allows the sampler to be programmed in the office, “locked,” and then placed into operation in the field without the danger of the program being modified. It also prevents unauthorized individuals or vandals from tampering with the sampler’s preset program.

The sampler’s program lock is engaged by placing the sampler into what is essentially a special program state. For a sampler in the standby state, pressing the CLEAR ENTRY key five times in succession places the sampler into a program state where the program lock can be engaged. This is indicated by PRGM STEP 99 being shown on the display. When PRGM STEP 99 is shown on the display, the sampler’s program lock may be engaged by entering the number “2910” on the numeric keypad and pressing the PROGRAM/STEP key. This engages the sampler’s program lock (as indicated by the LOCK legend of display being on) and returns the sampler to the standby state. The ENTER VALUE and CLEAR ENTRY keys also work as in the normal program state; however, the program lock is not engaged (or disengaged) until the PROGRAM/STEP key is pressed. When the program lock is engaged, of the program control keys only the START SAMPLING, HALT SAMPLING, and RESUME SAMPLING keys are functional, allowing the program to be started and stopped, but not changed. The ON, OFF, and all the manual control keys remain functional, allowing the sampler to be manually controlled. As long as the program lock is engaged, the LOCK legend on the display will be on.

To disengage the program lock, the sampler must be in the standby state. The program lock may then be disengaged by following the same procedures used to engage the lock: press the CLEAR ENTRY key five times in succession, enter “2910” on the keypad, and press the PROGRAM/STEP key. This “toggles” the sampler out of the program lock; the LOCK legend on the display will go out. The sampler’s program may then be changed as desired.
SELECTING UNITS OF MEASURE

The sampler's metric units of measure can be accessed by placing the sampler into a special program state. For a sampler in the standby state, pressing the HALT SAMPLING key five times in succession places the sampler into a program state where the units of measure (English or metric) can be selected. This is indicated by PRGM STEP 77 being shown on the display. When PRGM STEP 77 is shown on the display, the sampler's units of measure can be selected by entering the number 0 for English units or 1 for metric units on the numeric keypad and pressing the PROGRAM/STEP key.

English units of measure are suction head in feet, volume in milliliters, and suction line length in feet. The metric units of measure will be head in decimeters, volume in milliliters, and suction line length in meters.

PLACING THE SAMPLER INTO OPERATION

In summary, to place the Model 2910 Sampler into operation, the preparational steps described in Preparation for Use, on page 5 must be performed. The sample bottle tub must be prepared for use, the desired suction line attached, the suction line inlet properly placed in the liquid source, the sampler properly placed at the sampling site, and a power source connected to the sampler, and an external flow meter (if used) properly interfaced with the sampler.

Programming

After these preparational steps have been completed, the sampler may be programmed for automatic operation as described in Setting Up a Sampling Program, on page 16. The various program quantities must be set to select the mode of sampler operation, the interval between samples, the sample volume, etc.

Because the Model 2910 has an internal lithium battery providing continuous memory, the sampler may easily be programmed in the office or the lab, taken into the field, and placed into operation. In the field, the only program quantity that might need to be reprogrammed is the delay to first/next sample. To assure that the sampling program is started at the desired time. After the sampler has been properly prepared for use and programmed for operation, the sampling program is started by pressing the START SAMPLING key.

Immediate Collection of First Sample

Often, it is desired to collect the first sample while the operator is still present, as a final check that everything is working. For a sampler operating in the time mode, this may be accomplished in two ways, depending upon whether or not it is desired to synchronize the samples with real clock time. If synchronization is desired, the first sample may be collected by pressing the Manual Sample key (while the sampler is in the standby state), checking to be sure the delay to the first/next sample is set correctly to synchronize the samples with clock time, and then pressing the RESUME SAMPLING key. The first sample will be collected when the MANUAL SAMPLE key is pressed. The second sample will be collected when the programmed delay to the first/next sample times out, and subsequent samples will be collected at the programmed interval between samples. The second and remaining samples will be synchronized with real clock time; the first sample probably will not be, and there will probably be a nonuniform interval between the first and second samples.

If synchronization is not required, the first sample may be collected while the operator is present by programming a delay to the first/next sample of one minute, and then pressing the START SAMPLING key. The first sample will then be collected in approximately one minute and subsequent samples at the programmed interval between samples.

Flow Mode

For a sampler operating in the sequential or composite flow modes, the collection of the first sample while the operator is present may be accomplished by pressing the MANUAL SAMPLE key (while the sampler is in the standby state), and then pressing the RESUME SAMPLING key. The first sample will be collected when the MANUAL SAMPLE key is pressed, and subsequent samples will be collected at the programmed flow pulse interval between samples.

SAMPLER RECOVERY

The Model 2910 Sampler will automatically cease operation after all samples have been taken or after sampling has been stopped by the float shut-off. When the sampler's program has been completed, the display will read "FULL." Because of the automatic shut-off, timing of the recovery of the samples is not critical.

Recovering the Entire Sampler

When recovering the sampler, if it must be pulled from a manhole, be sure to keep it level to prevent spilling the collected samples. If the entire sampler is to be returned to the laboratory or office, disconnect the cable from the flow meter, if used. The sampler may be turned off, if desired, but this is not necessary. Separate the sample bottle tub from the center section, as described in Assembly and Disassembly of the Case, on page 5, and put a cap on the sample container. The sampler is now ready to transport.
Model 2910 Sampler

If the entire sampler is not to be returned to the lab, but only sample bottle tubs exchanged and the sampling restarted, the sampler should not be turned off while exchanging bottle tubs. This is because no purpose is served by turning the unit off, and if the sampling is being done in a time mode in synchronization with real clock time, the synchronization is preserved as long as the sampler is left on.

Check Battery

When exchanging bottle tubs, it is also good practice to consider the state of charge of the sampler's battery at this time, if one is being used. The charge duration of the sampler batteries is discussed in Table 2, on page 4. If the sampler's battery state of charge is questionable, it should be exchanged with a freshly charged battery.

Exchanging Sample Tube

The full sample bottle tub may be exchanged for an empty one by separating the tub from the center section as described in Assembly and Disassembly of the Case, on page 5 and installing an empty tub. After the full tub has been removed, place the cap on the bottle.

Restarting the Sampler

After the empty sample bottle tub has been installed, the sampling may be restarted by pressing the START SAMPLING key. Note that it may be necessary to reprogram the delay to the first/next sample to start the sampling process at the desired time.
Chapter 5 Routine Maintenance

ROUTINE MAINTENANCE
This chapter of the Model 2910 presents instructions for the routine maintenance necessary to keep the sampler in top operating condition. Included are sections providing information on cleaning the sampler and components, replacing the pump and suction tubing, charging the optional batteries, and changing the internal desiccant.

It is strongly recommended that the user thoroughly familiarize himself or herself with the routine maintenance procedures presented in the following sections. The Model 2910 Sampler, although ruggedly built to withstand difficult field operating conditions, will function best and maintain maximum reliability when these simple maintenance procedures are followed. As with any piece of field operated equipment, a certain amount of preventive maintenance is necessary to keep the sampler functioning properly.

CLEANING THE SAMPLER

The following sections present instructions for cleaning the sampler case, sampler tubing, and sample container, and cleaning protocols for priority pollutants.

CASE
The top cover and sample container tub may be cleaned by submersion in warm soapy water or by spraying them with a hose. The center section may also be cleaned in a similar manner provided that the FLOW METER external electrical connector is tightly capped and that the fuse holder is tightly screwed in place. It is good practice to minimize direct liquid contact with the control box. The sampler may be disassembled for cleaning by following the instructions found in Assembly and Disassembly of the Case, on page 5.

TUBING

The suction line and pump tubing may be cleaned by placing the end of the suction line in a cleaning solution and pumping this solution through the tubing system using the pump control keys (see Manual Controls, on page 10). Follow with a clean water rinse.

SAMPLE CONTAINERS

Both the polyethylene and glass sample containers have a wide mouth to facilitate cleaning. The wide mouth allows the insertion of an arm and brush for vigorous cleaning with a soapy water solution.

CLEANING PROTOCOLS FOR PRIORITY POLLUTANTS

The following sections are excerpted from U.S. Environmental Protection Agency Publications EPA-600/4-77-039 (“Sampling of Water and Wastewater” by Dr. Phillip E. Shelley) to provide an example of sampler cleaning procedures for priority pollutants.

The proper cleaning of all equipment used in the sampling of water and wastewater is essential to ensuring valid results from laboratory analysis. Cleaning protocols should be developed for all sampling equipment early in the design of the wastewater characterization program. Here also, the laboratory analyst should be consulted, both to ensure that the procedures and techniques are adequate, as well as to avoid including practices that are not warranted in view of the analysis to be performed.

As an example, Lai (1974) has set down the standard operating procedures for cleaning sample containers and field equipment used by USEPA Region IV Surveillance and Analysis field personnel engaged in NPDES compliance monitoring. They are reproduced below for a typical automatic sampler and related sampling equipment.

Iesco Glass Sample Containers

1. One spectro grade acetone rinse.
2. Dishwasher cycle (wash and tap water rinse, no detergent).
3. Acid rinse with at least 20 percent hydrochloric acid.
4. Dishwasher cycle, tap and distilled water rinse cycles, no detergent.
5. Replace in covered Iesco bases.

Suction Tubing (Vinyl or Teflon)

1. Do not reuse suction tubing. No cleaning required. New suction tubing is to be used for each new sampling setup.
2. Use Teflon tubing where samples for organics are to be collected.

Iesco Pump Tube

1. Rinse by pumping hot tap water through tubing for at least 2 minutes.
2. Acid wash tubing by pumping as least a 20 percent solution of hydrochloric acid through tubing for at least 2 minutes.
3. Rinse by pumping hot tap water through tubing for at least 2 minutes.
4. Rinse by pumping distilled water through tubing for at least 2 minutes.

Teflon Tubing
1. Rinse twice with spectro grade acetone.
2. Rinse thoroughly with hot tap water using a brush if possible to remove particulate matter and surface film.
3. Rinse thoroughly three times with tap water.
4. Acid wash with at least 20 percent hydrochloric acid.
5. Rinse thoroughly three times with tap water.
6. Rinse thoroughly three times with distilled water.
7. Rinse thoroughly with petroleum ether and dry by pulling room air through tubing.
8. Dry overnight in warm oven (less than 150°F) if possible.

REPLACEMENT OF PUMP TUBING
The pump tube provides two functions in the Model 2910 Sampler: first, it serves as a pump tube in the peristaltic pump, and second, it serves as a distribution tube, routing the sample liquid from the pump outlet to the sample container. The pump tube consists of a single 30 in. (76 cm) long piece of a special silicone rubber tubing. This particular type of silicone rubber tubing is used because of its superior mechanical properties and because it does not contain any organic materials. This latter point is extremely important if samples are to be collected in which organic materials are of interest. Other types of silicone rubber tubing may contain organic materials which are used as vulcanizing agents. During the vulcanizing process, these compounds are converted into other compounds which may be leached by the sample. Therefore, if another silicone tubing is used in the pump, the sample may be contaminated with organic compounds leached from the pump tubing. The silicone rubber tubing supplied by Isco for use with the Model 2910 will not contribute any organic material to the sample.

Inspection of Tubing
The silicone rubber pump tubing is reliable and long-lived. However, due to the constant mechanical strain placed on the tubing by the peristaltic action of the pump, it will eventually fatigue and fail. It is good practice to periodically remove the outer pump case half (as described below) and inspect the tubing for wear, replacing it with the spare pump tube included with the sampler if necessary. Additional pump tubing sections are available from Isco. If the liquid being sampled contains a high percentage of fairly large suspended solids, the inspections should be fairly frequent. If the liquid is relatively free of solids, the inspections may be less frequent. Note that since the amount of tubing (13.5 inches) actually used in the pump is less than half of the total length of the pump tube (30 inches), in certain cases the tube may be used twice in the pump by simply turning it around. This is possible, of course, only if the portion of the tube previously used in the pump has not been split or otherwise damaged to the point of leaking.

Removal from Float Cage
The first step in replacing the pump tube is to remove it from the float cage located on the underside of the center section. This is done by disconnecting power from the unit, separating the center section from the remainder of the sampler (as described in Assembly and Disassembly of the Case, on page 5), and turning this section over, as shown in Figure 17, on page 46. The pump tube may then be pulled out of the tube guide in the float cage assembly. Finally, turn the center section back over, and pull the tube out of the pump tube port.

Removing the Pump Tube
The pump tube may now be removed from the pump itself. First, remove the outer pump case half by loosening the four captivated thumbscrews. This will expose the pump tubing which is squeezed between one of the pump rollers and the curved surface of the inner pump case half. Extract the tubing and the pump tubing guide and clamp assemblies from the inner case half. Then, loosen and remove both pump tubing guide and clamp assemblies from the pump tube. Remove the suction line, if attached, as described in Replacement of Suction Tubing, on page 46. This completes the removal of the old pump tube.

Installing a New Pump Tube
To install the new pump tube, first reinstall the suction line, as described in Attaching the Suction Line, on page 5. Then, replace and tighten the pump tubing guide and clamp assemblies, as shown in Figure 18, on page 46. Be sure that the pump tubing guide and the clamp assembly at the outlet end of the pump tubing is positioned at the edge of the black band on the pump tube. The edge of the black band is located 13.5 inches (34.5 cm) from the inlet end of the pump tube and is used for placement of the outlet pump tubing guide and clamp assembly. This placement is critical to prolong the life of the pump tube and to assure efficient operation and accurate delivery volumes.
Figure 17 Removal of the Pump Tube

The pump tubing guide and clamp assemblies may now be replaced in the inner pump case half so that their grooves mate with the semicircular openings in the pump case, with the black band on the top of the pump. Slip the pump tubing under the rollers so that the pump tubing does not interfere with the installation of the outer pump case half. Replace the outer pump case half so that the grooves of the pump tubing guide and clamp assembly fit into both halves of the pump, and tighten the four thumbscrews.

Installation in the Pump

Next, feed the free end of the tube down through the pump tube port in the center section. Then, turn the center section over again, and feed the end of the tube into the tube guide in the float case assembly, as shown in Figure 17. Position the end of the pump tube such that the end of the tube is flush with the end of the tube guide. This completes the installation of the new pump tube. As a final check, inspect the length of exposed tube under the center section. There should be no excessive slack in this tube; it should be installed such that it continuously slopes downward from the bottom of the center section to the point where it enters the float cage. This is, of course, to prevent any low spots in the tube which might not completely drain of sample liquid. If there is any excessive slack, adjust the length of the tubing under the center section by pulling the tube out of the pump tube port.

Figure 18 Model 2910 Pump without Outer Case

Black Band  Tubing Guide and Clamp Assembly

Suction Line Port  Pump Roller  Pump Tube

Maximizing Tubing Life

To maximize pump tubing life and pumping efficiency, it is very important to maintain 13 to 13.5 inches of tubing inside the pump. This may normally be accomplished by carefully following the above instructions and correctly positioning the black band on the pump tube. However, as a final check, the following procedure may be followed. After the new pump tube has been installed as above, loosen the clamp on the top (outlet) of the pump. Then, using the PUMP JOG FWD. key, run the pump briefly, allowing the pump tubing to “seek” correct positioning in the pump. While the pump is still running, retighten the top clamp. The pump tube should now be correctly installed.

Replacement of Suction Tubing

It may be desirable to replace the sampler suction tubing for one of several reasons. The suction tubing may have been worn, cut, contaminated, or otherwise damaged. In critical sampling, it may be necessary to replace the suction line between sampling programs, to avoid cross-contamination. The vinyl suction tubing contains a very low PPM (parts per million) level of phenols. If this affects your samples, use the Teflon tubing or a laboratory grade of vinyl tubing. When sampling site conditions change, it may be necessary to replace the suction line with a different diameter or type of line (vinyl or Teflon).
Inspection

In any case, it is good practice to periodically inspect the suction line for damage. The suction line and the remainder of the pump tubing system should be cleaned occasionally as described in Tubing, on page 44.

REPLACEMENT LINES

Replacement vinyl suction lines are available from Isco in two forms. First, a complete suction line, with weighted strainer, is available in 10 foot and 25 foot lengths for the 1/4 in and 5/32 in ID vinyl suction tubes. Second, bulk suction tube in the 1/4 in. ID and 5/32 in. ID vinyl tube is available in 100, 500, and 1000 foot rolls.

The 5/32 in. ID Teflon suction tubing is available from Isco in lengths of 10 and 25 feet. If a stainless steel strainer was ordered with the Teflon suction line, it will be attached to the line at the factory.

The following sections discuss the replacement of the complete suction line-strainer assemblies, the sizing of the suction line, and the assembly and installation of the bulk tubing.

Vinyl Suction Line

The suction tube is removed from the pump by first removing the outer pump case half by loosening the four captive thumbscrews. Extract the pump tubing and loosen the pump inlet tubing guide and clamp assembly, and slip it up the pump tube to expose the junction between the suction line and pump tube. Finally, pull the suction line out of the pump tube.

If a complete new suction line-strainer assembly of the standard 10 or 25 foot length is to be used, it is installed as described in Vinyl Suction Line, on page 6.

If it is desired to utilize bulk suction tube in replacing the suction line, it will first be necessary to disassemble the old suction line, which was just removed. First, remove the small stainless steel ferrule from within the end of the suction line by loosening the hose clamp, and slipping the ferrule out of the tube. The ferrule serves as a union between the suction tubing when the pump tubing guide and clamp assembly is tightened. Then, remove the strainer and hose clamp from the opposite end of the suction line, as described above. Cut the new suction tube to the desired length, and force the stainless steel ferrule into the end of the suction tube, until approximately half of it is in the suction tube, and secure it in place with the hose clamp. Install the strainer on the opposite end of the suction tube and tighten the hose clamp. The new suction line may now be installed in the pump as described in Vinyl Suction Line, on page 6.

Teflon Suction Line

The suction tube is removed from the pump by first removing the outer pump case half by loosening the four captive thumbscrews. Extract the pump tubing and loosen the pump inlet tubing guide and clamp assembly, and slip it up the pump tube to expose the junction between the suction line and pump tube. Finally, pull the suction line out of the pump tube.

Stainless Steel Strainer

If a new suction line (either with or without the optional stainless steel strainer) is to be used, it is installed as described in Teflon Suction Line, on page 8. To install the optional stainless steel strainer, carefully slip the strainer’s tapered connector inside the suction line and tighten the hose clamp supplied with the strainer, as shown in Figure 19, on page 47.

Figure 19 Attaching the Stainless Steel Strainer to the Teflon Suction Line

CHANGING THE INTERNAL DESICCANT

If the humidity indicator indicates the presence of moisture inside the control box (see Humidity Indicator, on page 270, the control box should be inspected to determine if there is a leak, and the desiccant renewed. This is done by unscrewing the ten screws around the outer rim of the control box cover, and carefully lifting the cover off the control box.

⚠️ CAUTION

The control box contains electronic circuitry which will be damaged by static discharge. Open the control box only in a static free environment.

ALWAYS DISCONNECT THE POWER BEFORE OPENING THE CONTROL BOX.
Model 2910 Sampler

Inspection
Inspect the inside of the control box for obvious sources of leaks or the presence of collected moisture. If there is a leak, the leak should be repaired by returning the control box to the factory, since the factory has specialized equipment to detect leaks and thoroughly test the units after repair.

Renewing Desiccant Bags
Place a sheet of brown paper on a flat metal sheet. You can use a brown grocery bag and a typical cookie sheet. Place only the bags on the sheet. Do not stack the bags on top of each other or allow them to touch. Place in a vented, circulating forced air, convection oven in a well ventilated room. Allow two inches of air space between the top of the bags and the next metal tray above the bags. Keep the tray a minimum of 16 inches from heating element. Heat the bags at a temperature of 240 to 250°F (116 to 121°C) for 12 to 16 hours. At the end of the time period, the bags should be immediately removed and placed in an air tight container for cooling.

The desiccant will be recharged to approximately 80 to 90% of its previous capacity. After repeated recharging, the desiccant bag may require replacement. Replacement bags of desiccant are available from Isco.

Some will have the temperature and time for recharging the desiccant printed on the bag. If they differ, use the temperature and time printed on the bag. The procedure is completed by reinstalling the control box cover. Before reinstalling the cover, coat the cover's gasket with a light film of silicone grease. Tighten the ten screws which hold the control box cover in place using a cross-torquing pattern in even steps.

Figure 20 Control Box Internal Desiccant

Description of Mechanical Construction
The following paragraphs provide information on the weather and corrosion resistance of the sampler, on the pump and pump drive system of the sampler, and on the liquid distribution system of the sampler.

Weather and Corrosion Resistance
The Model 2910 Sampler is designed to be operated in hostile environments such as sanitary sewers without additional protection. However, since a great deal of plastic is utilized in the construction of the sampler, some restrictions regarding the environment must be observed to prevent premature failure of the plastic parts.

ABS exterior
The tan plastic used in the basic construction of the machine is ABS. ABS plastic exhibits good resistance to aqueous solutions containing common acids and bases. Resistance to hydrocarbons, alcohols, vapors from paint thinners such as ketone or aromatic solvents should be suspect however, and placing the sampler in such an environment should be preceded with a test of an ABS sample in the environment. Isco will supply ABS samples at no charge.
Model 2910 Sampler

Note

Iscio is not responsible for damage to plastic parts caused by chemical attack.

Use In Sunlight
ABS plastic is resistant to damage from sunlight, but will exhibit some weakening and hardening over a long period of direct sunlight exposure. It is recommended that the outside of the sampler case be sprayed with a good reflective paint, such as aluminum paint, if it is to be continually used in direct sunlight.

Other Materials
All hasps and other case fittings are made of stainless steel or black styrene-butadiene rubber (SBR). All other external components are made of either stainless steel, anodized aluminum, or acetyl plastic.

Control Box
The electronic circuitry, gear train, drive motor, etc. are housed in a Noryl plastic control box. The control box is a completely sealed unit that does not need to be opened during operation. The sampler is programmed and the display read via a label that covers the control box cover. A molded gasket seals the control box cover to the control box bottom section. The contents of the control box are further protected by a bag of moisture-absorbing desiccant installed inside the control box.

Submersion
Providing that the electrical connectors are either capped or properly attached to their mating connectors which are provided with O-ring seals and that the fuse holder is tightly screwed in place, the sampler will withstand a shallow submersion in water for reasonable periods of time without water leakage into the control box. However, such submersion should be avoided.

Temperature Range
The Model 2910 Sampler can be operated in a temperature range of between 32°F and 120°F. Short exposures to temperatures under 32°F can be tolerated if the suction line does not freeze.

Pump and Pump Drive System
Transfer of liquid from the source (flow stream) to the sample container is accomplished through the use of the peristaltic pump shown. Liquid is forced through the pump by the progressive squeezing action of the pump tube by two rollers turning inside the curved surface of the pump case. The tubing used in the pump is a special grade of silicone tubing 3/8 inch OD. Features of the peristaltic pump include self-priming, inherent pulsation of the flow stream to help prevent clogging, and a vacuum pulling capacity of 26 feet of water at sea level.

Pump Drive
The pump is driven by a high speed, direct current motor, coupled to the pump through a gear train, as shown in Figure 21, on page 50. The pump is run in one direction to draw liquid from a source and in the opposite direction to purge the suction line of liquid. At 3 feet of lift, the pump will typically deliver 1500 milliliters of liquid per minute through a 3/8 inch ID suction line. The delivery rate will vary directly with the voltage applied to the sampler. However, volumetric accuracy is not significantly affected by pump speed since the delivery volume is based on an electronic count of the number of revolutions of the pump shaft.

Liquid Distribution System
Liquid is transferred from the source to the pump through either 1/4 or 3/8 inch ID vinyl suction tubing or 3/8 inch ID Teflon suction tubing. The pump outlets directly into the sample container. The pump tube is held in place by the tube guide in the float cage assembly shown in Figure 17, on page 46. The float and float cage serve two purposes: 1) to locate the discharge of the pump tube over the composite container and 2) to provide a fail-safe shut-off of sampling in case of accidental overfilling of the composite container.

Electronic Circuity
The following is a general description of the Model 2910 Sampler electronic circuitry. Refer to Figure 22 through Figure 26. Note that in the following description reference will be made to components, such as R3, Q7, IC2, etc. Except as noted, the components will be located on the main circuit board assembly (mounted to the underside of the control box cover). The components located on the power circuit board assembly (located in the lower section of the control box) will be specifically identified in the text.

The Model 2910 is a microprocessor based instrument. The microprocessor is like a miniature computer that executes a program which is stored in the sampler. The program is a series of commands or instructions that tell the microprocessor what to do in order to accomplish the various functions which the sampler must perform.

The circuitry of the sampler (the "hardware") is discussed in the following paragraphs. However, the program that controls the system (the "software") is discussed only as is necessary to describe the operation of the hardware. A complete discussion of the software is beyond the scope of this manual.
Model 2910 Sampler

Figure 21 Interior View of the Control Box Lower Section

Pump Gear Train

Power Supply

The Model 2910 Sampler utilizes either a 12 volt battery or an Isco 12 volt DC normal speed power pack as its external power source. The external power source enters the Model 2910 through the 12 volt DC connector on the side of the control box. The power source is fused with a 2 amp slow blow fuse. Access to the fuse can be obtained on the side of the control box. Diodes D11 on the power circuit board and CR1 are isolation diodes, used to isolate the 5 volt circuitry from the 12 volt circuitry. Capacitor C2 and diode Z6 on the power board are used to filter high voltage spikes generated by the motors. C1 is used as a low voltage filter for the 5 volt regulator source.

The CMOS logic circuitry used in the Model 2910 is powered by a 5 volt supply rail. U1, Q5, R16, R17, R31, R32, C15, and C3 constitute the regulation circuitry for the 5 volt rail. The 5 volt rail is also current regulated. CR6, CR7, and R31 limit the maximum amount of current flow.

One other source of power is a battery contained within the RAM chip. The purpose of this battery is to keep the RAM rail supplied with enough voltage to maintain its memory (data stored in RAM). The battery will not source current until the 5 volt rail drops below a fixed point.

Clock

The time base for all operations of the Model 2910 Sampler is derived from a 1.2288 MHZ crystal. U2, R18, C14, C16 and the crystal form a 1.2288 MHZ oscillator. The zero output (pin 9) of U2 will clock the CPU (U5) with a 1.2288 MHZ clock signal. Inside U5 is a divide-by-eight counter which produces a 153.6 KHZ frequency that appears at TPA, pin 34 and TPB, pin 33.

U2 also generates a 97.6 KHZ clock signal (Q14, pin 3) which clocks U3, whose output forms the interrupt signal supplied to pin 36 of U5. All the registers are up-dated and flags serviced during each interrupt cycle.

The U3 output signal also clocks U3 reset, causing the removal of the wait signal on pin 2 of the CPU chip. After the servicing of the interrupt, U5 will output a high on pin 5 and pin 4. The output from pin 5 will reset U3, setting the stage for the next interrupt signal. The output from pin 4 will clock U3, causing the CPU to go into its wait mode of operation.

CPU

The central processing unit is a CDP1802 CMOS unit selected for its low current consumption. This unit controls the various data transfers that occur on its 8-bit data bus. It communicates with associated circuitry by sending or receiving 8-bit bytes from the data bus, sensing high or low levels on its external flag (EF) lines, or its interrupt input. It controls data transfers through its memory address lines, its "N" lines, the memory read line (MRD), and the memory write line (MWR).
Memory Select/Latch
The memory select and latch circuit consists of U7 and U17. These chips are required since the CPU issues a 16-bit memory address in two consecutive 8-bit bytes on the memory address lines, pins 25-32. When TMA occurs, U7 latches the 8 bits of the high order byte. U7 will then generate address lines A5 through A15. The address line A15 is used to select either U10 (FROM) or U13 (RAM). MA0 through MA12 are used to address specific locations within these chips. Memory address line 15 is utilized as both a chip select (CS) and a chip enable (CE) signal. The three IC chips concerned with the memory addressing are U5 (CPU), U13 (RAM), and U10 (ROM).

ROM
The read only memory (ROM) contains the list of steps (the program) which the CPU is to execute. U10 is an erasable programmable read only memory chip. This IC's program can be erased by exposing it to ultraviolet light. The contents of the ROM are non-volatile; that is, it does not change if power is removed or lost. When a particular byte is to be read, the sequence of events begins with the presentation of the high order memory address byte at the memory address lines of the CPU. When TPA goes high, U7 latches the memory address byte. The CPU then issues the lower order byte (MA0 through MA7) of the memory address to be read. The low order bits (MA0 through MA7) will determine the particular byte to be read within the ROM or RAM. Then, if MA15 is low, the PROM will be selected if MA15 is high, the RAM will be selected through U17. When the CPU issues the memory read signal (MRD), the selected byte of data will be placed on the data bus where it will be received by the CPU and perhaps by one of the auxiliary circuits connected to the data bus.

RAM
The random access memory (RAM) is a temporary data storage area. The RAM used by the Model 2910, U13, contains 2048 bytes, each byte consisting of 8 bits. The RAM, unlike the ROM, can be written into. The RAM is accessed in the same manner as the ROM.

If the RAM is selected by the memory latch and select circuit (U7 and U17), it will present the contents of the addressed cell to the data bus when the MRD line goes low (pin 20), or it will write the byte presented on the data bus into the addressed cell when the MWR line goes low (pin 21). The data contained in the RAM would ordinarily be retained only as long as power is present. In order not to lose data stored in the RAM, the RAM used in the Model 2910 contains an internal battery. (This battery is explained in the power supply circuit description.)

Start Up Circuity
When power is first applied to the Model 2910, the microprocessor and all the input/output ports must be reset. In order to accomplish this, U12, U6, R56, R57, R58, and C25 are used. U12 is used as a voltage detector.

When the 5 volt rail reaches 5 volts, determined by the voltage divider R56 and R57, the output (pin 4) of U12 will go high. This output then passes through two inverters (U6). This allows the 5 volt rail to stabilize before the clear line goes high, and allows the CPU to start.

Front Panel Keypad
The Model 2910 keypad utilizes a 6 row, 4 column touch keypad for all manual switching needs. The keypad operates on an "XY" axis system. U4, U16, U8, and U18 combine with the keypad (P1) to form the circuitry needed to read which key is being depressed. U10 is a decoder chip that has two inputs and four outputs. The purpose of U16 is to apply a ground potential on one of the columns at a specific time. The output that goes low is determined by the inputs to the IC. The inputs are derived from the output device U18. U18 receives its information from the data bus lines. To determine which switch is being depressed, U4, an input device, will read the rows of the keypad.

The program constantly strobes the keypad to determine if any switches are being depressed. This is accomplished by U18 first taking the information from the data bus lines and applying two bits to the inputs of U16. U16 then decodes those two bits and one of its four outputs will go low. This will place a ground potential on one of the four columns of the keypad. Next, U4 will be selected and read to determine if any of its inputs are low. The CPU can determine which switch has been depressed by knowing which column it placed low and which U4 input went low.

LCD Display
The LCD display circuit consists of U16, U18 through U23, and the LCD component. U22 is a four-digit CMOS display decoder and driver device. The information that will be decoded comes in on the data bus. After this information is decoded, U22 will output signals to the LCD component to drive specific segments of each digit.

U18 through U21 and U23 compile the circuitry that drives the individual legends located within the LCD component. The information that determines which legend is to be selected is passed to U18 and U19 via the data bus lines.
Model 2910 Sampler

U18 and U19 will then interpret this information and select the correct legend. This select signal will be passed through an exclusive-or gate prior to being applied to the LCD component.

Low Voltage Detect
The low voltage detect circuit consists of U11, U6, R53, R54, R55, and C24. This circuit monitors the 12 volt source and will enable the unit to go into a non-active (idle) state of operation when the source voltage is lower than approximately 9.2 volts. When the source voltage for the voltage divider R53 and R54 reaches approximately 9.2 volts, the output of U11 will go low. This low will cause a high signal on the output of the inverter U6. This high signal is then passed to the CPU and sets the interrupt to the CPU. The CPU will then go into an idle state until the source voltage is brought back above 9.2 volts.

Pump Motor Control
The circuitry that controls the pump motor is also located on the power circuit board. Transistors Q1, Q2, and Q6 to Q9 along with associated resistors are used to apply power to the pump motor when required. When the pump is to run in the forward direction, the CPU causes an output instruction to occur that sets pin 11 of U9 on the main circuit board to a high (+5 volt) level. This turns on Q1 on the power board which in turn biases Q6 and Q9. Q6 and Q9 then apply power to the pump motor.

Pump Volume Count Sensor
The pump interrupt module, U6, R39, R40, and C20 combine to form the pump volume count sensor circuitry. The pump interrupt module is an LED-photo transistor device. When the pump's volume disk rotates between the photo transistor and LED, a pulse is generated. This pulse passes through an inverter prior to going to the CPU. The CPU counts each pulse to determine the amount of volume that is being pumped. R40 and C20 form a timing constant to eliminate noise.

Flow Pulse
Flow pulse inputs from an external flow meter enter the sampler on pin C of the flow meter connector. They then pass through a wiring harness to P2, pin 12. R34 and Z1 maintain the flow pulse input level to U6 at 6.8 volts. R35 and C17 form a timing constant to eliminate any noise. U6 inverts the flow pulses and also forms a buffer between the input and U4. U4 is an input device which will place the flow pulse on the data bus so that this information can be retrieved by the CPU.

Event Mark Connector
The event mark signal present at pin E of the flow meter occurs during the beginning of a prepurge portion of a sampling cycle. It is a 12 volt DC signal, capable of driving a 2 amp load. The circuit consists of U9, Q2, Q3, Q4, R12, R13, R14, R15, and R30. At the beginning of a prepurge cycle, U9 will output a high signal from Q4 (pin 13). This high will bias Q2 on. Q2 in turn will bias Q3 on, which in turn biases Q4 on. When Q4 turns on, 12 volts will be applied to pin E of the flow meter connector.

Inhibit
If a Model 1040 Liquid Level Sampler Actuator is being used with the Model 2910, the inhibit signal enters the sampler through pin F of the flow meter connector. Pin F is normally pulled high by R46. When the inhibit signal is present, the high is pulled low. The low is inverted by U6. The resulting high is then passed to U5, which is the CPU device. The CPU notes the flag change and halts all sampling processes.

Overflow
R1, R2, Z1, Q4, on the power printed circuit board, R27, R3, C18, U4 on the main printed circuit board, and the microswitch all combine to form the overflow circuitry. When the input D14, pin 16 of U4 goes high (caused by the contact closure of the microswitch), the CPU then knows that the sample bottle is full and to discontinue any further sample processes. R1, R2, Z1, Q4, is circuitry that will only be utilized when a remote device is used to sense the volume of the sample bottle.

Beeper
U18, Q1, DS1, and R1 combine to form the beeper circuitry. When U18 outputs a 5 volt DC signal (Q0, pin 9) Q1 is biased. A biased Q1 places a ground on DS1 (beeper), which in turn allows 12 volts DC to be dropped across the beeper, causing an audio tone.
Figure 25 Main Circuit Board Assembly

Figure 26 Power Supply Circuit Board Assembly
Chapter 6 Servicing and Troubleshooting

SERVICING AND TROUBLESHOOTING

The sixth chapter of the Model 2910 Instruction Manual presents sampler servicing information and a troubleshooting guide to assist the user in correcting any malfunctions which might occur. Included are paragraphs providing information on the removal of the control box, on the care of CMOS circuitry in general, on gaining access to the electronic components, and on the description of the sampler's self-diagnostics. Also included is a troubleshooting section and illustrated replacement parts list.

Before attempting to service or repair the sampler, it is strongly suggested that Chapter 5 of this instruction manual covering the construction of the sampler be thoroughly read and understood. Should any service related questions arise, feel free to consult with our Customer Service Department at the location listed in the preface to this instruction manual.

REMOVAL OF THE CONTROL BOX

Should there be a problem with the sampler which requires factory service, it is usually easiest to return only the control box for repair. The control box is removed from the sampler in the following manner. First, separate the center section from the sampler following the procedure described in Assembly and Disassembly of the Case, on page 5 and disconnect the power source from the control box. Remove the suction tube from the pump, and turn the center section over, as shown in Figure 27. Pull the pump tube out of the float cage assembly, and feed it out of the pump tube port in the center section. The control box may then be removed by unscrewing the four screws indicated in Figure 27, and lifting the center section plastic off the control box. Screw the four screws and their lockwashers into the control box to prevent losing them.

When returning the control box to the factory for repair, be sure to pack it securely. Include a note explaining the problem.

TROUBLESHOOTING AND REPAIR OF CMOS CIRCUITRY

Most of the Model 2910 Sampler circuitry consists of complimentary CMOS components. Because of the extremely high input impedance of CMOS integrated circuits, certain precautions must be taken when working on such circuitry.

Figure 27 Removing the Control Box

Float Cage  Tube Guide  Pump Tube Port

Remove the Control Box by Unscrewing Four Screws.

The voltage levels present from static build-up due to walking static discharge over carpeted floors, movement of woolen or synthetic clothes over chair seats, workbenches, etc., are sufficiently high to destroy CMOS circuitry when performing repair work. Ideally, all tools, soldering irons, etc., should be conducted to a grounded metal work bench, with grounding straps applied to the wrists of personnel. It is recognized that in most field repair situations, such precautions are impractical. However, certain extreme hazards must be avoided.

1. Never remove the control panel or perform any electronic work in a room with a carpeted floor.
2. Always roll up work clothes sleeves so that your bare arms are in contact with the working surface.
3. Avoid using a work surface made of an extremely good insulator such as "Formica" or glass. Metal is best; a wood surface would be next best.
4. The degree of hazard will usually depend upon the level of humidity. Be particularly careful if the work place is extremely dry.
5. When arriving at the workplace, after the unit has been opened for repair, always make an effort to touch the metal chassis with at least one hand before touching any of the circuit conductors.
6. Be careful of the CMOS integrated circuits when they are removed from the rest of the circuitry. Simply being connected to the rest of the circuitry will, in most cases, provide some protection. Most of the circuitry is quite well protected from such damage when a battery or power pack is connected. However, never remove or replace an IC while the circuit is under power.

**ACCESS TO ELECTRONIC AND OTHER INTERNAL COMPONENTS**

All of the electronic components of the Model 2910 Sampler are mounted within the control box. The basic circuitry of the sampler is contained on a single circuit board assembly which is mounted to the underside of the control box cover.

**Observe Static Precautions**

As discussed in *Troubleshooting*, on page 61, Isco believes the Model 2910 is most efficiently serviced by returning it to the factory. However, should the user choose to service the unit, the electronic components may be accessed as follows. When handling the internal components, be sure to observe precaution regarding CMOS circuitry described in *Troubleshooting and Repair of CMOS Circuitry*.

To gain access to the electronic components, first disconnect the power source from the sampler. Then, remove the ten screws around the outer edge of the control box cover. Lift the cover off the control box's base, and turn it over, as shown in Figure 28. The control box cover assembly may be disconnected from the control box lower section by disconnecting the connector indicated in Figure 29, on page 59.

The main circuit board assembly of the Model 2910 is protected by an aluminum shield. To remove this shield, unscrew the four screws indicated in Figure 28, and lift the shield off. This will reveal the main circuit board, as shown in Figure 29. To remove the circuit board assembly from the control box cover, unscrew the four hex threaded standoffs, indicated in Figure 29. The circuit board may now be pulled away from the control box cover. To completely disconnect the circuit board assembly from the cover, disconnect the connector shown in Figure 29.

**Access to pump**

The shut-off microswitch and pump gear case assemblies are located in the lower section of the control box. To gain access to these and other components in the control box lower section, remove the three screws indicated in Figure 30, on page 59. Then lift the plastic tray straight up out of the control box. The power circuit board may now be removed, which will then allow access to the shut-off microswitch and its mounting bracket, located in the bottom of the cabinet. The pump gear case may then be removed by removing the pump's outer case and unscrewing the four screws on the pump's inner case.

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*Figure 28 View of the Underside of the Control Box Cover*
SELF-DIAGNOSTICS

The Model 2910 is programmed to run self-diagnostic routines to check out certain key circuit components and other aspects of its operation. Three different self-diagnostic routines are or may be run: power up diagnostics, diagnostics during normal operation, and manually initiated diagnostics. These are discussed individually in the following sections. The sampler’s error messages are summarized in Table 5, on page 24.
Power Up

Upon power up, the sampler runs diagnostic routines on its PROM (programmable read only memory) and RAM (random access memory). The PROM, which stores the sampler's operating program, has its checksum verified. The RAM, which is used for temporary storage, is subjected to a pattern check. Power up is defined as a condition where external power (either a battery or power pack) has been removed from the sampler for a period of time long enough for the capacitors to discharge (approximately 10 seconds), and then reconnected.

Upon power up, the sampler's display will show "PPPP," indicating that the PROM checks are being made. If the PROM check is successful, the display will show "EEEE," indicating that the RAM checks are being made. If the RAM check is successful, the display will be cleared indicating the end of the power up diagnostics. If the sampler fails either portion of the diagnostic checks, the display will "stick" on either "PPPP" or "EEEE," depending upon which failed. The display can be cleared only by powering the unit down and back up. However, this will cause the power up diagnostics to be run again, and the probability is high that the sampler will fail the diagnostics at the same point again.

Normal Operation

When the sampler is in the off, standby, and run states, a PROM checksum and RAM pattern check (similar to the power up diagnostic checks) are run approximately every 30 seconds. Thus, during the majority of the sampler's normal operation, the PROM and RAM are checked on a regular, frequent basis.

As long as the PROM and RAM checks are successful, the user will not even be aware that the checks are being run. However, should the sampler fail one of the checks, an error condition will be indicated on the display. If the sampler is operating in the off or standby states when an error is detected, the display will rotate between "-EE-" and either a " 1" or " 2." The 1 indicates a failure to pass the PROM check, while a 2 indicates a failure to pass the RAM check.

If the sampler is operating in run mode, two EE's ("-EE-") will replace time or flow pulse interval to the next sample in the normal rotation of the display. There will be no indication as to whether the error occurred during a PROM or RAM check.

However, if a sampler with an error detected while in the run state is subsequently transferred from the run to the off or standby state, the display will alternate between "-EE-" and either a " 1" or " 2."

Clearing Error Messages

The error message may be cleared from the display only by powering the unit down and back up. However, this will cause the power up diagnostics to be run again, and there is a good chance that a PROM or RAM error will again be detected. The exception to this is if the error were originally caused by transitory electronic malfunction ("glitch") and not a hard error.
MANUALLY INITIATED DIAGNOSTICS

A more extensive diagnostic routine may also be manually initiated when desired. For a sampler in the standby state, pressing the PUMP STOP key five times in succession will cause the manually initiated diagnostic routine to be run. The manually initiated diagnostic routine is composed of two portions. The first portion runs automatically. The second portion consists of a number of individual tests which may be run at the operator's option.

The automatic portion of the manually initiated diagnostics begins shortly after the PUMP STOP key is pressed five times. First, the eight legends are individually turned on in order (TIME, FLOW, COMP, PRGM, STEP, STNDY, LOCK, and RUN). Then, the following series of patterns are shown on the display:

"0000"
"1111"
"2222"
"3333"
"4444"
"5555"
"6666"
"7777"
"8888"
"9999"
"1234"
"2468"
"3579"
"_._._"
"FULL"
"HELP"

The display is then cleared, and the pump is turned on in the forward direction for approximately 2 seconds. After the pump shuts off, the display will alternate between two numbers. These numbers are used at the factory to check the optical system that counts revolutions of the pump. The smaller of these two numbers should be at least 100. If the optical system is inoperative, an error message will be shown on the display: a rotation between "-EE-" and "-6," indicating faulty pump rotation counting optics.

This completes the automatic portion of the manually initiated diagnostics. At this point, the user may choose to end the diagnostics, or may choose to run one or more of several individual diagnostic procedures. These procedures are started by pressing the keys listed below. When the procedure is ended, the display will return to the rotation between the two numbers that ended the automatic portion of the diagnostics. If there is no activity on the keypad within approximately 60 seconds after the diagnostics have ended, the sampler will automatically be transferred to the standby state.

Terminate Diagnostics

Pressing the OFF key terminates the diagnostics and transfers the sampler to the off state. Pressing the ON key terminates the diagnostics and transfers the sampler to the standby state.

Event Mark Check

Pressing the MANUAL SAMPLE key causes a single event mark signal to be sent out on pin E of the FLOW METER connector.

Time Base Check

Pressing the START SAMPLING key causes 37.5 Hz, 12 volt square wave to be sent out on pin E of the FLOW METER connector. This signal is a measure of the time base of the sampler, and should be accurate to within ± 0.0833%. This signal is present for approximately two minutes, and may be terminated by pressing any key except START SAMPLING.

Pump Tests

Pressing the PUMP JOG FWD key causes the forward pump test of the automatic portion of the test to be repeated. This again ends with the display rotating between two numbers. Pressing the PUMP JOG REV. key causes the same pump test to be run, except in the reverse direction.

Clearing error messages

An error message generated during the manually initiated diagnostics may be cleared from the display only by powering the unit down and back up. Upon power up, the display will return to the rotation of the two numbers that ended the automatic portion of the diagnostics.

TROUBLESHOOTING

The electronic circuitry of the Model 2910 is almost completely solid state, and its reliability is usually high. If the unit should fail to operate properly, the problem will most likely be mechanical. Items such as a broken or intermittent connection in the power cable or wiring harness should be suspected.

Factory Service

If an electronic problem is suspected, Isco strongly recommends that the sampler be returned to the factory for servicing. Due to the complex nature of the microprocessor-based sampler circuitry, specialized knowledge and instrumentation are required for troubleshooting. The Isco service department has the trained technicians and specially designed equipment necessary for timely, efficient troubleshooting and repair of the Model 2910 Sampler.
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User Servicing
To reiterate, Iaco believes that the user will normally be time and money ahead to return the sampler to the factory for service. However, if the user has the facilities and desires to service the unit her or himself, she or he is, of course, free to do so. In this case, the best aid to troubleshooting is a thorough understanding of the sampler circuitry, as described in Electrons Circuitry, on page 49. The Iaco Customer Service Department (at the location listed in the preface to this manual) is available to provide additional information and advice with regard to servicing.

Following are some hints which may be of use in troubleshooting the sampler. In attempting to isolate problems with the unit, the CPU and memory should be assumed to be working properly until attempts to find problems in peripheral circuitry have been exhausted. This is for two reasons. First, the likelihood of failure is far greater on transistor drive circuits, etc., than it is on the CPU or memory. Second, it is doubtful if the repair facility would have the equipment or the time to do meaningful troubleshooting on the CPU or memory.

The first question to be answered when a problem exists are, is the 5 volt rail up? Is there a shorted or open drive transistor? Is there a cold solder joint? These are the type of questions to be answered before attempting to troubleshoot the CPU and memory.

CPU Checks
Some checks on CPU operation can be made, however, with an oscilloscope operating at a high sweep rate (1 MHz or greater). If either of both SC0 or SC1 outputs (pins 6 and 5) of the CPU show activity, the CPU is at least running, and executing some part of the program. If no activity is present, the clear line to the CPU should be checked. It should be high. If not, circuitry external to the CPU is stopping the CPU. If it is high and the CPU is not running, check the terminals of the crystal to see if the oscillator is running. It should always run.

Troubleshooting Guide
To aid in troubleshooting relatively simple problems with the sampler, a troubleshooting guide is presented in Table 8, on page 62. If trouble symptoms persist and cannot be located, ship the unit to the factory or consult our Customer Service Department, at the location listed in the preface to this manual.

Replacement Parts List
An illustrated list of common replacement parts for the Model 2910 Sampler can be found in Appendix A RPL. Listing, on page 63. When ordering a replacement part, be sure to include the Iaco assembly or part number, a complete description, and the serial number of the sampler on which the part is to be used. The serial number can be found on the tag affixed to the side of the sampler control unit.

Table 8 Model 2910 Troubleshooting Guide

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Probable Cause</th>
<th>Solution</th>
</tr>
</thead>
</table>
| 1. Sampler completely inoperative; display does not light. | a. Dead battery  
b. Blown fuse | a. Replace or recharge battery  
b. Replace fuse, Removal of the Control Box, on page 57 |
| 2. Sample volumes incorrect | a. Pump tubing installed incorrectly  
b. Defective pump tubing  
c. Suction head or suction line values incorrectly programmed | a. Install pump tubing per instruction in Replacement of Pump Tubing, on page 45  
b. Replace pump tubing  
c. Program per Setting Up a Sampling Program, on page 18 |
| 3. Pump cycles on and off during sampling cycle | Low battery | Replace or recharge battery |
| 4. Display reads “HELQ” | a. Low battery  
b. Sampler's pump jammed by ice, broken pump tube, or foreign object | a. Replace or recharge battery  
b. Unjam pump |
| 5. Display reads “PPPP” or “EEEE” | a. Low battery  
h. Failed PROM or RAM check during power up | a. Replace or recharge battery  
b. Consult factory |
| 6. Display reads “EE-,” possibly alternating with a “1” or “2” | Failed PROM or RAM check while in off, standby or run status | Consult factory |
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Appendix A  RPL Listing
<table>
<thead>
<tr>
<th>Item No.</th>
<th>Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60-2904-002</td>
<td>Top Cover Assy</td>
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<tr>
<td>2</td>
<td>60-1393-142</td>
<td>Draw Catch Keeper Mod</td>
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<tr>
<td></td>
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<td>5</td>
<td>60-2910-002</td>
<td>Model 2910 RFL Control Box</td>
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<td>60-2914-009</td>
<td>Model 2910 Center Section Assy.</td>
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<td>Draw Latch Assy. - Small</td>
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<td>10</td>
<td>60-2714-000</td>
<td>Float Assy</td>
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<td>11</td>
<td>60-2714-020</td>
<td>Float Shaft Assy</td>
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<td>12</td>
<td>60-2713-003</td>
<td>Float</td>
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<td>60-2914-010</td>
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<td>Power Circuit Board Assy. - Q.A.</td>
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<td>60-1484-033</td>
<td>Shut-Off Microswitch</td>
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<td>60-2904-008</td>
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<td>60-2704-019</td>
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## Model 2910 Sampler

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### Model 2910 Sampler

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<td>80 1688 216</td>
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* Not Shown
One Year Limited Warranty *
Factory Service

Isco instruments covered by this warranty have a one-year limited warranty covering parts and labor.

Any instrument that fails during the warranty period, due to faulty parts or workmanship, will be repaired at the factory at no charge to the customer. Isco’s exclusive liability is limited to repair or replacement of defective instruments. Isco is not liable for consequential damages.

Isco will pay surface transportation charges both ways within the 48 contiguous United States if the instrument proves to be defective within 30 days of shipment. Throughout the remainder of the warranty period, the customer will pay to return the instrument to Isco, and Isco will pay surface transportation to return the repaired instrument to the customer. Isco will not pay air freight or customer’s packing and crating charges.

The warranty for any instrument is the one in effect on date of shipment. Warranty period begins on the shipping date, unless Isco agrees in writing to a different date.

Excluded from this warranty are normal wear; expendable items such as charts, ribbon, tubing, and glassware; and damage due to corrosion, misuse, accident, or lack of proper maintenance. This warranty does not cover Isco on-line Process Analyzers and certain Isco SFE instruments, which are covered under different warranty terms, nor does it cover products not sold under the Isco trademark or for which any other warranty is specifically stated in sales literature.

This warranty is expressly in lieu of all other warranties and obligations and Isco specifically disclaims any warranty of merchantability or fitness for a particular purpose. Any changes in this warranty must be in writing and signed by a corporate officer.

The warrantor is Isco, Inc. 4700 Superior, Lincoln NE 68504. U.S.A.

* This warranty applies to USA customers. Customers in other countries should contact their Isco dealer for warranty service.

Before returning any instrument for repair, please call, fax, or e-mail the Isco service department for instructions. Many problems can be diagnosed and corrected over the phone, or by e-mail, without returning the instrument to the factory.

Instruments needing factory repair should be packed carefully, preferably in the original carton, and shipped to the attention of the service department. Small, non-fragile items can be sent by insured parcel post. PLEASE BE SURE TO ENCLOSE A NOTE EXPLAINING THE DEFECT.

Return instruments to: Isco, Inc. - Attention Repair Service
4700 Superior Street
Lincoln NE 68504 USA

Mailing address: Isco, Inc.
PO Box 82531
Lincoln NE 68501 USA

Phone: Repair service: (800)775-2965 (lab instruments)
(800)228-4373 (samplers & flowmeters)
Sales & General Information (800)228-4373 (USA & Canada)

Fax: (402) 465-3001

Email: service@isco.com

Isco, Inc.
www.isco.com

November 2000 - #2217
Quality Assurance Project Plan (QAPP) for Post-Construction Monitoring

Appendix E

Standard Operating Procedure for Installation and Maintenance of Teledyne-ISCO 2150 Area Velocity Flow Modules
1. Installation Procedures

1.1. Install Battery Module Batteries

The Battery Module requires four 6V lantern-type batteries. Remove the battery door. To remove the door, turn it 1/4 turn counter-clockwise and pull it from the Battery Module. Pull the lantern battery carrier out of the Battery Module. Remove the old battery from the carrier. Insert a fresh battery in the carrier. Slide in the battery so that the springs contact the plate inside the carrier. Align the connectors and insert the battery carrier into the Battery Module. Check the humidity indicator disk inside the door. Replace the door. Repeat steps for additional batteries.

1.2. Inspect the Desiccant

A humidity indicator is mounted inside each battery cap on the Battery Module. The humidity indicators have regions that display 20, 30, and 40 percent humidity levels. Ideally each region should be completely blue. As the desiccant becomes saturated, the humidity levels will increase and the regions turn pink. When the 40 percent region turns pink, the Battery Module is no longer adequately protected and the desiccant must be replaced.

There is also a desiccant cartridge inserted into the side of the AV Module. The cartridge is filled with silica gel beads that will indicate when they are saturated. When dry, the beads are yellow or blue. As the desiccant becomes saturated, the humidity levels will increase and the beads turn green or pink. If the entire length of the desiccant cartridge turns green or pink, the reference air is no longer adequately protected and the desiccant must be replaced.

1.3. Replacing the Desiccant: AV Module

The desiccant is contained in a cartridge located on the left side of the AV Module. To remove the cartridge, unscrew the collar and slide the cartridge out of the AV Module. The clear tube reveals the silica gel desiccant inside.

To replace the silica gel desiccant:
1. Hold the cartridge upright with the collar at the top.
2. Push the collar off the cartridge.
3. Empty the saturated silica gel beads or granules.
4. Fill the tube with new (Isco P/N 099-0011-03) or reactivated silica gel desiccant.
5. Press the collar onto the tube.
6. Slide the cartridge into the AV Module. Tighten the collar to seal the cartridge in place.
1.4. Replacing the Desiccant: Battery Module

A bag of desiccant is located inside each of the battery caps behind the retaining plate. To replace the desiccant:

1. Loosen the two mounting screws that secure the metal retaining plate.
2. Rotate the retaining plate until it is free from the mounting screws.
3. Remove the spent desiccant bag from the cap and replace it with a new (Isco P/N 099-0002-33) or reactivated bag.
4. Replace the retaining plate and secure it with the screws.

1.5. Reactivating the Desiccant

Silica gel beads/granules and bags of desiccant can be reactivated.
• Use a vented oven in a well-ventilated room.
• Do not remain in the room while the regeneration is taking place.
• Use the recommended temperature. Avoid heating the desiccant at higher than recommended temperatures.

To reactivate the silica gel desiccant, pour the spent desiccant into a heat resistant container. Never heat the cartridge assembly; it will melt. Heat the silica gel in a vented convection oven at 212° to 350°F (100° to 175°C) for two to three hours, or until the blue or yellow color returns. Allow the desiccant to cool and store it in an airtight container until ready for use.

Bagged desiccant will often include reactivation or recharging instructions on the bag’s labeling. Always follow the instructions printed on the bag. If the instructions are not available, the bags may be heated in a vented convection oven at 245°F (120°C) for sixteen hours.

1.6. Connecting the Modules

The 2150 System is modular; you build the system by connecting modules together. Place the Battery Module at the bottom of the stack. This keeps the heavier items lower in the stack making it easier to transport and store.

Other modules may be attached to this stack to increase the site’s functions. You can add as many modules to the stack as long as each module uses a unique module name, and as long as you observe the power requirements of the extra modules.

To connect the AV and Battery modules:
1. On the top of the Battery Module, remove the cap and stow it on the holder. This exposes the communication connector on the Battery Module.

2. Prepare the Battery Module’s communication connector:
   
a. Inspect the connector. It should be clean and dry. Damaged O-rings must be replaced. Spare O-rings (Isco P/N 202-1006-69) are supplied in the maintenance kit (60-2099-001).

b. Spray the O-ring’s sealing surface with a silicone lubricant.

3. Place the carrying handle on the Battery Module.

4. Unlock the AV Module’s latch by pressing in on the latch release (right side).

5. Underneath the AV Module, remove the cap from the lower communication connector and stow it in the holder.

6. Lock the latch. Locking the latch correctly seats and aligns the lower cap in its holder.

7. Position the AV Module over the Battery Module. Align the connectors and lower the AV Module onto the Battery Module.

8. Unlock the AV Module’s latch by pressing in on the latch release (right side).

9. Firmly press the modules together and lock the AV Module’s latch (left side).

The Communications indicator will blink during the start-up routine to indicate the AV Module is operating.

1.7. Installing the Modules

The modules should be secured at the site. This prevents damage caused by accidental falls and from being swept away if the channel is flooded. In manholes, secure the module to a ladder rung or suspend from a spreader bar.

As the installation is completed, the following should be checked before leaving the site unattended:

1. The modules should be positioned where they will be protected from submersion. Should the modules become submerged, level readings may drift and the hydrophobic filter will seal to
protect the reference air line. If the possibility of short-term submersion cannot be avoided, you can prevent drifting level reading and damage to the hydrophobic filter. Attach a length of 1/8 inch I.D. tubing (Isco P/N 60-2003-104) to the hydrophobic filter. Route the other end of the tubing to a dry location.

2. Ensure that all of the protective caps are in place. Unused upper and lower communication connections must be capped. The caps prevent damage and terminate the communication lines. Caps for any communication connectors that are in use should be properly stowed.

3. Carefully route cables. Protect them from traffic in the area. Avoid leaving excess AV Sensor cable in the flow stream where it may collect debris.

1.8. Connecting the AV Sensor

The AV Sensor cable attaches to the sensor receptacle on the AV Module. To connect the AV Sensor:

1. Remove the protective caps:
   a. On the AV Module, push down on the sensor release while pulling the protective cap from the receptacle.
   b. On the AV Sensor cable, pull the cap from the end of its connector.

2. Prepare the AV Sensor connector:
   a. Inspect the connector. It should be clean and dry. Damaged O-rings must be replaced.
   b. Spray the O-ring’s sealing surface with a silicone lubricant.

3. Align and insert the connector. The sensor release will “click” when the sensor connector is fully seated.

4. Connect the two caps together.

1.9. Installing the AV Sensor

Install the AV Sensor in streams where the liquid covers the sensor. The AV Sensor can detect levels above approximately 0.033 feet (0.4 inch or 1.0 cm) and typically can measure velocities in streams as low as 0.08 ft (1 inch or 25 mm). Streams that run consistently below 1 inch are not a good application for the 2150 Module and AV Sensor.

Offsets - You can install the AV Sensor above the bottom of the flow stream or along the side of the channel, as long as it will be continually submerged. The AV Module can be calibrated to
measure level with the AV Sensor at nearly any depth. The AV Sensor cannot, of course, measure a liquid level that falls below its position in the flow stream. Installing the AV Sensor above the bottom has several advantages:

- It avoids heavy concentrations of silt, sand, or other solids.
- It aids installation in narrow or hard-to-reach locations.
- It maximizes level resolution over a specific level range.
- It can avoid obstructions in the flow stream.

When the AV Sensor is installed above the bottom of the channel, a Zero Level Offset must be entered in the program settings.

**Liquid properties** - Velocity measurements depend on the presence of some particles in the stream such as suspended solids or air bubbles. If the stream lacks particles it may be necessary to aerate the water upstream from the sensor. Handle with care - Abusive handling will damage the AV Sensor. Although the AV Sensor will survive normal handling and installation, treat the sensor with reasonable care. The internal components cannot be repaired.

**Protect the cable** - There is a vent tube inside the cable that must remain open. Do not kink the cable or overtighten the plastic ties while securing the cable.

**Secure the cable** - Secure the cable in place. Tying off the cable can often prevent lost equipment if excessive flow dislodges the sensor and its mounting.

### 2.0. Program the Module

After you have installed the AV Sensor in the flow stream, the flow stream properties must be defined. To do this, connect to the AV Module with Flowlink for Windows software and define the stream properties in the AV Module’s program settings. These ensure that the system correctly reads the liquid level and converts the measured level to flow rate.

Define the following properties:

- **Level** – Enter a liquid level measurement to calibrate the level readings from the AV Sensor.

- **Zero Level Offset** – If the AV Sensor is not installed in the bottom-center of the channel, an offset distance must be entered.

- **Set Flow Rate to zero if no velocity data checkbox**

  - Determines how the AV Module reports flow rates if stream velocity data is not available.
• Prevent velocity signal interference – When more than one sensor is measuring the same section of channel, the ultrasonic sound waves can interfere with each other. AV Modules can be synchronized to prevent velocity signal interference.

• Flow Conversion – The AV Module can store flow rate readings. To correctly convert the measured level and velocity readings to a flow rate, the flow conversion method and channel properties should be defined.

• Silt Level – (Area Velocity Flow Conversion Only) The AV Module can compensate for a buildup of silt around the AV Sensor.

These six settings should be considered a minimum requirement. Other settings, such as Data Storage Rates, Site Name, and Module Names, also may be set using Flowlink. Programming Data Storage Rates, Flow Conversions, and Communications Protocols for various sites and under various conditions can be quite technical. The AV Module comes from factory with a default Data Storage Rate of 15 minutes for the level, velocity, and flow rate, and 1 hour for total flow and input voltage readings. If the AV Module will require any programming other than factory default settings please consult the HWU Automation Manager.

2.1. Mounting Rings

Consult the Isco Mounting Rings Installation and Operation Guide for detailed hardware information.

The following sections describe sensor installation using the two options available for mounting the AV sensor in pipes or round-bottomed flow streams. For pipes up to 15" (38 cm) in diameter, stainless steel self-expanding mounting rings (Spring Rings) are available. For pipes larger than 15" in diameter, Teledyne Isco offers the Scissors Rings (Universal Mounting Rings). Area velocity sensors can also be installed using primary measuring devices.

2.1.1. Spring Rings

To install a spring ring, compress the ring, slip it inside the pipe, and then allow it to spring out to contact the inside diameter of the pipe. The inherent outward spring force of the ring firmly secures it in place.

These mounting rings are available for use in pipes with inside diameters of 15.2 cm (6"), 20.3 cm (8"), 25.4 cm (10"), 30.5 cm (12"), and 38.1 cm (15").

Attach the AV sensor to the ring either by using two 4-40 countersink screws or by snapping the optional probe carrier to the ring. This second method of attaching the
sensor allows for easy removal in case service is needed later.

To complete the sensor-spring ring assembly procedure, attach the sensor cable to the downstream edge of the ring. Follow the cable routing according to the wire tie locations. Other routing directions may affect measurement accuracy. The cable can actually create a stilling well downstream from the sensor, causing the level to read low. Use the self-locking plastic ties supplied with the ring. Install the ring in the pipe by compressing it. Press inward on both sides and slide the ring into the pipe.

Route the sensor cable out of the stream and secure it in position by placing the ties through the holes in the mounting ring and then locking them around the cable.

The spring ring may need anchoring. Under conditions of high velocity (greater than 1.5 meters per second or 5 feet per second), the ring may not have sufficient outward spring force to maintain a tight fit inside the pipe. The ring may start to lift off the bottom of the pipe, or may even be carried downstream. This problem is more prevalent in the larger diameter pipes and in pipes with smooth inside surfaces, such as plastic pipes. If any of these conditions are present, or if movement of the mounting ring is detected or suspected, you must anchor the ring in place. You can do this by setting screws through the ring into the pipe, or by other appropriate means. If there is a problem with the smaller diameter rings, it may be sufficient to simply increase the outward spring force of the ring by bending it into a less round configuration.

2.1.2. Scissors Mounting Ring

For pipes larger than 15" in diameter, Teledyne Isco offers the adjustable Scissors Ring (also known as the Universal Mounting Ring). This device consists of two or more metal strips that lock together with tabs to form a single assembly. There is a base section where the sensors are mounted, two or more extension sections (usually), and a scissors section at the top that expands the entire assembly and tightens it inside the pipe. The scissors section contains a long bolt that increases the length of the section as it is tightened.

The assembled scissors rings fit pipe diameters from 16" to 80". Secure the unit in place by tightening the scissors mechanism with a 5/8" socket wrench or other suitable tool. Ring sections are .040" thick half-hard 301 stainless steel sheet. All other parts are also stainless steel, except for the plastic cable ties in the hardware kit.

Each extension, 1, 2, 3, and 4, adds 9.0", 21.5", 31.5", or 41.5", respectively, to the circumference of the ring. Used alone, the base section fits a pipe that is approximately 16" to 19" in diameter. The 9.0" (smallest) extensions can be used to take up or remove
slack, to bring the scissors mechanism into a position where it can be effectively tightened.

To prevent debris from catching on the probe cable, it is important to attach the cable to the mounting ring so it offers as little resistance to the flow as possible. Attach the sensor cable to the downstream edge of the ring, using the self-locking plastic ties supplied with the ring. Place the ties through the holes in the mounting ring and then lock them around the cable.

2. Maintenance

2.1. Maintenance Overview

The 2150 system is designed to perform reliably in adverse conditions with a minimal amount of routine service requirements. To keep your system working properly, the following should be checked at regular intervals:

- Battery power
- Desiccant
- Channel conditions

Maintenance intervals are affected by many variables. The number of modules powered by a Battery Module and the Data Storage Rate will affect the battery life. Humidity levels obviously affect the service life of the desiccant, and the amount of debris in the stream can drastically alter the channel conditions.

As a guide, a basic system installed in an environment with moderate humidity levels and an AV Sensor installed in a channel relatively free from debris and silt, the maintenance interval should not exceed three months.

HWU Maintenance intervals are every two weeks.

2.2. Other Maintenance

**Hydrophobic Filter** - If the 2150 is in a humid location or submerged, a hydrophobic filter prevents water from entering the desiccant cartridge and reference line. Any amount of water will plug the filter and it must be rinsed with clean water and allowed to dry, or replaced so that the reference line can be reliably ventilated. Drifting level readings are often an indication that the hydrophobic filter may be plugged.
Remove the hydrophobic filter with a 5/8” or 16mm socket. Gently screw in the replacement filter (Isco part #209-0093-93).

**Cleaning** - The AV Module case may be cleaned with mild detergent and warm water. Before cleaning the module, ensure that all protective connector caps are in place. The cable and outer surfaces of the AV Sensor may also be cleaned with mild detergent and warm water.

If the flow stream carries a great deal of debris, beware of organic materials that may collect beneath the AV Sensor. This material swells as it becomes saturated with water and may exert pressure on the outer diaphragm. This can damage the transducer and permanently disable the AV Sensor. Keeping the ports clean not only prevents damage, but assures you that the AV Sensor will respond to the hydrostatic pressure above instead of the pressure created by swollen material.

If the ports become blocked:

1. Remove the sensor from its mounting ring, plate, or carrier.

2. Scrape any accumulated solids off the exterior of the sensor. Use a brush and flowing water.

3. Remove debris that has accumulated in the ports.

4. The outer diaphragm is behind the small round cover on the bottom of the sensor. It should be visible through the two small openings at the center of the cover. Gently flush the cover and holes with water to remove debris.

**Sensor Cable Inspection** - Erroneous level or velocity readings may not always indicate a fault inside the AV Sensor body. A damaged cable can affect the operation of the sensor, particularly if the reference air tube inside the cable is collapsed or blocked. Damaged cables cannot be spliced or repaired.

If the AV Sensor cable is damaged, you must replace the entire assembly, as the sensor body and cable are a factory-sealed unit. Keep the connector clean and dry and install the cable so that it is not at risk of damage resulting from other activity taking place in the area. The connector can be replaced in some instances, depending on the condition of the cable.

In temporary installations, do not leave cables lying around where they may be stepped on or run over by heavy equipment. Do not leave extra cable loose in the flow stream where it can trap debris.

In permanent installations, cables repeatedly subjected to abuse will fail and should be installed in conduit for protection. The conduit must be large enough to pass the connector through, as you cannot remove or replace it.
2.3. Factory Service

The internal components of the AV Module are not user-serviceable. The case is completely sealed to protect the internal components. To repair the unit, the case must be broken open and replaced. If you think your module requires repair, contact Teledyne Isco’s Technical Service Department.

Teledyne Isco
Technical Service Dept.
P.O. Box 82531
Lincoln, NE 68501 USA
Phone: (866) 298-6174
(402) 464-0231
FAX: (402) 465-3085
E-mail: IscoService@teledyne.com

The pressure transducer, the ultrasonic transducers, cable connections, and the electronic components of the AV Sensor are encapsulated in plastic resin and are not user-serviceable. If any part of the AV Sensor fails, it must be replaced.

Corresponding with a Teledyne Isco Technical Service Representative can sometimes resolve the problem without the need to return the item. If the difficulty cannot be resolved you will be issued a Return Authorization Number (RAN) and information on returning it to the factory.
Quality Assurance Project Plan (QAPP)
for Post-Construction Monitoring

Appendix F

Standard Operating Procedure for
Laboratory Analysis of
Biochemical Oxygen Demand (BOD) Samples
5-day BOD test
Standard Methods 5210 B

5-day Biochemical Oxygen Demand test

Apparatus:

- Magnetic Stirrer
- 2 mL automatic pipette set to 2 mL
- Large stir bar
- 100 mL graduated cylinder
- 8L aspirator bottle
- 2 mL volumetric pipette
- 20 BOD bottles w/caps (300 mL)
- 10 mL graduated pipette
- 500 mL Griffin beaker
- Dissolved Oxygen meter w/probe & stirrer
- Fish pump w/fritted end glass tube
- Deionized water wash bottle
- BOD Incubator 20°C ± 2°C

Chemicals:

- BOD Nutrient Buffer Pillows (1 large/6L)
- Polyseed Capsule
- Hach BOD standard solution (Glucose/Glutamic acid mix)

Samples:

Isolate a minimum of 1,000 mL of well-mixed composite sample from each Outfall to be tested and allow samples to warm to 20°C before analysis.

Holding Time: 6 hours recommended/48 hours regulatory (time begins with first aliquot of composite)

Procedure

Day before test setup
BOD Nutrient buffer water preparation

1. Fill 8L aspirator bottle to the 6000 mL mark with aerated, deionized water.
2. Air can be added by shaking plastic water jug or covering the top of the filled aspirator bottle and shaking to add dissolved oxygen.
3. Place the filled aspirator bottle in the BOD incubator until ready for use.

Morning of test

1. Remove the aspirator bottle from the incubator and place it on the magnetic stirrer.
2. Place a larger stir bar in the aspirator bottle.
3. Shake the BOD nutrient buffer pillows to mix, open them and add to aspirator bottle.
4. Turn on the magnetic stirrer for a minimum of thirty (30) minutes.
5. Place the aspirator bottle back into the incubator until ready for use.

2 hours before BOD setup
Preparation of seed control

1. Pour 500 mL of deionized water into a 500 mL Griffin beaker then add the contents of one Polyseed capsule.
2. Place fritted-end glass tube into the beaker and start the air pump.
3. Aerate the Polyseed/Nutrient Buffer water for two (2) hours to activate the bacteria.
4. After 2 hours of aeration unplug the pump and remove the fritted-end glass tube. The seed control will remain viable for up to four (4) hours.
5. Add 2 mL of gently stirred seed control to all samples except the Blank.
6. *Alternative seed control: Collect 1,000 mL of MLSS from an aeration basin. Allow the sample to settle for 30 minutes. Draw off the supernatant and aerate overnight.
BOD Setup

1. Turn the D.O. meter ON/OFF knob to the red line and allow to polarize at least 15 minutes.
2. If samples are not 20°C ±1°, bring them up to temperature before proceeding.
3. De-chlorination is not required on storm water samples.
4. Check the pH of the sample water. Record on the bench sheet. If the pH is greater than 8.5 or less than 6.0, add small amounts of acid or alkali solution to bring the pH back into the desired range. Do not dilute the solution with more than 0.5% acid or alkali. Record the final pH on the bench sheet. If the sample water contains chlorine, add sodium sulfite. If sodium sulfite is added, record the amount in the Data section.
5. Ensure that the sample water is not supersaturated. Test the DO content of the sample water. If the water contains more than 9 mg/L of DO at 20°C, then it is supersaturated and will lose some oxygen to the air. This problem may occur when testing cold water or water in which photosynthesis occurs.

If the water is supersaturated, place the sample in a partially filled bottle and agitate it by vigorous shaking or by aerating with clean, filtered compressed air. Continue until the DO content has dropped below 9 mg/L.
6. Calibrate the D.O. meter using the “Air” calibration procedure (see the D.O. meter manual).
7. Organize BOD bottles (Wheaton brand Mfr. #227497-00G) with the following designations:
   A. Blank – 1
   B. Seed Control – 3
   C. HACH BOD Standard – 300 mg/L ampoule
   D. Storm water outfall – 3 bottles per outfall
   E. Storm water outfall – 1 bottle (for 50 mL duplicate).
8. BLANK: Fill with BOD nutrient buffer water ONLY.
9. SEED CONTROL: 2mL Seed Control + BOD nutrient buffer water.
10. HACH BOD standard: 2 BOD bottles each filled with 2mL Seed Control + 2mL HACH BOD standard solution + BOD nutrient buffer water.
11. Outfall Samples: 3 – BOD bottles for each outfall containing serial dilutions of the sample + 2mL of Seed Control + BOD nutrient buffer water.
   a. Bottle #1: 20mL of sample
   b. Bottle #2: 50mL of sample
   c. Bottle #3: 125mL of sample
12. Once all bottles have the sample and seed control (Except blank) fill them with the BOD nutrient buffer water.
13. Analyze each bottle immediately for the Initial D.O. level & record on bench sheet. Rinse the electrode and stirrer with deionized water in between each sample to avoid contamination. Place stopper in bottle, add small amount of BOD nutrient buffer water to the top of the stopper and place the plastic cap on bottle.
14. Place the bottles in the BOD incubator at 20°C for five days.

Important notes:

1. When preparing seed control, ensure the mixing speed is not so fast that the mixing vortex is not so large that it touches the bottom of the beaker as this adds oxygen to the see control & causes the bacteria to work prematurely.
2. Ensure aliquots are from a well-mixed composite sample, but that air is not entrained into the sample during mixing.
3. When adding BOD nutrient buffer water tilt bottle slightly to one side and place tip of spigot on glass to allow water to run down the inside of bottle limiting introduction of air.
4. Cleanliness of glassware is critical to this test as dirt; debris will facilitate false BOD result.
5. Allow dissolved oxygen reading to stabilize before recording.
Henderson Water Utility
Standard Operating Procedure for Laboratory Analysis of Biochemical Oxygen Demand (BOD) Samples

End of 5-day incubation

1. Turn the D.O. meter ON/OFF knob to the red line and allow to polarize at least 15 minutes.
2. Remove samples from incubator.
4. Remove cap and stopper from the first BOD bottle and measure the dissolved oxygen level. This will be known as Final D.O.
5. Rinse the D.O. electrode with deionized water after each sample.

Calculation of results

1. Blank: the difference in the Initial and Final readings should be minor to negligible (0.1 – 0.2 mg/L). If the difference is greater than this quality control should be suspect.
2. SEED Control: There should be a drop between 0.5 – 1.0 mg/L. Use the average of the three SEED control samples for the final calculation of the storm water samples. This is known as the SCF (Seed Correction Factor).
3. HACH BOD standard: Actual concentration should be within 20% of the expected concentration.
4. All samples (except Blank & Seed Control) must have an uptake (drop in dissolved oxygen) of 2.0 mg/L and a final D.O. of 1.0 mg/L to be considered viable for use in averaging the serial dilutions into the final BOD result.
5. Calculation: \[
\text{BOD} = \frac{((\text{Initial D.O.} - \text{Final D.O.}) - \text{Seed Correction Factor}) \times 300 \text{ mL}}{\text{Volume of sample, mL}}
\]
Quality Assurance Project Plan (QAPP) for Post-Construction Monitoring

Appendix G

Standard Operating Procedure for Laboratory Analysis of Total Suspended Solids (TSS) Samples

Prepared 02/04/2013
Derek McGraw
Moss McGraw Environmental Lab
Procedures

1. **Purpose:** This procedure is utilized at Moss McGraw Environmental Lab for the purpose of measuring Total Suspended Solids (TSS) content in wastewater and storm water samples for compliance monitoring under NPDES discharge permit requirements.

2. **Scope:** This procedure shall be used for Total Suspended Solids (TSS) analysis of influent wastewater, effluent wastewater, and storm water samples.

3. **Summary of Procedure:** This procedure involves filtering a homogenized wastewater sample through a filter that is weight prior to and after filtration in order to ascertain the concentration in mg/L of total suspended solids.

4. **Procedure:**
   a. Prepare 47mm glass-fiber filter disks using the following procedure: Place filter, rough side up, onto filtration apparatus. With the vacuum pump on, rinse with three successive 20-mL aliquots of D.I. water and filter until disk is completely dry. After turning off the vacuum and discarding the rinse water, place the prepared glass filter disks into inert aluminum weighing pans and then into the drying oven at 103-105°C for at least one hour. Next place the filters disks into the desiccator to cool completely.
   b. Before analyzing any samples for TSS, weigh the discs with their respective aluminum pans and record the initial weight onto the benchsheet. **NOTE:** Make sure that the numbers on the aluminum pans matches the pan number on the benchsheet. **NOTE:** Look in the analytical balance calibration log book to check whether the calibration of the analytical balance has been verified with NIST traceable weights that day. If not, go and get the NIST weights out of the desiccator in the Bac-T lab and verify the calibration of the analytical balance and document this into the analytical balance log next to the balance.
   c. When you are prepared to analyze a NPDES wastewater sample for TSS, fully homogenize the sample by inverting the sample container several times.
   d. Promptly pour the sample into a graduated cylinder. Record the volume used onto the benchsheet. Choose a sample volume that will yield between 2.5 to 200mg of dried residue. The volume of sample can reach up to 1 Liter if this minimum residue requirement is not met. For samples that take more than 10 minutes to filter, re-filter the sample using a smaller volume.
   e. With the suction on place a prepared and pre-weighed glass filter disk onto the filtration apparatus.
   f. Before pouring the sample into the filtering apparatus, seat the filter by wetting it with a small amount of D.I. water.
   g. Pour the sample from the graduated cylinder into the filtration apparatus and allow suction until all the sample has drained into the drainage flask.
   h. With suction on rinse the filter with three successive 10-mL aliquots of D.I. water. Allow complete draining between washings.
i. Allow the suction to continue for at least three minutes after completion of filtration.

j. Carefully remove glass filter disk from the filtration apparatus. **NOTE:** Removing the filter too fast can cause it to tear in which case the analysis MUST be redone.

k. Place filter disk with sample residue onto an aluminum dish. Place the aluminum dish with filter disk into the drying oven at 103-105°C for one hour. Record the temperature of the oven on the benchsheet.

l. Remove the aluminum pan(s) with the disk(s) from the oven after an hour and allow to cool completely in the desiccator for at least an hour.

m. Weigh the pans on the analytical balance and record the final weight under the “Final Weight” column on the benchsheet.

n. Calculate TSS: mg TSS/L = ((A-B)X1,000,000)/sample volume, mL

   A = weight of dried residue + dish, grams

   B = weight of dish, grams

5. Interferences
Quality Assurance Project Plan (QAPP) for Post-Construction Monitoring

Appendix H

Tabulation of Permitted CSO Discharge Events

How to obtain Data Logger information and Analyze for the Presentation of Permitted Discharge Event Occurrences
Tabulation of Permitted CSO Discharge Events

CSO discharge events are recorded by ISCO 2150 Data Loggers.

Every two weeks, an Automation Specialist goes around to the data logger locations and retrieves the information. The information is saved in the following password-protected HWU network location:

\Hoth\Automation\ISCO 2150 Data Files

The information is in a Zip file, in Microsoft Access database format. Each zip file is cumulative. In other words, each file contains data from the date of collection all the way back to “Day One”. As such, only the most recent data file is needed. However, older database files can be used to restore information in case the most recent file has corrupted data.

When extracted from the Zip file, the file name becomes ISCO.mdb.

In order to help keep up with the date of data collection (to be sure you are using the correct version of the file), rename the file to include the date of data collection.

As an example, since this data was collected on November 15, 2012, the Access database file would be renamed to ISCO_2012-11-15.mdb. If the “Date modified” attribute changes because the database file is “resaved”, the date of collection will still be known. (See Fig. 1)

![Documents library table]

Fig. 1 – ISCO.mdb copied and renamed to ISCO_2012-11-15.mdb
Use Flowlink 5 software to extract individual discharge logged instances for each permitted discharge location. Open the database in Flowlink 5 and view the list of sites. (See Fig. 2)
The following example shows how to extract the information for CSO Discharge Site KPDES 004 – Jackson Street.

Expand the selection for Jackson Street CSO #4 (See Fig. 3).

Double-click on “Velocity” to add that item to the graph in the right-hand pane. Then add “Flow Rate” to the graph pane too, via drag-and-drop.

Fig. 3 – CSO Discharge Site KPDES 004 – Jackson Street
Click on **Actions > Properties** to open the Properties dialog box. (See Fig. 4)

![Properties dialog box](image-url)

**Fig. 4** – Click on **Actions > Properties** to open “Properties” dialog box
In the “Series” tab of the “Properties” dialog box, select “Velocity” and verify that the “Units” are set to ft/s (feet per second). (See Fig. 5)

Fig 5. – Verify that “Velocity” units are set to ft/s (feet per second)
In the “Series” tab of the “Properties” dialog box, select “Flow Rate” and verify that the “Units” are set to gpm (gallons per minute). (See Fig. 6)
In the “Time Scale” tab of the “Properties” dialog box, select an “Absolute” starting date, and the following additional settings:

- July 1 of the fiscal year being analyzed
- Timespan: 1 year
- Summary interval: 1 hour
- Reading interval: 5 minutes
- (Moving Window) interval: 5 minutes

(See Fig. 7)

![Fig. 7 – Time Scale tab settings in the Properties dialog box](image)

Click on “OK” to close the “Properties” dialog box.
The Isco Flowlink window should look something like Fig. 8.

Fig. 8 – Velocity and Flow Rate graph for Jackson Street CSO #4
Click on **File > Export...** to save the data to a CSV (Comma Separated Values) file for later use. (See Fig. 9)
Select the name and location you wish to use for the CSV file. It is helpful to include the outfall name and timescale in the file name. An example file name would be


See Fig. 10.

![Fig. 10 – Select a file name and location for the CSV (Comma Separated Values) file](image)

**Export**

- **Type or select the file where the exported data should go, then click the Export button.**
- **Export graph data**
  - To file: "flowLink (For CSD Data Logger Data)\KQAPP for Consent Judgment\Miss"
  - Series to export: 2: (Velocity,Flow Rate)
  - Records to export: 8743

![Fig. 10 – Select a file name and location for the CSV (Comma Separated Values) file](image)
Click on Export. The data will be saved for later use. (See Fig. 11)

Fig. 11 – The data was exported successfully

See Fig. 12 for a directory listing showing the exported file. The input data is now ready for further processing.

Fig. 12 – Exported .CSV (Comma Separated Values) file in directory listing
The .CSV (Comma Separated Values) file contains rows of data that indicate conditions that have been recorded by the Isco Data Logger. Fig. 13 shows sample data from a typical .CSV file.

Column A: Date and Time
Column B: Velocity (Feet per second) (Used as a “Flag” to indicate flow actually exists)
Column C: Flow Rate (Gallons per minute)

In Fig. 13, note that spreadsheet row 366 is a record for 7:18 p.m. on February 24, 2011. During the 5-minute interval from the previous spreadsheet row, the outfall experienced a discharge. The amount of discharge is:

\[(611.628 \text{ GPM}) \times (5 \text{ Minutes}) = 3,058.14 \text{ Gallons}\]

Column B (Velocity) is not used in the calculation. The “Velocity” value is used as a “Flag”. Actual flow is assumed only if BOTH “Velocity” and “Flow Rate” are greater than zero.
Henderson Water Utility has defined an overflow “event” to be one or more permitted discharges that occur with no more than 72 hours between measured flows. If discharge flows start and stop multiple times, but the time between successive measured flows is less than 72 hours, the multiple flows are lumped together as a single “event”.

If the time between measured discharges is greater than 72 hours, then a “new” event is counted.

The data in the .CSV file is tabulated into discharge events by an Excel spreadsheet tool called **Quad Capacity Parser for CSO Overflow Calculations (Revised 2012-07-20).xlsx**.

To “Parse” data means to break a data block into smaller pieces by following a set of rules. The spreadsheet tool breaks the .CSV data into pieces that have gaps in flow of no more than 72 hours. The parser tool then summarizes the data and presents a summary of discharge events as shown in Fig. 14.

![Fig. 14 – Sample output data from the spreadsheet parser tool](image)

Spreadsheet Column E (15. d Duration of the CSO) is a tabulation of the number of hours of actual flow (NOT counting the gaps between stops and re-starts in the same “event”).

Spreadsheet Column H (Clock Time Duration) is a tabulation of the number of hours between the start of the event and the end of the event, including the gaps between stops and re-starts in the same “event”).
Totals are manually added to spreadsheet Columns E and F. (See Fig. 15)

Fig. 15 – Totals manually added to Columns E and F in spreadsheet row 22

The original version of the spreadsheet parser tool was created in Excel 2003. That version of the program had a limit of 65,535 rows of data. Some annual analyses required more rows of data than the Excel 2003 version of the spreadsheet could handle. Note that one year of data values at 5-minute intervals equals 105,120 rows of data.

Excel 2010 can have 16 times more rows of data than Excel 2003. Excel 2010 can have up to 1,048,576 rows of data.

The Excel 2010 version of the spreadsheet tool is called “Quad Capacity Parser for CSO Overflow Calculations (Revised 2012-07-20).xlsx” because it can handle up to four times the number of rows of data as the original Excel 2003 version. The new version can handle up to 262,124 rows of data.

Detailed instructions on how to use the Quad Capacity Parser for CSO Overflow Calculations (Revised 2012-07-20).xlsx spreadsheet tool are included in the first workbook (Tab) of the spreadsheet, called "Instructions and Sample Data". (See Fig. 16)

Fig. 16 – “Instructions and Sample Data” Workbook (Tab)

The complete instructions in the Workbook (Tab) are shown in Fig. 17 on the following page.
Instructions for using this **CSO Overflow Parser** Spreadsheet

The data in Columns A, B, and C (to the left) represents real "Sample Data" from **CSO 004 - Jackson Street**.

Column A: Time and Date  
Column B: Flow Velocity (Ft/Sec)  
Column C: Flow (Gallons per Minute)

1. Copy the data you wish to analyze into the **CSO Overflow Parser** (Green Tab) worksheet, beginning in cell **A4** (Row 4, Column A).

2. In Cell **AB1** (green shading) enter the **Time** (in HOURS) you wish to use for the no-flow cutoff between outfall events.

3. In Cell **AC5** (Green Shading) select from the pull-down box the **outfall location** you are analyzing.

4. Outfall events will appear in **Columns S through Z**.

5. Copy the entire **Columns S through Z** to the clipboard, then **Paste Special** that information into Cell **A1** in the **Paste Special Cols. S-Z HERE** worksheet (Yellow Tab).  
   First **Paste Special** the **Formats**, and then **Paste Special** the **Values**.

6. Select the ENTIRE workbook by clicking the square above the column numbers and to the left of the row names (or by pressing **<CTRL>A**). Then SORT the workbook.
   Specify that there **IS a Header Row**, and **Sort Ascending** on **15. c1** (aka "Column C").

7. You are now finished. Copy and Paste the sorted information into the location of your choice.

**Note:** The light green tab worksheets "72 Hour Gap", "24 Hour Gap", "12 Hour Gap", etc. represent the sample data in Columns A, B, and C (to the left) after it has been processed by the **CSO Overflow Parser Spreadsheet**.

**LIMITATION:** The current version can process data points through **spreadsheet row 262,128**. That amounts to **262,124 rows of data**, plus 4 rows at the top.

The original version of the **CSO Overflow Parser** was limited only by Excel’s capability of 65,535 rows of data. The **CSO Overflow Parser** uses three (3) rows at the top, plus one (1) row at the bottom. That left a net useable input of 65,531 rows of data.

When data is exported to CSV spreadsheets, seven (7) rows at the top of the output are used for documentation. If there is enough CSV raw data to "max out" the spreadsheet at 65,535 rows, there is still enough room in the **CSO Overflow Parser** to handle the remaining 65,528 rows of input data.

For additional help, see John Baker at Henderson Water Utility (Cell phone (270) 823-2557).
Data Verification and Validation of CSO Discharge Events

**CSO Discharge Data Verification:** Review data sets for completeness, correctness and conformance/compliance. Discard data that is suspect, and detail in all reports the circumstances why the data is in question. Also, provide details of the circumstances surrounding missing and/or incomplete data.

**CSO Discharge Data Validation:** Examine the CSO discharge data to determine the quality of the data, relative to the tabulated CSO discharge events. Provide details of questionable data detail in all reports.