New York State Department of Environmental Conservation
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Standby Contract for Engineering Services (No. D007618)

Generic Field Activities Plan for Work Assignments

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Acronyms Used in the Report

ASP	Analytical Services Protocol
CRQLs	Contract Required Quantitation Limits
DCA	Dichloroethane
DCE	Dichloroethene
DNAPL	Dense Non-aqueous Phase Liquid
FSP	Field Sampling Plan
GPS	Global Positioning System
GW	Groundwater
gpm	gallons per minute
HASP	Site Specific Health and Safety Plan
IDL	Instrument Detection Limit
LNAPL	Light Non-aqueous Phase Liquid
MDL	Minimum Detection Limit
MPI	Malcolm Pirnie, Inc.
MS	Matrix spikes
MSD	Matrix spike duplicate
NBS	National Bureau of Standards
NYSDEC	New York State Department of Environmental Conservation
OSWER	Office of Solid Waste and Emergency Response
PARCCS	Precision, Accuracy, Representativeness, Completeness, Comparability, and Sensitivity
PCE	Perchloroethene (Tetrachloroethene)
RCRA	Resource Conservation and Recovery Act
PID	Photoionization Detector
PPE	Personal protective equipment
RFI	RCRA Facility Investigation
RPD	Relative percent difference
SOPs	Standard Operating Procedures
SVOCs	Semi-volatile organic compounds
SWMU	Solid Waste Management Unit
TAGM	Technical and Administrative Guidance Memorandum
TCA	Trichloroethane
TCE	Trichloroethene
VC	Vinyl chloride
VOA	Volatile Organic Analysis
VOCs	Volatile Organic Compounds
QA	Quality Assurance
QC	Quality Control
QAPP	Quality Assurance Project Plan
EPA	United States Environmental Protection Agency

1. Objectives

1.1. Purpose

This generic Field Activities Plan (FAP) has been prepared as a generic appendix to site-specific documents developed for work assignments issued under the New York State Department of Environmental Conservation (NYSDEC) Standby Contract D007618 for engineering services. The purpose of this document is to provide field methods, procedures, and protocols for the collection of data during the work assignments.

This generic FAP is provided as a supplement to the site-specific documents for each Work Assignment under the NYSDEC Standby Contract. Any deviations from, or additions to, the procedures and protocols provided in this generic FAP will be detailed in a Supplemental FAP, which would be provided as part of each work assignment.

1.2. FAP Objectives

The objective of this generic FAP is to ensure that field data collected during work assignment investigations are of suitable quality and quantity to meet the investigation objectives. To meet this objective, the following topics are presented and discussed in this FAP:

- Description and objective of field investigation procedures
- Calibration procedures

This FAP has been prepared to address field methods and sample collection procedures. In addition, this FAP addresses components that influence these processes and provides a detailed plan to ensure that decisions being made based on the field data are valid, accurate, and defensible in support of subsequent recommendations.

The results of the field activities will be used to support project decisions and meet overall project objectives. The procedures summarized in Section 2 were developed to ensure that the quality of the field data is such that the data is legally and scientifically defensible and is applicable for its anticipated use. Media-specific data quality objectives, which are discussed in the generic Quality Assurance Project Plan (QAPP), have been developed based on the factors presented above. A summary of field activity methods, documentation, DQOs, and QA/QC protocols is provided in Section 2.

2. Field Investigation Procedures

A summary of objectives, equipment, and procedures for the following field activities is provided in this section:

- Field quality control samples
    - Trip blanks
    - Field blanks
    - Matrix spike/matrix spike duplicates
    - Field duplicates
- Field measurements
    - Water level measurements
    - Water quality parameters
    - Field screening of soil samples
    - Field PCB test kits
    - Data collection using GPS and data point surveys
    - Membrane interface probes
    - Radiological screening
- Sample equipment decontamination
- Monitoring wells installation and development
- Groundwater sampling
- Surface water sampling
- Sediment sampling
- Surface soil sampling
- Subsurface Soil sampling
    - Direct-push soil sampling
    - Split-barrel (split spoon) soil sampling
- Exploratory test pits and trenches
- Soil vapor and air sampling
- Community air monitoring program
- Storage and disposal of investigation derived waste
- Field documentation
- Sample handling

2.1. Field Quality Control Samples

Quality control procedures will be employed to ensure that sampling, transportation and laboratory activities do not bias sample analytical quality. Trip blanks, field blanks, duplicate samples, matrix spike samples and matrix spike duplicates will provide a quantitative basis for validating the analytical data. A summary of the anticipated QA/QC samples for each media is included in each work a ssignment.

2.1.1. Trip Blanks

The trip blanks will be prepared by the laboratory by filling 40 ml vials with a Teflon-lined septum with deionized, analyte-free water. The trip blank will accompany the day's sample containers at all times. One trip blank will be returned to the laboratory with each cooler containing aqueous samples for volatile organic compound (VOC) analysis. The trip blank will be analyzed for VOCs to detect possible contamination during shipment. Trip blanks will remain in the shipping cooler from the time of packing, in the laboratory, to arrival back at the laboratory.

2.1.2. Field Blanks

A field blank consists of an empty set of laboratory-cleaned sample containers. At the field location, deionized, analyte-free water is passed through decontaminated sampling equipment and placed in the empty set of sample containers for analysis of the same parameters as the samples collected with the sampling equipment. One field blank will be collected per every 20 environmental samples sent to the analytical laboratory, per media.

2.1.3. Matrix Spike/Matrix Spike Duplicates

Matrix spike (MS) and matrix spike duplicate (MSD) sample pairs are analyzed by the laboratory to provide a quantitative measure of the laboratory's precision and accuracy. When performing USEPA SW-846 volatile organic or organic extractable analysis with NYSDEC Category B deliverables, the laboratory must be supplied with triple sample volume for each Sample Delivery Group (SDG) in order to perform MS/MSD analyses. Blanks do not require separate matrix spike or duplicate analyses regardless of their matrix.

The limits on an SDG are:

- Each Case for field samples, or
- Each 20 field samples within a Case, or
- Each fourteen calendar day period during which field samples in a Case are received (said period beginning with receipt of the first sample in the SDG), whichever comes first.

Field personnel will specify samples for MS/MSD analysis. Extra volume is not required for aqueous samples for inorganic analysis. Non-aqueous samples (soils) do not require that any extra volume of sample be submitted to the laboratory for MS/MSD samples.

2.1.4. Field Duplicates

For each sample matrix, a field duplicate sample will be collected for the analytical laboratory at a rate of one sample per 20 environmental samples, per media. The duplicate sample is collected at the same location as the environmental sample. The field duplicate sample is identified using the sample designation system described in Section 4.12. The identity of the field duplicate is not revealed to the laboratory. The analytical results of the environmental sample will be compared to the field duplicate sample, to evaluate field sampling precision.

2.2. Field Measurements

Tasks requiring recording of field measurements include field screening of samples, evaluating the progress of monitoring well development, monitoring well sample collection, collection of soil conductivity data, in-situ measurements, surveying sampling locations, and field analysis of samples using test kits. A summary of field measurements is provided below. Specific procedures for inspection and calibration of the related field equipment are provided in Section 3.

2.2.1. Water Level Measurements

2.2.1.1. Measurement Objectives

Water levels in monitoring wells will be measured and used in conjunction with horizontal and vertical ground survey data to determine horizontal and vertical components of groundwater flow. Water level measurements will also be used to determine the volume of standing water in monitoring wells for development and purging activities. These measurements made during the initial site activities will be utilized to provide a baseline of groundwater elevations and flow at the site prior to subsequent activities.

2.2.1.2. Measurement Equipment

The following equipment will be used for the measurement of water levels:

- Electronic water level indicator and/or interface probe.
- Field logbook and pen.
- Photoionization Detector.
- Deionized Water.
- Low Phosphate Detergent.

2.2.1.3. Measurement Procedure

The first time we measure water levels at sites where VOCs are the contaminant of concern, at each monitoring well, the expansion cap will be removed and the head space and breathing zone's air quality will be monitored with a PID. This step may be omitted in subsequent rounds of water level measurements in those monitoring wells that yielded no detectable amounts of vapors or gases from prior sampling rounds. If air quality readings in the breathing space around the well exceed action levels set in the site-specific health and safety plan (HASP), appropriate measures will be taken as listed in the HASP.

The battery of the electric water level indicator will be checked by pushing the battery check button, and waiting for the audible signal to sound or the instrument light to come on. The water level indicator will be decontaminated before collecting a measurement in each monitoring well by using an alconox wash and deionized water rinse. The instrument will then be turned on and the probe will be slowly lowered into the monitoring well, until the audible signal is heard or the instrument light goes on, indicating that the sensor in the probe has made contact with the water surface in the monitoring well.

In the presence of NAPL, an interface probe, which can indicate and differentiate between the contact surfaces of NAPL and water, will be used in the place of an electric water level indicator. The probe is checked, decontaminated, and used in the same manner as an electric water level indicator. When the sensor probe makes contact with the NAPL or water surfaces in a monitoring well, an audible signal will be heard. In order to distinguish between NAPL and water surfaces, a different audible signal is used for each medium (i.e., constant signal for NAPL, intermittent signal for water).

The depth to water will be recorded to the nearest one-hundredth of a foot, from the top of the measuring mark on the monitoring well riser. The date, time, monitoring well number, and depth to water will be recorded in the field book.

2.2.2. Water Quality Parameters

Water quality parameters, including pH, conductivity, dissolved oxygen, temperature, and turbidity are often measured during monitoring well development and groundwater and surface water sampling tasks. The parameters are typically measured using a multi-parameter water quality instrument equipped with a flow-through cell (e.g., Horiba U-22 or equivalent). A Generally Acceptable Procedure (GAP) for measuring water quality parameters is provided in the Low-flow Groundwater Sampling GAP presented in Appendix A.

At a minimum, the multi-parameter water quality instrument will measure the following field parameters:

- Temperature
- Conductivity
- Dissolved oxygen (DO)
- pH
- Turbidity
- Salinity

2.2.2.1. Instrument Operation

A thermistor is used by the instrument to measure temperature. The thermistor also measures the change in electrical resistance accompanying changes in temperature. The instrument uses the temperature data in conductivity temperature conversions, DO temperature compensation, and pH temperature compensation. The unit of measurement for temperature is ºC (Celsius). The conductivity of water is determined by measuring the resistance of ion flow in between charged plates because conductivity is inversely proportional to resistance. The instrument reports conductivity as mS/cm (milli Siemen / centimeter). The instrument uses the membrane-electrode method for Dissolved Oxygen (DO). A reduction reaction in the cathode is caused by oxygen diffusing through the membrane of the sensor to create a current. This current is proportional to the concentration of oxygen dissolved in water. DO is reported as mg DO/L.

The instrument uses a glass-electrode method to determine pH. The known pH of a reference solution is determined by using two electrodes, a glass electrode and a reference electrode, and measuring the voltage (difference in potential) generated between the two electrodes. The difference in pH between solutions inside and outside the thin glass membrane creates electromotive force in proportion to this difference in pH. The reporting unit is the standard unit of pH (for example, 7.00 pH units). The instrument measures turbidity using the light-transmission scattering method. The unit for turbidity is NTU (Nephelometric Turbidity Unit).

2.2.2.2. Water Quality Measurement Procedures

The Horiba U-22 utilizes a water flow-through cell during groundwater sampling, or can be used without the cell for measuring surface water parameters. Field personnel will follow all procedures outlined for calibration and operation of the Horiba U-22 or equivalent instrument when collecting field parameter measurements. Specific procedures for operation and calibration of the multi-parameter water quality instrument are provided in Appendix B.

For measuring surface water DO, a YSI 550A Dissolved Oxygen Instrument (or equivalent) may be used in conjunction with the Horiba U-22. This instrument provides greater accuracy in surface water bodies due to better agitation of samples, and is easier to use in surface water applications. Field personnel will follow all procedures outlined for calibration and operation of the YSI 550A or equivalent DO instrument when collecting field parameter measurements. Specific procedures for operation and calibration of the DO instrument are provided in AppendixB.

2.2.3. Field Screening of Soil Samples

Soil samples are screened using a photoionization detector (PID) to assess the presence of volatile organic vapors in soil samples from split-spoon samplers, direct-push core samples, and other soil sample types. The PID will be a MiniRAE 2000 or equivalent portable-type instrument that is programmable and contains the appropriate gas-discharge lamp (9.8, 10.6, or 11.7), measured in electron-volts (eV), based on the ionization potential of the target compound.

When field screening soil samples, field personnel will follow all procedures for calibration, operation, and preventive maintenance as specified in the operating manual provided by the manufacturer (Appendix B).

2.2.3.1. Field Screening Equipment

The following equipment may be used for field screening of soil samples:

- PID (MiniRAE 2000 or equivalent)
- Self-sealing quart-size polyethylene freezer bags, or 16 ounce glass jars. Jars must be decontaminated or certified as clean from a laboratory.

2.2.3.2. Field Screening Procedures

The polyethylene bag headspace method described below is one method to screen soil samples at the site. The collapse of the polyethylene bag during analysis allows uniform flow of contaminant vapors into the PID, giving accurate readings. However, a 16 ounce, decontaminated glass jar may be substituted or the soil in the split-spoon or macro-core may be screened directly.

1. Use a self-sealing quart-size polyethylene freezer bag. Half-fill the bag with sample (the volume ratio of soil to air is equal), then immediately seal it. Manually break up the soil clumps within the bag. Alternatively, soil in the split-spoon or direct-push macro-core may be screened directly immediately after opening the sampler.
2. When using glass jars:
    - Fill jars with a total capacity or 16 oz.
    - Seal each jar with one (1) or two (2) sheets of aluminum foil with the screw cap applied to secure the aluminum foil.

Note: Headspace development decreases with temperature. When temperatures are below the operating range of the instrument, perform headspace development and analysis in a heated vehicle or building. Record the ambient temperature during headspace screening. Complete headspace analysis within approximately 20 minutes of sample collection.

3. After headspace development, introduce the instrument sampling probe through a small opening in the bag to a point about one-half of the headspace depth. Keep the probe free of water droplets and soil particles.
4. Record the highest meter response on a sampling form. Maximum response usually occurs within about two seconds. Erratic meter response may occur if high organic vapor concentrations or moisture is present.

Note: any erratic headspace data in the sampling form. Do not collect analytical samples from the polyethylene bag.

2.2.4. Field PCB Test Kits

PCB Test Kits (e.g., RaPID Assay®) will be used to provide quantitative, semi-quantitative or qualitative enzyme immunoassay (EIA) for the analysis of PCB (polychlorinated biphenyl) in water (groundwater, surface water, well water) or soil. The PCB Test Kit allows reliable and rapid screening for PCB (measured and reported as Aroclor 1254), with quantitation between 0.5 and 10 ppb (as Aroclor 1254), in water.

The PCB RaPID Assay® kit applies the principles of enzyme linked immunosorbent assay (ELISA) to the determination of PCB and related compounds. The sample to be tested is added, along with an enzyme conjugate, to a disposable test tube, followed by paramagnetic particles with antibodies specific to PCB attached. Both PCB (which may be in the sample) and the enzyme labeled PCB (the enzyme conjugate) compete for antibody binding sites on the magnetic particles. At the end of an incubation period, a magnetic field is applied to hold the paramagnetic particles in the tube and allow the unbound reagents to be decanted. After decanting, the particles are washed with Washing Solution. The presence of PCB is detected by adding the enzyme substrate (hydrogen peroxide) and the chromogen (3,3',5,5' – tetramethylbenzidine). The enzyme labeled PCB analog bound to the PCB antibody catalyzes the conversion of the substrate/chromogen mixture to a colored product. After an incubation period, the reaction is stopped and stabilized by the addition of acid.

Since the labeled PCB was in competition with the unlabeled PCB for the antibody sites, the color developed is inversely proportional to the concentration of PCB in the sample:

- Darker color = lower concentration
- Lighter color = higher concentration

The determination of the PCB level in an unknown sample is interpreted relative to the standard curve generated from kit standards after reading with a spectrophotometer.

2.2.4.1. Field PCB Test Kit Procedures

Field personnel will follow all procedures for use, calibration, and standard preparation for the RaPID Assay® Field PCB test kits provided by the manufacturer. Manufacturers' instructions for applicability, use, and QA/QC procedures for RaPID Assay® Field PCB test kits are provided in Appendix B.

2.2.5. Site and Data Point Surveys and Basemap Preparation

Sampling locations, temporary groundwater sampling points, and groundwater monitoring wells will be surveyed with accuracy and precision requirements discussed in each work assignment. Measurement of sampling points will be recorded using either a portable Global Positioning System (GPS) unit suitable for field surveys, or appropriate land surveying equipment operated by a competent land surveyor under the supervision of a New York State Licensed Land Surveyor. Survey data will be used to develop a site basemap. Basemaps will be prepared using geographic information system (GIS) software.

2.2.6. Membrane Interface Probes (MIP)

A Membrane Interface Probe with Soil Conductivity sensor (MIP-SC) will be used to provide real-time vertical characterization of subsurface soils and provide subsurface contaminant data as detailed in each work assigment. The MIP-SC system is a subsurface, continuous-logging instrument developed by Geoprobe Systems®, a division of Kejr, Inc. of Salina, Kansas, to screen for the presence of volatile contaminants in soil. The instrument is comprised of a permeable membrane and carrier gas system used to detect volatile organic compounds (VOCs) and a dipole soil conductivity measurement tip. The MIP- system will be used to qualitatively characterize shallow subsurface VOC contamination at the site, including fuel releases, chlorinated solvents, and non-aqueous phase liquid (NAPL). The MIP system also includes a soil conductivity tip to measure soil conductivity for subsurface correlation and soil characterization.

The MIP portion of the probe uses a heated permeable membrane advanced into the formation by direct-push methods. The membrane does not allow fluids to move across the membrane, allowing the instrument to function in the saturated zone. The probe is advanced into the subsurface at a speed of approximately one foot per minute. A heating element within the probe heats the membrane, which in turn heats the surrounding soil and/or groundwater in contact with the membrane, causing VOCs present in the media to volatize and diffuse through the polymer membrane (Christy, 1996). The VOCs are collected by an inert carrier gas and carried to the surface detectors through a pressurized gas return tube within the MIP trunkline. The carrier gas is fed into an applicable detector, typically an ECD, PID or FID, which qualitatively measures the VOCs. The detector output (in millivolts) is recorded versus a corrected depth measurement based on the travel time of contaminants through the carrier gas return tube as determined by membrane response testing.

The SC tool uses a dipole arrangement at the tip of the probe, in which an alternating electrical current is passed from an insulated center electrode into the formation and returned to the probe body. The response of the formation to the current is measured as a voltage drop across the dipoles, which is then used to calculate formation resistance using Ohm's Law. The formation conductivity is determined as the inverse of the resistance (1/R), typically in units of milliSiemens per meter (mS/m).

2.2.6.1. Personnel

Generally, three personnel are required to operate the drilling and MIP equipment- two crew members under the direction of the field scientist overseeing field activities. One crew member operates the direct-push drilling equipment, and the other operates the MIP controller, logging equipment, and detectors as directed by the field scientist.

The field scientist overseeing SC-MIP operation and the assisting crew member will have a working knowledge of the principals of equipment operation and QA/QC procedures. The field scientist should also be familiar with the expected output of the detectors and how this output is affected by the SC-MIP system controls.

2.2.6.2. MPI-SC Detector Selection

Detector selection is based on the subsurface contaminants expected at the site. In general:

- The FID will be used for detection of unsaturated hydrocarbons, including methane;
- A PID will be used for general VOC screening including petroleum hydrocarbons; and,
- An ECD will be used primarily for detection of chlorinated VOCs (CVOCs).

Other detectors, including DSITMS and similar low-volume gas chromatography detectors, may be used to provide qualitative analysis and differentiation of VOC and CVOC compounds. More than one detector can be used simultaneously for initial investigations where subsurface contaminant characteristics are unknown.

Regardless of the detector used, each detector will be calibrated following the instructions provided by the manufacturer. All standards, methods, and operating procedures for the selected detector will be in accordance with manufacturer specifications. Detectors and associated equipment will be operated by a competent subcontractor trained in their operation and calibration.

2.2.6.3. MIP-SC Procedures

The general field procedures for MIP-SC sampling are outlined in the GAP provided in Appendix A. A subcontractor competent and trained in the operation and calibration of MIP equipment will provide MIP-SC services and equipment at the site. The contractor will follow all requirements of the Standard Operating Procedure (SOP) for MIP-SC logging provided by the manufacturer. Calibration and preparation of standards for the MIP will be performed in accordance with manufacturer specifications.

2.2.7. Radiological Screening

A radiological survey will be conducted to evaluate the presence of low level radioactive materials at levels two times greater than the background, which will be established based on non-impacted areas at the site or adjacent sites. Specific sampling objectives will be outlined in applicable work assigments. If radiological characterization of subsurface soil and groundwater is necessary based on survey results, levels of radioactive materials in soil will be compared to NYSDEC TAGM RAD-05-01 Cleanup Guidelines for Soils Contaminated with Radioactive Materials.

All radiological screening activities will generally follow the guidelines presented in the Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) (USEPA, 1997). Procedures and methods incorporated in the MARRISM are consistent with practices accepted by the NYSDEC, USEPA, and the United States Army Corps of Engineers (ACOE).

Characterization of the extent of radiological contamination in the surface soils at the site will be conducted through a scoping survey. If radioactive contamination is discovered during the radiological screening, additional methods and protocols for subsurface sampling of soil and groundwater will be provided as an addendum to the FSP.

2.2.7.1. Radiological Screening Equipment

Radiological screening field equipment will consist of the following:

Ludlum Model 44-10 (or equivalent) sodium iodide (NaI) Gamma Scintillator coupled with a Ludlum Model 2221 (or equivalent) Scaler/Ratemeter.

- Global Positioning System (GPS) unit.
- Latex gloves (disposable).
- Neoprene gloves.
- Field logbook and pen.

2.2.7.2. Radiological Screening Procedures

A screening of the soils outside of site buildings will consist of a “walk-over” using a calibrated Ludlum Model 44-10 (or equivalent) 2-inch by 2-inch NaI Gamma Scintillator coupled with a Ludlum Model 2221 (or equivalent) Scaler/Ratemeter. This type of scan is used to detect radiological materials on the surface and in the top foot of the subsurface. Scanning will be carried out by walking over the outdoor area of the property at a speed of approximately 0.5 meters per second (about 1.5 feet per second), moving the detector in a serpentine fashion. Transects will be spaced to assure complete coverage of the area. A portable GPS unit will be used to map and record the results of the scan.

2.3. Sampling Equipment Decontamination

Cross contamination of samples from any source is to be avoided. All sampling equipment must be clean and free from the residue of any previous samples. All non-dedicated sampling equipment must be cleaned initially and prior to being re-used. The following is the procedure for decontamination and does not apply to heavy equipment or drilling equipment, with the exception of split spoons or equivalent samplers. All heavy equipment and drilling equipment will be steam cleaned in a predesignated location prior to use and between locations.

2.3.1. Equipment and Supplies

The following equipment may be needed to decontaminate equipment and tools used to collect soil, sediment and water samples:

1. Tap water for initial cleaning and rinsing of equipment.
2. Distilled water for final rinsing of equipment after tap water or solvent rinse.
3. Non-phosphate detergent (e.g., Alconox™) for cleaning equipment.
4. Dishwashing detergent to remove oily or organic residue.
5. Nitric acid as a 1% solution for removing metal contaminants from equipment
6. Isopropyl alcohol
7. Organic solvent for final cleaning of equipment (e.g., hexane or equivalent)
8. Personnel protective equipment (PPE) - including disposable gloves (Nitrile preferred), first aid kit, and waterproof outerwear (if necessary).
9. Re-sealable buckets approved for waste collection.
10. Squirt bottles for water, alcohol, and solvents.
11. Brushes for cleaning equipment.
12. Field notebooks, pens, pencils, and digital camera to document decontamination procedures.

2.3.2. Decontamination Guidelines

1. Non-dedicated soil and water sampling and processing equipment should be decontaminated between sampling intervals and between locations.

2. All solvents must be captured and disposed of in appropriate, labeled, soil or aqueous waste containers. All instruments that come into contact with the sample water must be cleaned in the same manner as the sampling device.

3. Liquids collected into the chemical waste container must be discarded in an appropriate waste stream.

4. Staff performing decontamination procedures are required to wear appropriate PPE, gloves (*e.g.*, Nitrile) and eye protection.

5. Care should be taken during cleaning to prevent cleaning solution contact with clothing. If circumstances dictate that contact will occur (*e.g.*, high wind), waterproof outer clothing (e.g., foul weather gear or rain gear) and face shields must be worn.

6. The project work plan may designate collection of equipment rinse samples to document effectiveness of cleaning.

7. This Work Plan does not address radioactive waste decontamination, PPE for radioactive waste, or disposal of radioactive contaminated waste material.

2.3.3. Decontamination Procedure

The following procedures will be followed for decontamination:

1. Disassemble item(s) (if necessary).

2. Rinse each item with tap water.

3. Thoroughly scrub the item with a brush and soapy water, using non-phosphate detergent such as Alconox™ for non-oily residue, or a detergent for items with oily or other sticky organic residue.

4. During the scrubbing process, be sure to bleed Alconox™ solution or equivalent through small passageways/nozzles/vents, etc.

5. Rinse the item with tap water to remove all residual soap. Be sure to bleed tap water through small passageways/nozzles/vents, etc.

6. Rinse the item with 10% nitric acid to remove residual metals (if deemed necessary). Be sure to bleed 10% nitric acid through small passageways/nozzles/vents, etc.

7. Rinse the item with de-ionized water. Be sure to bleed de-ionized water through small passageways/nozzles/vents, etc.

8. Rinse the item with isopropyl alcohol. Be sure to bleed isopropyl alcohol through small passageways/nozzles/vents, etc.

9. Rinse the item with de-ionized water. Be sure to bleed de-ionized water through small passageways/nozzles/vents, etc.

10. Rinse the item with organic solvent (*e.g.*, hexane or equivalent) if deemed necessary. Be sure to bleed organic solvent through small passageways/nozzles/vents, etc.

11. Rinse the item with de-ionized or analyte-free water and allow to air dry. Be sure to bleed de-ionized or analyte-free water through small passageways, nozzles, vents, etc.

12. Re-assemble item(s) (if necessary).

13. Wrap the item(s) in aluminum foil or plastic bag to protect it until it is used.

Equipment used for sampling water from monitoring wells such as pneumatic bladder pumps will be decontaminated by thoroughly washing all internal and external surfaces with soapy water and rinsing with deionized water prior to use. All tubing must be dedicated to individual monitoring wells (i.e., tubing cannot be reused). Field instrumentation will be cleaned per manufacturer's instructions (Appendix B). Probes, such as those used in pH and conductivity meters, and thermometers will be rinsed prior to and after each use with deionized water.

2.3.4. Reference

American Society for Testing and Materials (ASTM), 1994. Standard Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites. Designation: D 5088 – 90.

2.4. Monitoring Well Installation and Development

2.4.1. Installation Objectives

Permanent monitoring wells will be installed to collect groundwater samples for chemical quality analysis. Groundwater levels in the wells will be measured to evaluate the horizontal component of groundwater flow.

2.4.2. Installation Equipment

A truck-mounted rotary drilling rig equipped with 4.25-inch (or 6.25-inch) hollow-stem augers will be used to create an eight-inch (or 10.5-inch) diameter borehole. For an overburden water table well, a two-inch diameter polyvinyl chloride (PVC) screen and riser pipe will be lowered through the borehole to five to seven feet below the water table by hand and with the use of the augers. Comparable methods may be used based on site conditions and project objectives. Probes and any other large pieces of equipment that come into contact with the soil must be steam cleaned before use and between boreholes. If visibly contaminated with free phase products or any other contaminants, probes and other equipment must be decontaminated by the following the procedures in Section 2.3

2.4.3. Installation Procedures (Rotary Drilling)

A minimum of six inches of clean filter pack sand will be emplaced into the bottom of the casing. The monitoring well assembly, consisting of two-inch inner diameter (I.D.) schedule-40 PVC casing with approximately five to 10 feet of continuous 0.01-inch slot schedule-40 PVC screen, will be inserted through the augers. For overburden water table wells, monitoring well screens will be placed so that a minimum of two feet of well screen is above the water table.

Clean filter pack sand will then be poured into the annular space between the augers and the monitoring well assembly as the augers are slowly removed. The filter pack sand will extend approximately two feet above the screened interval. A minimum one-foot thick layer of bentonite pellets will be placed above the filter pack by slowly dropping the pellets along the side of the monitoring well casing. If the bentonite pellets are emplaced above the water table, they will be hydrated with potable water. The augers will then be removed as the remainder of the annulus is tremie grouted to within two feet of the ground surface with a cement-bentonite grout. The cement-bentonite grout will consist of a mixture of portland cement and water in the proportion of five to six gallons of water per 94-pound bag of cement, with approximately three to five percent bentonite powder.

2.4.4. Monitoring Well Completion

Each well will be completed with a stick-up or flush-mount manhole cover set into a one square foot concrete pad as described in the monitoring well completion GAP document provided in Appendix A.

2.4.5. Monitoring Well Development

2.4.5.1. Development Objectives

Monitoring wells installed at the site will be developed to improve their hydraulic properties by removing sediment from the monitoring well and clearing the monitoring well screen of fine particles.

2.4.5.2. Development Equipment

The following equipment will be needed to develop the monitoring wells:

- Electric water level indicator;
- Polyethylene or nalgene tubing and foot-valve;
- Bottom-filling PVC bailer;
- Bailer cord;
- Temperature, pH, dissolved oxygen, oxidation-reduction potential (ORP), specific conductivity and turbidity meters;
- Photoionization Detector;

- Field logbook and field data sheets;
- Roll of polyethylene sheeting; and
- Decontamination equipment.

2.4.5.3. Development Procedures

Monitoring well development will be conducted using one or more of the following techniques:

- Bailing.
- Inertial Pumping.
- Surge Block.

Monitoring well development will be performed no sooner than 24 hours after well installation. Prior to developing each monitoring well, the initial water level and total depth will be measured. Following well development, the total depth will again be measured to evaluate the quantity of sediment removed (if any).

All equipment placed into the monitoring well will be either decontaminated prior to its introduction into the monitoring well, in accordance with Section 2.3, or it will be dedicated. Monitoring well development will proceed with repeated alternating sequences of surging and removal of water from the monitoring well, until the discharge water is relatively sediment free.

The effectiveness of the development procedure will be monitored after each well volume has been removed by measurements of field parameters, such as turbidity, pH, ORP, temperature, and conductivity, as described in Section 2.2.2. These field measurements and other observations will be recorded on a Well Development/Purging Log, an example of which is presented in Appendix C.

In general, monitoring well development will be discontinued after a minimum of 10 well volumes have been removed and stabilization of field parameter measurements has occurred, or when the turbidity of the discharge water reaches 50 nephelometric turbidity units (NTUs) or less. Specific procedures for monitoring well development are provided in the well development GAP document provided in Appendix A.

2.5. Groundwater Sampling

2.5.1. Sampling Objectives

Groundwater samples will be collected to evaluate the nature and extent of contaminants at concentrations greater than NYSDEC Class GA standards in groundwater. Specific sampling objectives are outlined in each work assigment. Samples will also be collected from temporary monitoring points utilizing a direct-push retractable screen sampler.

2.5.2. Sampling Equipment

The following equipment may be required for groundwater sampling:

- Electric water level indicator and/or interface probe
- Peristaltic pump.
- Polyethylene or Teflon®-lined polyethylene tubing.
- Silicone tubing.
- Direct-push retractable screen sampler or equivalent for soil boring groundwater grab samples.
- Temperature, pH, dissolved oxygen, ORP, specific conductivity, and turbidity meters.
- Photoionization detector.
- Field logbook and field data sheets.
- Laboratory prepared sample containers.
- Roll of polyethylene tubing.
- Decontamination equipment.
- Disposable latex or nitrile gloves.

2.5.3. Sampling Procedures (Permanent Monitoring Wells)

Groundwater sampling will typically be conducted in accordance with the USEPA Low-Flow Sampling Protocol (USEPA, 1998). Alternative methods, such as the collection of groundwater samples with passive diffusion bags or following purging of three well volumes, may be used at some sites based on project requirements and site conditions. Specific procedures are provided in the low-flow groundwater sampling and passive diffusion bag GAPs provided in Appendix A. General low-flow sampling procedures using a peristaltic pump are summarized below.

This step may be omitted in those monitoring wells which have already demonstrated in the previous rounds of water level measurement that they contain no or insignificant amounts of volatile organic vapors. The PID will be calibrated before the start of each sampling event.

Clean, new polyethylene or Teflon®-lined polyethylene tubing will be lowered into the water column to a maximum depth of two feet above the bottom of the monitoring well. The polyethylene tubing will be connected to a piece of silicone tubing that is inserted into the mechanical rollers of a peristaltic pump. By using the process of mechanical peristalsis, the peristaltic pump draws groundwater through the tubing to the surface, so that a sample can be collected. The well will be purged at a rate suitable to minimize drawdown. Field parameters, consisting of pH, specific conductance, temperature, dissolved oxygen, ORP, and turbidity will be measured in each sample collected from a monitoring point through the use of individual meters. Both the pH and the specific conductivity meters will be calibrated for water temperature before each sampling event.

The volume of water removed from each monitoring well will be dependent upon the amount of time required for stabilization of the field parameters. In general, the well will be considered stabilized for sample collection when field parameters have stabilized for three consecutive readings as follows:

■ pH:	+/- 0.1 standard units
■ Specific Conductance:	+/- 3%
■ Oxidation-Reduction Potential:	+/- 10 millivolts
■ Dissolved Oxygen	+/- 10%
■ Turbidity	+/- 10%

When the field parameters have stabilized, the volume of water purged will be recorded, and the monitoring point will be sampled in the same manner as was used to purge the well. Once a groundwater sample is collected from the well, the polyethylene tubing will be disposed of as ordinary solid waste.

After recording field measurements, the analytical parameters and order of sample collection for groundwater samples will be:

1. TCL VOCs;
2. TCL SVOCs.
3. Other Parameters (TAL Metals, Pesticides, PCBs, etc.)

The sample bottles will be pre-preserved by the laboratory. The sample bottles will be immediately placed in a cooler held at 4°C. Disposable latex or nitrile gloves will be worn by the sampling personnel and changed between sampling points. Data to be recorded in the field logbook will include purging and sampling methods, depth to water, volume of water removed during purging, pH, temperature, ORP, dissolved oxygen, turbidity, and specific conductivity values, and PID readings.

Groundwater that is purged from monitoring wells will be discharged to the ground surface within 50 feet of each monitoring well location in accordance with the NYSDEC Proposed Technical and Administrative Guidance Memorandum (TAGM) - Disposal of contaminated groundwater generated during Site Investigations, if the following criteria are met:

1. There is a defined site which is the source of the groundwater contamination;

2. There is no free product observed such as DNAPLs or LNAPLs;

3. The infiltrating groundwater is being returned to the same water bearing zone from which it is being purged;

4. Prior approval has been granted by the NYSDEC project manager.

If there is no recharge surface (i.e., grass, uncovered soil, etc.) located within 50 feet of a well, then the purge water will be containerized and disposed of off-site. Purge water requiring off-site disposal will be handled in accordance with Section 2.13.

2.5.4. Sampling Procedures (Temporary Sampling Points)

A direct-push retractable screen sampler or equivalent will be utilized to collect discrete groundwater samples at various depths at each location. A 1 ¾-inch hollow push rod with a steel drop off tip will be advanced to a designated depth and then retracted. When the push rod is retracted a filter screen is exposed, allowing groundwater to hydrostatically enter the inlet screen from the formation. Clean, new Teflon®-lined polyethylene tubing will be lowered into the water column to a maximum depth of two feet above the bottom of the monitoring well. The polyethylene tubing will be connected to a piece of silicone tubing that is inserted into the mechanical rollers of a peristaltic pump. By using the process of mechanical peristalsis, the peristaltic pump draws groundwater through the tubing to the surface, so that a sample can be collected. Field parameters, consisting of pH, specific conductance, temperature, dissolved oxygen, ORP, and turbidity will be measured in each sample collected from a monitoring point through the use of individual meters. Both the pH and the specific conductivity meters will be calibrated for water temperature before each sampling event.

The volume of water removed from each sampling point will be dependent upon the amount of time required for stabilization of the field parameters. In general, the point will be considered stabilized for sample collection when field parameters have stabilized for three consecutive readings as follows:

■ pH:	+/- 0.1 standard units
■ Specific Conductance:	+/- 3%
■ Oxidation-Reduction Potential:	+/- 10 millivolts
■ Dissolved Oxygen	+/- 10%
■ Turbidity	+/- 10%

When the field parameters have stabilized, the volume of water purged will be recorded, and the sampling point will be sampled in the same manner as was used to purge the well. The purge water will be handled in accordance with Section 2.5.3.

After taking field measurements, the analytical parameters and order of sample collection for groundwater samples will be:

1. TCL VOCs;
2. TCL SVOCs.
3. Other Parameters (TAL Metals, Pesticides, PCBs, etc.)

The sample bottles will be pre-preserved by the laboratory. The sample bottles will be immediately placed in an insulated cooler maintained at 4°C. Disposable latex or nitrile gloves will be worn by the sampling personnel and changed between sampling points.

2.6. Surface Water Sampling

2.6.1. Sampling Objectives

Surface water samples are collected from lakes, streams, rivers, stormwater catch basins, etc. to evaluate the nature and extent of contaminants of concern at concentrations greater than NYSDEC surface water standards.

2.6.2. Sampling Equipment

The following equipment will be needed to collect groundwater samples for analysis:

- Glass beaker.
- Laboratory prepared sample containers.
- Temperature, pH, dissolved oxygen, ORP, specific conductivity and turbidity meters.
- Field logbook and field data sheets.
- Disposable latex or nitrile gloves.

2.6.3. Sampling Procedures

The surface water sample will be collected directly from the surface water body by partially submerging a pre-cleaned glass beaker or unpreserved sample container into the surface water. The glass beaker will be allowed to fill slowly and continuously. Once the glass beaker is completely filled, the surface water will be transferred directly into the laboratory-provided sample containers by slightly tilting the mouth of the sample bottle below the beaker edge. Surface water in the beaker will be emptied slowly into the sample bottle to minimize the disturbance created during transfer. If the surface water is not at the surface, a stainless steel dipper will be utilized to collect a sample. The dipper will be lowered into the water and brought to the surface with minimal disturbance. The transfer of surface water from the dipper to the sample bottles will be the same as the procedure described using a beaker described above.

Field parameters, consisting of pH, specific conductance, temperature, dissolved oxygen, ORP, and turbidity will be measured prior to the collection of the sample. Both the pH and the specific conductivity meters will be calibrated for water temperature before the sampling event.

After taking field measurements, the analytical parameters and order of sample collection for groundwater samples will be:

1. TCL VOCs;
2. TCL SVOCs.
3. Other Parameters (TAL Metals, Pesticides, PCBs, etc.)

The sample bottles will be pre-preserved by the laboratory. The sample bottles will be immediately placed in an insulated cooler maintained at 4°C. Disposable latex or nitrile gloves will be worn by the sampling personnel and changed between sampling points.

2.7. Sediment Sampling

2.7.1. Sampling Objectives

Sediment samples will be collected to evaluate the nature and extent of contaminants at concentrations greater than 6 NYCRR Subpart 375-6 Remedial Program cleanup objectives, the NYSDEC Technical Guidance for Screening Contaminated Sediments criteria, or site-specific standards. The objectives of a sediment sampling program are to assess the nature and extent of sediment contamination and evaluate the need for remediation. The location of each surface soil sample will be measured relative to permanent site features or recorded using a GPS device and marked on a site diagram in the field logbook. Additionally, all sediment sampling locations in shallow water will be marked in the field with a survey stake and labeled with the sample I.D. to facilitate subsequent surveying of the sampling location.

2.7.2. Sampling Equipment

The following equipment will be needed to collect sediment samples for analysis:

- Stainless steel trowel, shovel, or scoop
- Stainless steel bowl
- Appropriate sampling device and/or transfer device

2.7.3. Sampling Procedures

In general, the following considerations should be taken into account during sediment sampling activities:

- Collect the sediment sample after the surface water sample if both media are to be sampled at the same location.
- Collect downstream sediment samples before upstream samples.
- Do not stand in the sediment deposits being sampled.
- Twigs, leaves roots, grass, and rocks are not considered part of the sediment matrix and will be removed from the sample.

- If collected as a composite, collect at least three small, equal-sized sediment sample aliquots. Carefully composite the sample in a stainless steel mixing bowl prior to homogenization and filling of the sample containers.

The preferred order of sample collection is as follows:

- In-situ measurements (i.e., temperature, pH and specific conductance)
- Volatile Organics (VOA) – Do not use homogenization or composite sampling techniques when sampling volatile compounds – collect a grab sample.
- Semi-volatile Organics (SVOA)
- TAL Metals
- Radionuclides and other parameters

Collect the VOA fraction using the stainless steel trowel/scoop or other sampling device, avoiding the collection of rocks, twigs, leaves and other debris. Fill the VOA sample containers to zero headspace, directly from the sampling device.

For non-VOA sample fractions, remove the sample from the sampling device or stainless steel trowel/scoop, avoiding the collection of rocks, twigs, leaves and other debris, and place the sample into a stainless steel bowl, then follow the procedure for homogenization:

1. Thoroughly mix the sample, using the same stainless steel trowel or scoop, as used during the sample collection. The sediment in the bowl should be scraped from the sides, corner and bottom, rolled to the middle of the bowl and initially mixed.
2. The sample should be quartered and separated.
3. Each quarter should be mixed individually and then rolled to the center of the bowl.
4. Mix the entire sample again.
5. Fill sample containers in the order specified above or as described in the work assignment.
6. Transfer the homogenized non-VOA fraction into the appropriate sample containers using the same stainless steel trowel or scoop used throughout this entire procedure.

Decontaminate sampling equipment between each location following the procedures discussed in Section 2.3.

2.8. Surface Soil Sampling

2.8.1. Sampling Objectives

Surface soil samples will be collected to evaluate the nature and extent of contaminants at concentrations greater than 6 NYCRR Subpart 375-6 Remedial Program cleanup objectives. The objectives of a surface soil sampling program are to assess the nature and extent of soil contamination and evaluate the need for remediation. The location of each surface soil sample will be measured relative to permanent site features or recorded using a GPS device and marked on a site diagram in the field logbook. Additionally, all sampling locations will be marked in the field with a survey stake and labeled with the sample I.D. to facilitate subsequent surveying of the sampling location.

2.8.2. Sampling Equipment

The following equipment may be required for surface soil sampling:

- Hand Augers (multiple size stainless steel buckets)
- Labels
- Power Auger (if required for 2+ foot depth)
- Cooler
- Stainless steel trowels
- Field log book
- Shovels (to remove gravel and debris)
- Soils Data form, Daily QC form, etc.
- Plastic sheeting and/or aluminum foil
- Decontamination equipment as required
- Appropriate sample bottles
- Hand tools (for equipment or other needs)
- Plastic bags (sealable)
- Camera and film
- Compass
- 200 ft tape

2.8.3. Sampling Procedures

Surface soil samples may be collected at the same location as a soil boring, but is not required. In the event that the surface soil sample is in the same location as a soil boring, a surface soil sample will be collected prior to initiation of boring and sampling.

Vegetation at the sample location is removed by cutting or scraping away with a stainless steel trowel. Twigs, leaves roots, grass, and rocks are not considered part of the soil matrix and will be removed from the sample. Remove gravel or other debris from the surface before advancing the auger or trowel to a depth of approximately six inches. Using pre-cleaned stainless steel equipment, extrude the soil directly into the sampling containers. If dedicated sampling equipment is not used, sampling equipment must be decontaminated before collecting another sample.

Samples for VOC analysis must be collected first. Fill VOC sample containers as full as possible to minimize headspace losses. Fill separate containers with a sufficient quantity of soil for analyses of other required parameters. Samples will be immediately placed in an insulated cooler and maintained at a temperature of 4°C. Enter all data into a permanent field log book. VOC samples will be collected as grab samples.

Other samples may be collected as grab samples or composite samples. For composite samples, a volume of soil 6 inches by 6 inches by 2 inches deep (72 cubic inches) will be collected using a stainless steel trowel and transferred to a stainless steel mixing bowl. Upon collection, the sample will be homogenized in a stainless steel bowl and classified. Twigs, leaves roots, grass, and rocks are not considered part of the soil matrix and will be removed from the sample. After the soil is homogenized, a sample will be placed in laboratory-provided sample containers.

A qualified geologist will describe the soil samples, screen the soil samples for VOCs with a PID, and record any observations in the field log. The location(s) for collection of field duplicates, field blanks, and matrix spike/matrix spike duplicate samples shall be determined in the field.

Sampling equipment will be decontaminated as discussed in Section 2.3. Disposable gloves will be worn by the sampling personnel and changed between sampling points.

2.9. Subsurface Soil Sampling

2.9.1. Soil Sampling Objectives

Soil samples will be collected at discrete depth intervals to evaluate the nature and extent of contaminants at concentrations greater than 6 NYCRR Subpart 375-6 Remedial Program cleanup objectives in subsurface soil and to document the underlying stratigraphy. Analytical data will be used to evaluate the need for remediation.

2.9.2. Soil Sampling Equipment

The following equipment may be used to collect soil samples:

- Photoionization Detector.
- Roll of polyethylene sheeting.

- Stainless steel spatula or spoon.
- Stainless steel trowel.
- Stainless steel bowl.
- Disposable nintrile or latex gloves.
- Certified, pre-cleaned sample containers.
- Aluminum foil.
- Field logbook and pen.
- Decontamination equipment.

2.9.3. Soil Sampling Procedures

2.9.3.1. Direct-push Soil Sampling

A direct-push drill rig (e.g., Geoprobe® or equivalent) will drive a dual-tube sampler, blind probe, or similar direct push system into the subsurface to create a borehole approximately 1.5 to two inches in diameter. Subsurface soil samples will be removed from the borehole in four- or five-foot intervals in acrylic tubes. The total number of four- or five-foot tubes collected from each soil boring will be dependent on the final depth of the boring.

Before the soil is characterized and the boring is logged, the plastic tube will be cut along its length and the soil core will be screened for VOCs using a PID. A qualified geologist will characterize the soil samples and record observations in the field log. A standard boring log is provided in Appendix C.

Soil samples designated for VOC analysis shall be collected directly from the sampling device. Each grab sample will be placed in laboratory-provided sample containers. Samples will be immediately placed in a cooler and held at 4ºC until the samples are sent to a NYSDOH ELAP and NYSDEC ASP-certified laboratory and analyzed for the applicable analyses. The location(s) for collection of field duplicates, field blanks, and matrix spike/matrix spike duplicate samples shall be determined in the field based on subsurface soil conditions.

Other samples may be collected as grab samples or composite samples, directly from the sampling device. For composite samples, soil will be directly from the sampling tube and transferred to a stainless steel mixing bowl, where it will be homogenized. After the soil is homogenized, a sample will be placed in laboratory-provided sample containers.

Sampling equipment will be decontaminated as discussed in Section 2.3. Disposable gloves will be worn by the sampling personnel and changed between sampling points.

2.9.3.2. Split-barrel (Split-spoon) Sampling

When direct-push sampling is not practical, a 24-inch long stainless steel split-barrel sampler can be driven a total of 24 inches into the undisturbed materials by typically dropping a 140-lb weight 30 inches. A 3- inch diameter split spoon may be used to increase the chances of sufficient volume recovery for sampling purposes. Split spoon samples will be collected in accordance with the American Society for Testing and Materials (ASTM) Method D 1586-99: Standard Test Method for Penetration Test and Split-barrel Sampling of Soils (ASTM, 1999).

Soil samples will be collected from the split-barrel sampler following the procedure described in Section 2.9.3.1.

2.10. Exploratory Test Pits and Trenches

Test pits and trenches will be excavated to determine stratigraphy to a maximum depth of approximately 15 feet. A contractor will be required to provide the backhoe or other equipment and an operator. Soil samples will be collected at various depths within the test pit as detailed below. A test pit excavation program will include recording of visual observations and information on the nature of the soil, including whether or not it is native soil or fill.

2.10.1. Test Pit Sampling Equipment

Materials useful for test pit excavations include the following:

- Test Pit Log
- Site Map
- Camera
- Measuring Tape
- Photoionization Detector (PID)
- Excavation Equipment
- Sheet polyethylene, hay bales, etc. for staging of excavated soil in compliance with appropriate erosion control/soil placement requirements.

2.10.2. Test Pit Sampling Procedures

A test pit log (Appendix C) should be provided for each test pit to record observations. The form will include information on the location of the test pit in relation to permanent site features, the excavated soil, and any other relevant observations, as listed below:

- Date test pit excavation was started/finished
- Test pit number
- Site/project/client name

- Project number
- Your name
- Surface conditions, such as asphalt, concrete, grass, mud, etc.
- Weather and temperature
- Excavation equipment make and model
- Contractor company name and personnel
- Site location

Prior to test pit excavation, site personnel will determine if there are any problems accessing the test pit location:

- Obtain underground utility clearance.
- Confirm that there are no overhead obstructions.
- Describe approximate location relative to landmarks and provide a sketch on test pit log.
- Create a contingency plan to enact if drums or other potentially hazardous materials are encountered during excavation.

Soil sampling procedures during test pit operations will be the same as those described for surface soil sampling (Section 2.8). In addition to documentation requirements for soil sampling, the following will also be noted during test pit sampling, and recorded on the test pit log (Appendix C):

- Describe the soil excavated, including color, texture, consistency, and moisture at a specific depth interval (e.g. every one or two feet)
- Record if there are any odors and, if so, describe.
- If appropriate, take and record a PID measurement at each depth interval.
- Collect soil samples at predetermined depths or as appropriate based on site conditions. Record sample number on test pit log.
- Sketch a cross section of the test pit showing any relevant observations.

2.11. Air and Soil Vapor Sampling

2.11.1. Air and Soil Vapor Sampling Objectives

Air and soil vapor sampling is intended to evaluate the potential for migration of VOCs from the subsurface into indoor air and the potential for current and future human exposures related to soil vapor intrusion. Indoor air, ambient air, soil vapor, and sub-slab vapor samples will be collected to evaluate the nature and extent of VOCs in these media. Ambient air samples will be collected from outside of the building to provide information on background VOC concentrations. Sub-slab soil vapor samples will be collected from just below the concrete slab of a building to evaluate the potential for soil vapor intrusion.

2.11.2. Air Sampling Equipment

Air and sub-slab soil vapor samples will be collected using a Summa canister sampling train. The typical Summa canister sampling train consists of the following:

- Summa canister.
- Flow controller.
- Particulate filter.
- Pressure gage.
- Fittings and a sampling line.

The laboratory will evacuate the canister to a minimum vacuum of negative 28 inches (± 2 inches) of mercury (in. Hg) prior to sampling. After sampling, the final vacuum will be recorded on a chain of custody form to confirm sample integrity. A pressure gage will be used to monitor the vacuum before, during, and after sampling. A seven micron particulate filter will be used upstream of the flow controller to prevent blockage of the flow controller. The sampling line will consist of new, unused, ¼-inch diameter flexible Teflon® tubing. All parts of the sampling train coming into direct contact with the sample will be made of stainless steel or Teflon®. The following general set-up procedure will be followed for each sampling location:

1. Place Summa canister at sampling location.
2. Note the environmental conditions in the sample area on the air sampling sheet.
3. Assemble the Summa canister sampling train. Follow the laboratory instructions for pressure measurement, particulate filter placement, and flow controller attachment.
4. Begin sampling following the procedures described below.

2.11.3. Indoor and Ambient Air Sampling Procedures

Indoor and ambient air samples will be collected in accordance with the NYSDOH Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (2006) and the Generally Acceptable Procedure for Air Sampling with Summa Canisters (Appendix A). The procedures implemented for the collection of indoor and ambient air samples are summarized as follows:

1. Remove the brass plug fitting covering the 6-liter stainless steel Summa canister sampling port using a wrench.
2. Connect the pressure gage or flow controller with integral pressure gage to the Summa canister sampling port. Open the valve on the canister and quickly measure the vacuum within the canister. If the vacuum is greater than negative 25 inches of

mercury, then the canister is acceptable for sampling. Any canisters with a vacuum less than negative 25 inches of mercury should not be used for sampling. Close the valve and record the measurement on the sampling sheet.

3. Assemble the sampling train. Each fitting should be hand tightened and then tightened with a wrench approximately ¼ turn.
4. Confirm that the sampling train is air tight by conducting a vacuum test. Place the brass cap at the end of the sampling train (particulate filter), quickly open and close the sampling valve and monitor the vacuum on the pressure gage. If the vacuum decreases, there is a leak in the system. All of the fittings should be rechecked and the vacuum test redone.
5. Initiate sampling by opening the Summa canister valve. Record starting time on the sampling sheet.
6. During sampling, the pressure will be monitored periodically to ensure that the flow controller is operating properly.
7. When the time corresponding to the calibrated flow controller (for indoor air – 24 hours) has elapsed, close the canister valve. Disassemble the sampling train. Check the vacuum within the canister using the pressure gage and record the measurement on the sampling sheet.
8. Since the flow rate into the canister can fluctuate due to variations in atmospheric conditions, the measured final vacuum may range from 4 to 12 in. Hg. If the measured vacuum is greater than 12 in. Hg or less than 3 in. Hg, the sample may be flagged and re-sampling may be needed.
9. Place the brass cap on the sampling port of the canister and tighten. The air sampling is complete.
10. Place the air sample in the travel box and complete the chain-of-custody forms and identification tag on the canister.
11. Send the canister to the laboratory via next day airmail service for analysis of VOCs by Method TO-15.

2.11.4. Sub-slab and Soil Vapor Sampling Procedures

Sub-slab vapor and soil vapor sampling points will be constructed in the same manner at all sampling locations to minimize possible discrepancies. Sub-slab vapor and soil vapor sampling points will be constructed in compliance with the procedures outlined in the NYSDOH Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (2006).

The building's heating system will be operating to maintain normal indoor air temperatures (i.e., 65 – 75 °F) for at least 24 hours prior to and during the scheduled sampling time. Prior to installation of the sub-slab vapor probe, the building floor will be inspected and any penetrations (cracks, floor drains, utility perforations, sumps, etc.) will be noted and recorded. Probes will be installed at locations where the potential for ambient air infiltration via floor penetrations is minimal.

Temporary sub-slab vapor sampling points will be constructed in accordance with the NYSDOH Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (2006) and will include the following:

- Drill a 1-inch diameter hole approximately 1-inch into the concrete floor slab using an electric hammer drill.
- Drill a 1/4-inch diameter hole through the 1-inch hole completely through the concrete floor slab, but extending no further than 2 inches below the bottom of the floor slab.
- Insert inert tubing, such as Teflon or Teflon-lined polyethylene tubing (¼-inch outside diameter [OD]), approximately 3 feet long; into the hole drilled in the floor, extending to the bottom of the floor slab.
- Seal the tubing at the floor penetration with bentonite, melted bees wax, or modeling clay ensuring that an effective seal has been established.
- Attach a syringe to the sampling tube and purge approximately 100 mL of air/vapor at a consistent flow rate that is less than or equal to 0.2 liters per minute. The syringe will be capped and the air released outside the building or into a Tedlar® bag using a three-way valve so as not to influence the indoor air quality.

Permanent sub-slab vapor sampling points will be constructed in accordance with the USEPA draft Standard Operating Procedure (SOP) for Installation of Sub-Slab Vapor Probes and Sampling Using EPA Method TO-15 to Support Vapor Intrusion Investigations and will include the following:

- 1.5-inch and ¼-inch holes will be drilled using the same methods described above for temporary sub-slab vapor sampling points.
- Recessed probes will be constructed with brass or stainless steel fittings and inert tubing (e.g., polyethylene, stainless steel, nylon, Teflon®, etc.) of the appropriate size (approximately 1/8-inch to ¼-inch diameter), and of laboratory or food grade quality;
- Tubing will not extend beyond the base of the concrete slab;
- Implants will be sealed to the slab with non-VOC-containing and non-shrinking cement grout.

Soil vapor probes will be semi-permanent and will be installed in accordance with the NYSDOH Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (2006). The actual locations of the points will be dependent on the locations of subsurface utilities. In general, the target depth for each of the soil vapor points will be the basement floor level of the adjacent residential structures or just above the groundwater table, whichever is shallower. The soil vapor points will be installed using a direct-push drilling rig to advance a borehole and collect soil samples continuously to the target depth. Upon reaching the target depth, a six-inch small-diameter stainless steel screen attached to Teflon or Teflon-lined tubing will be lowered to the bottom of the borehole. The bottom one-foot of the borehole will then be backfilled with clean silica sand. The remaining borehole annulus will be backfilled to the surface with hydrated bentonite. The point will be completed with a stick-up or flush mount casing.

To obtain representative samples that meet the data quality objectives, sub-slab and soil vapor samples will be collected in accordance with the NYSDOH Final Guidance for Evaluating Soil Vapor Intrusion in the State of New York (2006) and summarized as follows:

- To ensure samples collected are representative, one to three volumes (i.e., the volume of the sample probe and tube) will be purged using disposable syringes after installation of the probes and prior to collecting the samples;
- A vacuum will not be used to clear the sample hole after boring through the sub slab;
- Sample flow rates for both purging and collecting must will not exceed 0.2 liters per minute to minimize ambient air infiltration during sampling;
- If requested by the NYSDEC project manager, a helium tracer gas will be used to verify the integrity of the sub-slab vapor point seal. Prior to sampling the sub-slab vapor, the atmosphere in the immediate vicinity of the area where the vapor point tubing intersects the ground will be enriched with the tracer gas. This will be accomplished by using an inverted plastic pail to keep the tracer gas in contact with the vapor point during testing. A portable monitoring device (specific to the tracer gas) will be used to analyze a sample of sub-slab vapor for the tracer gas prior to and after sampling for VOCs. If the tracer gas is detected at a concentration of less than 10 percent, it will be assumed that the probe is sealed and the vapor sample has not been diluted by surface air;
- Samples will be collected, using conventional sampling methods as described in Section 2.11.3, in a laboratory-certified Summa canister that is consistent with the sampling and analytical methods;
- Summa canisters will be either batch or individually certified as analyte free by the laboratory; and
- Samples will be collected over the same period of time as concurrent indoor and outdoor air samples.

2.12. Community Air Monitoring Program

To provide a measure of protection for any potential downwind receptors, and to confirm that work activities do not generate airborne contaminants, Malcolm Pirnie will conduct continuous monitoring for volatile organic compounds (VOCs) and particulate matter (dust) during all ground intrusive activities. Monitoring will be conducted at the downwind perimeter of each work area.

2.12.1. VOC Monitoring, Response Levels, and Actions

Volatile organic compounds (VOCs) will be monitored on a continuous basis during all ground-intrusive activities. Upwind concentrations will be measured at the start of each workday and periodically thereafter to establish background conditions. VOC monitoring will be conducted using a MiniRae 2000 photoionization detector (PID) or PPB Rae PID (or equivalent meter). The PID will be calibrated at least daily using the span calibration gas recommended by the manufacturer. The PID measurements will be compared to the action levels specified below.

Action Levels

- If the ambient air concentration of total organic vapors at the downwind perimeter of the work area or exclusion zone exceeds 5 parts per million (ppm) above background for the 15-minute average, work activities will be temporarily halted and monitoring continued. If the total organic vapor level readily decreases (per instantaneous readings) below 5 ppm over background, work activities will resume with continued monitoring.

- If total organic vapor levels at the downwind perimeter of the work area or exclusion zone persist at levels in excess of 5 ppm over background but less than 25 ppm, work activities will be halted, the source of vapors identified, corrective actions taken to abate emissions, and monitoring continued. After these steps, work activities will resume provided that the total organic vapor level 200 feet downwind of the exclusion zone or half the distance to the nearest potential receptor or residential/commercial structure, whichever is less - but in no case less than 20 feet, is below 5 ppm over background for the 15-minute average.

- If the organic vapor level is above 25 ppm at the perimeter of the work area, all work activities will be stopped.

2.12.2. Particulate Monitoring, Response Levels, and Actions

Particulate concentrations will be monitored continuously at the upwind and downwind perimeter of the each work area during all ground-intrusive activities. Real-time monitoring equipment capable of measuring particulate matter less than 10 micrometers in size (PM-10) and capable of integrating over a period of 15 minutes (or less) will be used for the particulate monitoring. The equipment will be equipped with an audible alarm to indicate exceedance of the action levels summarized below. Any fugitive dust migration will also be visually assessed during all work activities.

Action Levels

- If the downwind PM-10 particulate level is 0.1 milligrams per cubic meter (mg/m^3) greater than background (upwind perimeter) for the 15-minute period or if airborne dust is observed leaving the work area, then dust suppression techniques will be employed. Work will continue with dust suppression techniques provided that downwind PM-10 particulate levels do not exceed 0.15 mg/m^3 above the upwind level and provided that no visible dust is migrating from the work area.
- If, after implementation of dust suppression techniques, downwind PM-10 particulate levels are greater than 0.15 mg/m^3 above the upwind level, work will be stopped and a re-evaluation of activities initiated. Work will resume provided that dust suppression measures and other controls are successful in reducing the downwind PM-10 particulate concentration to within 0.15 mg/m^3 of the upwind level and in preventing visible dust migration.

All particulate monitoring measurements readings will be recorded and made available for NYSDEC and NYSDOH review.

2.13. Storage and Disposal of Investigation Derived Waste

Investigation derived wastes (IDW) will be handled in accordance with the NYSDEC Final TAGM for the Disposal of Drill Cuttings. Soil cuttings and purged water requiring off-site disposal will be containerized in UN-approved, 55-gallon steel drums. Some disposable personal protective equipment (PPE) and decontamination fluids will be generated. Attempts will be made to wash surface contamination off so that PPE (i.e., gloves and other disposable items) may be disposed of as ordinary solid waste. If contamination is suspected, these materials will be collected and containerized in UN-approved, 55-gallon steel drums (separately from contaminated soil and groundwater) and disposed of off-site.

Containerized materials will be labeled and staged at a location designated by the NYSDEC. Malcolm Pirnie will maintain a log of the containers and their contents. The contents will be evaluated upon receipt of analytical results from the field investigations. Containerized IDW will be transported by a licensed waste hauler and disposed of at an approved facility in accordance with applicable regulations.

2.14. Field Documentation

Documentation of an investigative team's field activities often provides the basis for technical site evaluations and other such related written reports. All records and notes generated in the field will be considered controlled evidentiary documents and may be subject to scrutiny in litigation.

Personnel designated as being responsible for documenting field activities must be aware that all notes may provide the basis for preparing responses for legal interrogatories. Field documentation must provide sufficient information and data to enable reconstruction of field activities. Numerically serialized field logbooks provide the basic means for documenting field activities. The following information must be provided on the inside front cover of each field logbook:

- Project Name (Site Name).
- Site Location.
- Site Manager.
- Date of Issue.

Control and maintenance of field logbooks is the responsibility of the Field Team Leader.

2.14.1. Sample Designation

A sample numbering system will be used to identify each sample. This system will provide a tracking procedure to allow retrieval of information about a particular sample, and will assure that each sample is uniquely numbered. The sample identification will consist of at least three components as described below. Identification numbers for soil boring samples will also have a fourth component.

Project Identification: The first component consists of a two- or three-letter designation, which identifies the project site.

- Sample type: The second component, which identifies the sample type, will consist of a two-letter code as follows:
  - IA - Indoor Air
  - AA - Ambient Air
  - MW - Monitoring Well (Groundwater Sample)
  - SB - Soil Boring
  - SS - Surface Soil
  - SV - Soil Vapor
  - SW - Surface Water
- Sample Location: The third component identifies the sample location using a two-digit number.
- Sample Identification: The fourth component will only be used for soil boring samples to indicate the vertical interval from which the sample was collected.
- Quality Assurance/Quality Control Samples: The samples will be labeled with the following suffixes:
  - FB - Field Blank

- MS - Matrix Spike
- MSD - Matrix Spike Duplicate
- TB - Trip Blank

Duplicate samples will be numbered uniquely as if they were samples. A record of identification for duplicate samples will be maintained.

Examples of identification numbers are given below:

XX-SB-02-10:	Soil boring, boring location number 2, 10 feet below ground surface.
XX-MW-03-MSD:	Monitoring well groundwater sample, monitoring well sample location 3, matrix spike duplicate.
XX-SS-FB:	Field blank for surface soil sample.

2.14.2. Documentation of Field Activities

Field logbook entries must be legibly written and provide an unbiased, concise, detailed picture of all field activities. Use of preformatted data reporting forms must be identifiable and referenced to field notebook entries.

Step-by-step instructions and procedures for documenting field activities are provided below and in following sub-sections. Instruction and procedures relating to the format and technique in which field logbook entries are made are as follows:

- Leave the first two pages blank. They will provide space for a table of contents to be added when the field logbook is complete.
- The first written page for each day identifies the date, time, site name, location, Malcolm Pirnie personnel and their responsibilities, other non-personnel and observed weather conditions. Additionally, during the course of site activities, deviations from the work plan must also be documented.
- All photos taken must be traceable to field logbook entries. It is recommended to reference photo locations on the site sketch or map.
- All entries must be made in ink. Waterproof ink is recommended.
- All entries must be accompanied by the appropriate military time (such as 1530 instead of 3:30).
- Errors must be lined through and initialed. No erroneous notes are to be made illegible.
- The person documenting must sign and date each page as it is completed.
- Isolated logbook entries made by a team member other than the team member designated responsible for field documentation, must be signed and dated by the person making the entry.

- Additions, clarifications, or corrections made after completion of field activities must be dated and signed.

2.14.3. General Site Information

General site characteristics must be recorded. Information may include:

- Type of access into facility (locked gates, etc.).
- Anything that is unexpected on-site (e.g., appearance of drums that have not been previously recorded).
- Information obtained from interview with access or responsible party personnel (if applicable), or other interested party contact on-site.
- Names of any community contacts on-site.
- A site map or sketch may be provided. It can be sketched into the logbook or attached to the book.

2.14.4. Sample Activities

A chronological record of each sampling activity must be kept that includes:

- Explanation of sampling at the location identified in the sampling plan (e.g., discolored soil, stressed vegetation).
- Exact sample location, using permanent recognizable landmarks and reproducible measurements.
- Sample matrix.
- Sample descriptions, i.e., color, texture, odor (e.g., soil type) and any other important distinguishing features.
- Decontamination procedures, if used.

As part of chain-of-custody procedures, recorded on-site sampling information must include sample number, date, time, sampling personnel, sample type, designation of sample as a grab or composite, and any preservative used. Sample locations should be referenced by sample number on the site sketch or map. The offer and/or act of providing sample splits to a thirty party (e.g., the responsible party representative; state, county, or municipal, environmental and/or health agency, etc.) must be documented.

2.14.4.1. Soil Vapor and Ambient Air Sampling Information

In addition to the above information, the following will be documented during sub-slab soil vapor sample collection:

- Historic and current storage and uses of volatile chemicals;
- Type and operation of heating or air conditioning systems during sampling;
- Floor plan sketches that document the floor layout with sampling locations, chemical storage areas, garages, doorways, stairways, location of basement sumps or

subsurface drains and utility perforations through building foundations, HVAC system air supply and return registers, footings that create separate foundation sections;

- Weather conditions (e.g., precipitation and indoor and outdoor temperature) and ventilation conditions (e.g., heating system active and windows closed); and,
- Any additional pertinent observations, such as spills, floor stains, smoke tube results, odors and readings from field instrumentation.

The field sampling team will maintain a sample log sheet for each soil vapor sample location that includes the following:

- Sample identification;
- Date and time of sample collection;
- Sampling depth;
- Identity of samplers;
- Sampling methods and devices;
- Soil vapor purge volumes;
- Volume of soil vapor extracted;
- Vacuum of canisters before and after samples collected;
- Apparent moisture content (dry, moist, saturated, etc.) of the sampling zone; and,
- Chain of custody protocols and records used to track samples from sampling point to analysis.

2.14.5. Sample Dispatch Information

When sampling is complete, all sample documentation such as chain-of-custody forms shall be copied and copies placed in the project files. A notation of numbers of coolers shipped, carrier and time delivered to pick-up point should be made in a field notebook.

2.15. Sample Handling

The analytical laboratory will provide the sample containers necessary for all soil, groundwater, surface water, air, and soil vapor samples. Container closures for all samples, except air and soil vapor, will be screw-on type and made of inert materials. Sample containers will be cleaned and prepared by the laboratory prior to being sent to the site. Trip blanks will be used to check for false positives due to laboratory cleaning procedures or cross contamination during sample shipment.

All samples collected will be identified with a sample label. A label will be attached to each bottle and each sample will be identified with a unique sample number.

Immediately following sample collection, each sample container will be marked with the following information:

- Sample Code.
- Project Number.
- Date/Time.
- Sample Type.
- Requested Analysis.
- Preservative, if used.
- Sampler's Initials.

The sample code will indicate the site location, media sampled, and the sample station.

After all sample identification information has been recorded, each sample label will be covered with waterproof clear plastic tape to preserve its integrity. All samples will be recorded and tracked under strict chain-of-custody protocols. In the field, each sample will be checked for proper labeling. The samples will then be packed into coolers with ice and shipped to the laboratory, if applicable. A chain-of-custody form will be completed for each cooler. The form will be signed and dated by the person who collected the samples, the person the samples were relinquished to for transport to the laboratory, and the laboratory sample controller/custodian who receives the samples.

2.15.1. Chain-of-Custody Record

A chain-of-custody record is a printed form that accompanies a sample or group of samples as custody is transferred from person to person. A sample chain-of-custody form is included in Appendix C. It documents custody transfer from person to person and sample information recorded on bottle labels. A chain-of-custody record is a controlled document.

As soon as practicable after sample collection, preferably after decontamination, the following information must be entered on the chain-of-custody form. All information is to be recorded in black ink:

- Malcolm Pirnie project number. Enter the seven-digit alphanumeric designation assigned by Malcolm Pirnie that uniquely identifies the project site.
- Project name. Enter site name.
- Samplers. Sign the name(s) of the sampler(s).
- Station number. Enter the sample number for each sample in the shipment. This number appears on the Malcolm Pirnie, Inc. sample identification label.

- Date. Enter a six-digit number, indicating the year, month, and day of sample collection (YYMMDD); for example, 051125.
- Time. Enter a four-digit number indicating the military time of collection; for example, 1354.
- Composite or grab. Indicate the type of sample.
- Station location. Describe the location where the sample was collected.
- Number of containers. For each sample number, enter the number of sample bottles that are contained in the shipment.
- Remarks. Enter any appropriate remarks.

2.15.2. Transferring to Common Carrier

Instructions for Malcolm Pirnie, Inc. shipper transferring custody of samples to a common carrier are as follows:

12. Sign, date, and enter time under "Relinquished by" entry.
13. Enter name of carrier (e.g., UPS, Federal Express) under "Received by."
14. Enter bill-of-lading of Federal Express airbill number under "Remarks."
15. Place the original of the chain-of-custody form in the appropriate sample shipping package. Retain a copy with field records.
16. Sign and date the custody seal. The custody seal is part of the chain-of-custody process and is used to prevent tampering with samples after they have been collected in the field.
17. Wrap the seal across filament tape that has been wrapped around the package at least twice.
18. Fold the custody seal over on itself so that it sticks together.
19. Complete other carrier-required shipping papers.

Common carriers will usually not accept responsibility for handling chain-of-custody forms; this necessitates packing the record in the sample package.

2.15.3. Transferring Custody Directly to a Courier

To transfer custody of samples from the Malcolm Pirnie, Inc. sampler directly to a carrier, proceed as above, except eliminate the Malcolm Pirnie, Inc. shipper's signature.

3. Calibration Procedures

Instruments must be properly calibrated to produce technically valid data. Documented calibration and calibration check results verify that the instruments used for measurement are in proper working order and the data produced is reliable. The calibration requirements described or referenced in this section are necessary to support the data quality objectives for this project. When calibration requirements are met, the data will support the focused investigation decisions dealing with the nature and extent of contamination and safety concerns.

3.1. Calibration Procedures for Field Equipment

The manufacturer specifications for operation and maintenance procedures for the field equipment to be used during these tasks are provided in Appendix B. General calibration procedures and requirements include the following:

- All instruments will be calibrated at least once a month.
- All instruments will have the calibrations checked at a minimum at the start of each day before measurements are made.
- The calibration and calibration checks will indicate that the sensitivity of the instrument (practical detection limit) is adequate to meet project needs and that the instrument is accurate over the working range.
- All calibration information will be recorded in the field log book. This includes date and time, technician signature, calibration procedure, calibration results, calibration problems, recalibration and maintenance, and instrument serial numbers.

All calibration standards will be of National Bureau of Standards (NBS) quality and their sources listed and documented so that standards are traceable. In addition, only technicians trained in the use of the field instruments will operate them. If the instrument readings are incorrect at the time of the initial calibration, the instrument will either be calibrated by the technician or returned to the manufacturer for calibration. If the instrument readings are incorrect after a continuing calibration check, the preceding sample results will be reviewed for validity, and reanalyzed if necessary.

3.2. Laboratory Calibration Procedures

All samples analyzed according to the USEPA SW-846 analytical methodologies shall follow the procedures described in the applicable Statement of Work (SOW). The calibration procedures and frequency are specifically described for each analysis contained in the SOW. All calibration results shall be recorded and kept on file, and will be reviewed and evaluated by the data validator as part of analytical data validation procedures.

Instrument calibration will be checked with a reference standard prior to the analysis of any sample. The standards used for calibrations will be traceable to the NBS, and each calibration will be recorded in the laboratory notebook for the particular analysis. Any printouts, chromatograms, etc., generated for the calibration will be kept on file.

4. References

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New York State Department of Environmental Conservation
Generic FAP for Work Assignments

Appendix A:
Field Activities Generally Acceptable Procedures (GAPs)

MALCOLM PIRNIE

GENERALLY ACCEPTABLE PRACTICE (GAP)

GROUNDWATER MONITORING WELL SURFACE COMPLETION METHODS AND BEST PRACTICES

PURPOSE/ APPLICATION

The purpose of this document is to provide guidance in selecting an appropriate surface completion for groundwater monitoring wells. A groundwater monitoring well is typically completed at the surface using either a flush-mount design (well box, curb box, vault, or manhole) installed flush with the land surface, or an above-ground design (stick-up casing). The purpose of either design is to secure the well from potential tampering, protect the well casing at the surface, and reduce the potential for surface infiltration to move vertically along, or in to the monitoring well and to reach the groundwater. It is also important to confirm that the wellhead completion meets applicable State and local regulatory requirements for well construction.

TECHNIQUES

Flush-mount Surface Completion

Flush-mount surface completion is typically used in areas where monitoring wells may be exposed to vehicular traffic, such as parking lots or roadways, within buildings and/or work areas, or in areas where the visual impacts of above-ground well casings are considered undesirable. A flush-mount well casing terminates below the ground surface and is protected by a steel curb-box, vault, or man-hole installed in a concrete pad set flush with the ground surface or pavement. The benefits of flush-mount surface completion include:

- Protection of wellhead from vehicular traffic;
- Protection of wellhead in buildings and work areas; and,
- Lower visibility.

Potential drawbacks of flush-mount surface completion include:

- Wells can be difficult to locate;
- Wells can be obscured by vegetation or buried by sediment deposited by surface runoff, snow, work activities, storage of materials, etc.;
- Unsuitable for areas where wellhead location may be temporarily, seasonally, or permanently flooded (wetland areas, adjacent to streams, etc.); and,
- More susceptible to infiltration.

Above-ground (Stick-up) Surface Completion

Stick-up surface completion is typically used in areas where monitoring wells may be obscured by heavy vegetation, snowfall, or work activities, in areas where vehicular traffic is not a concern, or in areas where wells may be subject to surface water ponding or runoff. The benefits of stick-up surface completion include:

- Wells are highly visible and relatively easy to locate, as they are generally above low vegetation and/or snow cover;
- Top of well casing is generally high enough to avoid submergence during flooding; and,
- Wells are less susceptible to infiltration.

Limitations of stick-up surface completion include:

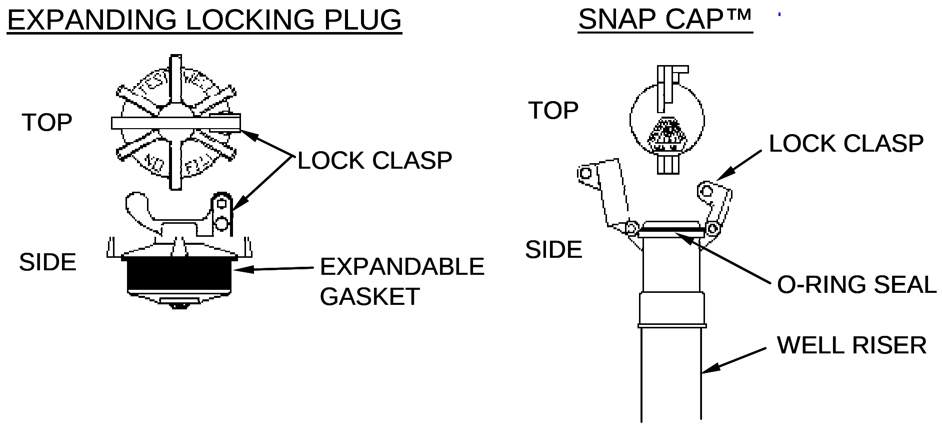
- Unsuitable for areas with heavy traffic; and,
- Unsuitable for aesthetically sensitive areas, such as parks.

EQUIPMENT

Well Plugs

Well plugs are used to seal the riser pipe of the well to prevent foreign material from entering the well (i.e., sediment, insects, debris, liquids, etc.). There are numerous types, the most common of which are expanding locking plugs and Snap Caps™ (Figure 1). The plugs come in various sizes appropriate for the diameter of riser being used. The most common type used for monitoring wells is the expanding locking type, which uses a gasket that expands to fit the top of the well casing to provide a water-tight seal.

Figure 1
Well Plugs



Curb Boxes

Curb boxes include various types of flush-mounted protective devices that secure the wellhead while providing access to the well. Curb boxes typically consist of a body or rim, lid or cover, and skirt. Common types of curb boxes include:

- Round curb boxes with non-bolted covers, used where security is not an issue and/or water-tight conditions are not required;
- Limited access curb boxes, with bolted and gasketed covers, that are used where access to the well must be limited and water-tight conditions are not required;
- Watertight monitoring well curb boxes, which limit or prevent the vertical movement of surface water into the wellhead area;
- Vaults (square manholes) for wells where sampling equipment is stored at the wellhead. This type is not typically used for monitoring well applications; and,
- Flush fill boxes, which mount directly to the monitoring well riser pipe and may or may not include a concrete pad. This type is typically used for temporary monitoring points or in areas not subject to vehicular traffic.

The choice of curb box will be dictated by the site conditions and the expected hazards to the well. Limited-access curb boxes and watertight monitoring well curb boxes are the most commonly used types of curb boxes for permanent groundwater monitoring wells.

Above-ground Well Protectors/ Casings

Above-ground protective casings include both round and square steel casings installed around the well casing to protect the casing from damage. Above-ground casings include lockable covers to secure the well. The protective casings are installed in a concrete pad for wells in unconsolidated formations, and are typically keyed into bedrock for bedrock monitoring wells. The protective casings can be painted in high-visibility colors to help avoid collisions by vehicles and other site equipment and to facilitate locating wells in vegetated areas. Also bollards can be constructed around the protective casings for additional protection from vehicle collisions.

PROCEDURES

Installation of Well Plugs

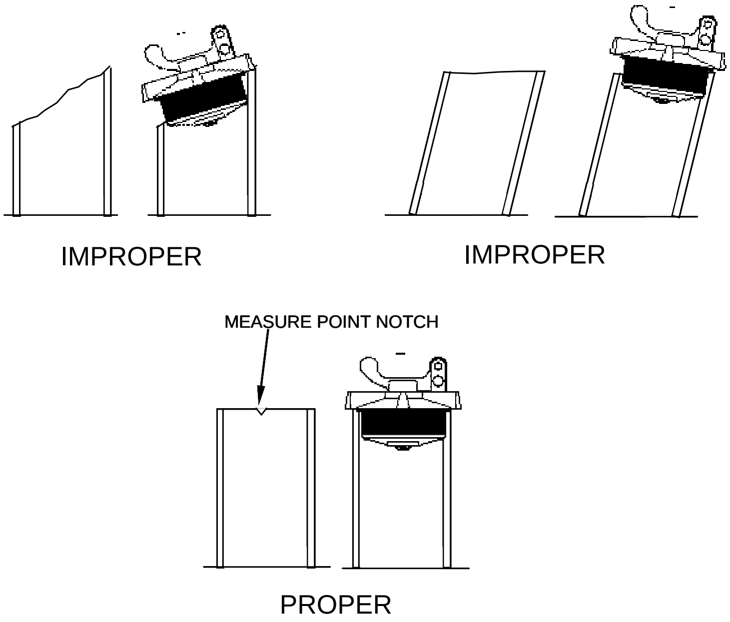
To increase the likelihood of a water-tight seal between the well casing and the well plug, final cutting of the well casing must be completed properly. The drilling contractor should verify the following when cutting the surface casing to final length:

1. The well casing is straight and level (plumb). If the casing is not plumb and cannot be made plumb, then the casing should be cut at right angles to the sides of the casing, not parallel with the ground surface (Figure 2).

2. When cut to finished length, the casing cut should be as smooth and level as possible. The top of the casing should not be cut at an angle that prevents the well plug from sealing properly (Figure 2).

3. The top of the casing should include a small notch or permanent mark to indicate the measuring point for water level measurements.

Figure 2
Proper Well Plug Installation



Flush-mount Installation

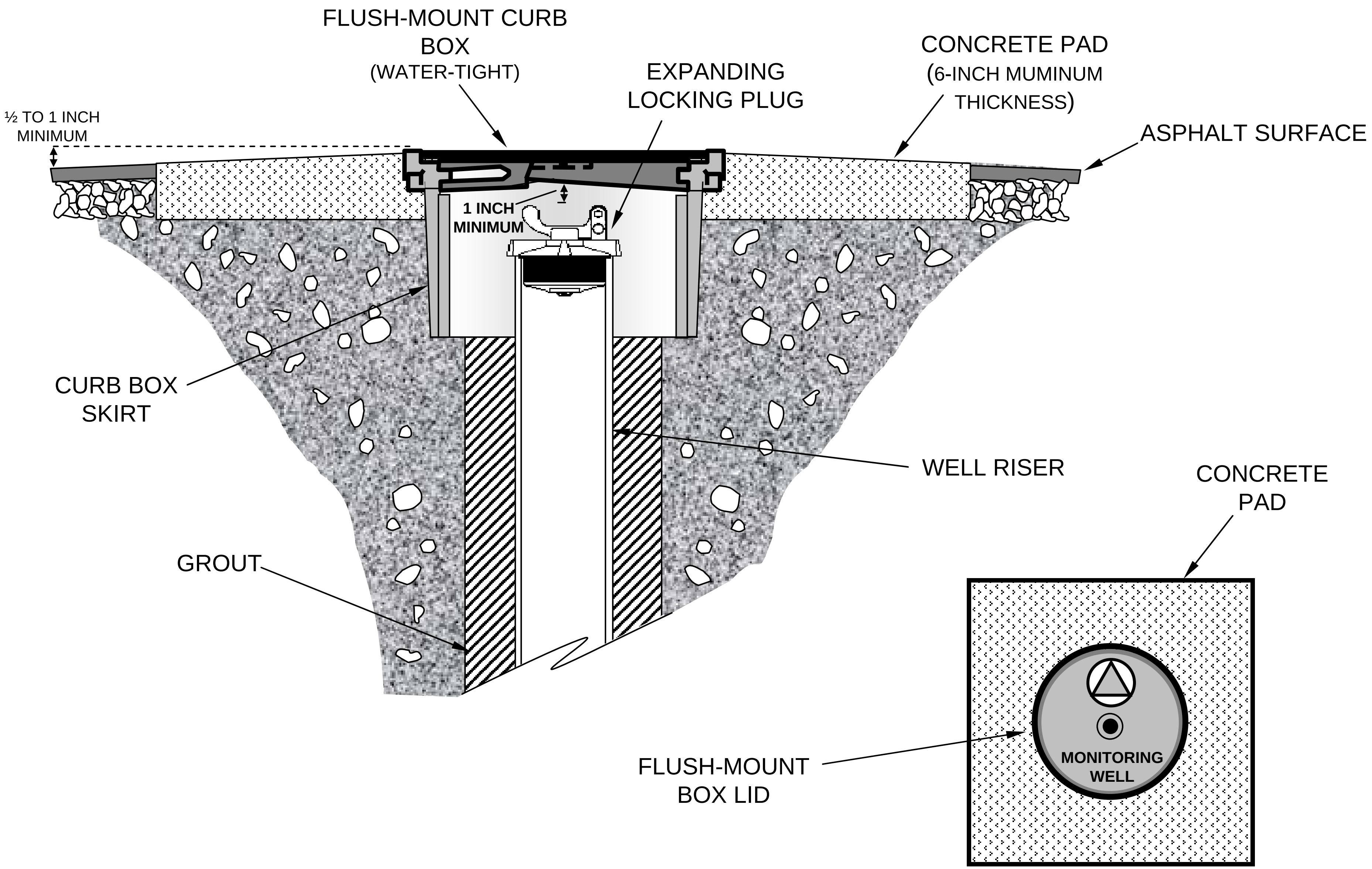
Typical flush-mount surface completions are shown on Figures 3 (pavement) and 4 (unpaved areas). For flush-mount installations, the following general procedures are required:

1. Excavate an area approximately equal to the diameter of the curb box skirt around the well casing to a depth approximate to the depth of the curb box skirt. Alternatively, the skirt typically can be installed in the concrete grout in the upper portion of the borehole.

2. Cut the well casing to a finished length, so that the top of the well casing (including well plug) will be a minimum of one inch below the bottom of the curb box lid.

3. Install the curb box so that the well casing is centered in the box (Figure 5).

4. Using a suitable form, pour a concrete pad to the top of the curb box rim to secure the curb box. The curb box should be slightly above ground level, with the pad constructed so that the pad surface slopes away from the curb box lid to reduce the potential for surface water to accumulate in the vicinity of the wellhead.



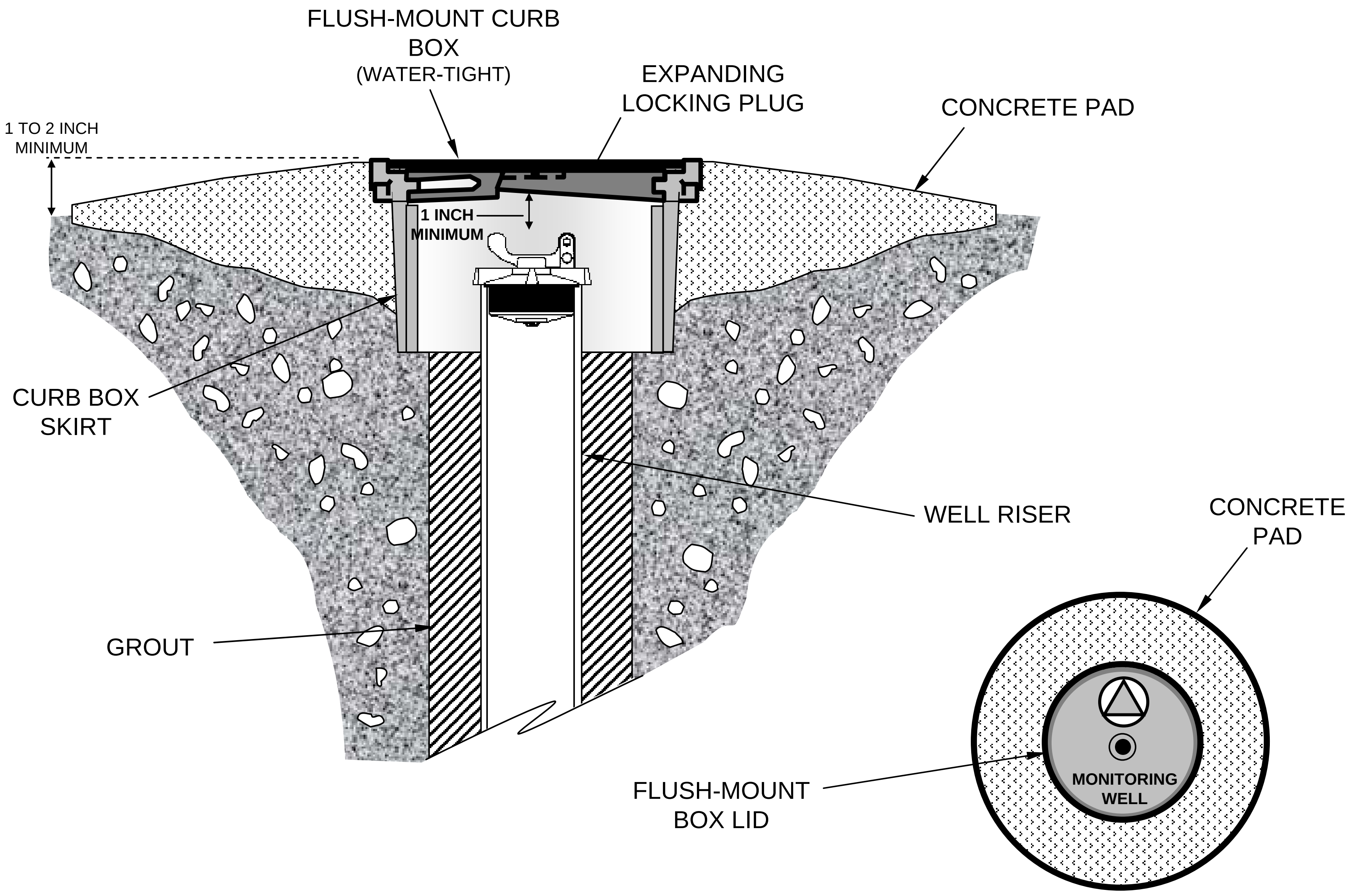
NOT TO SCALE

MALCOLM PIRNIE

GENERALLY ACCEPTED PRACTICE
MONITORING WELL SURFACE
COMPLETION

FLUSH MOUNT - PAVEMENT

FIGURE 3



NOT TO SCALE

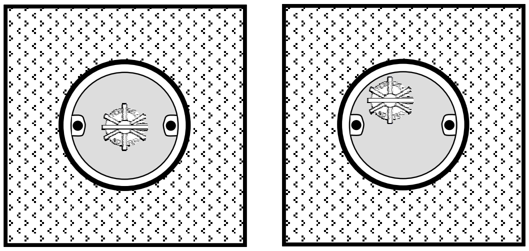
MALCOLM PIRNIE

GENERALLY ACCEPTED PRACTICE
MONITORING WELL SURFACE
COMPLETION

FLUSH MOUNT – UNPAVED AREA

FIGURE 4

Figure 5
Centering Casing in Curb Box


PROPER IMPROPER

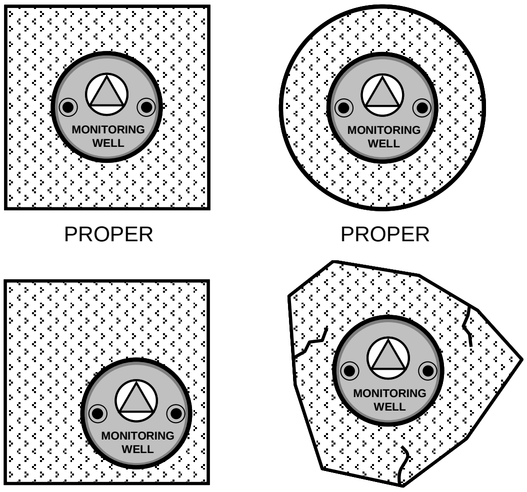
For flush-mount installations in pavement, the following additional procedures are required:

1. The pad should be constructed square or rounded, with a minimum nominal thickness of approximately 6 to 12 inches. In areas of heavy vehicular traffic, the pad should be at the thicker end of this range. Excavate the pad area as necessary to achieve this thickness. The pad should be of even thickness, and sloped away from the curb box as described above. At minimum, the curb box should be approximately ½ to 1 inch above the paved surface when completed.

2. The pad should not be oddly shaped (Figure 6), and should have a smooth surface. The curb box must be centered in the pad.

3. If a significant area of pavement was damaged during drilling, the pavement should be repaired using asphalt patch after installation of the concrete pad.

Figure 6
Concrete Pad Construction



PROPER PROPER

IMPROPER IMPROPER

Above-ground Installation

Typical above-ground surface completions are shown in Figures 7 (pavement) and 8 (unpaved areas). For above-ground installations, the following general procedures are required:

1. Install the surface casing in the borehole so that the surface casing extends below the frost line, or a minimum of three feet below ground surface, into the cement grout within the borehole.

2. Backfill the annular space between the well casing and protective casing with grout to ground surface.

3. Install a concrete pad around the protective casing to provide additional support of the casing. The pad should be constructed in the same manner as described for flush-mount wells (pavement or unpaved areas), with a thicker pad in areas of heavy vehicular traffic.

4. Install a 1/4-inch weephole in the protective casing just above the concrete pad to allow any water entering the protective casing to drain.

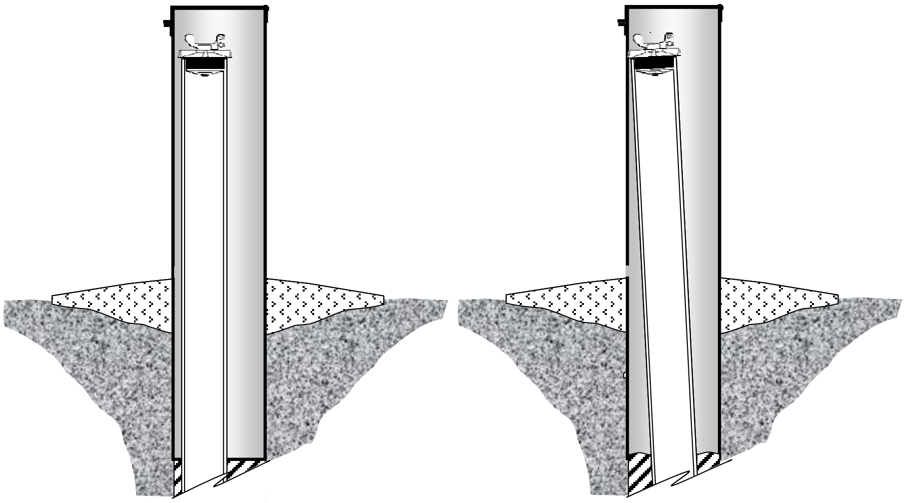
During installation of the protective casing, ensure the following:

1. The protective casing should be plumb.

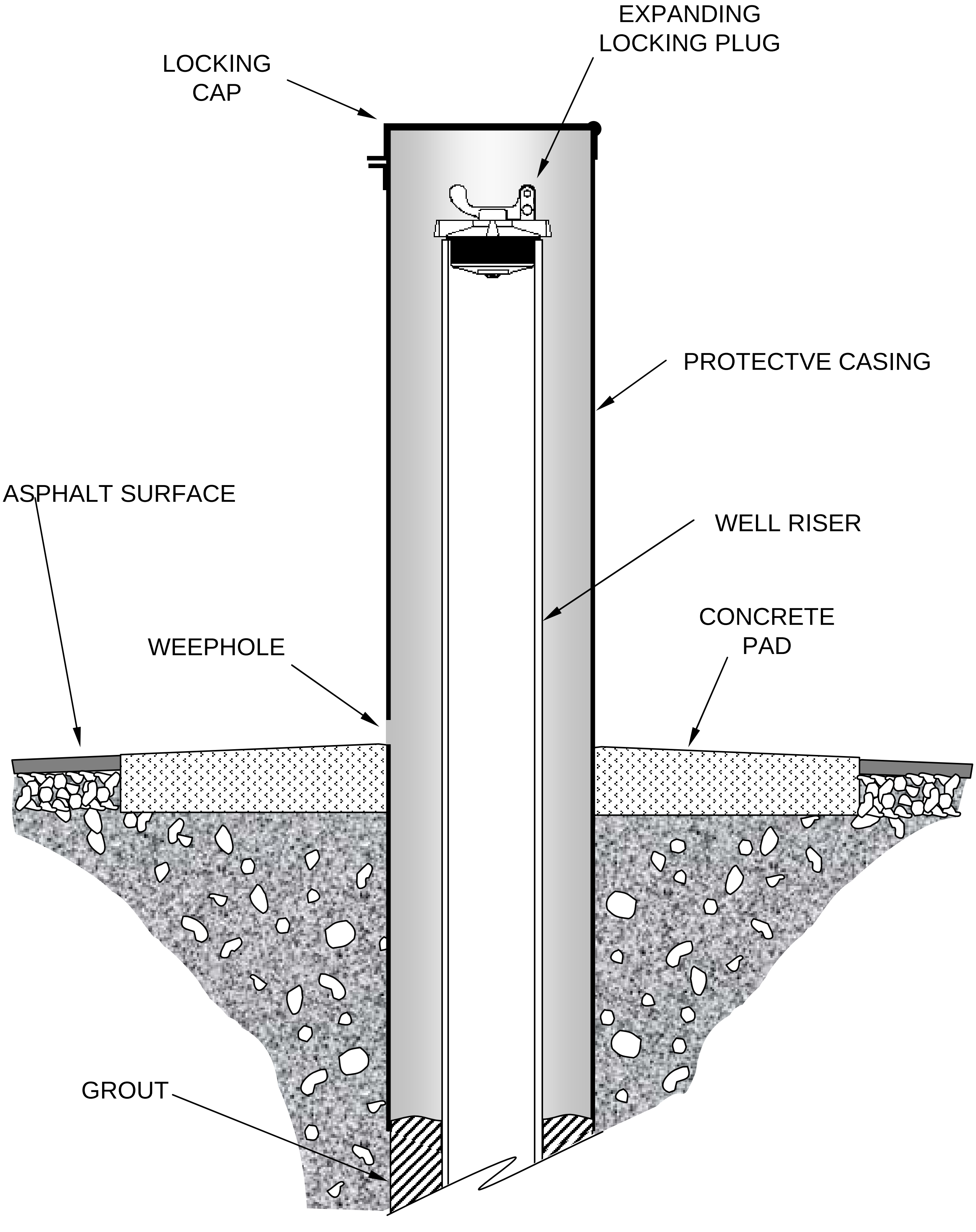
2. The well casing should be plumb and centered in the protective casing (Figure 9).

3. The top of the well casing should be no more than 4 inches below the protective casing lid, and no less than 1 inch below the protective casing lid.

Figure 9
Unacceptable Protective Casing Installations



CASING NOT CENTERED CASING NOT PLUMB

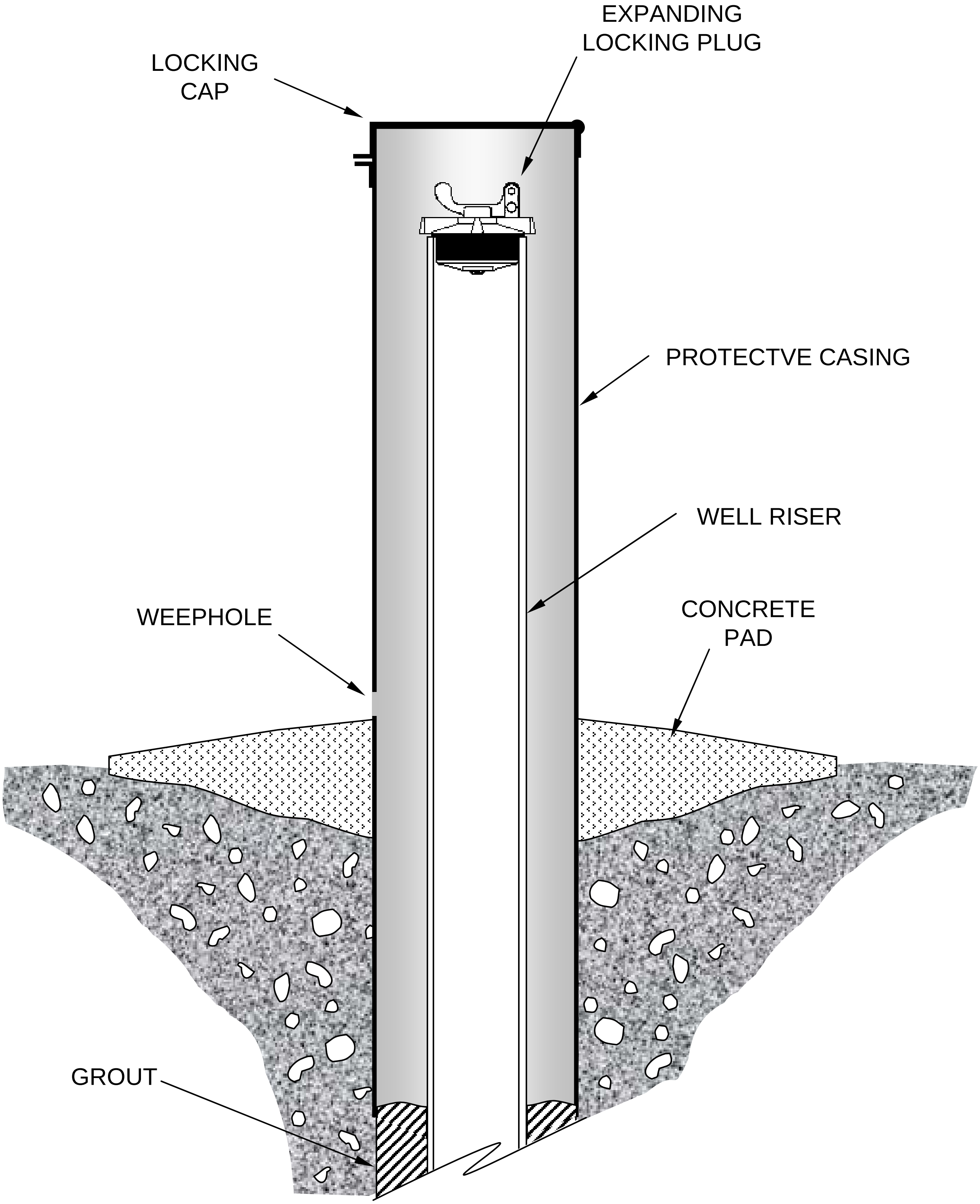


MALCOLM PIRNIE

GENERALLY ACCEPTED PRACTICE
MONITORING WELL SURFACE COMPLETION

ABOVE GROUND MOUNT – PAVEMENT

FIGURE 7



MALCOLM PIRNIE

GENERALLY ACCEPTED PRACTICE
MONITORING WELL SURFACE COMPLETION

ABOVE GROUND MOUNT – UNPAVED AREA

FIGURE 8

GENERALLY ACCEPTABLE PROCEDURE

FOR

MONITORING WELL DEVELOPMENT

INTRODUCTION

Drilling a borehole for monitoring well installation or sampling disrupts the natural alignment of soil particles in the formation adjacent to the borehole. With some drilling methods, bentonite or other fine-grained materials are added to drilling fluids to generate drilling mud, which is used to maintain an open borehole. The physical disturbance of the subsurface soils, and in some cases the use of drilling mud, affects the hydraulic conductivity of the saturated formation adjacent to the well and can create a "skin" of fine-grained material along the annulus of the borehole. The objectives of well development are to restore the natural alignment of soil particles to the extent possible, remove finer-grained particles and drilling fluids in and adjacent to the well, and ensure that water in the well is representative of formation groundwater. The appropriate development method to use will vary according to the hydraulic characteristics of the aquifer, the drilling method used, and the type of well completion. Of the various methods available for use in developing wells, mechanical surging, pumping, backwashing, and bailing are best suited for developing monitoring wells.

TECHNIQUES AND ASSOCIATED EQUIPMENT

The necessary equipment, monitoring instruments and field procedures are presented herein for four monitoring well development techniques. Since other procedures may be applicable depending on site conditions, references are provided for more complex development needs, including predevelopment techniques. Development using any of these methods should not be initiated less than 24 to 48 hours after final grouting of the monitoring well (USACE, 1998).

1. Mechanical Surging

Operation of a piston-like device (surge block) in combination with periodic purging of water from the well is a very effective development method, even in stratified formations with variable hydraulic conductivity. The surge block should be constructed with rubber disks secured to stainless steel or PVC pipe with a pipe fitting on top to attach it to drill rods or HDPE tubing. The rubber discs on the surge block should be slightly smaller than the inside diameter of the well. The surge block is carefully lowered into the well and an up-and-down plunging action is used to alternately force water to flow into and out of the well, similar to a piston in a cylinder. The use of a surge block can agitate and mobilize particulates around the well screen. Periods of surging should be alternated with periods of water extraction from the well so that sediment brought into the well is removed. Surging should initially be gentle to assure that water can come into the well and that the surge block is not so tight as to damage the well pipe or screen. For short well screens (1.6 m (5 ft) or less) in relatively homogeneous formations, the surge block does not have to be operated within the screen interval. However, if the screened interval includes materials of high and low hydraulic conductivities, the block may have to be operated gently within the screen.

Equipment needed for mechanical surging would include:

- Surge block
- HDPE pipe if drilling rig not used
- Water-level probe
- Pump or bailer for purging
- Graduated bucket or flow meter to measure volume of water removed
- Multi-parameter field instrument (at a minimum able to measure pH, specific conductance, turbidity, and temperature)

2. **Backwashing**

Backwashing is the reversal of flow through a well screen by first drawing water up through the well with a pump and then releasing the water back into the well. When supplemented with periodic purging, backwashing facilitates the removal of fine-grained materials from the formation surrounding the borehole. The well is pumped until water reaches the surface. At this point the pump is shut off, and water in the hose is drained by gravity creating a reversed flow through the well screen. At times this method can be effective; however in low hydraulic conductivity formations the flow may not be sufficient to achieve the desired results.

Equipment needed for backwashing would include:

- Water-level probe
- Pump for purging
- Tubing with no backflow preventer or check valve
- Graduated bucket or flow meter to measure volume of water removed
- Multi-parameter field instrument (at a minimum able to measure pH, specific conductance, turbidity, and temperature)

3. **Bailing**

The use of bailers is an effective way of manually developing small diameter wells that have a high static water table or are relatively shallow in depth (generally less than 20 feet). Since the diameter of the bailer is commonly close to the same diameter as the well screen, the bailer agitates the water in the well in much the same manner as a surge block. The well should be surged using the bailer for 10 to 20 minutes prior to beginning bailing. To have its most effective surging action, the bailer should be operated throughout the screened interval. Bottom loading bailers can extract sediment that has settled to the bottom of the well by rapid short upward/down motions of the bailer at the bottom of the well.

Equipment needed for bailing would include:

- Water-level probe
- Weighted, bottom-filling bailer (sized appropriately depending on well diameter)
- Graduated bucket or flow meter to measure volume of water removed
- Multi-parameter field instrument (at a minimum able to measure pH, specific conductance, turbidity, and temperature)

4. **Overpumping**

Overpumping is a commonly used development method and consists of pumping a well at a higher rate than water will be extracted during purging or sampling events. This overpumping, however, is usually only successful in relatively non-stratified, relatively homogeneous and permeable formations. By pumping the well at a higher rate than expected during sampling, the particulates may be mobilized and removed. Overpumping should be supplemented with the use of a bottom discharge/filling bailer, (for sediment removal). During development, water should be removed throughout the entire water column in the well by periodically lowering and raising the pump intake.

A disadvantage of only pumping the well is that the smaller soil grains of the filter pack may be bridged in the screen or in the filter pack, as the direction of flow is only toward the screen. To overcome this, overpumping is often used in conjunction with backwashing or surging. This technique is probably the least effective because the well development is occurring in the most permeable zones, often near the top of the well screen (Driscoll 1986). Additionally, overpumping may actually compact finer-grained soils.

Equipment needed for overpumping would include:

- Water-level probe
- Pump for purging
- Graduated bucket or flow meter to measure volume of water removed
- Multi-parameter field instrument (at a minimum able to measure pH, specific conductance, turbidity, and temperature)

PROCEDURES

Well development can be conducted by a drilling contractor or manually by field personnel. In either case, the techniques discussed above should be used and the procedures below should be followed and documented.

1. **Preparation**

In preparation of monitoring well development:

- Coordinate site access and obtain keys to well locks.
- Obtain information on each well to be developed (i.e., drilling method, well diameter, well depth, screened interval, anticipated contaminants).
- Obtain a water level meter, a weighted tape to measure well depth, air monitoring instruments and materials for decontamination, if necessary, and water quality instrumentation capable of measuring, at a minimum, pH, specific conductivity, temperature, and turbidity.
- Assemble graduated containers for temporary storage and measurement of water removed during well development. Containers must be structurally sound, compatible with anticipated contaminants, and easy to manage in the field. The use of truck-mounted or roll-off tanks may be necessary in some cases; alternately, a portable water treatment unit (i.e., activated carbon) may be used to treat the purge water.

2. **Operation**

Development should be performed as soon as it is practical after the well is installed, but no sooner than 48 hours after well completion to allow grout to set. No water shall be added to the well to assist development without prior approval of the regulatory agency. In some cases, small amounts of potable water could be added to help develop a poor yielding well. If practicable, at least five times the amount of water added should be recovered from the well to ensure that all added water is removed from the formation.

For typical well development, a minimum of three borehole volumes of water should be removed and water quality parameters should be measured in the field until it is evident that water purged from the well is representative of formation water. A borehole volume includes the volume of the water column in the well and the volume of water in the saturated portion of the filter pack. Assume 30 percent porosity of the filter pack unless more site-specific information is available. If drilling fluids were used or lost to the formation during well installation, a minimum of five times the estimated quantity of un-recovered water should be removed in addition to the minimum three borehole volumes.

Use the attached Monitoring Well Development/Purging Log and follow these procedures to develop a monitoring well:

- Assemble necessary equipment on a plastic sheet surrounding the well.
- Record pertinent information in the site or personal logbook (client, project, personnel, date, time, location ID, weather conditions, etc.).
- Open monitoring well and measure air quality at the top of casing and in the breathing zone as appropriate.

- ■ Measure and record depth to water and the total depth of the monitor well. Calculate the water column and borehole volume of the well. Note hard or soft bottom to indicate presence or absence of fines in the well.
- ■ Begin development and measure the initial pH, temperature, turbidity, and specific conductivity (at a minimum) of the water and record in the site logbook. Note the initial color, clarity, and odor of the water.
- ■ Continue to develop the well and periodically measure the water quality parameters indicated in step 5 (above). Depending on project objectives, development should proceed until these water quality parameters stabilize, or until the water has a turbidity of less than a predetermined threshold, preferably between 5 and 50 nephelometric turbidity units (NTUs). This may not be obtainable in some fine-grained formations.
- ■ Measure and record the volume of water removed during development, either with a flow meter or a graduated container. Estimate and record the well recovery rate if water is purged during development.
- ■ Containerize or treat water produced by development of contaminated or suspected contaminated wells. Each container must be clearly labeled with the well ID, date collected, and sampling personnel. Determination of the appropriate disposal method will be based on the analytical results from each well and regulatory requirements.
- ■ Note the final water quality parameters in the logbook along with the following data:
  - Well designation (location ID)
  - Date(s) of well installation
  - Date(s) and time of well development
  - Static water level before and after development
  - Quantity of water removed, and initial and completion time
  - Type and capacity of pump or bailer used
  - Description of well development techniques

3. Post-Operation

Follow these procedures to demobilize upon completing well development:

- ■ Decontaminate all equipment;
- ■ Secure and label holding tanks or containers of development water; and
- ■ Review analytical results and determine the appropriate water disposal method.

REFERENCES

Driscoll, Flecther G., 1986. *Groundwater and Wells*. Johnson Screens, pp 497-507.

U.S. Army Corps of Engineers, 1998. *Engineering and Design - Monitoring Well Design, Installation, and Documentation at Hazardous Toxic, and Radioactive Waste Sites.* Publication Number EM 1110-1-4000.

GENERALLY ACCEPTABLE PROCEDURE

FOR

LOW STRESS (LOW FLOW) GROUNDWATER SAMPLING

PURPOSE/APPLICATION

This low flow groundwater purging and sampling procedure presents a standard method for collecting groundwater samples that are representative of the formation from which they are being withdrawn. By using low flow rates for purging and sampling to minimize drawdown within the well, three primary benefits gained. First, using a low flow rate during sampling promotes laminar flow, which minimizes the disturbance of sediment at the bottom of a well or fine particles in the well's filter pack. Groundwater samples are therefore less turbid, which reduces sampling time and generally eliminates the need to filter. Second, the amount of groundwater purged from the sampling well is significantly reduced, minimizing investigation derived waste. Third, low flow purging and sampling reduces aeration and therefore helps to preserves the natural chemical characteristics of the groundwater sample. Low flow sampling may be used to collect groundwater samples for analysis of contaminants of concern, as well as geo-chemical and biological parameters.

This guideline is for information purposes and should not take precedence over the requirements of project specific plans. This is especially true for federal project sites, which are governed by regionally directed United States Environmental Protection Agency (USEPA) low flow groundwater sampling protocols.

EQUIPMENT

Low flow groundwater sampling requires traditional groundwater sampling equipment with the addition of the following:

- Multi-parameter water quality monitoring system (e.g. Horiba U-22 or equivalent) equipped with a flow through cell.
- An adjustable rate, positive displacement, groundwater pump (e.g., centrifugal, submersible, or bladder pumps) constructed of stainless steel or Teflon capable of achieving low flow pumping rates (i.e., 100 to 500 ml/min).
- Polyethylene tubing or equivalent.
- Flow measurement device (e.g., a graduated container and stop watch).
- A water level probe or oil/water interface probe.

PRE-SAMPLING PROCEDURES

The pre-sampling procedures for low flow groundwater sampling and purging are as follows:

1. To minimize the risk of cross-contamination, if possible, begin with the monitoring well that is known or believed to have the lowest contaminant concentrations.

2. Position a sheet of polyethylene over the monitoring well for placement of all sampling equipment.

3. Where applicable, measure the concentration of volatile organic compounds (VOCs) in the well's headspace with a photoionization detector (PID) and record the concentration in the field log book.

4. Measure and record the depth to water and if applicable, the depth to light non-aqueous phase liquid (LNAPL).

SAMPLING PROCEDURES

The procedures for collecting groundwater samples using low flow are as follows:

1. **Pump Installation:** Install the pump by slowly lowering the pump assembly and tubing into the well. The pump should be set to the appropriate depth with the intake being a minimum of two-feet above the bottom of the well to prevent disturbing and re-suspending any sediment at the bottom of the well.

2. **Water Level Measurement:** Measure the depth to groundwater from the top of the well casing using a water level probe. Leave the probe in the well for subsequent water level measurements.

3. **Purging:** Begin purging the well at a rate of 200 to 500 milliliters per minute (ml/min) and measure the water level. If excessive drawdown is observed in the well (i.e. greater that 0.3 feet), reduce the flow rate until the water level stabilizes. When the water level has stabilized, subsequent measurements should be made on five minute intervals. The flow rate, as well as flow rate adjustments should be recorded on a field purge log.

4. **Field Parameter Monitoring:** Field parameters (pH, conductivity, reduction/oxidation potential, DO, and turbidity) should be recorded every five minutes with water level measurements. The well is considered stable and ready to be sampled once the field parameters are stable over three consecutive readings (USEPA Region 2, 1998). The following criteria identify stabilized field parameters:
   - ± 0.1 for pH
   - ± 3.0 percent for conductivity
   - ± 10.0 mv for redox potential
   - ± 10.0 percent for DO and turbidity

   The pump should **<u>not</u>** be removed or shut off between purging and sampling.

5. **Sample Collection:** If necessary, reduce the flow rate to 100 to 250 ml/min to reduce turbulence while filling sample containers during sample collection. Where wells are purged at a flow rate less than 100 ml/min, maintain the same flow rate during sample collection. Disconnect the inflow line from the flow through cell and collect the groundwater sample. All sample containers should be filled directly from the tubing. Allow water to flow from the tubing gently down the inside of the containers to minimize turbulence during sample collection. Groundwater samples should be collected in order of importance, according to the project requirements.

6. **Pump Removal:** Once sampling is complete, slowly remove the pump assembly and tubing from the well. If the tubing is dedicated to the well, disconnect the tubing from the pump, re-insert the tubing into the well, and secure the tubing so it is easily accessible.

7. **Secure Well:** Secure the top of the well casing with a locking cap or expansion plug and close the well. In the case of a stick-up protective well cover, , lock the outer casing.

DECOMTAMINATION

All dedicated or "single use" groundwater sampling equipment should be disposed in accordance with all applicable local and federal regulations. The decontamination procedures for non-dedicated low flow groundwater sampling equipment are as follows:

1. **Pre-rinse:** Operate the pump and flush equipment thoroughly with deionized or distilled water for approximately five minutes.

2. **Wash:** Operate the pump and flush equipment thoroughly with Alconox or other non-phosphate detergent solution for approximately five minutes.

3. **Rinse:** Operate the pump and flush equipment thoroughly with deionized or distilled water for approximately five minutes or until all of the detergent has been removed from the equipment.

FIELD SAMPLING FORM

See attached.

REFERENCES

United States Environmental Protection Agency (USEPA) Region II, 1998, Ground Water Sampling Procedure, Low Stress (low flow) Purging and Sampling, GW Sampling SOP, March 16th.

POTENTIAL PROBLEMS/TROUBLESHOOTING

Insufficient yield, cascading, field parameters failing to stabilize, and aerating the groundwater sample are potential problems when trying to use low flow protocols to collect representative groundwater samples.

Insufficient Yield/Cascading

A low yielding well that cannot sustain a low flow purge rate may eventually go dry. The sampler should take care not to dewater the well below the top of the well screen to prevent cascading of the sand pack. Therefore, pumping a well dry should be avoided in all situations. If a well should go dry, the groundwater sample should be collected as soon as there is sufficient recharge to collect the sample. If the well has not recharged sufficiently within 48 hours, the well should not be sampled.

A low yielding well that consistently demonstrates that it cannot sustain a low flow purge rate of 250 ml/min or less should not be sampled using low flow protocols. Groundwater samples collected from low yielding wells are often representative of the stagnant groundwater within the well and the surrounding sand pack, and not representative of the geologic formation. In addition, these samples are typically very turbid, which can skew the analytical results of groundwater samples being analyzed for organic compounds and metals.

Key Field Parameters Fail to Stabilize

If any key parameters fail to stabilize within four hours of purging, then the following alternatives should be considered:

1. Continue purging until stabilization.
2. Stop purging, do not collect a sample, and document the activity.
3. Stop purging, collect a sample, and document the activity.
4. Stop purging, secure the well, and resume purging the following day.

The key parameter for samples being analyzed for VOCs is dissolved oxygen (DO). The key parameter for all other analytical samples is turbidity. Typically DO and turbidity take the longest to stabilize.

Non-stabilizing turbidity measurements may be avoided by periodically removing sediments that may be trapped in the flow through cell during purging. Trapped sediments may cause artificial fluctuations in turbidity measurements. Additionally, the sampler should visually compare the turbidity of the groundwater in the Cell with the groundwater entering the Cell. If the groundwater entering the Cell is clearer, disconnect the inflow line, drain the turbid groundwater from the Cell, and reconnect the inflow line. Turbidity readings should more accurately reflect true groundwater conditions.

Fluctuations in DO measurements may be caused by air bubbles that form in the flow through cell or sample tubing. Ensure that the inflow tubing is sealed tightly to the flow through cell to prevent the intrusion of air. It may be necessary to drain the flow through cell to remove all air bubbles that may interfere with accurate DO readings.

Aerating the Sample

To prevent inadvertently aerating the groundwater sample, the flow rate should be set so that pump suction and positive groundwater flow through the sample tubing is maintained. The sampler should minimize the length and diameter of the sample tubing. It is recommended that either one-quarter or three-eights-inch inner diameter tubing are used.

Where centrifugal pumps are being used to collect a groundwater sample from a deep well, preventing aeration and sustaining a low flow rate becomes problematic. These issues can be minimized if an impeller is removed from the pump. This allows the pump to run at a lower flow rate and reduces the potential for aerating the groundwater sample. There is also concern that the centrifugal pump will heat the groundwater sample, however, the increases in temperature rarely increases more than two degrees Celsius during sampling.

GENERALLY ACCEPTABLE PROCEDURE

FOR

PASSIVE DIFFUSION BAG SAMPLERS

PURPOSE/APPLICATION

Water-filled passive diffusion bag (PDB) samplers can be an effective, simple and inexpensive alternative to traditional groundwater sampling methods for measuring concentrations of a variety of volatile organic compounds (VOCs) in groundwater.

A typical passive diffusion bag sampler consists of low-density polyethylene lay-flat tube closed at both ends containing deionized water. The samplers operate by chemical diffusion across the semipermeable polyethylene membrane until a chemical equilibrium exists on both sides of the membrane. The samplers may be used individually or in "stacks" (several samplers positioned vertically at target depths) to assess the vertical distribution of VOCs in a well.

ADVANTAGES

- PDB samplers produce little to no purge water, thus reducing sampling and disposal costs.
- PDB samplers are relatively inexpensive.
- PDB samplers are simple to deploy and recover.
- PDB samplers are dedicated, single use, thus, there is no down-hole equipment to be decontaminated between wells.
- Sampler deployment and recovery is rapid, making PDB samplers desirable for use where access is a problem or where discretion is necessary (residential communities, business districts, or busy streets).
- PDB samplers are not affected by turbidity. The pore size of the polyethylene sampler is 10 angstroms or less which prevents sediment from entering the PDB sampler.
- PDB samplers reduce interference from purge water mixing.
- PDB samplers typically require less labor compared to traditional purge techniques.

LIMITATIONS

- PDB samplers are not effective for obtaining representative concentrations of all compounds. Water-filled polyethylene PDB samplers typically do not provide representative concentrations of MTBE (methyl-*tert*-butyl ether), acetone, SVOCs, PCBs, and metals. Factors that limit the ability of compounds to diffuse through the PDB membrane include molecular size, shape, and any hydrophobic properties of the compounds.

- PDB samplers typically take about 14 days to reach equilibrium concentrations. This could be a limitation if the goal of the sampling event is to gain a representative sample at a single point in time in an aquifer where VOC concentrations change more rapidly than the samplers equilibrate.
- In wells containing stratified chemical concentrations, concentrations in a single PDB sampler may not represent the zone with the highest concentration.
- Because wells sampled with PDB samplers are not purged, information on common field parameters is not obtained.
- Requires careful placement at known depth for repeatable results.
- PDB samplers provide only a limited sample volume.
- PDB samplers are not universally accepted by all regulatory agencies. Consult with regulators before using.

RECOMMENDED EQUIPMENT

- Polyethylene passive diffusion bags.
- Deionized water
- Stainless steel weights
- Rope/wire with sufficient strength to support the weight and sampler. The rope/wire should be non-elastic (i.e. polyester, nylon, or stainless steel or Teflon coated stainless steel wire).
- Hooks to secure the rope/wire to the well casing
- Electronic water level probe
- Measuring tape
- Nitrile or Latex protective gloves.

EQUIPMENT DECONTAMINATION

PDB samplers are single-use disposable samplers, thus no decontamination is necessary. To prevent cross-contamination, rope should not be used in more than one well. However, stainless steel weights and coated stainless steel wire can be reused after sufficient decontamination with low phosphate detergent (Alconox or equivalent) and water.

PROCEDURES

Deployment

- Using the electronic water level probe, measure the depth to water and the total well depth. Compare these measurements with previous measurements from the well and the reported depth of the well screen from the well construction record. This is to check if sediment has accumulated on the bottom of the well and if the well construction records are accurate.
- Attach a stainless steel weight to the end of the line. Sufficient weight should be added to overcome the buoyancy of the PDB sampler.

- Calculate the distance from the bottom of the well, to the depth where the PDB sampler is to be placed.
- At the designated point, secure the PDB sampler to the weighted line using the ring tabs on both ends of the sampler.
- Label PDB sampler(s) with well I.D. and depth (if using multiple PDBs in one well).
- For relatively short well screens (less than five feet), the center point of the PDB sampler should be suspended at the vertical midpoint of the saturated well-screen length.
- For well screens greater than five feet in length, it is suggested to use multiple PDB samplers vertically along the length of the well screen for at least the initial sampling. Multiple samplers are used to determine if contaminant stratification is present and to locate the zone with of highest concentration. The midpoint of each PDB sampler should be positioned at the midpoint of the sample interval.
- With PDB sampler(s) attached, lower the weighted line to the bottom of the well. The weighted line should be taut when the PDB sampler(s) is at the target depth(s).
- Secure the assembly in place. Attach the weighted line with a hook to the well riser or well cap. The well should be covered to prevent surface water infiltration.
- Allow the system to remain undisturbed while the PDB sampler(s) equilibrate (minimum 14 days recommended; 6 months or more allowable if needed).

Sample Recovery

- Remove the PDB sampler from the well using the attached line. Avoid exposing the sampler to excessive agitation as it is removed from the well.
- Examine the surface of the PDB sampler for tears, algae, iron, or other coatings. If there are tears in the membrane, the sample should be discarded. If the outside of the sampler is coated with any material, it should be noted.
- Detach the sampler from the weighted line and remove any excess fluids or materials from the exterior of the bag. This can be accomplished with paper towels.
- There are several acceptable methods for transferring water from the PDB sampler to the 40ml volatile organic analysis (VOA) vials:
  - If a discharge device is provided by the PDB sampler supplier, it can be inserted either in place of the fill plug or directly into the bag.
  - If no discharge device is provided, the PDB sampler can be cut at one end using scissors or a sharp probe. The water should then be poured gently from the PDB sampler to the 40 ml VOA vials.
- Samples should be preserved according to the analytical method and stored at approximately 4 °C in accordance with standard sampling protocol.
- Any unused water from the PDB samplers should be disposed in accordance with local, state, and federal regulations.

PDB Sampler Suppliers
Columbia Analytical Services
Lambertville, NJ
Phone: (609) 397-5326
Fax: (609) 397-5327

EON Product, Inc.
P.O. Box 390246
Snellville, GA 30039
Toll-Free: (800) 474-2490
Fax: (770) 978-8661

REFERENCES

Vroblesky, D.A., 2001, User's Guide for Polyethylene-Based Passive Diffusion Bag Samplers to Obtain Volatile Organic Compound Concentrations in Wells: U.S. Geological Survey Water-Resources Investigation Report 01-4060, p. 1-11.

Naval Facilities Engineering Command, Washington D.C. 20374-5065, 2000, Diffusion Membrane Samplers, A Low-Cost Alternative Groundwater Monitoring Tool for VOCs: NFESC TDS-2085-ENV, p. 1-2.

http://www.clu-in.org/products/newsltrs/gwc/gwc1297.htm

GENERALLY ACCEPTABLE PROCEDURE

FOR

GEOPROBE SYSTEMS® SOIL CONDUCTIVITY AND MEMBRANE INTERFACE PROBE (SC-MIP)

USE AND DATA QUALITY ASSURANCE/ QUALITY CONTROL (QA/QC)

INTRODUCTION

The SC-MIP is a subsurface, continuous-logging instrument developed by Geoprobe Systems®, a division of Kejr, Inc. of Salina, Kansas, to screen for the presence of volatile contaminants in soil. The instrument is comprised of a permeable membrane and carrier gas system used to detect volatile organic compounds (VOCs) and a dipole soil conductivity measurement tip. The SC-MIP system can be used to qualitatively characterize any site with shallow subsurface VOC contamination, including sites with fuel releases, chlorinated solvents, and non-aqueous phase liquid (NAPL).

POTENTIAL APPLICATIONS

Potential applications of the SC-MIP system include:

- High-resolution characterization of the vertical and lateral distribution of contaminants in the subsurface.
- Determining the presence of NAPL and locating source areas.
- Identification of VOCs present in the subsurface (depending on type of detector).
- Identification of low-permeability soil zones and relative characterization of stratigraphy.
- Focusing remediation efforts.
- Assessing performance of existing remedial systems and pilot studies.

ADVANTAGES

Advantages of the SC-MIP system include:

- Provides rapid, continuous measurements of the presence and vertical extent of VOCs in the subsurface.
- Can operate in both vadose zone and saturated zone.
- Can qualitatively identify specific compounds using a direct-sampling ion trap mass spectrometer (DSITMS).

- Provides useful information for accurately placing more conventional sampling points, such as monitoring wells, multi-level sampling systems, and soil borings.
- Provides simultaneous information on contaminant distribution, general stratigraphy, and the depth and vertical extent of low-permeability soils.
- The SC probe helps to identify low-permeability zones, helping to avoid drilling through an aquitard and possibly carrying contamination into a lower, uncontaminated zone.
- Potential cost savings over more conventional sampling techniques.

POTENTIAL LIMITATIONS

Potential Limitations of the SC-MIP system include:

- Cannot identify specific VOCs using electron capture detectors (ECD), photoionization detectors (PID), or flame ionization detectors (FID).
- ECD, PID, and FID instruments provide a relative (qualitative) response only.
- Results in vadose zone may be misleading due to increased sample area and greater availability of free vapor.
- Significant QA/QC protocols are required.
- The effectiveness of the system is highly dependent on the experience of the operator.
- Relatively shallow operating range (typically no greater than 60-80 feet below ground surface).
- The relatively small sampling area can make correlation between bulk media sampling (soil, groundwater) results and MIP results difficult.

EQUIPMENT DESCRIPTION

System Components

The major field components (see Figure 1) required to collect data and record a data log include the following:

- Field Instrument (FC4000)
- MIP Controller (MP3500)
- MIP/EC Acquisition Software
- MIP Probe, Pull Cap, and Drive Cap
- MIP Trunkline
- Detector (ECD, PID, FID, DSITMS, or other applicable detector)
- Direct-push Soil Boring Equipment (Geoprobe®, CPT rig, or equivalent)
- Stringpot and Stringpot Piston Weight (for depth measurement)
- Rod Rack with MIP Probe Rods
- Carrier Gas System (nitrogen or helium)

Other required or optional system components are listed in the Geoprobe Systems® MIP Standard Operating Procedure (SOP) (Kerj, Inc., 2003).

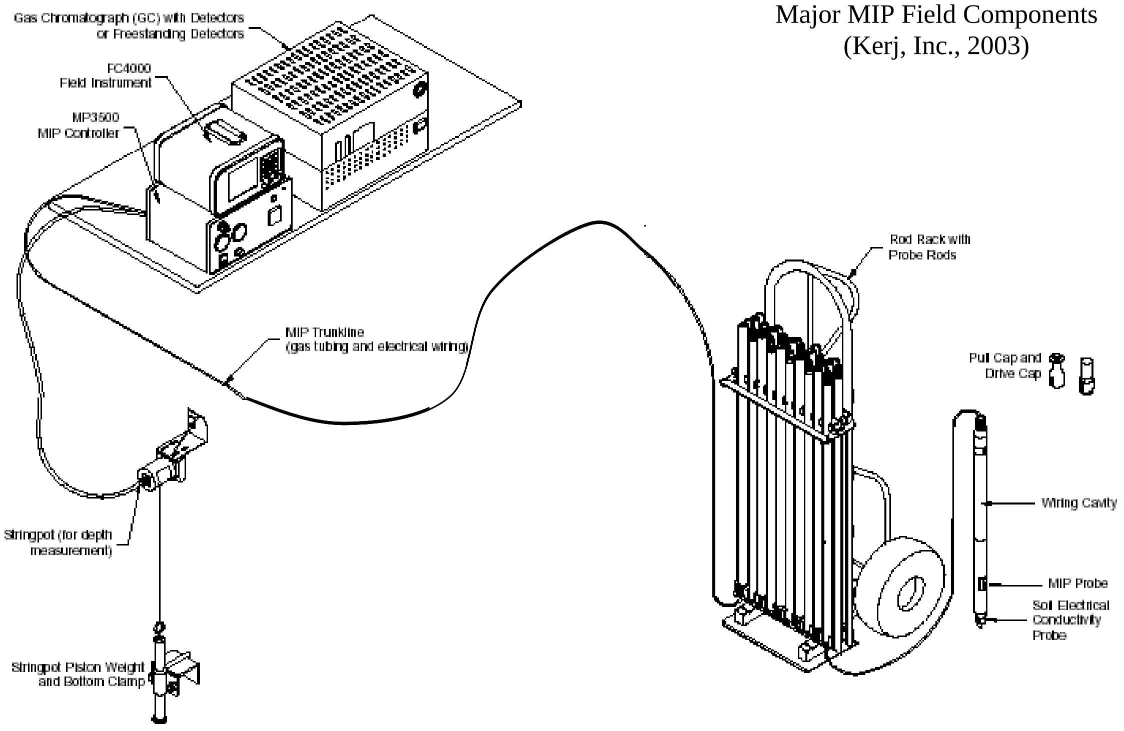


Figure 1.
Major MIP Field Components
(Kerj, Inc., 2003)

Principal of SC-MIP Operation

The MIP portion of the probe uses a heated permeable membrane advanced into the formation by direct-push methods (Figure 2). The membrane does not allow fluids to move across the membrane, allowing the instrument to function in the saturated zone. The probe is advanced into the subsurface at a speed of approximately one foot per minute. A heating element within the probe heats the membrane, which in turn heats the surrounding soil and/or groundwater in contact with the membrane, causing VOCs present in the media to volatize and diffuse through the polymer membrane (Christy, 1996). The VOCs are collected by an inert carrier gas and carried to the surface detectors through a pressurized gas return tube within the MIP trunkline. The carrier gas is fed into an applicable detector, typically an ECD, PID or FID, which qualitatively measures the VOCs. The detector output (in millivolts) is recorded versus a corrected depth measurement

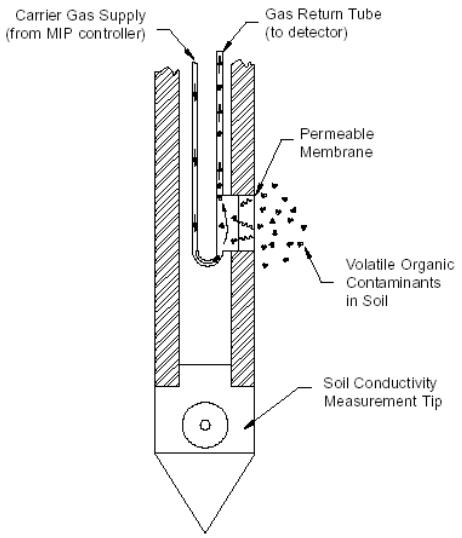


Figure 2.
Schematic of SC-MIP Probe
(Kerj, Inc., 2003)

(Figure 3) based on the travel time of contaminants through the carrier gas return tube as determined by membrane response testing.

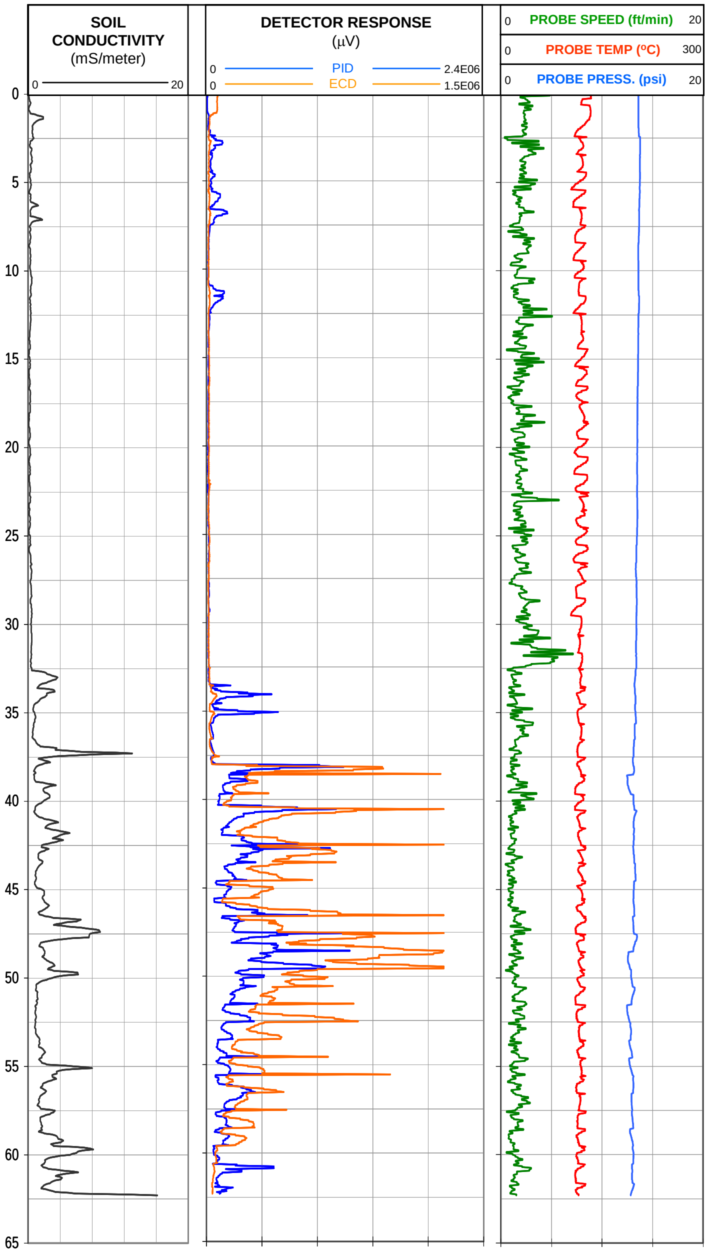
The SC tool uses a dipole arrangement at the tip of the probe, in which an alternating electrical current is passed from an insulated center electrode into the formation and returned to the probe body. The response of the formation to the current is measured as a voltage drop across the dipoles, which is then used to calculate formation resistance using Ohm's Law (Kerj, Inc., 1995):

$$Resistance\ (R) = \frac{Voltage(V)}{Current(I)}$$

The formation conductivity is determined as the inverse of the resistance (1/R), typically in units of milliSiemens per meter (mS/m).

Figure 3.

Example SC-MIP Output Log



EQUIPMENT OPERATION

Personnel

Generally, three personnel are required to operate the drilling and MIP equipment- two crew members under the direction of the field scientist overseeing field activities. One crew member operates the direct-push drilling equipment, and the other operates the MIP controller, logging equipment, and detectors as directed by the field scientist.

The field scientist overseeing SC-MIP operation and the assisting crew member should have a working knowledge of the principals of equipment operation and QA/QC procedures as outlined in this GAP. The field scientist should also be familiar with the expected output of the detectors and how this output is affected by the SC-MIP system controls.

Detector Selection

Detector selection is based on the subsurface contaminants expected at the site. In general:

- The FID is used for detection of unsaturated hydrocarbons, including methane;
- A PID is used for general VOC screening including petroleum hydrocarbons; and,
- An ECD is used primarily for detection of chlorinated VOCs (CVOCs).

Other detectors, including DSITMS and similar low-volume gas chromatography detectors, may be used to provide qualitative analysis and differentiation of VOC and CVOC compounds. More than one detector can be used simultaneously for initial investigations where subsurface contaminant characteristics are unknown.

Regardless of the detector used, each detector should be calibrated following the instructions provided by the manufacturer.

Membrane Response Testing

Response testing is an important check to examine if the system is operating properly and to demonstrate that the system is detecting the correct compounds. The response test also provides the operator with the travel time of the contaminant from membrane to detector, which allows the logging software to correct depth for each reading.

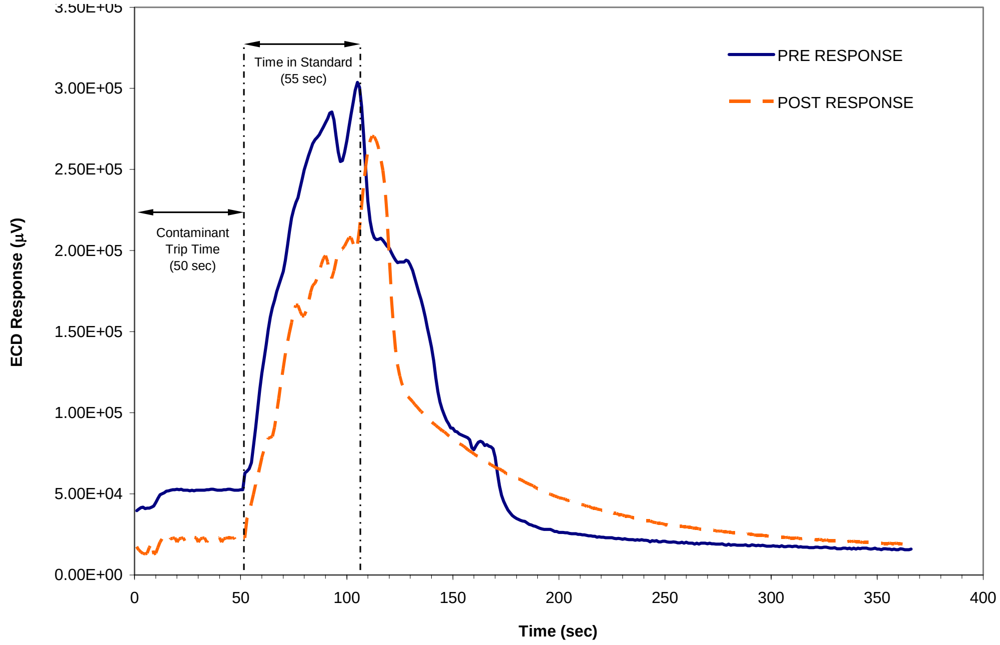
The procedure for response testing is detailed in the Geoprobe Systems® MIP SOP (Kerj, Inc., 2003). In general, the steps for response testing to be performed by the contractor are as follows:

1. Using a neat sample of the analyte of interest, prepare a stock standard of the analyte at a concentration of 50 mg/ml.
2. Immerse the probe in a 5-gallon bucket containing fine sand and distilled water, to simulate saturated subsurface conditions. The response represents the baseline reading.
3. Access the MIP time software and view the detector vs. time data - wait for the detector to stabilize to the baseline output.

4. Using 500ml of distilled water, mix the desired test concentration (working standard) using the stock standard solution in step 1 (above), following the instructions detailed in the Geoprobe Systems® MIP SOP (Kerj, Inc., 2003).
5. Pour the working standard into a 2-inch by 24-inch PVC test cylinder (Kerj, Inc., 2003) and insert the SC-MIP probe.
6. View the results of the MIP response using the MIP time software. Determine contaminant trip time and response time from the output graph.

Typical pre-logging and post-logging response curves are shown in Figure 4. Detector response during both the pre-logging and post-logging response tests should be at a minimum one order of magnitude above the baseline response. Additionally, the response test should be performed both prior to and after the subsurface run. The results of the pre-logging and post-logging response tests are then compared and should show detector responses within at least 10 percent of each other. If the pre-logging detector response is less than one order of magnitude above baseline response, ensure that the contractor performs the following checks:

Figure 4.
Typical Response Test (ECD) with 10ppm Standard



- ■ Inspect the detector for correct settings, and ensure that the detector is functioning properly.
- ■ If using a PID, inspect the lamp for film. A film may form on the detector lamp due to the constant flow of carrier gas over the lamp, causing the PID response to diminish. Clean or replace the lamp and repeat the response test.
- ■ Check the carrier gas trunkline for leaks, and ensure proper carrier gas pressure (approximately 13 to 17 psi).
- ■ Confirm the MIP is on and at proper temperature (80-125^{o}C, 100^{o}C optimal).

- Ensure the detector is calibrated to the instructions provided by the manufacturer.
- Visually inspect the membrane. Allow the membrane to cool, and apply water while the carrier gas system is operating. If bubbling occurs, or damage is observed indicating the membrane is compromised, replace the membrane as per the Geoprobe Systems® MIP SOP (Kerj, Inc., 2003) and repeat the response test.

Field Operation

The procedure for field operation of the SC-MIP system is detailed in the Geoprobe Systems® MIP SOP (Kerj, Inc., 2003). In general, the field operation procedure is as follows:

1. Power on the field equipment generator.
2. Turn on the carrier gas system and check the flow rate. Inspect the system for leaks or kinks. Allow the system to purge for at least 3 minutes prior to each boring.
3. Power up the detector(s) and allow them to warm-up as required. Ensure that the detectors are calibrated as per the instructions provided by the manufacturer.
4. Turn on the MIP controller and FC4000 Field Instrument.
5. Advance a pre-probe rod 3 to 4 feet into the subsurface at the location to be logged. Install the SC-MIP into the hole and connect to the direct-push drill string as per the Geoprobe Systems® MIP SOP (Kerj, Inc., 2003).
6. Load the MIP time software, and perform the pre-logging membrane response test to confirm that the system is responding as expected. If response is less than one order of magnitude above baseline, perform system checks as described above.
7. Ensure that the proper contaminant travel time is entered into the software. If the trip time is incorrect, restart the software and enter the correct contaminant travel time.
8. Prepare the SC-MIP system for driving (stringpot setup, drive cap, etc.) as per the Geoprobe Systems® MIP SOP (Kerj, Inc., 2003).
9. Record the carrier gas trunkline pressure, contaminant travel time, Detector response time, and baseline detector readings in a field notebook.
10. Advance the probe at a rate of 1 ft/min to the boring depth.
11. When the boring is complete, remove the probe as per the Geoprobe Systems® MIP SOP (Kerj, Inc., 2003).
12. Perform the post-logging membrane response test to confirm that the system continues to as expected. If response is less than one order of magnitude above baseline or is not within 10 percent of the pre-logging response test, perform system checks as described above.
13. Perform QA/QC checks as described below by reviewing the datalog and data plots.

If the post-logging membrane response test was not within 10 percent of the pre-logging response test, evaluate the data plot for the sample point. If the data is suspect (i.e., limited response or significant noise in the response) or the system stopped functioning properly during sampling (i.e., loss of carrier gas pressure of greater than +/- 1 psi, heater malfunction, etc.)

repeat the boring at a new location with steps 5 through 11 after completing system checks (as described above under membrane response testing).

If a new membrane was installed prior to performing the pre-logging response test, the difference in response between the pre-logging and post-logging test may be greater than 10 percent. However, the system should be thoroughly checked, and an additional post-logging response test performed, which should be within 10 percent of the first post-logging response test.

QUALITY ASSURANCE/ QUALITY CONTROL

The following are important to note when evaluating MIP data:

- The movement of VOCs across the permeable membrane is a function of the contaminant vapor pressure, which can be affected by temperature and the pressure gradient across the membrane created by the movement of carrier gas through the trunkline.
- The response of the MIP in the vadose zone may be misleading, as increased sample area and greater availability of free vapor may cause increased detector response.
- When an ECD is detecting very high levels of CVOCs in a particular zone, and the PID or FID is detecting relatively low levels of VOCs or unsaturated hydrocarbons in the same zone, be wary. High levels of CVOCs present in the subsurface may be detected by an FID or PID and misinterpreted as low levels of VOCs or unsaturated hydrocarbons when they are not in fact present.
- Carrier gas pressure should be kept within 1 psi of the pressure used during response testing, and monitored closely during logging. If the pressure increases or decreases more than 1 psi, the cause should be determined and corrected.
- If a trunkline restriction is suspected due to a loss of flow at pressure, reverse the gas system and purge the line. Restrictions in flow may be caused by kinks in the trunkline tubing or accumulation of debris at trunkline connection points.
- MIP temperature should remain between 100 to 120^{o}C during logging.
- As stated previously, the post-logging membrane response test should be within 10 percent of the pre-logging response test. A change in membrane response greater than 10 percent may indicate that the data is suspect or the system stopped functioning properly during sampling. Check the system thoroughly to determine a cause, and re-perform the response test.

REFERENCES

Christy, Thomas M., P.E., 1996. “A Permeable Membrane Sensor for the Detection of Volatile Compounds in Soil,” National Groundwater Association, National Outdoor Action Conference, Las Vegas, Nevada. May 1996.

Kerj, Inc., 1995. “A Percussion Probing Tool for the Direct Sensing of Soil Conductivity”, Geoprobe Systems Technical Paper No. 94-100.

Kerj, Inc., 2003. “Geoprobe Membrane Interface Probe (MIP) Standard Operating Procedure”, Geoprobe Systems Technical Bulletin No. MK3010.

McAndrews, B., Heinze, K., and DiGuiseppi, W., 2003. *Defining TCE Plume Source Areas Using the Membrane Interface Probe (MIP).* In: Soil & Sediment Contamination, 12: 799-813, 2003. Prepared by Earth Tech, Englewood, Co.

GENERALLY ACCEPTABLE PROCEDURE

FOR

AIR SAMPLING WITH SUMMA CANISTERS

INTRODUCTION

While several states and the United States Environmental Protection Agency (USEPA) have protocols and/or guidance and/or standards for estimating potential indoor inhalation exposures based on groundwater or soil vapor measurements, analytical data from indoor air sampling is the most direct method for estimating total inhalation exposures. However, it must be noted that such indoor air sampling data only represents conditions during the sampling and may also include molecules from other aboveground inside activities conducted by the property owner and/or tenant. Air samples for vapor intrusion investigations are most commonly collected in Summa canisters and Tedlar bags, which are available from numerous laboratories. A Summa canister is a stainless steel container with internal surfaces that have become nearly chemically inert using a “Summa” process. In order to minimize reactions with the sample, it is critical that the canister has a high degree of chemical inertness. Proper collection of air samples is important for obtaining useful analytical results. The laboratory prepares the canister for sampling by creating a vacuum in the canister of approximately 29.9 inches of mercury (Hg). Opening the valve allows air to enter the canister. Air sampling can occur anywhere a Summa canister or a tube connected to a canister can be placed. This document is intended as a guide for air sampling and is not a substitute for experience and does not include information for all sampling scenarios and field conditions.

POTENTIAL APPLICATIONS

Potential applications of air sampling include:

- Monitoring of and characterization of compounds in air
- Evaluation of human inhalation exposure
- Ambient air-quality studies
- Evaluation of soil vapor intrusion pathways into buildings

POTENTIAL LIMITATIONS

Potential limitations of the air sampling include:

- Sampling with Summa canisters in multiple distant locations concurrently can be time and labor intensive.

- Summa canisters, depending on the type of sampling train, may have valves and gauges with multiple joints or seals that may compromise sample integrity if there is a leak.
- Some laboratories may have limited quantities of canisters or associated equipment in stock.
- All equipment (e.g., canisters, gauges, valves, and flow controllers) must be individually or batch certified clean, which adds to the cost for sampling and lead time needed to receive equipment.
- Concentrations of compounds found in air often have temporal and spatial variations. This may make it difficult to accurately estimate the amount of human exposure.

CANISTER CERTIFICATION AND HOLDING TIME

The laboratory providing the Summa canisters must be notified as to the level of cleaning certification (e.g., 10% or 100%). The 10% certification process, in which 10% of the canisters are certified clean, is suitable for routine ambient air studies and projects where it is known that high concentrations are to be found. All Summa canisters are certified clean in the 100% certification process and do not contain target compounds (or other compounds likely to be found by the analytical procedure used to identify the target compounds) greater than the project reporting limits. Summa canisters can hold a vacuum for greater than 30 days. However, holding times for Summa canister samples are compound specific. Non-polar compounds, such as chloroform, benzene, and vinyl chloride, are stable in a canister for 30 days while polar compounds, such as methanol and acetone, are stable for 14 days (Air Toxics Ltd.; USEPA, 1999).

EQUIPMENT

Materials required for air sampling:

- Summa canister with valve
- Flow controller
- Particulate filter
- Vacuum gauge
- Razor blade knife
- Wrenches
- Pens
- Field data record sheets
- Field notebook

Summa Canister

Optional Equipment (application dependent)

- Clean, unused tubing (1/4" outside diameter tubing is probably needed to attach to the Summa canister)
- Three way valves

Equipment Decontamination Procedures

Equipment decontamination is not anticipated. All equipment should arrive certified clean (with paperwork to demonstrate that) from the laboratory. All Teflon tubing should be discarded after use.

SAMPLING TRAIN LEAK TEST

A Summa canister air sampling train can have many fittings. Some laboratories supply equipment that has one or more fittings between each of the following: Summa canister, flow controller, particulate filter, and pressure gage (Air Toxics provides the controller, filter and gage all in one unit so there is only one connection). At each of these connections, there is a chance that the fitting will fail and cause a leak. If a leak occurs the flow of air into the canister may be significantly faster than desired, resulting in the canister vacuum dropping to zero significantly faster than desired. During soil vapor sampling, a leak may allow ambient air into the sampling train thus diluting the soil vapor and biasing the sample low.

A quick way to confirm that there are no (significant) leaks in your sampling train is to attach the flow controller and pressure gage to the canister. The Summa canister usually comes with a brass cap that you screw on to the end of the sampling train to form a closed system. Open the valve and close it once the pressure gage equilibrates with the pressure in the canister (can take several seconds and also confirms the pressure in the canister). If there are no leaks the pressure should not change. If the pressure needle moves, tighten the fittings and repeat the test until the pressure stays constant.

PROCEDURES

1. **Site Inspection**
    a. Prior to sampling indoor air, a site inspection should be conducted.
    b. Create an inventory of all products at the site which may contain volatile organic compounds (VOCs) or other chemicals of concern.
    c. Remove any confounding sources from the site, if possible.
    d. Vapor measurements with photoionization detectors (PIDs) could be used during the inspection and the sampling event to help evaluate potential gross (high concentration) interferences.

e. Determine whether windows and doors are to be closed and ventilation used prior to and during sampling.
f. Determine whether normal daily operations are to occur at the site during sampling.

2. **Summa Canister Preparation**
   a. Upon receiving the canisters, verify that all associated equipment have arrived (e.g., chain-of-custody, particulate filter, gauge).
   b. Verify that gauges work properly.
   c. Verify that there is a vacuum in the canisters and perform pressure leak tests.
      1) Confirm valve is closed
      2) Remove the brass cap
      3) Attach pressure gauge, particulate filter, and flow controller (if required) to the Summa canister
      4) Attach brass cap to side of gauge tee fitting (if appropriate) and to the end of the sampling train to form a closed system
      5) Open the valve and close it once the pressure gage equilibrates with the pressure in the canister (can take several seconds and also confirms the pressure in the canister)
      6) If there are no leaks the pressure should not change. If the pressure needle moves, tighten the fittings and repeat the test until the pressure stays constant.

3. **Air Sampling**
   a. Place canister in desired sampling location and at the appropriate level (e.g. breathing zone -3-5 feet above ground surface).
   b. Make sure all valves, gauges, and filters are properly attached.
   c. Open valve ½ turn.
   d. Record initial vacuum pressure, time, and date on field data form.
   e. If gauge is in-line with the flow controller, check pressure in the canister while sampling to ensure the flow controller is working properly. Record all interim pressure readings/times.
   f. At the end of sampling, close valve.
   g. Verify and record final vacuum of canister on canister tag and on the field form.
   h. The final pressure should be close to minus (–) 5” Hg. If a canister is received at the laboratory with less than -1” Hg. vacuum the laboratory will note this in their case narrative and the data validator will most likely qualify and sometimes reject this data.
   i. Close valve, remove gauge and flow controller, and replace brass cap.
   j. Fill out canister sample tag, field form, and chain-of-custody.

k. Place the canister, gauge, flow controller, and filter back in the box and return to laboratory.

4. **Sample Labels**

Sample labels should include the following information

a. Site Name
b. Sample Number
c. Sample Type
d. Sample Identification (ID)
e. Canister ID
f. Flow controller ID
g. Date of Collection
h. Initial Vacuum
i. Final Vacuum
j. Start Time
k. Finish Time
l. Sampler(s) Name/Initials

5. **Field Forms**

A field sampling form is often provided by the laboratory for each canister. Check with the lab to make sure of this or create your own. The form should include the following information.

a. Client Name
b. Canister Serial Number
c. Date Cleaned
d. Client Sample Number
e. Site Name
f. Initial vacuum check including vacuum pressure, date, and initials from lab
g. Initial and interim field vacuum including vacuum pressure, date, and initials
h. Final field reading including vacuum pressure, date, and initials
i. Flow controller ID
j. Pressure gauge ID
k. Sampling duration
l. Flow setting/rate (ml/min)
m. Additional comments

6. **Chain-of-Custody**

The following information must be entered on the chain of custody form.

a. Project number – enter the alpha-numeric designation that uniquely identifies the project Site.
b. Project name.
c. Signature of sampler(s).
d. Sample number – enter the sample identification number for each sample in the shipment.
e. Date.
f. Time – enter a four digit number indicating the time of collection based on the 24-hour clock (e.g., 1300).
g. Sample matrix – enter the matrix (e.g., indoor air versus soil vapor) of the sample.
h. Parameters for analysis – enter the analytical method number for each sample collected.
i. Remarks – enter any appropriate remarks.

REFERENCES

Air Toxics Ltd. Guide to Air Sampling and Analysis: Canisters and Tedlar Bags, fifth edition.

USEPA. 1999. Compendium Method TO-15: Determination of Volatile Organic Compounds (VOCs) in Air Collected in Specially-Prepared Canisters and Analyzed By Gas Chromatography/Mass Spectrometry (GC/MS) in Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air, Second Edition. Center for Environmental Research Information, Office of Research and Development, U.S. Environmental Protection Agency, Cincinnati, OH 45268.

TROUBLESHOOTING

- In our experience, 5-10% of the canisters fail or the sampling train leaks for one reason or another, although sampling equipment has become more reliable in recent years. To better ensure a valid sample is collected from each sample location, two Summa canisters can be placed at each sample location (which is expensive); or if sampling a large indoor space, decrease the spacing between sample locations to improve the usefulness of the results. At the end of the sampling event, a decision can be made as to which canister should be analyzed. Limitations to this method include the extra cost for renting certified clean canisters. Performing a leak test, as described above, should minimize any sampling train leakage.
- Always perform a sampling train leak test.

- Considerations for collection of samples include:
  - There should be nothing obstructing the air flow around the canister;
  - Air flow through the buildings should be considered when deciding on a sample location;
  - Canisters should be located so as to ensure that samples are representative of the conditions inside the buildings;
  - The background samples should be located so as to ensure that local conditions (i.e., specific emission sources) do not impact the background.
- Suggest getting all equipment sent to the office prior to going to the site. Inspect all equipment to make sure that all necessary equipment has arrived so that you know that you have all the equipment you need before you get to the site.
- There should be dedicated pressure gauges, three way valves, and particulate filters for each Summa canister. They should be all connected together in the sampling train so that the pressure in the Summa canister can be monitored during sampling. Not all laboratories have the equipment necessary to do this so confirm this before selecting the laboratory. Some laboratories have flow controllers and pressure gauges that are combined in one device. See diagram below.

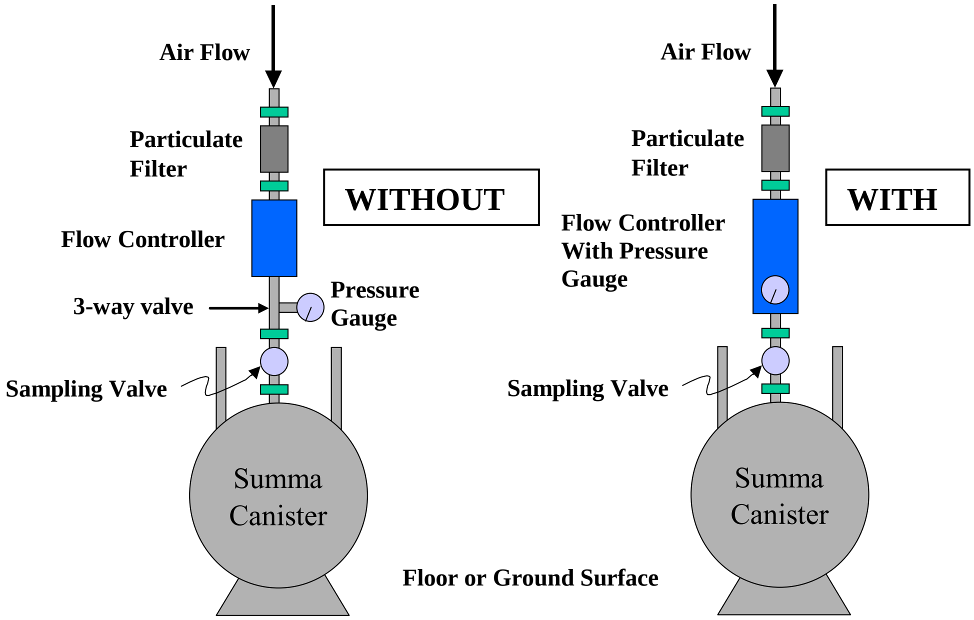


Diagram of Summa Canister Sampling Train With and Without Pressure Gauge in Flow Controller

- The initial sample pressure should be approximately –28 to –30 inches Hg. Do not use a canister if the initial vacuum is less than -25 inches Hg. Test the pressure prior to sampling to confirm pressure. The sample should be collected until approximately –5 inches Hg is reached. Leaving some vacuum in the canister allows the laboratory to check upon receipt and verify that the canister remained closed during shipment. If a canister is received at the laboratory with less than -1” Hg. vacuum the laboratory will note this in their case narrative and the data validator will most likely qualify and sometimes reject this data.

- Flow controllers allow air to flow through them at a specific rate. They are calibrated to reach approximately –5” Hg after a specific length of time from 5 minutes to 24 hours. You must tell the laboratory the desired sampling duration so that they provide the appropriately calibrated flow controller. The longer the sample time, the more effort it takes to identify if there are issues during sampling.
- You must also decide if you would like to sample with 6 liter or 1 liter canisters. 1 liter canisters are normally used for collecting high concentration grab samples (1-5 minutes). 1 liter canisters can be used for 0.5 to 2 hour integrated samples and 6 liter canisters for 0.5 to 24 hour integrated samples. 6-L canisters must be used if very low detection limits are required.
- Make sure the laboratory can achieve the required reporting limit. In New York, TCE must have a reporting limit of 0.25 $\mu g/m^3$ (0.046 ppbv) for indoor and outdoor air and 1 $\mu g/m^3$ (0.183 ppbv) for soil vapor samples. PCE must have a reporting limit of less than 3 $\mu g/m^3$ (0.434 ppbv).
- Particulate filters come in several types: 7 micron, 5 micron and even 2 micron. 7 micron filters are usually used with six liter canisters for the collection of integrated samples and 5 micron filters are used to slow down grab samples with one liter canisters.
- If pressure gauges are dedicated to each canister (which they should), the gauge ID should be recorded on the field sampling form. Each gauge is unique and different gauges may show slightly different pressures. Pressure gauges are not usually calibrated and are not accurate enough for measuring absolute pressures.
- Stay away from and do not use VOC sources, such as gasoline cans and Sharpie permanent markers, while air sampling. Make sure not to use permanent marking pens near the canisters as they may contain compounds that are on the target compound list.
- The canister pressure should be periodically checked throughout the sampling period. If the vacuum is not at the correct pressure, corrective action can be taken.
- Malcolm Pirnie staff who are familiar with Summa canisters include:
  - Mark Flusche, Stefan Bagnato, Jeremy Wyckoff, Diane Bertok, Chris Thomas, Ely Moskal, and Danielle Giroux (ALB)
  - Dwight Symonds (ROC)
  - Jeff Dekoskie and Matt Jones (NNJ)
  - Dominic DiSalvo (WHI)
  - Kelley Roe (ALB-SYR)

- Lance Kazzi, Curt Whipple, and Jennifer Hock (HAR)
- Fred Stanin and Elisabeth Hawley (NCA)
- Brad Walker (BUF)
- Jennifer Jones (BOS)

LABORATORIES

Air Toxics, LTD

Primary Contact:	Ausha Scott – Client Services Representative
Secondary Contacts:	Tara Laroche– Technical Sales Representative

Client Services
180 Blue Ravine Road, Suite B
Folsom, CA 95630
(800) 985-5955
(916) 985-1000
FAX – (916) 985-1020
AScott@airtoxics.com or tlaroche@airtoxics.com

Columbia Analytical Services, Inc./Air Quality Lab
Contact: Kate Aguilera
2655 Park Center Drive, Suite A
Simi Valley, CA 93065
805-526-7161 (phone)
805-526-7270 (fax)
kaguilera@caslab.com

Con-test Analytical Laboratory
Contact: Tim Kelley
39 Spruce Street
East Longmeadow, MA 01028
(413) 525-2332 x39 (Office)
(413) 525-6405 (Fax)
tkelley@contestlabs.com

TestAmerica Laboratories, Inc.
Contact: Don Dawicki
30 Community Drive, Suite 11
South Burlington, VT 05403
802-660-1990 (Office)
802-655-1919 (Fax)
Don.Dawicki@testamericainc.com

EQUIPMENT SUPPLIERS

Purchases

Permanent sub-slab vapor points
McMaster Carr - http://www.mcmaster.com/ 609-689-3415
Type 316 SS Smooth-Bore Seamless Tubing 1/4" OD, .18" ID, .035" Wall, 3' Length 89785K125
Steel Yor-Lok Tube Fitting Coupling for 1/4" Tube OD 5929K193
Steel Yor-Lok Tube Fitting Cap for Fitting for 1/4" Tube OD 5929K253

Teflon Tubing (¼ inch O.D.):
Greg Wooldridge - National Sales Manager
Geotech Environmental Equipment, Inc.
2650 E. 40th Ave., Denver, CO 80205
Phone 303-320-4764 1-800-833-7958
Fax 303-322-7242
gregjw@geotechenv.com www.geotechenv.com

Disposable Syringes and plastic 3-way valves
Cole-Parmer - http://www.coleparmer.com/
625 East Bunker Ct. Vernon Hills, IL 60061-1844
1-800-323-4340
60 mL B-D plastic disposable syringe, luer-lock tip, 40 / box - 07940-30
Stopcocks with Luer Connections; 3-way; male lock - 30600-02

Sampling Train Protective Cases (Pelican Cases)
CPD Industries
14020 Central Avenue, Unit 530
Chino, CA 91710
(800) 882-4730
FAX: (909) 465-5598
www.casebypelican.com
Part: Pelican 1620 (APP-160F) Case with Foam

Isolation Valves (Swagelok – three way, stainless steel, no lubricant):
Westchester Valve & Fitting Co.
565 North State Road Briarcliff Manor, NY 10510
(914) 762-6600
Attention: Joe Consoli
Part No.: SS-42XS4-1466

Other:
Forestry Suppliers, Inc.: (800) 647-5368
Fax: (800) 543-4203
Tech. Support: (800) 430-5566

Rentals

Malcolm Pirnie Equipment Facility
Tall Pines Industrial Park
382 Route 59, Section 286
Monsey, NY 10952
Attention: Max Bateman
(845) 357-0965
FAX: (845) 357-2819

Pine Environmental Services, Inc.
1900 Brewerton Rd.
Mattydale, NY 13211
(877) 903-PINE
(315) 455-5100
FAX: (315) 455-5130
http://www.pine-environmental.com

Ashtead Technology Rentals
1057 East Henrietta Road
Rochester, NY 14623
(800) 242-3910
(585) 424-2140
FAX: (585) 424-2166

SHIPPING

United Parcel Service	800-PICK-UPS (800-742-5877)
Federal Express	800-GO-FEDEX (800-463-3339)

New York State Department of Environmental Conservation
Generic FAP for Work Assignments

Appendix B: Operation and Calibration Procedures for Field Instruments

MALCOLM PIRNIE

MiniRAE 2000

Portable Handheld VOC Monitor

The rugged MiniRAE 2000 is the smallest pumped handheld volatile organic compound (VOC) monitor on the market. Its Photoionization Detector's (PID) extended range of 0 to 10,000 ppm makes it an ideal instrument for applications from environmental site surveying to HazMat/ Homeland Security.

AutoRAE Compatible

Wireless

Key Features

- **Proven PID technology** The patented sensor provides a 3-second response up to 10,000 ppm and sets a new standard for resistance to moisture and dirt.
- **Wireless communication enabled and certified**
- **Self-cleaning lamp and sensor** The patented self-cleaning lamp and sensor minimize the need for maintenance and calibration.
- **The MiniRAE 2000 lamp and sensor can be taken apart in seconds for easy maintenance without tools!**
- **Measure more chemicals than with any other PID.** With over 100 Correction Factors built into the MiniRAE 2000 memory and the largest printed list of Correction Factors in the world (300+), RAE Systems offers the ability to accurately measure more ionizable chemicals than any other PID. When a gas is selected from the MiniRAE 2000's library, the alarm points are automatically loaded into the meter.
- **User friendly** screens make it easy to use for simple applications and flexible enough for sophisticated operations.
- **Drop-in battery** When work schedules require putting in more than the 10 hours supplied by the standard NiMH battery, the drop-in alkaline pack supplied with every MiniRAE 2000 lets you finish the job.
- **Rugged Rubber Boot** The standard rubber boot helps assure that the MiniRAE 2000 survives the bumps and knocks of tough field use.
- **Strong, built-in sample pump** draws up to 100 feet (30 m) horizontally or vertically.
- **Tough, flexible inlet probe**
- **Large keys** operable with 3 layers of gloves.
- **Easy-to-read display** with backlight.
- **Stores up to 267 hours of data** at one-minute intervals for downloading to PC.
- **3-year 10.6 eV lamp warranty**

Applications

HazMat/Homeland Security

- Initial PPE (personal protective equipment) assessment
- Leak detection
- Safety perimeter establishment and maintenance
- Spill delineation
- Decontamination
- Remediation

Industrial Hygiene/Safety

- Confined Space Entry (CSE)
- Indoor Air Quality (IAQ)
- Worker exposure studies

Environmental

- Soil and water headspace analysis
- Leaking underground storage tanks
- Perimeter fenceline monitoring
- Fugitive emissions (EPA Method 21)
- Vapor recovery breakthrough
- Landfill monitoring

ver12_04.07

MiniRAE 2000

Specifications*

Detector Specifications

Size	8.2" L x 3.0" W x 2.0" H (21.8 x 7.62 x 5.0 cm)
Weight	20 oz with battery pack (553 g) w/o rubber boot
Sensor	Photoionization sensor with standard 10.6 eV or optional 9.8 eV or 11.7 eV UV lamp
Battery	• Rechargeable, external, field-replaceable Nickel-Metal-Hydride (NiMH) battery pack • Alkaline battery holder (for 4 AA batteries)
Operating Period	10 hours continuous operation
Display	Large LCD, backlight activated manually, by alarms or by darkness
Keypad	1 operation and 2 programming keys
Direct Readout	• VOCs as ppm by volume • High and low values • STEL and TWA (in hygiene mode) • Battery and shut down voltage
Alarms	90 dB buzzer and flashing red LED to indicate exceeded preset limits: • High: 3 beeps and flashes per second • Low: 2 beeps and flashes per second • STEL and TWA: 1 beep and flash per second • Alarms automatic reset or latching with manual override • Optional plug-in pen size vibration alarm • User adjustable alarm limits
Calibration	Two-point field calibration of zero and standard reference gas. Calibration memory of 8 calibration gases, alarm limits, span values and calibration date
Datalogging	267 hours (at one-minute intervals) with date/time. Header information includes monitor serial number, user ID, site ID, date and time
Sampling Pump	• Internal, integrated flow rate of 400 cc/min • Sample from 100' (30 m) horizontally or vertically
Low Flow Alarm	Auto shut-off pump at low flow condition
Communication	Download data and upload instrument set-up from PC through RS-232 link to serial port. Wireless communication enabled and certified (requires RAELink2 and ProRAE Remote to use)
Temperature	14° F to 104° F (-10° C to 40° C)
Humidity	0% to 95% relative humidity (non-condensing)
EM/RFI	Highly resistant to EMI /RFI. Compliant with EMC Directive 89/336/EEC
IP-rating	IP-55: protected against dust, protected against low-pressure jets of water from all directions
Hazardous Area Approval	• **US and Canada:** UL and cUL, Classified for use in Class I, Division 1, Groups A, B, C and D hazardous locations • **Europe:** ATEX II IG EEx ia IIC T4
Attachment	Durable bright yellow rubber boot w/belt clip & wrist strap
Warranty	Lifetime on non-consumable components (per RAE Systems Standard Warranty), 3 years for 10.6.V PID lamp, 1 year for pump and battery

* Specifications are subject to change
** Performance based on isobutylene calibration

Default Sensor Settings**

Gas Monitor (ppm)	Range (ppm)	Resolution Time (T90)	Response
VOCs	0 to 99.9 ppm	0.1 ppm	< 3 sec
	100 to 10,000 ppm	1 ppm	< 3 sec

MiniRAE 2000 and Accessories

Monitor only includes:

- RAE Systems UV lamp: 10.6 eV, 9.8 eV or 11.7 eV as specified
- ProRAE Suite software package for Windows® 98, NT, 2000 and XP
- Computer interface cable
- 5-inch Flex-I-Probe
- External filter
- Rubber boot with belt clip
- Alkaline battery adapter
- Tool kit
- Lamp cleaning kit
- Nickel-Metal-Hydride (NiMH) battery
- 120/230 V AC/DC wall adapter (if specified)
- Operation and maintenance manual

Monitor with accessories kit adds:

- Hard transport case with pre-cut foam padding
- 5 porous metal filters and O-rings
- Organic vapor zeroing adapter
- Gas outlet port and tubing

Optional calibration kit adds:

- 10 ppm isobutylene calibration gas, 34L
- Calibration regulator and flow controller

Optional Guaranteed Cost of Ownership Program:

- 4-year repair and replacement guarantee
- Annual maintenance service

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RAE SYSTEMS

MiniRAE 3000
User's Guide

Rev. A
April 2007
P/N 059-4020-000

Contents

Read Before Operating

This manual must be carefully read by all individuals who have or will have the responsibility of using, maintaining, or servicing this product. The product will perform as designed only if it is used, maintained, and serviced in accordance with the manufacturer's instructions. The user should understand how to set the correct parameters and interpret the obtained results.

CAUTION!

To reduce the risk of electric shock, turn the power off before removing the instrument cover. Disconnect the battery before removing sensor module for service. Never operate the instrument when the cover is removed. Remove instrument cover and sensor module only in an area known to be non-hazardous.

The instrument is classified as to intrinsic safety for use in Class I, Division 1, groups A, B, C, D, or non-hazardous locations only.

Special Notes

⚠ When the instrument is taken out of the transport case and turned on for the first time, there may be some residual organic or inorganic vapor trapped inside the detector chamber. The initial PID sensor reading may indicate a few ppm. Enter an area known to be free of any organic vapor and turn on the instrument. After running for several minutes, the residual vapor in the detector chamber will be cleared and the reading should return to zero.

⚠ The battery of the instrument discharges slowly even if it is turned off. If the instrument has not been charged for 5 to 7 days, the battery voltage will be low. Therefore, it is a good practice to always charge the instrument before using it. It is also recommended to fully charge the instrument for *at least 10 hours* before first use. Refer to this User Guide’s section on battery charging for more information on battery charging and replacement.

WARNINGS

STATIC HAZARD: Clean only with damp cloth.

For safety reasons, this equipment must be operated and serviced by qualified personnel only. Read and understand instruction manual completely before operating or servicing.

Use only RAE Systems battery packs, part numbers 059-3051-000 and 059-3052-000. This instrument has not been tested in an explosive gas/air atmosphere having an oxygen concentration greater than 21%. Substitution of components may impair intrinsic safety. Recharge batteries only in non-hazardous locations.

Do not mix old and new batteries or batteries from different manufacturers.

The calibration of all newly purchased RAE Systems instruments should be tested by exposing the sensor(s) to known concentration calibration gas before the instrument is put into service.

For maximum safety, the accuracy of the instrument should be checked by exposing it to a known concentration calibration gas before each day's use.

Do not use USB/PC communication in hazardous locations.

AVERTISSEMENT

DANGER RISQUE D'ORIGINE ELECTROSTATIQUE: Nettoyer uniquement avec un chiffon humide.

Pour des raisons de sécurité, cet équipment doit être utilisé, entretenu et réparé uniquement par un personnel qualifié. Étudier le manuel d’instructions en entier avant d’utiliser, d’entretenir ou de réparer l’équipement.

Utiliser seulement l'ensemble de batterie RAE Systems, la reference 059-3051-000 au 059-3052-000. Cet instrument n’a pas été essayé dans une atmosphère de gaz/air explosive ayant une concentration d’oxygène plus élevée que 21%. La substitution de composants peut compromettre la sécurité intrinsique. Ne charger les batteries que dans emplacements désignés non-dangereuse.

Ne pas melanger les anciennes et les nouvelles batteries, ou bien encore les batteries de differents fabriquants.

La calibration de toute instruments de RAE Systems doivent être testé en exposant l’instrument a une concentration de gaz connue par une procédure diétalonnage avant de mettre en service l’instrument pour la première fois.

Pour une securite maximale, la sensibilité du l’instrument doit être verifier en exposant l’instrument a une concentration de gaz connue par une procédure diétalonnage avant chaque utilisation journalière.

Ne pas utiliser de connection USB/PC en zone dangereuse.

Standard Contents

Instrument
Calibration Kit
Charging Cradle
AC/DC Adapter
Alkaline Battery Adapter
Data Cable
CD-ROM With User’s Guide, Quick Start Guide, and related materials

General Information

The compact instrument is designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It monitors Volatile Organic Compounds (VOC) using a photoionization detector (PID) with a 9.8 eV, 10.6 eV, or 11.7 eV gas-discharge lamp. Features are:

Lightweight and Compact

- Compact, lightweight, rugged design
- Built-in sample draw pump

Dependable and Accurate

- Up to 16 hours of continuous monitoring with rechargeable battery pack
- Designed to continuously monitor VOC vapor at parts-per-million (ppm) levels

User-friendly

- Preset alarm thresholds for STEL, TWA, low- and high-level peak values.
- Audio buzzer and flashing LED display are activated when the limits are exceeded.

Datalogging Capabilities

- 500,000-point datalogging storage capacity (>11 months) for data download to PC

The instrument consists of a PID with associated microcomputer and electronic circuit. The unit is housed in a rugged case with a backlit LCD and 3 keys to provide easy user interface. It also has a built-in flashlight for operational ease in dark locations.

Physical Description

The main components of the portable VOC monitoring instrument include:

- Three keys for user to interact with the instrument: 3 operation/programming keys for normal operation or programming
- LCD display with back light for direct readout and calculated measurements
- Built-in flashlight for illuminating testing points in dark environments
- Buzzer and red LEDs for alarm signaling whenever exposures exceed preset limits
- Charge contacts for plugging directly to its charging station
- Gas entry and exit ports
- USB communication port for PC interface
- Protective rubber cover

Specifications

Size:	9.25" L x 3.6" W x 2.9" H
Weight:	28 oz with battery pack
Detector:	Photoionization sensor with 9.8, 10.6, or 11.7 eV UV lamp
Battery:	A 4.2V/3300mAH rechargeable Lithium-Ion battery pack (snap in, field replaceable, at non-hazardous location only) Alkaline battery holder (for 4 AA batteries)
Battery Charging:	Less than 8 hours to full charge
Operating Hours:	Up to16 hours continuous operation
Display:	Large dot matrix screen with backlight

Measurement range & resolution

Lamp	Range	Resolution
10.6 eV	0.1 ppm to 15,000 ppm	0.1 ppm
9.8 eV	0.1 ppm to 5,000 ppm	100 ppb
11.7 eV	0.1 ppm to 2,000 ppm	100 ppb

Response time (T_{90}): 2 seconds

Accuracy (Isobutylene):	10 to 2000 ppm: ±3% at calibration point.
PID Detector:	Easy access to lamp and sensor for cleaning and replacement
Correction Factors:	Over 200 VOC gases built in (based on RAE Systems Technical Note TN-106)
Calibration:	Two-point field calibration of zero and standard reference gases
Calibration Reference:	Store up to 8 sets of calibration data, alarm limits and span values
Inlet Probe:	Flexible 5" tubing
Radio module:	Bluetooth (2.4GHz), RF module (433MHz, 868MHz , 915MHz, or 2.4GHz)
Keypad:	1 operation key and 2 programming keys; 1 flashlight switch
Direct Readout:	Instantaneous, average, STEL, TWA and peak value, and battery voltage
Intrinsic Safety:	US and Canada: Class I, Division 1, Group A, B, C, D Europe: ATEX (II 1G EEx ia IIC T4) IECEx (Ex ia IIC T4)
EM Interference:	Highly resistant to EMI/RFI. Compliant with EMC R&TTE (RF Modules)
Alarm Setting:	Separate alarm limit settings for Low, High, STEL and TWA alarm
Operating Mode:	Hygiene or Search mode
Alarm:	Buzzer 95dB at 30cm and flashing red LEDs to indicate exceeded preset limits, low battery voltage, or sensor failure
Alarm Type:	Latching or automatic reset
Real-time Clock:	Automatic date and time stamps on datalogged information
Datalogging:	800,000 points with time stamp, serial number, user ID, site ID, etc.
Communication:	Upload data to PC and download instrument setup from PC via USB on charging station.
Sampling Pump:	Internally integrated. Flow rate: 450 to 550 cc/min.
Temperature:	-20º C to 50º C (-4º to 122º F)
Humidity:	0% to 95% relative humidity (non-condensing)
Housing (including rubber boot):	Polycarbonate, splashproof and dustproof Battery can be changed without removing rubber boot.

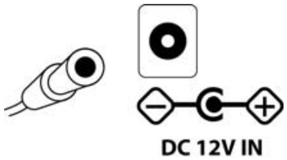
Charging The Battery

Always fully charge the battery before using the instrument. The instrument’s Li-ion battery is charged by placing the instrument in its cradle. Contacts on the bottom of the instrument meet the cradle’s contacts, transferring power without other connections.

Note: Before setting the instrument into its charging cradle, visually inspect the contacts to make sure they are clean. If they are not, wipe them with a soft cloth. Do not use solvents or cleaners.

Follow this procedure to charge the instrument:

1. Plug the AC/DC adapter’s barrel connector into the instrument’s cradle.



2. Plug the AC/DC adapter into the wall outlet.
3. Place the instrument into the cradle, press down, and lean it back. It locks in place and the LED in the cradle glow

The instrument begins charging automatically. The “Primary” LED in the cradle blinks green to indicate charging. During charging, the diagonal lines in the battery icon on the instrument’s display are animated and you see the message “Charging...”

When the instrument’s battery is fully charged, the battery icon is no longer animated and shows a full battery. The message “Fully charged!” is shown. The cradle’s LED glows continuously green.

Note: If you see the “Battery Charging Error” icon (a battery outline with an exclamation mark inside), check that the instrument or rechargeable battery has been set into the cradle properly. If you still receive the message, check the Troubleshooting section of this guide.

Note: If the instrument or battery has been in the cradle for more than 10 hours and you see the “Battery Charging Error” icon and a message that says, “Charging Too Long,” this indicates that the battery is not reaching a full charge. Try changing the battery and make sure the contacts between the instrument (or battery) are meeting the cradle. If the message is still shown, consult your distributor or RAE Systems Technical Services.

Charging A Spare Rechargeable Battery

A rechargeable Li-ion battery can be charged when it is not inside the monitor. The charging cradle is designed to accommodate both types of charging. Contacts on the bottom of the battery meet the contacts on the cradle, transferring power without other connections, and a spring-loaded capture holds the battery in place during charging.

1. Plug the AC/DC adapter into the monitor’s cradle.
2. Place the battery into the cradle, with the gold-plated contacts on top of the six matching charging pins.
3. Plug the AC/DC adapter into the wall outlet.

The battery begins charging automatically. During charging, the Secondary LED in the cradle blinks green. When charging is complete, it glows steady green.

Release the battery from the cradle by pulling it back toward the rear of the cradle and tilting it out of its slot.

Note: If you need to replace the Li-ion battery pack, replacements are available from RAE Systems. The part number is 059-3051-000.

Note: An Alkaline Battery Adapter (part number 059-3052-000), which uses four AA alkaline batteries (Duracell MN1500 or Energizer E91), may be substituted for the Li-Ion battery.

WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge and replace batteries only in areas known to be non-hazardous. Remove and replace batteries only in areas known to be non-hazardous.

Low Voltage Warning

When the battery’s charge falls below a preset voltage, the instrument warns you by beeping once and flashing once every minute, and the “empty battery” icon blinks on and off once per second. You should turn off the instrument within 10 minutes and either recharge the battery by placing the instrument in its cradle, or replace the battery with a fresh one with a full charge.

Clock Battery

An internal clock battery is mounted on one of the instrument’s printed circuit boards. This long-life battery keeps settings in memory from being lost whenever the Li-ion battery or alkaline batteries are removed. This backup battery should last approximately five years, and must be replaced by an authorized RAE Systems service technician. It is not user-replaceable.

Data Protection While Power Is Off

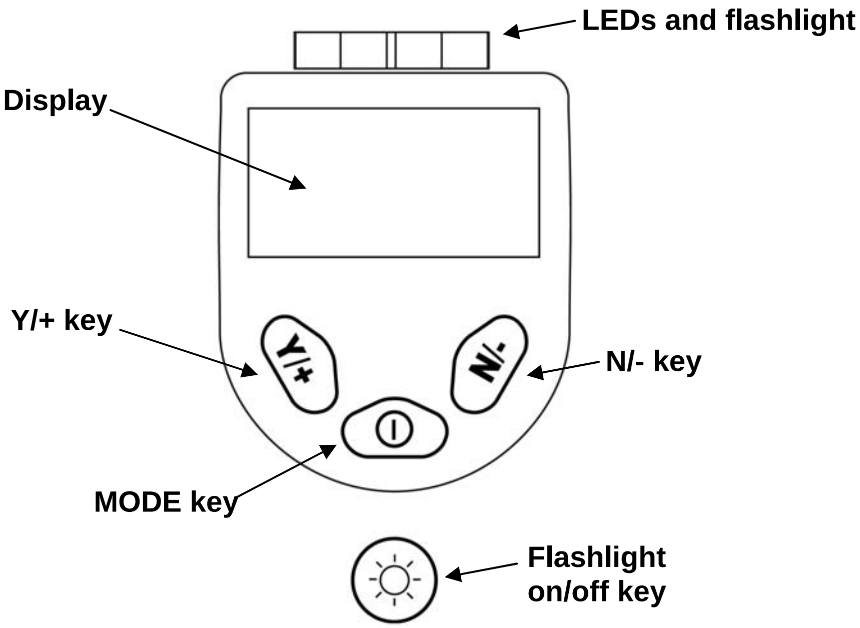
When the instrument is turned off, all the current real-time data including last measured values are erased. However, the datalog data is preserved in non-volatile memory. Even if the battery is disconnected, the datalog data will not be lost.

User Interface

The instrument's user interface consists of the display, LEDs, an alarm transducer, and four keys. The keys are:

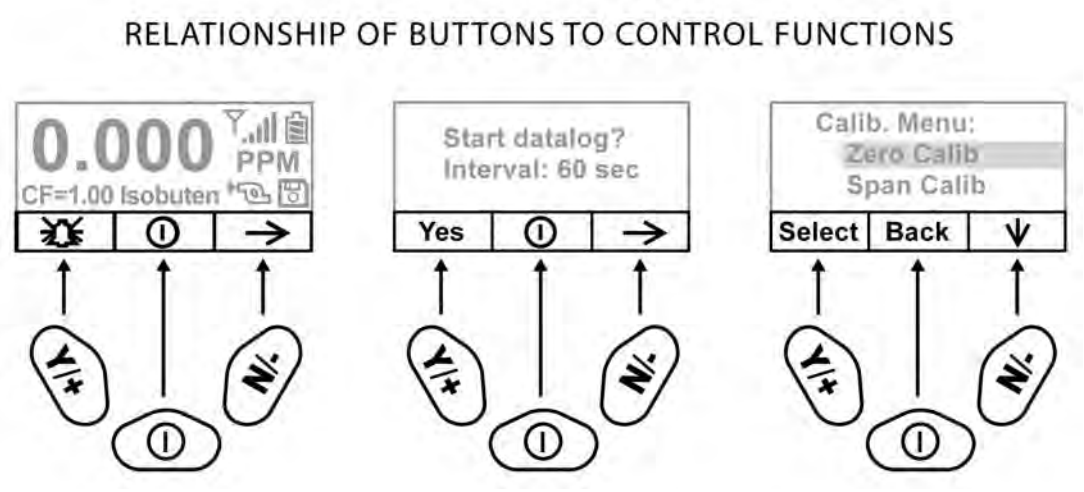
Y/+
MODE
N/-
Flashlight on/off

The LCD display provides visual feedback that includes the reading, time, battery condition, and other functions.



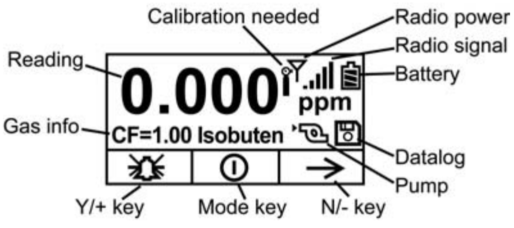
In addition to their labeled functions, the keys labeled Y/+, MODE, and N/- act as "soft keys" that control different parameters and make different selections within the instrument's menus. From menu to menu, each key controls a different parameter or makes a different selection.

Three panes along the bottom of the display are "mapped" to the keys. These change as menus change, but at all times the left pane corresponds to the [Y/+] key, the center pane corresponds to the [MODE] key, and the right pane corresponds to the [N/-] key. Here are three examples of different menus with the relationships of the keys clearly shown:



Display

The display shows the following information:



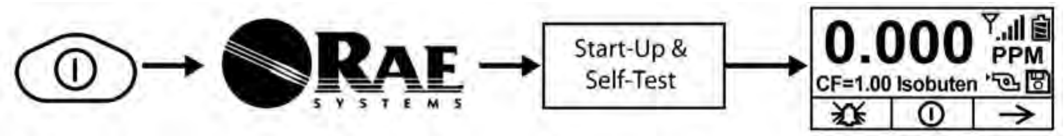
Graph	Graphic representation of concentration plotted over time
Gas info	Tells the Correction Factor and type of calibration gas
Reading	Concentration of gas as measured by the instrument
Calibration needed	Indicates that calibration should be performed
Radio power	Indicates whether radio connection is on or off
Radio signal	Indicates signal strength in 5-bar bargraph
Battery	Indicates battery level in 3 bars
Pump	Indicates that pump is working
Datalog	Indicates whether datalog is on or off
Y/+	Y/+ key's function for this screen
MODE	MODE key's function for this screen
N/-	N/- key's function for this screen

Operating The Instrument

The instrument is designed as a broadband VOC gas monitor and datalogger for work in hazardous environments. It gives real-time measurements and activates alarm signals whenever the exposure exceeds preset limits. Prior to factory shipment, the instrument is preset with default alarm limits and the sensor is pre-calibrated with standard calibration gas. However, you should test the instrument and verify the calibration before the first use. After the instrument is fully charged and calibrated, it is ready for immediate operation.

Turning The Instrument On

1. With the instrument turned off, press and hold [MODE].
2. When the display turns on, release the [MODE] key.



The RAE Systems logo should appear first. (If the logo does not appear, there is likely a problem and you should contact your distributor or RAE Systems Technical Support.) The instrument is now operating and performs self tests. If any tests (including sensor and memory tests fail), refer to the Troubleshooting section of this guide.

Once the startup procedure is complete, the instrument shows a numerical reading screen with icons. This indicates that the instrument is fully functional and ready to use.

Turning The Instrument Off

1. Press and hold the Mode key for 3 seconds. A 5-second countdown to shutoff begins.
2. Once the countdown stops, the instrument is off. Release the Mode key.
3. When you see “Unit off...” release your finger from the [MODE] key. The instrument is now off.

Note: You must hold your finger on the key for the entire shutoff process. If you remove your finger from the key during the countdown, the shutoff operation is canceled and the instrument continues normal operation.

Operating The Built-In Flashlight

The instrument has a built-in flashlight that helps you point the probe in dark places. Press the flashlight key to turn it on. Press it again to turn it off.

Note: Using the flashlight for extended periods shortens the battery's operating time before it needs recharging.

Pump Status

IMPORTANT!

During operation, make sure the probe inlet and the gas outlet are free of obstructions. Obstructions can cause premature wear on the pump, false readings, or pump stalling. During normal operation, the pump icon alternately shows inflow and outflow as shown here:

During duty cycling (PID lamp cleaning), the display shows these icons in alternation:

If there is a pump failure or obstruction that disrupts the pump, you will see this icon blinking on and off:

If you see this blinking icon, consult the Troubleshooting section of this guide.

Calibration Status

The instrument displays this icon if it requires calibration:

Calibration is required (and indicated by this icon) if:

- The lamp type has been changed (for example, from 10.6 eV to 9.8 eV).
- The sensor has been replaced.
- It has been 30 days or more since the instrument was last calibrated.
- If you have changed the calibration gas type without recalibrating the instrument.

Operating Modes

Your instrument operates in different modes, depending on the model and its factory default settings. In some cases, you can change modes using a password and using the instrument's navigation. In other cases, you must use ProRAE Studio software.

The default setting for your instrument is:

User Mode: Basic
Operation Mode: Hygiene

This is outlined in detail on page 56.

The other options, covered later in this guide, are:

User Mode: Advanced (page 59)
Operation Mode: Search (page 61)

User Mode: Advanced (page 59)
Operation Mode: Hygiene (page 59)

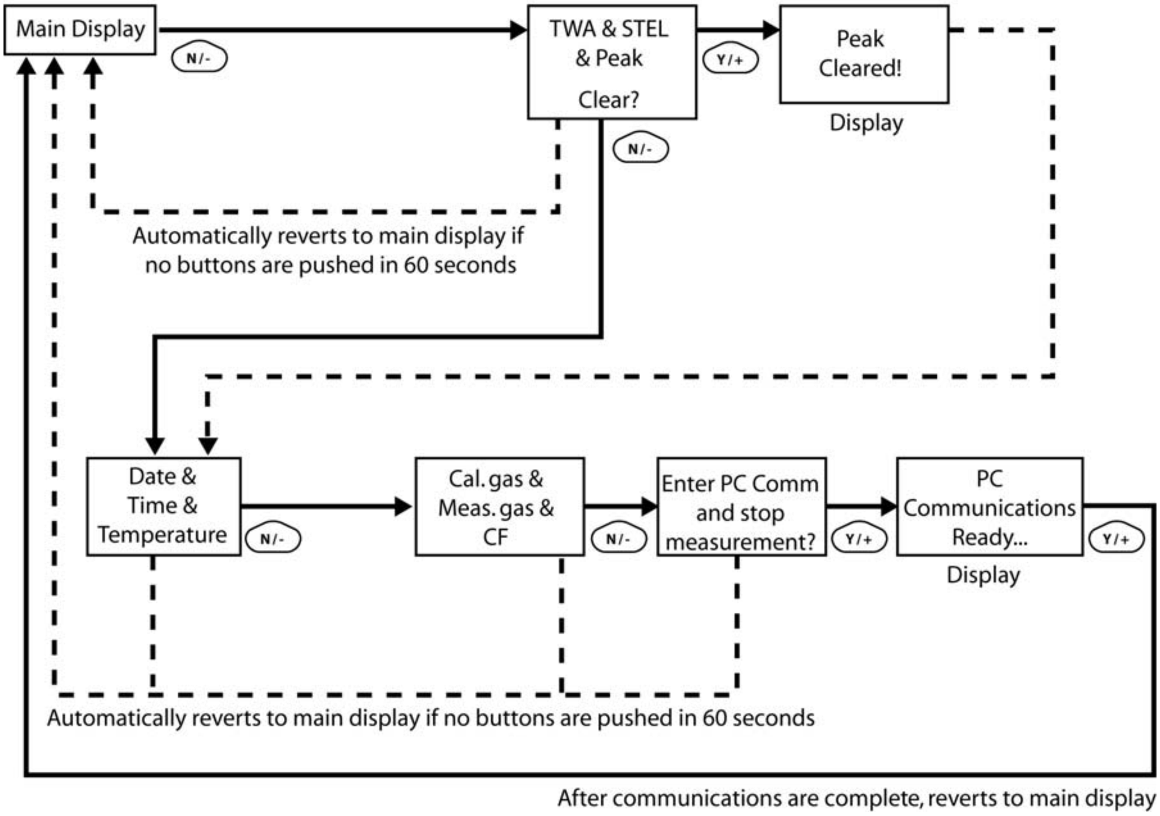
Using ProRAE Studio allows access to other options. In addition, Diagnostic Mode (page 62) is available for service technicians.

Basic User Level/Hygiene Mode (Default Settings)

The instrument is programmed to operate in Basic User Level/Hygiene Mode as its default. This gives you the most commonly needed features while requiring the fewest parameter adjustments.

Pressing [N/-] steps you from one screen to the next, and eventually return to the main display. If you do not press a key within 60 seconds after entering a display, the instrument reverts to its main display.

Note: While viewing any of these screens, you can shut off your instrument by pressing [MODE].



Note: Dashed line indicates automatic progression.

After the instrument is turned on, it runs through the start-up menu. Then the message "**Please apply zero gas…**" is displayed.

At this point, you can perform a zero air (fresh air) calibration. If the ambient air is clean, you can use that. Otherwise, use a cylinder of zero air. Refer to Zero Calibration on page 28 for a more detailed description of zero calibration.

Start zero calibration by pressing Start. You see the message "Zeroing…" followed by a 30-second countdown.

Note: You can press [MODE] to quit, bypassing the zero air calibration.

When zero calibration is complete, you see the message:

Zeroing is done!
Reading = 0.00 ppm

The instrument is now sampling and collecting data.

Note: At the Average & Peak, Date & Time & Temperature, Calibration Gas & Measurement Gas & Correction Factor, and PC Communications screens, the instrument automatically goes to the main display after 60 seconds if you do not push a key to make a selection.

Alarm Signals

During each measurement period, the gas concentration is compared with the programmed alarm limits (gas concentration alarm limit settings). If the concentration exceeds any of the preset limits, the loud buzzer and red flashing LED are activated immediately to warn you of the alarm condition.

In addition, the instrument alarms if one of the following conditions occurs: battery voltage falls below a preset voltage level, failure of the UV lamp, or pump stall.

Alarm Signal Summary

Message	Condition	Alarm Signal
HIGH	Gas exceeds “High Alarm” limit	3 beeps/flashes per second*
OVR	Gas exceeds measurement range	3 beeps/flashes per second
MAX	Gas exceeds electronics’ maximum range	3 beeps/flashes per second
LOW	Gas exceeds “Low Alarm” limit	2 beeps/flashes per second*
TWA	Gas exceeds “TWA” limit	1 Beep/flash per second*
STEL	Gas exceeds “STEL” limit	1 Beep/flash per second*
Pump icon flashes	Pump failure	3 beeps/flashes per second
Lamp	PID lamp failure	3 beeps/flashes per second plus “Lamp” message on display
Battery icon flashes	Low battery	1 flash, 1 beep per minute plus battery icon flashes on display
CAL	Calibration failed, or needs calibration	1 beep/flash per second
NEG	Gas reading measures less than number stored in calibration	1 beep/flash per second

* Hygiene mode only. In Search mode, the number of beeps per second (1 to 7) depends upon the concentration of the sampled gas. Faster rates indicate higher concentrations.

Preset Alarm Limits & Calibration

The instrument is factory calibrated with standard calibration gas, and is programmed with default alarm limits.

Cal Gas (Isobutylene)	Cal Span	unit	Low	High	TWA	STEL
MiniRAE 3000	100	ppm	50	100	10	25

Testing The Alarm

You can test the alarm whenever the main (Reading) display is shown. Press [Y/+], and the audible and visible alarms are tested.

Integrated Sampling Pump

The instrument includes an integrated sampling pump. This diaphragm-type pump that provides a 450 to 550 cc per minute flow rate. Connecting a Teflon or metal tubing with 1/8" inside diameter to the gas inlet port of the instrument, this pump can pull in air samples from 200' (61 m) away horizontally, or 90' (27.5 m) vertically, at about 3' (0.9 m) per second flow speed.

Note: In Search Mode, the pump turns on when a sample measurement is started, and turns off when the sample is manually stopped.

If liquid or other objects are pulled into the inlet port filter, the instrument detects the obstruction and immediately shuts down the pump. The alarm is activated and a flashing pump icon is displayed.

You should acknowledge the pump shutoff condition by clearing the obstruction and pressing the [Y/+] key while in the main reading display to restart the pump.

Backlight

The LCD display is equipped with an LED backlight to assist in reading the display under poor lighting conditions.

Datalogging

During datalogging, the instrument displays a disk icon to indicate that datalogging is enabled. The instrument stores the measured gas concentration at the end of every sample period (when data logging is enabled). In addition, the following information is stored: user ID, site ID, serial number, last calibration date, and alarm limits. All data are retained (even after the unit is turned off) in non-volatile memory so that it can be downloaded at a later time to a PC.

Datalogging event

When Datalogging is enabled, measurement readings are being saved. These data are stored in "groups" or "events." A new event is created and stored each time the instrument is turned on and is set to automatic datalogging, or a configuration parameter is changed, or datalogging is interrupted. The maximum time for one event is 24 hours or 28,800 points. If an event exceeds 24 hours, a new event is automatically created. Information, such as start time, user ID, site ID, gas name, serial number, last calibration date, and alarm limits are recorded.

Datalogging sample

After an event is recorded, the unit records a shorter form of the data. When transferred to a PC running ProRAE Studio, this data is arranged with a sample number, time, date, gas concentration, and other related information.

Auto/Manual/Snapshot Datalogging

The instrument has three datalog types:

Auto	Default mode. Collects datalog information when the instrument is sampling.
Manual	Datalogging occurs only when the instrument's datalogging is manually started (see page 48 for details).
Snapshot	Datalogs only during snapshot (single-event capture, initiated by pressing [MODE]) sampling. See page 49 for details.

Note: You can only choose one datalog type to be active at a time.

Accessories

The following accessories are included with the instrument:

- An AC Adapter (Battery Charger)
- Alkaline battery adapter
- External Filter
- Organic Vapor Zeroing kit

Hard-case kits also include these accessories:

- Calibration adapter
- Calibration regulator and Flow controller

Standard Kit & Accessories

AC Adapter (Battery Charger)

WARNING

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in area known to be non-hazardous.

Ne charger les batteries que dans emplacements designés non-dangereuses.

A battery charging circuit is built into the instrument cradle. It only needs a regular AC to 12 VDC adapter (wall-mount transformer, part number 500-0114-000) to charge the instrument.

To charge the battery inside the instrument:

1. Power off the instrument.
2. Connect the AC adapter to the DC jack on the instrument’s cradle. If the instrument is off, it automatically turns on.
3. While charging, the display message shows “Charging.” The Primary LED on the cradle flashes green when charging.
4. When the battery is fully charged, the LED changes to glowing green continuously, and the message “Fully charged” appears on the display. If there is a charging error, the LED glows red continuously.

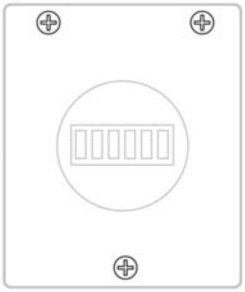
A completely discharged instrument can be charged to full capacity within 8 hours. Batteries drain slowly even if an instrument is off. Therefore, if the instrument has been in storage or has not been charged for several days or longer, check the charge before using it.

The factory-supplied battery is designed to last for 16 hours of normal operation (no alarm), for a new battery under the optimum circumstances. As the battery becomes older or is subject to adverse conditions (such as cold ambient temperature), its capacity will be significantly reduced.

Alkaline Battery Adapter

An alkaline battery adapter is supplied with each instrument. The adapter (part number 059-3052-000) accepts four AA alkaline batteries (use only Duracell MN1500 or Energizer E91) and provides approximately 12 hours of operation. The adapter is intended to be used in emergency situations when there is no time to charge the Li-ion battery pack.

To insert batteries into the adapter:



1. Remove the three Philips-head screws to open the compartment in the adapter.
2. Insert four fresh AA batteries as indicated by the polarity (+/-) markings.
3. Replace the cover. Replace the three screws.

To install the adapter in the instrument:

1. Remove the Li-ion battery pack from the instrument by sliding the tab and tilting out the battery.
2. Replace it with the alkaline battery adapter
3. Slide the tab back into place to secure the battery adapter.

IMPORTANT!

Alkaline batteries cannot be recharged. The instrument's internal circuit detects alkaline batteries and will not allow recharging. If you place the instrument in its cradle, the alkaline battery will not be recharged. The internal charging circuit is designed to prevent damage to alkaline batteries and the charging circuit when alkaline batteries are installed inside the instrument. If you try to charge an alkaline batteries installed in the instrument, the instrument's display will say, "Alkaline Battery," indicating that it will not charge the alkaline batteries.

Note: When replacing alkaline batteries, dispose of old ones properly.

WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge the battery only in areas known to be non-hazardous. Remove and replace the battery only in areas known to be non-hazardous.

External Filter

The external filter is made of PTFE (Teflon®) membrane with a 0.45 micron pore size to prevent dust or other particles from being sucked into the sensor manifold, which would cause extensive damage to the instrument. It prolongs the operating life of the sensor. To install the external filter, simply connect it to the instrument's inlet tube.

Optional Accessories

Calibration Adapter

The calibration adapter for the instrument is a simple 6-inch Tygon tubing with a metal adapter on one end. During calibration, simply insert the metal adapter into the regular gas inlet probe of the instrument and the tubing to the gas regulator on the gas bottle.

Calibration Regulator

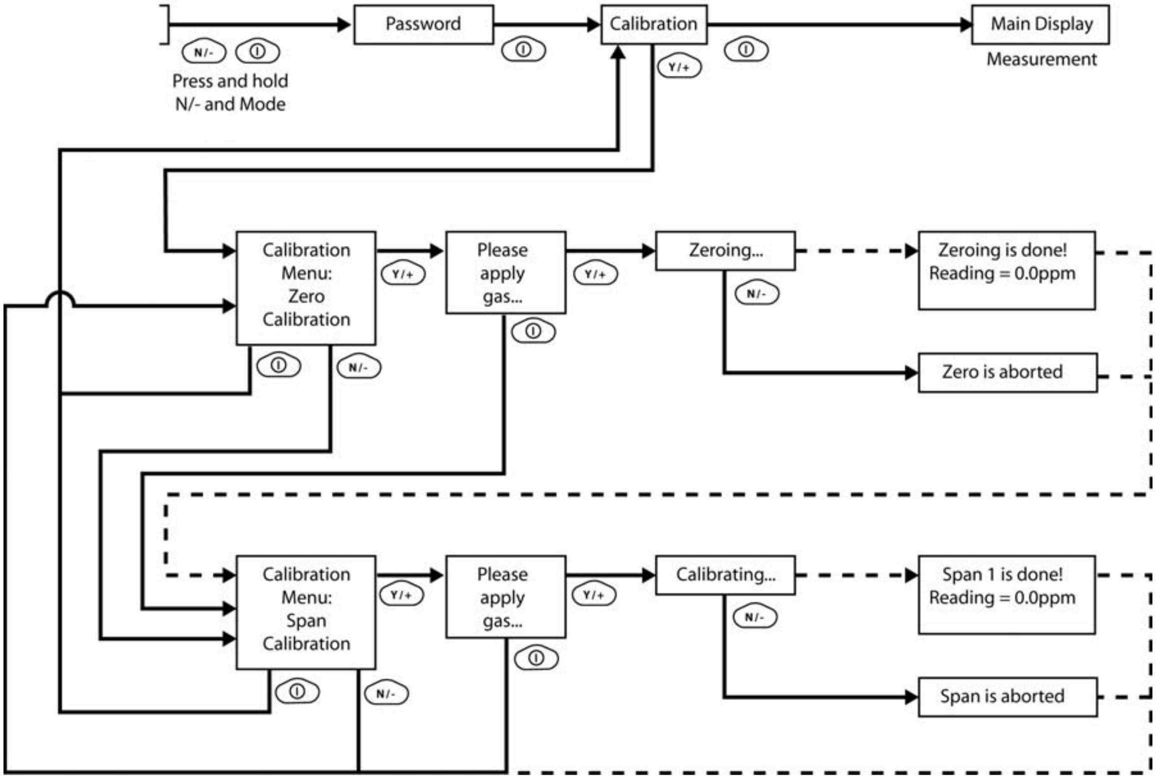
The Calibration Regulator is used in the calibration process. It regulates the gas flow rate from the Span gas cylinder into the gas inlet of the instrument during calibration process. The maximum flow rate allowed by the flow controller is about 0.5L/min (500 cc per min.). Alternatively, a demand-flow regulator or a Tedlar gas bag may be used to match the pump flow precisely.

Organic Vapor Zeroing Kit

The Organic Vapor Zeroing Kit is used for filtering organic air contaminants that may affect the zero calibration reading. To use the Organic Vapor Zeroing Kit, simply connect the filter to the inlet port of the instrument.

Standard Two-Point Calibration (Zero & Span)

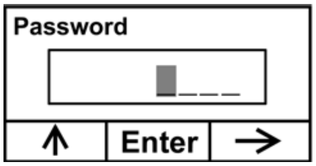
The following diagram shows the instrument's calibrations in Basic/Hygiene mode.



Note: Dashed line indicates automatic progression.

Entering Calibration

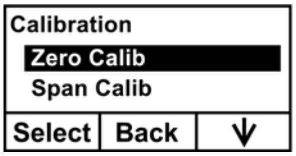
1. Press and hold [MODE] and [N/-] until you see the Password screen.



2. In Basic User Level, you do not need a password to perform calibrations. Instead of inputting a password, enter calibration by pressing [MODE].

   Note: If you inadvertently press [Y/+] and change any of the numbers, simply press [MODE] and you will be directed to the calibration menu.

The Calibration screen is now visible with Zero Calibration highlighted.



These are your options:

- Press [Y/+] to select the highlighted calibration (Zero Calib or Span Calib).
- Press [MODE] to exit calibration and return to the main display and resume measurement.
- Press [N/-] to toggle the highlighted calibration type.

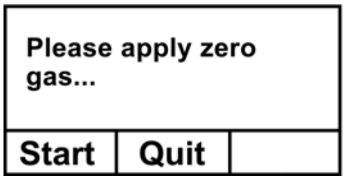
Zero (Fresh Air) Calibration

This procedure determines the zero point of the sensor calibration curve. To perform a fresh air calibration, use the calibration adapter to connect the instrument to a “fresh” air source such as from a cylinder or Tedlar bag (optional accessory). The “fresh” air is clean, dry air without organic impurities and an oxygen value of 20.9%. If such an air cylinder is not available, any clean ambient air without detectable contaminants or a charcoal filter can be used.

At the Zero Calibration menu, you can proceed to perform a Zero calibration or bypass Zero calibration and perform a Span calibration. You may also go back to the initial Calibration menu if you want to exit calibration.

- Press [Y/+] to start calibration.
- Press [MODE] to quit and return to the main calibration display.

If you have pressed [Y/+] to enter Zero calibration, then you will see this message:



Please apply zero gas...

1. Turn on your Zero calibration gas.
2. Press [Y/+] to start calibration.

   Note: At this point, you may press [MODE] if you decide that you do not want to initiate calibration. This will take you directly to the Calibration menu, highlighted for Span calibration.

3. Zero calibration starts a 30-second countdown and displays this message:

   Zeroing...

During the zeroing process, the instrument performs the Zero calibration automatically and does not require any action on your part.

Note: To abort the zeroing process at any time and proceed to Span calibration, press [N/-] at any time while zeroing is being performed. You will see a confirmation message that says “Zero aborted!” and then the Span calibration menu appears.

When Zero calibration is complete, you see this message:

Zeroing is done!
Reading = 0.000 ppm

The instrument will then show the Calibration menu on its display, with Span Calib hightlighted.

Span Calibration

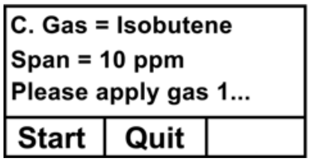
This procedure determines the second point of the sensor calibration curve for the sensor. A cylinder of standard reference gas (span gas) fitted with a 500 cc/min. flow-limiting regulator or a flow-matching regulator is the simplest way to perform this procedure. Choose the 500 cc/min. regulator only if the flow rate matches or slightly exceeds the flow rate of the instrument pump. Alternatively, the span gas can first be filled into a Tedlar bag or delivered through a demand-flow regulator. Connect the calibration adapter to the inlet port of the instrument, and connect the tubing to the regulator or Tedlar bag.

Another alternative is to use a regulator with >500 cc/min flow but allow the excess flow to escape through a T or an open tube. In the latter method, the span gas flows out through an open tube slightly wider than the probe, and the probe is inserted into the calibration tube.

At the Span Calibration menu, you perform a Span calibration. You may also go back to the Zero calibration menu or to the initial Calibration menu if you want to exit calibration.

- Press [Y/+] to enter Span calibration.
- Press [N/-] to skip Span calibration and return to Zero calibration.
- Press [MODE] to exit Span calibration and return to the top calibration menu.

If you have pressed [Y/+] to enter Span calibration, then you will see the name of your Span gas (the default is isobutylene) and the span value in parts per million (ppm). You will also see this message that prompts you:



C. Gas = Isobutene
Span = 10 ppm
Please apply gas 1...

1. Turn on your span calibration gas.
2. Press [Y/+] to initiate calibration.

   Note: You may press [MODE] if you decide that you do not want to initiate calibration. This will abort the span calibration and take you directly to the Calibration menu for Zero calibration.

3. Span calibration starts and displays this message:

   Calibrating...

During the Span calibration process, there is a 30-second countdown and the instrument performs the Span calibration automatically. It requires no actions on your part.

Note: If you want to abort the Span calibration process, press [N/-] at any time during the process. You will see a confirmation message that says "Span is aborted!" and then the Zero calibration menu appears. You can then proceed to perform a Zero calibration, perform a Span calibration, or exit to the topmost Calibration menu.

When Span calibration is complete, you see a message similar to this (the value is an example only):

Span 1 is done!
Reading = 100. ppm

The instrument then exits Span calibration and shows the Zero calibration menu on its display.

Note: The reading should be very close to the span gas value.

Exiting Two-Point Calibration In Basic User Level

When you are done performing calibrations, press [MODE], which corresponds with “Back” on the display. You will see the following message:

Updating settings…

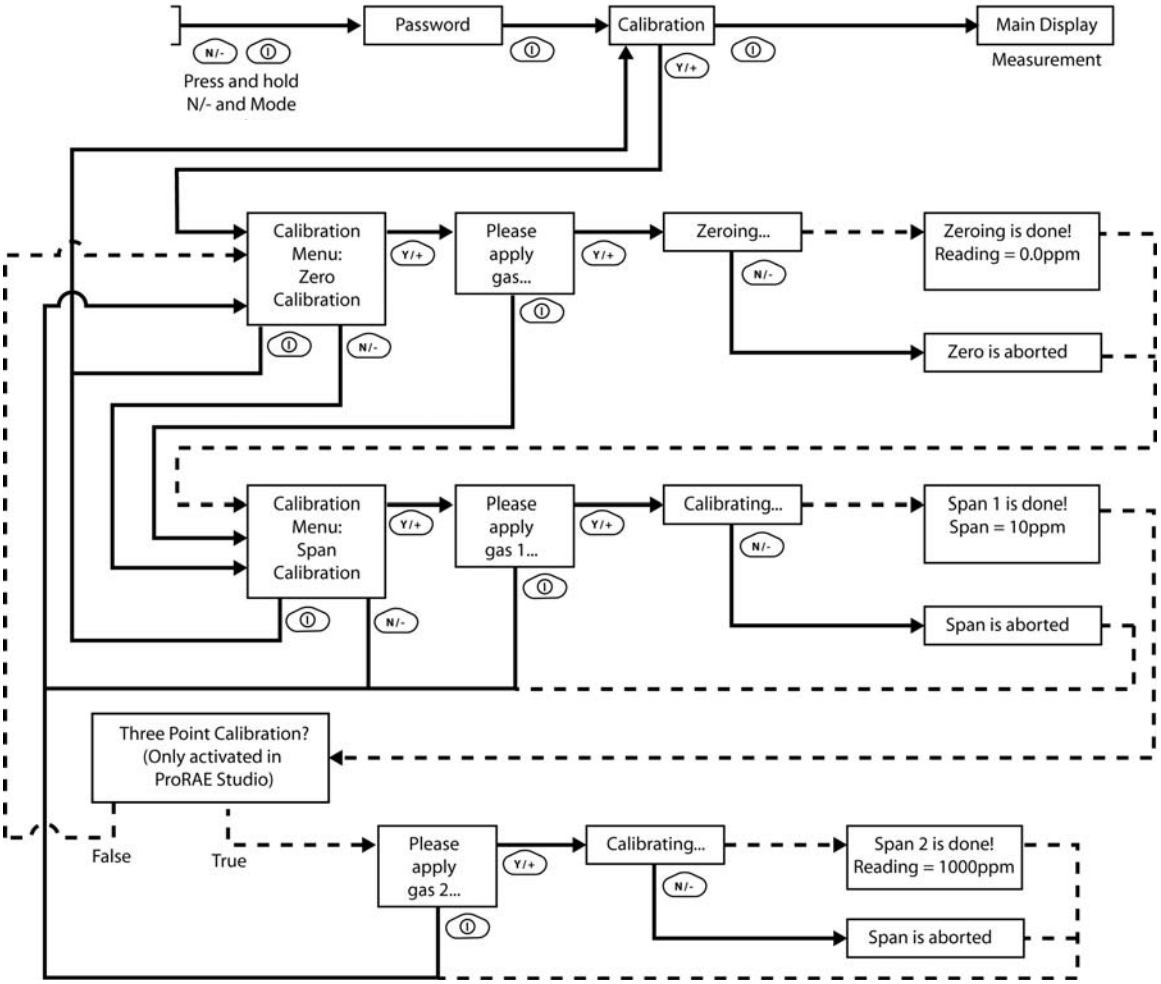
The instrument updates its settings and then returns to the main display. It begins or resumes monitoring.

Three-Point Calibration

For enhanced accuracy, it is possible to perform a second Span calibration in addition to the Zero and Span calibrations outlined in the previous section. Your instrument first must be set to allow this third calibration. This requires using ProRAE Studio software and a PC, as well as a higher concentration of calibration gas.

Note: Once the third calibration is set, you do not need to use ProRAE Studio to allow future 3-point calibrations. Also, you can only disable 3-point calibration capability by using ProRAE Studio again.

Perform the Zero and Span calibrations. After the first Span calibration (Span 1) is completed, the display a second Span calibration (Span 2) can be performed. The process is identical to the first calibration. As in the Span 1 calibration, you may exit and return to the Zero calibration screen if you choose not to perform this calibration or to abort it.



Note: Dashed line indicates automatic progression.

Span 2 Calibration

A cylinder of standard reference gas (span gas) fitted with a 500 cc/min. flow-limiting regulator or a flow-matching regulator is the simplest way to perform this procedure.

Note: This gas should be of a higher concentration than the gas used for Span 1 calibration.

Choose the 500 cc/min. regulator only if the flow rate matches or slightly exceeds the flow rate of the instrument pump. Alternatively, the span gas can first be filled into a Tedlar bag or delivered through a demand-flow regulator. Connect the calibration adapter to the inlet port of the instrument, and connect the tubing to the regulator or Tedlar bag.

Another alternative is to use a regulator with >500 cc/min flow but allow the excess flow to escape through a T or an open tube. In the latter method, the span gas flows out through an open tube slightly wider than the probe, and the probe is inserted into the calibration tube.

At the Span Calibration menu, you perform a Span calibration. You may also go back to the Zero calibration menu or to the initial Calibration menu if you want to exit calibration.

- Press [Y/+] to enter Span 2 calibration.
- Press [N/-] to skip Span calibration and return to Zero calibration.
- Press [MODE] to exit Span calibration and return to the top calibration menu.

If you have pressed [Y/+] to enter Span calibration, then you will see the name of your Span gas (the default is isobutylene) and the span value in parts per million (ppm). You will also see this message that prompts you:

> Please apply gas...

4. Turn on your span calibration gas.
5. Press [Y/+] to initiate calibration.

   Note: You may press [MODE] if you decide that you do not want to initiate calibration. This will take you directly to the Calibration menu for Zero calibration.

6. Span calibration starts a 30-second countdown and displays this message:

   > Calibrating...

During the Span calibration process, the instrument performs the Span calibration automatically and does not require any action on your part.

Note: If you want to abort the Span calibration process, press [N/-] at any time during the process. You will see a confirmation message that says "Span is aborted!" and then the

Zero calibration menu will appear. You can then proceed to perform a Zero calibration, perform a Span calibration, or exit to the topmost Calibration menu.

When Span calibration is complete, you will see a message similar to this (the value shown here is for example only):

> Span 2 is done!
> Reading = 1000 ppm

The instrument then exits Span calibration and shows the Zero calibration menu on its display.

Note: The reading should be very close to the span gas value.

Exiting Three-Point Calibration

When you are done performing calibrations, press [MODE], which corresponds with "Back" on the display. You will see the following message:

> Updating settings…

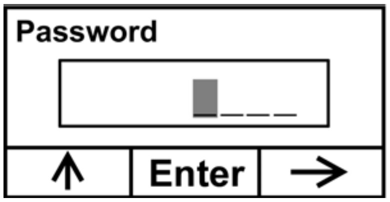
The instrument updates its settings and then returns to the main display. It begins or resumes monitoring.

Programming Mode

Programming Mode can be entered from either Hygiene Mode or Search Mode. If the current user mode is Basic, you must provide a 4-digit password to enter.

Entering Programming Mode

1. Press and hold [MODE] and [N/-] until you see the Password screen.



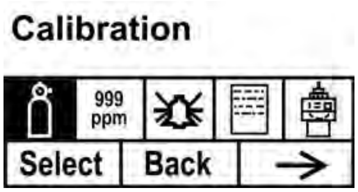
2. Input the 4-digit password:

- Increase the number from 0 through 9 by pressing [Y/+].
- Step from digit to digit using [N/-].
- Press [MODE] when you are done.

If you make a mistake, you can cycle through the digits by pressing [N/-] and then using [Y/+] to change the number in each position.

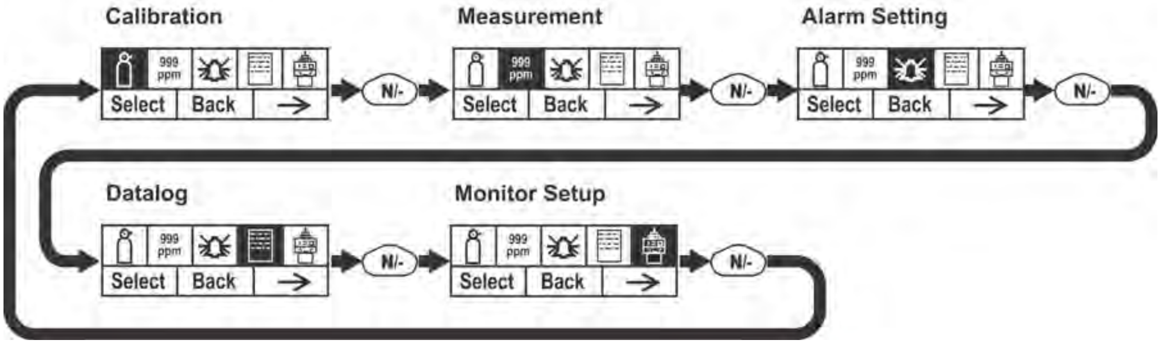
Note: The default password is 0000.

When you have successfully entered Programming Mode, you see this screen:



Note: The password can only be changed by connecting the instrument to a PC running ProRAE Studio software. Follow the instructions in ProRAE Studio to change it.

The Calibration label is shown and its icon is highlighted, but you can press [N/-] to step from one programming menu to the next, with the name of the menu shown at the top of the display and the corresponding icon highlighted. As you repeatedly press [N/-], the selection moves from left to right, and you see these screens:



Note: When you reach Monitor Setup and press [N/-], the menu cycles back to Calibration.

Programming Mode Menus

The Programming Mode allows anyone with the password to change the instrument's settings, calibrate the instrument, modify the sensor configuration, enter user information, etc. Programming Mode has five menus. Each menu includes several sub-menus to perform additional programming functions.

This table shows the menus and sub-menus:

Calibration	**Measurement**	**Alarm Setting**	**Datalog**	**Monitor Setup**
Zero Calibration	Meas. Gas	High Alarm	Clear Datalog	Op Mode
Span Calibration	Meas. Unit	Low Alarm	Interval	Site ID
		STEL Alarm	Data Selection	User ID
		TWA Alarm	Datalog Type	User Mode
		Alarm Type		Date
		Buzzer & Light		Time
				Pump Duty Cycle
				Pump Speed
				Temperature Unit
				Language
				Radio Power
				Real Time Protocol
				Power On Zero
				Unit ID
				LCD Contrast

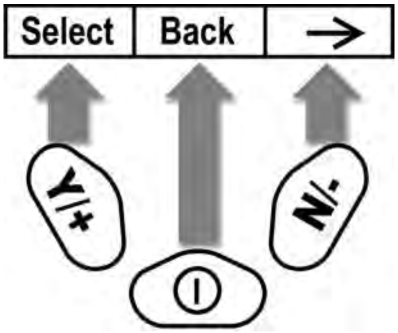
Once you enter Programming Mode, the LCD displays the first menu, Calibration. Each subsequent menu is accessed by pressing [N/-] repeatedly until the desired menu is displayed. To enter a sub-menu of a menu, press [Y/+].

Exiting Programming Mode

To exit Programming Mode and return to normal operation, press [MODE] once at any of the programming menu displays. You will see “Updating Settings…” as changes are registered and the mode changes.

Navigating Programming Mode Menus

Navigating through the Programming Mode menus is easy and consistent, using a single interface format of “Select,” “Back” and “Next” at the top level. The three control buttons correspond to these choices as shown:



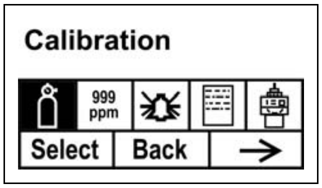
Note: Pressing [MODE] in the Programming Mode’s top level causes the instrument to exit Programming Mode and return to monitoring.

The three keys perform the following functions in Programming Mode:

Key	Function in Programming Mode
[MODE]:	Exit menu when pressed momentarily or exit data entry mode
[Y/+]:	Increase alphanumerical value for data entry or confirm (yes) for a question
[N/-]:	Decrease alphanumerical value for data entry or deny (no) for a question

Calibration

Two types of calibration are available: Zero (fresh air) and Span.



Select Zero or Span Calibration by pressing [N/+]. Once your choice is highlighted, press [Y/+].

Zero Calibration

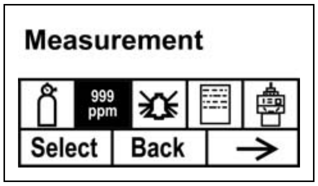
The procedure for performing a zero calibration is covered on page 27.

Span Calibration

The procedure for performing a basic span calibration is covered on page 27.

Measurement

The sub-menus for Measurement are Measurement Gas and Measurement Unit.



Meas. Gas

Measurement gases are organized in four lists:

- My List is a customized list of gases that you create. It contains a maximum of 10 gases and can only be built in ProRAE Studio on a PC and transferred to the instrument. **Note:** The first gas in the list is always isobutylene (it cannot be removed from the list).

- Last Ten is a list of the last ten gases used by your instrument. The list is built automatically and is only updated if the gas selected from Custom Gases or Library is not already in the Last Ten. This ensures that there is no repetition.
- Gas Library is a library that consists of all the gases found in RAE Systems' Technical Note TN-106 (available online at www.raesystems.com).
- Custom Gases are gases with user-modified parameters. Using ProRAE Studio, all parameters defining a gas can be modified, including the name, span value(s), correction factor, and default alarm limits.

1. Scroll through each list by pressing [N/-].
2. Press [Y/+] to select one (My List, Last Ten, Gas Library, or Custom Gases).
3. Once you are in one of the categories, press [N/-] to scroll through its list of options and [Y/+] to select one. (If you press [MODE], you exit to the next submenu.)
4. Press [Y/+] to save your choice or [N/-] to undo your selection.

Leave the sub-menu and return to the Programming Mode menus by pressing [MODE].

Meas. Unit

Standard available measurement units include:

Abbreviation	**Unit**	**MiniRAE 3000**
ppm	parts per million	Yes
ppb	parts per billion	
mg/m3	milligrams per cubic meter	Yes
ug/m3	micrograms per cubic meter	

- Scroll through the list by pressing [N/-].
- Select by pressing [Y/+].
- Save your selection by pressing [Y/+] or undo your selection by pressing [N/-].

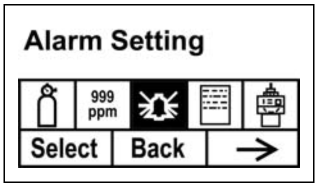
Leave the sub-menu and return to the Programming Mode menus by pressing [MODE].

Alarm Setting

During each measurement period, the gas concentration is compared with the programmed alarm limits (gas concentration alarm limit settings: Low, High, TWA and STEL). If the concentration exceeds any of the preset limits, the loud buzzer and red flashing LED are activated immediately to warn of the alarm condition.

An alarm signal summary is shown on page 21.

In this menu, you can change the High and Low alarm limits, the STEL limit, and the TWA. Press [Y/+] to to enter the Alarm Setting menu.
Note: All settings are shown in ppb (parts per billion), or mg/m3 (milligrams per cubic meter), depending on your setting.



1. Scroll through the Alarm Limit sub-menu using the [N/-] key until the display shows the desired limit to be changed (High Alarm, Low Alarm, STEL Alarm, and TWA Alarm)
2. Press [Y/+] to select one of the alarm types. The display shows a flashing cursor on the left-most digit of the previously stored alarm limit.
3. Press [Y/+] to increase each digit’s value.
4. Press [N/-] to advance to the next digit.
5. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

Press [MODE] when you are done.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

When all alarm types have been changed or bypassed, press [MODE] to exit to the Programming Menu.

High Alarm

You can change the High Alarm limit value. The value is typically set by the instrument to match the value for the current calibration gas. It is expressed in parts per billion (ppb).
Note: The default value depends on the measurement gas.

To change the High Alarm value:

1. Press [Y/+] to increase each digit’s value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.
When you have completed your selections, press [MODE]. You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

Press [Y/+] to save the changes.
Press [N/-] to undo the changes and revert to the previous settings.

Low Alarm

You can change the Low Alarm limit value. The value is typically set by the instrument to match the value for the current calibration gas. It is expressed in parts per billion (ppb).
Note: The default value depends on the measurement gas.

To change the Low Alarm value:

1. Press [Y/+] to increase each digit’s value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

When you have completed your selections, press [MODE]. You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

STEL Alarm

You can change the STEL Alarm limit value. The value is typically set by the instrument to match the value for the calibration gas. It is expressed in parts per billion (ppb). **Note:** The default value depends on the measurement gas.

To change the STEL Alarm value:

1. Press [Y/+] to increase each digit's value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

When you have completed your selections, press [MODE]. You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

TWA Alarm

You can change the TWA (time-weighted average) Alarm limit value. The value is typically set by the instrument to match the value for the calibration gas. It is expressed in parts per billion (ppb). **Note:** The default value depends on the measurement gas.

To change the TWA Alarm value:

1. Press [Y/+] to increase each digit's value.
2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

When you have completed your selections, press [MODE]. You will see two choices:

- Save
- Undo

You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

Alarm Type

There are two selectable alarm types:

Latched	When the alarm is triggered, you can manually stop the alarm. The latched setting only controls alarms for High Alarm, Low Alarm, STEL Alarm, and TWA alarm. **Note:** To clear an alarm when the instrument is set to "Latched," press [Y/+] when the main (Reading) display is shown.
Automatic Reset	When the alarm condition is no longer present, the alarm stops and resets itself.

   1. Press **[N/-]** to step from one alarm type to the other.
   2. Press **[Y/+]** to select an alarm type.

1. When you have completed your selections, press [MODE].

   You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

   - Press [Y/+] to save the changes.
   - Press [N/-] to undo the changes and revert to the previous settings.

Buzzer & Light

The buzzer and light alarms can be programmed to be on or off individually or in combination. Your choices are:

- Both on
- Light only
- Buzzer only
- Both off

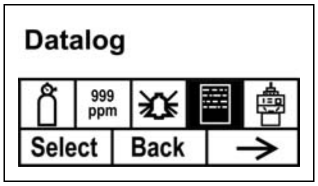
2. Press [N/-] to step from one option to the next.
3. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates your selection).
4. When you have completed your selections, press [MODE].

   You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

   - Press [Y/+] to save the changes.
   - Press [N/-] to undo the changes and revert to the previous settings.

Datalog

The instrument calculates and stores the concentration and ID of each sample taken. In the datalog sub-menu, a user can perform the tasks and functions shown below.



1. Scroll through the Datalog sub-menu using the [N/-] key until the display shows the desired parameter to be changed:

   Clear Datalog
   Interval
   Data Selection
   Datalog Type

2. Press [Y/+] to make your selection. Exit by pressing [MODE] for Back.

Clear Datalog

This erases all the data stored in the datalog.

Note: Once the datalog is cleared, the data cannot be recovered.

Press [Y/+] to clear the datalog. The display asks, "Are you sure?"

- Press [Y/+] if you want to clear the datalog. When it has been cleared, the display shows "Datalog Cleared!"
- Press [N/-] if you do not want to clear the datalog.

The display changes, and you are taken to the next sub-menu, Interval.

Interval

Intervals are shown in seconds. The default value is 60 seconds. The maximum interval is 3600 seconds.

1. Press [Y/+] to increase each digit's value.

2. Press [N/-] to advance to the next digit.
3. Again, use [Y/+] to increase the number.

Repeat this process until all numbers are entered.

When you have completed your selections, press [MODE].

You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

Data Selection

Data Selection allows you to select which types of data are stored and made available when you offload your datalog to a computer via ProRAE Studio software.

You can choose any or all of three types of data (you must choose at least one):

- Average
- Maximum
- Minimum

1. Press [N/-] to step from one option to the next. The highlighter indicates your choice.
2. Press [Y/+] to toggle your selection on or off (the check box indicates "on" with an "X").
3. When you have completed your selections, press [MODE].

You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

- Press [Y/+] to save the changes.
- Press [N/-] to undo the changes and revert to the previous settings.

Datalog Type

The instrument has three datalog types:

Auto	Default mode. Collects datalog information when the instrument is sampling.
Manual	Datalogging occurs only when the instrument's datalogging is manually started (see page 48 for details).
Snapshot	Datalogs only during single-event capture sampling.

Note: You can only choose one datalog type to be active at a time.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].

You will see two choices: Save and Undo. You have the opportunity to register the new settings or to change your mind and revert to your previous settings.

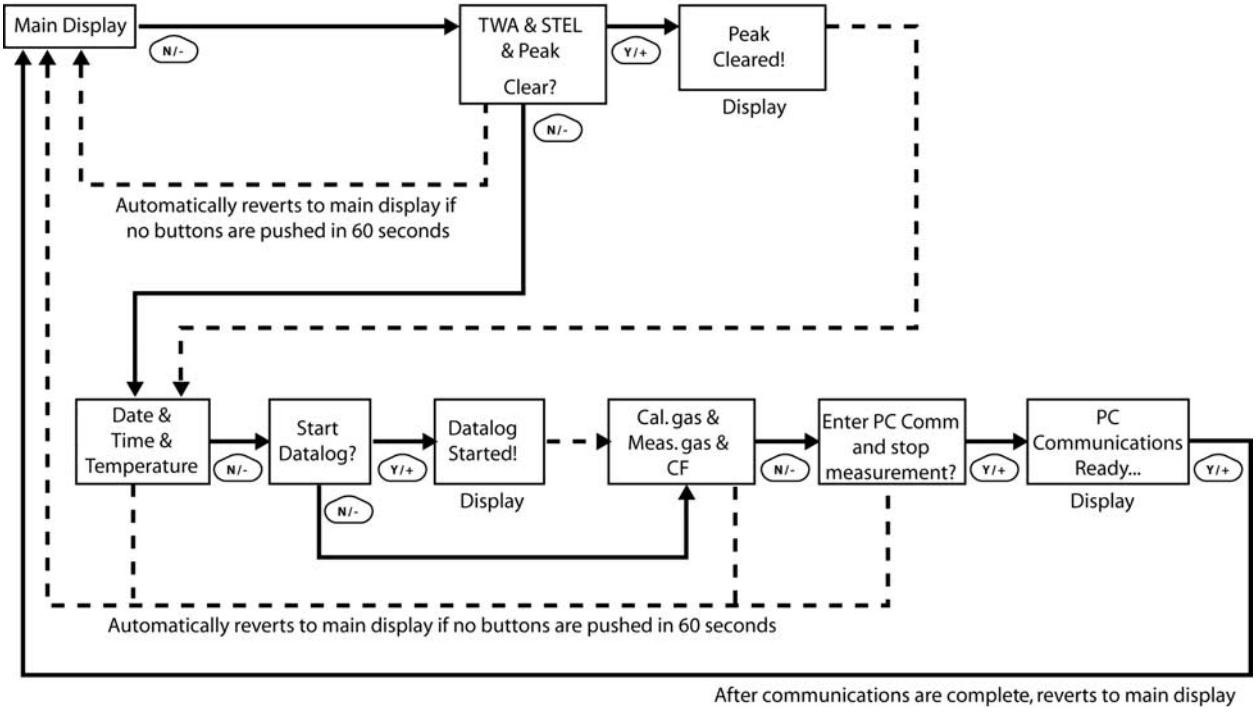
- Press [Y/+] to save the changes.

Press [N/-] to undo the changes and revert to the previous settings.

Manual Datalog

When the instrument is set to Manual Datalog, you turn datalogging on and off by stepping through the displays from the Main Display, and then pressing the keys to select datalog on/off functions.

- When you reach the screen that says "Start Datalog?" press [Y/+] to start it. You see "Datalog Started," confirming that datalogging is now on.
- When you reach the screen that says "Stop Datalog?" press [Y/+] to stop it. You see "Datalog Stopped," confirming that datalogging is now off.



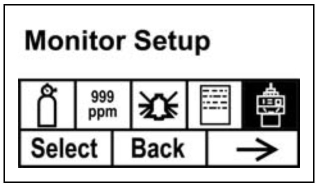
Snapshot Datalog

When the instrument is in Snapshot datalogging mode, it captures a single “snapshot” of the data at the moment of your choosing. Whenever the instrument is on and it is set to Snapshot, all you have to do is press [MODE] each time you want to capture a snapshot of the data at that instant.

When you send the data to a computer using ProRAE Studio, the data snapshots are uniquely identified by time and other parameters.

Monitor Setup

Many settings can be accessed in this menu, including setting the date and time and adjusting the pump’s on/off duty cycle.



Op Mode

Under Monitor Setup is “Op Mode.”

Press [Y/+] to select.

You see two options (one is highlighted):

Hygiene
Search

The current mode is indicated by a dark circle within the circle in front of either Hygiene or Search.

1. Select Hygiene or Search by pressing [N/-]. The highlighting changes from one to the other each time you press [N/-].
2. Press [Y/+] to select that mode for the instrument.
3. Press [MODE] when you want to register your selection to place the instrument in the selected mode.
4. Press [Y/+] to commit the change and exit to the Monitor Setup screen, or press [N/-] to Undo (exit to the Monitor Setup screen without changing the Mode).

Site ID

Enter an 8-digit alphanumeric/character Site ID in the programming mode. This Site ID is included in the datalog report.

1. Press [Y/+] and the display shows the current site ID. Example: "RAE00001." Note that the left-most digit flashes to indicate it is the selected one.
2. Press [Y/+] to step through all 26 letters (A to Z), 10 numerals (0 to 9) and symbols (- / .). **Note:** The last four digits must be numerals.
3. Press [N/-] to advance to the next digit. The next digit to the right flashes.

   Repeat this process until all eight digits of the new site ID are entered.

Press [MODE] to exit.

If there is any change to the existing site ID, the display shows "Save?" Press [Y/+] to accept the new site ID. Press [N/-] to discard the change and move to the next sub-menu.

User ID

Enter an 8-digit alphanumeric User ID in the programming mode. This User ID is included in the datalog report.

1. Press [Y/+] and the display shows the current User ID. Example: "RAE00001." Note that the left-most digit flashes to indicate it is the selected one.
2. Press [Y/+] to step through all 26 letters (A to Z) and 10 numerals (0 to 9).
3. Press [N/-] to advance to the next digit. The next digit to the right flashes.

   Repeat this process until all eight digits of the new User ID are entered.

Press [MODE] to exit.

If there is any change to the existing User ID, the display shows "Save" Press [Y/+] to accept the new site ID. Press [N/-] to discard (undo) the change and move to the next sub-menu.

User Mode

The instrument has two user modes:

Basic	Basic users can only see and use a basic set of functions.
Advanced	Advanced users can see all screens and perform all available functions.

Note: The default value for User Mode is Basic.

To change the User Mode:

1. Press [N/-] to step from one option to the next. The highlighting changes each time you press [N/-].
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
4. Press [Y/+] to accept the new User Mode. Press [N/-] to discard the change and move to the next sub-menu.

Date

The Date is expressed as Month/Day/Year, with two digits for each.

1. Press [Y/+] and the display shows the current date. Note that the left-most digit flashes to indicate it is selected.
2. Press [Y/+] to step through all 10 numerals (0 to 9).
3. Press [N/-] to advance to the next digit. The next digit to the right flashes.

   Repeat this process until all six digits of the new date are entered.

Press [MODE] to exit.

- Press [Y/+] to save the new date.
- Press [N/-] to undo the change and move to the next sub-menu.

Time

The Time is expressed as Hours/Minutes/Seconds, with two digits for each. The time is in 24-hour (military) format.

1. Press [Y/+] and the display shows the current time. Note that the left-most digit flashes to indicate it is selected.
2. Press [Y/+] to step through all 10 numerals (0 to 9).

3. Press [N/-] to advance to the next digit. The next digit to the right flashes.

   Repeat this process until all six digits of the new time are entered.

Press [MODE] to exit.

- Press [Y/+] to save the new date.
- Press [N/-] to undo the change and move to the next sub-menu.

Duty Cycle

The pump's duty cycle is the ratio of its on time to off time. The duty cycle ranges from 50% to 100% (always on), and the period is 10 seconds. Therefore, a duty cycle of 60% means that the pump is on for 6 seconds and off for four seconds. Duty cycling is employed by the instrument to clean the PID. A lower duty cycle has a greater effect on keeping the PID clean than a higher duty cycle.

Important! Pump duty cycling is interrupted when the instrument senses a gas. The pump's duty cycle is disabled when the measurement is greater than the 2ppm threshold and is re-enabled when the reading falls below 90% of the threshold (1.8 ppm).

1. Press [Y/+] to increase the value.
2. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the new duty cycle value.
   - Press [N/-] to undo the change and move to the next sub-menu.

Temperature Unit

The temperature display can be switched between Fahrenheit and Celsius units.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the new temperature unit.
   - Press [N/-] to undo the change and move to the next sub-menu.

Pump Speed

The pump can operate at two speeds, high and low. Running at low speed is quieter and conserves a small amount of power. There is almost no difference in sampling accuracy.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the new temperature unit.
   - Press [N/-] to undo the change and move to the next sub-menu.

Language

English is the default language, but other languages can be selected for the instrument.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates "on").
3. When you have completed your selection, press [MODE].
   - Press [Y/+] to save your new language choice.
   - Press [N/-] to undo it and return to the previous language selection.

Radio Power

The radio connection can be turned on or off.

1. Press [N/-] to step from one option to the next (on or off).
2. Press [Y/+] to make your selection (the dark circle in the "radio button" indicates that the option is selected).
3. When you have completed your selection, press [MODE].

   - Press [Y/+] to accept the new radio setting (on or off).
   - Press [N/-] to discard the change and move to the next sub-menu.

Real Time Protocol

Real Time Protocol is the setting for data transmission.

The choices are:

P2M (cable)	Point to multipoint. Data is transferred from the instrument to multiple locations using a wired connection. Default data rate: 19200 bps.
P2P (cable)	Point to point. Data is transferred only between the instrument and one other location, such as a computer. Default data rate: 9600 bps.
P2M (wireless)	Point to multipoint, wireless. Data is transferred wirelessly and can be received by multiple receivers.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the “radio button” indicates “on”).
3. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the new real-time communications protocol.
   - Press [N/-] to undo the change and move to the next sub-menu.

Power On Zero

When Power On Zero is on, the instrument performs a zero calibration when it is turned on.

1. Press [N/-] to step from one option to the next.
2. Press [Y/+] to make your selection (the dark circle in the “radio button” indicates your selection).
3. When you have completed your selection, press [MODE].
   - Press [Y/+] to save the change.
   - Press [N/-] to discard the change and move to the next sub-menu.

Unit ID

This three-digit number keeps data separated by instrument when more than one instrument is used in a network. If multiple sensing units are attempting to communicate with the same Host, then the units must all have a different Unit ID.

1. Press [Y/+] to step through all 10 numerals (0 to 9). If you pass the numeral you want, keep pressing [Y/+]. After it counts up to 9, it starts counting up from 0 again.
2. Press [N/-] to advance to the next digit. The next digit to the right flashes.

Repeat this process until all three digits of the Unit ID are entered.

3. Press [MODE] when you are done.
   - Press [Y/+] to save the change.
   - Press [N/-] to discard the change and move to the next sub-menu.

LCD Contrast

The display's contrast can be increased or decreased from its default setting. You may not need to ever change the default setting, but sometimes you can optimize the display to suit extreme temperature and ambient brightness/darkness conditions.

- The minimum value is 20.
- The maximum value is 60.

1. Press [Y/+] to increase the value or [N/-] to decrease the value.
2. Press [MODE] to save your selection.
   - Press [Y/+] to save your new contrast value.
   - Press [N/-] to undo it and return to the previous value.

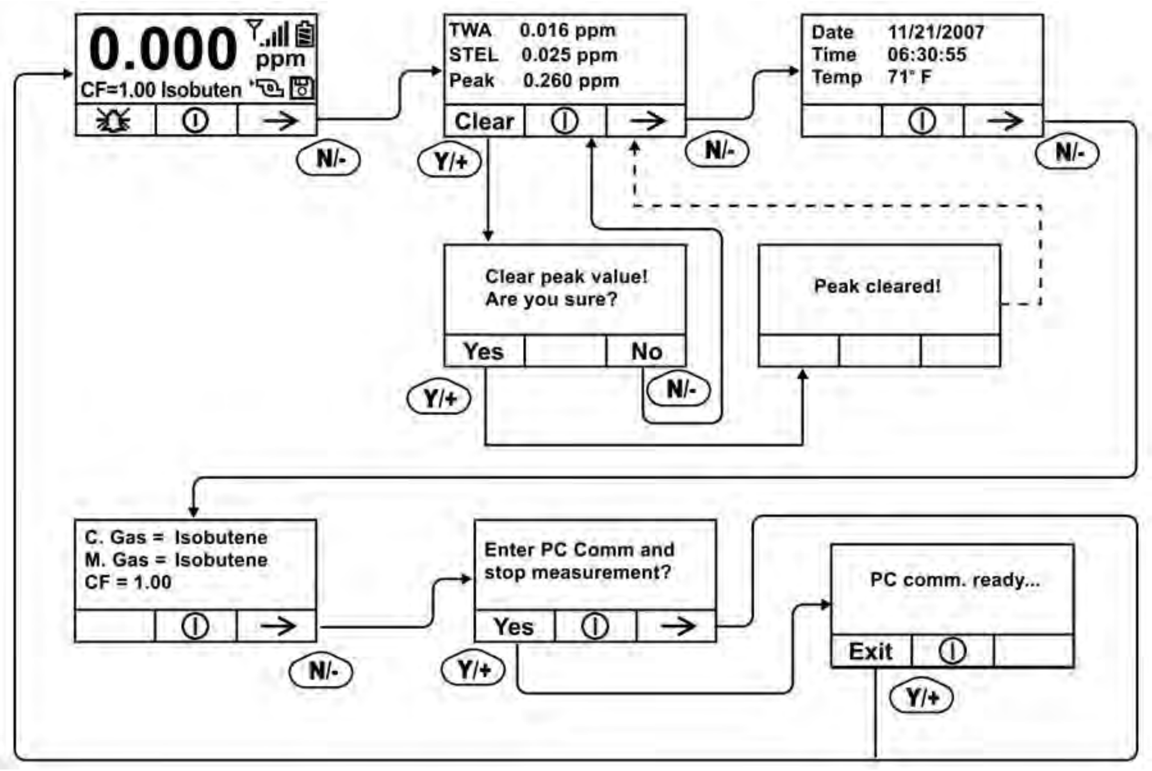
Hygiene Mode

The instrument usually operates in Hygiene Mode, which provides basic functionality. However, it is possible to operate it in a second mode called Search Mode. Here are the primary differences:

Hygiene Mode:	Automatic measurements, continuously running and datalogging, and calculates additional exposure values.
Search Mode:	Manual start/stop of measurements and display of certain exposure values.

Basic User Level & Hygiene Mode

The default setting is navigated in the following way:



Note: Dashed line indicates automatic change to another screen.

Pressing [N/-] steps you from screen to screen. Options include clearing the Peak value and turning on the instrument’s PC Communications for data transfer to a PC.

Entering Search Mode From Hygiene Mode

In order to change the instrument’s operational mode from Hygiene Mode to Search Mode, you must enter the password-protected Programming Mode:

1. Hold [MODE] and [N/-] until you see the password screen.
2. Use [Y/+] to increment to the number you want for the first digit. (If you pass by the desired number, press [Y/+] until it cycles through to 0 again. Then press [Y/+] until you reach the desired number.)
3. Press [N/-] to advance to the next digit.
4. Again press [Y/+] to increment the number.
5. Press [N/-] to advance to the next digit.

Continue the process until all four numbers of the password have been input. Then press [MODE] to proceed.

The screen changes to icons with the label “Calibration.”

1. Press [N/-] to advance to “Monitor Setup.”
2. Press [Y/+] to select Monitor Setup.

Under Monitor Setup, you will see “Op Mode.”

Press [Y/+] to select.

You will see:

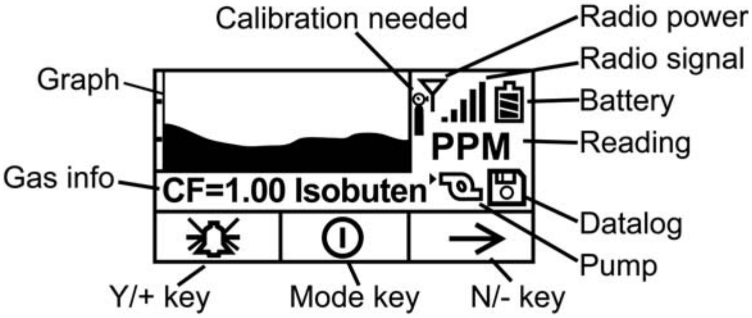
Hygiene
Search

The current mode is indicated by a dark circle within the circle in front of either Hygiene or Search.

1. Select Hygiene or Search by pressing [N/-].
2. Press [Y/+] to place the instrument into the selected mode.
3. Press [MODE] when you want to register your selection to place the instrument in the selected mode.
4. Press [Y/+] to commit the change and exit to the Monitor Setup screen, or press [N/-] to Undo (exit to the Monitor Setup screen without changing the Mode).

Optional Graphic Screen In Search Mode

Using ProRAE Studio, you can set your instrument to show a graphic display instead of a numeric display of ongoing data. Consult your ProRAE Studio disc for information.



During sampling, the display's readings are shown numerically, plus the graph tracks the highest readings over time. The numeric reading alternates between the value and the measurement units, as well:

Advanced User Level (Hygiene Mode Or Search Mode)

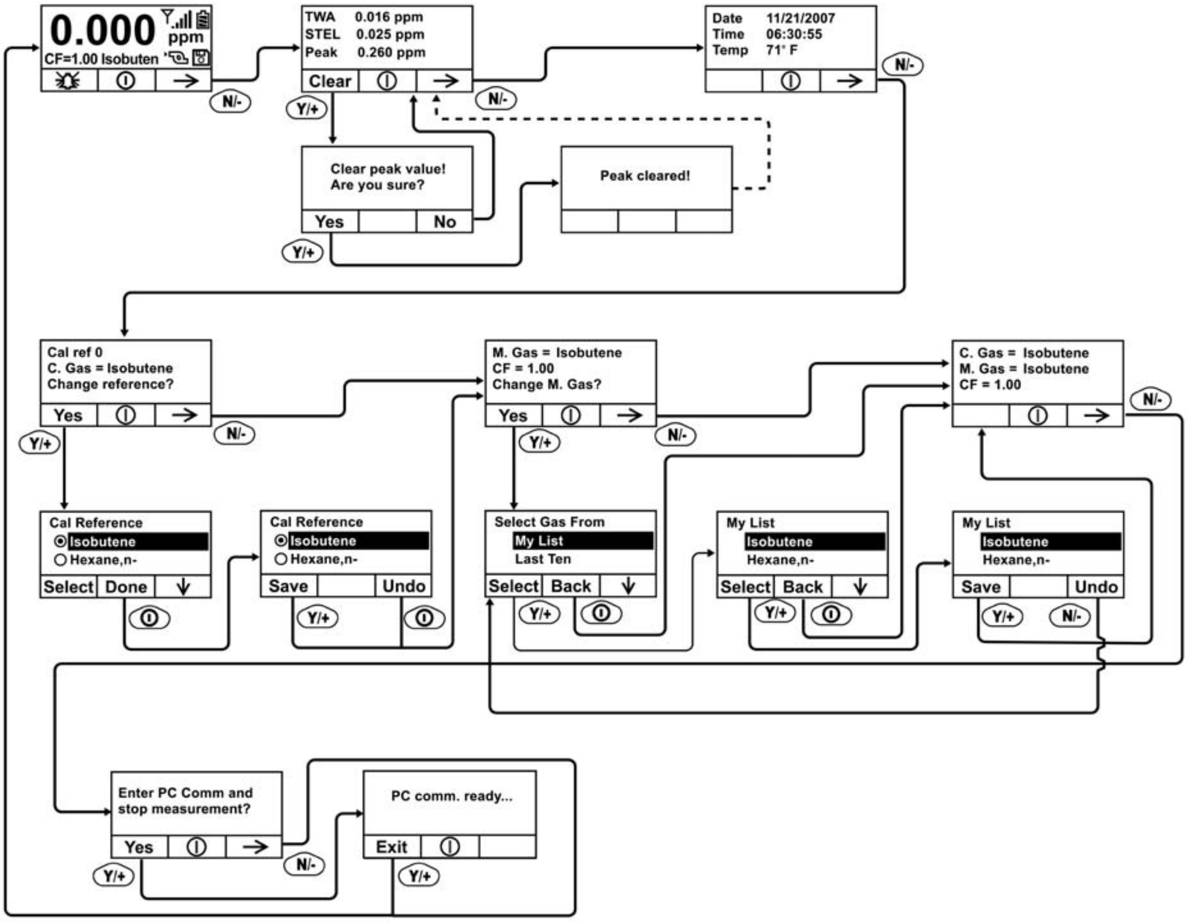
The User Mode called Advanced User Level allows a greater number of parameters to be changed than Basic User Level. It can be used with either of the Operation Modes, Hygiene Mode or Search Mode.

Advanced User Level & Hygiene Mode

With the instrument in Operation Mode: Hygiene Mode, enter User Mode: Advanced User Level (refer to the section called Monitor Mode for instructions).

Once you are in Advanced User Level and Hygiene Mode together, you can change the calibration reference and measurement gas, in addition to performing normal monitoring functions.

Pressing [N/-] progresses through the screens, while pressing [Y/+] selects options. Pressing [MODE] makes menu choices when it is shown for “Done” or “Back.” Pressing and holding [Mode] whenever the circle with a vertical line in the middle is shown activates the countdown to shutoff.

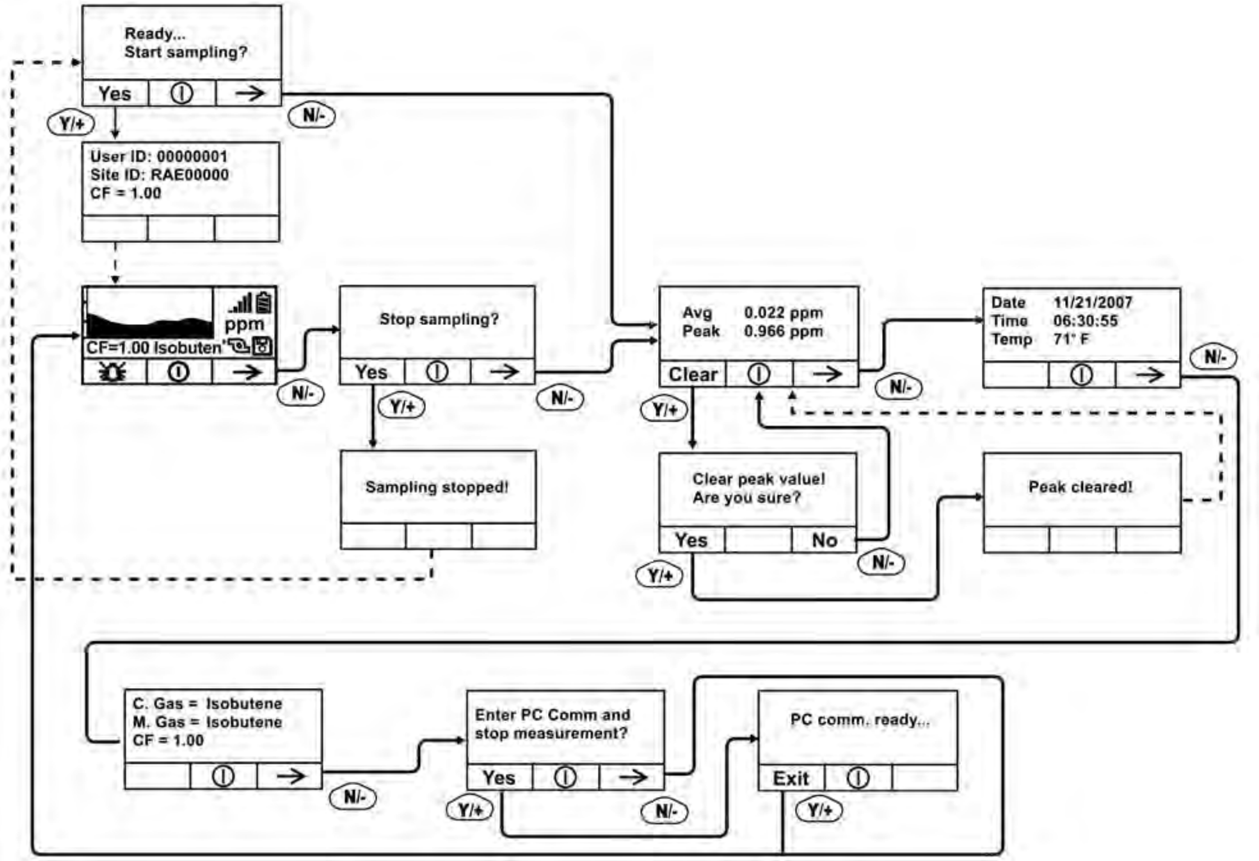


Note: Dashed line indicates automatic change to another screen.

Basic User Level & Search Mode

With the instrument in Operation Mode: Search Mode, enter User Mode and select Basic User Level (refer to the section called User Mode for instructions).

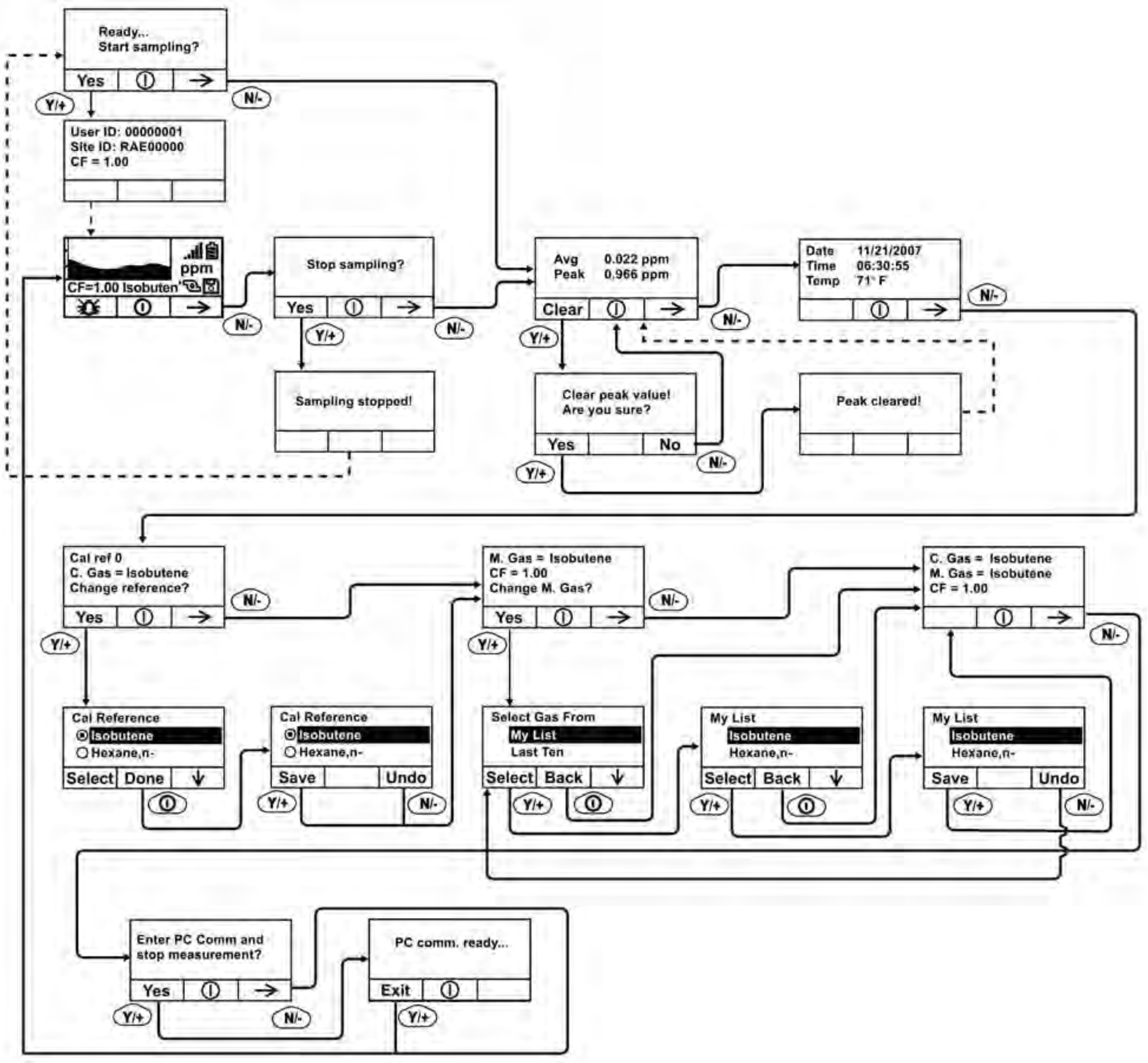
When the instrument is in Search Mode, it only samples when you activate sampling. When you see the display that says, "Ready…Start sampling?" press [Y/+] to start. The pump turns on and the instrument begins collecting data. To stop sampling, press [N/-] while the main display is showing. You will see a new screen that says, "Stop sampling?" Press [Y/+] to stop sampling. Press [N/-] if you want sampling to continue.



Note: Dashed line indicates automatic change to another screen.

Advanced User Level & Search Mode

With the instrument in Operation Mode: Search Mode, enter User Mode and select Advanced User Level (refer to the section called Monitor Mode for instructions). Operation is similar to Basic User Level & Sampling Mode, but now allows you to change calibration and measurement reference gases. Refer to the section on measurement gases on page 39 for more details.



Note: Dashed line indicates automatic change to another screen.

Diagnostic Mode

IMPORTANT! Diagnostic Mode is designed for servicing and manufacturing, and therefore is not intended for everyday use, even by advanced users. It provides raw data from sensors and about settings, but only allows adjustment of pump stall parameters, which should only be changed by qualified personnel.

Note: If the instrument is turned on in Diagnostic Mode and you switch to User Mode, datalog data remains in raw count form. To change to standard readings, you must restart the instrument.

Entering Diagnostic Mode

Note: To enter Diagnostic Mode, you must begin with the instrument turned off.

Press and hold [Y/+] and [MODE] until the instrument starts.

The instrument goes through a brief startup, and then displays raw data for the PID sensor. These numbers are raw sensor readings without calibration. The instrument is now in Diagnostic Mode.

Note: In Diagnostic Mode, the pump and lamp are normally on.

You can enter Programming Mode and calibrate the instrument as usual by pressing both [MODE] and [N/-] for three seconds.

You can enter Monitoring Mode by pressing [MODE] and [Y/+] together for three seconds.

Once the instrument is started up in Diagnostic Mode, you can switch between Diagnostic Mode and Monitoring Mode by pressing and holding [MODE] and [Y/+] simultaneously for two seconds.

In Diagnostic mode, you can step through parameter screens by pressing [MODE].

Adjusting The Pump Stall Threshold

If the gas inlet is blocked but the pump does not shut down, or the pump shuts down too easily with a slight blockage, the pump stall threshold value may be set too high or too low.

Use the following steps to adjust the pump stall threshold:

Pump High

In Diagnostic Mode, press the [MODE] key until “Pump High” is displayed. The pump shows the maximum, minimum, and stall values for the pump at its high speed.

Block the gas inlet and watch the pump current reading (labeled "I") increase. Write down the blocked reading. If the pump current reading does not increase significantly (for example, more than 10 counts), then there may be a leak in the gas inlet or the pump is weak or defective.

Use the [Y/+] or [N/-] key to increase or decrease the stall value until it is the average of the maximum block count and the maximum idle count.

Press the [MODE] key to exit this display.

Pump Low

In Diagnostic Mode, press the [MODE] key until "Pump Low" is displayed. The pump shows the maximum, minimum, and stall values for the pump at its low speed.

Block the gas inlet and watch the pump current reading (labeled "I") increase. Write down the blocked reading. If the pump current reading does not increase significantly (for example, more than 10 counts), then there may be a leak in the gas inlet or the pump is weak or defective.

Use the [Y/+] or [N/-] key to increase or decrease the stall value until it is the average of the maximum block count and the maximum idle count.

Press the [MODE] key to exit this display.

Exiting Diagnostic Mode

You can exit Diagnostic Mode and go directly to Programming Mode or Monitor Mode as outlined above, or you can exit Diagnostic Mode completely.

To exit Diagnostic Mode so that it cannot be re-entered without a restart:

Shut down the instrument. When it is off, restart it by holding the [MODE] key. Diagnostic Mode cannot be entered until the instrument is restarted as outlined in "Entering Diagnostic Mode."

Transferring Data To & From A Computer

Once you have connected your instrument cradle to the PC, you can can transfer data, including a download of the datalog to the computer and updates of firmware to the instrument (should this ever be necessary).

Downloading The Datalog To A PC

1. Connect the data cable to the PC and the cradle.
2. Place the instrument into its cradle. The charging LED should be illuminated.
3. Start ProRAE Studio on your PC.
4. From ProRAE Studio, select "Operation" and select Setup Connection.
5. Select the COM port to establish a communication link between the PC and the instrument.
6. To receive the datalog in the PC, select "Downlog Datalog."
7. When you see "Unit Information," click OK.

During the data transfer, the display shows a progress bar.

When the transfer is done, you will see a screen with the datalog information. You can now export this datalog for other use or printing.

Uploading Firmware To The instrument From A PC

Uploading new firmware to your instrument requires connecting the instrument and PC. Follow these steps to make the connection:

1. Connect the data cable to the PC and the cradle.
2. Place the instrument into its cradle. The charging LED should be illuminated.
3. Start ProRAE Studio on your PC.
4. From ProRAE Studio, select "Operation" and select Setup Connection.
5. Select the COM port to establish a communication link between the PC and the instrument.
6. Select Operation → Download Firmware.

Once communication is established, follow the instructions that accompany ProRAE Studio and the firmware to upload the new firmware to your instrument.

Note: Check for the latest updates to ProRAE Studio at www.raesystems.com.

Maintenance

The major maintenance items of the instrument are:

- Battery pack
- Sensor module
- PID lamp
- Sampling pump
- Inlet connectors and filters

Note: Maintenance should be performed by qualified personnel only.

NOTE: The printed circuit board of the instrument is connected to the battery pack even if the power is turned off. Therefore, it is very important to disconnect the battery pack before servicing or replacing any components inside the instrument. Severe damage to the printed circuit board or battery may occur if the battery pack is not disconnected before servicing the unit.

Battery Charging & Replacement

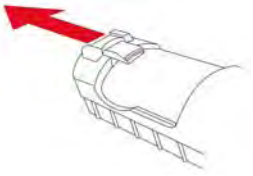
When the display shows a flashing empty battery icon, the battery requires recharging. It is recommended to recharge the instrument upon returning from fieldwork. A fully charged battery runs a instrument for 16 hours continuously. The charging time is less than 8 hours for a fully discharged battery. The battery may be replaced in the field (in areas known to be non-hazardous), if required.

WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in areas known to be non-hazardous.

Replacing Li-ion Battery

1. Turn off the instrument.
2. Located on the rear of the instrument is a battery tab. Slide it down to unlock the battery.



3. Remove the battery pack from the battery compartment by tilting it out.

4. Replace a fully charged spare battery pack inside the battery compartment. Make sure the battery pack is oriented properly inside the compartment.
5. Slide the capture tab back up to its locked position.

Replacing The Alkaline Battery Adapter

An alkaline battery adapter is supplied with each instrument. The adapter (part number 059-3052-000) accepts four AA alkaline batteries (use only Duracell MN1500) and provides approximately 12 hours of operation. The adapter is intended to be used in emergency situations when there is no time to charge the Li-ion battery pack.

To insert batteries into the adapter:

1. Remove the three Philips-head screws to open the compartment.
2. Insert four fresh AA batteries as indicated by the polarity (+/-) markings.
3. Replace the cover. Replace the three screws.

To install the adapter in the instrument:

1. Remove the Li-ion battery pack from the battery compartment by sliding the tab and tilting out the battery.
2. Replace it with the alkaline battery adapter
3. Slide the tab back into place to secure the battery adapter.

IMPORTANT!

Alkaline batteries cannot be recharged. The instrument's internal circuit detects alkaline batteries and will not allow recharging. If you place the instrument in its cradle, the alkaline battery will not be recharged. The internal charging circuit is designed to prevent damage to alkaline batteries and the charging circuit when alkaline batteries are installed inside the instrument.

Note: When replacing alkaline batteries, dispose of old ones properly.

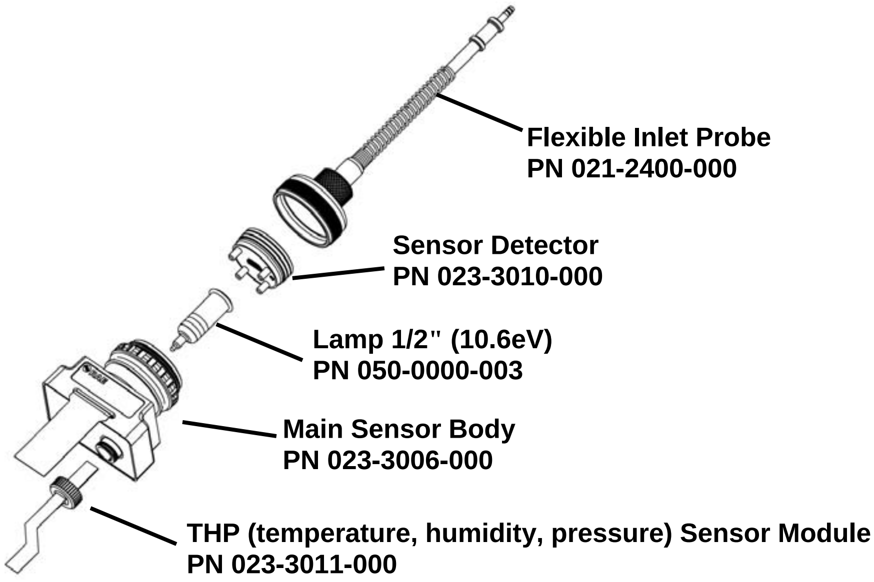
WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge the battery only in areas known to be non-hazardous. Remove and replace the battery only in areas known to be non-hazardous.

Note: The internal charging circuit is designed to prevent charging to alkaline batteries.

PID Sensor & Lamp Cleaning/Replacement

The sensor module is made of several components and is attached to the lamp-housing unit as shown below.



Sensor Components

Note: The cleaning procedure is not normally needed. Clean the PID sensor module, the lamp and the lamp housing only when one of the following has happened:

1. The reading is inaccurate even after calibration.
2. The reading is very sensitive to air moisture.
3. A chemical liquid has been sucked into the unit and damaged the unit.

Use of the external filter helps to prevent contamination of the sensor.

To access the sensor components and lamp, gently unscrew the lamp-housing cap, remove the sensor adapter with the gas inlet probe and the metal filter all together. Then hold the PID sensor and pull it straight out. A slight, gentle rocking motion helps release the sensor.

Cleaning The PID Sensor

Place the entire PID sensor module into GC grade methanol. It is highly recommended that an ultrasound bath to be used to clean the sensor for at least 15 minutes. Then dry the sensor thoroughly. Never touch the electrodes of the sensor by hand.
Also use a methanol-soaked cotton swab to wipe off the lamp housing where it contacts the sensor when the sensor is installed.

Turn over the sensor so that the pins point up and the sensor cavity is visible. Examine the sensor electrodes for any corrosion, damage, or bending out of alignment. The metal sensor electrode “fingers” should be flat and straight. If necessary, carefully bend the sensor fingers to ensure that they do not touch the Teflon portions and that they are parallel to each other. Make sure that the nuts on the sensor pins are snug but not overtight. If the sensor is corroded or otherwise damaged, it should be replaced.

Cleaning The Lamp Housing Or Changing The Lamp

If the lamp does not turn on, the instrument will display an error message to indicate replacement of the lamp may be required.

1. If the lamp is operational, clean the lamp window surface and the lamp housing by wiping it with GC grade methanol using a cotton swab using moderate pressure. After cleaning, hold the lamp up to the light at an angle to detect any remaining film. Repeat the process until the lamp window is clean. Never use water solutions to clean the lamp. Dry the lamp and the lamp housing thoroughly after cleaning.

   CAUTION: Never touch the window surface with the fingers or anything else that may leave a film. Never use acetone or aqueous solutions.

2. If the lamp does not turn on, remove the lamp from the lamp housing. Place the lamp O-ring onto the new lamp. Insert the new lamp, avoiding contact with the flat window surface.
3. Reinstall the PID sensor module.
4. Tighten the Lamp Housing Cap.

Sampling Pump

When approaching the end of the specified lifetime of the pump, it will consume higher amount of energy and reduce its sample draw capability significantly. When this occurs, it is necessary to replace or rebuild the pump. When checking the pump flow, make sure that the inlet connector is tight and the inlet tubing is in good condition. Connect a flow meter to the gas inlet probe. The flow rate should be above 450 cc/min when there is no air leakage.

If the pump is not working properly, refer the instrument to qualified service personnel for further testing and, if necessary, pump repair or replacement.

Cleaning The Instrument

Occasional cleaning with a soft cloth is recommended. Do not use detergents or chemicals.

Visually inspect the contacts at the base of the instrument, on the battery, and on the charging cradle to make sure they are clean. If they are not, wipe them with a soft, dry cloth. Never use solvents or cleaners.

Ordering Replacement Parts

If you need replacement parts, contact your local RAE Systems distributor. A list is available online:

http://www.raesystems.com

In the U.S., you can order sensors, replacement batteries, and other accessories online at:

http://istore.raesystems.com/

Special Servicing Note

If the instrument needs to be serviced, contact either:

1. The RAE Systems distributor from whom the instrument was purchased; they will return the instrument on your behalf.

   or

2. The RAE Systems Technical Service Department. Before returning the instrument for service or repair, obtain a Returned Material Authorization (RMA) number for proper tracking of your equipment. This number needs to be on all documentation and posted on the outside of the box in which the instrument is returned for service or upgrade. Packages without RMA Numbers will be refused at the factory.

Troubleshooting

Problem	Possible Reasons & Solutions	
Cannot turn on power after charging the battery	**Reasons:**	Discharged battery. Defective battery.
	Solutions:	Charge or replace battery.
Lost password	**Solutions:**	Call Technical Support at +1 408-752-0723 or toll-free at +1 888-723-4800
Reading abnormally High	**Reasons:**	Dirty filter. Dirty sensor module. Excessive moisture and water condensation. Incorrect calibration.
	Solutions:	Replace filter. Blow-dry the sensor module Calibrate the unit.
Reading abnormally Low	**Reasons:**	Dirty filter. Dirty sensor module. Weak or dirty lamp. Incorrect calibration.
	Solutions:	Replace filter. Remove Calibration Adapter. Calibrate the unit. Check for air leakage.
Buzzer Inoperative	**Reasons:**	Bad buzzer.
	Solutions:	Check that buzzer is not turned off. Call authorized service center.

Inlet flow too low	**Reasons:**	Pump diaphragm damaged or has debris. Flow path leaks.
	Solutions:	Check flow path for leaks; sensor module O-ring, tube connectors, Teflon tube compression fitting. Call Technical Support at +1 408-752-0723 or toll-free at +1 888-723-4800
“Lamp” message during operation	**Reasons:**	Lamp drive circuit. Weak or defective PID lamp, defective.
	Solutions:	Turn the unit off and back on. Replace UV lamp

Technical Support

To contact RAE Systems Technical Support Team:

Monday through Friday, 7:00AM to 5:00PM Pacific (US) Time
Phone (toll-free): +1 888-723-4800
Phone: +1 408-952-8461
Email: tech@raesystems.com

Life-critical after-hours support is available:

+1 408-952-8200 select option 8

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Appendix A: Regulatory Information

059-4020-000-APNDX Rev A.

Intrinsic Safety:	US and Canada: Class I, Division 1, Group A, B, C, D
	Europe: ATEX (II 1G EEx ia IIC T4)
	IECEx (Ex ia IIC T4)
Temperature:	-20º C to 50º C (-4º to 122º F)
Humidity:	0% to 95% relative humidity (non-condensing)

Basic Operation

Turning The Instrument On

1. With the instrument turned off, press and hold [MODE].
2. When the display turns on, release the [MODE] key.

The instrument is now operating and performs self tests. Once the self tests are complete, the display shows a graph or numerical gas reading. This indicates that the instrument is fully functional and ready to use.

Turning The Instrument Off

1. Press and hold the Mode key for 3 seconds. A 5-second countdown to shutoff begins.
2. When you see “Unit off...” release your finger from the [MODE] key. The instrument is now off.

Note: You must hold your finger on the key for the entire shutoff process. If you remove your finger from the key during the countdown, the shutoff operation is canceled and the instrument continues normal operation.

Alarm Signals

During each measurement period, the gas concentration is compared with the programmed alarm limits (gas concentration alarm limit settings). If the concentration exceeds any of the preset limits, the loud buzzer and red flashing LED are activated immediately to warn you of the alarm condition.

In addition, the instrument alarms if one of the following conditions occurs: battery voltage falls below a preset voltage level, failure of the UV lamp, pump stall, or when the datalog memory is full.

Alarm Signal Summary

Message	**Condition**	**Alarm Signal**
HIGH	Gas exceeds “High Alarm” limit	3 beeps/flashes per second*
OVR	Gas exceeds measurement range	3 beeps/flashes per second
MAX	Gas exceeds electronics’ maximum range	3 beeps/flashes per second
LOW	Gas exceeds “Low Alarm” limit	2 beeps/flashes per second*
TWA	Gas exceeds “TWA” limit	1 Beep/flash per second*
STEL	Gas exceeds “STEL” limit	1 Beep/flash per second*
Pump icon flashes	Pump failure	3 beeps/flashes per second
Lamp	PID lamp failure	3 beeps/flashes per second plus “Lamp” message on display
Battery icon flashes	Low battery	1 flash, 1 beep per minute plus battery icon flashes on display
CAL	Calibration failed, or needs calibration	1 beep/flash per second
NEG	Gas reading measures less than number stored in calibration	1 beep/flash per second

Preset Alarm Limits & Calibration

The instrument is factory calibrated with standard calibration gas, and is programmed with default alarm limits.

Cal Gas (Isobutylene)	Cal Span	unit	Low	High	TWA	STEL
ppbRAE 3000	10	ppm	10	25	10	25
MiniRAE 3000	100	ppm	50	100	10	25
MiniRAE Lite	100	ppm	50	100	10	25
UltraRAE 3000	100	ppm	50	100	10	25

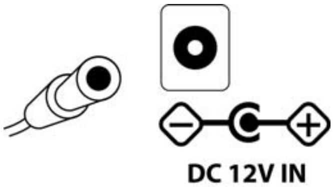
Charging The Battery

Always fully charge the battery before using the instrument. The instrument's Li-ion battery is charged by placing the instrument in its cradle. Contacts on the bottom of the instrument meet the cradle's contacts, transferring power without other connections.

Note: Before setting the instrument into its charging cradle, visually inspect the contacts to make sure they are clean. If they are not, wipe them with a soft cloth. Do not use solvents or cleaners.

Follow this procedure to charge the instrument:

1. Plug the AC/DC adapter's barrel connector into the instrument's cradle.



2. Plug the AC/DC adapter into the wall outlet.
3. Place the instrument into the cradle, press down, and lean it back. It locks in place and the LED in the cradle glows.

   Note: To release the instrument, press down and tilt the top out of the cradle and lift up.

The instrument begins charging automatically. The LED on the front of the cradle marked "Primary" blinks during charging. During charging, the diagonal lines in the battery icon on the instrument's display are animated and you see the message "Charging..."

When the instrument's battery is fully charged, the battery icon is no longer animated and shows a full battery. The message "Fully charged!" is shown and the Primary LED on the cradle glows continuously green.

Note: A spare Li-ion battery (part number 059-3051-000) can be charged by placing it directly in the charging port on the back of the cradle. It can be charged at the same time as the instrument. Press the battery in place, sliding it slightly toward the front of the cradle. This locks it in the cradle. To release the battery, slide it forward again and tilt it up.

Note: An Alkaline Battery Adapter (part number 059-3052-000), which uses four AA alkaline batteries (Duracell MN1500 or Energizer E91), may be substituted for the Li-Ion battery.

WARNING!

To reduce the risk of ignition of hazardous atmospheres, recharge and replace batteries only in areas known to be non-hazardous. Remove and replace batteries only in areas known to be non-hazardous.

Low Voltage Warning

When the battery's charge falls below a preset voltage, the instrument warns you by beeping once and flashing once every minute, and the battery icon blinks once per second. You should turn off the instrument within 10 minutes and either recharge the battery by placing the instrument in its cradle, or replace the battery with a fresh one with a full charge.

Clock Battery

An internal clock battery is mounted on one of the instrument's printed circuit boards. This long-life battery keeps settings in memory from being lost whenever the Li-ion battery or alkaline batteries are removed. This backup battery should last approximately five years, and must be replaced by an authorized RAE Systems service technician. It is not user-replaceable.

WARNING

To reduce the risk of ignition of hazardous atmospheres, recharge battery only in area known to be non-hazardous. Remove and replace battery only in an area known to be non-hazardous.

Replacing the Rechargeable Li-Ion Battery

Caution: Turn off the instrument before removing or replacing the battery.

Alkaline Battery Adapter

An alkaline battery adapter is supplied with each instrument. The adapter (part number 059-3052-000) accepts four AA alkaline batteries (use only Duracell MN1500 or Energizer E91).

Do not mix old and new batteries or batteries from different manufacturers.

Troubleshooting

Problem	Possible Reasons & Solutions	
Cannot turn on power after charging the battery	**Reasons:**	Discharged battery. Defective battery.
	Solutions:	Charge or replace battery.
Lost password	**Solutions:**	Call Technical Support at +1 408-752-0723 or toll-free at +1 888-723-4800

Reading abnormally High	**Reasons:**	Dirty filter. Dirty sensor module. Excessive moisture and water condensation. Incorrect calibration.
	Solutions:	Replace filter. Blow-dry the sensor module Calibrate the unit.
Reading abnormally Low	**Reasons:**	Dirty filter. Dirty sensor module. Weak or dirty lamp. Incorrect calibration.
	Solutions:	Replace filter. Remove Calibration Adapter. Calibrate the unit. Check for air leakage.
Buzzer Inoperative	**Reasons:**	Bad buzzer.
	Solutions:	Check that buzzer is not turned off. Call authorized service center.
Inlet flow too low	**Reasons:**	Pump diaphragm damaged or has debris. Flow path leaks.
	Solutions:	Check flow path for leaks; sensor module O-ring, tube connectors, Teflon tube compression fitting. Call Technical Support at +1 408-752-0723 or toll-free at +1 888-723-4800
"Lamp" message during operation	**Reasons:**	Lamp drive circuit. Weak or defective PID lamp, defective.
	Solutions:	Turn the unit off and back on. Replace UV lamp

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Rev. A
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P/N 059-4020-000

STRATEGIC DIAGNOSTICS INC.

RaPID Assay® PCB Test Kit
A00133/A00134

Intended Use

The RaPID Assay® PCB Test Kit can be used as a quantitative, semi-quantitative or qualitative enzyme immunoassay (EIA) for the analysis of PCB (polychlorinated biphenyl) in water (groundwater, surface water, well water). For applications in other matrices please contact our Technical Service department or refer to the soil application procedure provided. The RaPID Assay® PCB Test Kit allows reliable and rapid screening for PCB (measured and reported as Aroclor 1254), with quantitation between 0.5 and 10 ppb (as Aroclor 1254), in water. The minimum detection level of the kit is 0.2 ppb (as Aroclor 1254.)

Test Principles

The PCB RaPID Assay® kit applies the principles of enzyme linked immunosorbent assay (ELISA) to the determination of PCB and related compounds. The sample to be tested is added, along with an enzyme conjugate, to a disposable test tube, followed by paramagnetic particles with antibodies specific to PCB attached. Both PCB (which may be in the sample) and the enzyme labeled PCB (the enzyme conjugate) compete for antibody binding sites on the magnetic particles. At the end of an incubation period, a magnetic field is applied to hold the paramagnetic particles (with PCB and labeled PCB analog bound to the antibodies on the particles, in proportion to their original concentration) in the tube and allow the unbound reagents to be decanted. After decanting, the particles are washed with Washing Solution.

The presence of PCB is detected by adding the enzyme substrate (hydrogen peroxide) and the chromogen (3,3',5,5' – tetramethylbenzidine). The enzyme labeled PCB analog bound to the PCB antibody catalyzes the conversion of the substrate/chromogen mixture to a colored product. After an incubation period, the reaction is stopped and stabilized by the addition of acid. Since the labeled PCB (conjugate) was in competition with the unlabeled PCB (sample) for the antibody sites, the color developed is inversely proportional to the concentration of PCB in the sample.

NOTE: Color development is inversely proportional to the PCB concentration.

Darker color = lower concentration
Lighter color = higher concentration

The determination of the PCB level in an unknown sample is interpreted relative to the standard curve generated from kit standards after reading with a spectrophotometer.

Performance Characteristics

The PCB RaPID Assay® will detect different PCB Aroclors to different degrees. Refer to the table below for data on several of these. The PCB RaPID Assay® kit provides screening results. As with any analytical technique (GC, HPLC, etc.) positive results requiring some action should be confirmed by an alternative method.

The PCB RaPID Assay® immunoassay test does not differentiate between PCB and other related compounds. The table below shows compounds at the method detection limit (MDL) which is the lowest concentration of the compound, in water, that can be picked up in the assay. The limit of quantitation (LOQ) is an approximate concentration, in water, required to yield a positive result at the lowest standard. **This is the lowest concentration of the compound that can be quantified in the assay**. The IC50 is the concentration required to, inhibit one half of the color produced by the negative control. It is also used to calculate cross-reactivity values to similar compounds.

Compound	MDL (ppb)	LOQ (ppb)	IC50 (ppb)
Aroclor 1254	0.20	0.50	3.6
Aroclor 1260	0.20	0.32	2.3
Aroclor 1248	0.22	0.59	4.22

Aroclor 1242	0.34	1.22	8.8
Aroclor 1262	0.36	0.66	4.74
Aroclor 1232	0.84	2.61	18.76
Aroclor 1268	0.92	3.03	21.80
Aroclor 1016	0.94	3.56	25.60
Aroclor 1221	13.54	22.58	162.60

*The following compounds demonstrated no reactivity in the PCB RaPID Assay® test kit at concentrations up to 10,000 ppb: Biphenyl, 2,5-Dichlorophenol, 2,3,5-Trichlorophenol, Di-n-octyl-phthalate.

The presence of the following substances up to 250 ppm were found to have no significant effect on PCB RaPID Assay® results: copper, nickel, zinc, mercury, manganese, phosphate, sulfate, sulfite, magnesium, calcium, nitrate and thiosulfate. Humic acid up to 25 ppm and iron to 100 ppm were found to have no significant effect. In addition, sodium chloride concentrations up to 1.0 M showed no effect on results.

Precautions

- Training is strongly recommended prior to using the RaPID Assay® test system. Contact Strategic Diagnostics for additional information.
- Treat PCB, solutions that contain PCB, and potentially contaminated samples as hazardous materials.
- Use gloves, proper protective clothing, and methods to contain and handle hazardous material where appropriate.
- Reagents must be added in a consistent manner to the entire rack. A consistent technique is the key to optimal performance. Be sure to treat each tube in an identical manner.
- Water samples should be at a neutral pH prior to analysis. Samples containing gross particulate should be filtered (e.g. 0.2 um Anotop™ 25 Plus, Whatman, Inc.) to remove particles.
- Store all test kit components at 2°C to 8°C (36°F to 46°F). Storage at ambient temperature (18°C to 27°C or 64°F to 81°F) on the day of use is acceptable. *Test tubes require no special storage and may be stored separately to conserve refrigerator space.*
- Allow all reagents to reach ambient temperature (18°C to 27°C or 64°F to 81°F) before beginning the test. This typically requires at <u>least</u> 1 hour to warm from recommended storage conditions.
- Do not freeze test kit components or expose them to temperatures above 100°F (39°C).
- Do not use test kit components after the expiration date.
- Do not use reagents or test tubes from one test kit with reagents or test tubes from a different test kit.
- Do not mix reagents from kits of different lot numbers.
- Use approved methodologies to confirm any positive results.
- Do not under any circumstances attempt to disassemble the base of the magnetic rack. Magnets will be violently attracted to each other.
- Adequate sample number and distribution are the responsibility of the analyst.
- The photometer provided in the accessory kit requires electricity and comes with a 110V adapter. Adapters for 220V are available. Do not attempt to operate with a car adaptor.
- Do not expose color solution to direct sunlight.
- Do not dilute or adulterate test reagents or use samples not called for in the test procedure; this may give inaccurate results.
- Tightly recap the standard vials when not in use to prevent evaporative loss.

Materials Provided

- Antibody Coupled Paramagnetic Particles in buffered saline containing preservative and stabilizers.

  30 test kit: one 20 mL vial
  100 test kit: one 65 mL vial
- Enzyme Conjugate.

  30 test kit: one 10 mL vial
  100 test kit: one 35 mL vial
- Standards

Three concentrations (0.25, 1.0 and 5.0 ppb) of PCB standards (as Aroclor 1254) in buffered saline containing preservative and stabilizers are supplied. Each vial contains 4 mL.

- Control

  A concentration (approximately 3 ppb) of PCB (as Aroclor 1254) in buffered saline containing preservative and stabilizers. A 4 mL volume is supplied in one vial.

- Diluent/Zero Standard

  Buffered saline containing preservative and stabilizers without any detectable PCB.

  30 test kit: one 10 mL vial
  100 test kit: one 35 mL vial

- Color Solution containing hydrogen peroxide and 3,3',5,5'-tetramethylbenzidine in an organic base.

  30 test kit: one 20 mL vial
  100 test kit: one 65 mL vial

- Stop Solution containing a solution of 2M sulfuric acid.

  30 test kit: one 20 mL vial
  100 test kit: one 60 mL vial

- Washing Solution containing preserved deionized water.

  30 test kit: one 70 mL vial
  100 test kit: one 250 mL vial

- Polystyrene test tubes

  30 test kit: one 36 tube box
  100 test kit: three 36 tube boxes

- User's Guide

Materials Required and Ordered Separately

See "Ordering Information" for the appropriate catalogue numbers.

Rapid Assay® Accessory Kit

Accessory equipment may be rented or purchased from Strategic Diagnostics. See "Ordering Information" for the appropriate catalogue numbers.

The accessory kit contains the following items:

- Adjustable Volume Pipet
- Eppendorf™ Repeater® Pipettor
- Electronic timer
- Portable balance capable of weighing 10 g (for soil samples)
- Vortex mixer
- Magnetic separation rack
- RPA-I RaPID Analyzer (or equivalent spectrophotometer capable of reading 450 nm in a 1 mL sample size).

Other Items

- 12.5 mL Combitips® for the Repeater pipettor - for 0.25 mL to 1.25 mL dispensing volumes (5)
- Pipet tips for adjustable volume pipet (100-1000 uL)

NOTE: Order replacement Combitips® and pipet tips separately. See the "Ordering Information" section.

Materials Required but Not Provided

- Methanol (HPLC grade or equivalent) – for water analysis
- Protective clothing (e.g., latex gloves)
- Absorbent paper for blotting test tubes
- Liquid and solid waste containers
- Marking pen
- Instructional video (optional)

Suggestions for Pipettor Use

- Practice using both pipettes (adjustable volume and Repeater pipettor) with water and extra tips before you analyze your samples.
- Use a new tip each time you use the Repeater pipettor to pipette a different reagent to avoid reagent cross-contamination. Tips can be rinsed thoroughly, dried completely and reused. By using the same tip to dispense the same reagent each time you can avoid cross contamination.

NOTE: Repeator tips should be changed periodically (after ~10 uses) since precision deteriorates with use.

- Draw the desired reagent volume into the Repeater pipettor and dispense one portion of the reagent back into the container to properly engage the ratchet mechanism. If you do not do this, the first volume delivered may be inaccurate.
- To add reagents using the Repeater pipettor, pipette down the side of the test tube just below the rim.
- When adding samples and standard using the positive displacement pipettor, always pipette into the bottom of the tube without touching the sides or bottom of the tube.
- Use a new adjustable volume pipet tip each time you pipette a new unknown.

Assay Procedure

Prior to performing your first Rapid Assay®, please take time to read the package inserts in their entirety and review the videotape if available. **On site training is strongly recommended for new users of this test system.** Please contact your account manager for further information. This procedure is designed for quantitative analysis. For running the kit semi-quantitatively or qualitatively, please contact Technical Support.

Collect/Store the Sample

The following steps explain how to properly collect and store your samples.

1. Water samples should be collected in glass vessels with teflon cap liners). **Immediately upon collection, water samples should be diluted with an equal volume (1:1) of methanol (HPLC grade) to prevent adsorptive losses to the glass containers.** This is a 2x dilution, which must be accounted for when interpreting results. See "Results Interpretation", Section 3a for further details. Use this diluted sample as "sample" in "Perform the Test".

NOTE: This 2x dilution is <u>not</u> required for soil samples.

2. Samples should be collected in appropriately sized and labeled containers.
3. If testing soil samples, follow the SDI Sample Extraction Kit User's Guide or the appropriate technical bulletin to properly collect and store your sample.
4. Samples should be tested as soon as possible after collection. If this is not possible, storage at 4°C (39°F) is recommended to minimize evaporative losses.

Set Up

1. Remove kits from refrigerator. All reagents must be allowed to come to room temperature prior to analysis. Remove reagents from packaging and place at room temperature <u>at least</u> 1 hour prior to testing.
2. Turn on the RPA-1 or other spectrophotometer. The RPA-1 should be warmed up for at least 30 minutes prior to the run.
3. Label five 12.5 mL Combitips "Conjugate", "Particles", "Wash", "Color" and "Stop". In addition, add the name of the compound you are testing for to each Combitip.
4. Remove nine clean blank test tubes for standards and control and one test tube for each sample (if testing in singlicate). Label the test tubes according to contents as follows.

<u>Tube #</u>	<u>Contents</u>
1	Negative control (replicate 1)
2	Negative control (replicate 2)
3	Standard 1 (replicate 1)
4	Standard 1 (replicate 2)
5	Standard 2 (replicate 1)
6	Standard 2 (replicate 2)
7	Standard 3 (replicate 1)
8	Standard 3 (replicate 2)
9	Control
10	Sample 1
11	Etc.

***Label at top of tubes to avoid interference with reading of tubes in photometer**

Sample Extraction, Filtration and Dilution

Filtration may be necessary to remove gross particulate from the water sample. If testing samples at levels higher than standard kit level is desired, contact SDI for special instructions. Water samples should be diluted 1:1 in methanol as described in "Collect/Store the Sample".

Please follow the instructions from the SDI Sample Extraction Kit to prepare and dilute the soil extract prior to running the assay.

Perform the Test

1. Separate the upper rack from the magnetic base. Place labeled test tubes into the rack.

2. Add **200 uL** of standards, control or samples to the appropriate tubes using the adjustable volume pipet with the dial set on **0200**. The negative control, standards and control must be run with each batch of samples.

NOTE: Sample should be added to the bottom of the tube by inserting the pipet tip into the tube without touching the sides or the bottom of the tube. Take care not to contact sample with pipette tip once dispensed into bottom of the tube.

3. Using the Repeater Pipettor with the "Conjugate" tip attached and the dial set on **"1"**, add **250 uL** of Enzyme conjugate down the **inside wall** of each tube. (Aim the pipet tip ¼" to ½" below the tube rim or tube wall; deliver liquid gently to avoid splashback.)

4. Thoroughly mix the magnetic particles by swirling (avoid vigorous shaking) and attach the "Particles" tip to the Repeater Pipettor. With the dial set on **"2"** add **500 uL** of magnetic particles to each tube, aiming down the side of the tube as described above. Vortex, mixing each tube 1 to 2 seconds at low speed to minimize foaming. Pipetting of magnetic particles should be kept to 2 minutes or less.

5. Incubate 15 minutes at room temperature.

6. After the incubation, combine the upper rack with the magnetic base and press all tubes into the base; allow 2 minutes for the particles to separate.

7. With the upper rack and magnetic base combined, use a smooth motion to invert the combined rack assembly over a sink and pour out the tube contents.

NOTE: If the rack assembly inadvertently comes apart when lifting to pour out tube contents, re-combine and wait an additional 2 minutes to allow particles to separate.

8. **Keep the rack inverted** and gently blot the test tube rims on several layers of paper towels. It is important to remove as much liquid as possible but **do not bang** the rack or you may dislodge the magnetic particles and affect the results.

9. Set the Repeater Pipettor dial to **"4"** and put on the tip labeled "Wash". Add **1 mL** of Washing Solution down the inside wall of each tube by using the technique described earlier. Vortex tubes for 1-2 seconds. **Wait 2 minutes** and pour out the tube contents as described previously. **Repeat this step one more time.**

NOTE: The number of washes and wash volume are important in ensuring accurate results.

10. Remove the upper rack (with its tubes) from the magnetic base. With the "Color" tip attached to the Repeater Pipet and the dial set to **"2"** add **500 uL** of Color Reagent down the inside wall of each tube as described previously. Vortex 1 to 2 seconds (at low speed).

11. Incubate 20 minutes at room temperature. During this period, add approximately 1 mL of Washing solution to a clean tube for use as an instrument blank for "Results Interpretation".

12. After the incubation, position the Repeater pipettor at Setting **"2"** and use the "Stop" tip to add **500 uL** of Stop solution to all test tubes.

13. Proceed with results interpretation.

WARNING: **Stop solution contains 2M sulfuric acid. Handle carefully.**

Results Interpretation

1. After addition of Stop Solution to the test tubes, results should be read within 15 minutes.

2. Wipe the outside of all antibody coated tubes prior to photometric analysis to remove fingerprints and smudges.

Photometric Interpretation Using the RPA-I

1. The RPA-I photometer (provided in the Rapid Assay® Accessory kit) can be used to calculate and store calibration curves. It is preprogrammed with

various RaPID Assay® protocols. For the PCB RaPID Assay® test kit, parameter settings are as follows:

Data Reduct: Lin. Regression
Xformation : Ln/LogitB
Read Mode : Absorbance
Wavelength : 450 nm
Units : PPB
Rgt Blk : 0

Calibrators:
# of Cals : 4
# of Reps : 2

Concentrations:
#1: 0.00 ppb
#2: 0.25 ppb
#3: 1.00 ppb
#4: 5.00 ppb
Range : 0.10 – 5.00
Correlation : 0.990
Rep. %CV : 10%

NOTE: Prior to analysis the RPA-I User's Manual should be thoroughly reviewed for more detailed operation instructions.

2. Follow the instrument prompts to read the absorbance of all tubes:

Instrument Display	Operator Response
SELECT COMMAND RUN PROTOCOL	Press RUN Scroll using the YES [] or NO [] keys until the desired protocol appears. Then press ENTER
SPL. REPLICATES (1-5)	Press 1 (for analysis of samples in singlicate.) Press ENTER
BLANK TUBE, INSERT TUBE, EVALUATING TUBE, REMOVE TUBE (Beep)	Insert blank tube containing 1mL wash solution. Remove tube
CAL #1, REP. #1, INSERT TUBE, EVALUATING TUBE, REMOVE TUBE (Beep)	Insert Tube #1 Remove tube

Follow prompts to read tubes.

NOTE: Tube order is important. The RPA-I expects to see the standards in ascending order, in duplicate, starting with the negative control.

Following evaluation of all standards, the instrument will display:

PRINTING DATA,	Data will print
PRINTING CURVE	Curve will print only if programmed to print (See RPA1 User's Manual).
CTRL #1 REP #1, INSERT TUBE, EVALUATING TUBE, REMOVE TUBE (Beep)	Insert Control Tube Remove Tube
EDIT CALIBRATORS YES/NO	Press NO (if editing is necessary press YES and refer to the RPA1 User's Manual).
SPL #1 REP#1 INSERT TUBE EVALUATING TUBE REMOVE TUBE (Beep)	Insert first sample tube Remove tube

Continue to follow prompts. After all samples have been read, press STOP.

Expected Results:

- **%CV (coefficient of variation) between standard duplicates of 10% or less.**
- **Absorbance reading for the 0 ppb standard should be between 0.8 and 2.0 for all assays.**
- **Correlation (r) of 0.990 or greater for all assays.**
- **Kit control within range specified on vial.**

- **Absorbance of negative control and standards should be as follows:**

  Negative Control>Std. 1>Std. 2>Std. 3.

3. Concentrations will be indicated for all samples on the RPA-I printout.

   a) The concentration, as indicated on the printout, is multiplied by the appropriate dilution factor (if applicable) introduced in the procedure. The quantitation range of the kit is also multiplied by this factor.

EXAMPLE: Water samples were diluted 2-fold with methanol upon collection (see "Collect/Store the Sample" in this User's Guide). As a result, the concentrations listed on the printout should be multiplied by 2 to determine the sample concentration. The standard concentrations are also multiplied by 2 to give a quantitation range in water for this test kit of 0.5 to 10 ppb.

   b) Samples with an "nd" and no concentration listed have an absorbance greater than the negative control; therefore, no concentration can be computed for these samples. Results must be reported as < 0.5 ppb (or Standard 1 multiplied by the dilution factor.)

   c) Samples with an "nd" next to a listed concentration have an estimated concentration below the minimum detection level of the test kit. Results must be reported as <0.5 ppb (or Standard 1 multiplied by the dilution factor.)

   NOTE: Any samples with concentrations determined to be lower than Standard 1 (the limit of quantitation) must be reported as < 0.5 (or Standard 1 multiplied by the dilution factor.) Quantitation is not possible below this standard as this is outside the linear range of the assay.

   d) Similarly, samples with a "hi" next to a listed concentration have an estimated concentration higher than Standard 3 and must be reported as >10 ppb (or Standard 3 multiplied by the dilution factor.)

NOTE: In order to determine the concentration of samples with concentrations greater than Standard 3, they must be subjected to repeat testing using a diluted sample. A ten-fold or greater dilution of the sample is recommended with an appropriate amount of PCB diluent. This additional dilution must then be taken into account when calculating the concentration. Please contact technical support for assistance in performing dilutions.

Photometric Interpretation Using Other Photometers

Other photometers may also be used to interpret results obtained from the RPA-I photometer. It is important that the photometer be able to read absorbance at 450nm and that the instrument can read at a 1 mL fill volume. Absorbances obtained from other spectrophotometers (reading at 450 nm) may be used to manually calculate sample concentrations as outlined below.

1. Calculate the mean absorbance for each of the three standards and the negative control.

2. Determine the standard deviation and %CV (coefficient of variation) of each standard and ensure %CV is less than 10% for each.

3. Calculate the %B/Bo for each standard by dividing the mean absorbance value for the standard by the mean absorbance value for the negative control and multiplying the results by 100.

4. Construct a standard curve by plotting the %B/Bo for each standard on the vertical logit (y) axis versus the corresponding analyte concentration on the horizontal logarithmic (x) axis on the graph paper provided in the test kit. **Graph papers are specific for each method. Use only the graph paper supplied with each kit.**

5. Draw the best straight line through all points. Using the %B/Bo of the sample, the concentration can be interpolated from the standard curve.

6. Multiply results by the appropriate dilution factor (if applicable) introduced in the procedure. For example, if the sample was diluted 10-fold to increase the detection levels of the kit then the results must be multiplied by 10. This dilution also changes the range of the assay (standards) by the same factor.

NOTE: Do not forget to account for the 2x dilution introduced in the "Collect/Store the Sample" procedure for water samples.

Limitations of the Procedure

The Rapid Assay® PCB Test Kit is a screening test **only**. Sampling error may significantly affect testing reliability. Adequate sample number and distribution are the responsibility of the analyst.

Ordering Information

Description	**Catalogue Number**
Rapid Assay® PCB Kit	A00133/A00134
Rapid Assay® Accessory Kit**	6050100
Adjustable Volume Pipet Tips (100-1000 uL)	A00013
12.5 mL Combitip for Repeating Pipette (1 each)	A00009
PCB Diluent	A00136
PCB Soil Proficiency Sample	A00175
Rapid Assay® Accessory Kit Rental	6997010
**** To obtain part numbers and pricing for individual items in the Accessory Kit contact SDI at the number below.**	

Ordering/Technical Assistance

Should you have any questions regarding this procedure prior to analysis contact Technical Service to avoid costly mistakes.

To Place an Order or Receive Technical Assistance, please call Strategic Diagnostics Inc. at:

Call toll-free **800-544-8881**`

Or 302-456-6789 Phone
302-456-6782 Fax
Web site: www.sdix.com
E-mail: techservice@sdix.com

General Limited Warranty

SDI's products are manufactured under strict quality control guidelines and are warranted to be free from defects in materials and workmanship. New instruments and related non-expendable items are warranted for one year from date of shipment against defective materials or workmanship under normal use and service.
Warranty obligation is limited to repair or replacement of the defective product or to refund of the purchase price, at the discretion of SDI. Other warranties, express or implied, are disclaimed. SDI's liability under any warranty claim shall not exceed the refund of the purchase price paid by the customer. Under no circumstances shall SDI be liable for special, indirect or consequential damages.

Safety

To receive an MSDS for this product, visit our web site at www.sdix.com.

Z00245.1, Rev 4/4/00

Material Safety Data Sheet

PCB

MATERIAL IDENTIFICATION

Manufacturer/Distributor:	Strategic Diagnostics Inc. 111 Pencader Drive Newark, DE 19702
Phone Number:	1-(302) 456-6789
Trade Names and Synonyms:	PCB (A00133; A00134)
NFPA Ratings	Health: 2 Flammability: 3 Reactivity: 1

OSHA HAZARD DETERMINATION

Hazardous Ingredients	CAS Number	Weight Percent
Dimethylformamide DMF	68-12-2	≤ 1
Sulfuric acid Oil of Vitriol; Hydrogen Sulfate; Sulphuric acid	7664-93-9	≤ 1
1,2,6-Trihydroxyhexane Hexanetriol-1,2,6; Hexane-1,2,6-triol	106-69-4	≤ 5
Tris 2-amino-2-(hydroxymethyl) propane-1,3-diol; trimethylolaminomethane	77-86-1	≤ 3
Methanol Methyl alcohol, Wood alcohol	67-56-1	~50

PHYSICAL DATA

Plastic kit containing small amounts of various liquids and powders.

HAZARDOUS REACTIVITY

Instability	Stable - Reactivity not expected with the product.

FIRE AND EXPLOSION DATA

Fire and Explosion Hazards	There is a fire and explosion hazard with this kit. 86°F (closed cup) TAG ASTW D-56 for 50% methanol.
Extinguishing Media	Use media appropriate for surrounding material.
Special Fire Fighting Instructions	Firefighters must wear appropriate protective clothing and self – contained breathing apparatus.

HEALTH HAZARD INFORMATION

Primary Route(s) of Exposure/Entry: Skin, Eyes and Mouth. Flush skin and eyes with large amounts of water. If sulfuric acid is ingested, do NOT induce vomiting. Seek prompt medical attention.

Signs and Symptoms of Exposure/Medical Conditions Aggravated by Exposure:

Eye exposure to concentrated sulfuric acid solution may cause severe damage, often leading to blindness. Dilute solutions produce more transient effects from which recovery may be complete. Exposure to the mist causes eye irritation and lacrimation. Skin contact with sulfuric acid may cause severe irritation and pain, burns and vesiculation.

Sulfuric acid is corrosive and may cause severe burning pain in the throat, mouth and abdomen followed by vomiting and diarrhea. Asphyxia may occur from the swelling of the throat. Perforation of the esophagus and stomach may occur.

Methanol may be fatal if swallowed. Methanol may be harmful, if inhaled or absorbed through skin. Vapor or mist is irritating to eyes, mucous membranes, and respiratory tract. Skin contact with chemical may cause irritation. Methanol may also cause irritation / damage to kidneys and other gastrointestinal organs. May also cause convulsions.

Dimethylformamide (DMF) may cause abdominal pain, loss of appetite, nausea, vomiting, diarrhea, increased blood pressure, and liver injury, if inhaled. Contact with eyes or skin, may cause irritation. DMF may cause with prolonged or repeated skin contact, dermatitis with the systematic effects the same as if inhaled. If ingested, seek prompt medical attention.

The toxicological properties of the kit components have not been fully defined. Contact may cause irritation to eyes, skin, and mucous membranes. If inhaled or ingested, may cause irritation. Limit exposure to material.

Carcinogenicity: None of the components in this material is listed by IARC, NTP, OSHA, or ACGIH as a carcinogen.

Applicable Exposure Limits

Dimethylformamide
OSHA / PEL: 10 ppm
ACGIH /TLV: 10 ppm TWA 8 H, skin

Sulfuric acid
OSHA/ PEL 1 mg/m ^{3}
ACGIH/TLV 1 mg/m^3

1,2,6-Trihydroxyhexane
TXDS: orl-rat LD_{50} 15500 mg/kg
ivn-rat LD_{50} 5600 mg/kg
skn-rbt LD_{50} 20 gm/kg

Tris
TXDS: orl-rat LD_{50} 5900 mg/kg
ivn-mus LD_{50} 1210 mg/kg

Methanol
OSHA/PEL 262 mg/m3
ACGIH /TLV 262 mg/ m3
TXDS: orl-rat LD_{50} 5628 mg/kg
ihl-rat LC_{50} 64000 ppm/4H
orl-mice LD_{50} 7300 mg/kg
skn-rbt LD_{50} 15800 mg/kg

FIRST AID

Inhalation	Remove from exposure. If irritation is evident, seek prompt medical attention.
Skin Contact	The compound may cause irritation. If irritation occurs, flush skin with large amounts of water. Remove contaminated clothing and shoes, wash before reuse. If irritation persists, get medical attention.
Eye Contact	In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Call a physician.

Ingestion The compound is toxic by ingestion. If sulfuric acid is ingested, do NOT induce vomiting. Call a physician immediately.

PROTECTION INFORMATION

General Control Measures and Precautions: Ventilation - Natural ventilation.

Personal Protective Equipment:

Respiratory Protection: None normally required.

Protective Gloves: Are highly recommended.

Eye Protection: Safety glasses are required.

Other Protective Equipment: Lab coat or other long sleeved garment is required to limit skin exposure. Access to a safety shower and eyewash.

SPILL, LEAK AND DISPOSAL INFORMATION

Spill, Leak, or Release Review FIRE AND EXPLOSION HAZARDS and SAFETY PRECAUTIONS before proceeding with clean up.

Use appropriate PERSONAL PROTECTIVE EQUIPMENT during clean up. Contain spill and collect in a suitable waste container. Avoid contact or materials with skin or eyes. Use adequate ventilation.

No special clean up practices are required.

Waste Disposal Dispose of as solid waste in accordance with any applicable federal, state, and local requirements.

SHIPPING INFORMATION

DOT	Proper Shipping Name	Not DOT regulated.
IATA/IMO	Proper Shipping Name	Not restricted.

TITLE III HAZARD CLASSIFICATION

Acute	No
Chronic	No
Fire	No
Reactivity	No
Pressure	No

REGULATORY INFORMATION

OSHA HAZARD DETERMINATION: This material is not known to be hazardous as defined by OSHA's Hazard Communication Standard, 29 CFR 1910.1200

EPA DETERMINATIONS:
COMPREHENSIVE ENVIRONMENTAL RESPONSE, COMPENSATION, & LIABILITY ACT (CERCLA/SUPERFUND), 40 CFR 302 - This material is not known to contain hazardous substances in sufficient quantity to make it subject to CERCLA regulations.

TOXIC SUBSTANCES CONTROL ACT (TSCA), 40 CFR 710
The material is a mixture as defined by TSCA. The chemical ingredients in this material are in the Section 8(b) Chemical Substance Inventory and/or are otherwise in compliance with TSCA. In the case of ingredients obtained from other manufacturers, Strategic Diagnostics, Inc. relies on the assurance of responsible third parties in providing this statement.

RESOURCE CONSERVATION AND RECOVERY ACT (RCRA), 40 CFR 261, SUBPARTS C AND D
The material, when discarded or disposed of, is not specifically listed as a hazardous waste in Federal regulations; however, it could be considered hazardous if it meets criteria for being toxic, corrosive, ignitable or reactive according to U.S. EPA definitions (40 CFR 261). This material could also become a hazardous waste if it is mixed with or comes in contact with a listed hazardous waste. If it is a hazardous waste, regulations 40 CFR 262-266 and 268 may apply.

HAZARDOUS MATERIALS TRANSPORTATION REGULATIONS, 49 CFR 171-178 - This material is not known to contain hazardous substances in sufficient quantity to make it subject to the Regulations.

FOREIGN REGULATIONS: CANADIAN HAZARDOUS PRODUCTS ACT (WHMIS)
The material is not a WHMIS Controlled Product.

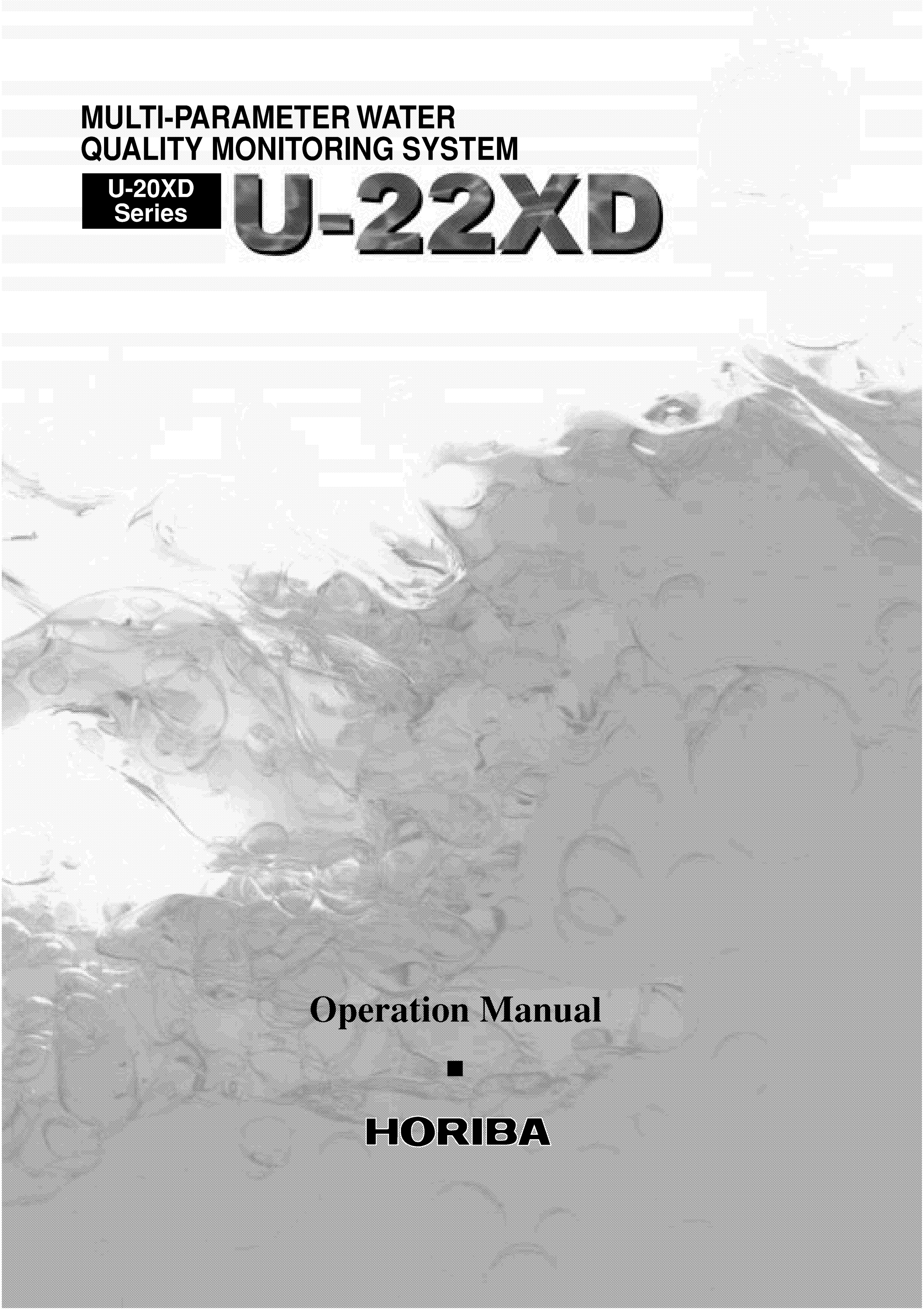
STATE REGULATIONS:
CALIFORNIA SAFE DRINKING WATER AND TOXIC ENFORCEMENT ACT OF 1986 (“PROPOSITION 65”)
The material is not known to contain any ingredients (s) subject to the Act.

PENNSYLVANIA WORKER AND COMMUNITY RIGHT TO KNOW ACT
This material is not known to contain any ingredient(s) subject to the Act. Non-hazardous ingredient(s) information is withheld as trade secret in accordance with Section 11 of the Pennsylvania Worker and Community Right to Know Act.

The above data are based on tests, experience, and other information which Strategic Diagnostics Inc. believes reliable and are supplied for informational purposes only. However, some ingredients may have been purchased or obtained from third-party manufacturers. In these instances, Strategic Diagnostics, Inc., in good faith, relies on information provided by those third parties. Since conditions of use are outside our control, STRATEGIC DIAGNOSTICS INC. DISCLAIMS ANY LIABLITITY FOR DAMAGE OR INJURY WHICH RESULTS FROM USE OF THE ABOVE DATA. NOTHING CONTAINED HEREIN SHALL CONSTITUTE A GUARANTEE, WARRANTY (INCLUDING WARRANTY OF MERCHANTABILITY) OR REPRESENTATION (INCLUDING FREEDOM FROM PATENT LIABILITY) BY STRATEGIC DIAGNOSTICS, INC. WITH RESPECT TO THE DATA, THE MATERIAL DESCRIBED, OR ITS USE FOR ANY SPECIFIC PURPOSE, EVEN IF THAT PURPOSE IS KNOWN TO STRATEGIC DIAGNOSTICS INC.

Responsibility for MSDS:
Strategic Diagnostics Inc.
111 Pencader Drive
Newark, DE 19702
(302) 456-6789

* End of MSDS *



MULTI-PARAMETER WATER QUALITY MONITORING SYSTEM

U-20XD Series

U-22XD

Operation Manual

■

HORIBA

HORIBA's Warranty and Responsibility

Your U-20XD series multi-parameter water quality monitoring system is covered by HORIBA's warranty for a period of one (1) year, under normal use. Although unlikely, if any trouble attributable to HORIBA should occur during this period, necessary exchange or repairs shall be conducted by HORIBA, free of charge.

The warranty does not cover the following:

- Any trouble or damage attributable to actions or conditions specifically mentioned in the operation manuals to be avoided
- Any trouble or damage attributable to use of the multi-parameter water quality monitoring system in ways or for purposes other than those described in the operation manuals
- If any repairs renovations, disassembly, etc. are performed on this multi-parameter water quality monitoring system by any party other than HORIBA or a party authorized by HORIBA
- Any alteration to the external appearance of this multi-parameter water quality monitoring system attributable to scratches, dirt, etc. occurring through normal use
- Wear and tear to parts, the exchange of accessories, or the use of any parts not specified by HORIBA

INSTALLATION ENVIRONMENT

This product is designed for the following environment:

→ Installation Categories II
→ Pollution degree 2

LIMITATION OF LIABILITY FOR DAMAGES

HORIBA will not accept responsibility for damage or malfunction that may occur as a result of operation or situation not recommended in this manual. HORIBA shall not be liable for Customer's incidental, consequential or special damages, or for lost profits or business interruption losses, in connection with the operation of the Manufactured Parts, CPU hardware, disk drives or Software.

CE MARKING

U-20XD Series conforms with the following directive(s) and standard(s):

Directives:
the EMC Directive 89/336/EEC, in accordance with Article 10(1) of the Directive
the Low Voltage Directive 73/23/EEC

Standards:
[the EMC Directive] EN61326:1997+A1:1998
(EMISSION : Class B, IMMUNITY Category : General)
[the Low Voltage Directive] EN61010-1:1993 +A2:1995

FCC Warning

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

Unauthorized reprinting or copying of this operation manual

No unauthorized reprinting or copying of all or part of this operation manual is allowed. The utmost care has been used in the preparation of this operation manual. If, however, you have any questions or notice any errors, please contact the HORIBA customer service printed on the back cover of this operation manual.

Preface

Thank you very much for purchasing HORIBA's “MULTI-PARAMETER WATER QUALITY MONITORING SYSTEM” U-20XD Series.

Compact and one-hand-held, our multi-parameter water quality monitoring system makes measurements about a large number of items simultaneously.

The instrument uses a large-sized LCD display and has a variety of functions through easy operation, being useful for use at sites where measurements are to be made.

The water-proof construction of the instrument is compliant with IP-67 of IEC 529, “Water-proof test on electrical and mechanical equipment and tools and protection grade against entry of solids.” Please use the instrument by following the information in this Operation Manual to maintain the water-proof construction of the instrument.

IP-67 standards

- Keeping dust and grit out of the instrument
- Up to 5 °C difference between water and an instrument employed and no entry of water into. the inside of the instrument at a depth of 1 m for 30 minutes

This Operation Manual contains information on the basic way of handling the instrument, notes, etc. for the user. Be sure to read through the Operation Manual before use.

Symbols employed

The symbols employed herein have the following meanings:

⚠ WARNING : Improper use can result in serious injury or even death.

⚠ CAUTION : The improper use of the instrument may cause the following dangers:

- Danger of injury
- Danger of damage to the instrument, its peripherals, and data

🛇 : Description of what should never be done, or what is prohibited.

❗ : Description of what should be done, or what should be followed.

Important : Explanation necessary for the proper operation of the instrument

◖Note◗ : Explanation that is useful and necessary for handling the instrument

☞ : Refer to the item shown.

Symbols employed in screen description

The symbols ☼ and 〔 〕 used in screen description have the following meanings:

☼ : The letters and numbers in this symbol are blinking on the screen.

〔 〕 : The letters and numbers in this symbol are lighting up on the screen.

◍ CONTENTS ◍

1. Introduction

2. Before use

3. Basic operation

4. Using the data memory function

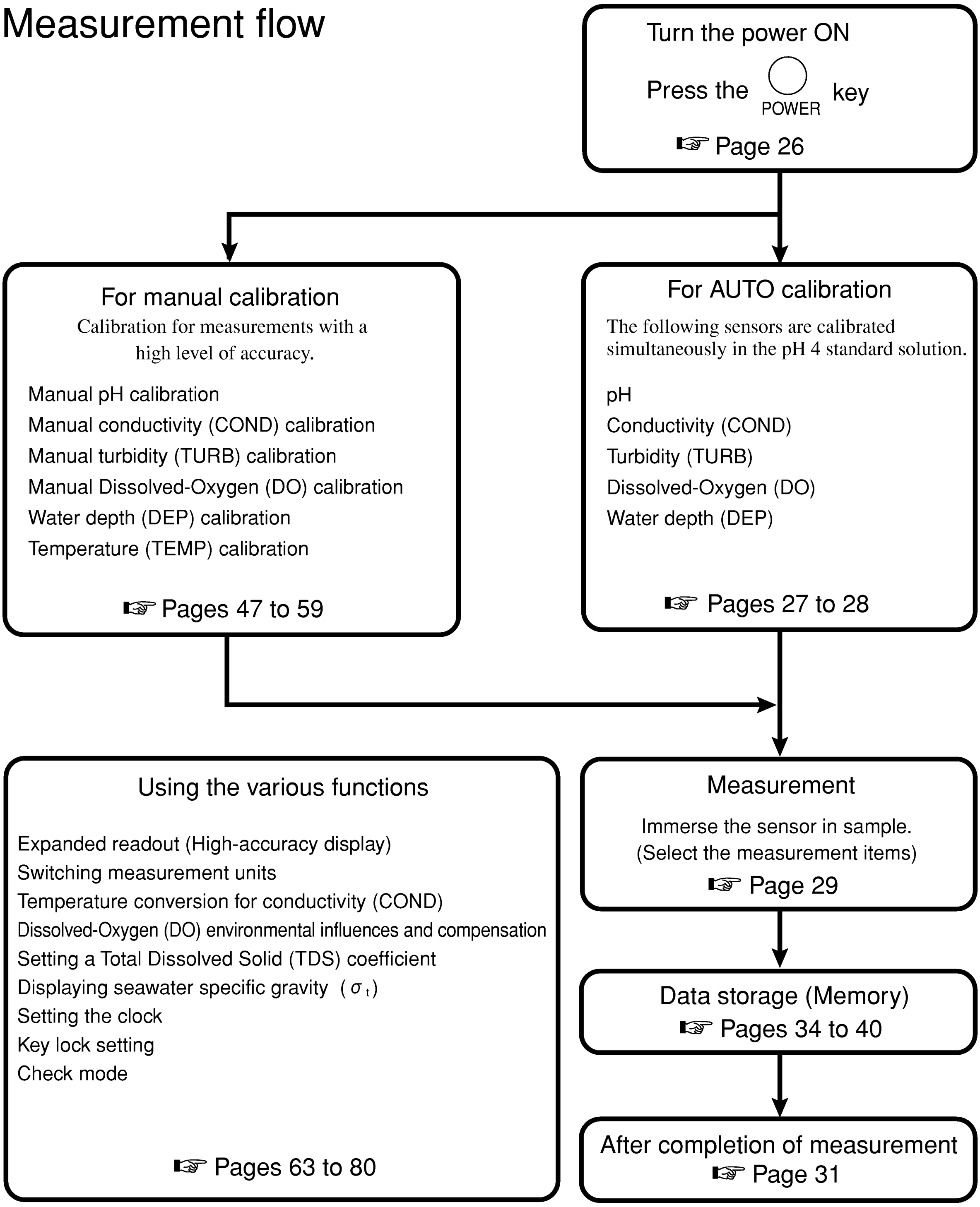
5. Techniques for more accurate measurement

6. Using the various functions

7. Instrument specifications

8. Reference data

Measurement flow



Turn the power ON

Press the ○ POWER key

☞ Page 26

For manual calibration

Calibration for measurements with a high level of accuracy.

- Manual pH calibration
- Manual conductivity (COND) calibration
- Manual turbidity (TURB) calibration
- Manual Dissolved-Oxygen (DO) calibration
- Water depth (DEP) calibration
- Temperature (TEMP) calibration

☞ Pages 47 to 59

For AUTO calibration

The following sensors are calibrated simultaneously in the pH 4 standard solution.

- pH
- Conductivity (COND)
- Turbidity (TURB)
- Dissolved-Oxygen (DO)
- Water depth (DEP)

☞ Pages 27 to 28

Measurement

Immerse the sensor in sample.
(Select the measurement items)

☞ Page 29

Data storage (Memory)

☞ Pages 34 to 40

After completion of measurement

☞ Page 31

Using the various functions

- Expanded readout (High-accuracy display)
- Switching measurement units
- Temperature conversion for conductivity (COND)
- Dissolved-Oxygen (DO) environmental influences and compensation
- Setting a Total Dissolved Solid (TDS) coefficient
- Displaying seawater specific gravity (σ_t)
- Setting the clock
- Key lock setting
- Check mode

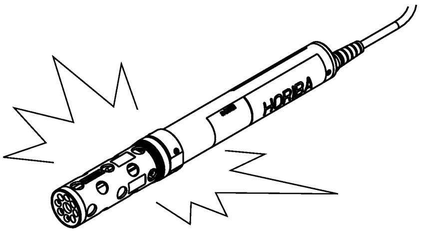
☞ Pages 63 to 80

1. Introduction

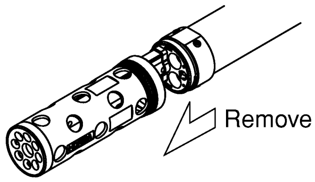
1.1 Notes on handling the instrument

Handling of sensor probe

⊘ Do not give a shock to the sensor probe.
The sensor will be damaged.

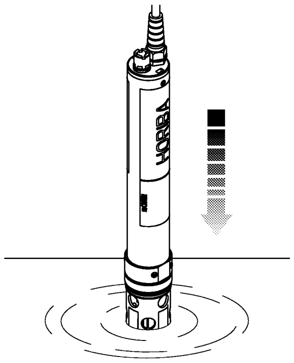


⊘ Do not remove the protection cover from the sensor probe to use.
Damage may occur to the sensor.



❗ Slowly lower the sensor probe into the sample.

⊘ Dropping it from a height of 1m or more may cause damage to the sensor.
Do not immerse the sensor probe at the depth of exceeding 100 m.
The device can resist the hydraulic pressure at the dept up to 100 m.



- The protection cover may rust due to the environment in which it is used. The damage caused by this usage shall not be warranted by the manufacturer. Solve it with parts which users need to replace periodically.

⚠ WARNING

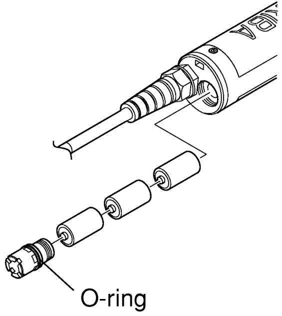
- Fix the sensor probe to the cable or the reel to use.
- In place with a large distance to the water level or with a rapid water flow, fix the sensor probe hook to a point except your body before use for safety purposes.
  Be careful not to let go off the sensor probe by mistake. Otherwise, the sensor probe together with the instrument will fall into the water or a sharp shock will occur to yourself while you are holding the instrument.

Replacing batteries and sensor of the sensor probe

⊘ Do not replace the sensor probe batteries and sensor in the atmosphere of high temperature and humidity.

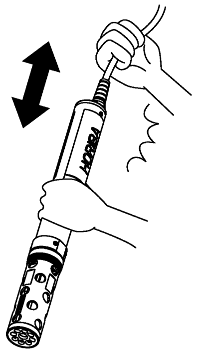
❗ Put connector plugs into the sensor probe connectors with sensors off.

❗ The sensor probe's battery cover is kept waterproof by the use of an O-ring. After checking that there are no foreign bodies adhering to the O-ring, apply silicon grease (included) to the face of the O-ring and close. Be sure to close it all the way to the indicated level. Do not close with the O-ring twisted or warped.

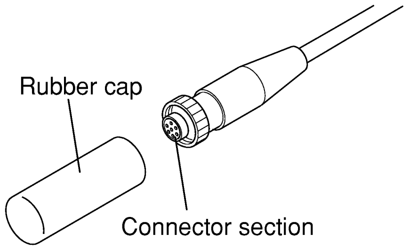


Handling of cable

🚫 Do not store the cable with its connector being greatly tensed or bent.
Do not submit the connector to strong shocks or the cable will snap.

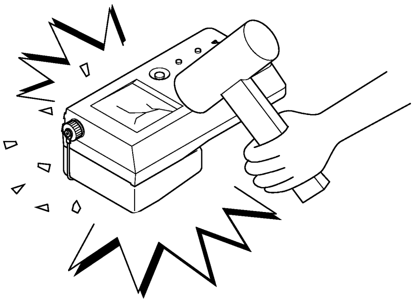


❗ If sample waterdrops remain onto the connector section, metal part of the connector is likely to rust. When storing, wipe the area around the connector well and cover it with the rubber cap.

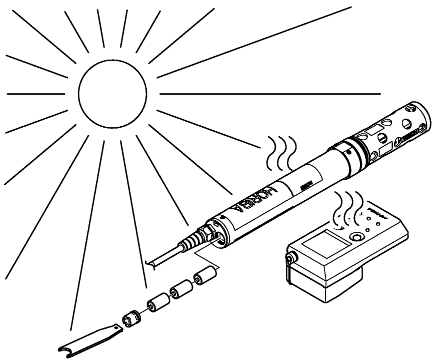


Handling of the instrument

🚫 Do not give a shock to or drop the sensor or instrument. The sensor or instrument will be damaged.

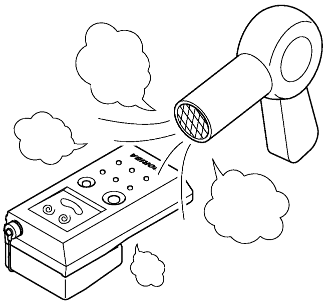


🚫 The display part includes LCD. Do not expose the instrument to ultraviolet rays for a long time. Otherwise, the LCD may deteriorate.

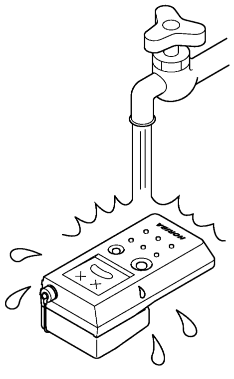


❗ The instrument will be water-proof in construction (IP-67) when the sensor connector is connected to the instrument. However, if the instrument has been dropped into water or become wet, use a soft cloth to dry up the instrument.

🚫 Do not use a hair dryer to dry up the instrument.

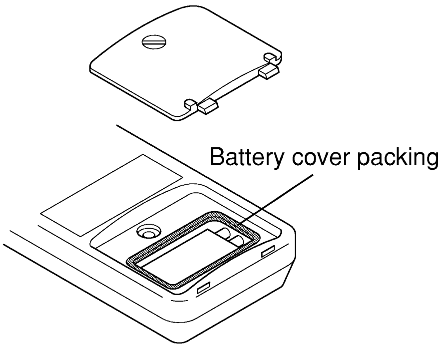


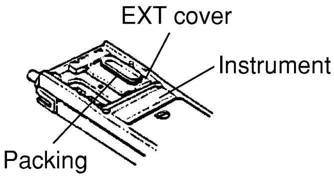
🚫 Do not wash directly the instrument using tap water from the faucet.



Note on replacing battery of the instrument and the section to which the EXT unit is attached

Waterproof function of the main unit is maintained by the packing of battery cover and EXT unit cover. Foreign matter on the packing can cause water to enter the instrument. Check for foreign matter on the packing before closing the battery cover and the EXT cover.
If the packing is twisted, do not close the battery cover and the EXT cover.





For a long use

We recommend that the packing be replaced once a year.
For battery cover packing replacement, contact your sales agent.

Note on place for use

- Avoid continuous measurement in water containing alcohol, organic solvent, strong acid, strong alkali or neutral detergent; otherwise the sensor surface will deteriorate.
- Do not use the instrument in the atmosphere with ambient temperatures below 0 °C (incl.) or above 55 °C (incl.).
- Avoid using the instrument in the condition exposed to strong vibrations or corrosive gases.
- Do not use the instrument near a source of strong electromagnetic field such as high-voltage cables and motors.

Batteries

The improper use of batteries may cause leaks and explosion.
Observe the followings:

- Set the batteries in place properly while paying attention to the plus (+) and minus (-) poles.
- Do not use both an old and new batteries or batteries of different types.
- Batteries for use in the instrument are not of the rechargeable type.
- Remove the batteries when not in use for a long time.
  In case of leaks, wipe off the solution in the battery case thoroughly and place new batteries in position.

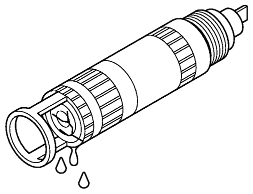
Handling the DO sensor

- In case of breakage of DO sensor diaphragm, replace DO sensor or replace just the diaphragm by using diaphragm replacement unit, without directly touching the internal solution.
- When removing the DO sensor from the sensor probe, make sure to install the short socket (included).

- Do not give a shock to the DO sensor. The sensor will be damaged.

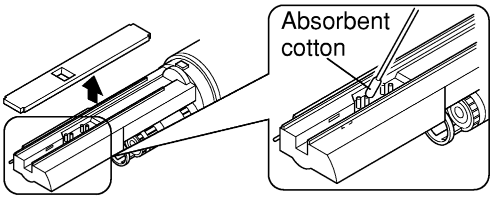
⚠CAUTION

- The DO sensor holds a strong-alkaline solution. Protect the eye and skin from the solution. If there is any solution in the eye or on the skin, immediately use sufficient water to wash off the solution. Consult a doctor as required.



Handling the COND/TURB unit

When cleaning the COND/TURB unit, use an absorbent cotton to avoid damage to the TURB cell.

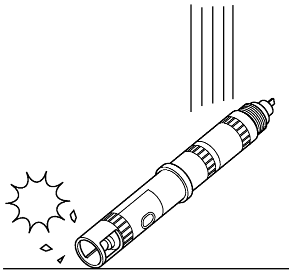


Handling the pH/ORP sensor

The pH/ORP sensor has a glass electrode at the end. Handle the sensor carefully to avoid a break in the glass electrode.

⚠CAUTION

- Be careful not to break the glass on the top of the sensor. Otherwise you may get hurt with a piece of glass.



Disposal

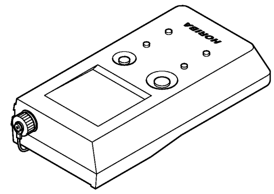
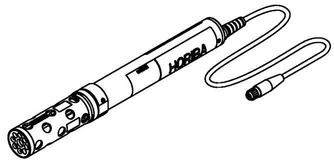
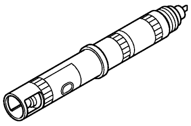
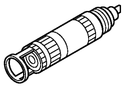
Dispose of this product as special waste, otherwise this may affect the environment.

Handling in transportation

- When transporting this product as freight, use the carrying case to prevent damage.
- Remove the flow cell from the sensor probe in transportation.

1.2 Packing list

The U-20XD series is comprised of the following items.

Model	U-22XD
Meter (U-2000)	
Sensor probe	
Sensor	pH/ORP sensor 
	DO (Dissolved-Oxygen) Sensor 
Accessories	pH 4 standard solution (500 mL) pH internal solution (250 mL)
	pH syringe with needle
	Sensor spanner
	Calibration beaker
	Probe cap
	Grip holder
	Carrying case
	Manganese battery 6F22 (006P) (1 piece)
	Alkaline batteries LR03 (AAA) (3 pieces)
	Silicon grease
	Sensor O-ring (S8) (10 pieces)
	Sponge for probe cap (5pieces)
	Operation manual

- The included battery is for the monitor. Its life is not guaranteed.

2. Before Use

2.1 Introduction to the instrument

2.1.1 Measurement items

Components that can be measured with the U-20XD series models are as follows:

Model	U-22XD
Measurement items	
pH	○
Dissolved Oxygen (DO)	○
Conductivity (COND)	○
Salinity (SAL) [Conductivity conversion]	○
Total dissolved solids (TDS) [Conductivity conversion]	○
Specific gravity of seawater [Conductivity conversion]	○
Temperature (TEMP)	○
Turbidity (TURB)	○
Water depth (DEP)	○
Oxidation-Reduction Potential (ORP)	○

○ .... Measurable

2.1.2 Introduction to functions of the instrument

Outline of the functions of the instrument is described below.

Feature	Function name	Page
Data obtained during measurement can be saved in the memory.	Manual data storage	Page 34
Data can be automatically saved in the memory at constant time intervals.	Auto data storage	Page 36
Saved data can be called.	DATA OUT	Page 41
The latest date of calibration and its details can be called.	Calibration history	Page 43
Enlarged display is available.	Expand readout	Page 63
Measurement units can be switched.	Switching measurement unit	Page 64

* Other functions possible in the check mode are available. (☞ Page 73)

2.1.3 Functions of expansion units

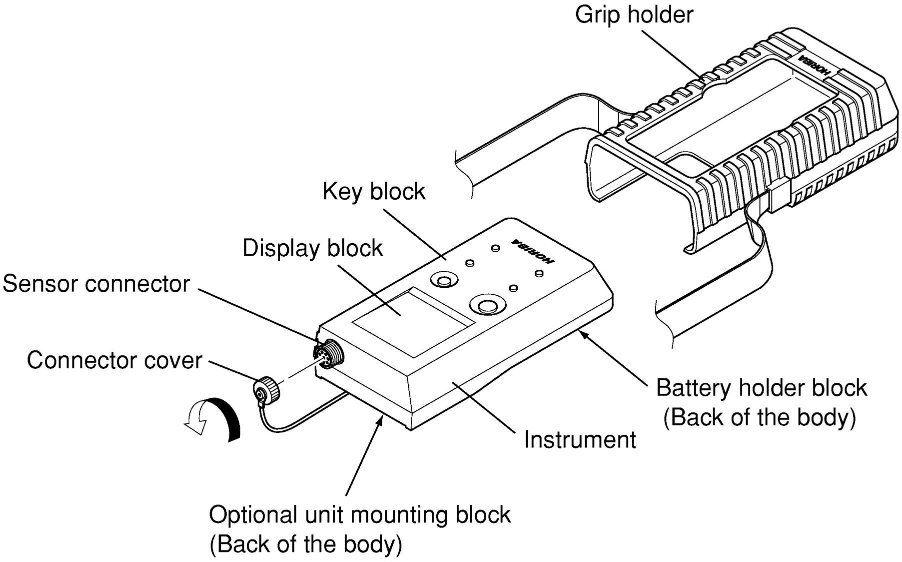
For the U-20XD series, use of expansion units allows communications with personal computers through RS-232C, the storage of G.P.S. data in the memory, and printer output, and commercial power supply.
Expansion units are available in the following two types:

Unit/name	Contents	Functions
U-2001 Expansion adaptor	• Expansion adaptor • Software for PC	<RS-232C communications, G.P.S connection, and printer output> The above functions cannot be used at the same time. One of the connectors for these three functions needs to be used.
U-2002 System unit	• System unit contain case • Software for PC • G.P.S. unit • Printer set	<RS-232C communications, G.P.S connection, printer output, battery power supply*> The above functions can be used at the same time. * A battery power supply can be used for measurements outdoors for 30 consecutive days.

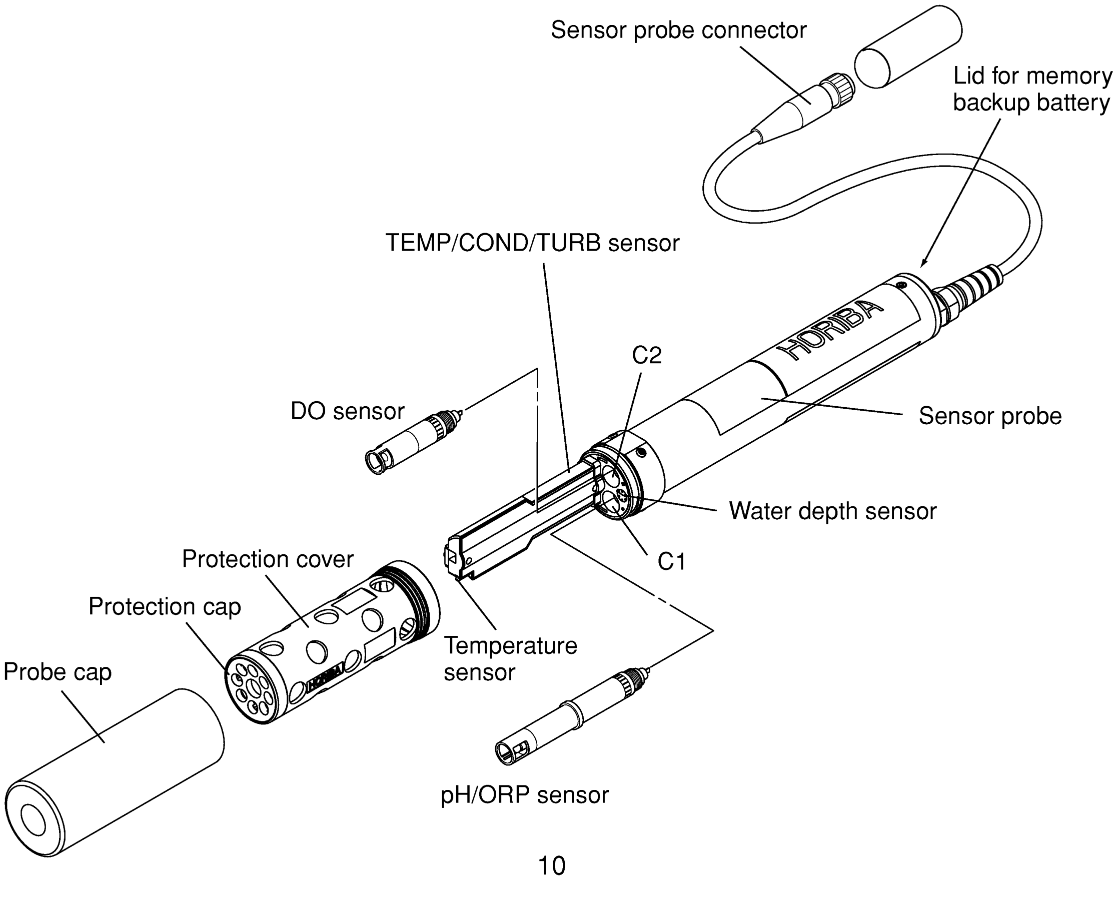
* U-2001 and U-2002 can operate on a commercial power supply through the use of an AC adapter (optional). However, the AC adapter cannot be used for the G.P.S. unit or printer set.

2.2 Names of the parts

2.2.1 Instrument name

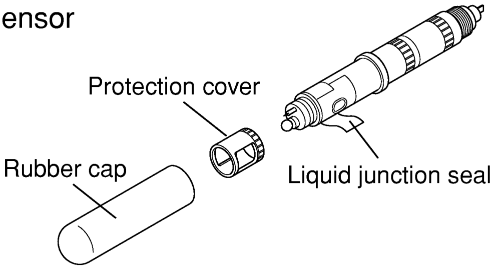


2.2.2 Sensor probe names

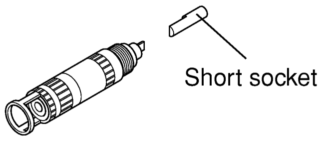


2.2.3 Sensor names

pH/ORP sensor



DO sensor



2.2.4 Use of carrying case

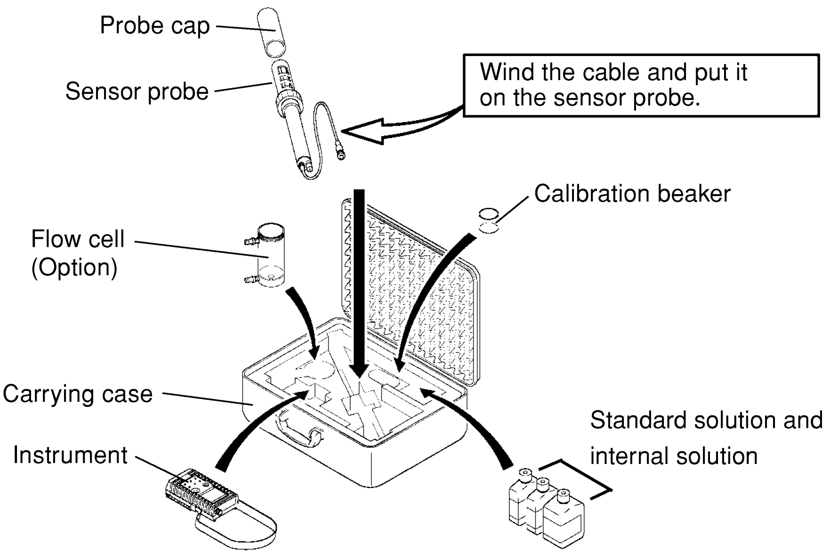
The carring case models W-2010 and W-2030 are applicable to store or transport U-22XD series.

Model	Applied to	Storage temperature	Material
W-2010	Cable length 10 m or less	-5 to 60℃	PP, ABS
W-2030	Cable length 30 m or more		

⚠CAUTION

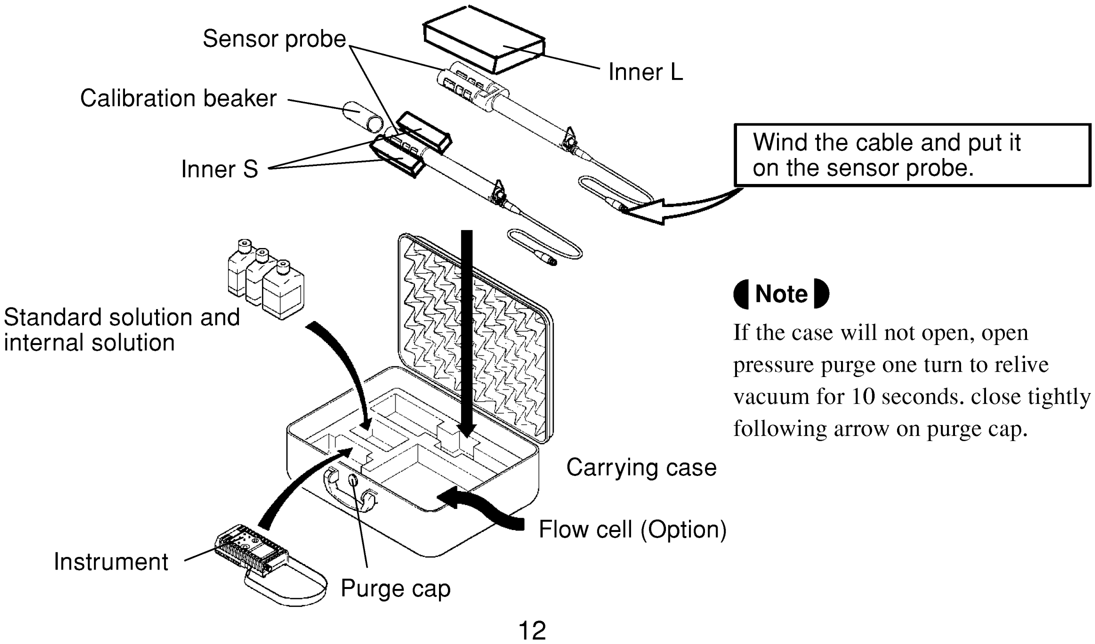
- Do not drop or hit the carring case to protect the units against damage.
- When using the sensor probe with flow cell, separate them for strage.
- Be careful not to catch your finger, when fastening or releasing the laches.

● W-2010



Wind the cable and put it on the sensor probe.

● W-2030

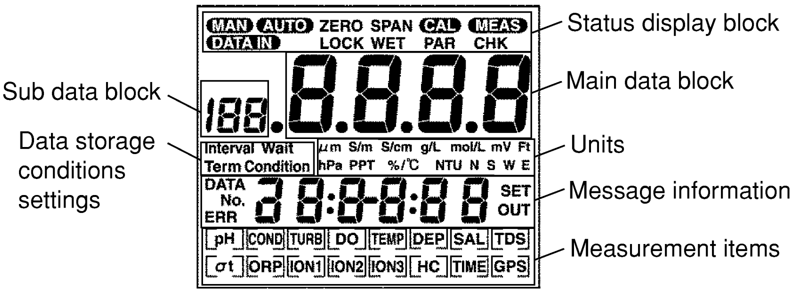


Wind the cable and put it on the sensor probe.

Note

If the case will not open, open pressure purge one turn to relive vacuum for 10 seconds. close tightly following arrow on purge cap.

2.2.5 Display



Status display block

MAN .... On when the data memory and calibration settings are set to manual.
AUTO .... On when the data memory and calibration settings are set to automatic.
DATA IN ..... On when the data memory operation and the data memorys operation settings are being performed. Blinking during calibration.
ZERO .... On in the Zero calibration mode.
SPAN .... On in the Span calibration mode.
CAL .... On in the Calibration mode.
MEAS .... On in the Measurement mode. (Measurements are being made when light up.)
LOCK .... On when the keys are locked.
CHK .... On when the instrument is in the check mode.

Sub data block

Display of the pH, Latitude (degree), Longitude (degree), Year and Check No.

Main data block

Display of Measurement data, Latitude (minute, 〔second〕), Longitude (minute, 〔second〕), and month and day.

Data storage conditions setting

Interval .... On when a time interval is set for storage of data.
Wait .... On when a time is set for waiting from the automatic data storage instruction until the start and during data processing through individual operations.
Term .... On when a period is set for automatic data storage.

Units

Displays the units for measurement items.

Message information

Displays the stored data (data mode) and the data No. when the data is stored.
SET .... Indicates that the instrument is in Set mode.

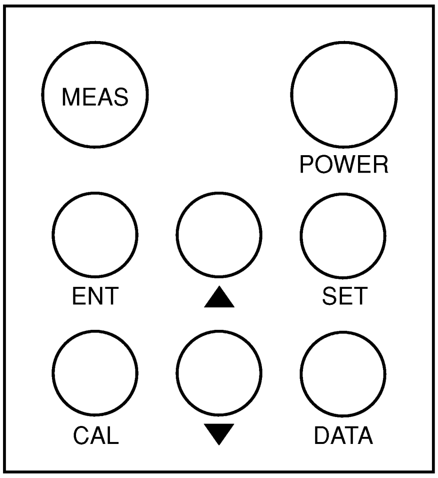
Measurement items

Displays the measurement items for the data in the main data block display. The display is read as follows.
Items without brackets ([ ]) .... Items with the highlighted text will be stored in the data memory.
(☞ *Measurement item setting,* page 76)
Items with brackets ([ ]) .... Displays the measurement items with data display.
(☞ *Measurement item setting,* page 76)

Note

- Because of the instrument's automatic power off function, the indication will disappear if the unit is not used for about 30 minutes. For operation of the unit and display of the indication, turn ON the instrument again.

2.2.6 Key names



POWER: Power key

Turns the instrument On and Off. Immediately after the power is switched on, the initial screen is displayed to indicate the status of the instrument.

MEAS: Measurement key

In the Measurement mode (MEAS is on), this key switches the measurement item. In addition, pressing the MEAS key returns you from the Setting, Calibration and Memory Call Up modes to the Measurement mode.

◖Note◗

- Regardless of which mode the instrument is in, it is always possible to return to the Measurement mode by pressing the MEAS key.

ENT: Enter key

In the Measurement mode (MEAS is on), pressing the ENT key stores the data in memory.
In the Calibration mode (CAL is on), pressing the ENT key performs calibration.
In the Setting mode, pressing the ENT key switches the setting and registers entered setting values.

CAL: Calibration key

Pressing the CAL key switches the instrument to the Calibration mode. If automatic data storage is in progress, it is aborted.

SET: Set key

Pressing the SET key switches the instrument from the Measurement mode to the Set mode. If the SET key is pressed on the "year, month, day, time" display screen, it switches the instrument to the Check mode.

DATA: DATA key

Pressing the DATA key switches the instrument to the Data mode.

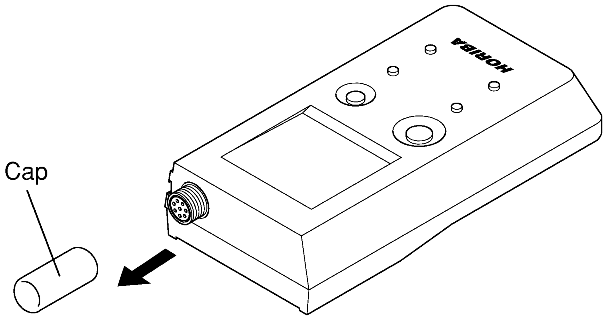
▲▼ : UP/DOWN keys

Use the UP/DOWN (▲▼) keys to set the calibration value in the Manual mode.

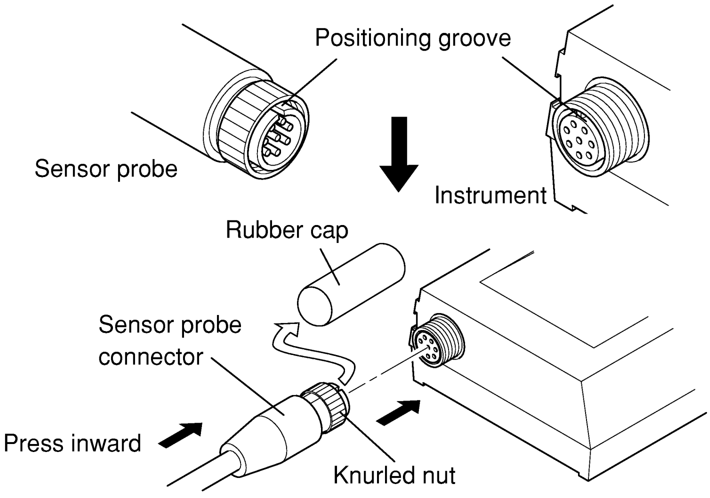
2.3 Setting up the U-20XD series models

2.3.1 Instrument and sensor probe connection

1. Remove the cap from the instrument's connector.



2. Align the positioning grooves of the instrument's connector and sensor probe connectors, and fit the connector of the sensor probe into the this other.



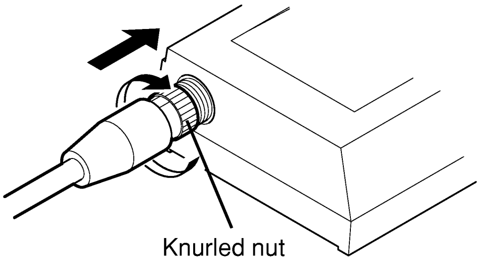
3. Press the sensor probe connector inward and turn. Tighten the connector until it will not turn any more.

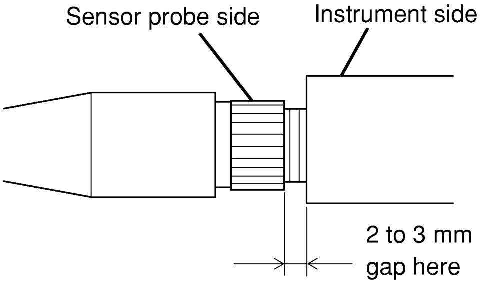
⚠CAUTION

- Turn the knurled nut with holding the knurled part. Otherwise, it will cause breaking of wire.

Important

- The connector cover or sensor probe connector should be connected to the instrument. Otherwise, the instrument will not be waterproof.
- Unless snugly attached, the instrument is not fully waterproof. When the sensor probe connector is tightened as far as it can go, a 2 to 3 mm gap is left between the instrument's connector and sensor probe connector.





Note

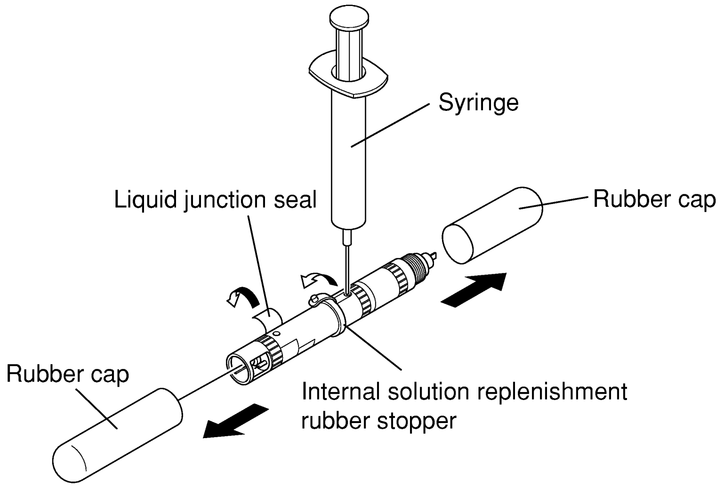
- Tighten the sensor probe connector until it will not turn any more.

2.3.2 Sensor installation

Connect the Dissolved Oxygen (DO) and pH/ORP sensors to the sensor probe.

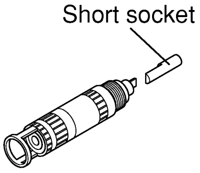
Preparing pH/ORP sensor

1. Remove the liquid junction seal and rubber caps.
2. Open the internal solution replenishment rubber stopper. Then use a syringe to take internal solution (#330).
   Air bubbles in the internal solution may impair the pressure compensation of the sensor. Allow as few air bubbles as possible to enter the inside solution.



Preparing DO sensor

1. Remove the short socket.



Important

- Provide the DO sensor with a short socket or connect the sensor to the sensor probe for storage. Otherwise, the sensor may have a shorter life or stable instructions may not be obtained.
- The short socket is used when storing. Do not throw it away.

Resetting the DO sensor when storing without having installed the short socket.

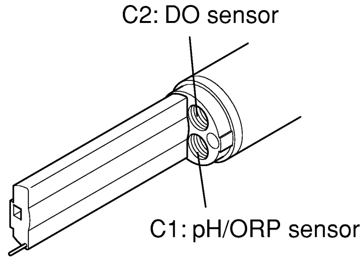
When leaving the DO sensor unattended for a brief period (1 or 2 days) without the short socket, the DO sensor can be reset by connecting it to the short socket or the probe. However, an amount of time corresponding to the period it was left unattended is necessary. If left unattended without being connected to the short socket or the probe for a long period (1 month), it cannot be reset.

Where to attach

1. The hole on the sensor probe in which each sensor is attached is determined by the type of sensor. Check the type of sensor and the assigned hole before attaching anything.

Important

- Installing the sensor in the wrong hole will damage both the sensor and sensor probe.

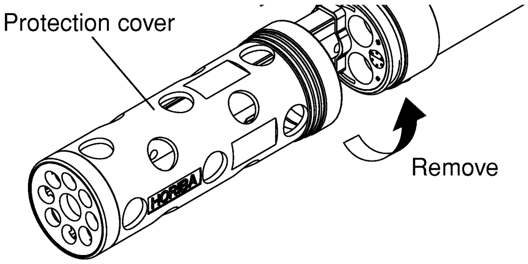


Installation procedure

Important

- With the U-22XD sensor probe install the DO sensor first and then the pH/ORP sensor.
- We recommend that the O-ring of the sensor be replaced with a new one each time the sensor is removed.

1. Remove the probe cap and remove the protection cover from the sensor probe.



When the protection cover's screws are firmly fixed in place and cannot be removed by hand, place a spanner on the protection cover and the surface of the cover guide and remove.

Do not try to remove the protection cover by hitting it or submitting it to shocks.

2. Apply silicon grease to the DO sensor's O-ring.

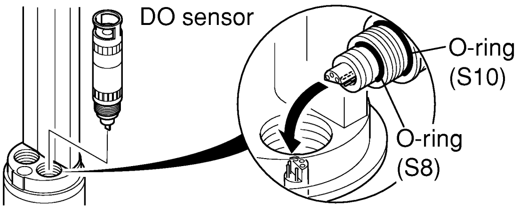
Make sure that no silicon grease gets on the connector.

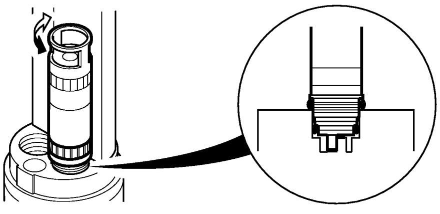
3. Fit the DO sensor inside the sensor probe hole, being careful to align the shape of the connectors.

- Make sure that the O-ring is not scratched or twisted. Leakage will cause failures.
- Remove the DO sensor connected to the probe and, when reconnecting them, replace the O-ring (S8) on the smaller end of the DO sensor with a new O-ring.

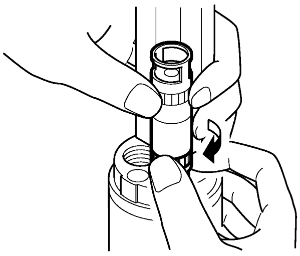
Important

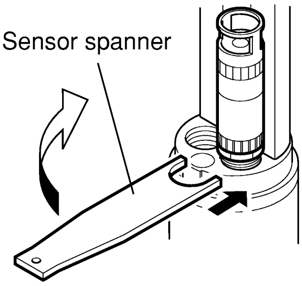
- Press the sensor slightly inward and try turning to check the fit. The sensor cannot be turned if inserted properly.





4. Turn the screw 2 or 3 turns by hand and then fully tighten with the sensor spanner.



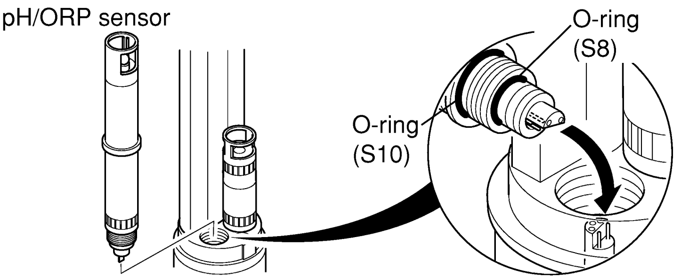


5. Apply silicon grease to the pH/ORP sensor's O-ring.

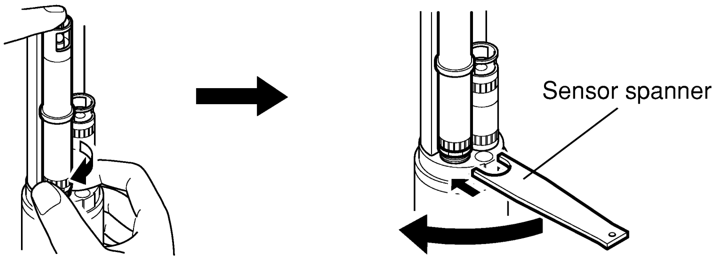
Make sure not to get silicon grease on the connector.

6. Fit the pH/ORP sensor inside the sensor probe hole, being careful to align the shape of connectors.

- Make sure that the O-ring is not scratched or twisted. Leakage will cause failures.
- Remove the pH/ORP sensor connected to the probe and, when reconnecting them, replace the O-ring (S8) on the smaller end of the pH/ORP sensor with a new O-ring.



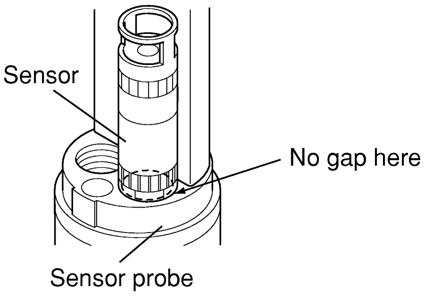
7. Holding the top of the pH/ORP sensor with your finger, turn the screw 2 or 3 turns by hand and then fully tighten with the sensor spanner.



CAUTION

- Unless snugly attached, the sensor is not fully waterproof. The sensor is snugly fit inside the sensor probe when tightened as far as it will go.

Example for DO sensor



8. Attach the removed protection cover to the sensor probe as it was.

Important

- Before attaching each sensor to the sensor probe, do not soak the connector block in water.
- Be careful not to contaminate or wet the sensor probe or sensor connector.

Fasten the guard cover with your hand until it touches the end surface. If improperly fastened, it will slacken and, when storing the instrument, there will be a lack of humidity control. Fastening by hand is enough, do not use a spanner or other tool to fasten or the screws may break.

2.3.3 Installation and replacement of the battery

The U-20XD series is shipped from the factory with the battery packed separately.
When using the instrument for the first time or replacing the battery, perform the following procedure:

Type of battery:

Instrument (U-2000) .... Alkaline battery 6LR61 (Manganese battery 6F22 [006P])
1 piece. (Battery for instrument operation)
Sensor probe .... Alkaline batteries LR03 [AAA] (Manganese battery [R03])
3 pieces. (Battery for memory backup)

Notes on handling the battery

The improper use of battteries may cause leaks and explosion.
Observe the followings:

- Set the batteries in place properly while paying attention to the plus (+) and minus (-) poles.
- Do not use both an old and new batteries at a time or batteries of different types.
- Battteries for use in the instrument are not of the rechargeable type.
- Remove the batteries when not in use for a long.
  In case of leaks, wipe off the solution in the battery case thoroughly and place new battteries in position.

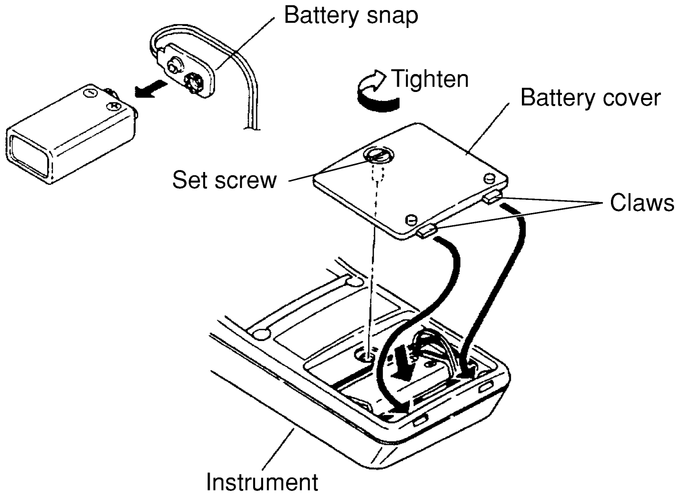
Note

- The battery originally attached to your unit is for monitor and the service life of the battery cannot be guaranteed.

Instrument (U-2000)

1. Loosen the set-screw on the battery cover and remove the cover.
2. Remove any old battery.
3. Fit the battery snaps to a new battery and insert the battery assembly into the instrument.
4. Insert the claws on the battery cover into the grooves in the instrument. Then tighten the set screw.

   The battery snap may be loose for some batteries. In such a case use radio pliers and tighten the metal snap fittings.

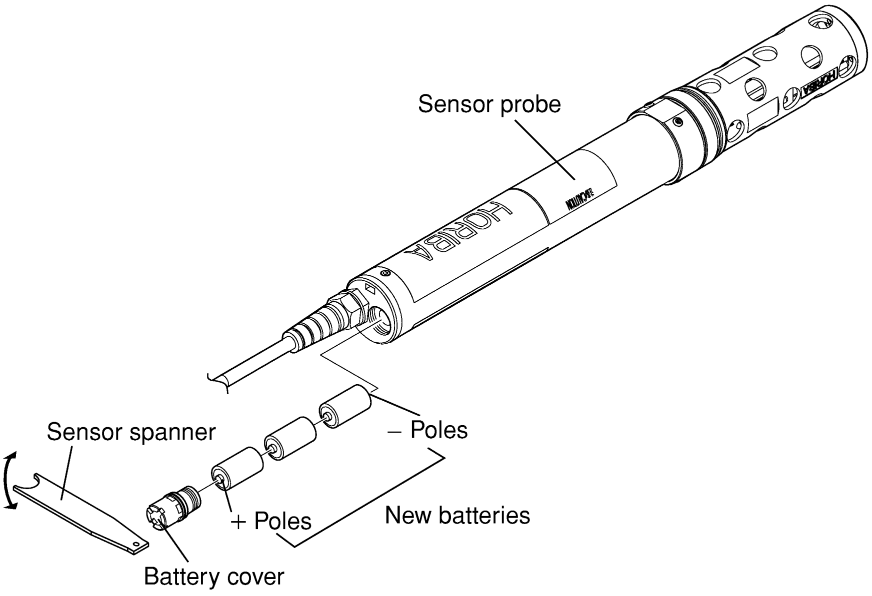


Important

- When removing the battery snap, do not pull it too strongly.

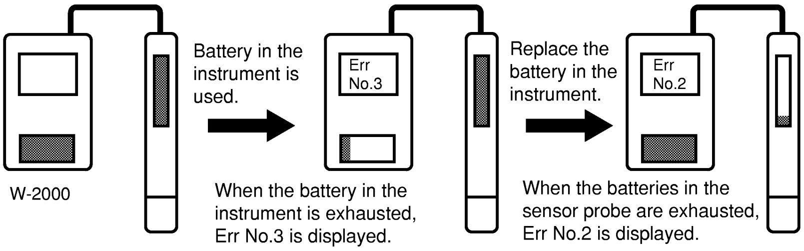
Sensor probe (for memory back up)

1. Remove the battery cover using a sensor spanner or a suitable object.
2. Remove any old batteries.
3. Insert new batteries making sure that the plus (+) and minus (-) poles match the terminals correctly.
4. To keep the sensor probe water-resistant, use a chip spanner as illustrated below and tighten the battery cover until the cover does not turn any more.



⚠CAUTION

- When replacing the batteries of the sensor probe, be sure to connect the sensor probe to the instrument. Otherwise, the memory will be reset and all the data saved in the memory will disappear.
- When the sensor probe is connected to the instrument, battery in the instrument is consumed.



Battery in the instrument is used.

When the battery in the instrument is exhausted, Err No.3 is displayed.

Replace the battery in the instrument.

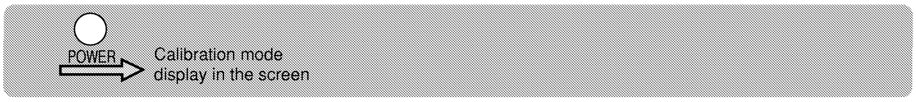
When the batteries in the sensor probe are exhausted, Err No.2 is displayed.

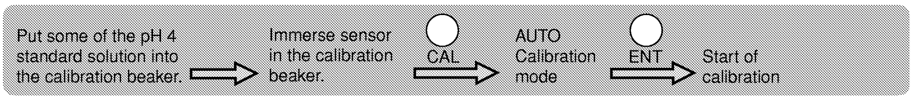
◖Note◗

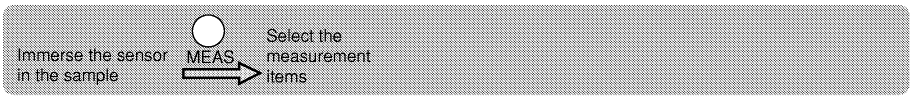
- The battery on the main unit is used up first allowing up to 30 hours use at room temperature. (When using alkaline batteries.)
- Life is reduced by approximately one half when manganese batteries are used.

3. Basic operation

The pH, conductivity (COND), turbidity (TURB), dissolved-oxygen (DO) and water depth (DEP) sensors can be calibrated automatically. Upon completion of this chapter, even beginners should be able to make measurements easily.







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Before use
Basic operation
Using the data memory function
Techniques for more accurate measurement
Using the various functions
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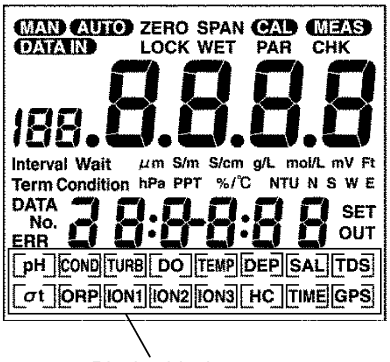
3.1 Key operations and mode switching

Measuring items and displays which are switched with the MEAS key

The items measurable with individual models are displayed. The items selected with the MEAS key will be indicated with [ ].

Example: In the pH Measurement mode: [pH]



The symbols displayed and their meanings are as follows:

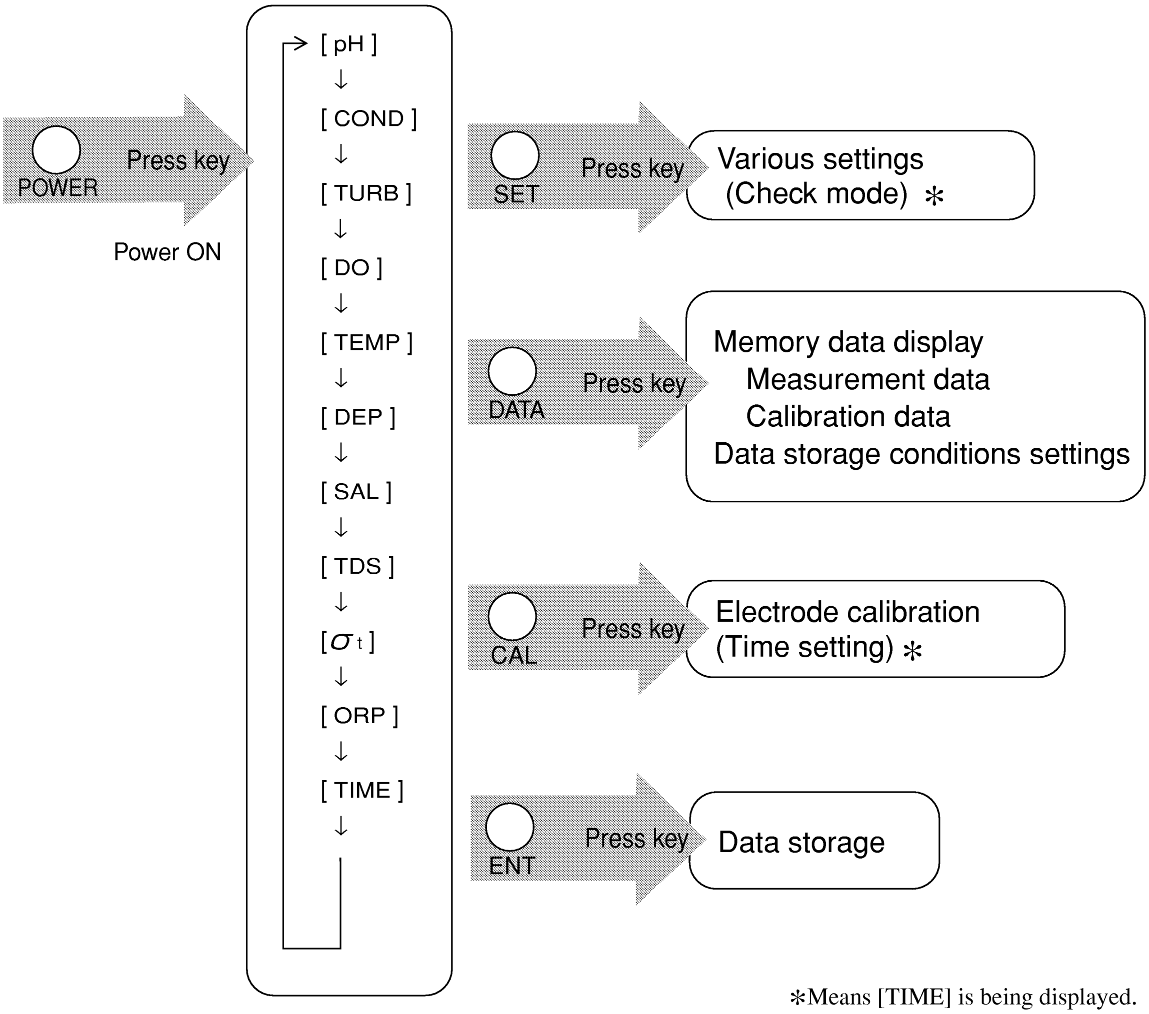
pH	pH
COND	Conductivity
TURB	Turbidity
DO	Dissolved-Oxygen
TEMP	Temperature
DEP	Depth
SAL	Salinity
TDS	Total dissolved solids
σ_t	Specific gravity of seawater
ORP	Oxidation-reduction potential
TIME	Display of date and time
GPS	G.P.S. (Global Positioning System) for imformation of position

Note

- [GPS] lights up when the optional G.P.S. sensor has been connected to the instrument and position information is received from the G.P.S. sensor during the measurement. For more information, refer to the instruction manual for the expansion units.

Measurement mode

MEAS When the MEAS key is pressed,
the next measurement item appears.



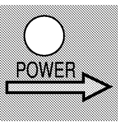
∗Means [TIME] is being displayed.

Note

- "*Measurement item setting*" on page 76 explains how to set the display so items are not displayed.

3.2 Operation procedure

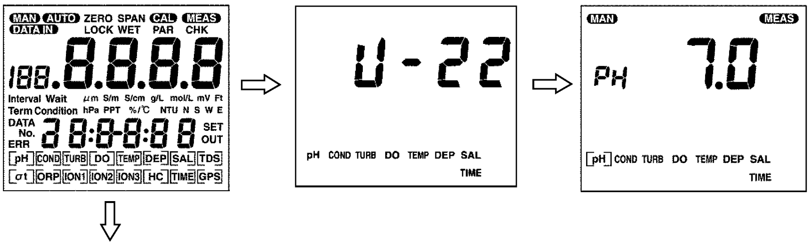
3.2.1 Power ON



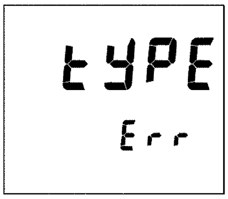
Calibration mode
display in the screen

1. Press the **POWER** key.

The display will change in the order of All segment display → Sensor detector display → pH Measurement mode.



With the sensor probe is not connected,



is displayed.

Before turning ON the instrument, connect the sensor probe properly.

3.2.2 AUTO calibration method

To obtain correct measurement, it is necessary to calibrate the sensor using the standard solution before performing measurement. Previous calibration records shown in calibration log.
(☞ 4.3.2 *Calling up The calibration log*, page 43.)

◖Note◗

- In the AUTO calibration mode, the pH, COND, and TURB sensors are calibrated in the pH 4 standard solution, and the DO and DEP sensors in the atmosphere simultaneously.
  Calibrate contents at 25°C are as follows:
  pH: set at 4.01 (zero calibration) and the Span is the adjustment value at the factory when shipping.
  COND: 0.449 S/m (Span calibration), the Zero is the adjustment value at the factory when shipping.
  TURB: 0 NTU (zero calibration), the Span is the adjustment value at the factory when shipping.
  DO: 8.52 mg/L (Span calibration), the Zero is the adjustment value at the factory when shipping.
  DEP: 0 m (Zero calibration), the Span is the adjustment value at the factory when shipping.
- Values may be unstable if there is temperature fluctuation. Calibrate after waiting for about an hour.

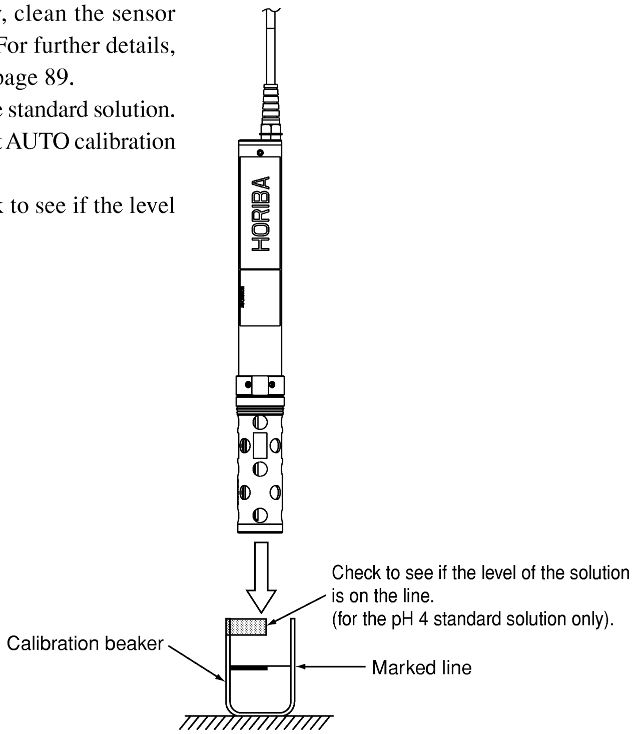
Put some of the pH 4 standard solution into the calibration beaker. ⇨ Immerse sensor in the calibration beaker. ○ CAL ⇨ AUTO Calibration mode ○ ENT ⇨ Start of calibration

Calibrate using the following procedure.

1. Wash the sensor in distilled water a few times and put some of the pH 4 standard solution into the calibration beaker to the marked line. Then immerse the sensor in it.

Important

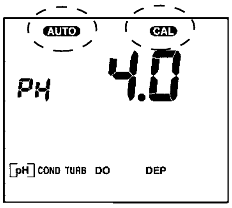
- To carry out calibration for turbidity accurately, clean the sensor surface that will be soaked in standard solution. For further details, see "Troubleshooting for the TURB sensor" on page 89.
- Use the "100-4" manufactured by HORIBA for the standard solution. With other standard solutions, you cannot carry out AUTO calibration correctly.
- Use the label on the calibration beaker and check to see if the level of the calibration solution is on the label line.



Standard sensor calibration

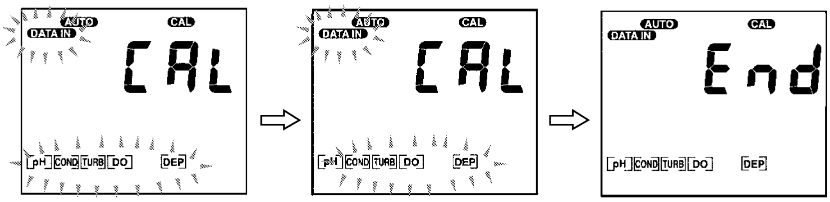
2. Press the **CAL** key in one of the Measurement modes pH, COND, TURB, DO and DEP.

AUTO and **CAL** appear and the instrument enters the AUTO Calibration mode.



3. Press the **ENT** key to start AUTO Calibration.

Upon completion of all of the pH, COND, TURB, DO, and DEP modes, End will be displayed.
During calibration, **DATA IN** and [ ] for the selected measurement item blink. [ ] light up for the item of which calibration is finished.

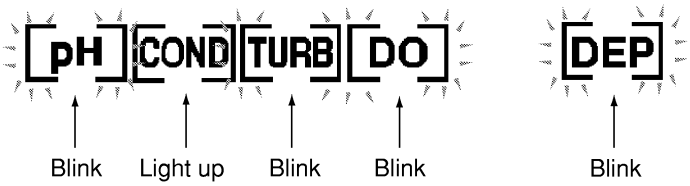


End of calibration

With DATA IN is blinking

To stop calibrating the sensor .... press the CAL key.
To establish the calibration .... press the ENT key.

Example: When COND calibration is finished:
[ ] for [COND] stops blinking and light up steadily.



Note

- [ ] continues to blink because calibration is not performed for the item for which an error has happened. If two or more errors happen, an error with a smaller number appears. (See pages 85 to 88 for these errors and ways to solve them.) These calibration errors disappear when the sensor is calibrated properly again, or when the instrument is turned ON again.
- Calibration should be performed for maximum three minutes. When the indications become stable, calibration should be finished.

4. Press the **MEAS** key to return to the Measurement mode.

Important

- Neutralize any basic pH 4 fluids before disposal.

3.2.3 Measurement

Immerse the sensor in the sample ○ MEAS ⇨ Select the measurement items

1. Immerse the sensor in the sample.

2. Select the measurement item.

Use the MEAS key to switch measurement items in the following order:

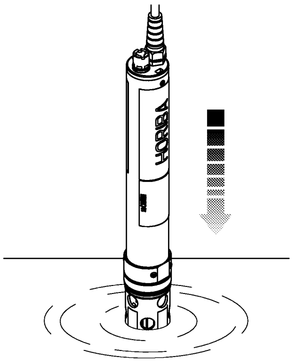
pH → COND → TURB → DO → TEMP → DEP → SAL → TDS → σ_t → ORP →
TIME → then back to pH.

Note

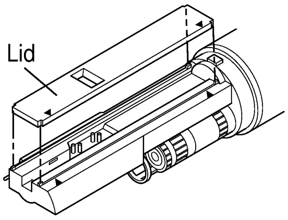
- [GPS] lights up when the optional G.P.S. sensor is connected to the instrument and position information is received from the G.P.S. sensor.
- The above measurement items can be changed by setting “”*Measurement item setting*” described on page 76.

Important

- When immersing the sensor probe in the sample, slowly lower the sensor probe into the sample.
- Dropping it from a height of 1m or more may cause damage to the sensor.



- Don't remove the COND/TURB lid during calibration or measurement.
- Attach the lid to the cell with fitting four corners and facing ▲ marks each other.



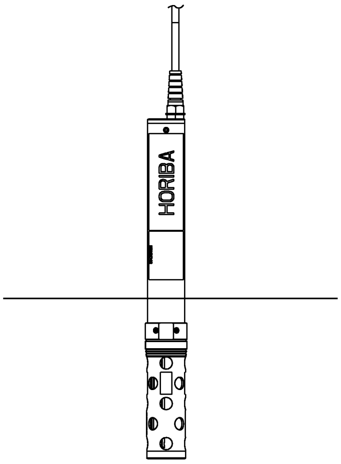
- Perform AUTO calibration after attaching the lid again, when the lid has been removed for the cleaning. A slight difference of the fitting position of the lid causes the difference of the indicated value for turbidity.
- Contacting with a different kind of metal, protection cover of the sensor probe may cause an error in measurement. Be careful not to let protection cover touch with any metal in measurement.

Two useful uses of the U-20XD Series models

Making measurements

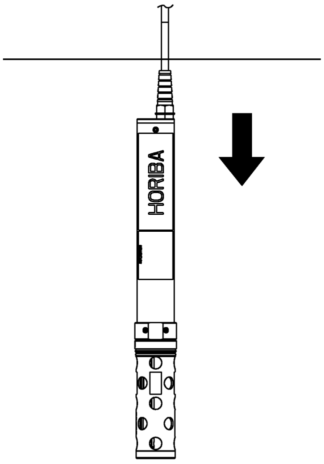
1. Manually storing the measurement data after checking the indication becomes stable

Example: After switching measurement items with the MEAS key, you can then store the measurement data after checking the indication becomes stable.
(☞ 4.1 *Manual storage of data while monitoring the measurement data*, page 34.)



2. Storing data

Example: Data can be stored continuously at constant intervals from the start of the automatic data storage.
This function is useful in obtaining data in depth direction and in storing data continuously.
(☞ 4.2 *Automatic data storage*, page 36.)



Notes in obtaining data on depth

- When the instrument is placed at a depth of 100 m or more, the instrument may be broken.

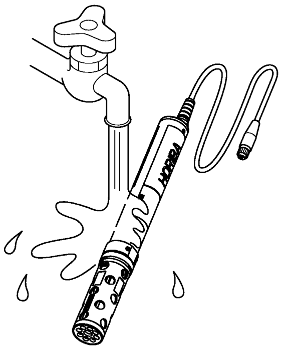
Notes for reliable measurements

- Any sensor contamination may affect measurements. Use the AUTO calibration mode to check for contamination on sensors about once a week for measurements.

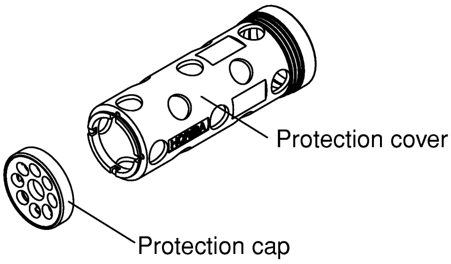
3.2.4 After completion of measurement

1. Turn the power to the instrument off.

2. Use tap water to completely wash off the sample on the sensor and then wipe waterdrops.



Remove the protection cover once and completely wash out with tap water the left over sample on the screws. Reinstall the cover after having wiped off the drops of water. If there is any sample (especially sea water) left over on the screws, rust may form which may prevent the protection cover from being removed. (☞ Installation procedure, page 18.)
Depending on the level of contamination, remove the rubber protection cap from the tip of the protection cover and wash out with tap water. Reinstall it after wiping off the drops of water.



3. Pour about 20 mL (about 2 cm from the bottom)of pure water in the probe cap and install it on the sensor probe. Place the rubber cap on the connector and store the instrument in the carrying case. (☞ 2.2.2 Sensor probe names, page 10.)

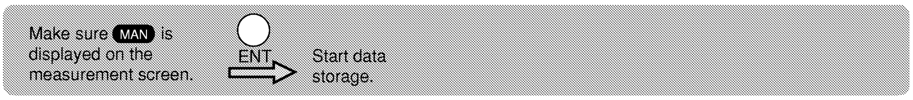
When storing with the ph/ORP and DO sensors attached to the probe, make sure to install the probe cap after having poured pure water into it.
Letting the ph/ORP and DO sensors get dry may cause deterioration of the instrument's performance. Should the sponge inside the probe cap be contaminated, replace it with a clean sponge (included).

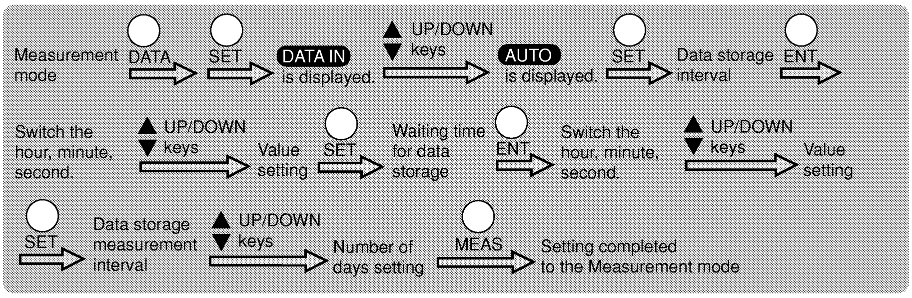
Now you have read the description for performing measurements. For further information on how to use the instrument, refer to the chapters hereafter.

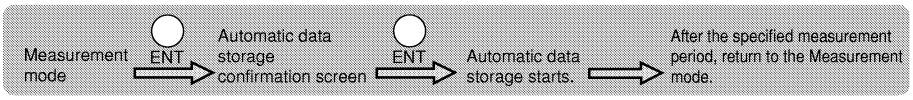
MEMO

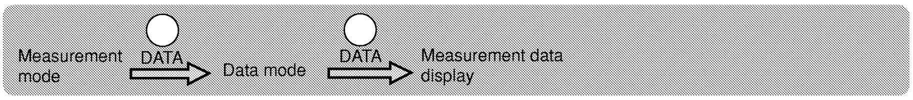
4. Using the data memory function

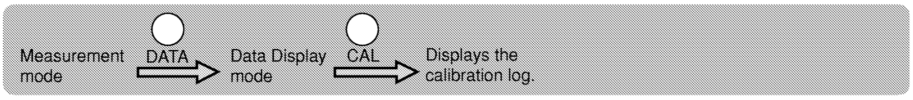
The data memory function can be used to store manualy measurement values with associated data numbers and to store automatically measurement values at fixed intervals (data logger).











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Basic operation
Using the data memory function
Techniques for more accurate measurement
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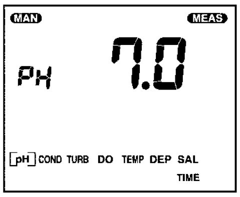
4.1 Manual storage of data while monitoring the measurement data

Make sure **MAN** is displayed on the measurement screen. → ENT → Start data storage.

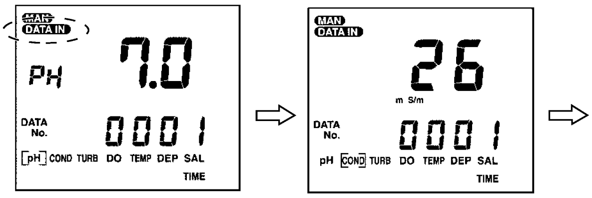
1. Make sure that **MAN** is displayed on the Measurement mode.

If **AUTO** is displayed, switch to **MAN** display.
(☞ page 35, Switch to **MAN** display on the measurement mode)



2. Press the **ENT** key.

Data storage starts, **DATA IN** and the data No. are displayed on the screen, and the measured value to be stored and the measurement item are displayed in order at approximately 0.5 second intervals.



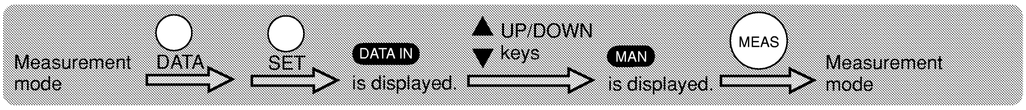
All measurement items and times are stored in sequence.

After the data is stored in memory, the screen returns to the original Measurement mode.

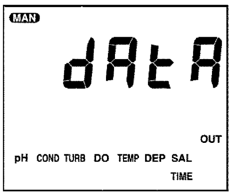
◖Note◗

- Up to 2880 sets of data can be stored in the memory.
  When 2880 sets of data have been stored in the memory, ERR 9 appears and no more data can be stored. In this case, "*Data memory clear*" while referring to page 78, and you can store new data in the memory.

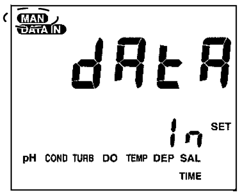
When AUTO is displayed
Switch to MAN display on the measurement mode



1. Press the **DATA** key in the Measurement mode.



2. Press the **SET** key.
   DATA IN is displayed.
3. Press the **UP/DOWN** (▲ ▼) keys to display MAN.

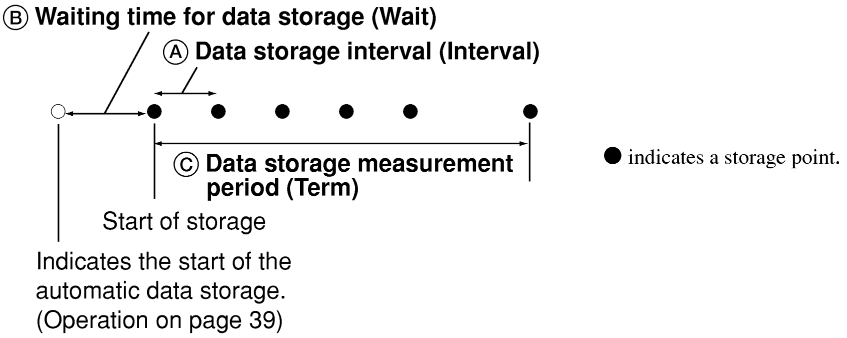


4. Press the **MEAS** key to return to the Measurement mode.

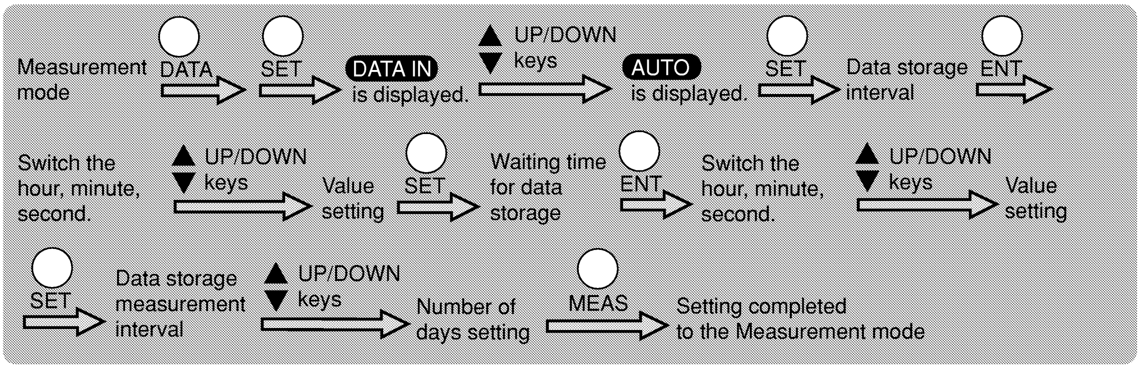
4.2 Automatic data storage

Measured values are stored automatically at constant time intervals. Before using the automatic storage, the following condition settings are required:

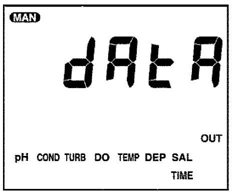
- Setting of data storage interval (4.2.1, step 4)
- Setting of waiting time for data storage (4.2.1, step 6)
- Setting of the data storage measurement period (4.2.1, step 8)



4.2.1 Data memory conditions settings



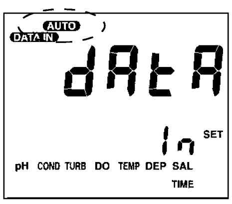
1. Press the **DATA** key in the Measurement mode.



2. Press the **SET** key.

DATA IN is displayed.

3. Press the **UP/DOWN** (▲ ▼) keys to display AUTO.

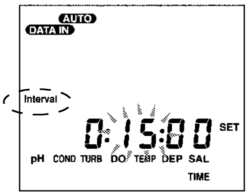


4. Press the **SET** key to display the screen for setting the data storage interval Ⓐ.

"**Interval** " is displayed.

5. Press the **ENT** key to switch the among "hour", "minute" and "second" and set the value using the **UP/DOWN** (▲ ▼) keys.

(Data storage intervals can be set to 2 seconds to 24 hours.)
The current setting location will blink.



6. Press the **SET** key to display the screen for setting the waiting time for data storage Ⓑ.

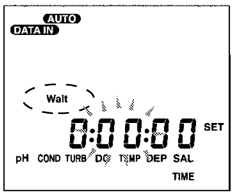
"**Wait** " is displayed.

7. Press the **ENT** key to switch among "hour", "minute" and "second" and set the value using the **UP/DOWN** (▲ ▼) keys.

(The waiting time for data storage can be set to 2 seconds to 24 hours.)
The current setting location will blink.

Important

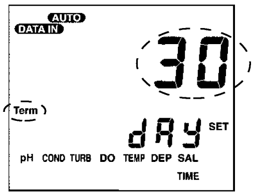
- If wait time is set to "0", note that data is not stored in a memory the first time.



8. Press the **SET** key to display the screen for setting the data storage measurement period ⓒ (number of days).

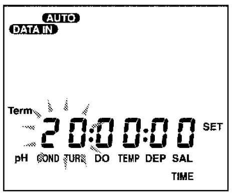
"**Term** " is displayed.

9. Use the **UP/DOWN** (▲ ▼) keys to set the value (number of days).



Setting of less than 24 hours

First set the number of days to 00 then press ENT key to select the “hour/minute/second” setting. Use the UP/DOWN (▲ ▼) keys to set the hour, the minute and second. During setting, the number to be set blinks.

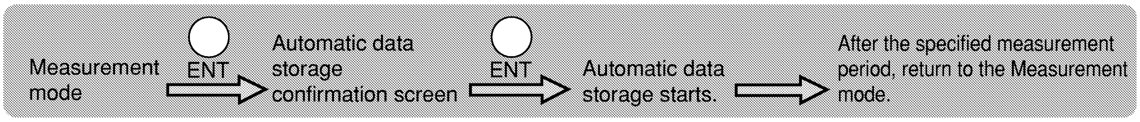


Note

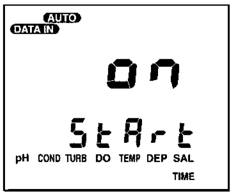
- Press the SET key to return to step 4.

10. When the **MEAS** key is pressed, setting will be completed and the instrument will return to the Measurement mode.

4.2.2 Start of automatic data storage



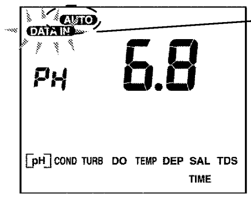
1. Make sure that **AUTO** is displayed on the Measurement mode.
2. Press the **ENT** key. A confirmation screen will be displayed asking if you wish to start automatic data storage.



◖Note◗

- If you do not wish to proceed with automatic data storage, press the CAL key to return to the Masurement mode.

3. Press the **ENT** key to start automatic data storage.



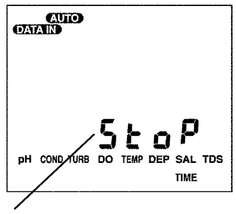
While **DATA IN** is blinking, the automatic data storage is being executed.

◖Note◗

- During the automatic data storage, measurement items can be switched by pressing the MEAS key.

Important

- During the automatic data storage, the ENT, SET, and DATA keys do not function and therefore calibration, setting change and stored data display cannot be performed.
- To stop automatic data storage, press the CAL key.



Confirmation display for canceling automatic data storage appears.
To stop the automatic data storage .... Press the ENT key.
To return to the screen for the automatic data storage ... Press the DATA key.

4. After the specified measurement period, **DATA IN** disappears and the instrument returns to the normal Measurement mode.

◖Note◗

- When the instrument is turned on, **AUTO** lights up and **DATA IN** blink if automatic data storage is being performed with the sensor probe.

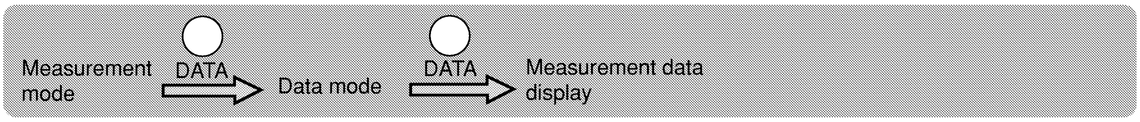
Notes for automatic data storage

- For long-term data storage, replace the sensor probe battery with a new one.
- You can remove the connector from the main unit. It can still be used for up to 60 hours at room temperature with the battery in the sensor probe (alkaline battery). Life is reduced by approximately one half when manganese batteries are used.
- If the sensor probe is connected to the instrument for monitoring, the instrument battery is first consumed to protect the memory of the sensor.
- When 2880 sets of data have been stored in the memory, ERR 9 appears and no more data can be stored. The automatic data storage is automatically ended and the instrument returns to the normal Measurement mode.

4.3 Calling up data from the memory

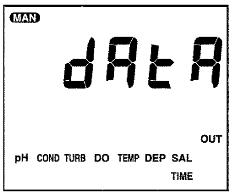
4.3.1 Calling up measurement data

Reading out data that has been stored manually or automatically.



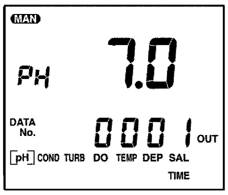
1. Press the **DATA** key in the Measurement mode.

The instrument goes to the DATA mode.



2. Press the **DATA** key.

The measurement data is displayed.
Data you want to call can be displayed by selecting a measurement item and data No.



DATA key .... Selects switching of measurement item or memory data No.

When switching measurement items: Measurement item blinks.
When switching data No. : Data No. blinks.

UP/DOWN (▲▼) keys .... Switch measurement item or No. which has been selected with the DATA key.

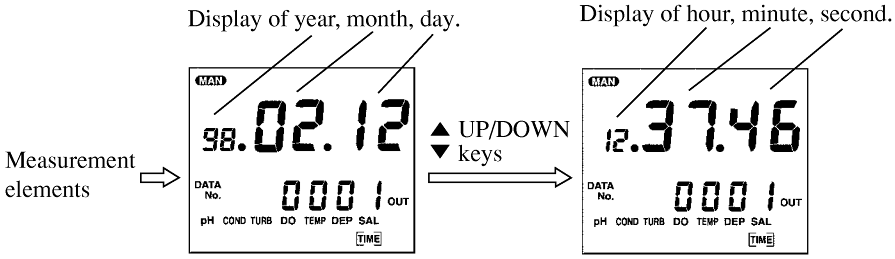
Note

- If you push the CAL key, only the data numbers will be displayed, allowing rapid changing of the numbers. Push the UP/DOWN (▲▼)keys to find the number, then press the SET key to display the data.

3. Press the **DATA** key.

TIME data

Use the UP/DOWN (▲▼) keys to switch between “Yer, Month, Day” and “Hour, Minute, Second”.



Display of year, month, day.

Display of hour, minute, second.

Measurement elements

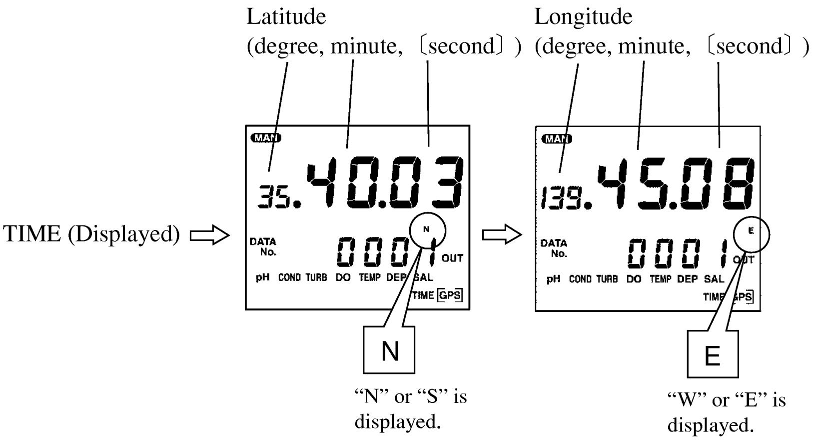
▲ UP/DOWN
▼ keys

Note

- The time in the automatic memory can be out by about 2 seconds.

G.P.S. data (only when G.P.S. data is present)

Use the UP/DOWN (▲ ▼) keys to switch between “Latitude” and “Longitude”.



Latitude
(degree, minute, 〔second〕)

Longitude
(degree, minute, 〔second〕)

TIME (Displayed)

“N” or “S” is displayed.

“W” or “E” is displayed.

Latitude N → The North latitude S → The South latitude
Longitude E → The East longitude W → The West longitude

ENT key .... Prints all measurement data for the displayed memory data item. (when the printer is connected to the instrument)

Useful uses of keys in automatic storage

SET + UP (▲) key .... Displays the first part of the next data automatically stored.
SET + DOWN (▼) key .... Displays the first part of the previous data automatically stored.
If there is manual data, then the previous or next manual data is shown.

Display for automatic storage

For the first and last data in one session of automatic storage the following identification marks are displayed in front of the values representing the data Nos.:

[: displayed for the first data in automatic storage.
] : displayed for the last data in automatic storage.

Note

- When the MEAS key is pressed, data calling is stopped and the instrument returns to the Measurement mode.
- Data is called from the sensor probe so to get one piece of data takes about one second.

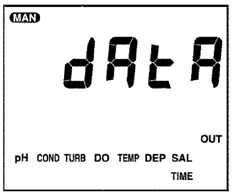
4.3.2 Calling up the calibration log

A calibration log is a record containing the “year, month, day” and “hour and minute” of the last calibration of individual measurement items and their calibration method. The instrument automatically stores the calibration log.

Measurement mode ○ DATA ⇨ Data Display mode ○ CAL ⇨ Displays the calibration log.

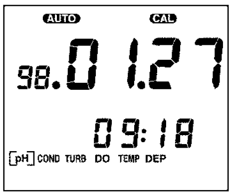
1. Press the **DATA** key in the Measurement mode.

The instrument goes to the DATA Display mode.



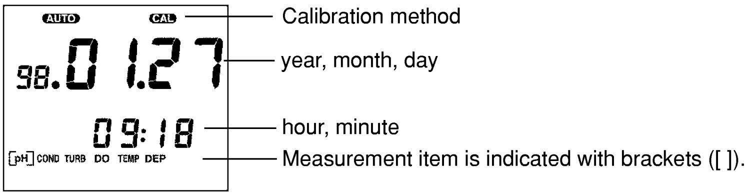
2. Press the **CAL** key.

The calibration log is displayed.



UP/DOWN (▲▼) keys: Switch the measurement item.
ENT key: Prints the entire calibration log. (when the printer is connected to the instrument)

Calibration log.



Calibration method

AUTO CAL : AUTO calibration
MAN ZERO CAL : Manual zero calibration
MAN SPAN CAL : Manual span calibration
MAN ZERO SPAN CAL : Manual zero calibration and span calibration

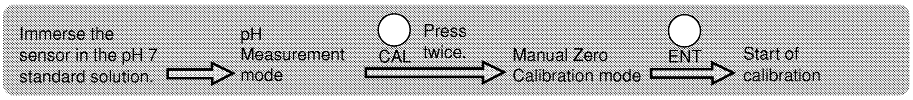
◖Note◗

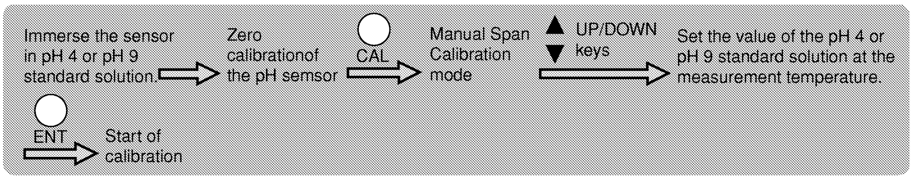
- Press the MEAS key to abort the data calling and return to the Measurement mode.

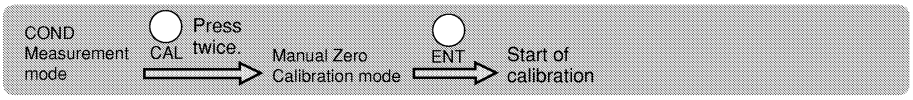
MEMO

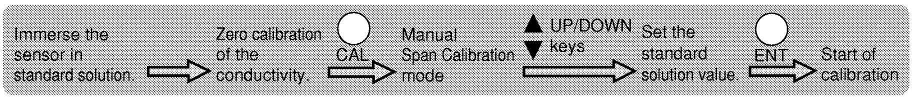
5. Techniques for more accurate measurement

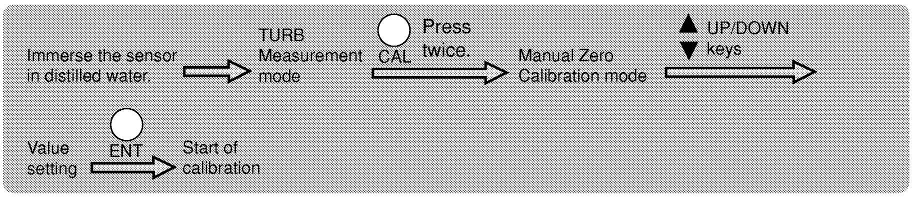
In normal operation, calibration using the AUTO Calibration mode described earlier in the basic operation section provides sufficient accuracy. However, for more accurate measurement, manual calibration is effective. When measurement with high-accuracy extended display is needed, be sure to perform manual calibration. Attention: The extended display mode is entered automatically when manual calibration is selected.











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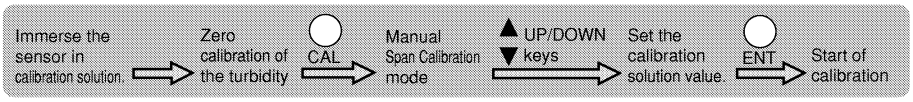
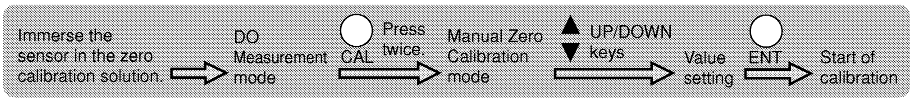
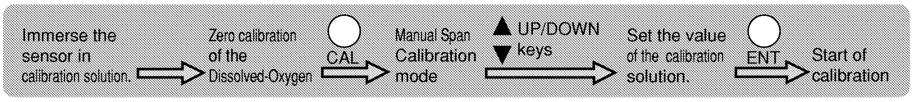
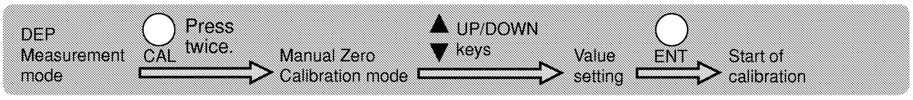
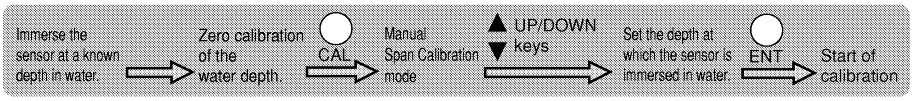
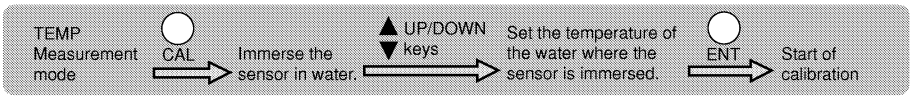

Immerse the sensor in calibration solution.
Zero calibration of the turbidity
CAL
Manual Span Calibration mode
▲ UP/DOWN ▼ keys
Set the calibration solution value.
ENT
Start of calibration


Immerse the sensor in the zero calibration solution.
DO Measurement mode
CAL
Press twice.
Manual Zero Calibration mode
▲ UP/DOWN ▼ keys
Value setting
ENT
Start of calibration


Immerse the sensor in calibration solution.
Zero calibration of the Dissolved-Oxygen
CAL
Manual Span Calibration mode
▲ UP/DOWN ▼ keys
Set the value of the calibration solution.
ENT
Start of calibration

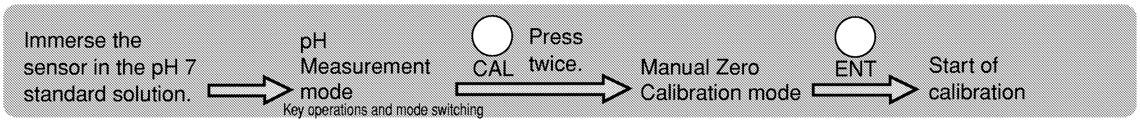

DEP Measurement mode
CAL
Press twice.
Manual Zero Calibration mode
▲ UP/DOWN ▼ keys
Value setting
ENT
Start of calibration


Immerse the sensor at a known depth in water.
Zero calibration of the water depth.
CAL
Manual Span Calibration mode
▲ UP/DOWN ▼ keys
Set the depth at which the sensor is immersed in water.
ENT
Start of calibration


TEMP Measurement mode
CAL
Immerse the sensor in water.
▲ UP/DOWN ▼ keys
Set the temperature of the water where the sensor is immersed.
ENT
Start of calibration

5.1 Manual pH calibration

5.1.1 Zero calibration

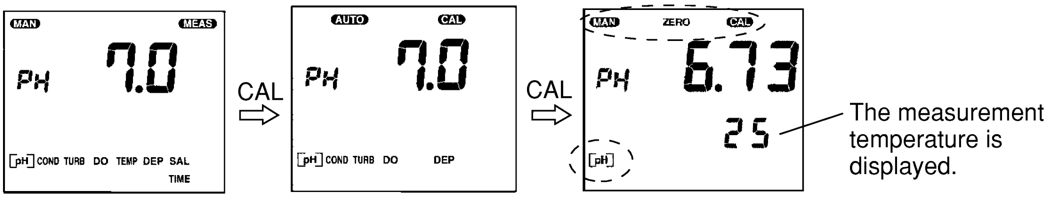


Key operations and mode switching (☞ Page 25)

1. Wash the sensor two or three times using distilled water, then pour some pH 7 standard solution into the calibration beaker, and immerse the sensor in it.

2. Press the **CAL** key twice in the pH Measurement mode.

When the instrument enters the Manual Zero Calibration mode, **MAN**, **ZERO** and **CAL** light up.

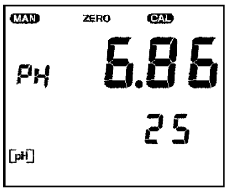


The measurement temperature is displayed.

Manual Zero Calibration mode

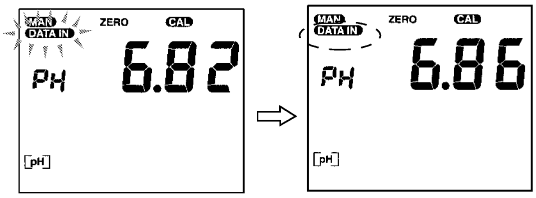
3. Use the **UP/DOWN** (▲ ▼) keys to input the value for the pH 7 standard solution at the measurement temperature.

(☞ *8. Reference data*, page 96.)



4. Press the **ENT** key.

The manual zero calibration starts.

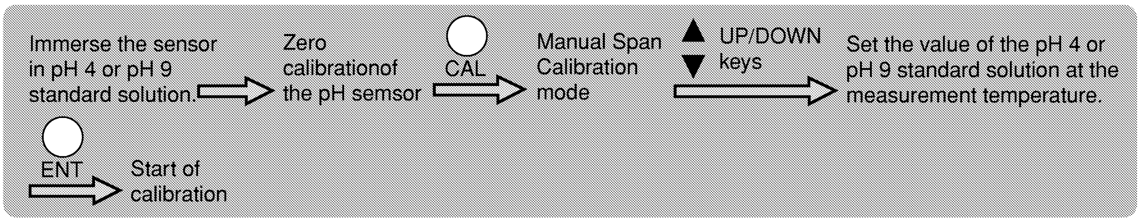


End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration .... Press the ENT key.

5.1.2 Span calibration

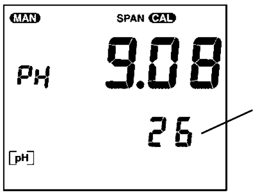


1. Wash the sensor two or three times using distilled water, then pour some pH 4 or pH 9 standard solution into the calibration beaker, and immerse the sensor in it.

2. After the zero calibration of the pH sensor, press the **CAL** key to make sure that the instrument is in the Manual Span Calibration mode.

MAN, **SPAN** and **CAL** light up.

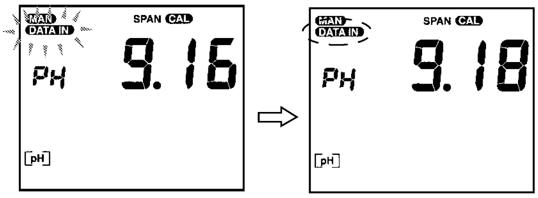
3. Use the **UP/DOWN** (▲ ▼) keys to set the value for the pH 4 or pH 9 standard solution at the measurement temperature.



The measurement temperature is displayed.

4. Press the **ENT** key.

The manual span calibration starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration .... Press the ENT key.

5. Press the **MEAS** key to return to the Measurement mode.

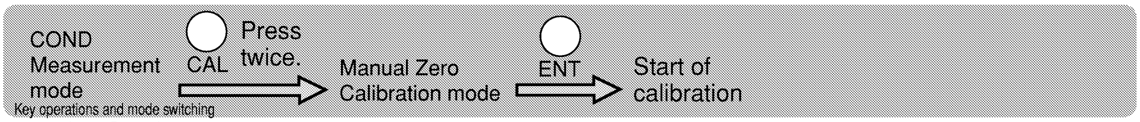
◖Note◗

- When the SET and CAL keys are pressed during the manual pH calibration mode, the calibration data for the pH sensor can be deleted.

5.2 Manual conductivity (COND) calibration

The U-20XD series models can measure conductivity (COND) in the range from 0.90 to 9.99 S/m. Depending on the concentration of the sample, these models automatically select the most suitable measuring range from three ranges: 0.0 to 99.9 mS/m, 0.090 to 0.999 S/m, and 0.90 to 9.99 S/m. The zero point is common to the three measuring ranges.

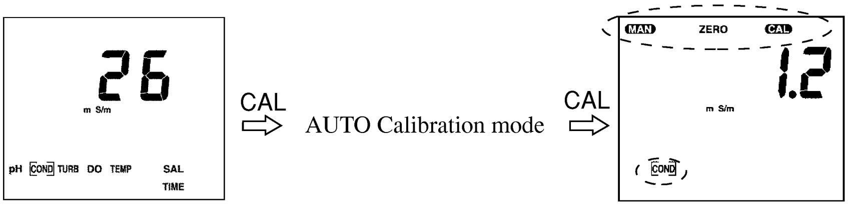
5.2.1 Zero calibration



Key operations and mode switching
(☞ Page 25)

1. Wash the conductivity (COND) sensor two or three times using distilled water. Completely remove the water on the sensor and calibrate the instrument in the atmosphere.
2. Press the **CAL** key twice in the Conductivity (COND) Measurement mode.

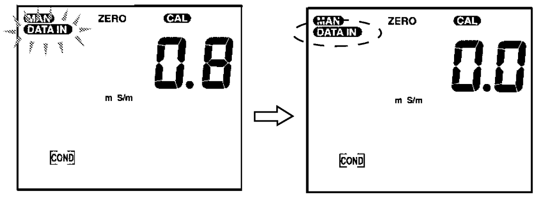
   When the instrument enters the Manual Zero Calibration mode, **MAN**, **ZERO** and **CAL** light up.



Manual Zero Calibration mode

3. Use the **UP/DOWN** (▲ ▼) keys to set the value to 0.0.
4. Press the **ENT** key.

   The manual zero calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking

To stop calibrating the sensor .... Press the CAL key.

To establish the calibration .... Press the ENT key.

5.2.2 Span calibration

Preparation of calibration solution (Potassium chloride (KCl) standard solution)

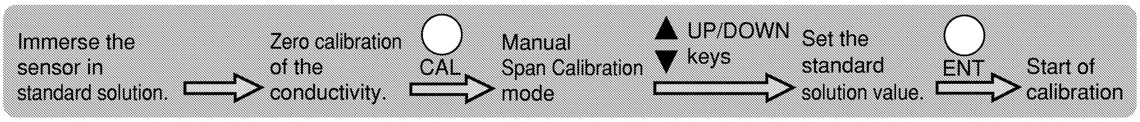
Dry Potassium chloride (KCl) powder (high-grade commercially available) at 105 °C for two hours, and leave it to cool in a desiccator.
Consult the following table and measure a portion of potassium chloride (KC1), then prepare standard potassium chloride (KC1) solution following the procedure below.

Potassium chloride (KCL) standard solution	Conductivity (COND) value	Potassium chloride (KCl) mass (g) at solution temperature of 25 °C	Calibration range
0.005 mol/L	71.8 mS/m	0.373	0.0 to 99.9 mS/m
0.050 mol/L	0.667 S/m	3.73	0.090 to 0.999 S/m
0.500 mol/L	5.87 S/m	37.2	0.90 to 9.99 S/m

1. Dissolve the weighed Potassium Chloride (KCl) in distilled water.
2. Put the dissolved Potassium Chloride (KCl) into a 1 L measuring flask, and fill to the 1 L mark with distilled water.

Calibration procedure

Perform the span calibration using the three types of standard solution as follows.

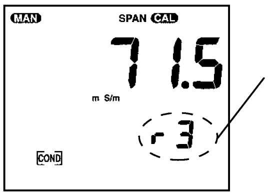


Important

- Set the temperature of the span standard solution to 25 ± 5 °C.
- The sensor should be calibrated in the three standard solutions in the order of increasing concentration.

1. Wash the sensor two or three times using distilled water, then pour some standard solution into the calibration beaker, and immerse the sensor in it.
2. After the zero calibration of the conductivity (COND) sensor, press the **CAL** key to make sure that the instrument is in the Manual Span Calibration mode.
   MAN, **SPAN** and **CAL** light up.

3. Use the **UP/DOWN** (▲ ▼) keys to set the standard solution value.



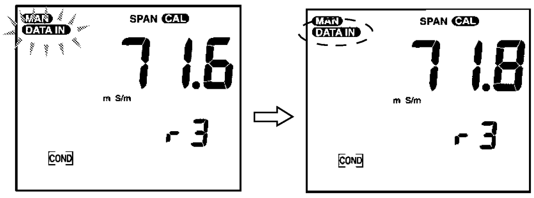
The calibration range is displayed.

Note

- The sensor automatically identifies the calibration solution and the relevant calibration range is displayed.
  r 1 : 0.90 to 9.99 S/m
  r 2 : 0.090 to 0.999 S/m
  r 3 : 0.0 to 99.9 mS/m

4. Press the **ENT** key.

The manual span calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration .... Press the ENT key.

5. Press the **CAL** key and use each standard solution and perform steps 1 to 4 above for calibration.

6. Press the **MEAS** key to return to the Measurement mode.

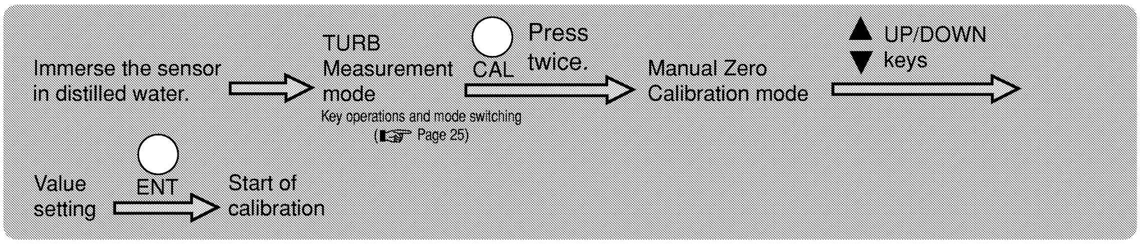
Note

- When the SET and CAL keys are pressed during the manual Conductivity (COND) Calibration mode, the calibration data for the conductivity (COND) sensor can be deleted.
- Perform the calibration again after deleting the present calibration data when calibration error occurs and the calibration cannot be performed.
- Perform the calibration again after deleting the present calibration data when the value cannot be read off because of unsettled digit of the measurement value.

5.3 Manual turbidity (TURB) calibration

5.3.1 Zero calibration

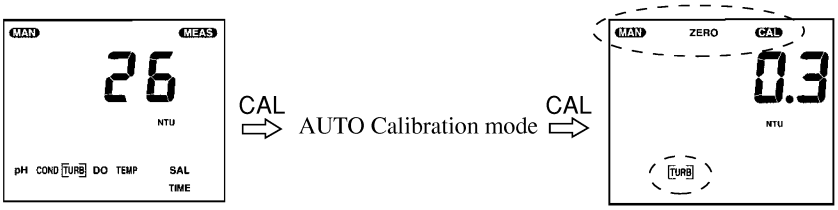
In zero calibration, distilled water is used as a calibration solution. If you cannot obtain distilled water, you may use ion exchange water, which can be considered to have a turbidity of zero.
When the turbidity (TURB) sensor is calibrated, it is particularly important that the probe is completely contamination-free. Do not use a contaminated probe. Otherwise unreliable calibration will result.



1. Wash the sensor two or three times using distilled water, then place some distilled water into the calibration beaker, and immerse the sensor in it.

2. Press the **CAL** key twice in the Turbidity (TURB) Measurement mode.

When the instrument enters the Manual Zero Calibration mode, **MAN**, **ZERO** and **CAL** light up.

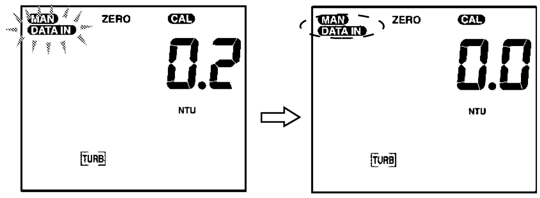


Manual Zero Calibration mode

3. Use the **UP/DOWN** (▲ ▼) keys to set the value to 0.0.

4. Press the **ENT** key.

The manual zero calibration is started.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

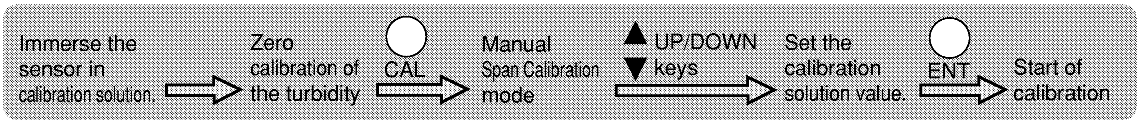
With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration .... Press the ENT key.

5.3.2 Span calibration

Preparation of calibration solution

Weigh out 5.0 g of hydrazine sulfate, and dissolve it in 400 mL of distilled water. Next dissolve 50 g of hexamethylene tetramine in 400 mL of distilled water, and mix the two solutions together. Finally add distilled water until the total solution volume is 1000 mL, and mix well. Store this solution at a temperature of 25 ± 3 °C for 48 hours. The turbidity value (TURB) of this solution is equivalent to 4000 NTU.
Use the solution as span calibration solution for turbidity (TURB) of 800 NTU by diluting this solution by a factor of 5 (use a pipette to measure 50 mL of the 4000 NTU solution and pour it into a 250 mL measuring flask, and add 200 mL of distilled water).

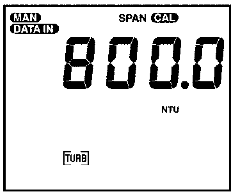
Calibration procedure



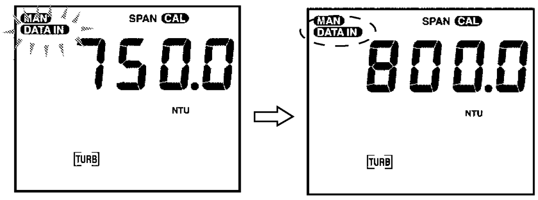
1. Wash the sensor two or three times using distilled water, then pour standard solution into a calibration beaker, and immerse the sensor in it.

2. After the zero calibration of the turbidity (TURB) sensor, press the **CAL** key to make sure that the instrument is in the Manual Span Calibration mode.
   MAN, **SPAN** and **CAL** light up.

3. Use the **UP/DOWN** (▲ ▼) keys to set the value to 800.0.



4. Press the **ENT** key.
   The manual span calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking

To stop calibrating the sensor .... Press the CAL key.
To establish the calibration .... Press the ENT key.

5. Press the **MEAS** key to return to the Measurement mode.

Important

- When it is known beforehand that the solution for measurement has a low turbidity (0 to 100 NTU), calibrate the sensor in the span calibration solution of 80 NTU. To prepare an 80 NTU calibration solution, dilute the 4,000 NTU calibration solution with distilled water by a factor of 50.

Note

- When the SET and CAL keys are pressed during the manual Turbidity (TURB) Calibration mode, the calibration data for the turbidity (TURB) sensor can be deleted.

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5.4 Manual Dissolved-Oxygen (DO) calibration

It is necessary to prepare a new calibration solution each time directly before calibration of the Dissolved-Oxygen (DO) sensor.

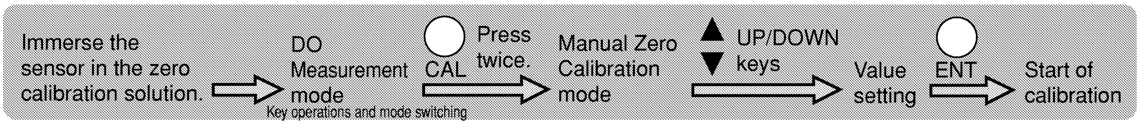
5.4.1 Zero calibration

Use ion exchange water or tap water with sodium sulfite dissolved in it.

Preparation of calibration solution

Add approximately 50 g of sodium sulfite to 1,000 mL of water (either ion exchange water or tap water) and stir the mixture to dissolve the sodium sulfite in it.
The calibration beaker (included) cannot be used to manually calibrate the DO sensor.
Use a container that can immerse the DO sensor.

Calibration procedure

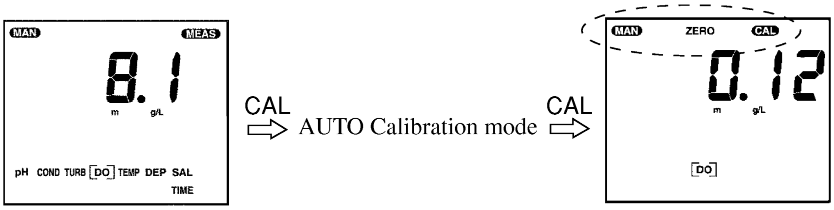


Key operations and mode switching
(☞ Page 25)

1. Wash the sensors 2 to 3 times with pure water and immerse the DO sensor completely in zero calibrated liquid.

2. Press the **CAL** key twice in the Dissolved-Oxygen (DO) Measurement mode.

When the instrument enters the Manual Zero Calibration mode, **MAN**, **ZERO** and **CAL** light up.

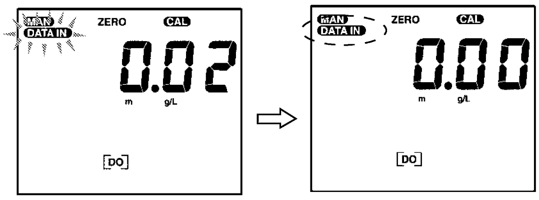


Manual Zero Caliburation mode

3. After the display has stabilized, use the **UP/DOWN** (▲ ▼) keys to set the value to 0.0.

4. Press the **ENT** key.

The manual zero calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration .... Press the ENT key.

Important

- After calibration, use tap water to clean the sensor.

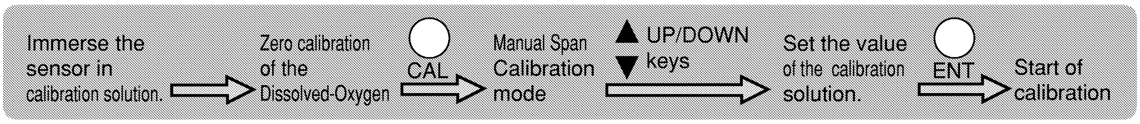
5.4.2 Span calibration

Use ion exchange water or tap water with saturated dissolved oxygen as the span calibration liquid.

Preparation of standard solution for span calibration

Pour 1 to 2 liters of water into a container (either ion exchange water or tap water).
Using a pneumatic pump, feed air into the water and froth up the solution until oxygen is saturated.
The calibration beaker (included) cannot be used to manually calibrate the DO sensor.
Use a container that can immerse the DO sensor.

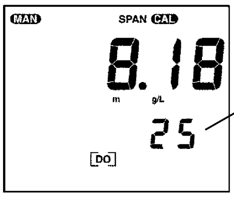
Calibration procedure



1. Wash the sensors 2 to 3 times with pure water and immerse the DO sensor completely in span calibrated liquid.

2. After the zero calibration of the Dissolved-Oxygen (DO) sensor, press the **CAL** key to make sure that the instrument is in the Manual Span Calibration mode.
MAN, **SPAN** and **CAL** light up.

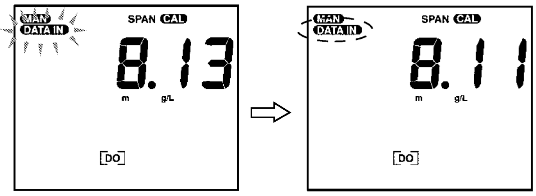
3. After the display has stabilized, use the **UP/DOWN** (▲ ▼) keys to set the amount of saturated dissolved oxygen in water at the temperature.



The temperature setting is displayed.
Refer to the table given on page 56 and set a value equivalent to the amount of saturated dissolved oxygen at the temperature.

4. Press the **ENT** key.

The manual span calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration .... Press the ENT key.

5. Press the **MEAS** key to return to the Measurement mode.

◖Note◗

- When the SET and CAL keys are pressed during the manual Dissolved-Oxygen (DO) calibration mode, the calibration data for the dissolved-oxygen (DO) sensor can be deleted.

Amounts of saturated dissolved oxygen in water at various temperatures (salinity=0.0%)

JIS K0101

Temp. (˚C)	DO (mg/L)	Temp. (˚C)	DO (mg/L)	Temp. (˚C)	DO (mg/L)	Temp. (˚C)	DO (mg/L)
0	14.16						
1	13.77	11	10.67	21	8.68	31	7.42
2	13.40	12	10.43	22	8.53	32	7.32
3	13.04	13	10.20	23	8.39	33	7.22
4	12.70	14	9.97	24	8.25	34	7.13
5	12.37	15	9.76	25	8.11	35	7.04
6	12.06	16	9.56	26	7.99	36	6.94
7	11.75	17	9.37	27	7.87	37	6.86
8	11.47	18	9.18	28	7.75	38	6.76
9	11.19	19	9.01	29	7.64	39	6.68
10	10.92	20	8.84	30	7.53	40	6.59

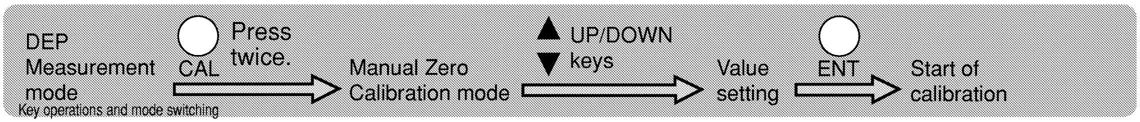
ISO5814

Temp. (˚C)	DO (mg/L)	Temp. (˚C)	DO (mg/L)	Temp. (˚C)	DO (mg/L)
0	14.62				
1	14.22	11	11.03	21	8.91
2	13.83	12	10.78	22	8.74
3	13.46	13	10.54	23	8.58
4	13.11	14	10.31	24	8.42
5	12.77	15	10.08	25	8.26
6	12.45	16	9.87	26	8.11
7	12.45	17	9.66	27	7.97
8	11.84	18	9.47	28	7.83
9	11.56	19	9.28	29	7.69
10	11.29	20	9.09	30	7.56

AUTO calibration is based on the JIS tables. When you need the measured data based on ISO, calibration should be done according to the procedure of span calibration.

5.5 Water depth (DEP) calibration

5.5.1 Zero calibration

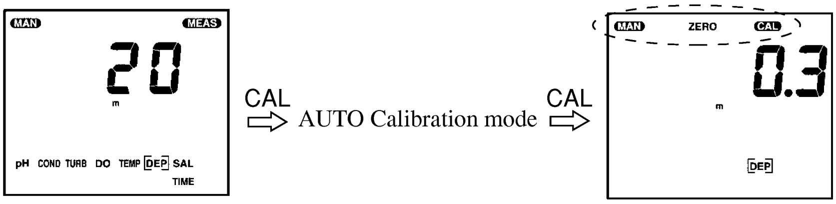


Key operations and mode switching
(☞ Page 25)

1. Immerse the sensor in the sample water for approximately 30 minutes so that sensor probe and sample temperatures become the same.

2. Press the **CAL** key twice in the Water Depth (DEP) Measurement mode.

When the instrument enters the Manual Zero Calibration mode, **MAN**, **ZERO** and **CAL** light up.



Manual Zero Calibration mode

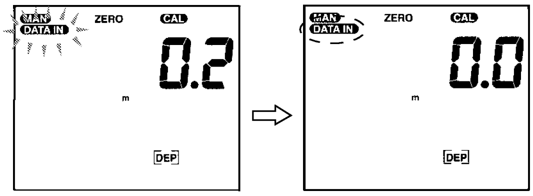
Important

- Sensor probe should be immersed to the depth where the battery cover comes level with the surface. And the level is uses as 0 m in depth.

3. Use the **UP/DOWN** (▲ ▼) keys to set the value to 0.0.

4. Press the **ENT** key.

The manual zero calibration is starts.



End of calibration

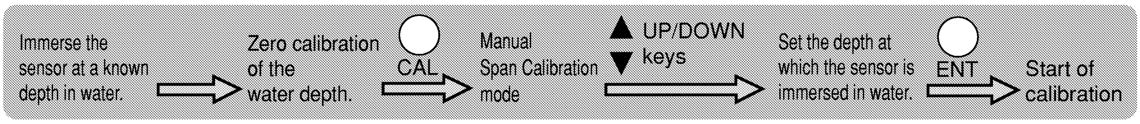
The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration .... Press the ENT key.

Important

- Since the water depth (DEP) sensor depends greatly on temperature, calibrate the sensor at the same temperature as the sample for more accurate measurement.
- Use the AUTO Calibration mode because calibration error becomes large when using in a place with flow velocity or where it is shallow.

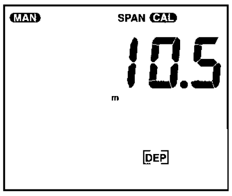
5.5.2 Span calibration



1. Immerse the sensor at a known depth in water. (Set the depth of the lid for memory backup battery as the depth setting.)

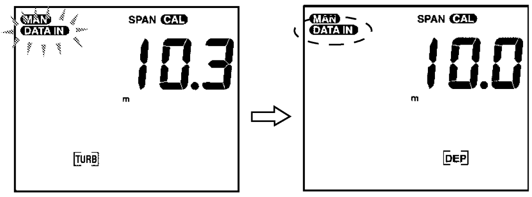
2. After the zero calibration of the water depth (DEP) sensor, press the **CAL** key to make sure that the instrument is in the Manual Span Calibration mode.
MAN, **SPAN** and **CAL** light up.

3. Use the **UP/DOWN** (▲ ▼) keys to set the depth at which the sensor is immersed in water.



4. Press the **ENT** key.

The manual span calibration is starts.



End of calibration

The measured value is displayed during calibration, and **DATA IN** blinks until the indicated value stabilizes. When the indicated value has stabilized, **DATA IN** lights up and the calibration finishes.

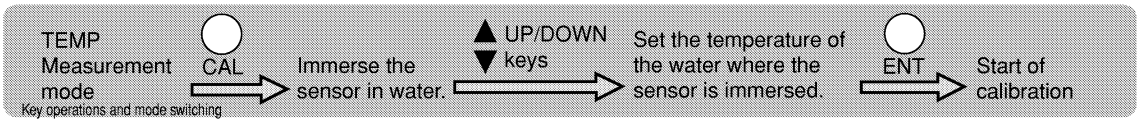
With DATA IN is blinking
To stop calibrating the sensor .... Press the CAL key.
To establish the calibration .... Press the ENT key.

5. Press the **MEAS** key to return to the Measurement mode.

◖Note◗

- When the SET and CAL keys are pressed during the manual Water depth (DEP) Calibration mode, the calibration data for the water depth (DEP) sensor can be deleted.

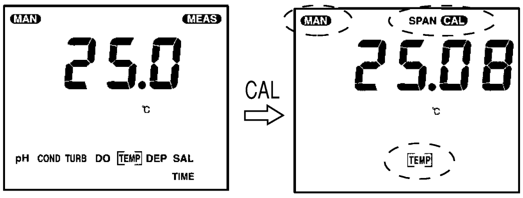
5.6 Temperature (TEMP) calibration



(☞ Page 25)

1. Press the **CAL** key in the Temperature (TEMP) Measurement mode.

Select the manual calibration mode.

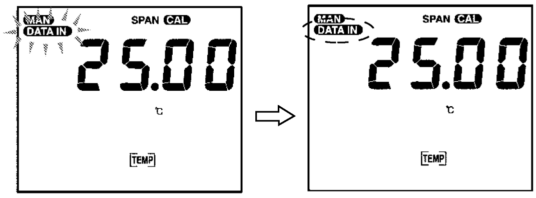


2. Immerse the sensor in water at a known temperature.

3. Use the **UP/DOWN** (▲ ▼) keys to set the temperature of the water where the sensor is immersed as a calibration value.

4. Press the **ENT** key.

The manual calibration is starts.



End of calibration

The measured value is displayed during calibration, and DATA IN blinks until the indicated value stabilizes. When the indicated value has stabilized, DATA IN lights up and the calibration finishes.

With DATA IN is blinking

To stop calibrating the sensor .... Press the CAL key.

To establish the calibration .... Press the ENT key.

5. Press the **MEAS** key to return to the Measurement mode.

◖Note◗

- When the SET and CAL keys are pressed during the manual Temperature (TEMP) calibration mode, the calibration data for the temperature (TEMP) sensor can be deleted.

5.7 Operation check using ORP standard solution

Note

- Standard solution is not used only for calibration of the meter, but to confirm whether or not the condition of electrodes is good.

1. Add 250 mL pure (ion exchange) water to one packet of any of the below listed standard solutions and mix well.
   When mixing, the excess quinhydrone (a black powder) will float to the surface of the solution.
2. Immerse a washed and dried ORP electrode in the ORP standard solution and measure the mV value.
3. If the electrode and the meter, itself, are working correctly, numerical values within 15 mV or less of those listed in Table 1 should be obtained.
4. If measurements that fall within 15 mV of the values listed above are not obtained using this method, measure the solution again after replacing the reference electrode internal solution and removing the dirt from the surface of the metal electrode by moistening a cotton swab with alcohol or a neutral cleaning agent and lightly rubbing the electrode or by soaking the electrode in diluted nitric acid (1:1 nitric acid).
5. If measurements within 15 mV of the values listed above are still not obtained after re-measuring, the reference electrode or the meter may be faulty. Either replace the electrode or have the meter inspected.

Important

- If the prepared ORP standard solution is allowed to stand in open air for one hour or more, it may undergo transformation. For this reasons ORP standard solution that has finished being prepared cannot be stored.
- When measuring a solution that has low concentrations of oxidants and reductants after conducting an operational check using a standard substance, the measured values may not stabilize or the results of measurement might not be repeatable.
  If this is the case, use the meter after immersing the electrodes in the solution again and mixing it thoroughly.

Precautions when measuring actual samples

- Note that when measuring the ORP of solution that has extremely low concentrations of oxidants and reductants, such as tap water, well water, or water treated with purifying equipment, there may be less responsiveness, repeatability, and stability, in general.
- When alkaline water is allowed to stand, its ORP undergoes big changes. Always measure alkaline ion water promptly.

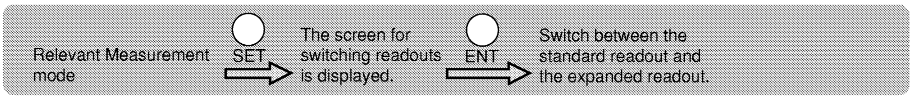
ORP standard solution

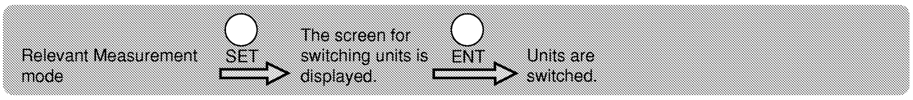
There are two kinds of standards substances. Under normal circumstances, it is sufficient to use only the one type of substance that is closest to the measured value.

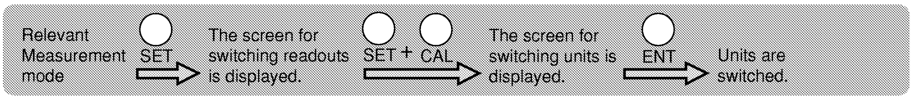
Indicated value of ORP standard solution at various temperatures

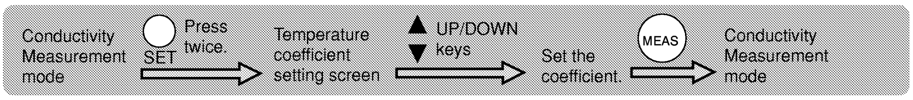
Standard solution ℃	160-22	160-51
	Phthalic-acid chloride + quinhydrone	Neutral phosphate + quinhydrone
5	+274.2	+111.9
10	+270.9	+106.9
15	+266.8	+101.0
20	+262.5	+95.0
25	+257.6	+89.0
30	+253.5	+82.7
35	+248.6	+76.2
40	+243.6	+69.0

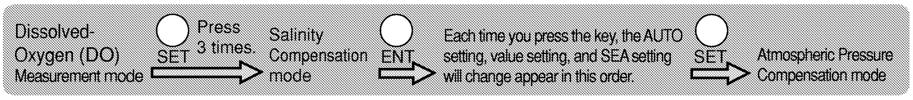
6. Using the various functions

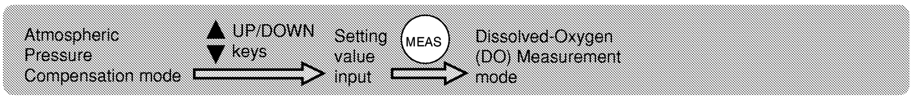


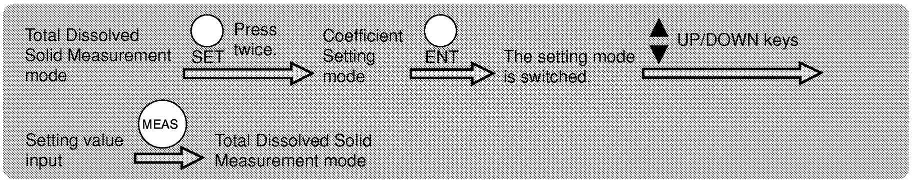


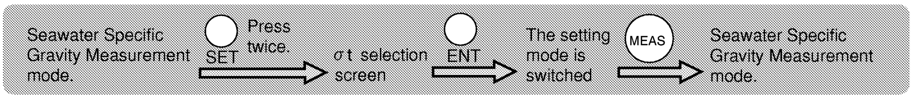


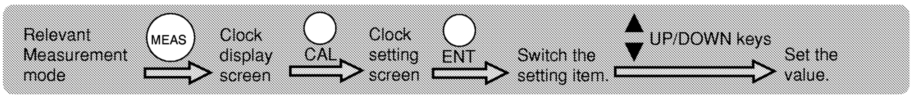


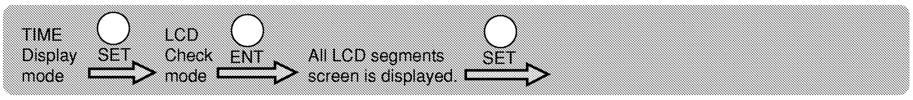


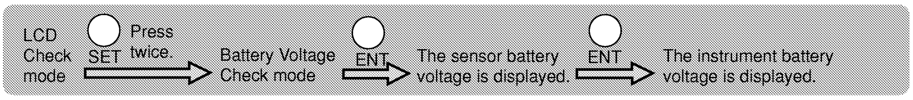


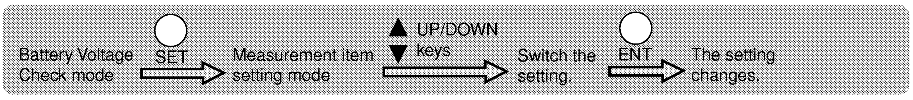


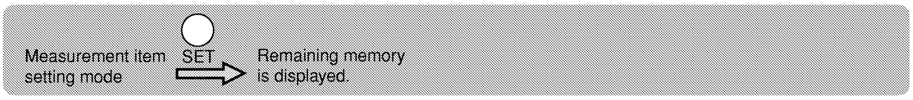

Seawater Specific Gravity Measurement mode.
SET
Press twice.
σt selection screen
ENT
The setting mode is switched
MEAS
Seawater Specific Gravity Measurement mode.

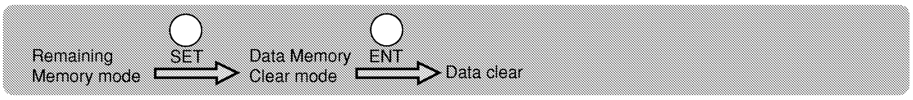

Relevant Measurement mode
MEAS
Clock display screen
CAL
Clock setting screen
ENT
Switch the setting item.
▲ ▼ UP/DOWN keys
Set the value.

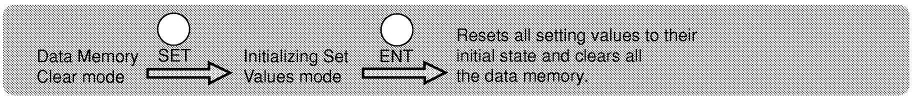

TIME Display mode
SET
LCD Check mode
ENT
All LCD segments screen is displayed.
SET

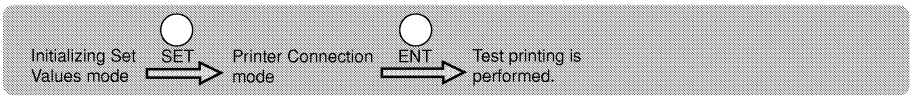

LCD Check mode
SET
Press twice.
Battery Voltage Check mode
ENT
The sensor battery voltage is displayed.
ENT
The instrument battery voltage is displayed.


Battery Voltage Check mode
SET
Measurement item setting mode
▲ ▼ UP/DOWN keys
Switch the setting.
ENT
The setting changes.


Measurement item setting mode
SET
Remaining memory is displayed.


Remaining Memory mode
SET
Data Memory Clear mode
ENT
Data clear


Data Memory Clear mode
SET
Initializing Set Values mode
ENT
Resets all setting values to their initial state and clears all the data memory.


Initializing Set Values mode
SET
Printer Connection mode
ENT
Test printing is performed.

6.1 Switching to Expanded readout (High-accuracy display)

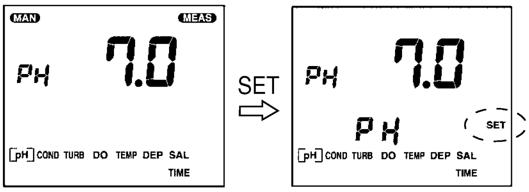
With the exception of oxidation-reduction potential (ORP), it is possible to switch between the Standard readout and the Expanded readout for the measurement value.

Relevant Measurement mode → SET → The screen for switching readouts is displayed. → ENT → Switch between the standard readout and the expanded readout.

Key operations and mode switching
(☞ Page 25)

1. Press the **SET** key in the relevant Measurement mode.

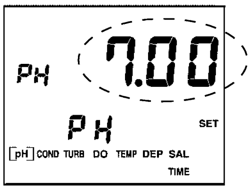
The screen for switching readouts is displayed.



Standard readout

2. Press the **ENT** key.

The screen can be switched between the standard readout and the expanded readout (High-accuracy display).



Expanded readout (High-accuracy display)

Note

- Switch readouts for each measurement items.
- Use the manual 2-point calibration (zero and span) when high accuracy is required for expanded readout (High-accuracy display).
- The expanded readout mode is automatically activated when the manual 2-point calibration mode is chosen.

3. Press the **MEAS** key to return to the Measurement mode.

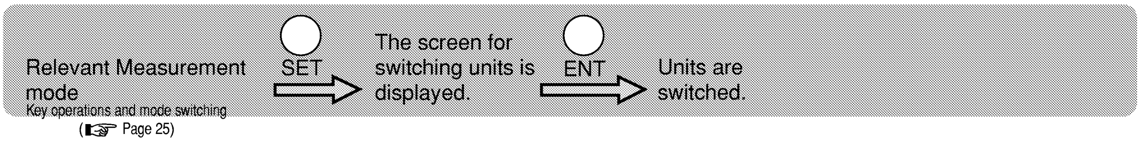
6.2 Switching measurement units

It is possible to switch between measurement units.

The units which can be switched are as follows:

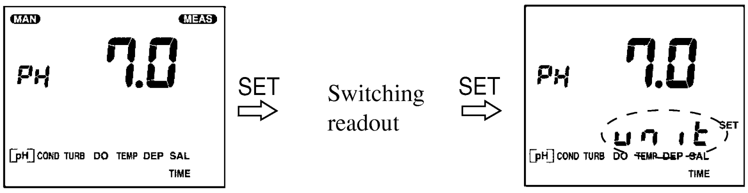
pH	pH or mV
Conductivity (COND)	S/m or mS/cm
Water depth (DEP)	m or ft
Turbidity (TURB)	NTU or mg/L
Dissolved Oxygen (DO)	mg/L or % (Oxygen saturation ratio)

In the case of pH, TURB, DO



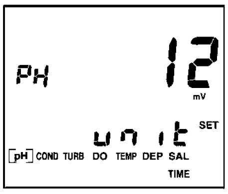
1. Press the **SET** key twice in the relevant Measurement mode.

Confirm that unit is displayed on the screen for switching units.



2. Press the **ENT** key.

Units are switched.



3. Press the **MEAS** key to return to the Measurement mode.

In the case of COND and DEP

Relevant Measurement mode $\xrightarrow{\text{SET}}$ The screen for switching readouts is displayed. $\xrightarrow{\text{CAL + SET}}$ The screen for switching units is displayed. $\xrightarrow{\text{ENT}}$ Units are switched.

1. Press the **SET** key in the Relevant Measurement mode.

   The screen for switching readout is displayed.

2. Press the **SET** key while holding down the **CAL** key.

   Confirm that unit is displayed on the screen for switching units.

3. Press the **ENT** key.

   Units are switched.

4. Press the **MEAS** key to return to the Measurement mode.

Measurement range

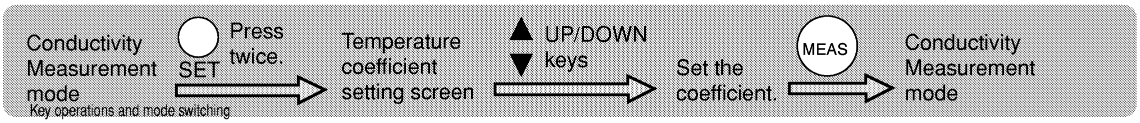
Measurement item		Measurement range		Measurement units
		Expanded	Standard	
pH		0.00 to 14.00	0.0 to 14.0	pH
		—	−1999 to 1999	mV in pH measurement
Conductivity (COND)	Range 1	0.90 to 9.99	0.9 to 9.9	S/m
		9.0 to 99.9	9 to 99	mS/cm
	Range 2	0.090 to 0.999	0.09 to 0.99	S/m
		0.90 to 9.99	0.9 to 9.9	mS/cm
	Range 3	0.0 to 99.9	0 to 99	mS/m
		0.000 to 0.999	0.00 to 0.99	mS/cm
Turbidity (TURB) *1		0.0 to 800.0	0 to 800	NTU (nephelometric turbidity units) or mg/L
Dissolved-oxygen (DO)		0.00 to 19.99	0.0 to 19.9	mg/L
		0.0 to 199.9	0 to 199	%
Temperature (TEMP)		0.00 to 55.00	0.0 to 55.0	˚C
Water depth (DEP)		0.0 to 100.0	0 to 100	m
		0.0 to 330.0	0 to 330	ft
Salinity (SAL)		0.00 to 4.00	0.0 to 4.0	%
Total dissolved solids (TDS) *2	Range 1	5.5 to 65.0	5 to 65	g/L
	Range 2	0.55 to 6.50	0.5 to 6.5	g/L
	Range 3	0.000 to 0.650	0.00 to 0.65	g/L
Seawater specific gravity (σ_t)		0.0 to 50.0	0 to 50	–
Oxygen-reduction potential (ORP)		—	−1999 to 1999	mV

*1: Depending on the concentration range, the minimum turbidity is displayed as follows:
0 to 100 NTU ... 1 NTU for standard readout, 0.1 NTU for expanded readout.
100 to 800 NTU ... 10 NTU for standard readout, 1 NTU for expanded readout.

*2: The TDS range depends on the TDS factor settings. (Above ranges are given for a TDS coefficient of 0.65.)

6.3 Temperature conversion for conductivity (COND)

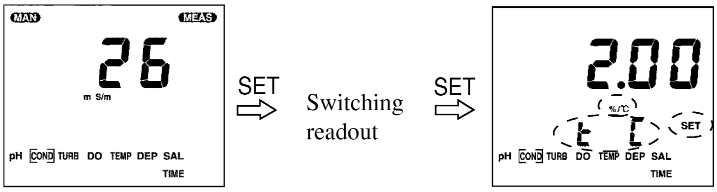
Sample conductivity (COND) varies with temperature, and this instrument uses a temperature conversion coefficient to automatically standardize the conductivity (COND) to the value at 25 °C. The initial setting value is 2 %/°C, which is the generally used value.



Key operations and mode switching
(☞ Page 25)

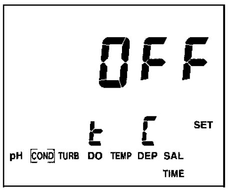
1. Press the **SET** key twice in the Conductivity (COND) Measurement mode.

The screen for setting temperature coefficients is displayed.



2. Use the **UP/DOWN** (▲ ▼) keys to set the coefficient.

The setting range is 0.00 to 3.00 %/°C.



With the ENT key, the temperature conversion is switched between ON and OFF.

The temperature conversion OFF mode is not a 25°C coefficient but a coefficient at the temperature of the sample.

3. Press the **MEAS** key.

The instrument returns to the Conductivity (COND) Measurement mode.

Note

- For temperature coefficients, refer to *Reference data*, page 98 to 99.

6.4 Dissolved-Oxygen (DO) environmental influence compensation

6.4.1 Salinity compensation

The indicated dissolved oxygen (DO) value can go over the actual value if salinity compensation isn't added because of the increase in salinity in the sample. To obtain a correct measured value for dissolved oxygen (DO) in the sample containing salinity, therefore, salinity compensation is needed. The following modes are available for calculation of salinity compensation.

AUTO........ Salinity compensation is performed automatically with salinity converted from a measured value for conductivity.

SEA .... Compensation value appropriate for normal seawater is used.

Dissolved-Oxygen (DO) Measurement mode ○ SET Press 3 times. ⇨ Salinity Compensation mode ○ ENT ⇨ Each time you press the key, the AUTO setting, value setting, and SEA setting will change appear in this order. ○ SET ⇨ Atmospheric Pressure Compensation mode

Key operations and mode switching
(☞ Page 25)

1. Press the **SET** key 3 times in the Dissolved-Oxygen (DO) Measurement mode.

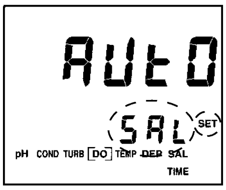
   The salinity compensation mode currently set is displayed.

Important

- If you do not change the salinity compensation mode currently set, press the MEAS key to return to the Dissolved-Oxygen (DO) Measurement mode or press the SET key to select the Pressure Compensation mode.

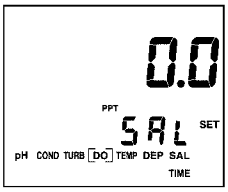
2. Press the **ENT** key.

   The following screens are displayed in sequence each time the ENT key is pressed: AUTO setting, value setting, SEA setting and AUTO setting.



3. From the screen on which the value is displayed, use the **UP/DOWN** (▲ ▼) keys to enter the setting value if the salinity is known.

   For AUTO and SEA setting, this step need not be performed.
   The setting range is 0.0 to 40.0 ppt (parts per thousand).



4. When the **SET** key is pressed, setting will be completed and the instrument will enter the Pressure Compensation mode.
5. Press the **MEAS** key to return to the Dissolved-Oxygen (DO) Measurement mode.

6.4.2 Atmospheric pressure compensation

Differences in the atmospheric pressure of the measurement location influence the Dissolved-Oxygen (DO) measurement. By setting (input) the actual atmospheric pressure of the measurement location into the instrument, it is possible to standardize the measured Dissolved-Oxygen (DO) value to a value at the standard atmospheric pressure (1013 hPa).

Atmospheric Pressure Compensation mode ⇨ ▲ UP/DOWN ▼ keys ⇨ Setting value input ⇨ MEAS ⇨ Dissolved-Oxygen (DO) Measurement mode

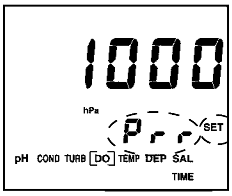
1. When the **SET** key is pressed on the salinity compensation screen, setting will be completed and the instrument will enter the Pressure Compensation mode.

Important

- If you do not change the Pressure Compensation mode currently set, press the MEAS key to enter the Dissolved-Oxygen (DO) Measurement mode.

2. Use the **UP/DOWN** (▲ ▼) keys to input a setting value.

The setting range is 100 to 1999 hPa.



3. When the **MEAS** key is pressed, setting will be completed and the instrument will enter the Dissolved-Oxygen (DO) Measurement mode.

Relation between height (m) and atmospheric pressure (hPa)

Height (m)	0	200	400	600	800	1000	1200	1400	1600	1800	2000	3000	3400
Pressure (hPa)	1013	990	966	943	921	899	877	856	835	815	795	701	666

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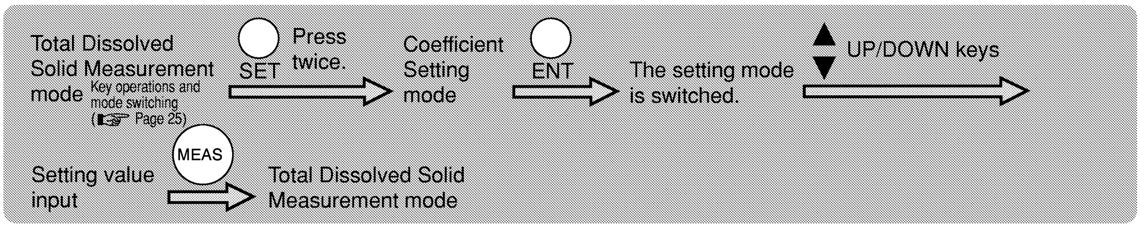
6.5 Setting a total dissolved solid (TDS) coefficient

The total dissolved solid amount (TDS) is a converted value obtained by multiplying the conductivity (COND) value by a known coefficient. Based on a conversion for KCl and $CaCO_3$ solutions, the coefficient initially set for the instrument depends on the conductivity (COND) value as shown below.

Conductivity (COND) (S/m)	Conversion coefficient
< 0.05	0.65
0.05 to 0.5	0.64
0.5 to 1	0.63
1 to 3	0.62
3 to 5	0.61
> 5	0.60

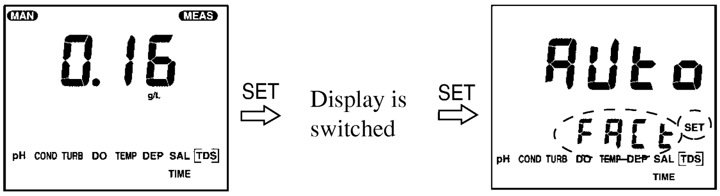
AUTO .... Used to automatically calculate the total dissolved solid (TDS) amount with an initially set coefficient.

Setting value input .... Used to determine the total dissolved solid (TDS) amount by setting any conversion coefficient irrespective of the conductivity (COND) value.



1. Press the **SET** key twice in the Total Dissolved Solid (TDS) Measurement mode.

The Coefficient Setting mode currently set is displayed.

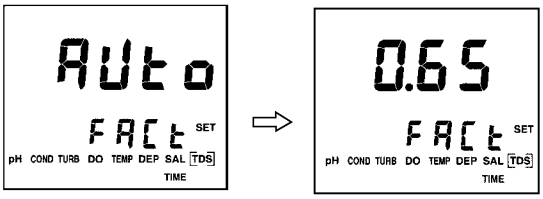


Important

- If you do not change the coefficient currently set, press the MEAS key to enter the Total Dissolved Solid (TDS) Measurement mode.

2. Press the **ENT** key.

The setting mode changes (AUTO/setting value input).



3. Use the **UP/DOWN** (▲ ▼) keys to input a setting value if required.

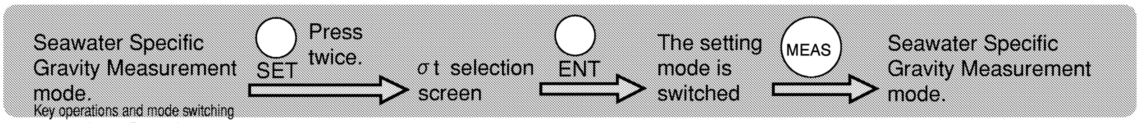
The setting range is 0.50 to 1.00.

4. When the **MEAS** key is pressed, setting will be completed and the instrument will enter the Total Dissolved Solid (TDS) Measurement mode.

6.6 Displaying seawater specific gravity (σ_0, σ_{15})

The specific gravity of seawater varies with temperature. By converting the measured value based on the value for a reference temperature, it is possible to compare sample measurement values at different temperatures.

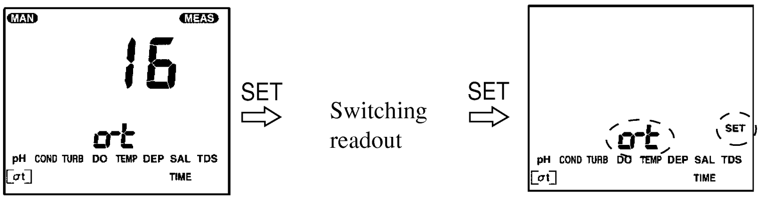
σ_t .... Specific gravity of seawater at the measurement temperature.
σ_0............ Seawater specific gravity at 0 °C.
σ_{15} .... Seawater specific gravity at 15 °C.



Key operations and mode switching
(☞ Page 25)

1. Press the **SET** key twice in the Seawater Specific Gravity (σ_t) Measurement mode.

Seawater specific gravity (σ_t) selection screen is displayed.

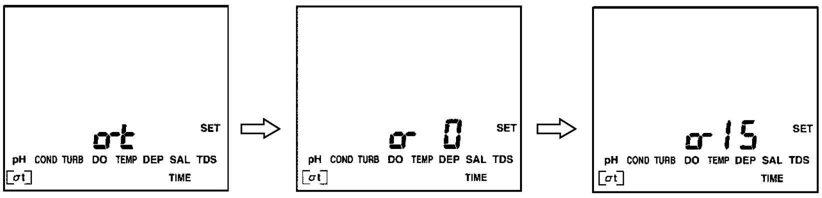


Important

- If you do not change the specific gravity currently set, press the MEAS key to enter the Seawater Specific gravity (σ_t) Measurement mode.

2. Press the **ENT** key.

The setting mode is switched.
($\sigma_0 \rightarrow \sigma_{15} \rightarrow \sigma_t \rightarrow \sigma_0 \ldots$)

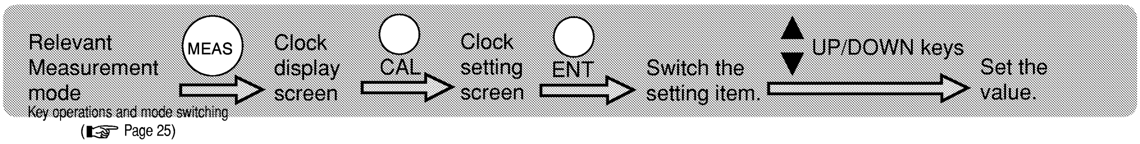


3. When the **MEAS** key is pressed, setting will be completed and the instrument will enter the Seawater Specific Gravity (σ_t) Measurement mode.

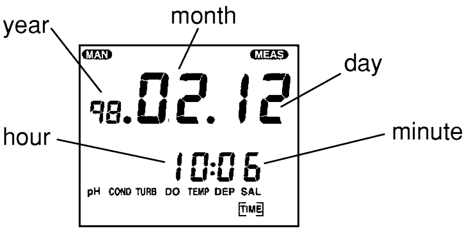
Note

- See page 100 for more about seawater specific gravity.

6.7 Setting the clock

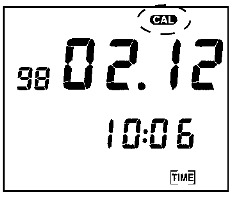


1. Use the **MEAS** key in the measurement mode to switch to the clock display screen.



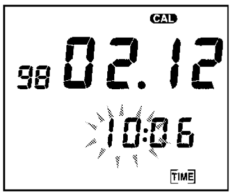
2. Press the **CAL** key.

CAL light up and clock setting screen is displayed.



3. Press the **ENT** key to switch the measuring item.

(year → month → day → hour → minute → year ...). The setting item will blink.



4. Use the **UP/DOWN** (▲ ▼) keys to set the value.

5. Press **SET** key to confirm the setting.

Note

- When the MEAS key is pressed, the instrument will return to the clock display.

Important

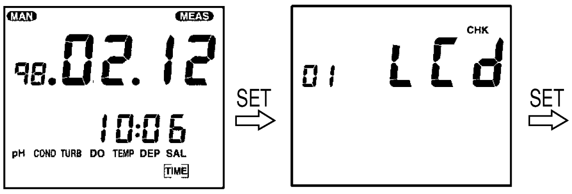
- When the MEAS key is pressed without pressing the SET key and the clock display is displayed again, settings are not changed.

6.8 Key lock setting

If you press the POWER key while pressing the UP (▲) key when the power is off, the instrument is then turned ON with the key locked and the key lock function works.
With the key locked, only the POWER and MEAS keys can be used and [LOCK] is displayed on the screen. To release this function, turn the instrument OFF first and then ON again.

6.9 Check mode

When the SET key is pressed in the measurement mode from the screen where “year, month, day and time” are displayed, the instrument performs self-diagnosis check.



Each time the SET key is pressed, the check mode item is switched sequentially.

Check mode items

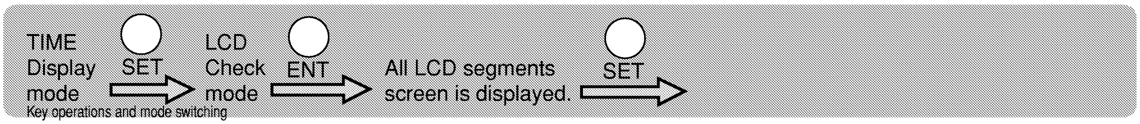
1 :	LCD check	Checks if all LCD segments will be displayed. (☞ Page 74)
2 :	Battery voltage check	Performs a simple battery voltage check for the instrument and sensors. (☞ Page 75)
3 :	Measurement item setting	Can set the measurement item to be stored. (☞ Page 76)
4 :	Remaining memory	Displays the number of data that can be stored now. (☞ Page 77)
5 :	Data memory clear	Clears the data memory. (☞ Page 78)
6 :	Initializing set values	Initializes all memory settings. (☞ Page 79)
7 :	Printer connection, test print	Performs a test print. (☞ Page 80)

Note

- In the check mode, it is possible to return to the Measurement mode by pressing the MEAS key.

6.9.1 LCD check

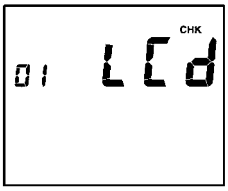
All LCD segments are displayed.



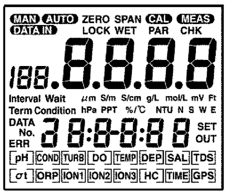
Key operations and mode switching
(☞ Page 25)

1. Press the **SET** key in the Clock Display mode.

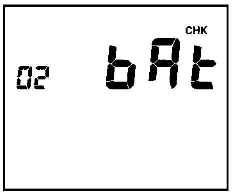
   LCD check mode screen is displayed.



2. Press the **ENT** key.
3. Check to see if all LCD segments are displayed.



4. When the **SET** key is pressed, the instrument goes to the battery voltage check.



◖Note◗

- When the MEAS key is pressed, the instrument returns to the Clock Display mode.

6.9.2 Battery voltage check

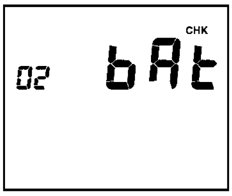
The battery voltage in use is displayed.

LCD Check mode ○ SET Press twice. ⇒ Battery Voltage Check mode ○ ENT ⇒ The sensor battery voltage is displayed. ○ ENT ⇒ The instrument battery voltage is displayed.

Check mode
(☞ Page 73)

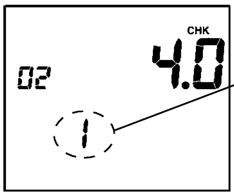
1. Press the **SET** key twice in the LCD Check mode.

Battery Voltage Check mode screen is displayed.



2. Press the **ENT** key.

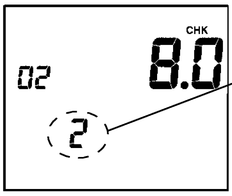
The sensor battery voltage is displayed.



1: Sensor battery voltage
Criteria
3.0 to 5.0 V : Normal
Less than 3.0 V: Replace the battery.
(Error No. 2 will blink.)

3. Press the **ENT** key.

The instrument battery voltage is displayed.



2: Instrument battery voltage
Criteria
5.5 to 11.0 V : Normal
Less than 5.5 V : Replace the battery.
(Error No.3 will blink.)

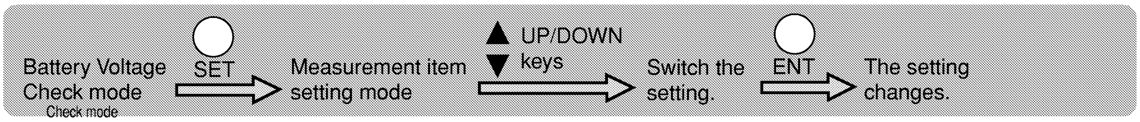
4. When the **SET** key is pressed, the instrument goes to the measurement item setting.

Note

- When the MEAS key is pressed, the instrument returns to the Clock Display mode.

6.9.3 Measurement item setting

Measuring items can be set.



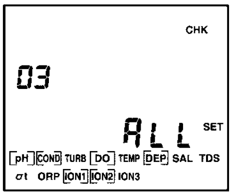
Check mode
(☞ Page 73)

1. **Press the SET key in the Battery Voltage Check mode.**

   Display setting mode screen is displayed.

2. **Use the UP/DOWN (▲ ▼) keys to switch the measurement item.**

   The selected item blinks.



3. **Press the ENT key to switch between [set/ not set] for the blinking item.**

   An item for which “set” is selected is indicated with [ ].

◖Note◗

- If the temperature is “not set” data for each component is not temperature-compensated and is displayed as data at 25 °C.

4. **When the SET key is pressed, the instrument goes to the remaining memory display.**

◖Note◗

- When the MEAS key is pressed, the instrument returns to the Clock Display mode.

6.9.4 Remaining memory

The number of date that can be stored can be displayed.

Measurement item setting mode SET ⇒ Remaining memory is displayed.
Check mode
(☞ Page 73)

Press the **SET** key in the Display Setting mode.

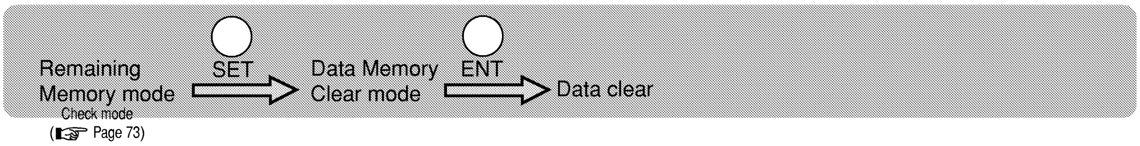
Remaining memory is displayed.

Note

- When the **SET** key is pressed, the instrument goes to the Data Memory Clear mode.
- When the MEAS key is pressed, the instrument returns to the Clock Display mode.

6.9.5 Data memory clear

All the data memory is cleared.

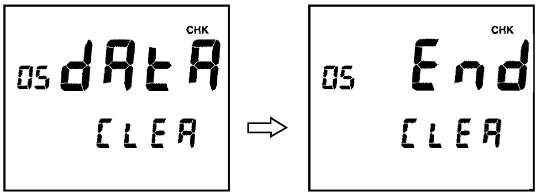


1. Press the **SET** key in the Remaining Memory mode.

   Data memory clear mode screen is displayed.

2. Press the **ENT** key.

   The data is cleared.



3. When the **SET** key is pressed, the instrument goes to the Memory Initialization mode.

◖Note◗

- When the MEAS key is pressed, the instrument returns to the Clock Display mode.

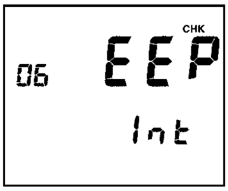
6.9.6 Initializing set values

All setting values are reset to their initial state.

Data Memory Clear mode
Check mode
(☞ Page 73)
○ SET ⇨ Initializing Set Values mode ○ ENT ⇨ Resets all setting values to their initial state and clears all the data memory.

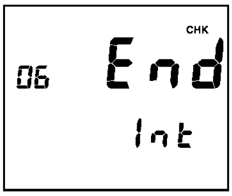
1. Press the **SET** key in the Data Memory Clear mode.

Initializing Set Values mode screen is displayed.



2. Press the **ENT** key.

All setting values are reset to their initial state.



3. When the **SET** key is pressed, the instrument goes to the Printer Connection mode.

◖Note◗

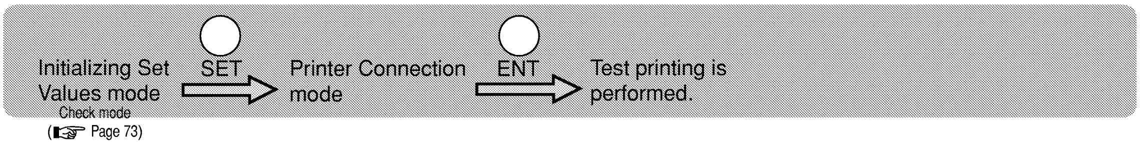
- When the MEAS key is pressed, the instrument return to the Clock Display mode.
- Data stored in the memory remains.

Initial setting

Item	Description	Initial value
Common	Display setting	Standard
	Data storage	Manual
pH	Unit	pH
COND	Unit	S/m
	Temperature coefficient	2.0 %/°C
DO	Salinity setting	AUTO
	Atmospheric pressure setting	1013 hPa
	Unit	mg/L
TURB	Unit	NTU
DEP	Unit	m
TDS	Coefficient	AUTO
σ_t	Unit	σ_t

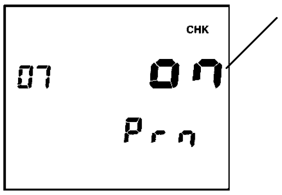
6.9.7 Printer connection, test print

This mode only operates when the function expansion unit is connected. A test print is performed if a printer is connected.



1. Press the **SET** key in the Initializing Set Values mode.

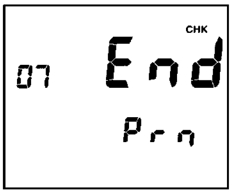
Printer Connection mode screen is displayed.



Displayed as OFF when not connected.

2. Press the **ENT** key to start printing.

Normally, “End” is displayed. If an error has occurred, “Err” is displayed.



3. When the **SET** key is pressed, the instrument will return to the first LCD check mode.

◖Note◗

- When the MEAS key is pressed, the instrument returns to the Clock Display mode.

7. Instrument specifications

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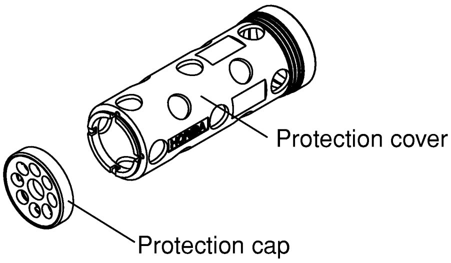
7.1 Daily maintenance

Sensor probe

● Storage method

After use, wash out with tap water and wipe off all contamination. Pour about 20 mL of pure water into the probe cap, install it on the sensor probe, and store in the carrying case.
In order to use the instrument regularly for a long time, store it after wiping off all contamination from the cable, sensor probe, and sensors.

❗ Remove the protection cover once and completely wash out with tap water the left over sample on the screws. Reinstall the cover after having wiped off the drops of water. If there is any sample (especially sea water) left over on the screws, rust may form which may prevent the protection cover from being removed. (☞ Installation procedure, page 18.)
Depending on the level of contamination, remove the rubber protection cap from the tip of the protection cover and wash out with tap water. Reinstall it after wiping off the drops of water.

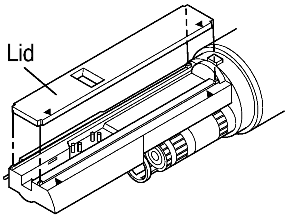


❗ When storing with the pH/ORP and DO sensors attached to the probe, make sure to install the probe cap after having poured pure water into it.
Letting the pH/ORP and DO sensors get dry may cause deterioration of the instrument's performance. Should the sponge inside the probe cap be contaminated, replace it with a clean sponge (included).

TEMP/COND/TURB units

● To remove contamination

1. Remove the lid from the cell.
2. Clean the unit in tap water. If the unit is severely contaminated, use an absorbent cotton to remove contamination.
3. Attach the lid to the cell block before storage. (☞ page 29)



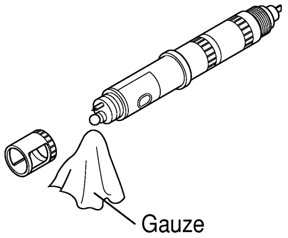
Important

- The cell has a window for turbidity measurement. Be careful to avoid damage to the window.
  In case of measurements, attach the lid to the cell in the correct direction.
- Don't remove the COND/TURB lid during calibration or measurement.
- Attach the lid to the cell with fitting four corners and facing ▲ marks each other.

pH/ORP sensors

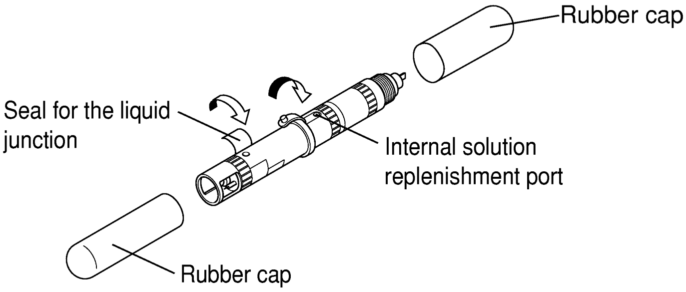
● To remove contamination

Use a piece of gauze dampened with detergent and wipe off contamination.



● Long-term storage

Remove the sensor from the sensor probe and check the internal solution replenishment port is closed. Then, attach a seal to the liquid junction and attach the rubber caps before storage.



● Monthly maintenance

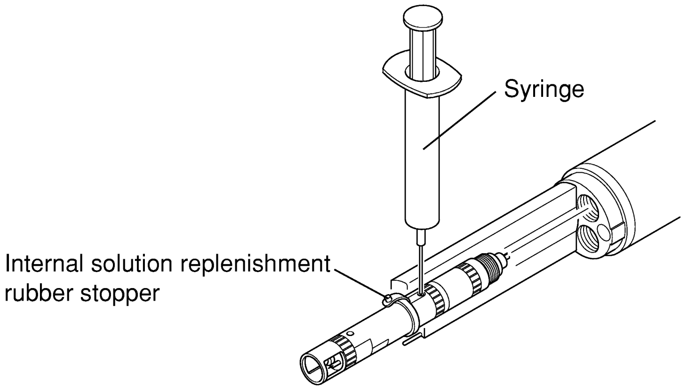
Replace the internal solution as described below:

1. Remove the sensor from the sensor probe using a sensor spanner.
2. Open the internal solution replenishment rubber stopper and remove the internal solution with a syringe.
3. Pour new internal solution (#330) to the level near rubber stopper. Be careful to avoid air bubbles from coming in the solition.
   Air bubbles in the internal solution will impair the sensors' pressure compensation function.

Important

- Shake the sensor to avoid bubbles in the internal solution from remaining at the bottom of the sensor.

4. Attach the sensor to the sensor probe.



DO sensor

● To remove contamination

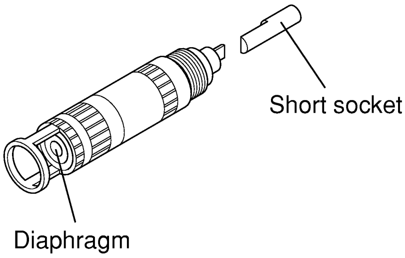
Wipe off contamination with gauze to avoid damage to the diaphragm.

● Long-term storage

Remove the sensor from the sensor probe using a sensor spanner. Set the supplied short socket and store the sensor in a cool(0 to 10℃), dark place.

Important

- Provide the DO sensor with a short socket or connect the sensor to the sensor probe for storage. Otherwise, the sensor may have a shorter life or stable instructions may not be obtained.
- The short socket is used when storing. Do not throw it away.



● Resetting the DO sensor when storing without having installed the short socket.

When leaving the DO sensor unattended for a brief period (1 or 2 days) without the short socket, the DO sensor can be reset by connecting it to the short socket or the probe. However, an amount of time corresponding to the period it was left unattended is necessary. If left unattended without being connected to the short socket or the probe for a long period (1 month), it cannot be reset.

● To replace the diaphragm.

Please read the instruction manual of the DO diaphragm replacement kit. (☞ page 89)

7.2 Troubleshooting

The instrument has a simple error message that informs users of operational errors and failure. Err No. is displayed at the bottom of the screen.

● Error message list

Err No.	Designation	Err No.	Designation
1	Sensor memory failure	6	Span calibration error
2	Sensor battery voltage drop	7	Calibration stability error
3	Instrument battery voltage drop	8	Printer error
4	Communications error	9	DATA IN error
5	Zero calibration error		

● Error and remedy

Important

- For err Nos. 5 to 7, the calibration err display disappears when a proper calibration is performed after the following action, or when the instrument is turned on again. For the other err Nos., the err display disappears after any of the following actions is taken.
- Error Nos. 2 and 3 are displayed even when using the AC adapter if the sensor probe battery voltage or instrument battery voltage drops is low on voltage.

Err NO.	Problem	Cause	Remedy
1	No data can be read from or written into the sensor probe memory.	Internal IC failure	Call your nearest store for sensor probe repair.
2	Sensor probe battery voltage drop	① Battery voltage drop ② Improper installation of the battery	① Replace the sensor probe battery. ② Set the batteries (LR03) in the correct direction.
3	Instrument battery voltage drop	① Battery voltage drop ② Improper installation of the battery	① Replace the instrument battery. ② Set the battery (6LR61) in the correct direction.
4	No communications possible between the instrument and the sensor probe	① Improper connection of the connector to the instrument ② Cable disconnection	① Connect the connector to the instrument properly and turn on the instrument again. ② Call your nearest store for cable repair.
5	No zero calibration possible	pH • The standard solution is contaminated. • Contamination on the pH glass membrane • Change in concentration of the internal solution for the reference electrode • Cracks in the pH glass electrode COND • The standard solution is contaminated. • The sensor is dirty. • The COND sensor is broken.	pH • Change the standard solution. • Clean the pH glass membrane. • Replace the internal solution for the reference electrode. • Replace the sensor. COND • Change the standard solution. • Clean the sensor. • Contact your nearest store.

Err NO.	Problem	Cause	Remedy
5	Zero calibration not possible	TURB	TURB
		• Air bubbles in the cell	• Swing the sensor probe while drawing a large arc.
		• Cell contamination	• Clean the cell.
		DO	DO
		• Damage to the diaphragm of the DO sensor	• Check the sensor and replace it if damaged.
		DEP	DEP
		• Contamination on the DEP sensor	• Clean the DEP sensor.
		• Damage to the DEP sensor	• Contact your nearest store.
6	Span calibration not possible	pH	pH
		• Contamination on the pH glass membrane	• Clean the pH glass membrane.
		• Change in concentration of the internal solution for the reference electrode	• Replace the internal solution for the reference electrode.
		• Cracks in the pH glass electrode	• Replace the sensor.
		• Damage to the connector pin	• Replace the sensor.
		COND	COND
		• The standard solution isn't correct.	• Calibrate with correct standard solution.
		• The standard solution value is set uncorrectly.	• Delete the calibration data for the conductivity, then calibrate the sensor again. (☞ Page 50)
		• The COND sensor is broken.	• Contact your nearest store.
		TURB	TURB
		• Air bubbles in the cell	• Swing the sensor probe while drawing a large arc.
		• Cell contamination	• Clean the cell.
		• The lid is attached uncorrectly.	• Confirm if the lid is attached correctly, then calibrate the sensor again. (☞ Page 29)
		DO	DO
		• Damage to DO sensor diaphragm	• Check the DO sensor and replace it if damaged.
		• DO sensor is unstable.	• Connect DO sensor to the sensor probe. Calibrate the sensor again 1 day later.
		• Damage to the connector pin	• Replace the sensor.
		DEP	DEP
		• Contamination on the DEP sensor	• Clean the DEP sensor.
		• Damage to the DEP sensor	• Contact your nearest store.
		TEMP	
		• Damage to the TEMP sensor	• Contact your nearest store.
7	The calibration value does not become stable within approximately three minutes.	① Sensor contamination	① Clean each sensor.
		② Dry sensor surface	② Pour the standard solution into the calibration beaker. Calibrate the sensor again 1 to 2 hours later.
		③ Severe temperature change	③ Calibrate the sensor in a place at a stable temperature or in a thermostatic oven.

Err NO.	Problem	Cause	Remedy
8	Printer unit failure		Turn OFF the instrument and use the remedy described below. Then turn ON the printer again.
		① Paper has jammed in the printer	① Remove the jammed sheet of paper
		② Improper printer unit connection	② Check to see if the printer is properl connected to the instrument.
		③ Printer failure	③ Replace the printer. * Contact your nearest store if the instrument does not recover after replacement of the printer.
9	Data cannot be stored because the memory is full.	No free space in the memory	Delete the data stored in the memory. (☞ Page 78)

● Other troubles

Remedies for various trouble with no Err No. displayed are described below.

Problem	Cause	Remedy
No data display with the power on	• No batteries	• Set new batteries.
	• Improper position of the positive and negative poles	• Set the batteries properly while paying attention to the positive and negative poles.
	• Battery voltage drop	• Replace the batteries with new ones.
	• Improper instrument battery contact	• Use radio pliers to narrow the positive terminal of the battery snap.
No setting change possible	• Automatic data storage is under way	• Press the CAL key to stop the automatic data storage.
No key operation possible	• The key lock function is working	• Turn OFF the instrument. Then turn ON the instrument again. (☞ Page 73)
	• Failure to calibrate the sensor or wrong calibration.	• Calibrate the sensor properly.
Blinking measured value	• Improper measurement sample	• Use a sample that is in the measurement range.
	• Sensor contamination	• Clean each sensor.
	• Poor calibration is possible. (The standard solution is contaminated.)	• Carry out correct calibration.
tYPE Err	• Improper connection of the cable connector to the instrument	• Connect the connector to the instrument properly and turn on the instrument again.
The Err is displayed and the	• Cable disconnection	• Contact your nearest store.
operation cannot be performed.	• Instrument inside failure	• Contact your nearest store.

● Troubleshooting for the TURB sensor

If an abnormal value such as -10, 800 or more is indicated, or indication does not become stable, follow as below instructions.

Remove the contamination of the sensor

Remove the cover of the turbidity (TURB) sensor, and clean the sensor with cotton swab.
Contamination or bubbles on the sensor may cause fluctuation of TURB values.

Remove bubbles around the sensor

When immersing sensor in the calibration cup, be sure lower it slowly. Quick immersion may cause bubbles on the sensor, which can have bad influence on calibration accuracy to give abnormal value indication.

Use of new standard solution

When calibration, clean the sensor before immersing it in the new standard solution. In case of zero calibration, when the standard solution is turbid or contaminated, calibrate again with the new standard one.

Points to be noted in making measurement

Immerse the sensor slowly in the sample. In case of abnormal measurement value observed, contamination or bubbles adhering may be suspected. So, shake greatly the sensor. Since immersion of the sensor in the sludge layer at the bottom of the sample can prohibit accurate measurement, shake greatly enough to remove the sludge.

● Maintenance of DO sensor

Durable life of DO sensor is generally one year, however, it may vary depending on the using condition. In case of the failure of calibration or breakage of the diaphragm, take either of the following steps according to the using period.

Within one year after purchasing :

Obtain diaphragm replacement kit (optional) to replace the used diaphragm and replenish the internal solution for restoration.

When exceeding one year after purchasing :

Replace by the new DO sensor.

● **Materials**

#5460 DO Sensor Diaphragm Replacement Kit Operation Manual

This operation manual explains how to replace the DO Sensor (#5460) Diaphragm.

1 This kit comes with the following.

● Diaphragm sheets	10 sheets
● Diaphragm retaining ring	5 pcs.
● O−ring (S9)	5 pcs.
● Internal solution #305 (50 mL)	1 bottle
● Diaphragm retaining plate	1 pc.
● Replacement stand	1 pc.
● Syringe and needle	1 set
● Operation manual	1 sheet

2 Diaphragm Replacement

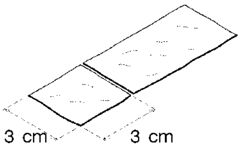
Chemical solution

Caution

The internal solution contains pottasium hydroxide (KOH) solution of high concentration.
If the solution comes in contact with hands or skin, wash immediately with water. If the solution comes in contact with the eyes, flush with ample amounts of water, then seek medical assistance.

1 Cut a diaphragm sheet to about 3 x 3 cm in size.

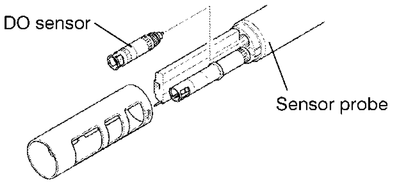
Note▶▶▶ Don't get any fingerprints or dust on the center part of the square.



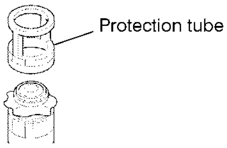
2 Detach the DO sensor from the sensor probe.

Ref▶▶▶ Refer to the U−21.22.23 Operation Manual, section 2.3.2 "Sensor Installation".

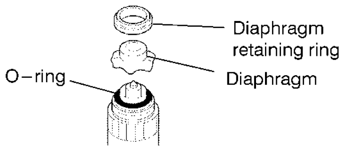
Note▶▶▶ If the short socket is not attached, instability may be seen when the sensor is used again.
Wear vinyl work gloves when handling the sensor. The KOH inside it is a strong alkaline and can irritate skin.



3 Detach the protection tube that holds the diaphragm in place. If it is difficult to remove, use some spanner, etc. to remove it.

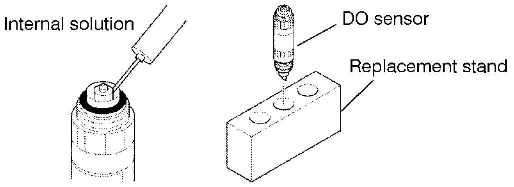


4 Detach the diaphragm retaining ring and diaphragm.
Detach the diaphragm retaining ring and diaphragm if damaged or no longer functional.

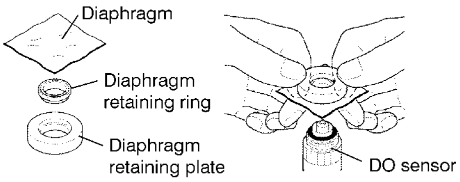


5 Set the sensor in the replacement stand ,and fill the internal solution with the attached syringe until the sensor tip is soaked with the solution.

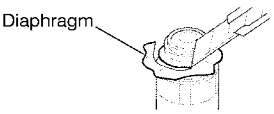
Note▶▶▶ Use the internal solution included in the kit for best performance.
In case some white crystals are seen, wipe them out completely with a Kimwipe®, etc.
In case the internal solution includes white crystals, remove the internal solution and fill up again. If the white crystals cannot be seen, just fill up.



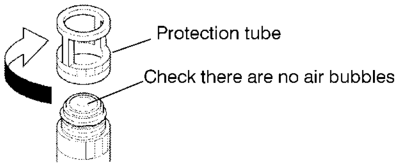
6 Fit the diaphragm retaining ring into the diaphragm retaining plate. Then, lay the diaphragm over the sensor and carefully cover with the ring and plate so that the diaphragm does not wrinkle. Finally, remove the retaining plate.



7 Cut the draped edge of the diaphragm to the shape of the sensor.

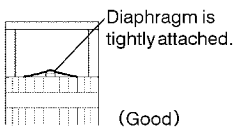


8 Check there are no air bubbles inside the sensor and tighten the protection tube securely.

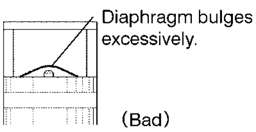


9 Check the diaphragm bulges upward as shown on the below left and that it is not wrinkled.

Note▶▶▶ Check that span calibration can be made correctly. Sensitivity lowers and response speed slows if the diaphragm does not bulge sufficiently.



(Good)



(Bad)

For any question regarding this product, please contact your local agency, or inquire from the Customer Registration website (www.horiba.co.jp/register).

HORIBA, Ltd.

7.3 Specifications

NOTE ○: Applicable
—: Unapplicable

		U-22XD
Instrument	Water-proof construction	IP67
	Mass	Approximately 500 g (including the grip holder)
Sensor *1	Use in 2-inch well	○
	Measurement temperature	0 to 55 °C
	Storage temperature	-5 to 60 °C
	Measurement depth	to 100 m
	Maximum sensor outside diameter	47 mm
	Sensor length	380 mm
	Continuous use available *2	30 days
	Automatic data gathering at set time	○
	Mass (Cable10 m)	Approximately 1.9 kg
pH	Measuring principle	Glass electrode method
● Two-point calibration	Range	pH0 to 14
● Automatic temperature compensation	Resolution	0.01 pH
	Repeatability	±0.05 pH
	Accuracy	±0.1 pH
Dissolved-Oxygen	Measuring principle	Diaphragm galvanic battery method
● Salinity conversion (0 to 40 ppt/Auto)	Range	0 to 19.99 mg/L
● Automatic temperature compensation	Resolution	0.01 mg/L
	Repeatability	±0.1 mg/L
	Accuracy	±0.2 mg/L
Conductivity	Measuring principle	4 AC electrode method
● Auto range	Range	0 to 9.99 S/m
● Automatic temperature conversion (25 °C)	Resolution	0.1 % of full scale
	Repeatability	±1 %
	Accuracy	±3 %
Salinity	Measuring principle	Conductivity conversion
	Range	0 to 4 %
	Resolution	0.01 %
	Repeatability	±0.1 %
	Accuracy	±0.3 %
Total Dissolved Solid(TDS)	Measuring principle	Conductivity conversion
● Conversion factor setting	Range	0 to 99.9 g/L
	Resolution	0.1 % of full scale
	Repeatability	±2 g/L
	Accuracy	±5 g/L
Seawater specific gravity	Measuring principle	Conductivity conversion
● Display σ_t, σ_0, σ_{15}	Range	0 to 50 σ_t
	Resolution	0.1 σ_t
	Repeatability	±2 σ_t
	Accuracy	±5 σ_t
Temperature	Measuring principle	Thermistor method
	Range	0 to 55 °C
	Resolution	0.01 °C
	Repeatability	±0.3 °C
	Accuracy	±1.0 °C

		U-22XD
Turbidity (TURB)	Measuring principle	Penetration and scattering method
● Unit selection	Range (NTU or mg/L)	0 to 800 NTU
	Resolution	0.1 NTU
	Repetability	±3 %
	Accuracy	±5 %
Water depth	Measuring principle	Pressure method
	Range	0 to 100 m
	Resolution	0.1 m
	Repetability	±3 %
	Accuracy	±5 %
Oxidation-reduction potential (ORP)	Measuring principle	Platinum electrode method
	Range	± 1999 mV
	Resolution	1 mV
	Repetability	± 5 mV
	Accuracy	±15 mV
Simultaneous measurement items		10

Note: The accuracy rating value is obtained from measurements at intermediate point of the standard solution after two-point calibration (at room temperature and pressure). The repeatability and accuracy rating percentages are based on the full scale (except for salinity).

*1: Organic solvents, strong acids, and strong alkaline solvents cannot be measured.

*2: Based on the data measured automatically at 15 minutes intervals. The battery life taken into account. Periodical maintenance and calibration is necessary when a lot of shellfishes and seaweeds exist at the measurement point.

7.4 Spare parts

Sensors

Sensor	Model	Spare part number
pH sensor	6230	9037-0056-00
pH/ORP sensor	6280	9037-0057-00
DO sensor	5460	9037-0058-00

Standard and internal solutions

Solution	Model	Spare part number	Remark
pH 4 standard solution (500 mL)	100-4	9003-0016-00	Standard solution for AUTO calibration, which is in addition used for manual pH span calibration.
pH 7 standard solution (500 mL)	100-7	9003-0017-00	Standard solution for pH zero calibration
pH 9 standard solution (500 mL)	100-9	9003-0018-00	Standard solution for manual pH span calibration
Powder for ORP standard solution (250 mL × 10)	160-51	9003-0031-00	Powdered standard solution to be used for checking ORP behavior
Powder for ORP standard solution (250 mL × 10)	160-22	9003-0030-00	
pH reference internal solution (250 mL)	330	9037-0052-00	Replenishment internal solution for pH reference electrode

Others

	Model	Spare part number	Remark
Calibration beaker XD	–	9037-0086-00	This is similar to the standard accessory, and used for sensor calibration.
Connector plug for the prove	–	9037-0071-00	When using the probe separately from the instrument, this is used to maintain waterproof of the connector.
Sensor spanner	–	9037-0088-00	This is used to connect the sensor to the probe. Similar to the standard accessory.
DO diaphragm replacement kit	–	9037-0074-00	In case of breakage of the DO sensor diaphragm, it is used in the replacement of the diaphragm to restore the sensor.
Battery cover packing	–	9096-0013-00	Replacement packing to be used for battery box of the main unit.
System unit cover O-ring	–	9096-0014-00	Replacement packing to be used for EXT cover of the main unit.
Sensor O-ring	–	9037-0076-00	Replacement O-ring to be used for connector of pH/ORP sensor and Do sensor.
Probe cap XD	–	9037-0087-00	This cap is to be used when storing the sensor probe.
Battery caver O-ring	–	9037-0084-00	This replacement O-ring is used for the sensor probe's battery cover.
Silicon grease	–	9037-0085-00	This silicon grease is applied on the sensors' O-rings. Similar to the standard accessory.
Protection cover packing	–	9037-0091-00	This is packing for when taking off the probe cap and seal after installing the protection cover. (board packing and O-ring set)
Sponge	–	9037-0089-00	This replacement sponge is used for the probe cap XD.
Protection cap	–	9037-0090-00	This cap is to be attached to the protection cover.

* The spare parts above are prepared by dealers.
Order the part by designating the parts name, model and spare parts number.

7.5 Option

Parts name	Model	Remark
Expansion adaptor	U-2001	This is applicable to AC adapter connection, RS-232C communication, GPS connection, printer output, and data-collecting software.
System unit *	U-2002-100V U-2002-110V U-2002-220V	This is applicable to AC adapter connection, RS-232C communication, GPS connection, printer output, and data-collecting software. GPS and printer are included in a complete set.
AC adaptor (for 100 V)	AC-10	AC adapter intended to drive the U-20 series by AC power supply. This should be used together with U-2001 and U-2002.
Carrying case	W-2010	Compact carrying case for cable below 10 m in length . Not large enough to hold flow cell or guard.
Carrying case	W-2030	Bigger-sized carrying case for cable exceeding 30 m in length. Large enough to hold flow cell.
Flow cell	W-2100	To be used for measurement at a pumping up sample.
Probe guard	W-2200	To be used for measurement at a location where there is a flow or a location with a thick sludge layer residing at the bottom.
PC connection cable	—	Nine-pin connection cable to PC.

* Specify the power source and voltage of the printer when ordering.

8. Reference Data

● pH measurement

1. Principle of pH measurement

U-20XD series use the glass electrode method for pH measurements. The glass electrode method measures a potential difference between the glass film for pH and the comparison electrode. For more information, refer to JIS Z 8802 pH measurement method.

2. Temperature compensation

The electromotive force generated by the glass electrode changes depending on the temperature of the solution. Temperature compensation is used to compensate for the change in electromotive force caused by temperature.
This function does not compensate the change in pH caused by the temperature of the solution. When pH is to be measured, the temperature of the solution when the pH is measured must be recorded along with that pH value, even if a meter that has automatic temperature compensation is used. If the solution temperature is not recorded, the results of the pH measurement may be meaningless.

3. Types of standard solutions

When measuring pH, the pH meter must be calibrated using a standard solution. There are five kinds of standard solutions specified in "JIS 28802 pH measurement". For normal measurement, two of standard solutions with a pH of 4, 7, and 9 are sufficient to accurately calibrate the meter.
For standard solutions, refer to "JIS Z 8802 pH measurement".

pH 4 standard solution .... 0.05 mol/L potassium hydrogen phthalate aqueous solution
(Phthalate)
pH 7 standard solution .... 0.025 mol/L potassium dihydrogenphosphate, 0.025 mol/L sodium phospate aqueous solution
(Neutral phosphate)
pH 9 standard solution .... 0.01 mol/L tetra-sodium boric acid aqueous solution
(Borate)

pH values of pH standard solutions at various temperatures settings.

Temp. (˚C)	pH 4 standard solution Phthalate	pH 7 standard solution Neutral phosphate	pH 9 standard solution Borate
0	4.01	6.98	9.46
5	4.01	6.95	9.39
10	4.00	6.92	9.33
15	4.00	6.90	9.27
20	4.00	6.88	9.22
25	4.01	6.86	9.18
30	4.01	6.85	9.14
35	4.02	6.84	9.10
40	4.03	6.84	9.07
45	4.04	6.84	9.04

4. Supplements for pH measurement

Pressure compensation diaphragm

U-20XD series can measure pH with high accuracy through the pressure compensation diaphragm without being affected by hydraulic pressure. Attention should be paid to the following points so that the diaphragm may function fully.
Before measurement, use a syringe and fill the reference electrode up to the replenish port with the internal solution. When injecting the polarity reference internal solution, be careful that air bubbles do not get into the solution.

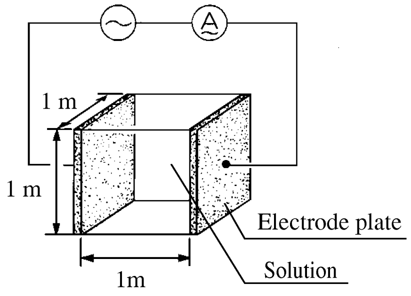
● COND measurement

1. Four-AC-electrode method

Conductivity is an index of the flow of electrical current in a substance.

Salts dissolved in water are separated into cations and anions. Such solution is called electrolytic solution. Electrolytic solution has the property of allowing the flow of current according to Ohm's law. This property is referred to as ionic conductivity, since current flow is caused by ion movement in electrolytic solution. Metals, on the other hand, allow the flow of current by means of electrons. This property is called electronic conductivity, which is distinguished from ionic conductivity.

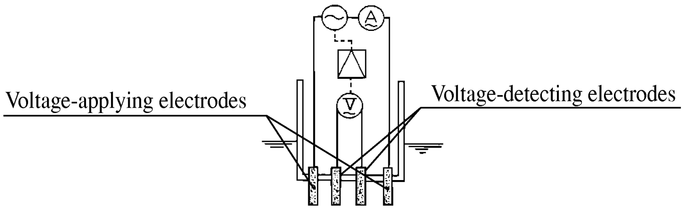
A cube with 1 m on each side, as shown in Fig. 1, is used to demonstrate an electrolytic solution. Two electrode plates are placed on opposite sides, and the cube is filled with a solution. If the resistance between these two electrode plates is represented by r (Ω), the conductivity of the solution L ($S.m^{-1}$) is represented as L=1/r. S stands for Siemens, a unit of measurement of conductance.



(Fig. 1 Definition of conductivity)

The most general method for measuring conductivity is based on the above principle, and is called the 2-electrode method. In the 2-electrode method the influence of polarization cannot be ignored for solutions with high conductivity and conductivity cannot be measure accurately. In addition, contamination on the surface of the electrode increases apparent resistance, resulting in inaccurate measurement of conductivity.

The U-20XD series has adopted the 4-electrode method to overcome these disadvantages of the the 2-electrode method. As shown in Fig. 2, the U-20XD series uses two voltage-detecting electrodes and two voltage-applying electrodes, for a total of four electrodes. The voltage-detecting electrodes are for detecting AC voltage, and the voltage-applying electrodes are for applying AC voltage.



(Fig. 2 Principle of the 4-electrode method)

Let us assume that the current, I (A), flows in a sample of conductivity L – under automatic control of the voltage-applying electrodes – so that the voltage at the voltage detecting-electrodes, E (V), remains constant at all times. Then, the resistance of the sample, R (Ω), across the voltage-detecting electrodes is represented as R=E/I. The resistance, R, of the sample is inversely proportional to its conductivity, L. Accordingly, a measurement of conductivity, Is, of a standard solution of known conductivity, Ls, enables calculation of conductivity of a sample according to the formula L = Ls (I/Is) from the ratio L : Ls = I : Is.

Even in the 4-electrode method, polarization occurs, since AC current flows in the voltage-applying electrodes. The voltage-detecting electrodes are, however, free from the effects of polarization, since they are separated from the voltage-applying electrodes, and furthermore, current flow is negligible. Therefore, the 4-electrode method is an excellent method to enable measurement of conductivity covering a very high range.

2. SI units

New measurement units, called SI units, have been in use from 1996. Accordingly, the U-20XD series also uses SI units. The following conversion table is provided for people who use the conventional kind of conductivity meter. Note that along with the change in unit systems, the measurement values and cell counts have also changed.

	Former units	→	SI units
Measurement value	0.1 mS/cm	→	0.01 S/m
	1 mS/cm	→	0.1 S/m
	100 mS/cm	→	10 S/m

3. Temperature coeffcient

In general, the conductivity of a solution varies largely with its temperature. The conductivity of a solution depends on the ionic conductivity, described earlier. As the temperature rises, conductivity becomes higher since the movement of the ions becomes more active. The temperature coefficient shows the change in % of conductivity per °C, with a certain temperature taken as the reference temperature. This is expressed in units of %/°C. The temperature coefficient assumes the premise that the conductivity of a sample changes linearly according to temperature. Strictly speaking, with actual samples, however, conductivity changes along a curve. Furthermore, the cuve varies with the type of sample. In the ranges of smaller temperature changes, however, samples are said to have the temperature coefficient of 2 %/°C (at reference tempreture 25 °C) this holds for most samples, except in certain special cases.
(The temperature coefficients for various types of solutions are listed on the next page.)
The U-20XD series uses an automatic temperature conversion function to calculate conductivity at 25 °C at a temperature coefficient of 2 %/°C, based on the measured value of the temperature. Results are displayed on the readout.
The U-20XD series's temperature conversion function is based on the following formula.

$$L_{25} = L_t / \{ 1 + K (t - 25) \}$$

L_{25} : Conductivity of solution converted to 25 °C
(value displayed on U-20XD series)
t : Temperature of solution at time of measurement (°C)
L_t : Conductivity of solution at t (°C)
K : Temperature coeffcient (%/°C)

Conductivity and temperature coefficient for various types of solutions

Conductivity and related temperature coefficients of representative substances (at 25 °C) are shown in the table below.

Substance	Concentra -tion wt%	Conducti -vity S/m	Temperature coeffcient %/°C	Tempera -ture °C
NaOH	5	19.69	2.01	15
	10	31.24	2.17	
	15	34.63	2.49	
	20	32.70	2.99	
KOH	25.2	54.03	2.09	15
	29.4	54.34	2.21	
	33.6	52.21	2.36	
	42	42.12	2.83	
NH_3	0.1	0.0251	2.46	15
	1.6	0.0867	2.38	
	4.01	0.1095	2.50	
	8.03	0.1038	2.62	
HCl	5	39.48	1.58	18
	10	63.2	1.56	
	20	76.15	1.54	
	30	66.20	1.54	
H_2SO_4	5	20.85	1.21	18
	10	39.15	1.28	
	20	65.27	1.45	
	40	68.00	1.78	
	50	54.05	1.93	
	60	37.26	2.13	
	100.14	1.87	0.30	
HNO_3	6.2	31.23	1.47	18
	12.4	54.18	1.42	
	31	78.19	1.39	
	49.6	63.41	1.57	
H_3PO_4	10	5.68	1.04	15
	20	11.29	1.14	
	40	20.70	1.50	
	45	20.87	1.61	
	50	20.73	1.74	
NaCl	5	6.72	2.17	18
	10	12.11	2.14	
	15	16.42	2.12	
	20	19.57	2.16	
	25	21.5	2.27	

Substance	Concentra -tion wt%	Conducti -vity S/m	Temperature coeffcient %/°C	Tempera -ture °C
Na_2SO_4	5	4.09	2.36	18
	10	6.87	2.49	
	15	8.86	2.56	
Na_2CO_3	5	4.56	2.52	18
	10	7.05	2.71	
	15	8.36	2.94	
KCl	5	6.90	2.01	18
	10	13.59	1.88	
	15	20.20	1.79	
	20	26.77	1.68	
	21	28.10	1.66	
KBr	5	4.65	2.06	15
	10	9.28	1.94	
	20	19.07	1.77	
KCN	3.25	5.07	2.07	15
	6.5	10.26	1.93	
NH_4Cl	5	9.18	1.98	18
	10	17.76	1.86	
	15	25.86	1.71	
	20	33.65	1.61	
	25	40.25	1.54	
NH_4NO_3	5	5.90	2.03	15
	10	11.17	1.94	
	30	28.41	1.68	
	50	36.22	1.56	
$CuSO_4$	2.5	10.90	2.13	18
	5	18.90	2.16	
	10	32.00	2.18	
	15	42.10	2.31	
CH_3COOH	10	15.26	1.69	18
	15	16.19	1.74	
	20	16.05	1.79	
	30	14.01	1.86	
	40	10.81	1.96	
	60	4.56	2.06	

Introduction
Before use
Basic operation
Using the data memory function
Techniques for more accurate measurement
Using the various functions
Instrument specifications
Reference data

● SAL conversion

The U-20XD series is designed to measure salinity as well as the other parameters.

Note that the "salinity" referred to here is the salinity of sea water. There is a constant relation between conductivity and salinity at certain temperatures.

Therefore, if data on the conductivity and temperature are available, the corresponding salinity is known. In other words, the salinity measurement of the U-20XD series is based on the principle of calculating the salt content, making use of the measured values of conductivity and temperature.

Note therefore, that measured results of all substances whose conductivity is detected are displayed as salinity. For example, the measured result is displayed as NaCl concentration, even if in fact the sample component is, for example, hydrochloric acid (HCl).

● TDS conversion

TDS is short for Total Dissolved Solids and means the total dissolved solid amount.

The conductivity of a solution is affected by the amount of salinity, minerals, and dissolved gases. That is, conductivity is an index that shows the total amount of all substances in the solution. Of these substances, TDS indicates only the amount of dissolved solids.

TDS can be used for a comparison of the state of substances composed of a single component such as NaCl. However, the use of TDS for the comparison of solutions of different types causes serious errors.

Conductivity and TDS are expressed by the following formulas:

Conductivity in SI units (S/m) .... TDS(g/L) = L (S/m) × K × 10
TDS(g/L) = L (mS/m) × K ÷ 100
Conductivity in the old units (mS/cm) .... TDS(g/L) = L (mS/cm) × K
K = TDS coefficient

Initial settings use the values listed in the table (☞ Page 70) that generally uses TDS coefficients.

For accurate TDS comparisons, find the TDS coefficient from measured conductivity values. Then set the value thus obtained and make measurements.

● σ_t conversion

Specific gravity of seawater

The density and specific gravity of seawater are equal numerically and generally are not distinguished strictly. Since seawater density ρ is between 1.000 and 1.031, 1 is subtracted from ρ and σ is obtained by multiplying the value by 1000.

The resultant value is used as the specific gravity of seawater.

$$\sigma = (\rho - 1) \times 1000$$

The density of seawater ρ is expressed by temperature, hydraulic pressure, and salinity functions. The density of seawater σ under the atmospheric pressure is expressed as σ_t. The density of seawater under the atmospheric pressure is determined by temperature and salinity.

The U-20XD series models make salinity measurement through temperature measurements and conductivity conversion and find σ_t through calculations.

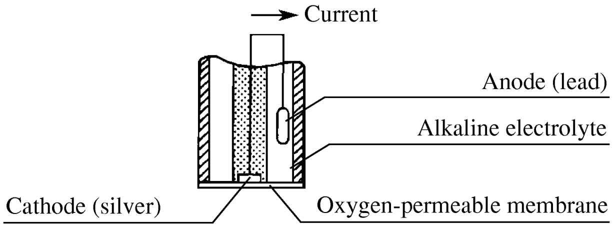
In Japan σ_{15} at 15 °C is called a standard specific gravity and widely used while in foreign countries σ_0 at 0 °C is employed. σ_{15} and σ_0 are determined by the function of salinity.

In ocean surveys, in particular, these values σ_t, σ_{15}, and σ_0 are more widely used than conductivity and salinity and, in the U-20XD series models, newly added as measurement components.

● DO measurement

1. Principle of measurement

The “DO” referred to here means the concentration of oxygen dissolved in water. DO is essential to self-purification of river and sea and to water creatures such as fish. DO measurement is also essential to drainage and water quality control.
Fig. 3 shows the principle of measurement using a DO sensor.



(Fig. 3 Principle of DO sensor)

A noble metal (silver) is fitted closely to an oxygen-permeable membrane to make the cathode; a base metal (lead) is used as the anode. Both are immersed in an alkaline electrolyte with the anode-to-cathode external circuit closed. Oxygen diffusing through the oxygen-permeable membrane causes a reduction reaction at the cathode; this allows flow of current in the external circuit:

$$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$$

At the anode, oxidation reaction occur as follows:

$$2Pb \rightarrow 2Pb2^+ + 4e^-$$

The current is proportional to the quantity of oxygen diffusing through the oxygen-permeable membrane. Accordingly, measurement of the current makes the DO in a sample known.
The DO measuring method based on this principle is called the membrane-electrode method. This method allows convenient measurement of DO, especially when compared with chemical-analysis method, which needs complicated pre-treatment to eliminate the effects of oxidizing or reducing substances.

2. DO correction for salinity

When a solution and air are in contact and in complete equilibrium (saturated), DO: C [mg/L] in the solution, and the oxygen partial-pressure: Ps [MPa] in air are in the following relation:

$$C = Ps/H$$

H [MPa/ (mg/L)] is referred to as Henry’s constant, which depends on the composition of the solution. In general, C becomes smaller as the salinity in the solution increases, since H becomes larger.
A DO sensor is intended to detect Ps in the above expression. Therefore, the DO measurement would be in error if the DO sensor were immersed either in air-saturated pure water or in solution with salt. To settle this problem, it is necessary to correct the DO reading based on the salinity of the sample using salinity correction.
Conventional DO meters make this salinity correction by inputting a known salinity value. This poses no problems if the salinity of the sample is known. In general, however, the salinity of the sample is usually not known, and the method is not practical even if the DO meters are equipped with the salinity correction function.
The U-20XD series is capable of measuring the salinity of a sample and automatically correcting the using this function.

3. Features of the U-20XD series DO sensors

In conventional DO measurements, it was necessary to keep the velocity of the flow constant because the velocity of flow led to fluctuation in indicated values. In our U-20XD series models, improvements in sensors have made it possible to make measurements with stable indications and with little influence of the velocity of flow.

● Turbidity (TURB) measurement

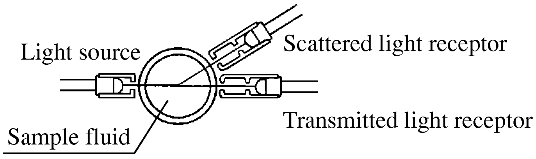
1. Principle of measurement

From among several types of turbidity-measuring methods available, the U-20XD series uses the light-transmission-scattering method, shown in Fig. 4.

Irradiation of a beam of light onto a sample brings about separation of the beam into (1) the light transmitted through the solution and (2) the light scattered by turbidity components in the sample. In the light-transmission-scattering method, the intensity of both transmitted light and the scattered light are measured using separate receptors, and the turbidity is obtained based on the ratio of the two.

With the U-20XD series, the light source is a pulse-lighting infrared-emission diode. The scattered light is measured at a point 60° offset from the light source. This light-absorption-scattering method has several advantages, including the fact that (1) the actual color of the sample fluid has little effect on the measurement of turbidity, (2) fluctuations in light quantity from the light source are easily compensated for, and (3) it allow the U-20XD series to be operated with relatively low-power consumption.

The turbidity value differs with the structure of the cell so changes with the instrument.



(Fig. 4 Principle of the light-transmission-scattering method)

2. Standard solution

U-20XD series can perform calibration using formazin (NTU) or kaolin standard solutions as a turbidity standard solution. However, units for the solution used for calibration should be displayed in measurements. Do not use more than 400 mg/L of kaolin standard solution because it increases precipitation speed, resulting in measurement error.

● DEP measurement

1. Depth (DEP) measurement

For the U-22XD model, depth measurement can be made through use of a pressure gauge. The principle of the depth measurement uses the relation between depth and pressure.

Although the measurement with the depth sensor is affected by atmospheric pressure, the depth sensor, however, makes zero-point adjustments through the automatic calibration before measurements.

2. Influence of temperature and calibration

The depth sensor depends greatly on temperature. For a wide difference between the temperature at which the sensor has been automatically calibrated and the temperature of the measurement sample, the sensor can make depth measurements with a higher accuracy by the following method:

Immerse the depth sensor of the sensor probe into the sample.

Keep the sensor immersed in the sample for approximately 30 minutes until the temperatures of the sensor and the sample are the same.

Then make the zero calibration of the sensor manually. (☞ Page 57)

● Measuring mV (oxidation-reduction potential (ORP))

ORP principles

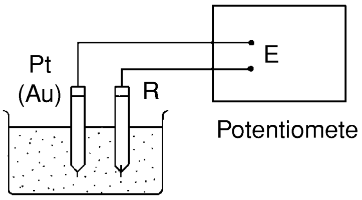
ORP (or “redox potential”) is an abbreviation for oxidation-reduction potential. ORP is the energy level (potential) determined according to the state of equilibrium between the oxidants (M^{Z+}) and reductants $M^{(Z-N)+}$) that coexist within a solution.

$M^{z+} + ne^{-} \Leftrightarrow M^{(z-n)+}$............①

If only ① exists within a solution, a metal electrode (platinum, gold, etc.) and a reference electrode are inserted into the solution, forming the ORP measuring system shown in Fig. 5. Measuring the potential (ORP) that exists between the two electrodes enables the potential to generally be expressed by the following equation.

$$E = E_0 - \frac{RT}{nF} \ln \frac{a_{M^{(z-n)+}}}{a_{M^{z+}}} \quad ..... ②$$

E: Electric potential
E_0 : Constant
R : Gas constant
T : Absolute temperature
n : Electron count
F : Faraday constant
a : Activity



(Fig. 5 Measuring mV)

For example, for a solution in which trivalent iron ions coexist with bivalent iron ions, equations ① and ② would be as follows.

$Fe^{3+} + e^{-} \Leftrightarrow Fe^{2+}$..............①

$$E = E_0 - \frac{RT}{F} \ln \frac{a_{Fe^{2+}}}{a_{Fe^{3+}}} \quad .....②$$

When only one type of state of equilibrium 1 exists in the solution, the ORP of the solution can be determined uniquely by equation 2. What is important here is that ORP is determined by the ratio of activity between the oxidant (Fe^{3+}) and the reductant (Fe^{2+}) (using the equation $a_{Fe}{}^{2+}/a_{Fe}{}^{3+}$). Actually, however many kinds of states of equilibrium exist simultaneously between various kinds of ions, in most solutions. This means that under actual circumstances, ORP cannot be expressed using the simple equation shown above and that the physical and chemical significance with respect to the solution is not very clear.

In this respect, the value of ORP must be understood to be only one indicator of the property of a solution. The measurement of ORP is widely used, however, as an important index in the analysis of solutions (potentiametric titration) and in the disposal and treatment of solutions.

Recently, there have appeared various claims regarding this matter, such as that a high degree of ORP is effective in sterilization or that drinking water that has a low ORP reduces the chance of illness by reacting with the activated oxygen in the cells of the body. ORP is used as an index for alkaline drinking water.

Standard electrode (reference electrode) types and ORP

The ORP of a solution that is obtained through measurement is a value that corresponds to the reference electrode employed.

If different kinds of reference electrodes are used for measurement, the ORP value of the same solution may appear to be different. HORIBA uses Ag/AgCl with 3.33 mol/L KCl as the reference solution for reference electrodes. According to general technical literature, standard hydrogen electrodes (N.H.E.) are often used as the standard electrode.

The relationship between N.H.E. and the ORP that is measured using an Ag/AgCl with 3.33 mol/L KCl electrode is expressed by the following equation.

$E_{\text{N.H.E.}} = E + 206 - 0.7\,(t - 25)\text{mV} \qquad t = 0 - 60\,℃$

$E_{\text{N.H.E.}}$: Measured ORP value using N.H.E. as the reference electrode

E: Measured ORP value using Ag/AgCl with 3.33 mol/L KCl as the reference electrode

Potential sign

Standard ORP is expressed in the following way, in literature related to electrochemistry and analytical chemistry.

A $Li^{+} + e^{-} \rightarrow Li$

$E0 = -3.024$ V VS N.H.E.

However, in some literature, the "+" and "-" signs are reversed.

B $Li \rightarrow Li^{+} + e^{-}$

$E0 = +3.024$ V VS N.H.E.

In expressions like B, above, the reaction is just reversed and there is no essential difference. But this kind of expression does invite confusion. The majority of the world, today, is consistent in its use of the signs as they are used in A, above. For this reason, HORIBA, too, uses signs concerning ORP that are consistent with A, above.

表 3

表4

For any question regarding this product,
please contact your local agency,
or inquire from the Customer Registration
website (www.horiba.co.jp/register).

HORIBA, Ltd.

First edition: November 2001
CODE : I1000908000

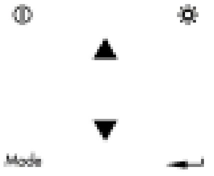
FIELD OPERATION GUIDE
YSI 550 DO INSTRUMENT

TURNING THE INSTRUMENT ON

The YSI 550 DO keypad consists of six keys. There are four function keys, and one up and one down arrow keys. The top left key that has a green circle and line is the ON/OFF key. The top right key is the back light. The bottom left is the Mode key, and the bottom right is the Enter key.

Turn the instrument on by pressing and releasing the **ON/OFF** button on the front of the instrument.

NOTE: Since the probe has not yet been prepared, the data on the display will be inaccurate.



The light key is at the top right of the keypad. Pushing the **LIGHT** key will turn on or off the back light. The light will power off automatically after two minutes of non-use.

CHANGING THE TEMPERATURE UNITS

The YSI 550 DO Instrument can display the temperature units in either Fahrenheit or Celsius. To change the units that are displayed, turn the instrument on. Pressing both the down arrow keys and the mode key at the same time will switch the units between C or F.

CHOOSING THE RIGHT MEMBRANE

The YSI 5906 Standard Membrane Kit is supplied with the YSI 550 DO Instrument. This kit contains six cap membranes and a bottle of electrolyte solution. YSI recommends the 5906 membranes for all applications.

MEMBRANE CAP INSTALLATION

To install a new membrane cap on your YSI 550 dissolved oxygen probe:

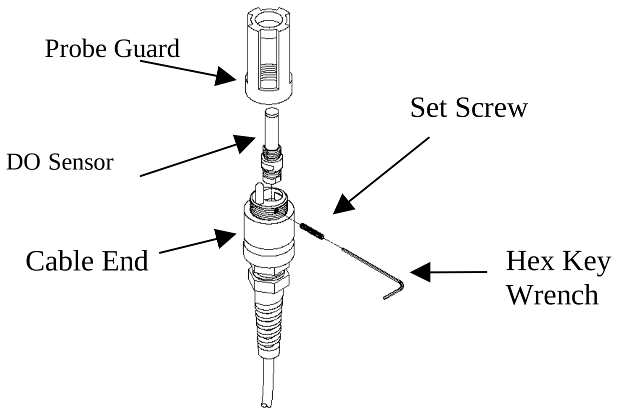
Unscrew and remove the probe sensor guard.

1. Unscrew and remove the old membrane cap.
2. Thoroughly rinse the sensor tip with distilled or DI water.
3. xPrepare the electrolyte according to the directions on the solution bottle.Hold the membrane cap and fill it at least 1/2 full with the electrolyte solution.
4. Screw the membrane cap onto the probe moderately tight. A small amount of electrolyte should overflow.
5. Screw the probe sensor guard on moderately tight.

CAUTION: **Do not touch the membrane surface.**

HOW TO REPLACE THE DO PROBE TIP

In the YSI 559 dissolved oxygen module replacement kit YSI supplies a YSI 559 DO Sensor, a YSI 5906 membrane kit, the set screw that holds the sensor in place, a hex key wrench to help install the probe, and an instruction sheet.



1. Remove probe guard.

2. **IMPORTANT:** Thoroughly dry the sensor so that no water enters the probe port when the sensor is removed.

3. Insert the long end of the hex key wrench into the small hole in the side of the DO sensor module. Turn the wrench counter clockwise and remove the screw. (You do not have to remove the screw all the way to release the sensor.)

4. Pull the DO sensor out of the module. The DO sensor is keyed, or has a flat side, so that it can not be removed improperly.

5. Insert the new probe. Make sure that the inside of the module, and the o-ring of the sensor are clean, with no contaminants, such as grease, dirt, or hair. The DO sensor is keyed, or has a flat side, so that it can not be installed improperly.

6a. **IF you did not remove the screw all the way in Step 3:** Use the hex key wrench to tighten the screw in properly, making sure that the screw does not stick out on either side of the DO sensor module.

6b. **IF you removed the screw all the way in Step 3:** Insert the set screw into the small hole in the side of the DO sensor module, and turn clockwise to rethread.

7. The YSI 559 DO module is shipped dry. **Before using the YSI 550 with a new YSI 559 sensor, the protective membrane on the probe tip must be removed, the membrane cap must be filled with electrolyte solution and a new membrane must be installed.** Follow the instructions below to install the electrolyte solution and membrane.

8. Insert the new probe. Make sure that the inside of the module, and the o-ring of the sensor are clean, with no contaminants, such as grease, dirt, or hair. The DO sensor is keyed, or has a flat side, so that it can not be installed improperly.

> **CAUTION:** Make sure that you do not cross-thread the screw. Use the hex key wrench to tighten the screw in properly, making sure that the screw does not stick out on either side of the cable end. The probe guard will not thread on properly and damage may result if the screw is allowed to stick out on either side of the cable end.

THE CALIBRATION PROCESS

Before you calibrate the YSI 550 DO Instrument complete the procedures discussed **in Section 2, Preparing the YSI 550** and **Section 3, Preparing the Probe**.

Note: While testing to EN-61000-4-6, Conducted RF Immunity, per Table A.1 of EN61326, Electrical Equipment for Measurement, Control and Laboratory Use, the YSI 550 exhibited an ERROR 8 message from 8.6 MHz 22.8 MHz at induced RF voltages of 3-Volts to 1-Volt RMS on the 25-foot probe cable. If you observe this interference please relocate the probe-cable away from heavy industrial equipment power and control cables or communications equipment cables which may be causing the interference.

To accurately calibrate the YSI 550, you will need to know the following information:

- The approximate salinity of the water you will be analyzing. Fresh water has a salinity of approximately zero. Seawater has a salinity of approximately 35 parts per thousand (ppt). If you are uncertain what the salinity of the sample water, use a YSI 30 Salinity-Conductivity-Temperature instrument to determine salinity.

- IF you are going to calibrate in % saturation mode, you need to know the approximate altitude of the region where you are located.

1. Ensure that the sponge inside the instrument's calibration chamber is moist. Insert the probe into the calibration chamber.

2. Turn the instrument on by pressing the **ON/OFF** button on the front of the instrument. Wait for the dissolved oxygen and temperature readings to stabilize (usually 15 minutes is required after turning the instrument on).

3. To enter the calibration menu, use two fingers to press and release both the **UP ARROW** and **DOWN ARROW** keys at the same time.

TO CALIBRATE IN MG/L:

To switch between mg/L and percent saturation to be displayed as the oxygen readings units, press the Mode key. Either a “mg/L” or “%” will be displayed on the right side of the screen.

4. Make sure that the DO reading (large display) is stable, then press the **ENTER** button. The YSI 550 DO instrument should now display **CAL** in the lower left of the display, the calibration value should be displayed in the lower right of the display and the current DO reading (before calibration) should be on the main display.

5. Make sure that the DO reading (large display) is stable, then press the **ENTER** button. The LCD will prompt you to enter the approximate salinity of the water you are about to analyze. You can enter any number from 0 to 40 parts per thousand (PPT) of salinity. Use the arrow keys to increase or decrease the salinity setting. When the correct salinity appears on the LCD (zero for fresh water), press the **ENTER** key. The instrument will return to normal operation.

Once the calibration process is complete, the only keys that will remain operational are the **MODE** key, the **LIGHT** key and the **ON/OFF** key. You can move back and forth from reading dissolved oxygen in the mg/L mode or the % air saturation mode by pressing the **MODE** key. If you are working in a dark area and have difficulty reading the LCD, press the **LIGHT** key to activate the back-light of the YSI 550. The **ON/OFF** key turns the instrument on or off.

For best results:

- Each time the YSI 550 DO Instrument is turned off, re-calibrate before taking measurements.
- Calibrate at a temperature within ±10°C of the sample temperature.

TO CALIBRATE IN % SATURATION:

To switch between mg/L and percent saturation to be displayed as the oxygen readings units, press the Mode key. Either a “mg/L” or “%” will be displayed on the right side of the screen.

4. IF you are calibrating in % saturation mode, the LCD will prompt you to enter the local altitude in hundreds of feet. Use the arrow keys to increase or decrease the altitude.

EXAMPLE: Entering the number 12 here indicates 1200 feet.

6. When the proper altitude appears on the LCD, press the **ENTER** key. The YSI 550 DO Instrument should now display **CAL** in the lower left of the display, the calibration value should be displayed in the lower right of the display and the current DO reading (before calibration) should be on the main display.

7. Make sure that the DO reading (large display) is stable, then press the **ENTER** button. The LCD will prompt you to enter the approximate salinity of the water you are about to analyze. You can enter any number from 0 to 40 parts per thousand (PPT) of salinity. Use the arrow keys to increase or decrease the salinity setting. When the correct salinity appears on the LCD (zero for fresh water), press the **ENTER** key. The instrument will return to normal operation.

Once the calibration process is complete, the only keys that will remain operational are the **MODE** key, the **LIGHT** key and the **ON/OFF** key. You can move back and forth from reading dissolved oxygen in the mg/L mode or the % air saturation mode by pressing the **MODE** key. If you are working in a dark area and have difficulty reading the LCD, press and hold the **LIGHT** key to activate the back-light of the YSI 550. The **ON/OFF** key turns the instrument on or off.

For best results:

- Each time the YSI 550 DO Instrument is turned off, re-calibrate before taking measurements.
- Calibrate at a temperature within ±10°C of the sample temperature.

CONVERSION CHART

To Convert From	To	Equation
Feet	Meter	Multiply by 0.3048
Meter	Feet	Multiply by 3.2808399
Degrees Celsius	Degrees Fahrenheit	(°C × 9/5) + 32
Degrees Fahrenheit	Degrees Celsius	(°F - 32) × 5/9
Milligrams per liter (mg/L)	Parts per million (ppm)	Multiply by 1

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Item #655127
Drawing #A655127
Revision A
March 2000

YSI Environmental

Pure
Data for a
Healthy
Planet.™

YSI 550A
Dissolved Oxygen Instrument

Operations
Manual

CONTENTS

GENERAL DESCRIPTION

The YSI 550A Handheld Dissolved Oxygen Instrument is a rugged, microprocessor based, digital instrument with a field-replaceable YSI dissolved oxygen probe. The YSI 550A DO Instrument is impact-resistant and waterproof.

The YSI 550A DO Instrument is designed for field use and is available with cable lengths of 12, 25, 50, or 100 feet (3.5, 7.5, 15, 30.5 meters). The body of the probe has been manufactured with stainless steel to add rugged durability and sinking weight. The large Liquid Crystal Display (LCD) is easy to read and is equipped with a backlight for use in dark or poorly lighted areas.

The YSI 550A DO Instrument can be easily calibrated with the press of a few keys. Additionally, the instrument's microprocessor performs a self-diagnostic routine each time the instrument is turned on. The self-diagnostic routine provides you with useful information about the function of the instrument circuitry and the quality of the readings you obtain.

The system displays temperature in either ^{o}C or ^{o}F and dissolved oxygen in either mg/L (milligrams per liter) or % air saturation. The system requires only a single calibration regardless of which dissolved oxygen display is used, and will calibrate in either mode. Salinity compensation values can be changed at any time without performing a new calibration.

A detachable calibration chamber is mounted to the back of the instrument. A small sponge in the chamber can be moistened to provide a water saturated air environment that is ideal for air calibration. This chamber is also designed for transporting and storing the probe. When the probe is stored in the chamber, the moist environment will prolong effective membrane performance and probe life.

The YSI 550A DO Instrument is powered by 4 C-size alkaline batteries. A new set of alkaline batteries will provide approximately 2000 hours of continuous operation. If the backlight is used often, batteries will be depleted faster.

The YSI 550A case is waterproof with an IP-67 rating. The instrument is 100% corrosion proof and can be operated in a wet environment without damage to the instrument.

INITIAL INSPECTION

When you unpack your new YSI 550A DO Handheld Instrument for the first time, check the packing list to make sure you have received everything. If there is anything missing or damaged, call the dealer from whom you purchased the YSI 550A. If you do not know which authorized dealer sold the system to you, call YSI Customer Service at 800-897-4151 or 937-767-7241.

WARRANTY REGISTRATION

Please complete the Product Registration on the YSI website at www.ysi.com. If you are not online, you may complete the Warranty Card included with your instrument and return it to YSI Incorporated. Your purchase of this quality instrument will then be recorded in YSI's customer database. Once your purchase is recorded, you will receive prompt, efficient service in the event any part of your YSI 550A DO Instrument should ever need repair.

WARRANTY

The YSI 550A DO Instrument is warranted for three years from date of purchase by the end user against defects in materials and workmanship. YSI 550A DO probes and cables are warranted for one year from date of purchase by the end user against defects in material and workmanship. Within the warranty period, YSI will repair or replace, at its sole discretion, free of charge, any product that YSI determines to be covered by this warranty.

To exercise this warranty, write or call your local YSI representative, or contact YSI Customer Service in Yellow Springs, Ohio. Send the product and proof of purchase, transportation prepaid, to the Authorized Service Center selected by YSI. Repair or replacement will be made and the product returned, transportation prepaid. Repaired or replaced products are warranted for the balance of the original warranty period, or at least 90 days from date of repair or replacement.

Limitation of Warranty

This Warranty does not apply to any YSI product damage or failure caused by (i) failure to install, operate or use the product in accordance with YSI's written instructions, (ii) abuse or misuse of the product, (iii) failure to maintain the product in accordance with YSI's written instructions or standard industry procedure, (iv) any improper repairs to the product, (v) use by you of defective or improper components or parts in servicing or repairing the product, or (vi) modification of the product in any way not expressly authorized by YSI.

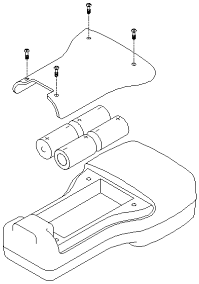
THIS WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. YSI's LIABILITY UNDER THIS WARRANTY IS LIMITED TO REPAIR OR REPLACEMENT OF THE PRODUCT, AND THIS SHALL BE YOUR SOLE AND EXCLUSIVE REMEDY FOR ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY. IN NO EVENT SHALL YSI BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES RESULTING FROM ANY DEFECTIVE PRODUCT COVERED BY THIS WARRANTY.

FEATURES OF THE YSI 550A

KEYPAD

⏻	Powers the unit on or off. The instrument will activate all segments of the display for a few seconds, and then will show a self-test procedure for several more seconds. During this power on self-test sequence, it is normal to error messages appear and disappear. If the instrument were to detect a problem, a **continuous** error message would be displayed.
☼	Turns the display backlight on or off. The light will turn off automatically after two minutes of non-use.
Mode	During DO calibration it allows the user to select between % and mg/L. After selection, it may be pressed several times to exit back to measurement mode without completing the calibration. During measurement, it switches the instrument display between DO %, DO mg/L, and salinity calibration.
▲ and ▼	Increases or decreases the value during calibrations.
▼ and **Mode**	Press at the same time to switch the temperature units between Fahrenheit (F) and Celsius (C).
▲ and **Mode**	Press at the same time to increase or decrease the resolution of the instrument in mg/L or % measurement mode.

BATTERIES



The YSI 550A DO Instrument is powered by 4 C-size alkaline batteries. A new set of alkaline batteries will provide approximately 2000 hours of continuous operation. When batteries need to be replaced, the LCD will display a **"LO BAT"** message. When the message first appears, the instrument will have approximately 50 hours of life left, provided the back light is not used.

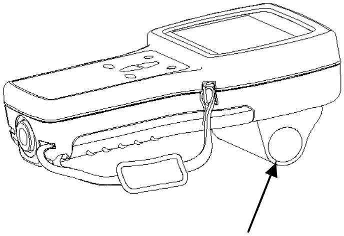
INSTRUMENT CASE

The waterproof instrument case is sealed at the factory and is not to be opened, except by authorized service technicians.

Caution: Do not attempt to separate the two halves of the instrument case as this may damage the instrument, break the waterproof seal, and will void the manufacturer's warranty.

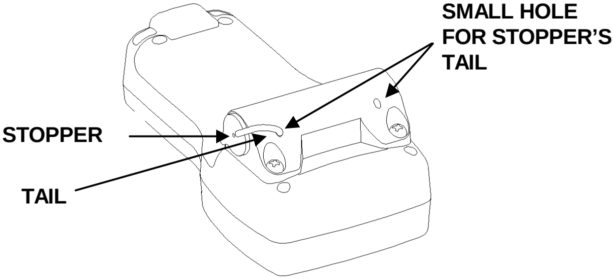
CALIBRATION/STORAGE CHAMBER

The YSI 550A DO Instrument has a convenient calibration/storage chamber that can be attached to the instrument's back. The calibration chamber can be used from either side of the instrument, by moving the rubber stopper to either end.



If you look into the chamber, you should notice a small round sponge in the bottom. Carefully put 3 to 6 drops of clean water into the sponge. Turn the instrument over and allow any excess water to drain out of the chamber. The wet sponge creates a 100% water saturated air environment for the probe. This environment is ideal for dissolved oxygen calibration and for storage of the probe during transport and non-use.

The YSI 550A DO Instrument's storage chamber can be conveniently used from either side of the instrument.



1. Remove the chamber from the instrument by unscrewing the two screws.
2. Remove the rubber stopper from the chamber by pulling the "tail" free of the small hole on the chamber.
3. Re-attached the rubber stopper to the storage chamber by threading the "tail" through the opposite small hole on the chamber.
4. Re-attached the storage chamber to the instrument using the two screws.

HAND STRAP

The hand strap is designed to allow comfortable operation of the YSI 550A DO Instrument with minimum effort. If the hand strap is adjusted correctly, it is unlikely that the instrument will be dropped or bumped from your hand. The hand strap can be conveniently used from either side of the instrument.

To switch the hand strap from one side to the other:

1. Pull the two velcro strips apart.
2. Pull the strap free of the upper and lower hooks.
3. Feed the strap through the hooks on the other side of the instrument.
4. Adjust the strap length so that your hand is snugly held in place.
5. Press the two velcro strips back together.

PRINCIPLES OF OPERATION

The sensor consists of a silver body as the anode and a circular gold cathode embedded in the end. In operation, this end of the sensor is filled with a solution of electrolyte containing a small amount of surfactant to improve wetting action.

A thin semi-permeable membrane, stretched over the sensor, isolates the electrodes from the environment, while allowing gases to enter. When a polarizing voltage is applied to the sensor electrodes oxygen that has passed through the membrane reacts at the cathode causing a current to flow.

The membrane passes oxygen at a rate proportional to the pressure difference across it. Since oxygen is rapidly consumed at the cathode, it can be assumed that the oxygen pressure inside the membrane is zero. Hence, the force causing the oxygen to diffuse through the membrane is proportional to the partial pressure of oxygen outside the membrane. As the oxygen partial pressure varies, so does the oxygen diffusion through the membrane. This causes the probe current to change proportionally.

PREPARING THE PROBE

MEMBRANE CAP INSTALLATION

The YSI 550A DO probe is shipped with a dry, protective membrane. Before using the instrument for the first time, remove the protective cap and replace it with a new one following these instructions:

1. Remove the probe sensor guard to access the probe tip.
2. Unscrew and remove the old membrane cap and discard.
3. Thoroughly rinse the sensor tip with distilled or DI water.
4. Fill a new membrane cap with O_2 probe solution that has been prepared according to the directions on the bottle. Be very careful not to touch the membrane surface. Lightly tap the side of the membrane cap to release bubbles that may be trapped.
5. Thread the membrane cap onto the probe. It is normal for a small amount of electrolyte to overflow.
6. Replace the probe sensor guard.

MEMBRANE MAINTENANCE

Additional membrane changes will be required over time. The average replacement interval is 4 to 8 weeks, although they may last longer if kept clean. To clean the membrane, use a lint-free cloth, such as a Kimwipe, and rubbing alcohol to gently remove the contamination. In harsh environments, such as wastewater, membrane replacements may be required every 2 to 4 weeks.

DISSOLVED OXYGEN CALIBRATION

Dissolved oxygen calibration must be done in an environment with known oxygen content. The YSI 550A DO Instrument can be calibrated in either mg/L or % saturation. Sections below include instructions on how to calibrate in either mode.

BEFORE YOU CALIBRATE

To accurately calibrate the YSI 550A, you will need to know the following information:

- The approximate salinity of the water you will be analyzing. Fresh water has a salinity of approximately zero. Seawater has a salinity of approximately 35 parts per thousand (ppt). If you are uncertain what the salinity of the sample water is, use a YSI 30 Salinity-Conductivity-Temperature instrument to determine a salinity value.

- For calibration in % saturation mode, the approximate altitude (in feet) of the region where you are located is required. This information can be obtained over the internet or from a local airport or weather station. To convert from meters to feet, divide by 0.3048.

For best results:

- Check calibration with each use and recalibrate as necessary to prevent drift. Dissolved oxygen readings are only as good as the calibration.

- Calibrate at a temperature within ±10°C of the sample temperature.

CALIBRATION IN % SATURATION

1. Ensure that the sponge inside the instrument's calibration chamber is moist. Insert the probe into the calibration chamber.

2. Turn the instrument on. Allow it to warm up and readings to stabilize for about 15-20 minutes.

3. Press and release both the **UP ARROW** and **DOWN ARROW** keys at the same time to enter the calibration menu.

4. Press the **Mode** key until “%” is displayed on the right side of the screen for oxygen units. Press **ENTER**.

5. The LCD will prompt you to enter the local altitude in hundreds of feet. Use the arrow keys to increase or decrease the altitude. When the proper altitude appears on the LCD, press the **ENTER** key.
   EXAMPLE: Entering the number 12 here indicates 1200 feet.

6. **CAL** will now display in the lower left corner of the screen, the calibration value in the lower right corner and the current DO reading (before calibration) will be the main display. Once the current DO reading is stable, press the **ENTER** button.

7. The LCD will prompt you to enter the approximate salinity of the water you are about to analyze. You can enter any number from 0 to 70 parts per thousand (PPT) of salinity. Use the arrow keys to increase or decrease the salinity setting. When the correct salinity appears on the LCD, press the **ENTER** key. The instrument will return to normal operation.

CALIBRATION IN MG/L

1. Turn the instrument on. Allow it to warm up and readings to stabilize for about 15-20 minutes.

2. Place the probe in a solution with a known mg/L reading. Continuously stir or move the probe through the sample at a rate of at least 1/2 foot per second (16cm per second) during the entire calibration process.

3. Press and release both the **UP ARROW** and **DOWN ARROW** keys at the same time to enter the calibration menu.

4. Press the **Mode** key until “mg/L” is displayed on the right side of the screen for oxygen units. Press **ENTER**.

5. **CAL** will now display in the lower left corner of the screen and the current DO reading (before calibration) will be on the main display. Once the current DO reading is stable, use the up and down arrow keys to select the mg/L value of the known solution, then press the **ENTER** button.

6. The LCD will prompt you to enter the approximate salinity of the water you are about to analyze. Enter any number from 0 to 70 parts per thousand (PPT) of salinity. Use the arrow keys to increase or decrease the salinity setting. When the correct salinity appears on the, press the **ENTER** key. The instrument will return to normal operation.

SALINITY COMPENSATION CALIBRATION

1. Press the **Mode** key until salinity calibration is displayed on the screen.
2. Use the **UP ARROW** and **DOWN ARROW** keys to adjust the salinity value to that of the samples you will be measuring, 0-70 ppt.
3. Press the **ENTER** key to save the calibration.
4. Press **Mode** to return to dissolved oxygen measurement

PROBE OPERATION

NOTE: The YSI 550A DO Instrument should not be used in a purpose other than that specified by YSI Incorporated. See **Warranty** for details.

STIRRING

It is important to recognize that a very small amount of oxygen dissolved in the sample is consumed during probe operation. It is therefore essential that the sample be continuously stirred at the sensor tip. If stagnation occurs, measurements will appear artificially low.

Stirring may be accomplished by mechanically moving the sample around the probe tip, or by moving the probe through the sample. The YSI Model 550A has a flow dependence of <25%. The rate of stirring required is 1/2 foot per second (16cm per second).

MEASUREMENT PROCEDURE

1. Insert the probe into the sample to be measured.
2. Continuously stir or move the probe through the sample.
3. Allow temperature and dissolved oxygen readings to stabilize.
4. Observe/Record readings.
5. If possible, rinse the probe with clean water after each use.

PRECAUTIONS

1. Membranes last longer if properly installed and regularly maintained. Erratic readings can result from loose, wrinkled, damaged, or fouled membranes, large (more than 1/8" diameter) air bubbles in the electrolyte reservoir, or membrane coating by oxygen consuming (e.g. bacteria) or oxygen producing (e.g. algae) organisms. If unstable readings or membrane damage occurs, replace both the membrane cap and electrolyte solution.

2. Chlorine, sulfur dioxide, nitric oxide, and nitrous oxide can affect readings by behaving like oxygen at the probe.

3. Avoid substances such as acids, caustics, and strong solvents, which may damage probe materials. Probe materials include the PE membrane, acrylic plastic, EPR rubber, stainless steel, epoxy, polyetherimide and the PVC cable covering.

4. Always store the probe in the calibration/storage chamber with the moistened sponge.

PROBE ELECTRODE MAINTENANCE

SILVER ANODE

After extended use, a thick layer of AgCl builds up on the silver anode reducing the sensitivity of the sensor. The anode must be cleaned to remove this layer and restore proper performance. The cleaning can be chemical or mechanical:

- **Chemical cleaning:** Remove the membrane cap and rinse the electrodes deionized or distilled water. Soak the entire anode section in a 14% ammonium hydroxide solution for 2 to 3 minutes (or a 3% solution may be used and soaked overnight for 8-12 hours). Rinse heavily in cool tap water followed by a thorough rinsing with distilled or deionized water. The anode should then be thoroughly wiped with a wet paper towel to remove the residual layer from the anode.

  Warning: Chemical cleaning should be performed on an as-needed basis, and no more often than once a year (or once per six months in wastewater environments). When readings appear unstable or the instrument will not calibrate, first attempt a membrane change and recalibrate. If a new membrane does not resolve the problem, then proceed with the chemical cleaning.

- **Mechanical cleaning:** Sand off the dark layer from the silver anode with 400 grit wet/dry sandpaper. Wrap the wet sandpaper around the anode and twist the probe. Rinse the anode with clean water after sanding, and wipe thoroughly with a wet paper towel.

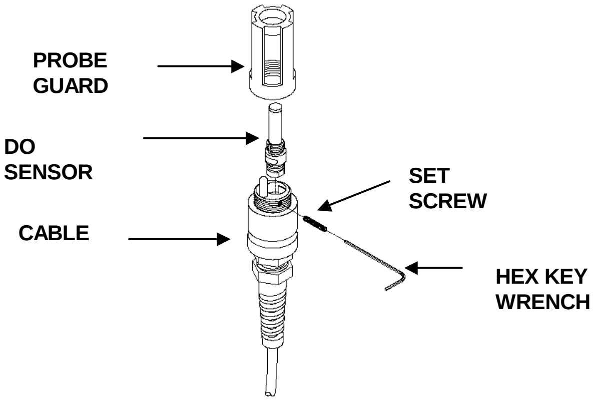
GOLD CATHODE

For correct probe operation, the gold cathode must be textured properly. It can become tarnished or plated with silver after extended use. The gold cathode can be cleaned by using the YSI 5238 Probe Reconditioning Kit or 400 grit wet/dry sandpaper. Never use chemicals or abrasives not recommended or supplied by YSI.

Using the sanding paper provided in the YSI 5238 Probe Reconditioning Kit, wet sand the gold with a twisting motion about 3 times or until all silver deposits are removed and the gold appears to have a matte finish. If the cathode remains tarnished, return the probe for service. Wipe the gold cathode thoroughly with a wet paper towel before putting on a new membrane cap.

REPLACEMENT OF THE DO ELECTRODES

Should replacement of the DO Electrodes be required, the user may purchase a YSI 559 Replaceable DO Module Kit. The kit includes an instruction sheet, DO sensor module, set screw, and hex key wrench.



1. Remove probe guard.
2. **IMPORTANT:** Thoroughly dry the sensor so that no water enters the probe port when the sensor is removed.
3. Insert the long end of the hex key wrench into the small hole in the side of the DO sensor. Turn the wrench counter clockwise until the sensor is released.
4. Pull the DO sensor out of the probe. The DO sensor is keyed, or has a flat side, so that it can not be removed or inserted improperly.
5. Make sure that the inside of the connector and the o-ring of the sensor are clean and dry, with no contaminants, such as grease, dirt, or hair. Insert the new sensor.
6. Use the hex key wrench to tighten the screw, making sure that the screw does not stick out on either side of the DO sensor module. Also, if the hex screw was removed completely, make sure that it is not cross-threaded when replaced.
7. The YSI 559 DO module is shipped with a dry, protective membrane. Before using for the first time, remove the protective cap and replace it with a new one following the instructions for **Membrane Cap Installation**.

ACCESSORIES/REPLACEMENT PARTS

The following parts and accessories are available from YSI or any YSI Authorized Dealer.

YSI Model Number	Description
5908	Membrane Kit, 1.25 mil PE, 6 caps and bottle of electrolyte solution
559	Replaceable DO Module
5238	Probe Reconditioning Kit, 10 sanding discs (400 grit) and sanding tool
5065	Form-Fitted Cover with Shoulder Strap
614	Ultra Clamp, C-Clamp Mount
4654	Tripod
5085	Hands Free Harness
5050	Small, Hard-sided Carrying Case, Foam-lined
5060	Small, Soft-sided Carrying Case, Precut Foam Interior
5080	Small, Hard-sided, Pelican Carrying Case, Precut Foam Interior

SPECIFICATIONS

Display	Resolution	Range	Accuracy
Dissolved O_2 mg/L	0.01 mg/L or 0.1 mg/L, user selectable	0 to 20 mg/L	± 0.3 mg/L or ± 2% of reading, whichever is greater
		20 to 50 mg/L	± 6% of reading
Dissolved O_2 %	0.1% or 1%, user selectable	0 to 200%	± 2% air sat or ± 2% of reading, whichever is greater
		200 to 500%	± 6% of reading
Temperature ºC	0.1 ºC	-5 to +45 ºC	± 0.3 ºC
Temperature ºF	0.1 ºF	23 to 113 ºF	± 0.6 ºF

Medium: Fresh, sea or polluted water
Dissolved Oxygen Sensor: Steady-state polarographic
Dissolved Oxygen Probe: Field-replaceable module
Dissolved Oxygen Response Time: 95% of end value in 9 seconds
Temperature Units: Celsius or Fahrenheit, user selectable
Parameter Compensation: Automatic temperature compensation for dissolved oxygen
Automatic salinity compensation (0-70 ppt) for dissolved oxygen
Altitude compensation for dissolved oxygen percent calibration
Size: 4.7 in. width; 9 in. length (11.9 cm x 22.9 cm)
Weight with Batteries: 2 lb. (0.91 kg)
Power: 4 alkaline C-cells
Battery life: Over 2000 hours at 25°C (77ºF)
Cables: 12, 25, 50, and 100-foot lengths
(3.5, 7.5, 15, 30.5 meter lengths)
Other Features: Waterproof to IP-67
High-impact resistance
Push-button calibration
Built-in calibration chamber
Large back-lit display
Low battery indicator on display
Manual salinity input
CE-compliance

TROUBLESHOOTING

NOTE: An error displayed briefly during the first few seconds after turning the instrument on does NOT indicate a problem.

SYMPTOM	POSSIBLE SOLUTION
1. Instrument will not turn on, LCD displays "LO BAT", or Main display flashes “OFF”	A. Low battery voltage, replace batteries B. Batteries installed incorrectly, check battery polarity C. Return system for service
2. Instrument will not calibrate.	A. Replace membrane and electrolyte B. Clean probe electrodes C. Return system for service
3. Instrument "locks up".	A. Remove batteries, wait 15 seconds for reset, replace batteries B. Replace batteries C. Return system for service
4. Instrument readings are inaccurate.	A. Verify calibration altitude and salinity settings are correct and recalibrate. B. Probe may not have been in 100% water saturated air during calibration procedure. Moisten sponge in calibration chamber and recalibrate. C. Replace membrane and electrolyte. Recalibrate. D. Clean probe electrodes. E. Return system for service.
5. Main display reads “Over” or “Undr”.	A. Sample O_2 concentration is more than 60 mg/L or 500%, or less than –0.02 mg/L or -0.3%. B. Verify calibration altitude and salinity settings are correct and recalibrate. C. Replace membrane and electrolyte. Recalibrate. D. Clean probe electrodes. E. Return system for service.
6. Main display reads “Over” or “Undr” during calibration.	A. Replace membrane and electrolyte. Recalibrate. B. Clean probe electrodes. C. Return system for service.

SYMPTOM	POSSIBLE SOLUTION
7. Secondary display reads "Ovr" or “Undr”.	A. Sample temperature is less than -5° C (23°F) or more than +45°C (122°F). Increase or decrease the sample temperature to bring within the allowable range. B. Return system for service.
8. Main display reads “Err” and Secondary display reads “RO”, “RA”, or “AdC”.	A. Return system for service
9. Main display reads “Err” or burn” and Secondary display reads “EEP”	A. Return system for service

CONTACT INFORMATION

YSI offers a wide range of customer assistance and technical support functions to ensure that you have the information required to use our products. Contact YSI Environmental if you need assistance or have questions regarding any YSI Environmental Product. Business hours are Monday through Friday, 8AM to 5PM ET.

YSI Environmental Incorporated
1725 Brannum Lane
Yellow Springs, OH 45387
Toll Free: 800-897-4151
Phone: 937 767-7241
Fax: 937 767-1058
E-Mail: environmental@ysi.com
www.ysi.com/environmental

REQUIRED NOTICE

The Federal Communications Commission defines this product as a computing device and requires the following notice:

This equipment generates and uses radio frequency energy and if not installed and used properly, may cause interference to radio and television reception. There is no guarantee that interference will not occur in a particular installation. If this equipment does cause interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- re-orient the receiving antenna
- relocate the YSI Instrument with respect to the receiver
- move the YSI Instrument away from the receiver
- plug the YSI Instrument into a different outlet so that the computer and receiver are on different branch circuits.

If necessary, the user should consult the dealer or an experienced radio/television technician for additional suggestions. The user may find the following booklet, prepared by the Federal Communications Commission, helpful: "How to Identify and Resolve Radio-TV Interference Problems." This booklet is available from the U.S. Government Printing Office, Washington, DC 20402, Stock No. 0004-000-00345-4.

Note: While testing to EN-61000-4-6, Conducted RF Immunity, per Table A.1 of EN61326, Electrical Equipment for Measurement, Control and Laboratory Use, the YSI 550A exhibited an ERROR 8 message from 8.6 MHz 22.8 MHz at induced RF voltages of 3-Volts to 1-Volt RMS on the 25-foot probe cable. If you observe this interference please relocate the probe-cable away from heavy industrial equipment power and control cables or communications equipment cables which may be causing the interference.

New York State Department of Environmental Conservation
Generic FAP for Work Assignments

Appendix C:
Field Logs

MALCOLM PIRNIE

TEST BORING LOG

BORING No.

PROJECT	LOCATION	SHEET OF
CLIENT		PROJECT No.

DEPTH FT.	SAMPLE TYPE, RECOVERY, NUMBER	BLOWS ON SAMPLE SPOON PER 6"	PID	GRAPHIC LOG	GEOLOGIC DESCRIPTION KEY - Color, Major, Minor Mositure, Etc.	ELEV. / DEPTH	WELL Constr.	REMARKS

MALCOLM PIRNIE

TEST PIT LOG

DATE STARTED: ______________________ DATE FINISHED: ________ TEST PIT NUMBER: ________

SITE/PROJECT/CLIENT NAME: ____ PROJECT NUMBER: ________

PHOTOGRAPH NUMBER(S): ______________________ FIELD LOGGER: ______________________

SURFACE CONDITIONS: ______________________ WEATHER & TEMP: ______________________

EQUIPMENT MAKE/MODEL: ______________________ CONTRACTOR: ______________________

TEST PIT LOCATION: ____

APPROXIMATE LENGTH _____________FEET, WIDTH _____________ FEET, AND DEPTH _____________ FEET

DEPTH	DESCRIPTION (COLOR, TEXTURE, CONSISTENCY, MOISTURE)	SAMPLE #	PID	ODOR

MAP/SITE/TEST PIT LOCATION SKETCH:

N

TEST PIT CROSS SECTION(S):

___ ft.

___ ft.

MALCOLM PIRNIE

CHAIN OF COUSTODY RECORD

518-250-7300
fax: 518-250-7300

MALCOLM PIRNIE, INC.
855 ROUTE 146, SUITE 210
CLIFTON PARK, NEW YORK 12065
http://www.pirnie.com

CLIENT: ____________________

PROJECT: ____________________

PROJECT NUMBER: ____________________

PROJECT MANAGER: ____________________

LABORATORY: ____________________

LABORATORY CONTACT: ____________________

SPECIAL INSTRUCTIONS:

LAB ID	SAMPLE ID/ DESCRIPTION	DATE	TIME	MATRIX	GRAB/ COMPOSITE	No. of Cont.	ANALYSIS REQUIRED	NOTES / PRESERVATIVE

Matrix Identification:

S - SOIL
SE- SEDIMENT
SO - SOLID
SL - SLUDGE
DW - DRINKING WATER
GW - GROUND WATER
O - OIL
SW - SURFACE WATER
L - LEACHATE
A - AIR
WI - WIPE
DS - DRUM SOLID
DL - DRUM LIQUIDS
X - OTHER
WW - WASTE WATER

LAB USE ONLY

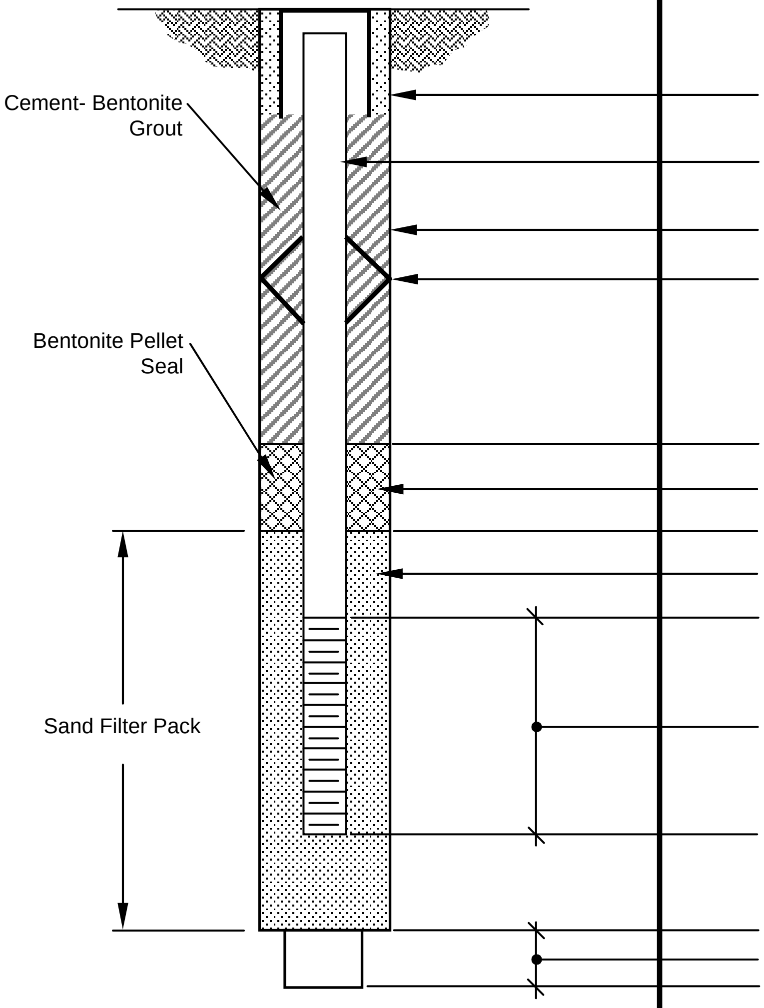
SAMPLED BY (SINGATURE):	DATE/TIME	RECEIVED BY (SIGNATURE):	DATE/TIME:
RELINQUISHED BY (SIGNATURE):	DATE/TIME	RECEIVED BY (SIGNATURE):	DATE/TIME:
RELINQUISHED BY (SIGNATURE):	DATE/TIME	RECEIVED BY (SIGNATURE):	DATE/TIME:
METHOD OF SHIPMENT:	DATE/TIME	LAB USE ONLY:	
RECEIVED AT LABORATORY:	DATE/TIME		

Overburden
Monitoring Well Construction Sheet

WELL NO. ______________

Project	Start Date	End Date	Drilling Co.
Project No.	Field Geologist		Driller(s)
Location			Drilling Method(s)
			Development Method(s)

Not To Scale



Depth to Top of Grout/ Bottom of Cement .... ______________

Riser Diameter and Material .... ______________

Borehole Diameter .... ______________

Depth to Centralizers .... ______________

Depth .... ______________

Pellet Size .... ______________

Depth .... ______________

Sand Size .... ______________

Depth .... ______________

Screen Diameter, Slot Size and Material .... ______________

Depth .... ______________

Depth .... ______________

Backfill Material .... ______________

Bottom of Borehole .... ______________

NOTE: DEPTHS ARE FEET BELOW GRADE

MALCOLM PIRNIE

MALCOLM PIRNIE

GROUNDWATER MONITORING WELL INSPECTION

SITE/PROJECT NAME: ______________________ PROJECT NUMBER: ______________________

DATE OF INSPECTION: ______________________ INSPECTOR: ______________________

WELL DESIGNATION: ____

WELL LOCATION: ____

Outward Appearance

Flushmount Diameter	______ inches	N/A [ ]		
Approximate Stickup Height	______ feet	N/A [ ]		
Integrity of Protective Casing	Describe: ________________________________			
Protective Casing Material	Steel [ ]	Stainless Steel [ ]	Other ________________________	
Protective Casing Width or Dia.	______ inches			
Weep Hole in Protective Casing	Yes [ ]	No [ ]		
Surface Seal/Apron Material	Cement [ ]	Bentonite [ ]	Not apparent [ ]	Other ________
Integrity of Surface Seal/Apron	Describe: ________________________________			
Surface Drainage	Away from Wellhead [ ]	Toward Wellhead [ ]		
Bollards Present?	Yes [ ]	No [ ]	Describe: ______________________________	
Well ID. Visible?	Yes [ ]	No [ ]	Describe: ______________________________	
Lock Present and Functional?	Yes [ ]	No [ ]	Describe: ______________________________	
Photograph Taken? Photo #	Yes [ ]	No [ ]	Describe: ______________________________	

Inner Appearance

Integrity of Well Casing	Describe: ________________________________			
Integrity of Cap Seal	Describe: ________________________________			
Surface Water in Casing?	Yes [ ]	No [ ]	Describe: ______________________________	
Well Casing Diameter	______ inches			
Well Casing Material	PVC [ ]	Steel [ ]	Stainless Steel [ ]	
Inner Cap	Threaded [ ]	Slip [ ]	Expansion Plug [ ]	None [ ]
Reference/Measuring Point	Groove [ ]	Indelible Mark [ ]	None [ ]	
Evidence of Double Casing?	Yes [ ]	No [ ]	Describe: ______________________________	

Downhole

Odor	Yes [ ]	No [ ]	Describe: ______________________________	
PID Reading	______ ppm			
Depth to Water (to top of casing)	______ feet (nearest 0.01)	Depth to LNAPL	_____ feet (nearest 0.01)	N/A [ ]
Total Well Depth (to top of casing)	______ feet (nearest 0.1)			
Sediment (Hard/Soft Bottom)	Describe: ________________________________			

Additional Comments:

____

____

____

____

____

____

MALCOLM PIRNIE

WELL DEVELOPMENT/ PURGING LOG

WELL NUMBER: ____________________ DATE:____________________

PROJECT NAME: ____________________
PROJECT NUMBER: ____________________
SAMPLERS: ____________________

A: Total Casing and Screen Length: ____________

B: Casing Internal Diameter: ____________

C: Water Level Below Top of Casing: ____________

D: Volume of Water in Casing: ____________

Well I.D.	**Vol. Gal./ft.**
1"	**0.04**
2"	**0.17**
3"	**0.38**
4"	**0.66**
5"	**1.04**
6"	**1.50**
8"	**2.60**

$$v = 0.0408\,(B)^2 \times (A-C) = D$$

$v = 0.0408\,(\qquad\qquad)^2 \times (\qquad - \qquad) =$ _______________ gal.

PARAMETER	ACCUMULATED VOLUME PURGED											
Time												
Gallons												
Well Volume												
Conductivity (mohm/cm)												
Dissolved Oxygen												
REDOX (mV)												
pH												
Temperature (^{o}C)												
Trubidity												
Salinity												
TDS												

Notes: ____________________

MALCOLM PIRNIE

AIR, SUB-SLAB VAPOR, AND SOIL VAPOR SAMPLING FIELD LOG

PROJECT NAME: ____________________ DATE: ____________________

PROJECT LOCATION: ____________________ WEATHER: ____________________

PROJECT NUMBER: ____________________ TEMPERATURE: ____________________

PERSONNEL: ____________________ LABORATORY: ____________________

Sample ID	Outdoor (OA)	Soil Vapor (SV)	Sub-slab vapor (SS)	Crawl Space (CS)	Basement Air (BA)	1st Floor (FA)	Canister Size (1-L or 6-L)	Canister #	Flow controller #	Sample Duration (hours)	Initial Time (military)	Initial Vacuum (in. Hg)	Final Time (military)	Final Vacuum (in. Hg)	Volume of Vapor Purged (cc)	VOCs (ppb) Pre	VOCs (ppb) Post	Sampler's Initials

Notes: ____________________