

TIMBERLINE INSTRUMENTS
TL2X00 AMMONIA/NITRATE ANALYZER

SYSTEM INSTRUCTION MANUAL

Timberline Model TL2X00 Ammonia/Nitrate Analyzer

System Instruction Manual

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SECTION 1 - INTRODUCTION

PRINCIPLES OF OPERATION

The Timberline Model TL2100 (Single Channel) and TL2200 (Dual Channel) Ammonia/Nitrate Analyzers are based on the principle of diffusion across a gas diffusion membrane coupled with electrical conductivity measurement as first described by Carlson¹

The pump directs the sample, caustic, and absorbing solutions into the Membrane Diffusion Cell. Within the cell, the sample is mixed with a caustic solution. The resulting solution has a pH sufficiently high (pH 11-13) to convert virtually all of the ammonium ion present in the sample to dissolved ammonia gas, as shown in EQUATION 1. The sample/caustic solution flows past one side of a membrane that is permeable to gases but not to liquids or ionic species. The dissolved ammonia gas in the sample/caustic mixture will diffuse across the membrane.



On the other side of the membrane, a buffered solution² absorbs the diffused ammonia gas. The buffered solution then flows into the conductivity detector. The flow passes through a low volume heat exchanger to establish thermal equilibrium of the solution before it reaches the conductivity cell. The conductivity cell measures the change in electrical conductance of the absorbing solution. This change is proportional to the concentration of ammonium in the original sample.

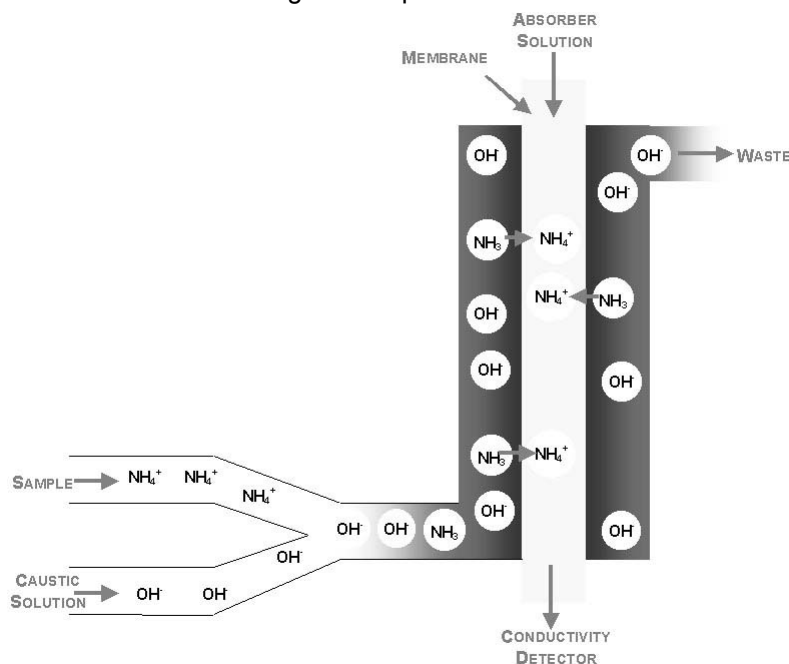


Figure 1-1: Diffusion Membrane Cell Operation Principles

INTRODUCTION TO NITRATE/NITRITE ANALYSIS

Passing the sample/caustic mixture through an optional zinc reduction cartridge reduces nitrate and nitrite ions to ammonium, allowing measurement of the total inorganic nitrogen concentration.³ If ammonium has previously been determined on an unreduced sample, nitrate plus nitrite may be calculated from the difference in values before and after reduction. The nitrate and nitrite in the sample is reduced to ammonia, the metal is oxidized, and hydrogen gas is evolved.



¹ Carlson, R.M.; *Anal. Chem.*, 50 (1978) 1528

² Patent Pending, Hansen-Williams Patent

³ Carlson, R.M.; *Anal. Chem.*, 58(1986) 1590

Small amounts of hydrogen gas are generated at irregular intervals and cause erratic pulses of air to enter the sample channel. These erratic pulses of gas cause an unstable signal due to the increased concentration of ammonia in the air gaps. The introduction of a continuous airflow from air segmentation in the sample/caustic line eliminates these pulses.

Carlson best outlines nitrate determination in his 'Reduction of Nitrate to Ammonia with Zinc' article (Robert M. Carlson, "Continuous Flow Reduction of Nitrate to Ammonia with Granular Zinc," *Analytical Chemistry*, (1985)).

Use of zinc allows for quantitative measurement of ammonia and nitrate. Since many practical samples contain more nitrate than ammonia it is possible to obtain the nitrate values by difference is an acceptable quantitative method.

$$\text{Total Amount Ammonia + Nitrate} - \text{Amount Ammonia} = \text{Amount of Nitrate} \quad \text{Eq: 1-3}$$

INTERFERENCE'S

Interference's can be expected from any substance that can transfer across the membrane and dissolve in the absorbing solution to change its conductivity. From the alkaline sample/caustic stream, the likely candidates for interference are volatile amines. Volatile amines such as Methyl and Ethyl amines will interfere but are not present in most practical samples.

Volatile acids will not cause problems for ammonia determination at the high pH produced by the KOH/DTPA reagent. If the sample were analyzed at a low pH, volatile acids (i.e., carbonic, acetic, etc.) would traverse the membrane and produce a response. The instrument can be used to determine such acids by mixing the sample with a nonvolatile acid (i.e. sulfuric, citric, etc.).

The reduction of ammonia volatility by complex formation with some metals may reduce its availability to transfer across the membrane. Some metallic ions, such as mercury, are known to form very stable complexes with ammonia, but experience to date indicates that the DTPA binds the metal ions sufficiently to release the sample ammonia and thus eliminate this potential interference.

Wetting agents or organic solvents must be avoided. They can cause the membrane to wet out and lose its ability to exclude solution transfer.

WHAT YOU WILL NEED

In addition to the Ammonia/Nitrate Analyzer you will need:

- pH measuring device

REQUIRED REAGENTS

- Ammonia-Free Deionized Water
- Potassium or Sodium Hydroxide, Reagent Grade, ACS or Better
- Diethylenetriaminepentaacetic Acid (DTPA), Reagent Grade, ACS or Better
- A High Purity Ammonium Salt for Standards
- Copper Sulfate (for Nitrate Reduction)
- Boric Acid, Reagent Grade, ACS or Better (For Absorbing Solution)
- Ammonium Hydroxide, Reagent Grade, ACS or Better (For Neutralizing Boric Acid Solution)

SYSTEM COMPONENTS

DIFFUSION MEMBRANE CELL AND COMPARTMENT

The Diffusion Membrane Cell directs the liquid flow through the tubular membrane to the conductivity detector. These include the caustic solution, the absorbing solution, the samples, and a recommended air segmentation line. The caustic and sample solutions are mixed in a tee before entering the gas diffusion cell. This cell is housed in a temperature-controlled enclosure. Included in this enclosure are two pre-heating coils used to heat the incoming reagents to a stable temperature. The temperature should be maintained at least 5°C above the highest expected ambient temperature. Temperature control improves baseline stability, reproducibility and detections limits.

With proper care, the diffusion cell should last indefinitely. It is warranted against manufacturing defects for 1 year.

FLUID LINE CONNECTIONS FOR VARIOUS APPLICATIONS

Optional zinc reduction cartridges, filter cartridges, and air tees can be added between the sample/caustic tee and the sample/caustic inlet. FIGURE 1-2: shows the fluid connections for different applications of the system. See Section 4: TOTAL INORGANIC NITROGEN ANALYSIS for further information.

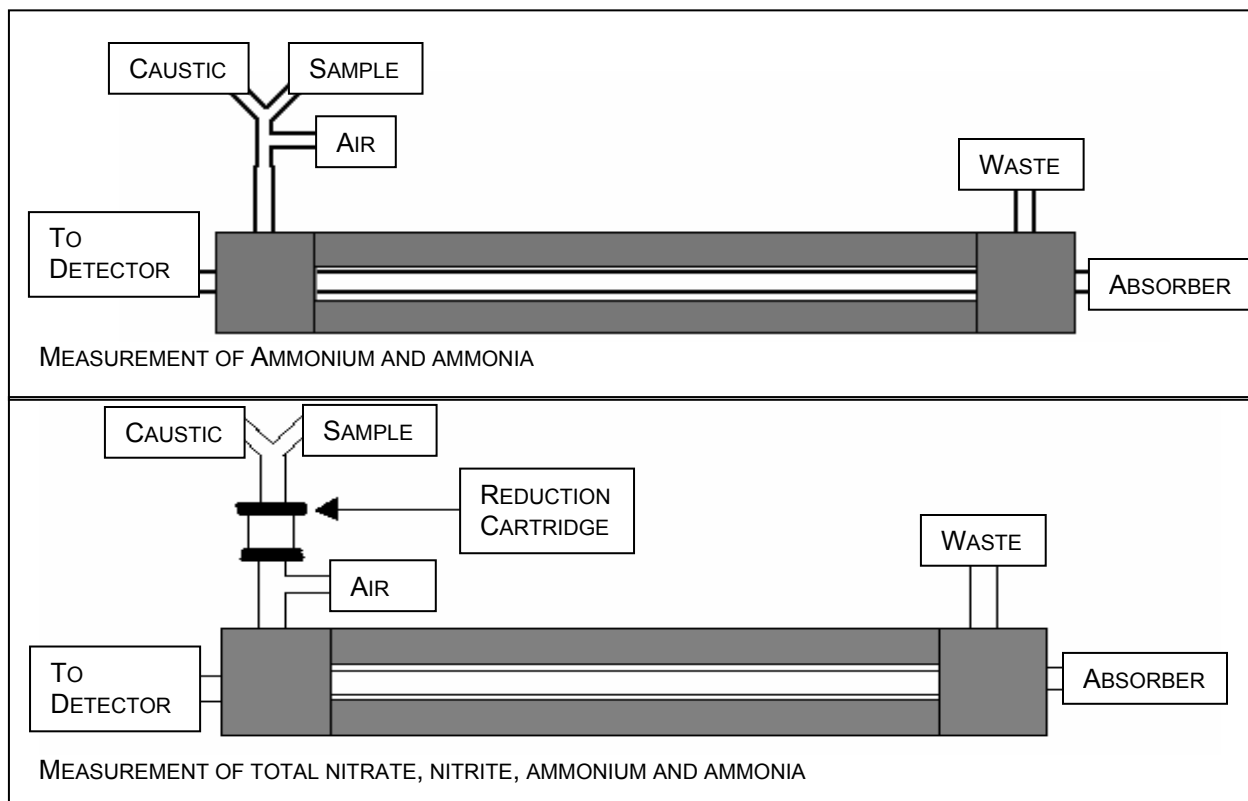


Figure 1-2: Fluid Connections for Various Applications from the Diffusion Membrane Cell

Diffusion Membrane Cell Pressure

The pressures inside the Diffusion Membrane Cell must be maintained to achieve minimum baseline noise and efficient ammonia transfer. All the system pressures should be kept in the range of 5-12 psig. The pressure on the caustic/sample side of the membrane must be lower than the pressure on the absorber side.

Caustic/Sample Pressure

To achieve this, the waste outlet of the Diffusion Membrane Cell must drain to a waste reservoir placed at least 12" below the system. Additionally, the tubing supplied to connect the waste outlet of the Diffusion Membrane Cell to the waste reservoir, is of a large diameter, providing a loose slip fit between two different sizes of flexible Tygon tubing. This connection is intentionally left loose to allow air to enter and avoid creation of vacuum within the tube. Extreme caution should be used to ensure that the waste line does not become disconnected. Alternatively, the larger Tygon tubing can be removed and the waste can drip from the membrane cell outlet into a waste reservoir placed below the outlet.

Absorber Pressure

To increase the pressure on the absorber side of the Diffusion Membrane Cell, the tubing leading into and out of the conductivity detector is 0.03" ID. A restriction tube is placed in the absorber outlet line. A convenient restrictor would be 10 - 12" of 0.01" ID PEEK Tubing (blue), nominal pressure 10 psig. Do not change the ID of these tubes or dramatically alter the length. Changing these parameters will affect the pressure on the diffusion membrane.

PERISTALTIC PUMP

A peristaltic pump is used to direct the reagents and samples into the system. The flexible tubing is held against the pump rollers with a channel cartridge. Stops on the tubing secure the tubing to the cartridge. The flow rate is controlled by the ID of the tube. The ID is indicated by the color of the tubing stops. The pump tubing is considered a consumable. With use, the tubing will wear and must be replacing. If 3 stop tubing is used, the tube can be used twice as long. On the Timberline Pump, use maximum compression. The flow rate is 2-2.5 cc/min. at 45 rpm. The actual flow rate can be determined by measuring the time required to collect an volume of water measured with a graduated cylinder.

CONDUCTIVITY MEASUREMENT

An ultra sensitive conductivity monitoring system is used to detect the ammonia present in the absorbing solution after it passes through the diffusion membrane. The flow cell is located in a temperature-controlled compartment close to the outlet of the diffusion membrane. The electrical signal obtained from this cell is collected and reported by the conductivity meter. The meter is capable of correcting for the background conductance of the absorbing solution by using a zeroing circuit. The meter also has operating ranges to accommodate a wide range of sample concentrations. The output of the meter is displayed on the front panel and directed to the output plug for collection by a strip chart recorder or computerized data system.

TOTAL INORGANIC NITROGEN ANALYSIS COMPONENTS

Reduction of nitrate and nitrite to ammonium ion allows for the determination of total inorganic nitrogen. An inline reduction cartridge performs this conversion. In its simplest form, the reduction cartridge can be manually installed in the sample/caustic line after the mixing tee. An automated system for on-line reduction is also available.

OPTIONAL COMPONENTS

You may wish to add the following components for an automated system:

- A strip chart recorder or data system capable of accepting analog voltage data (either 0-10mV or 0-1V)
- Timberline Data Acquisition System (24 Bit A/D with control software for auto sampler).
- An automated sample delivery system similar to Cetac, Model ASX-510

SECTION 2 - REAGENT PREPARATION

The Ammonia/Nitrate analyzer uses a caustic solution to convert the ammonium ion to dissolved ammonia gas and an absorbing buffer solution to absorb the ammonia gas as it diffuses across the membrane.

All solutions should be made from ammonia-free de-ionized water. Reagent grade chemicals should be used; any un-dissolved salts should be filtered from the solution before use. Filter cartridges or zinc reduction cartridges can be included in the sample/caustic solution fluid path to remove particulate or produce chemical changes in the solution. Generally, the system can be run without filters. However, a filter cartridge can be placed in the sample/caustic line to eliminate any particles from the sample or caustic solutions, or those that may form during the mixture of these, from entering the system. The zinc reduction cartridge is used instead of the filter cartridge when total inorganic nitrogen determination is desired.

CAUSTIC SOLUTION

The caustic solution contains potassium hydroxide (or sodium hydroxide) and a complexing agent, diethylenetriaminepentaacetic acid (DTPA).

PURPOSE

The caustic solution serves two purposes:

- To neutralize acid in the sample and raise the pH sufficiently high (11-13) to shift the $\text{NH}_3\text{-NH}_4\text{OH}$ equilibrium substantially toward NH_3 gas.
- To complex any metals in the sample and prevent their precipitation at the elevated pH values of the caustic solution. For routine wastewater samples, sodium hydroxide works quite well and can be conveniently prepared from commercial 50% NaOH.

CHEMICAL PURITY

The highest grade of KOH and DTPA available should be used. Less pure chemicals may contain ammonia contamination, which will raise the baseline or contain insoluble salts that block the system flow path. It is suggested that reagent solutions are filtered or a filter is used to prevent any un-dissolved solids from entering the system. Potassium hydroxide is favored over sodium hydroxide because potassium has fewer tendencies than sodium to complex with DTPA, leaving more DTPA available to form a complex with the metals present in the sample. EDTA may be used instead of DTPA when little or no magnesium is present in the sample, but it is not recommended. The MgDTPA complex stability is substantially greater than that of the MgEDTA.

EXCESS OF DTPA & KOH

The caustic reagent should have enough diethylenetriaminepentaacetic acid (DTPA) to chelate the maximum concentration of calcium, magnesium or other metals expected in the samples and provide 10% in excess. The potassium hydroxide (KOH) concentration needs to be high enough to convert the DTPA to the penta-potassium salt and neutralize the maximum amount of acid expected in the sample. It must also provide a minimum amount of 0.1M free KOH in the final mixed sample/caustic stream. An excess of DTPA and KOH in the final mixture is recommended although extreme excess should be avoided. Slight ammonia contamination is generally found in the DTPA and KOH. Excessive amounts may increase the background reading. Since samples and standards are both mixed with the same caustic solution in the same ratio, this slight ammonia contamination is automatically corrected.

In addition to the maximum expected calcium and magnesium concentration and sample acidity, the required caustic solution composition depends on the relative sample and reagent pumping rates. Actual pumping rates for the individual channels are easily estimated by timing the removal of liquid using a small graduated cylinder.

The composition of the caustic solution may be varied to accommodate various sample compositions. TABLE 1 provides representative recipes that have been used successfully in particular applications. For optimal caustic solution, suspend the DTPA in solution and then add the KOH. Mix until dissolved, dilute to volume, and filter.

ANALYSIS	KOH	DTPA
Pure Water, sub ppm	13g	0g
Water, Soil	25 g	10 g
2% Acetic Acid Extracts	36 g	10 g
Kjeldahl Digests	150 g	15 g

Figure 2-1: Commonly Used Caustic Solutions: Mass of KOH (potassium hydroxide) and DTPA (diethylenetriaminepentaacetic acid) added to 1 liter of deionized water.

Always observe the sample/caustic mixture after changing the sample matrix or caustic solution. Any particles being formed are a result of too little DTPA. Check the pH of the final sample/caustic stream mixture (waste) to ensure it is between 11-13 (which is necessary to convert the ammonium ion to ammonia gas).

In general, exact concentrations of reagents are not necessary for successful operation. A slight excess of reagents is always desirable.

ABSORBER SOLUTION

Boric acid buffered in de-ionized water, adjusted to pH of seven by addition of ammonium hydroxide is recommended as the absorbing solution. The use of pH 7 borate buffer substantially enhances baseline stability and provides greater sensitivity.

EXAMPLE CALCULATION FOR PREPARATION OF 100PPM BORIC ACID BUFFER SOLUTION:

Calculation for Grams Per Liter:

$$200\text{ppm Boric Acid} = \frac{200\text{mg Boric Acid}}{1\text{L}} \times \frac{1\text{g}}{1000\text{mg}} = \frac{0.1\text{g Boric Acid}}{1\text{L deionized water}} \quad \text{Eq: 2-11}$$

After preparing the Boric Acid in solution, dilute some aqueous ammonium hydroxide with de-ionized water, and add drops of this until the pH of the solution is neutralized at 7.

CARE OF THE ABSORBER LINE AND SOLUTION

The absorbing channel should be left full at all times. This reduces the chance of getting air bubbles lodged in the conductivity cell. The absorbing solution may be re-circulated when the ammonia concentration is low. It is recommended to continuously stir the solution using a magnetic stir bar and plate to maintain a homogenous solution. For low level work (sub 40ppb) the absorber reservoir should be protected with a trap containing an acidic ion exchange resin.

DEGASSING THE ABSORBER SOLUTION

The absorbing solution should be thoroughly degassed after preparation and each day before use or air bubbles may become lodged in the cell or pass through and cause baseline disturbances. The absorbing solution can be degassed by one of the following methods:

- Sparging with helium: Turn the helium tank flow on, but do not exceed 50psi. Let this run for a minute and then turn the helium flow off. The solution should be free of bubbles.
- Applying a Vacuum: Pour the solution into a heavy walled vacuum flask, cap the flask with a Teflon or rubber stopper, and attach a water aspirator or vacuum pump to the side arm of the flask. Pull a vacuum on the flask until bubbles stop appearing. Slowly pour the degassed solution in the appropriate reservoir.
- Filtering: Filter through a 0.2 micron membrane filter under vacuum
- Sonication: Sonication in an ultrasonic bath

PREPARATION OF STANDARDS

Ammonium standards should be prepared from non-hygroscopic ammonium salts such as ammonium nitrate or ammonium sulfate. Nitrate standards should be made from potassium nitrate or sodium nitrate. The standards should be prepared according to the unit of ammonia/nitrate you wish to report, i.e. ammonium ion, ammonia-N, nitrate ion, nitrate-N, etc. A high concentration standard can be made from the salt and then be diluted to lower concentrations.

SECTION 3 - OPERATION

INITIAL START-UP

1. Turn on the system and wait for it to reach thermal stability.
2. Prepare the caustic solution and place it in the 1000mL caustic reservoir bottle. Fill the absorbing solution reservoir with prepared buffer. Fill a beaker with ion-free water.
3. Place all the fluid lines SAMPLE, CAUSTIC and ABSORBER, in the beaker of water. Start the pump. Observe all connections for leaks.
4. Once all the air is purged from the lines of the system, STOP the pump, and transfer the ABSORBER fluid line to the Absorbing solution. Start the pump and allow the system to equilibrate. Equilibration is noted by the stabilization of the electrode output reading (not changing more than ± 0.1). Turn the OFFSET knob until the FINE knob is able to zero the electrode output.
5. Transfer the CAUSTIC fluid line to the caustic solution and observe the change in the output reading. This is the amount of diffusible ions present in the caustic solution.
6. Turn the OFFSET knob until the FINE knob is able to zero the electrode output. Start the recorder or data acquisition system.
7. Introduce a 10ppm Ammonia standard into the sample line. Observe and record the increase in conductance and sample response time.

This initial set up procedure should be repeated whenever any of the following occur:

- Air is introduced into the absorbing solution line.
- A new batch of caustic or absorbing solution is used.
- The instrument is "cold-started" after the power has been off for more than 24 hours.

ROUTINE OPERATION

WARM-UP TIME

Under normal circumstances, the power to the analyzer should be left ON at all times with the pump turned off. If this has been done, essentially no warm-up time is required, and the instrument may be used as soon as the flow has stabilized. If the instrument has been shut down for a prolonged period, then the Initial Set-up procedures should be followed.

FLOW STABILIZATION

1. Degas the absorbing reagent solution and replace.
2. Start the pump.
3. Observe and record the background reading of the conductivity meter.

Note: If the reading is much larger than that observed during previous operation, the caustic solution might be passing through a hole in the membrane. Observe the pH of the absorbing solution exiting the absorber outlet of the Diffusion Membrane Cell.

4. Set the scale knob to appropriate range for samples to be tested.

Range	Concentration
B	0ppm - 1.5ppm
C	1.5ppm - 20ppm
D	20ppm - 200ppm
E	200ppm +

Figure 1-1: Range Selection Table

5. Use OFFSET and FINE knobs to zero the conductivity meter.

RUNNING SAMPLES

Samples are analyzed by placing the sample line into a reservoir of a sample and waiting approximately 60 seconds for the detector reading to reach a maximum level. The concentration of ammonia in the sample may then be determined by reference to a calibration curve.

A return to baseline is desired between samples. Therefore, de-ionized water is introduced before continuing with the next sample.

This process can be automated by the optional Timberline data acquisition system.

SHUT DOWN PROCEDURE

1. Shut off the pump and transfer the sample, caustic, and absorber lines to a reservoir of de-ionized water.
2. Start the pump and pump for 10-15 minutes to thoroughly rinse the system with water.
3. Remove the sample and caustic lines from the de-ionized water. Clear the sample and caustic lines by pumping de-ionized water until all the solution has been displaced.
4. The absorber line should remain full of de-ionized water to avoid air from entering the system during down time.
5. Shut off pump.
6. Empty the waste reservoirs or make sure that the level of both the absorber and caustic waste reservoirs are below that of the instrument so that waste will not siphon back through the system.

Note: The POWER to the analyzer should be left ON if the instrument will be used in the near future.

USING REDUCTION CARTRIDGES

1. If the instrument has been in operation for ammonia determination, clear the sample and caustic lines by pumping de-ionized water through them. Add the air segmentation to the sample/caustic line if not already present.
2. Place the reduction cartridge in the sample/caustic/air segmentation line and before the diffusion cell.
3. Place the sample line in both samples and standards. Record the detector reading after the signal has stabilized. Remove the reduction cartridge and repeat the analysis of each sample and standard.
4. Prepare two calibrations curves for nitrate and ammonia standards, one with reduction (total inorganic nitrogen concentration), and one without (ammonia concentration). Compare the sample values to the appropriate calibration curves. The concentration of nitrate (plus nitrite) in the sample is determined from the difference between the total inorganic nitrogen concentration and the ammonia concentration.

If there are doubts about the functioning of the reduction cartridge, reduction can be confirmed by comparing the signal from nitrate and ammonium standards of identical nitrogen concentration when both are run through the instrument with the reduction cartridge in place

The freshly prepared reduction cartridges should last 1-2 days depending on the amount of nitrate/nitrite processed. In routine operation, the cartridges should be replaced when half of the zinc has been consumed.

SECTION 4 - MAINTENANCE AND TROUBLESHOOTING

ROUTINE MAINTENANCE

Because of its simple, rugged design, the analyzer requires only minimal maintenance or service on a regular basis. This section deals with the solutions to problems that may arise in routine operation.

REPLACEMENT OF THE DIFFUSION MEMBRANE CELL

The tubular membrane should last for an extended amount of time. If the membrane fails, it must be replaced. The entire Diffusion Membrane Cell needs to be removed and returned to Timberline Instruments. You can order Diffusion Membrane Cells from Timberline Instruments, LLC. The diffusion cells are guaranteed against defective workmanship and unconditionally guaranteed for 1 year.

FIGURE 1-1: Troubleshooting Charts: Typical Problems

SYMPTOM	CAUSE	REMEDY
Noisy Baseline	Trapped air bubbles	Operate at 10-12 psig. Depression once.
	Absorbing solution not degassed	Degas absorbing solution
	Air in absorbing solution line	Helium de-gas.
	Irregular pump flow	Shut off pump. If baseline is quiet, replace pump tubing
	Tubing stretched	Monitor flow rate and replace tubing if necessary
	Flat places in tubing	Replace tubing
Baseline Drift	Temperature fluctuations	Allow system to equilibrate if room temperature is close to operating temperature, try operating at a higher temperature
	New absorbing or caustic solution	Allow system to equilibrate
	Bubbles in absorbing solution	Degas absorbing solution

Figure 1-2: Troubleshooting Charts: Flow Problems

SYMPTOM	CAUSE	REMEDY
Solution Emerging from Sample or Air Ports	Sample/caustic path blocked	Clear path
Reduced Liquid Flow	Filter or zinc reduction cartridges blocked	Replace cartridge
	Path blocked by solids from reagents	Locate blocked section and backflush with water and filter reagents
	Solids from sample blocking tubing	Locate blocked section and backflush with water and filter all samples
	Precipitate forming in sample/caustic mixture	Not enough DTPA to chelate the metals in the sample
	Caustic left in instrument	Flush with water before shutdown

APPENDIX A: APPLICATIONS

Robert M. Carlson, "Automated Separation and Conductimetric Determination of Ammonia and Dissolved Carbon Dioxide," *Analytical Chemistry*, 50 (1978) 1528.

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David R. Hershey and J.L. Paul, "Iron Nutrition of the Broadleaf Evergreen Shrub, *Euonymus Japonica* Thunb," *Journal of Plant Nutrition*, 7 (1984) 641.

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Hansen-Williams Patent

APPENDIX B: WARRANTY AND RETURNS

WARRANTY

Timberline warrants its products against defects in workmanship or material under normal use or service for one year. All obligations or liabilities under this warranty are limited to repair or replacement, at Timberline's option, F.O.B. Boulder, CO, of parts that are returned, freight prepaid and which are accepted as being defective upon inspection of Timberline.

Components that are subject to normal wear and/or are scheduled for routine replacement within the warranty period, and/or parts that are subjected to effects of corrosion or deterioration by chemical or other action are excluded from the above warranty. Repair or replacement will not be made under warranty for malfunction because of inadequate facilities, operating conditions or utilities.

Equipment and components must be returned with Timberline's prior approval and contain a Timberline Return Authorization Number. Call Timberline (1-800-777-5996).

Guarantees/Warranties on accessories and equipment included by Timberline from other manufacturers are limited to the guarantees given on such equipment by the respective manufacturers.

Any modifications made to equipment covered by this warranty, without written permission from Timberline will void the warranty. Timberline reserves the right not to honor this warranty if the products are obviously mishandled by the user.

Timberline assumes no responsibility for consequential, economic, incidental damages of any nature, or on-site re-installation costs arising out of future alleged failure of any of its products or their accessories.

This warranty supersedes any and all previous warranties unless otherwise agreed upon at the time of sale, such as for customized equipment.

SHIPMENTS

All shipments are made F.O.B. Boulder, CO. Instruments and major components will be packed and shipped via surface, unless otherwise requested. Supplies and/or replacement parts are packed and shipped via UPS, UPS Blue, air parcel post, or parcel post, unless otherwise requested.

DAMAGED SHIPMENTS

The Interstate Commerce Commission has held that carriers are as responsible for concealed damage as for visible damage in transit. Unpack shipment promptly after receipt, as there may be concealed damage even though no evidence of it is apparent. When concealed damage is discovered, cease further unpacking of the unit involved and request immediate inspection by the local agent or carrier and secure a written report of the findings to support a claim. This request must be made within 15 days of receipt. Otherwise, the carrier will not honor the claim. Do not return damaged goods to the factory without first securing an inspection report and contacting Timberline for a return authorization number.

FILING OF CLAIMS

After a damage inspection report has been secured, Timberline will cooperate in supplying replacements and handling a claim that may be initiated by either party.

RETURNS

No returns may be made without prior notification and authorization. If for any reason, it is necessary to return material to us, please contact our customer service department for a return authorization number and forwarding instructions.

APPENDIX C: SPECIFICATIONS

Figure B-1: Timberline TL-2X00 Ammonia/Nitrate Specifications

Principle of Operation:	Membrane Diffusion / Conductivity Detection
Conductivity Range:	10 ppb – 1000 ppm
Detection Limit:	10 ppb
Sample Rate:	Up to 1 per minute
Power:	100V, 60Hz;
Detection:	Alternating Current, Synchronous Detection, 10KHz Frequency
Range:	A-F
Noise:	Less than 0.0004 μ S (DI Water, 1mL/min)
Drift:	Less than 0.004 μ S/hr (DI Water, 1mL/min, 35°C)
Insulation:	Minimum 1/2" all sides
Heater:	25W DC heating element vulcanized to aluminum block
Preheater:	Tefzel tubing knitted and encased in high thermal mass housing
Fluid Path:	Wetted parts are inert polymers (PEEK, Tefzel) & Stainless Steel
Pump Channels:	8 Synchronous
Flow Rates:	0.04 to 18.0 ml/min
Pump motor speed	1 – 50 rpm

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