WARM SPRINGS PONDS

OPERATING MANUAL

ANACONDA MINERALS COMPANY
ANACONDA REDUCTION WORKS
ANACONDA, MONTANA

By: George Duffield
March 1985

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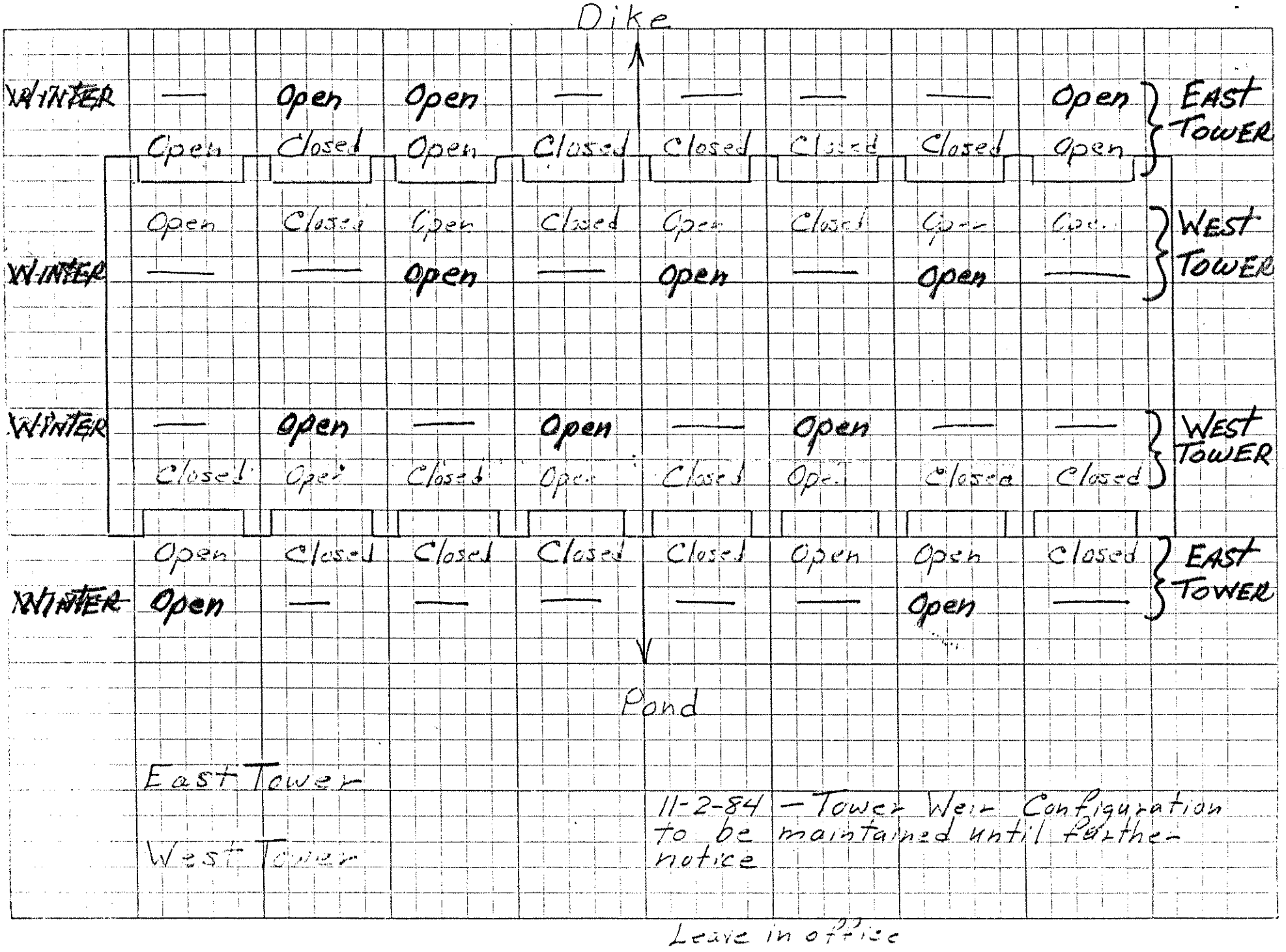
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West Tower
11-2-84 to be maintained until further notice
— Tower Weir Configuration
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This operating manual contains a description of, and operating criteria for the Warm Springs Water Treatment Ponds associated with the now defunct Anaconda Reduction Works of the Anaconda Minerals Company. Where specific operating limits and conditions are identified, they should be adhered to.

No operating manual could cover all of the circumstances which may arise within this system. This manual is intended for use by qualified individuals trained in the operation of this facility.

I DESCRIPTION

A. GENERAL

The Warm Springs Ponds area covers approximately 2,600 acres of which 1,400 acres are wetted. Pond 2 and pond 3 are active and in a direct circuit as a water treatment facility. Pond 1 is indirectly linked to the facility with approximately 30% of its area being used.

B. DIRECT CIRCUIT

Silver Bow Creek enters pond 3 through a set of flow control gates at the upper pH station. Burnt lime is added at this point for pH control and metals precipitation. A bypass channel which connects with Mill-Willow Creek allows excessively high flow to be diverted around the ponds.

The Opportunity D1 and D2 pond discharges are introduced to pond 3 by ditches and inverted siphons which transport the flows under the Mill-Willow Bypass.

Water is discharged from pond 3 to pond 2 through two decant structures with board weirs for pond level control.

The final effluent of treated water is discharged from pond 2 to the Mill-Willow Bypass through a decant spillway equipped with board weirs for pond level control.

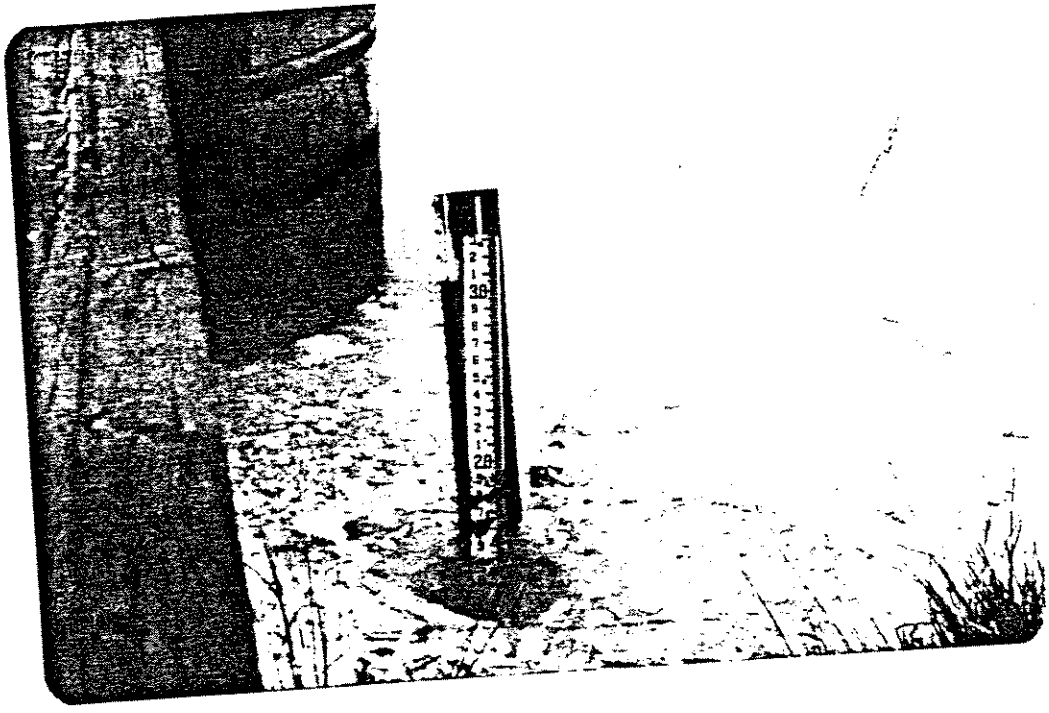
C. INDIRECT CIRCUIT

Seepage from the pond system is collected downgradient by means of a series of bulkheads and pumped to the east cell of pond 1. Burnt lime is added at the pump discharge for pH control and metals precipitation. After settling the supernatant is pumped to pond 2 for final discharge with other waters in the system.

II POND LEVEL CONTROL

A. POND 1

Pond 1 Staff Gage



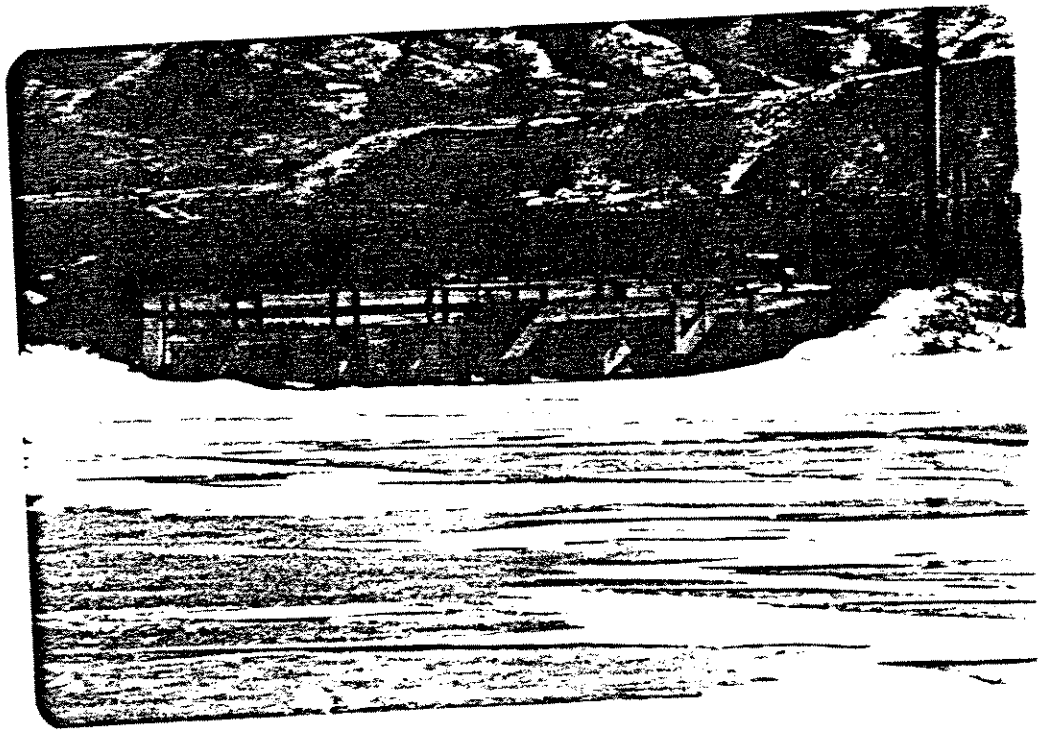
Only the east cell of the pond is in use. The pond level is indicated by a staff gage located at the pond 1 transfer pump in the southeast corner of the pond. Pond level is controlled with the pond 1 transfer pump. (See PUMPING section for pump operation.)

During the spring, summer and early fall, optimum level for the pond is between 0 and 0.60 feet on the gage; higher levels will result in increased seepage from the pond and consequently increased seepage pump running time. During the later fall and winter (freezing weather) months, the pond level has to be raised to fluctuate between 0.50 and 1.20 feet to avoid freezing the transfer pump sump.

With the transfer pump off or recycling allow the pond to rise to the desired maximum level, begin pumping to pond 2; when the pond level falls to the desired low level repeat the cycle.

B. POND 2

Pond 2 Discharge



The reference point for pond level is a staff gage in the pond on the west side of the pond discharge. Pond level is controlled by means of a decant spillway equipped with removable weir boards.*

During the spring while there is the likelihood of heavy runoff and precipitation events, the pond level is controlled between 1.00 and 1.30 feet.* The preferred level is 1.30 feet in order to increase pond retention time but as runoff increases, the lower level of 1.00 feet should be maintained to provide added storage capacity for stream cresting which occurs during the night while the system is unattended.

After the threat of runoff has passed (usually late June), the pond is raised to between 1.60 and 1.70 feet* to promote the development of aquatic plant life along the banks and shores thus creating large heavy masses of plants. After the plant masses become matured (small masses begin breaking away and floating toward the discharge) the pond is dropped very quickly to between 1.00 and 1.10 feet to anchor the plant

masses. This level is maintained until late fall when the plants begin to die and decay from colder water temperatures.

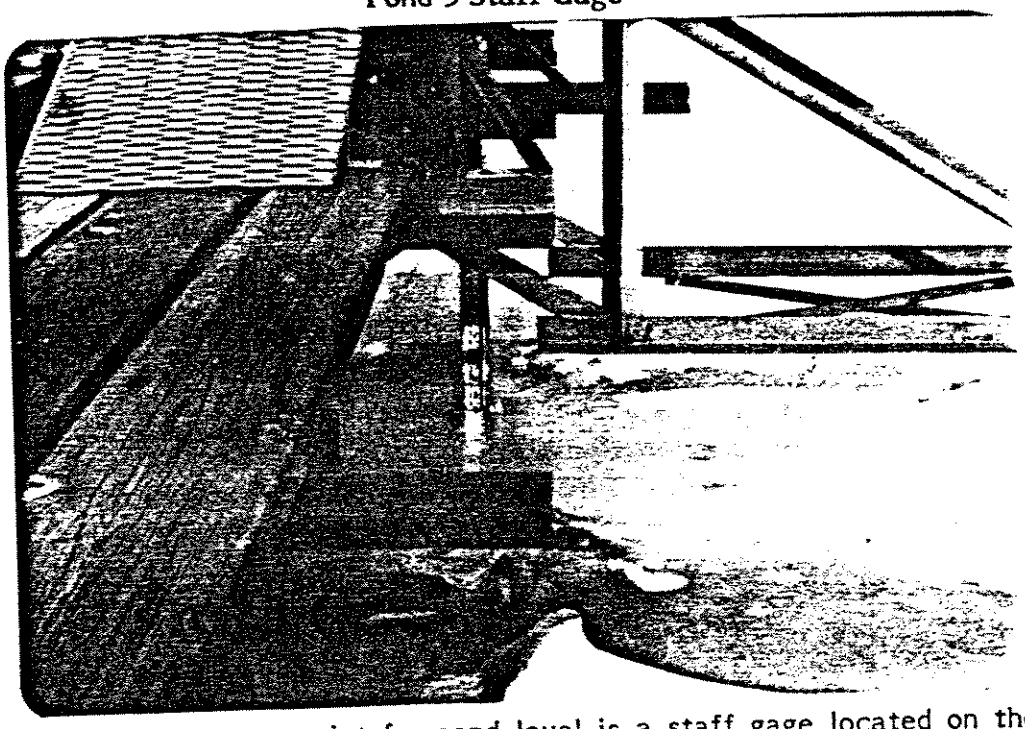
During the late fall (usually late October) the pond level is increased to between 1.50 and 1.60 feet* to allow ice formation over the entire pond, thus avoiding channelling during the winter. This should be accomplished when the temperatures are cold enough to form a 3 to 4 inch ice cover quickly to avoid extreme wave and ice erosion on the dikes. If the pond freezes before the level is raised, the ice pack will freeze to the bottom and will not float when the pond is raised, thus reducing the pond area causing severe channeling.

After a 3 to 4 inch ice cover is established over the entire pond surface, the level is dropped to between 1.25 and 1.30 feet very quickly to anchor the ice on the edges of the pond and reduce dike and decant structure damage from large free-floating ice packs.

The pond level will fluctuate through the winter influenced by inflow variations caused by "ice packing" on Silver Bow Creek. No deliberate level control is necessary** through the winter under normal conditions.**

C. POND 3

Pond 3 Staff Gage



The reference point for pond level is a staff gage located on the west decant tower beneath the walkway. Pond level is controlled by two decant towers equipped with removable weir boards.

During the spring while there is the likelihood of heavy runoff and precipitation events, the pond level is maintained between 0.70 and 0.75 feet to allow adequate storage for extreme flow events.

After the threat of runoff has passed, the pond is raised to between 0.90 and 1.00 feet* thus increasing retention time and reducing the possibility of re-entraining precipitated metals during high velocity wind storms. A higher pond level would be desirable to accomplish these purposes but wave erosion on the dikes increases dramatically at higher pond levels.

During late fall (usually later October), the pond level is raised to between 1.30 and 1.40 feet* to allow ice formation over the entire pond, thus avoiding channeling during the winter. Care should be taken not to raise the pond too soon before ice cover begins to form because at this high level wave erosion is extreme.

After a 3 to 4 inch ice cover is established over the entire pond surface, the pond level is dropped very quickly to between 0.90 and 1.00 feet to anchor the ice on the edges of the pond and reduce dike and decant tower damage from large free-floating ice packs. Because of the large area of this pond, if the ice pack is allowed to float unanchored, entire dikes may be pushed out or decant towers may be tipped over.

Pond level will fluctuate through the winter influenced by "ice packing" on Silver Bow Creek. No deliberate pond level control** is necessary through the winter under normal conditions.***

Note:

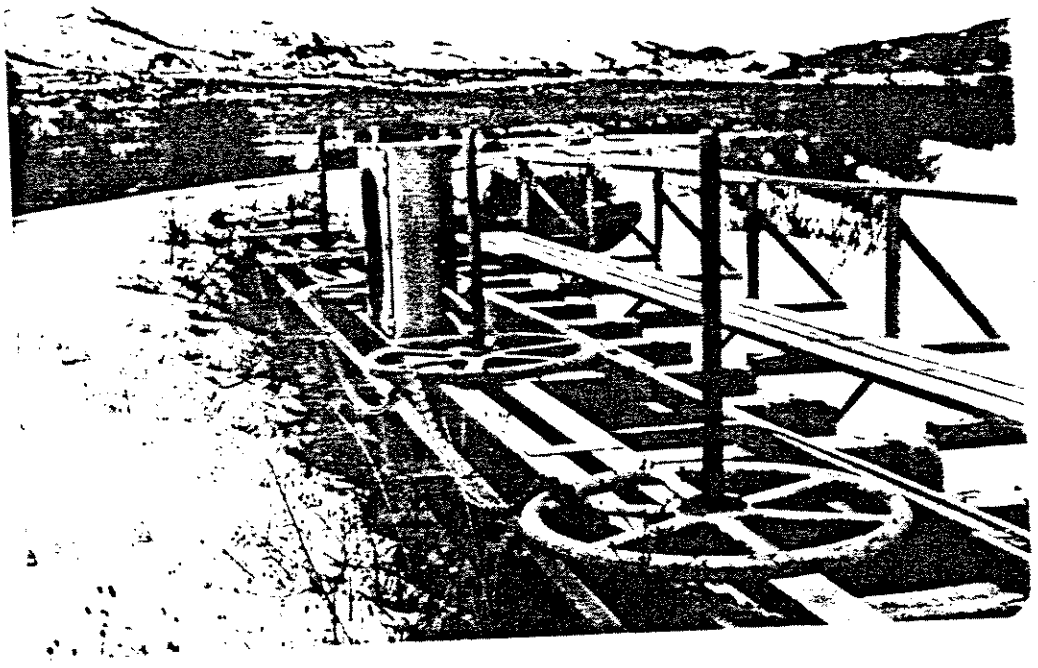
*Unless otherwise stated, pond level changes should be made slowly over a period of days by removing or adding: 2 or 3 boards at a time on the pond 2 discharge or 4 to 6 boards at a time on one of the pond 3 decant towers.

Decent weirs **MUST be cleared of ice every day through the winter to assure continued pond discharge.

***The traditional mid-January thaw is to be watched very carefully since at this time of year frozen ground which causes a "tin roof" effect in runoff and frozen pond level control weirs make the pond system very vulnerable.

D. UPPER pH INLET GATES

Upper pH Gate Wheels



A group of 6 gates control the flow of Silver Bow Creek into the pond system. Gates are opened and closed with a screw and wheel mounted on top of each gate. Openings on gates are referred to in inches and measured from the top of the screw to the wheel.

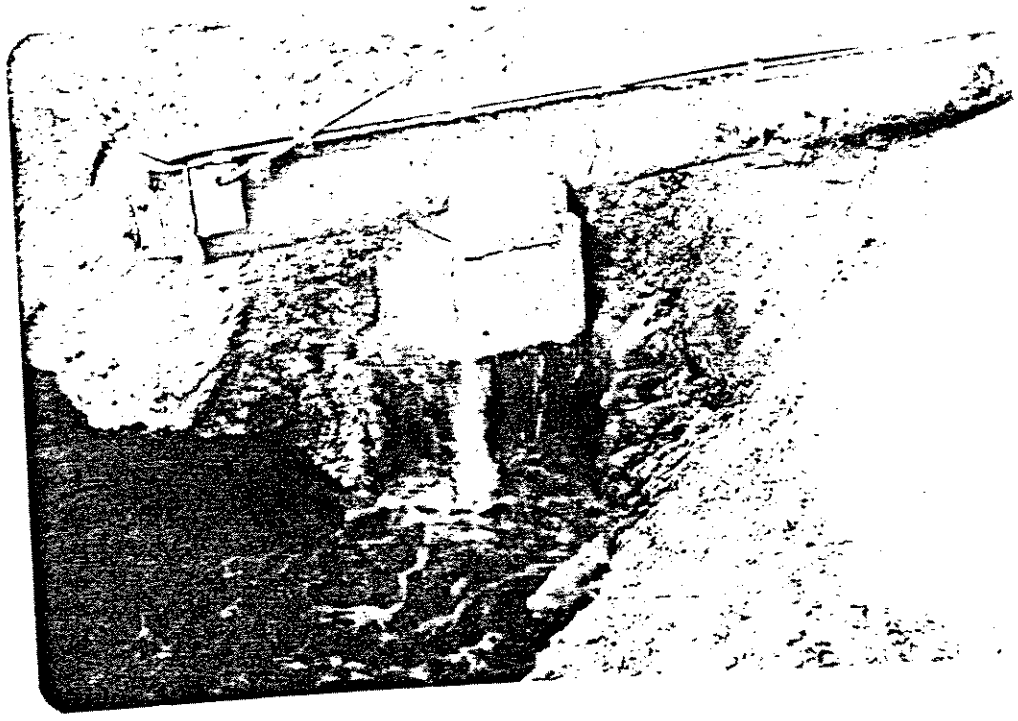
Under normal flow conditions the entire flow from Silver Bow Creek is treated and passes through the pond system. However, during spring runoff peak flows often exceed the throughput capacity of the system. Therefore, during this period, only 5 of the 6 gates are opened to 18 inches, thus allowing a maximum flow through the system and causing excess flow to be routed around the ponds by means of the Mill-Willow Bypass.

During the winter, ice jamming in the flow control gates raises the creek level to the point that bypassing would occur if measures were not taken to prevent it. To prevent this bypassing, a burm 5 feet high and extending the full width of the bypass channel is constructed. This burm is washed out each year by spring runoff and must be replaced by the end of October.

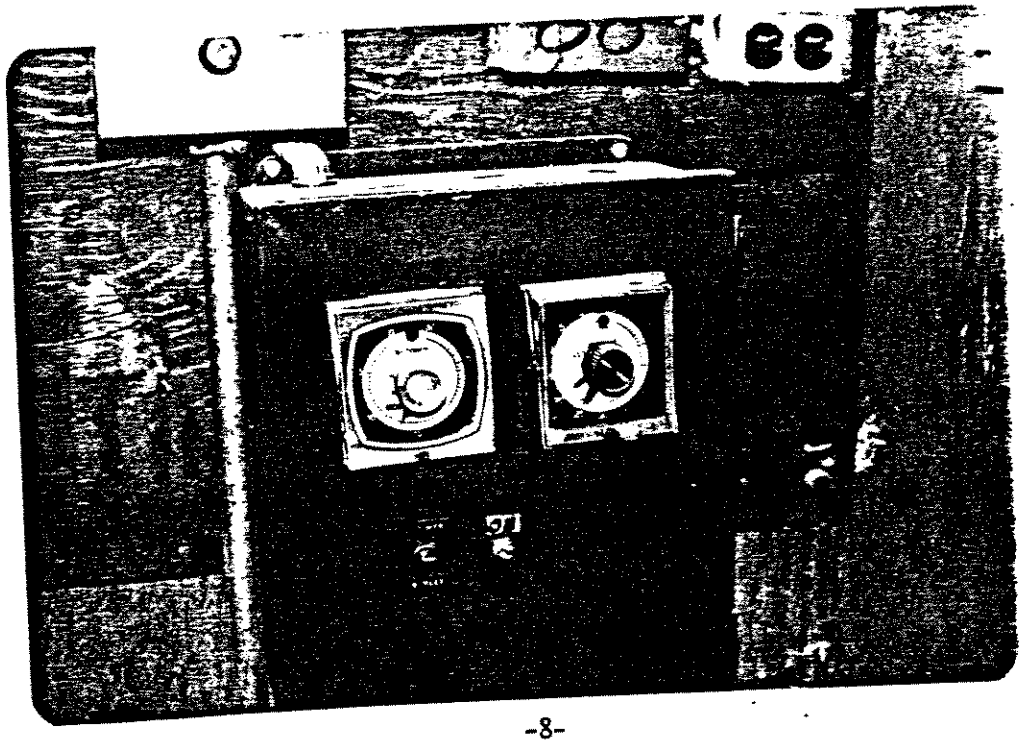
III BURNT LIME ADDITION

A. POND 1

Pond 1 Burnt Lime Screw Conveyor



Pond 1 Burnt Lime Feeder Timers



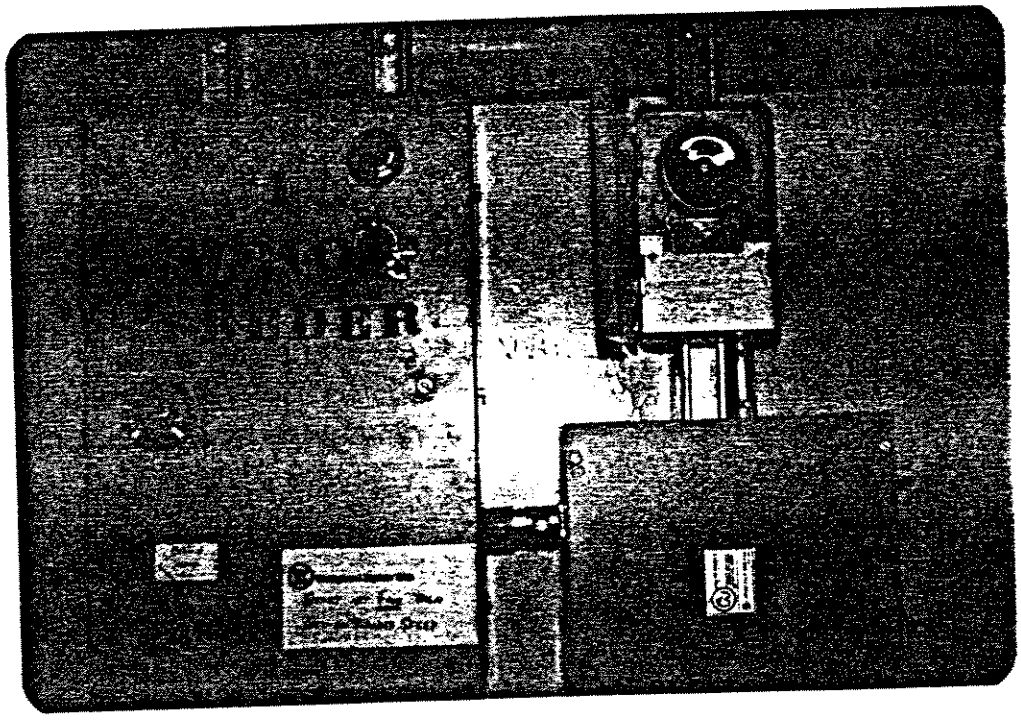
Burnt lime is added at the seepage pump discharge with a screw conveyor fed from a storage hopper. The electrical circuit which operates the screw is in series with the seepage pump electrical circuit so as to allow screw operation only when the pump is operating.

The lime feed rate is controlled by the use of two timers, an interval timer and an episode timer. The interval timer controls the frequency of lime addition and is divided into 1 minute increments ranging from 0 to 60 minutes. The episode timer controls the screw running time and is divided into 1 second increments ranging from 0 to 30 seconds.

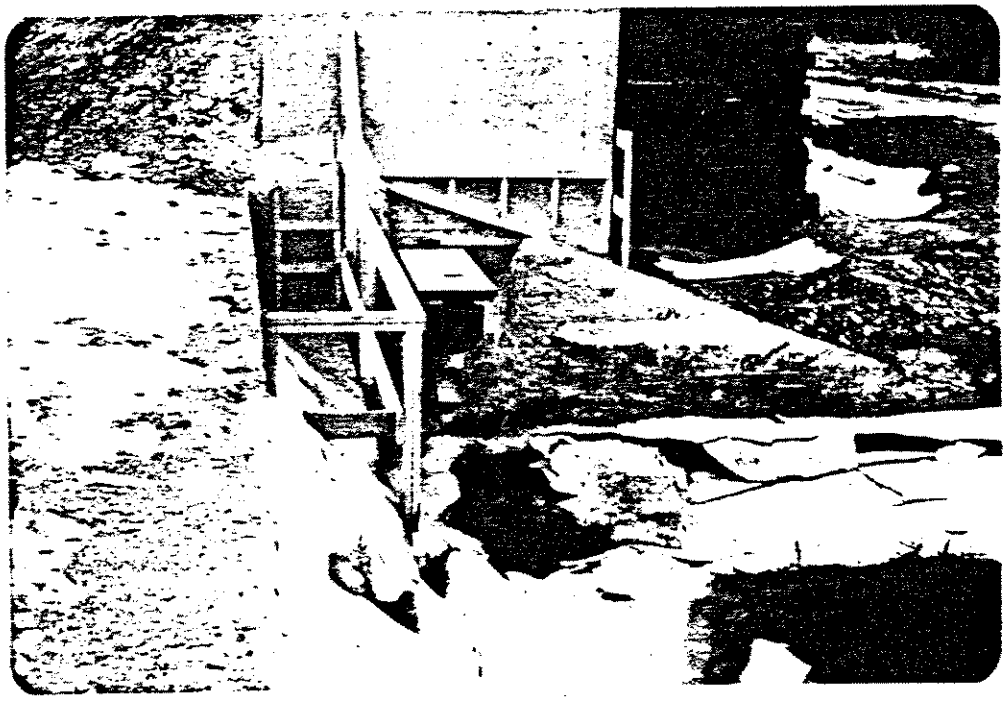
During normal operation the interval timer is set on 25 minutes and the episode timer is set on 13 seconds. Lime demand is determined by the pond 1 transfer pump discharge pH. It should be maintained between 8.0 and 8.3.

B. UPPER pH STATION

Upper pH Burnt Lime Feeder Controls



Upper pH Burnt Lime Screw Conveyor



Burnt lime is added to Silver Bow Creek with a screw conveyor fed from a storage hopper. The screw is driven by a reostat controlled, variable speed, DC motor. Screw operation is controlled by a 24-hour timer with 15 minute increments. Therefore the lime feed rate can be controlled by adjusting the screw speed or running time.

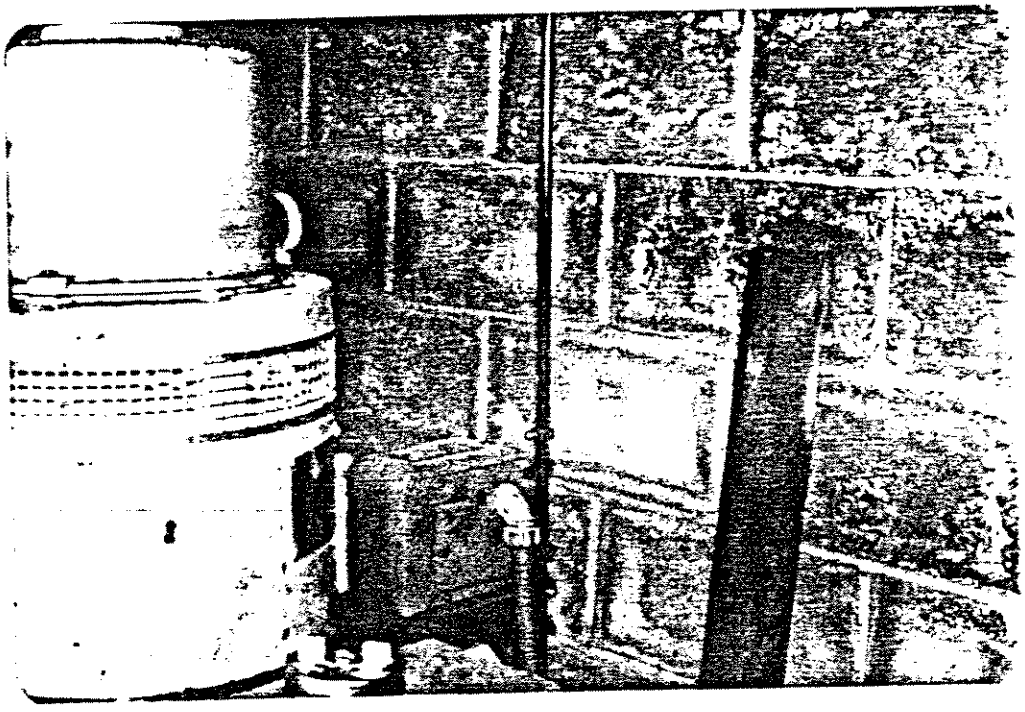
When the screw is started the reostat control **MUST** be set at or above 5 on the dial to avoid burnout. Therefore when the timer circuit is in use, the reostat has to be set above 5.

During normal operation, the reostat is set on 5 with the timer set to operate the screw for 15 minutes per day. The optimum time for lime addition is between 2:00 and 4:00 P.M., since by this time of day the water is at its warmest, resulting in better lime reaction and during winter months openings in the creek ice cover, if they occur, will have developed. Lime demand is determined by pond 2 discharge pH.

IV PUMPING

A. SEEPAGE PUMP

Seepage Pump Float Switch



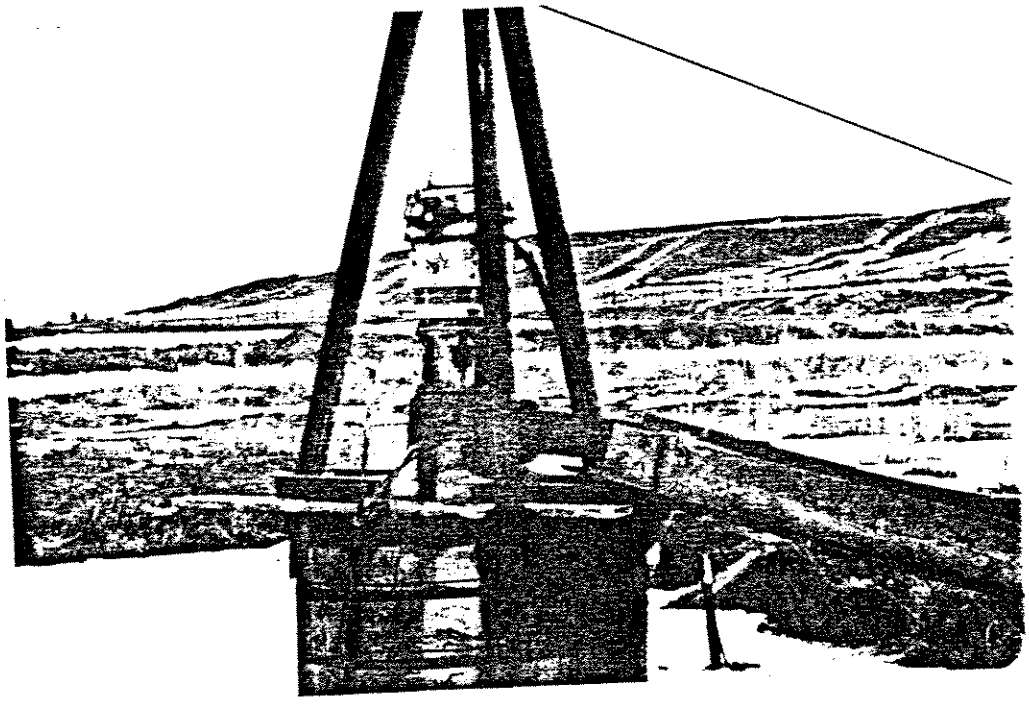
Seepage is collected down gradient from the pond system using a series of ditches and bulkheads. A pump located approximately 200 feet north from the northeast corner of pond 1 then pumps this seepage to pond 1 at a rate of 500 gpm. Pump operation is controlled by a mechanical float switch.

This pump requires little maintenance but should be checked daily to assure maximum performance. The pump discharge is underground and drains well therefore causing no freezing problems.

The composition of the water being pumped causes severe scaling and iron buildup in the discharge line; therefore the line has to be pigged at least every six weeks.

B. POND 1 TRANSFER PUMP

Pond 1 Transfer Pump



Pond 1 Transfer Pump Controls

Treated and settled water from pond 1 is pumped to pond 2 with a 500 gpm vertical Johnston pump located in the southeast corner of pond 1. The pump is operated manually by a switch located on the pump utility pole.

Pond levels discussed in the pond level control section should be adhered to and maintained by starting or stopping the pump.

During the winter, to avoid freezing the pump sump, the pump must be left running. Pond level control is accomplished by opening or closing the pump discharge line at a point about 200 feet from the pump thus recirculating water in the pond until a peak level is reached.

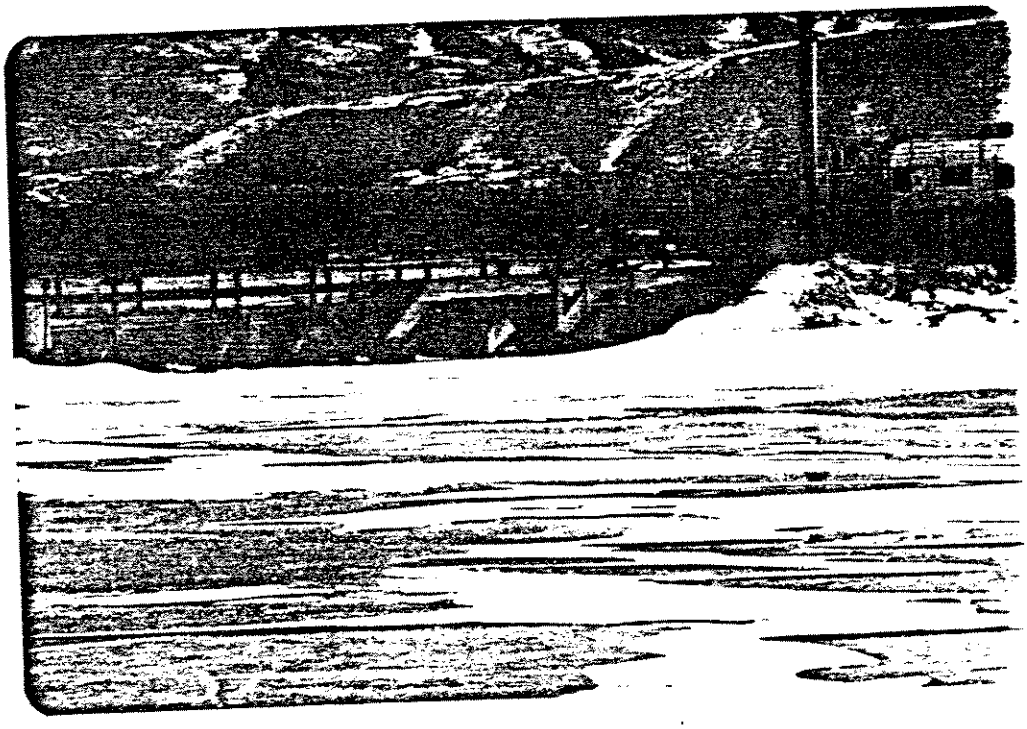
V SAMPLING

A. POND OPERATIONS

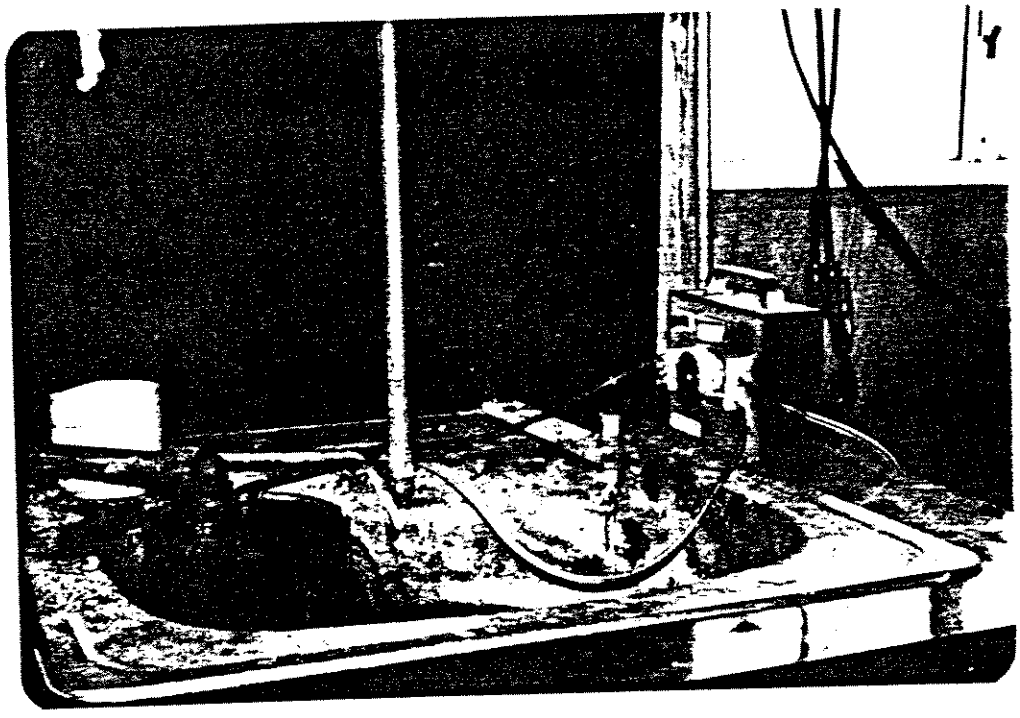
Pond performance is monitored on a regular basis using 5 sampling locations. The locations are sampled for pH on a weekly basis and 3 of the locations are sampled for trace metals on a monthly basis. (See Appendix A for location descriptions and reporting forms.) (See Appendix B for pH meter operation.)

B. MPDES COMPLIANCE

Pond 2 Discharge and Sampler Trailer



Pond 2 Discharge 24-Hour Composite Sample Pump



Compliance sampling is conducted in the trailer located at the pond 2 discharge. Pond 2 discharge sample is pumped through the trailer by a continuously running submersible pump. Sample is collected with a timed 24-hour composite pump.

A daily visit to the pond 2 discharge sampler trailer should include as a regular activity the following items:

1. check sample transport pump and lines

2. check 24-hour composite pump

3. take discharge pH (See Appendix B for meter operation)

4. observe discharge staff gage reading (See Appendix A for rating table) (located on culverts 300 feet down stream)

5. record all data on appropriate forms (See Appendix A)

VI MPDES PERMIT

The quality of wastewater discharged from the Warm Springs Ponds is governed by an MPDES (Montana Pollutant Discharge Elimination System) permit issued by the Montana Department of Health and Environmental Sciences. Permit number MT-0000183 governs this facility; a copy of the permit is contained in the following pages.

MT-0000183

MONTANA DEPARTMENT OF HEALTH
AND
ENVIRONMENTAL SCIENCES

AUTHORIZATION TO DISCHARGE UNDER THE

MONTANA POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with Section 75-5-101 et seq., MCA, and ARM 16.20.901 et seq., and 16.20.601 et seq.,

Anaconda Minerals Company
P. O. Box 689
Butte, Montana 59703

is authorized to discharge from a facility located at Warm Springs, Montana,

to receiving waters named the Clark Fork River, via Silver Bow Creek,

in accordance with effluent limitations, monitoring requirements and other conditions set forth in Parts I, II, and III hereof.

This permit shall become effective on the date of issuance.

This permit and the authorization to discharge shall expire at midnight, January 31, 1988.

FOR THE MONTANA DEPARTMENT OF HEALTH
AND ENVIRONMENTAL SCIENCES

Steven L. Pilcher, Chief
Water Quality Bureau
Environmental Sciences Division

Dated this 17th. day of June 1983

POND SYSTEM MAP

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. Immediate Effluent Limitations

Effective immediately and lasting through that date established by an approved compliance schedule, the quality of effluent discharged by the facility from discharge 001 (Warm Springs Pond 1 discharge) and discharge 002 (Warm Springs Pond 2 discharge) shall, as a minimum, meet the limitations as set forth below:

Parameter	Effluent Concentration Daily Maximum (mg/l) a/
Total Copper	0.20
Total Zinc	0.50
Total Iron	2.20
Total Lead	0.10
Total Cadmium	0.010
Total Arsenic	0.050
Total Mercury	0.001
Sulfate	625
Total Suspended Solids	45

The pH of the discharge shall not be less than 6.5 standard units nor greater than 9.5 standard units.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

a/ Compliance with these limitations shall be determined by composite sample.

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. Final Effluent Limitations

Effective on that date established by an approved compliance schedule and in no case later than January 31, 1988, the quality of effluent discharged by the facility from discharge 001 (Warm Springs Pond 1 discharge) and discharge 002 (Warm Springs Pond 2 discharge) shall, as a minimum, meet the limitations as set forth below:

Parameter	Effluent Concentration Instantaneous Maximum a/ (mg/l)
Total Copper	0.09
Total Zinc	0.30
Total Iron	2.20
Total Lead	0.10
Total Cadmium	0.010
Total Arsenic	0.050
Total Mercury	0.001
Sulfate	625
Total Suspended Solids	45

The pH of the discharge shall not be less than 6.5 standard units nor greater than 9.5 standard units.

There shall be no discharge of floating solids or visible foam in other than trace amounts.

a/ For compliance purposes, any single analysis and/or measurement beyond this limitation shall be considered a violation of the conditions of this permit.

POND SYSTEM MAP

2. Self-Monitoring Requirements

The permittee shall monitor discharge 001 and discharge 002 as shown below:

Parameter	Frequency	Type a/
Flow	Daily	Instantaneous
Total Copper	Twice/week	Composite
Total Zinc	Twice/week	Composite
Total Iron	Twice/week	Composite
Total Lead	Twice/week	Composite
Total Cadmium	Twice/week	Composite
Total Arsenic	Twice/week	Composite
Total Mercury	Twice/week	Composite
Sulfate	Twice/week	Composite
pH	Daily	Grab
Total Suspended Solids	Twice/week	Composite

Samples taken in compliance with the monitoring requirements specified above shall be taken prior to entry into the Mill-Willow bypass channel.

a/ See Definitions

POND SYSTEM MAP

B. SCHEDULE OF COMPLIANCE

1. The permittee shall achieve compliance with the effluent limitations specified for discharges in accordance with the following schedule:

The permittee shall submit to the Department by no later than January 31, 1985, an implementation plan for an abatement program designed to achieve the final effluent limitations specified in this permit. The implementation plan shall consist of an outline of intended design, construction and operation, including a compliance schedule setting forth the dates by which compliance with the effluent limitations will be reached.

Upon approval of the implementation plan by the Department, the schedule of compliance shall become conditions of this permit.

2. No later than 14 calendar days following a date identified in the schedule of compliance, the permittee shall submit either a report of progress, or in the case of specific actions being required by identified dates, a written notice of compliance or noncompliance. In the latter case, the notice shall include the cause of noncompliance, any remedial actions taken, and the probability of meeting the next scheduled requirement.

POND SYSTEM MAP

C. MONITORING AND REPORTING REQUIREMENTS

1. Representative Sampling

Samples and measurements taken as required herein shall be representative of the volume and nature of the monitored discharge.

2. Reporting

Monitoring results obtained during the previous month shall be summarized for each month and reported on a Discharge Monitoring Report Form (EPA No. 3320-1), postmarked no later than the 28th day of the month following the completed reporting period.

Duplicate signed copies of these, and all other reports required herein, shall be submitted to the Department and the Regional Administrator at the following addresses:

(a) Montana Department of Health and Environmental Sciences
Water Quality Bureau
Room A-206, Cogswell Building
Helena, Montana 59620

(b) Regional Administrator
U. S. Environmental Protection Agency
1860 Lincoln Street
Denver, Colorado 80295
ATT: Water Mgt. Div.
Compliance Branch

If no discharge occurs during the reporting period, "no discharge" shall be reported, in letter form, to the above agencies.

3. Definitions

(a) The "Act" means the Federal Water Pollution Control Act.

(b) The "Administrator" means the administrator of the United States Environmental Protection Agency.

(c) A "composite" sample, for monitoring requirements is defined as a minimum of four (4) grab samples collected at equally spaced two (2) hour intervals and proportioned according to flow.

(d) The "Department" means the Montana Department of Health and Environmental Sciences.

(e) The "EPA" means the United States Environmental Protection Agency.

(f) A "grab" sample, for monitoring requirements, is defined as a single "dip and take" sample collected at a representative point in the discharge stream.

(g) An "instantaneous" measurement, for monitoring requirements, is defined as a single reading, observation, or measurement using acceptable monitoring equipment.

(h) The "Regional Administrator" means the administrator of the region of EPA with jurisdiction over federal water pollution contol activities in the state of Montana.

(i) For compliance purposes, the "daily maximum" concentration shall be determined by the analysis of a properly preserved composite sample composed of a minimum of four (4) grab samples collected at equally spaced two (2) hour intervals and proportioned according to flow at the time of sampling.

4. Test Procedures

Test procedures for the analysis of pollutants shall conform to regulations published in or subsequent revisions to Part 136, Title 40 of the Code of Federal Regulations. Sample collection and preservation shall be in accordance with the best methods technologically feasible, and shall be in a manner acceptable to the Department. (The Department's Treatment and Preservation Guide should be consulted for acceptable sample collection and preservation techniques.)

All flow-measuring and flow-recording devices used in obtaining data submitted in self-monitoring reports must indicate values within 10 percent of the actual flow being measured.

5. Recording of Results

For each measurement or sample taken pursuant to the requirements of this permit, the permittee shall record the following information:

(a) the exact place, date, and time of sampling;

(b) the dates the analyses were performed;

(c) the person(s) who performed the analyses;

(d) the analytical techniques or methods used; and

(e) the results of all required analyses.

6. Additional Monitoring by Permittee

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report Form (EPA No. 3320-1). Such increased frequency shall also be indicated.

7. Records Retention

All records and information resulting from the monitoring activities required by this permit including all records of analyses performed and calibration and maintenance of instrumentation and recordings from continuous monitoring instrumentation shall be retained for a minimum of three (3) years, or longer if requested by the Department or the Regional Administrator.

MANAGEMENT REQUIREMENTS

1. Change in Discharge

All discharges authorized herein shall be consistent with the terms and conditions of this permit. The discharge of any pollutant identified in this permit more frequently than or at a level in excess of that authorized shall constitute a violation of the permit. Any anticipated facility expansions, production increases, or process modifications which will result in new, different, or increased discharges of pollutants must be reported by submission of a new NPDES application or, if such changes will not violate the effluent limitations specified in this permit, by notice to the Department of such changes. Following such notice, the permit may be modified to specify and limit any pollutants not previously limited.

2. Noncompliance Notification

If, for any reason, the permittee does not comply with or will be unable to comply with any effluent limitation specified in this permit, the permittee shall provide the Department and the Regional Administrator with the following information, in writing, within five (5) days of becoming aware of such condition:

(a) A description of the discharge and cause of noncompliance; and

(b) The period of noncompliance, including exact dates and times; or, if not corrected, the anticipated time the noncompliance is expected to continue, and steps being taken to reduce, eliminate and prevent recurrence of the noncomplying discharge.

3. Facilities Operation

The permittee shall at all times maintain in good working order and operate as efficiently as possible all treatment or control facilities or systems installed or used by the permittee to achieve compliance with the terms and conditions of this permit.

4. Adverse Impact

The permittee shall take all reasonable steps to minimize any adverse impact to state waters resulting from noncompliance with any effluent limitations specified in this permit, including such accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

5. Bypassing

Any diversion from or bypass of treatment or control facilities or systems necessary to maintain compliance with the terms and conditions of this permit is prohibited, except (i) where unavoidable to prevent loss of life

POND SYSTEM MAP

or severe property damage, or (ii) where excessive storm drainage or runoff would damage any facilities necessary for compliance with the effluent limitations and prohibitions of this permit. The permittee shall promptly notify the Department and the Regional Administrator in writing of each such diversion or bypass.

If, for other reasons, a partial or complete bypass of the wastewater treatment facilities is considered necessary, a request for such bypass shall be submitted to the Department and to the Regional Administrator at least sixty (60) days prior to the proposed bypass. If the proposed bypass is judged acceptable by the Department and by the Regional Administrator, the bypass will be allowed subject to limitations imposed by the Department and the Regional Administrator.

If, after review and consideration, the proposed bypass is determined to be unacceptable by the Department and the Regional Administrator, or if limitations imposed on an approved bypass are violated, such bypass shall be considered a violation of this permit; and the fact that application was made, or that a partial bypass was approved, shall not be defense to any action brought thereunder.

6. Removed Substances

Solids, sludges, filter backwash, or other pollutants removed in the course of treatment or control of wastewaters shall be disposed of in a manner such as to prevent any pollutant from such materials from entering state waters.

7. Power Failures

In order to maintain compliance with the effluent limitations and prohibitions of this permit, the permittee shall either:

(a) In accordance with the Schedule of Compliance contained in Part I, provide an alternative power source sufficient to operate the wastewater control facilities;

or, if such alternative power source is not in existence, and no date for its implementation appears in Part I,

(b) Take such precautions as are necessary to maintain and operate the facility under his control in a manner that will minimize upsets and insure stable operation until power is restored.

B. RESPONSIBILITIES

1. Right of Entry

The permittee shall allow the head of the Department or the Regional Administrator, and/or their authorized representatives, upon the presentation of credentials:

(a) To enter upon the permittee's premises where an effluent source is located or in which any records are kept; and

(b) At reasonable times to have access to and copy and records required to be kept under the terms and conditions of this permit; to inspect any monitoring equipment or monitoring method required in this permit; and to sample any discharge of pollutants.

2. Transfer of Ownership or Control

In the event of any change in control or ownership of facilities from which the authorized discharges emanate, the permittee shall notify the succeeding owner or controller of the existence of this permit by letter, a copy of which shall be forwarded to the Department and the Regional Administrator.

3. Availability of Reports

Except for data determined to be confidential under Section 308 of the Act, all reports prepared in accordance with the terms of this permit shall be available for public inspection at the offices of the Department and the Regional Administrator. As required by the Act, effluent data shall not be considered confidential. Knowingly making any false statement on any such report may result in the imposition of criminal penalties as provided for in Section 75-5-633, MCA.

4. Permit Modification

After notice and opportunity for a hearing, this permit may be modified, suspended, or revoked in whole or in part during its term for cause including, but not limited to, the following:

(a) Violation of any terms or conditions of this permit;

(b) Obtaining this permit by misrepresentation or failure to disclose fully all relevant facts; or

(c) A change in any condition that requires either a temporary or permanent reduction or elimination of the authorized discharge.

5. Toxic Pollutants

Notwithstanding Part II, B-4 above, if a toxic standard or prohibition (including any schedule of compliance specified in such effluent standard or prohibition) is established under Section 307(a) of the Act for a toxic pollutant which is present in the discharge and such standard or prohibition is more stringent than any limitation for such pollutant in this permit, this permit shall be revised or modified in accordance with the toxic effluent standard or prohibition and the permittee so notified.

6. Civil and Criminal Liability

Except as provided in permit conditions on "Bypassing" (Part II, A-5), and "Power Failures" (Part II, A-7), nothing in this permit shall be construed to relieve the permittee from civil or criminal penalties for noncompliance.

7. Oil and Hazardous Substance Liability

Nothing in this permit shall be construed to preclude the institution of any legal action or relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Act.

8. Property Rights

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property or any invasion of personal rights, nor any infringement of Federal, State or local laws or regulations.

9. Severability

The provisions of this permit are severable, and if any provision of this permit, or the application of any provision of this permit to any circumstance, is held invalid, the application of such provision to other circumstances, and the remainder of this permit, shall not be affected thereby.

10. Reapplication

If the permittee desires to continue to discharge beyond the expiration date of this permit, he shall reapply, in writing, to the Department at least 180 days prior to the expiration date of this permit.

POND SYSTEM MAP

SAMPLING SCHEDULE

Station No.	Description	pH Determination	Metal Analysis
5	Pond 2 Discharge	Daily	2/Week
44A	D1 Discharge at Frontage Road	Weekly	Monthly
44B	D2 Discharge at Frontage Road	Weekly	Monthly
75	Pond 3 East Decant Tower	Weekly	
76	Pond 3 West Decant Tower	Weekly	
81	Silver Bow Creek at Upper pH	Weekly	Monthly

JB/302

OPERATOR _____

STATION NO. _____

DAILY FLOW CALCULATIONS

DAY	TIME	STAFF READING Ft.	GATE CHANGE Yes / No	STAFF READING AFTER CHANGE Ft.	AVERAGE STAFF READING Ft.	AVERAGE FLOW RATE mgh	TIME hrs.	FLOW mgd
in.								
on.								
ues.								
ed.								
hurs.								
ri.								
at.								
un.								
					TOTAL SUNDAY TO SATURDAY			

COMPOSITE CALCULATIONS

Sample Date

__/__/__ Mon./Total_____ml

__/__/__ Tues/Total_____

__/__/__ Wed./Total_____

__/__/__ Thur/Total_____

__/__/__ Fri./Total_____

__/__/__ Sat./Total_____

__/__/__ Sun./Total_____

COMPOSITE TOTAL_____ml

POND #1 SEEPAGE PUMP

	Time	Reading	Hours
Mon.			
Tues.			
Wed.			
Thurs.			
Fri.			
Sat.			
Sun.			

SUNDAY _____
(Date)

FIELD DATA - STREAM MONITORING PROGRAM

Daily Stations

ıtion / ɔer/Day	Turbidity F.T.U. Hi/Low	pH Hi/Low or Catch	Staff Ft.	Temp. °C	Time
ɔn.					
ıes.					
ed.					
hurs.					
ri.					
;at.					
;un.					

Mon.					
Tues.					
Wed.					
Thurs.					
Fri.					
Sat.					
Sun.					

Weekly Stations

Sunday			
5			
4A			
4B			
4C			
75			
76			
CF			
NSC			

DAILY pH MEASUREMENTS

Date	--	UPPER pH	44a	44b	ET	WT	#5	#2		

THE ANACONDA COMPANY
ANACONDA REDUCTION DEPARTMENT
ANACONDA, MONTANA 59711

MGD = K * gage feet ^ N
K = 25.29
N = 2.24

Date: 11/30/79
"*" indicates calibration points

Station: 5
WARM SPRINGS POND NO. 2 DISCHARGE COMPANY EFFLUENT

GAGE FEET	FLOW MGH	FLOW MGD	GAGE FEET	FLOW MGH	FLOW MGD	GAGE FEET	FLOW MGH	FLOW MGD	GAGE FEET	FLOW MGH	FLOW MGD
*0.00	*0.00	*0.00	0.50	0.223	5.35	1.00	1.05	25.3			
0.01	0.000	0.001	0.51	0.233	5.60	1.01	1.08	25.9			
0.02	0.000	0.004	0.52	0.244	5.85	1.02	1.10	26.4			
0.03	0.000	0.010	0.53	0.254	6.10	1.03	1.13	27.0			
0.04	0.001	0.019	0.54	0.265	6.36	1.04	1.15	27.6			
0.05	0.001	0.031	0.55	0.276	6.63	1.05	1.18	28.2			
0.06	0.002	0.046	0.56	0.288	6.90	1.06	1.20	28.8			
0.07	0.003	0.065	0.57	0.299	7.18	1.07	1.23	29.4			
0.08	0.004	0.088	0.58	0.311	7.46	1.08	1.25	30.0			
0.09	0.005	0.115	0.59	0.323	7.76	1.09	1.28	30.7			
0.10	0.006	0.146	0.60	0.336	8.05	1.1?	1.30	31.3			
0.11	0.008	0.180	0.61	0.348	8.36						
0.12	0.009	0.219	0.62	0.361	8.67						
0.13	0.011	0.262	0.63	0.374	8.98						
0.14	0.013	0.309	0.64	0.388	9.31						
0.15	0.015	0.361	0.65	0.401	9.64						
0.16	0.017	0.417	0.66	0.415	9.97						
0.17	0.020	0.478	0.67	0.430	10.3						
0.18	0.023	0.543	0.68	0.444	10.7						
0.19	0.026	0.613	0.69	0.459	11.0						
0.20	0.029	0.687	0.70	0.474	11.4						
0.21	0.032	0.767	0.71	0.489	11.7						
0.22	0.035	0.851	0.72	0.505	12.1						
0.23	0.039	0.940	0.73	0.521	12.5						
0.24	0.043	1.03	0.74	0.537	12.9						
0.25	0.047	1.13	0.75	0.553	13.3						
0.26	0.052	1.24	0.76	0.570	13.7						
0.27	0.056	1.35	0.77	0.587	14.1						
0.28	0.061	1.46	0.78	0.604	14.5						
0.29	0.066	1.58	0.79	0.621	14.9						
0.30	0.071	1.70	0.80	0.639	15.3						
0.31	0.076	1.83	0.81	0.657	15.8						
0.32	0.082	1.97	0.82	0.676	16.2						
0.33	0.088	2.11	0.83	0.694	16.7						
0.34	0.094	2.26	0.84	0.713	17.1						
0.35	0.100	2.41	0.85	0.732	17.6						
0.36	0.107	2.56	0.86	0.752	18.0						
0.37	0.114	2.73	0.87	0.771	18.5						
0.38	0.121	2.90	0.88	0.791	19.0						
0.39	0.128	3.07	0.89	0.812	19.5						
0.40	0.135	3.25	0.90	0.832	20.0						
0.41	0.143	3.43	0.91	0.853	20.5						
0.42	0.151	3.62	0.92	0.874	21.0						
0.43	0.159	3.82	0.93	0.896	21.5						
0.44	0.168	4.02	0.94	0.917	22.0						
0.45	0.176	4.23	0.95	0.939	22.5						
0.46	0.185	4.44	0.96	0.962	23.1						
0.47	0.194	4.66	0.97	0.984	23.6						
0.48	0.204	4.89	0.98	1.01	24.2						
0.49	0.213	5.12	0.99	1.03	24.7						

THE ANACONDA COMPANY
ANACONDA REDUCTION DEPARTMENT
ANACONDA, MONTANA 59711

MGD = K * gage feet ^ N
K = 26
N = 1.95

Date: 11/30/77
"*" indicates calibration points

Station: S
WARM SPRINGS POND NO. 2 DISCHARGE COMPANY EFFLUENT

GAGE FEET	FLOW MGH	FLOW MGD
1.11	1.33	31.9
1.12	1.35	32.4
1.13	1.37	33.0
1.14	1.40	33.6
1.15	1.42	34.1
1.16	1.45	34.7
1.17	1.47	35.3
1.18	1.50	35.9
1.19	1.52	36.5
1.20	1.55	37.1
1.21	1.57	37.7
1.22	1.60	38.3
1.23	1.62	38.9
1.24	1.65	39.5
1.25	1.67	40.2
1.26	1.70	40.8
1.27	1.73	41.4
1.28	1.75	42.1
1.29	1.78	42.7
1.30	1.81	43.4
1.31	1.83	44.0
1.32	1.86	44.7
1.33	1.89	45.3
1.34	1.92	46.0
1.35	1.94	46.7
1.36	1.97	47.4
1.37	2.00	48.0
1.38	2.03	48.7
1.39	2.06	49.4
1.40	2.09	50.1
1.41	2.12	50.8
1.42	2.15	51.5
1.43	2.18	52.2
1.44	2.21	52.9
1.45	2.24	53.7
1.46	2.27	54.4
1.47	2.30	55.1
1.48	2.33	55.8
1.50	2.39	57.3
1.51	2.42	58.1
1.52	2.45	58.8
1.53	2.48	59.6
1.54	2.51	60.3
1.55	2.55	61.1
1.56	2.58	61.9
1.57	2.61	62.7
1.58	2.64	63.4
1.59	2.68	64.2
1.60	2.71	65.0
1.61	2.74	65.8
1.62	2.78	66.6
1.63	2.81	67.4
1.64	2.84	68.2
1.65	2.88	69.0

THE ANACONDA COMPANY
ANACONDA REDUCTION DEPARTMENT
ANACONDA, MONTANA 59711

MGD = K * gage feet ^ N
K = 33.3
N = 1.44

Date: 11/30/77
"*" indicates calibration points

Station: S
WARM SPRINGS POND NO. 2 DISCHARGE COMPANY EFFLUENT

GAGE FEET	FLOW MGH	FLOW MGD
1.66	2.88	69.1
1.67	2.90	69.2
1.68	2.93	70.3
1.69	2.95	70.9
1.70	2.98	71.5
1.71	3.00	72.1
1.72	3.03	72.7
1.73	3.06	73.3
1.74	3.08	73.9
1.75	3.11	74.5
1.76	3.13	75.2
1.77	3.16	75.8
1.78	3.18	76.4
1.79	3.21	77.0
1.80	3.23	77.6
1.81	3.26	78.3
1.82	3.29	78.9
1.83	3.31	79.5
1.84	3.34	80.1
1.85	3.36	80.8
1.86	3.39	81.4
1.87	3.42	82.0
1.88	3.44	82.6
1.89	3.47	83.3
1.90	3.50	83.9
1.91	3.52	84.6
1.92	3.55	85.2
1.93	3.58	85.8
1.94	3.60	86.5
1.95	3.63	87.1
1.96	3.66	87.8
1.97	3.68	88.4
1.98	3.71	89.1
2.00	3.76	90.3
2.01	3.79	91.0
2.02	3.82	91.7
2.03	3.85	92.3
2.04	3.87	93.0
2.05	3.90	93.6
2.06	3.93	94.3
2.07	3.96	94.9
2.08	3.98	95.6
2.09	4.01	96.3
2.10	4.04	96.9
2.11	4.07	97.6
2.12	4.09	98.3
2.13	4.12	98.9
2.14	4.15	99.6
2.15	4.18	100
2.16	4.21	101
2.17	4.23	102
2.18	4.26	102
2.19	4.29	103
2.20	4.32	104
2.21	4.35	104
2.22	4.38	105
2.23	4.40	106
2.24	4.43	106
2.25	4.46	107
2.26	4.49	108
2.27	4.52	108
2.28	4.55	109
2.29	4.58	110
2.30	4.60	110
2.31	4.63	111
2.32	4.66	112
2.33	4.69	113
2.34	4.72	113
2.35	4.75	114
2.36	4.78	115
2.37	4.81	115
2.38	4.84	116
2.39	4.87	117
2.40	4.89	117
2.41	4.92	118
2.42	4.95	119
2.43	4.98	120
2.44	5.01	120
2.45	5.04	121
2.46	5.07	122
2.47	5.10	122
2.48	5.13	123
2.50	5.19	125
2.51	5.22	125
2.52	5.25	126
2.53	5.28	127
2.54	5.31	127
2.55	5.34	128
2.56	5.37	129
2.57	5.40	130
2.58	5.43	130
2.59	5.46	131
2.60	5.49	132
2.61	5.52	133
2.62	5.55	133
2.63	5.58	134
2.64	5.61	135
2.65	5.65	135
2.66	5.68	136
2.67	5.71	137
2.68	5.74	138
2.69	5.77	138
2.70	5.80	139
2.71	5.83	140
2.72	5.86	141
2.73	5.89	141
2.74	5.92	142
2.75	5.95	143
2.76	5.99	144
2.77	6.02	144
2.78	6.05	145
2.79	6.08	146
2.80	6.11	147
2.81	6.14	147
2.82	6.17	148
2.83	6.21	149
2.84	6.24	150
2.85	6.27	150
2.86	6.30	151
2.87	6.33	152
2.88	6.36	153
2.89	6.40	154
2.90	6.43	154
2.91	6.46	155
2.92	6.49	156
2.93	6.52	157
2.94	6.56	157
2.95	6.59	158
2.96	6.62	159
2.97	6.65	160
2.98	6.69	160
2.99	6.72	161
3.00	6.75	162
3.01	6.78	163
3.02	6.81	164
3.03	6.85	164
3.04	6.88	165
3.05	6.91	166
3.06	6.94	167
3.07	6.98	167
3.08	7.01	168
3.09	7.04	169
3.10	7.08	170
3.11	7.11	171
3.12	7.14	171
3.13	7.17	172
3.14	7.21	173
3.15	7.24	174
3.16	7.27	175
3.17	7.31	175
3.18	7.34	176
3.19	7.37	177
3.20	7.41	178
3.21	7.44	179
3.22	7.47	179
3.23	7.51	180
3.24	7.54	181
3.25	7.57	182
3.26	7.61	183
3.27	7.64	183
3.28	7.68	184
3.29	7.71	185
3.30	7.74	186
3.31	7.78	187
3.32	7.81	187
3.33	7.84	188
3.34	7.88	189
3.35	7.91	190
3.36	7.95	191
3.37	7.98	192
3.38	8.01	192
3.39	8.05	193
3.40	8.08	194
3.41	8.12	195
3.42	8.15	196
3.43	8.19	196
3.44	8.22	197
3.45	8.25	198
3.46	8.29	199
3.47	8.32	200
3.48	8.36	201
3.49	8.39	201

BECKMAN

Models 3500, 3550, and 3560 Digital pH Meters

Beckman Instruments, Inc. • Scientific Instruments Division • Irvine, California 92713

CONTENTS

ILLUSTRATIONS

SECTION ONE INTENDED USE

The Beckman Models 3500, 3550, and 3560 Digital pH Meters, Figures 1, 2, and 3, are designed for use in a wide variety of industries and applications. One of these applications includes *in vitro* diagnostic pH and other potentiometric measurements. Operators should be experienced with the methodolgy of these types of measurements.

The Beckman Models 3500, 3550, and 3560 Digital pH Meters employ the latest electronic technology to afford the user both ease of operation and versatility. Essentially compatible with all electrodes, these instruments provide all the necessary functions required today. All three will operate with pH-sensing, metallic, and ion-selective electrodes. Features include: separate electronic adjustments for slope correction and temperature compensation; variable recorder output; adjustable instrument zero point; and an internal test circuit for diagnostic troubleshooting.

Figure 1. Model 3500 Digital pH Meter

Figure 2. Model 3550 Digital pH Meter

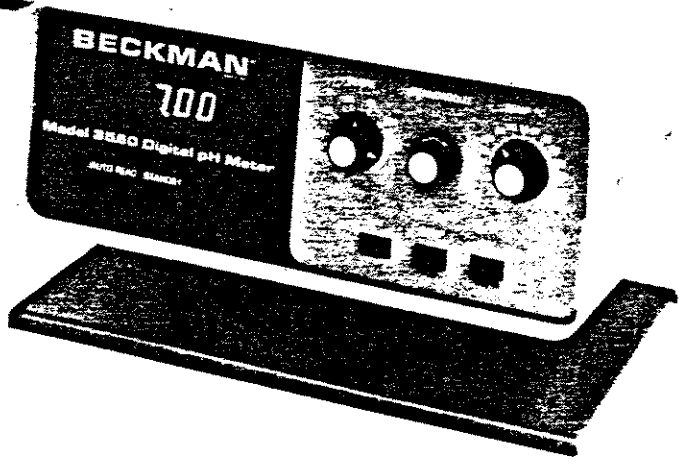


Figure 3. Model 3560 Digital pH Meter

SECTION TWO INSTALLATION

Each instrument is packaged to guard against damage during shipment. To learn of possible harm in transit, carefully inspect the instrument and items included in the shipping kit. Notify your nearest Beckman Sales or Service Representative of any breakage.

2.1 POWER REQUIREMENTS

All three instruments are wired for operation on $120^{+10}_{-15}\%$ volts, 50/60 Hz. For operation on $220^{+10}_{-15}\%$ volts, 50/60 Hz, an internal switch must be adjusted. If it has not already been done at the factory, this conversion must be made by a qualified Beckman Service Representative.

2.2 INSTALLATION OF ELECTRODE STAND

The electrode stand that is provided with the Models 3500, 3550, and 3560 pH Digital Meters may be attached to either side of the pH meter base, Figure 4, or it may be assembled and used as a free-standing unit. To assemble and attach electrode stand to pH meter:

1. Locate stand base, rod, attachment plate, and hardware.
2. Attach rod to stand base, using nut and washer supplied.
3. Tilt pH meter onto its back.
4. Tilt stand base in same orientation as pH meter.
5. Place attachment plate over studs on bottom of stand base, and secure with nuts and washers supplied.
6. Place holes on other edge of attachment plate over studs on bottom of pH meter, and secure with nuts and washers supplied.
7. Return pH meter, with attached stand, to operating position.

2.3 INSTALLATION OF ELECTRODES

1. Place electrodes in the electrode holder, and plug electrode leads into proper receptacles on back of instrument.
2. Prepare electrodes for first use, as directed in the instructions packaged with each electrode.

2.4 INSTRUMENT GROUNDING

The power cord on the instrument is a three-conductor cable fitted with a three-pronged plug. To ensure greatest stability of operation, and to lessen personal hazard, the instrument case connects to earth ground by means of the grounding prong on power plug.

2.5 SOLUTION GROUNDING

An accurate measurement cannot be obtained if a direct-current connection between the instrument and the sample solution occurs by any means other than through the electrodes. For measurements where the electrodes are immersed in a grounded solution, no additional ground connection should be made. If the solution is not grounded, the instrument solution ground can be used to eliminate the effects of alternating current (AC) pickup at the electrodes. This can occur if there are AC sources in close proximity to the instrument.

CAUTION

Do not connect solution to the solution ground terminal on the rear panel of the instrument if the solution is already grounded.

The solution ground terminal may be used to connect the shield wire of an electrode. This would be done, for example, when using the glass portion of a combination electrode, and the reference pin jack would be connected to the solution ground to complete shielding. The sample solution must not otherwise be grounded.

BEFORE OPERATING ANY OF THESE INSTRUMENTS, READ THESE BECKMAN INSTRUCTIONS, 015-082378-C.

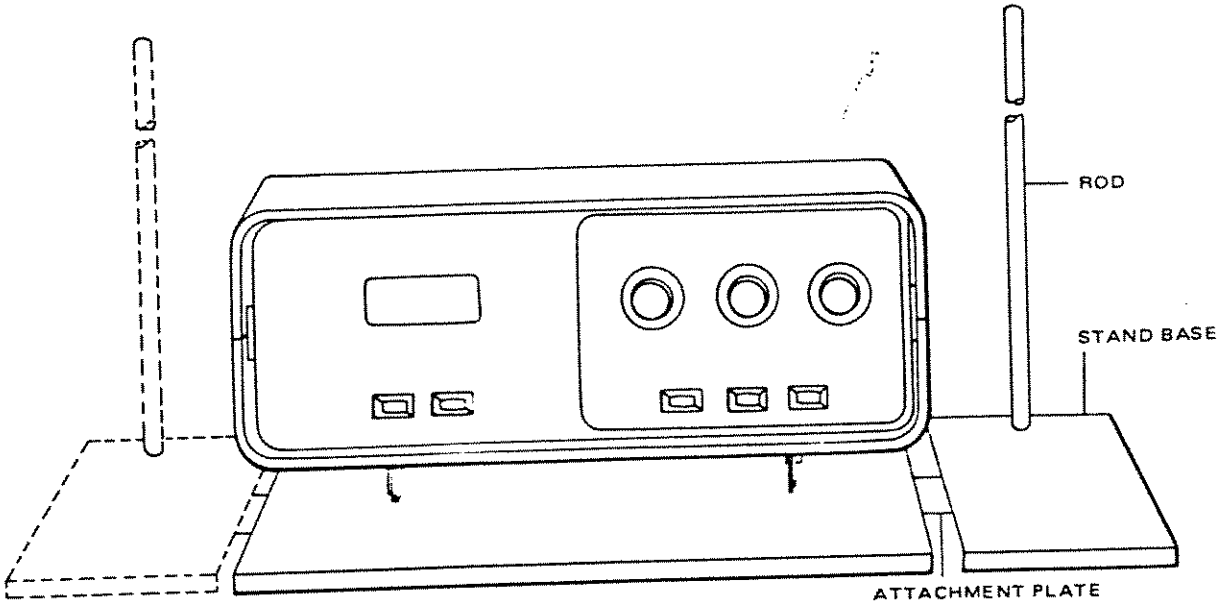


Figure 4 pH Meter With Attached Electrode Stand

SECTION THREE PRINCIPLES OF OPERATION

The electrodes develop a voltage that is applied to a high-impedance input amplifier. The Models 3500, 3550, and 3560 Digital pH Meters have solid-state amplifiers that apply the potential from pH electrodes, and other potentiometric electrodes, to their Digital Displays.

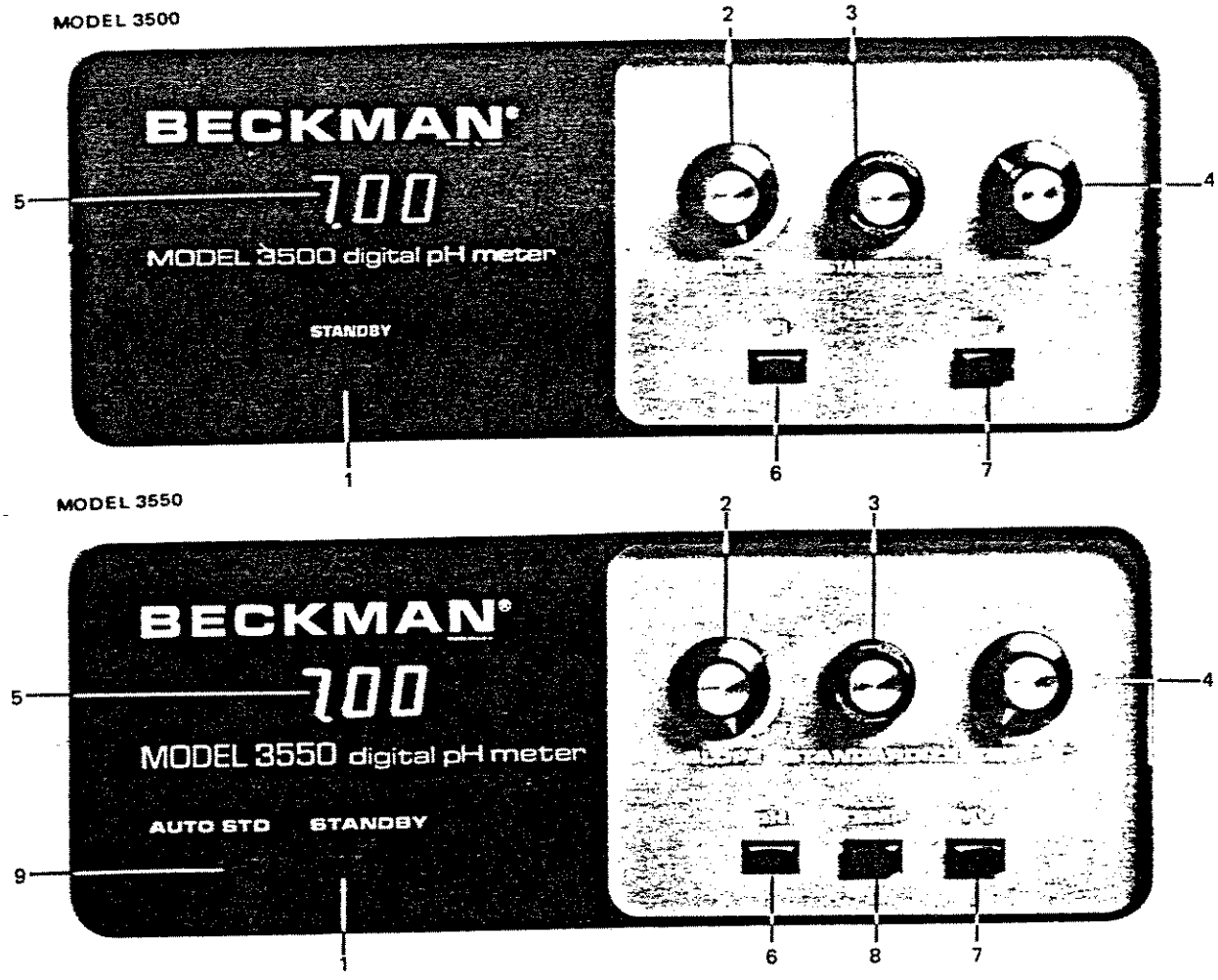
The modes of operation provided are: pH, MV (millivolts); and, on the Models 3550 and 3560, TEMP (temperature). The pH mode is used when the voltage from a pH glass electrode is to be read using the pH scale or when employing a cation-selective electrode and reading pC+. In this mode, both the temperature and slope controls are active. The MV (millivolts) mode is used for direct readout of voltage from any electrode. Temperature or slope adjustments do not affect the reading in the MV (millivolts) mode. In the TEMP (temperature) mode of Models 3550 and 3560, the automatic temperature compensation probe is used to read temperature of the sample.

An electrode pair or a combination electrode may be employed with these pH meters. The voltage developed at the glass or indicating electrode is compared with the stable reference electrode voltage. A complete list of pH glass, Redox or metallic, reference, combination, and SelectIon® * electrodes that may be used with these meters is available by requesting Beckman Bulletin 7686.

*SelectIon is a registered trademark of Beckman Instruments, Inc.

SECTION FOUR OPERATING CONTROLS

The operating controls and indicators are shown and described in Figure 5. The various terminals, pushbuttons, and controls on the back panel are shown and described in Figure 6.



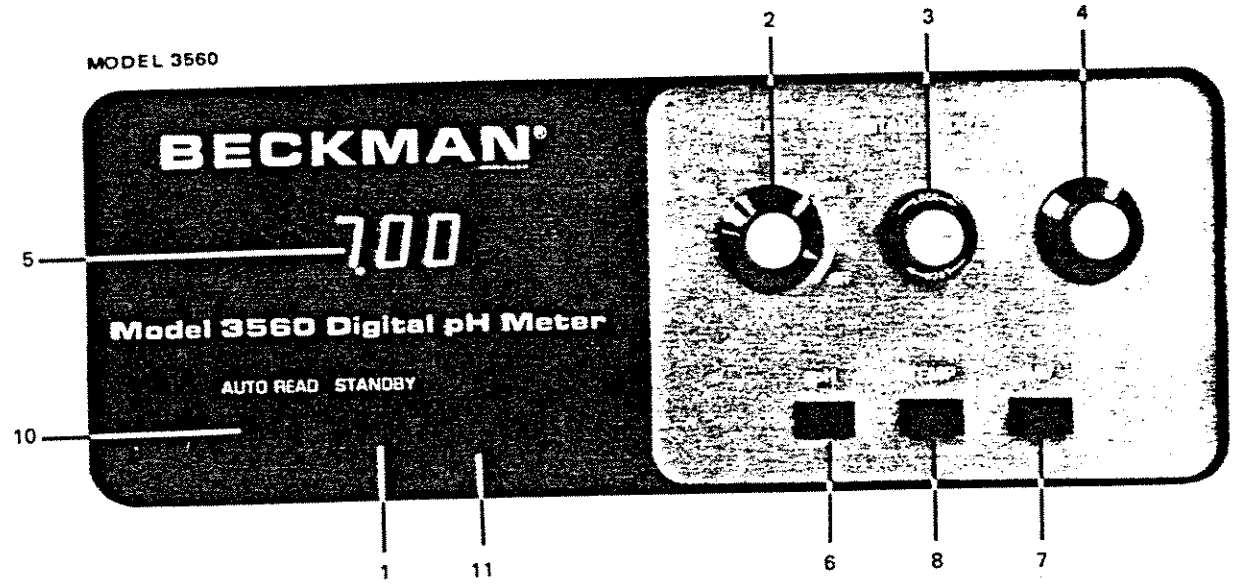
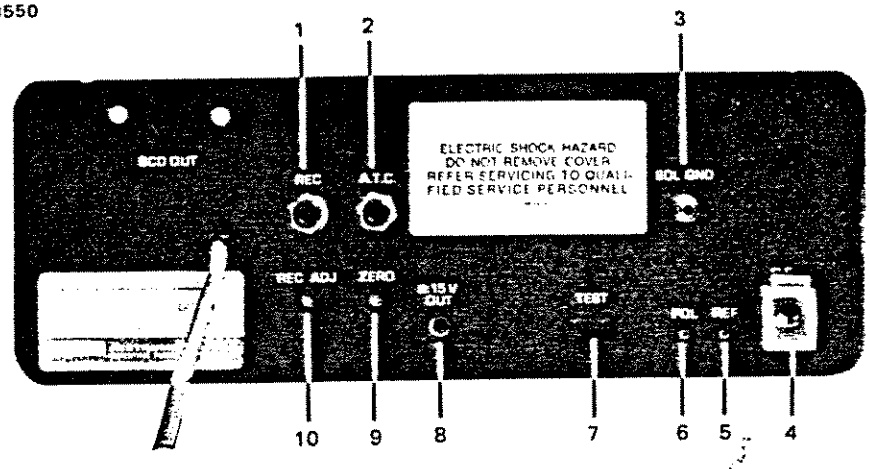


Figure 5. Operating Controls (Continued)

1. STANDBY Pushbutton
   The position of this control determines whether the instrument is in Standby or Read.
   Standby
   When the STANDBY Pushbutton is depressed (that is, in the in position), the instrument is in Standby. The electrodes are electrically disconnected and the amplifier input is shorted. Standby is used to prevent polarization of the glass electrode when the electrodes are removed from solution.
   Read
   When the STANDBY Pushbutton is released (that is, in the out position), the instrument is in Read. The electrodes are connected and the circuit is switched in so that pH, millivolt, or temperature values can be read on Digital Display. (The temperature mode is on the Model 3550 and Model 3560, and is not available on the Model 3500.)
2. SLOPE Control
   This control is employed to compensate for possible deviation of the electrode output from the true Nernst slope. Control is at 100% SLOPE when it is in the OFF Position. (SLOPE Control must be rotated clockwise sufficiently to engage the OFF Switch.)
3. STANDARDIZE Control (With Lock)
   This control applies a continuously-variable offset potential to the input circuit. Preparatory to pH measurements, electrodes are immersed in buffer solution of accurately known pH. With instrument in Read (STANDBY Pushbutton released), the STANDARDIZE Control is adjusted for the corresponding reading on Digital Display. (Model 3550 only): An automatic standardization circuit is provided, which performs this adjustment automatically.
4. TEMP °C Control (Manual Temperature Compensation Control)
   This control is set at temperature of sample to adjust amplifier gain to correct for temperature-dependent electrode variations in the pH-versus-millivolt relationship. Control is active with pH Pushbutton depressed and is inoperative with the MV Pushbutton depressed, or when the ATC (Automatic Temperature Compensating) Probe is connected.
5. Digital Display
   Displays pH from less than 0.00 to more than 14.00 with pH Pushbutton depressed. With MV (millivolts) Pushbutton depressed, displays millivolts from +1999 to −1999 millivolts. With the TEMP (temperature) Pushbutton depressed (Models 3550 and 3560 only) displays temperature from 0°C to 100°C.
6. pH Pushbutton
   This pushbutton is depressed—that is, in the in position—when measuring the pH of a sample.
7. MV (millivolts) Pushbutton
   This pushbutton is depressed — that is, in the in position — when measuring output potential of samples in millivolt units; for example, when using metallic or ion-selective electrodes.
8. TEMP (temperature) Pushbutton (Models 3550 and 3560 only) This pushbutton is depressed — that is, in the in position — when reading temperature of sample. The 39095 ATC (Automatic Temperature Compensating) Probe is used as the temperature-sensing device.
9. AUTO STD Pushbutton (On Model 3550 only).
   The Automatic Standardization Pushbutton is depressed — that is, in the in position — when the electrode is to be standardized to a given buffer. This pushbutton is used in conjunction with the ZERO Control on the back panel.
10. AUTO READ Pushbutton (On Model 3560 only).
    When this pushbutton is depressed — that is, in the in position — the instrument is in the Automatic Read Function. This function provides the operator with an indication that a stable reading is obtained and locks in on that reading. (See Auto Read Light, immediately following, and AUTO READ FINE Pushbutton, on back panel.)
11. Auto Read Light (On Model 3560 only).
    When the instrument is in Automatic Read Function (AUTO READ Pushbutton depressed), this light illuminates to indicate when a stable reading has been obtained.

MODELS 3500 and 3550



MODEL 3560

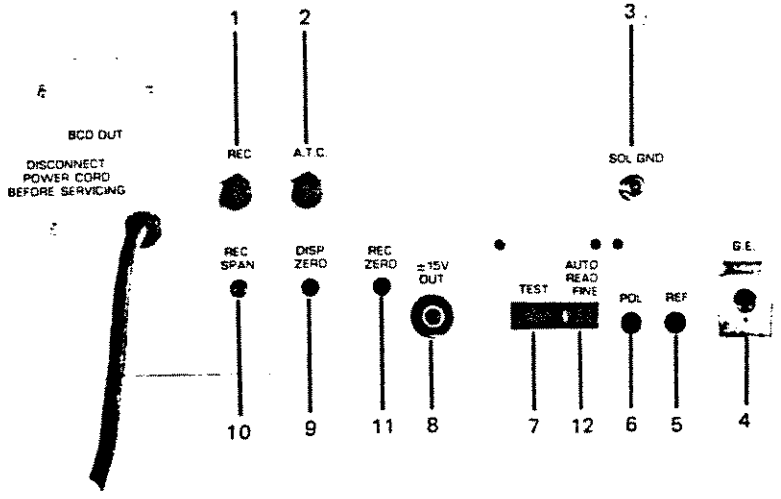


Figure 6. Controls, Pushbuttons, and Terminals on Back Panel

1. REC Output Terminal
   Recorder Output Terminal accepts standard phone jack connector for potentiometric recorder. The 93583 Recorder Cable is used for this purpose.
2. A.T.C. Terminal
   A.T.C. Terminal accepts Beckman 39095 ATC (Automatic Temperature Compensating) Probe for automatic temperature compensation in pH Function. Also used for temperature readout (Models 3550 and 3560).
3. SOL GND Terminal
   Solution Ground Terminal is used to minimize electrode AC pickup when AC sources are present.
4. G.E. Input Terminal
   Glass Electrode Input Terminal is used to connect measuring electrode to pH meter.
5. REF Input Terminal
   Reference Input Terminal is used to connect reference electrode or reference side of combination electrode to pH meter.
6. POL Output Terminal
   Polarization current outlet providing a nominal 10 microampere output.
7. TEST Pushbutton
   An instrument feature that is intended to minimize down-time and factory service. By utilizing the STANDBY and TEST Pushbuttons, the user can independently determine whether the Digital Display and pH amplifier are functioning properly.
8. ±15V OUT
   Power Outlet for connecting accessories.
9. ZERO Control (On Models 3500 and 3550); DISPLAY ZERO Control (On Model 3560)
   Adjusted by screwdriver, the ZERO Control (or the DISPLAY ZERO Control) is employed when the user desires to adjust the SLOPE Control from an initial buffer point other than pH 7.00; for example, 6.86 or other buffer values between 4.00 and 10.00. This control sets the buffer value to which the meter will be standardized if the SLOPE or AUTO STD Pushbutton is used. ZERO Control should be set at 7.00 pH if these functions are not used.
10. REC ADJ (Recorder Adjust) Control (On Models 3500 and 3550); REC SPAN (Recorder Span) Control (On Model 3560)
    Adjusted by screwdriver, this control is used to vary the potential at REC Output Terminal (1) from 0 to 100 millivolts per pH unit, or per 100 millivolts in the millivolt mode.
11. REC ZERO (Recorder Zero) Control (On the Model 3560 Only)
    Adjusted by screwdriver, the Recorder Zero Control is used to vary the offset potential at the Recorder Output Terminal (1). This provides the capability of expanded readability of different portions of the pH scale.
12. AUTO READ FINE Pushbutton (On the Model 3560 Only)
    This pushbutton is used in conjunction with the AUTO READ Pushbutton. A stable reading is indicated by the Auto Read Light, front panel, illuminating. When this pushbutton is depressed, greater stability is required before the Auto Read Light will indicate a stable reading. See Paragraph 5.8, Auto Read Function With Model 3560. (Also see AUTO READ Pushbutton and AUTO READ Light.)

SECTION FIVE OPERATION

The electrodes should be soaked overnight in 566576 Electrode Storage Solution before use. Fill the reference electrode with appropriate internal filling solution until the liquid level is at the lower edge of the filling hole. Connect measuring electrode (pH, ion-selective, metallic, etc.) to G.E. (Glass Electrode) Input Terminal and reference electrode to REF (Reference) Input Terminal. For standardization, use buffer close to expected sample pH value. Between successive buffer or sample measurements, wash electrodes with the next solution to be measured, or with deionized water.

To start up pH meter, depress STANDBY Pushbutton and connect power cord to electrical outlet of proper voltage.

NOTE

The procedures that follow refer occasionally to the AUTO STD Pushbutton or to the AUTO READ Pushbutton. The Automatic Standardization Function, which is available on the Model 3550 only, is explained in Paragraph 5.7. The Automatic Read Function, which is available on the Model 3560 only, is explained in Paragraph 5.8.

5.1 pH MEASUREMENTS WITH MANUAL TEMPERATURE COMPENSATION

Peform pH measurements with temperature compensation as follows:

1. Put instrument in Standby by depressing STANDBY Pushbutton.
2. Depress pH Pushbutton and turn SLOPE Control to OFF. Model 3550 *Only*: In addition, if Automatic Standardization is to be used, adjust ZERO Control on back panel to obtain pH value of standard buffer on Digital Display.
3. Set TEMP °C Control (Manual Temperature Compensation Control) at temperature of buffer.
4. Rinse electrodes with, and place in, standard pH buffer solution.
5. Put instrument in Read by releasing STANDBY Pushbutton. Model 3560 *Only*: In addition, activate the Automatic Read Function by depressing AUTO READ Pushbutton. Wait until Auto Read Light indicates a stable reading. Be sure AUTO READ FINE Pushbutton on back panel is set at the desired stability. (Note that the Model 3560 can be operated without utilizing the advantages of Auto Read.)
6. Adjust STANDARDIZE Control to obtain buffer pH value on Digital Display, and then lock control. Model 3550 *Only*: Activate the Automatic Standardization Function by depressing AUTO STD Pushbutton. Model 3560 *Only*: Before adjusting STANDARDIZE Control, release AUTO READ Pushbutton to unlock Digital Display. Then adjust and lock control.
7. Put instrument in Standby by depressing STANDBY Pushbutton. Model 3560 *Only*: In addition, depress AUTO READ Pushbutton. Leave the Automatic Read Function activated for the steps that follow.
8. Set TEMP °C Control at temperature of sample.
9. Rinse electrodes in sample or deionized water and place in sample. If deionized water is used as a rinse, blot gently with tissue to remove excess liquid before placing in sample. Allow electrodes to reach thermal equilibrium.
10. Put instrument in Read. Read sample pH value on Digital Display. Model 3560 *Only*: Read sample value after Auto Read Light indicates stability.
11. Put instrument in Standby.

5.2 pH MEASUREMENTS WITH AUTOMATIC TEMPERATURE COMPENSATION

Perform pH measurements with automatic temperature compensation, as follows:

1. Put instrument in Standby by depressing STANDBY Pushbutton.
2. Depress the pH Pushbutton and turn SLOPE Control to OFF. Model 3550 *Only*: In addition, if Automatic Standardization is to be used, adjust ZERO Control on back panel to obtain pH value of standard buffer on Digital Display.

3. Connect the 39095 ATC Probe to the A.T.C. Terminal on the back panel of the pH meter and place the probe in the electrode holder with the electrodes.
4. Rinse electrodes and ATC Probe with, and place in, standard pH buffer solution.
5. Put instrument in Read by releasing STANDBY Pushbutton. The meter will automatically be compensated for changes in solution temperature when electrode and ATC Probe equilibrate with the solution. Model 3560 *Only*: In addition, activate the Automatic Read Function by depressing AUTO READ Pushbutton. Wait until Auto Read Light indicates a stable reading. Be sure AUTO READ FINE Pushbutton on back panel is set at the desired stability. (Note that the Model 3560 can be operated without utilizing the advantages of Auto Read.)
6. Adjust STANDARDIZE Control to obtain buffer pH value on Digital Display, and then lock control. Model 3550 *Only*: Activate Automatic Standardization Function by depressing AUTO STD Pushbutton. Model 3560 *Only*: Before adjusting STANDARDIZE Control, release AUTO READ Pushbutton to unlock Digital Display. Then adjust and lock control.
7. Put instrument in Standby. Model 3560 *Only*: In addition, depress AUTO READ Pushbutton. Leave the Automatic Read Function activated for all steps that follow.
8. Rinse electrodes and ATC Probe with sample or deionized water and place in sample. If deionized water is used as a rinse, blot electrodes and probe gently with tissue to remove excess liquid before placing in sample. Allow electrodes and probe to reach thermal equilibrium.
9. Put instrument in Read. Read sample pH value on Digital Display. Model 3560 *Only:* Read sample value after Auto Read Light indicates stability.
10. Put instrument in Standby.

5.3 pH MEASUREMENTS WITH SLOPE ADJUSTMENT

Perform pH measurements with slope adjustment as follows:

1. Put instrument in Standby by depressing STANDBY Pushbutton.
2. Depress pH Pushbutton and turn SLOPE Control OFF.
3. Adjust ZERO Control on back panel, or DISPLAY ZERO Control on Model 3560, to obtain pH value of initial standard buffer on Digital Display.
4. Rinse electrodes with, and place in, initial standard buffer solution. Since two buffers are required for this procedure, of the two, the initial buffer should have the pH value closer to 7.
5. Put instrument in Read by releasing STANDBY Pushbutton. Model 3560 *Only*: In addition, activate the Automatic Read Function by depressing AUTO READ Pushbutton. Wait until Auto Read Light indicates a stable reading. Be sure AUTO READ FINE Pushbutton on back panel is set at the desired stability. (Note that the Model 3560 can be operated without utilizing the advantages of Auto Read.)
6. Adjust STANDARDIZE Control to obtain initial buffer value on Digital Display, and then lock control. Model 3550 *Only*: Activate the Automatic Standardization Function by depressing AUTO STD Pushbutton. Model 3560 *Only*: Before adjusting STANDARDIZE Control, release AUTO READ Pushbutton to unlock Digital Display. Then adjust and lock control.
7. Put instrument in Standby.
8 Rinse electrodes with and place in second standard buffer solution. (With initial buffer, this should bracket expected sample pH value.)
9. Put instrument in Read. Model 3560 *Only*: In addition, depress AUTO READ Pushbutton. As soon as the Auto Read Light indicates a stable reading, release AUTO READ Pushbutton to unlock Digital Display. (The reading need not be recorded. The Auto Read Function is used to ensure that the electrodes are stable before making the adjustment that follows.)
10. Adjust SLOPE Control to obtain pH value of second buffer on Digital Display.
11. Put instrument in Standby. Model 3560 *Only*: In addition, depress AUTO READ Pushbutton. Leave the Automatic Read Function activated for all steps that follow.

12. Rinse electrodes with sample or deionized water and place in sample. If deionized water is used as a rinse, blot electrodes gently with tissue to remove excess liquid before placing in sample. Allow electrodes to reach thermal equilibrium.
13. Put instrument in Read. Read sample pH on Digital Display. Model 3560 *Only*: Read sample value after Auto Read Light indicates stability.
14. Put instrument in Standby.

5.4 MILLIVOLT MEASUREMENTS USING ION-SELECTIVE OR METALLIC ELECTRODES

Perform millivolt measurements using ion-selective or metallic electrodes, as follows:

1. Put instrument in Standby by depressing STANDBY Pushbutton.
2. Depress the MV Pushbutton. Model 3550 *Only*: In addition, if Automatic Standardization is to be used, adjust ZERO Control on back panel to obtain 0.00 on Digital Display.
3. Using the 700 Terminal Connector and 8980 Shorting Strap (optional accessories), short-circuit the G.E. (Glass Electrode) Input Terminal and the REF (Reference) Input Terminal.
4. Put instrument in Read by releasing STANDBY Pushbutton. Model 3560 *Only*: In addition, release AUTO READ Pushbutton.
5. Adjust STANDARDIZE Control to obtain a reading of zero millivolts on Digital Display. Model 3550 *Only*: Activate the Automatic Standardization Function by depressing AUTO STD Pushbutton.
6. Put instrument in Standby. Model 3560 *Only*: In addition, depress AUTO READ Pushbutton. Leave Automatic Read Function activated (pushbutton depressed) for all steps that follow.
7. Remove shorting strap and connect the ion-selective or metallic electrode to G.E. (Glass Electrode) Input Terminal and the reference electrode to the REF (Reference) Input Terminal.
8. Rinse electrodes with, and place in, sample.
9. Put instrument in Read and record millivolt reading on Digital Display. Model 3560 *Only*: Read millivolt value after Auto Read Light indicates stability.
10. Put instrument in Standby.
11. In order to construct a calibration curve when using Selectlon® Electrodes, more than one standard measurement is required. To perform these measurements, repeat Steps 8 through 10, immediately preceding, on a series of standard solutions.

5.5 RECORDING pH MEASUREMENTS

This paragraph tells how to set up a pH meter and recorder so that pH measurements can be recorded. Proceed as follows:

1. Connect pH meter to recorder using 93583 Recorder Cable.
2. Depress STANDBY and pH Pushbuttons.
3. Connect electrodes to appropriate input terminals. Model 3550 *Only*: In addition, if Automatic Standardization is to be used, adjust ZERO Control on back panel until Digital Display reads pH value of initial buffer.
4. Place electrodes in initial buffer and put instrument in Read by releasing STANDBY Pushbutton. Allow reading on Digital Display to stabilize.
5. Use STANDARDIZE Control to adjust Digital Display to read an appropriate value (table, Page 10). Then adjust recorder zero on the recorder until the recorder reads the same value. Model 3560 *Only*: Short recorder inputs and adjust zero on recorder to the point where the appropriate value will be located. Disconnect a release recorder short and adjust REC ZERO (Recorder Zero) on the pH meter until the recorder pen is at the same point.
6. To set recorder span, adjust STANDARDIZE Control until Digital Display reads the other value (table, Page 10). Then turn REC ADJ (Recorder Adjust) Control, or REC SPAN Control on Model 3560, until the recorder reads the same value. Recorder now has correct span and zero points for recording pH values within the desired range.

	Desired Span	Buffer	Appropriate Value*	Other Value*
EXAMPLES	7 to 8	7.00	7.00	8
	8 to 10	9.18	8.00	10
	0 to 4	4.01	4.00	2

NOTE

*An *appropriate value* is defined as a pH value that is within the desired pH span and that is also as close as possible to pH 7.00. For convenience, the value is usually an integer. Frequently, a limit of the desired span is selected as an appropriate value. The *other value* is a second pH value that is within the desired pH span. It is also often a limit of the desired span, but it need not be, as in the example above in which the desired span is 0 to 4.

7. To standardize the pH meter, adjust STANDARDIZE Control until Digital Display reads initial buffer pH value. Model 3550 *Only*: To automatically standardize the pH meter, depress AUTO STD Pushbutton.
8. Put instrument in Standby.
9. After set-up, follow one of the specific procedures described in Paragraphs 5.1, 5.2, and 5.3.

5.6 TEMPERATURE MEASUREMENTS USING MODEL 3550 OR MODEL 3560

Perform temperature measurements using Model 3550 or 3560 as follows:

1. Connect the 39095 ATC Probe to the A.T.C. Terminal on the back panel.
2. Place the probe in the sample and activate the Temperature Function by depressing the TEMP Pushbutton.
3. Put instrument in Read by releasing STANDBY Pushbutton. Wait until temperature reading stabilizes.
4. Note reading on Digital Display.

5.7 AUTOMATIC STANDARDIZATION WITH MODEL 3550

The Automatic Standardization Function allows the user to automatically standardize the pH measuring system. When the AUTO STD Pushbutton is depressed, the meter will automatically seek the voltage required to offset the voltage from the electrodes in order to make Digital Display read a zero value. The AUTO STD Pushbutton is used in conjunction with the ZERO Control, which is set at the buffer value.

EXAMPLE

Assume that the pH measuring system is to be standardized to a *tris* buffer having a pH of 7.38.

1. Put instrument in Standby by depressing STANDBY Pushbutton, and select pH Function by depressing pH Pushbutton.
2. Adjust ZERO Control on back panel until Digital Display reads 7.38.
3. Place electrodes in *tris* buffer and put instrument in Read by releasing STANDBY Pushbutton. Using Digital Display as an indication of stability, allow time for electrodes to stabilize in the *tris* buffer.
4. Depress AUTO STD Pushbutton. Digital Display will flash a series of values as the instrument searches for the buffer value
5. The pH meter is standardized when the value 7.38 ±0.01 is displayed. As long as the AUTO STD Pushbutton remains depressed, the pH meter is standardized to this initial pH measurement. All subsequent pH measurements are made relative to this standardized value. In order to change the standardization, release the AUTO STD Pushbutton and repeat the above procedure, using the same 7.38 *tris* buffer or another standard buffer. If the pH of the standard buffer differs from 7.38, the ZERO Control must be readjusted.

The Automatic Standardization Function is useful where frequent standardization is required. For example, if a buffer standardization is required after three samples and a series of samples are being measured, the Automatic Standardization Function can be used to reset the standardization with only a short interruption in the sample measurements. Be certain that the electrodes are allowed to equilibrate in the buffer and that Digital Display is allowed to come to a stable reading before depressing the AUTO STD Pushbutton. Also be sure that the ZERO Control is set to the standarizing buffer pH value before depressing the AUTO STD Pushbutton because Digital Display standardizes to the ZERO Control value.

5.5 AUTOMATIC READ FUNCTION WITH MODEL 3560

The Automatic Read Function provides the operator with an indication of when a stable reading is obtained. It performs this function by comparing readings over a period of time to see if a significant change has occurred.

To initiate the comparison cycle, depress AUTO READ Pushbutton and put instrument in Read by releasing STANDBY Pushbutton. At completion of the cycle, when stability requirements are met, the red Auto Read Light illuminates and Digital Display locks on a single value. Digital Display unlocks when the AUTO READ Pushbutton is released or when the STANDBY Pushbutton is depressed and released. As long as the AUTO READ Pushbutton is depressed, the comparison cycle is initiated every time the instrument is put in Read.

The AUTO READ FINE Pushbutton on the back panel is used to set the required stability. If the AUTO READ FINE Pushbutton is depressed, a stability of approximately ±0.01 pH is required for approximately 20 seconds before the Auto Read Light indicates stability and the Digital Display locks. If the AUTO READ FINE Pushbutton is released, a stability of approximately ±0.05 pH is required. If the required stability is not obtained, the red Auto Read Light will not be illuminated, and Digital Display will not lock on a specific value. This pushbutton should be set at the preferred stability before utilizing the Automatic Read Function.

In the millivolt mode, the corresponding stability requirements are ±1.0 millivolt with AUTO READ FINE Pushbutton depressed and ±5.0 millivolts with AUTO READ FINE Pushbutton released.

SECTION SIX PERFORMANCE CHARACTERISTICS AND SPECIFICATIONS

CATALOG NUMBERS
123602 Model 3500 Digital pH Meter, 120 Volts, 50/60 Hz.
123606 Model 3550 Digital pH Meter, 120 Volts, 50/60 Hz.
123604 Model 3560 Digital pH Meter, 120 Volts, 50/60 Hz.

pH RANGE
0.00 to 14.00 (Digital Display reads beyond ends of this range).

MILLIVOLT RANGE
±1999.

REPEATABILITY
±0.01 pH; ±1 millivolt.

DIGITAL LINEARITY
±1 count.

INSTRUMENT TEST SWITCH
13.50 to 14.50 pH with TEMP °C Control at 25°C.

POLARIZING CURRENT
+10 ±3 microamperes.

POWER REQUIREMENTS
120^{+10}_{-15} % volts, 60 Hz, 30 watts.
220^{+10}_{-15} % volts, 60 Hz, 30 watts.

ZERO ADJUSTMENT RANGE
4.00 to 10.00 pH

RECORDER SPAN
1 to 100 millivolts per pH unit or per 100 millivolts.

RECORDER ZERO (Model 3560 *Only*)
±200 millivolts.

AUTOMATIC TEMPERATURE COMPENSATION
0°C to 100°C.

MANUAL TEMPERATURE COMPENSATION
0°C to 100°C. ±1°C from 10°C to 60°C and ±2°C from 0° C to 10°C and from 60°C to 100°C.

INPUT BIAS CURRENT
Less than one picoampere.

STANDARDIZATION CONTROL
±3.3 pH units (±200 millivolts).

TEMPERATURE READOUT (Repeatability on Models 3550 and 3560)
±1°C.

TYPICAL DRIFT
Less than 3 millivolts per 10 hours.

SECTION SEVEN PERFORMANCE CHECKOUT

The operator should be able to obtain desired results by carefully following Beckman Instructions 015-082378-C. If verification of the entire system is desired, three parts of the measuring system may be checked. A periodic check of pH meter, electrode, and buffer specifications can assure the operator of a correctly-performing system. The following specifications are recommended for periodic check of system accuracy.

1. pH METER
   a. Test Operation
      See procedure in Section Eight.
   b. Repeatability
      ±0.01 pH.
   c. Drift
      Less than 3 millivolts per ten hours.
   d. Response
      Less than two seconds to 98% of final reading.
   e. Span of STANDARDIZE Control
      ±3.3 pH units (±200 millivolts).
   f. Temperature Linearity
      ±1°C from 10°C to 60°C and ±2°C from 0°C to 10° C and from 60°C to 100°C.
   g. Relative Accuracy
      ±0.01 pH at 30°C from 0 to 14 pH range, or ±1 millivolt, when tests are performed at ambient conditions of 15°C to 40°C and at 85% or less relative humidity.
   h. Bias Current
      Less than one picoampere.

2. ELECTRODES
   a. Beckman electrodes are tested for span error. The most common electrode configurations are tested to better than ±0.02 pH per unit pH from standardization; however, with electrode aging and use, the span error may increase. It is suggested that a value of less than ±0.06 pH per unit pH from standardization be used as a point to indicate where rejuvenation or replacement of the glass electrode may be necessary. Therefore, when spanning between pH 4.01 and pH 9.18 with National Bureau of Standards (NBS)-type buffers, no greater than ±0.3 pH unit error should be noted at 100% span.
   b. Repeatability
      ±0.02 pH unit.
   c. Response
      Ten seconds to 98% of final reading with NBS-type buffers.
   d. Reference Potential
      Potential difference between two reference electrodes with same type of internals should not exceed 0.0 ±5 millivolts.

3. BUFFERS
   Checked against NBS Standard Buffers, ±0.01 pH.

SECTION EIGHT CALIBRATION PROCEDURES

The following procedures are for verification of performance specifications as performed by qualified personnel.

8.1 pH METER CALIBRATION PROCEDURE

8.1.1 TEST OPERATION

The instrument incorporates a test circuit that will be extremely helpful if system problems occur. The test circuit operation should be checked when the instrument is initially installed as follows:

1. Put instrument in Standby by depressing STANDBY Pushbutton.
2. Select pH Function by depressing pH Pushbutton.
3. Adjust ZERO Control on back panel for reading of 7.00 ±0.01 on Digital Display. On Model 3560 this control is labelled DISPLAY ZERO.
4. Adjust TEMP °C Control to 25°C.
5. Put instrument in Read by releasing STANDBY Pushbutton.
6. Activate Test Function by depressing TEST Pushbutton. (This pushbutton is momentary—that is, it operates only as long as it is depressed.)
7. The reading should lie between 13.50 and 14.50 *Record this test number for future reference.* Instrument should repeat this value within ±0.05 pH units whenever this test procedure is used.

8.1.2 DRIFT

Using the 700 Terminal Connector and 8980 Shorting Strap (optional accessories), short-circuit the G.E. (Glass Electrode) and the REF (Reference) Input Terminals. Connect recorder output to 100-millivolt recorder, using 93583 Recorder Cable. Depress MV Pushbutton and put instrument in Read by releasing STANDBY Pushbutton. Adjust STANDARDIZE Control to obtain 100 millivolts on Digital Display. Adjust recorder output so that 100 millivolts is fullscale. Reduce standardization voltage until meter reads approximately 50 millivolts. Allow to run for ten hours at slowest chart speed. Drift should be less than 3 millivolts.

8.1.3 SPAN OF STANDARDIZE CONTROL

Using the 700 Terminal Connector and 8980 Shorting Strap (optional accessories), short-circuit the G.E. (Glass Electrode) and the REF (Reference) Input Terminals. Depress MV Pushbutton and put instrument in Read by releasing STANDBY Pushbutton. Adjust STANDARDIZE Control to extremes of range. A minimum of ±200 millivolts should be displayed at the extremes of this control. Return control to a setting of zero millivolts.

NOTE

An accurate millivolt source that can provide up to ±520 millivolts is needed for verification of the remaining meter checks.

8.1.4 RESPONSE

Connect 500-millivolt source to G.E. (Glass Electrode) and REF (Reference) Input Terminals. Depress MV Pushbutton and put instrument in Read by releasing STANDBY Pushbutton. Adjust millivolt source control so that Digital Display indicates 500. Put instrument in Standby. It should take less than two seconds to 98% of final reading when instrument is put in Read by releasing STANDBY Pushbutton.

8.1.5 TEMPERATURE LINEARITY

Depress pH Pushbutton. With a zero millivolt input to pH meter, adjust STANDARDIZE Control until Digital Display reads 7.00 pH. With instrument in READ, apply the following millivolt values to pH meter input — that is, across the G.E. and REF Input Terminals. Turn the TEMP °C Control until

Digital Display indicates exactly pH 14. The TEMP °C Control should read the values indicated below within ±1°C at temperatures from 10° to 60°C, and ±2°C at temperatures from 0°C to 10°C and from 60°C to 100°C.

Millivolts Applied to Input	Temperature °C (With Digital Display at 14.0 pH)
-379.4	0
-421.0	30
-462.7	60
-518.3	100

8.1.6 RELATIVE ACCURACY

Depress pH Pushbutton. With a zero millivolt input to pH meter, adjust STANDARDIZE Control until Digital Display reads 7.00 pH. The following millivolt values should indicate the pH value within ±0.01 pH at 30°C.

Millivolts	pH	Millivolts	pH
± 60.15	6,8	±300.8	2,12
±120.3	5,9	±360.9	1,13
±180.5	4,10	±421.0	0,14
±240.6	3,11		

8.1.7 BIAS CURRENT

Connect properly shielded millivolt source to G.E. (Glass Electrode) and REF (Reference) Input Terminals on pH meter. After calibrating pH meter to zero millivolt, apply 100 millivolts to pH meter. Note reading. Connect 573954 Test Resistor to the G.E. Input Terminal and its pin jack to the millivolt source. Connect the other terminal of millivolt source to the REF Input Terminal on the pH meter. Apply 100 millivolts and note reading. Readings should be within ± 3 millivolts of each other.

8.2 ELECTRODES

Specifications and procedures for electrode verification require a properly working reference electrode.

8.2.1 SPAN

The 582517 (pH 4.01) and 3009 (pH 9.18) NBS-type buffers (at 25°C) are used to check the span of the electrode pair. Standardize the electrode pair in pH 4.01 buffer. After rinsing electrodes and blotting, place electrodes in pH 9.18 buffer. Allow enough time to obtain a stable reading. Meter should read 9.18 ±0.3 pH. If error is greater than ±0.3 pH, electrode should be rejuvenated as per instruction sheet provided, or it should be replaced.

8.2.2 REPEATABILTIY

A series of 10 pH measurements in a stable NBS-type buffer — for example, 582517 pH 4.01 buffer — should agree within ±0.02 pH.

8.2.3 RESPONSE

Place electrodes in pH 9.18 buffer. After a stable reading is reached, standardize pH meter. Rinse electrodes and place in pH 4.01 buffer (at same temperature as 9.18 buffer). Within ten seconds, 98% of final reading should be obtained.

8.2.4 REFERENCE ELECTRODE POTENTIAL

Test against another reference electrode with identical internals (for example, calomel versus calomel) in each of the test buffers. Potential shall be 0.0 ±5 millivolts and shall remain constant to ±2

millivolts from buffer to buffer. If electrode fails test, see instruction sheet that accompanies electrode.

8.3 BUFFERS

Weigh out NBS-certified salts and follow NBS procedure to produce the primary buffer having pH closest to that of the buffer being verified. Rinse and place electrodes in NBS buffer. Measure buffer temperature and set TEMP °C Control at that temperature. After a stable reading is obtained, standardize meter to specified buffer pH for that temperature. Rinse and place electrodes in buffer to be tested. Bring to same temperature (±0.2°C) as prepared NBS buffer, and note reading. Buffer should be within ±0.01 pH of labelled value for that temperature.

SECTION NINE OPERATIONAL PRECAUTIONS AND LIMITATIONS

The following operational precautions and limitations are cited so that the operator may avoid those actions that can damage the meter or electrodes, or adversely affect the validity of a quantitative determination.

1. Read Beckman Instructions 015-082378-C before operating the pH meter.
2. Care should be taken not to transfer body capacitance charge to glass electrodes when blotting electrodes. Blot only, DO NOT WIPE. Drift of reading will be experienced if charge is transferred. If glass electrodes obtain charge, wait for discharge before proceeding.
3. Put instrument in Standby when electrodes are not in solution.
4. Slowly lower electrodes into solution so as to prevent breakage of electrodes on bottom of beaker.
5. Standardize pH measuring system periodically.
6. Checklist for accurate pH measurements:
   a. Standardization and sample measurement should be made using the same technique — for example, both stirred or both quiet.
   b. Standardize close to sample pH value.
   c. Maintain sample and buffer at same temperature.
   d. Allow at least three minutes stabilization time for each measurement.
   e. Test reference and glass electrodes to the performance specifications.
7. Shield against magnetic or electrical noise, where needed.
8. Store reference junction in 566576 Electrode Storage Solution when not in use. This will prevent junction from becoming clogged.
9. Glass or combination electrodes should be soaked before first use. It is convenient and beneficial to store the electrodes in 566576 Electrode Storage Solution.

SECTION TEN SERVICE

Verification of electrode performance and meter performance, as previously outlined, is the only operator service recommended. Electrode replacement is recommended when the electrode does not meet span requirements and does not improve with rejuvenation procedures outlined in the individual electrode instruction sheets.

10.1- 587439 BCD OUTPUT CABLE ACCESSORY

The 587439 BCD Output Cable Accessory is designed to connect the Models 3500, 3550, and 3560 Digital pH Meters to the Model 3115 or Model 39 Printer. THIS CABLE IS TO BE INSTALLED ONLY IN THE FACTORY OR BY QUALIFIED SERVICE PERSONNEL.

WARNING

DISCONNECT POWER CORD FROM ELECTRICAL OUTLET BEFORE INSTALLING CABLE.

1. Remove two top screws from each side of the pH meter. Lift off top cover.
2. Remove two screws that hold plate over BCD outlet hole on rear panel. Retain screws for reassembly.
3. Connect end of BCD Output Cable (with board connector) to digital panel meter board, Figure 7. On the Models 3550 and 3560, the digital panel meter board is oriented vertically.

NOTE

The connector has nine blank pins on one end (four on top and five on bottom). This end of the connector must face the rear of the instrument.

4. Place 835305 Strain Relief Clamp on cable approximately 7.5 inches (19 cm) from connector, Figure 8, with the open side horizontal to the chassis and the large end to the outside of the instrument. Squeeze the strain relief clamp closed into position on the cable. Force the strain relief clamp into the BCD outlet hole in back panel, Figure 9.
5. Install the 585921 Clamp Plate to the inside of the rear panel (in same position from which the cover plate was removed). Secure plate with screws removed from cover plate, Figure 10. Figure 11 is an overall view of completed installation.
6. Replace the top cover and secure with four screws.
7. Connect other end of BCD Output Cable to the multi-pin connector on the Model 3115 or Model 39 Printer. The connector wiring diagram (at printer end of cable) is shown in Figure 12.

Figure 7. Installation of Connector

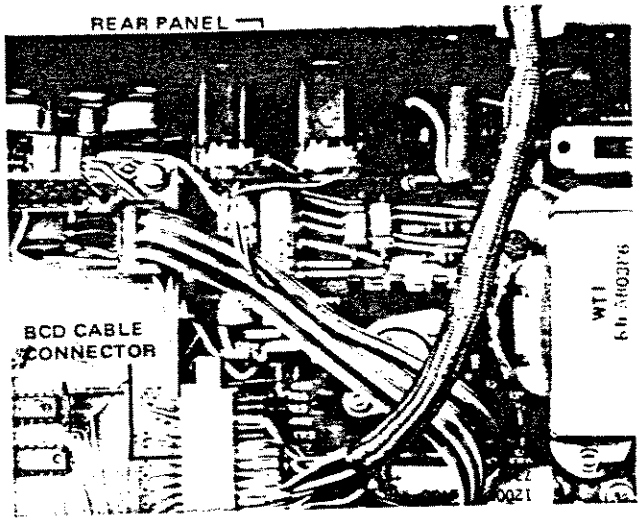
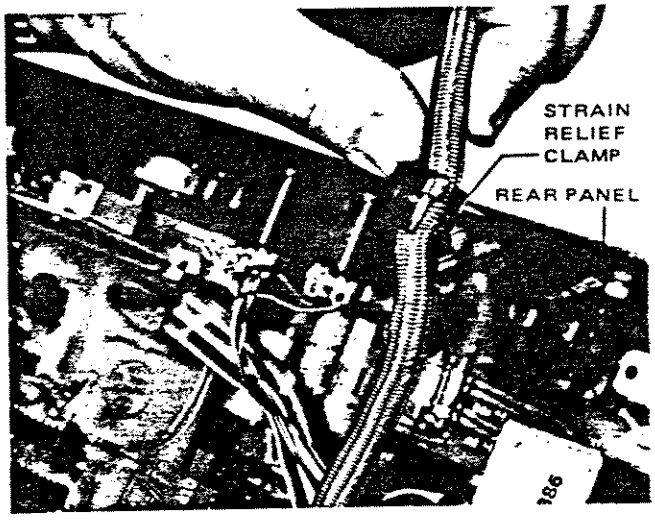


Figure 8. Installation of Strain Relief Clamp on Cable



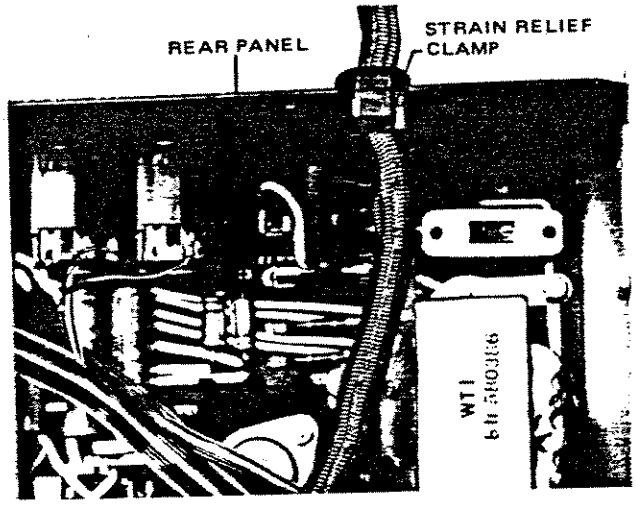


Figure 9. Installation of Strain Relief Clamp in BCD Outlet Hole

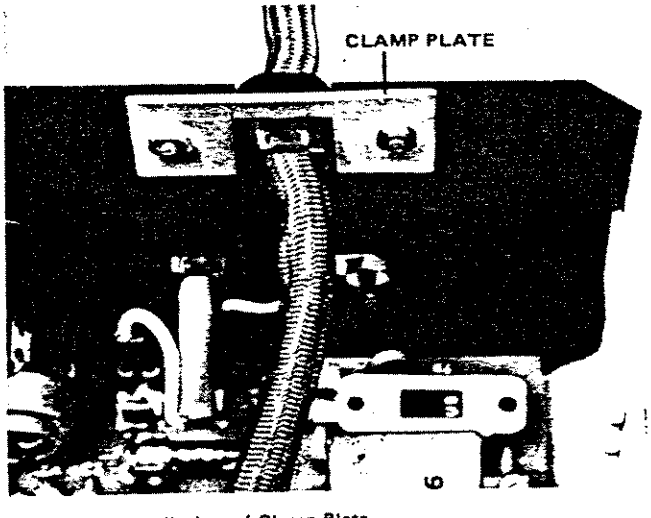


Figure 10. Installation of Clamp Plate

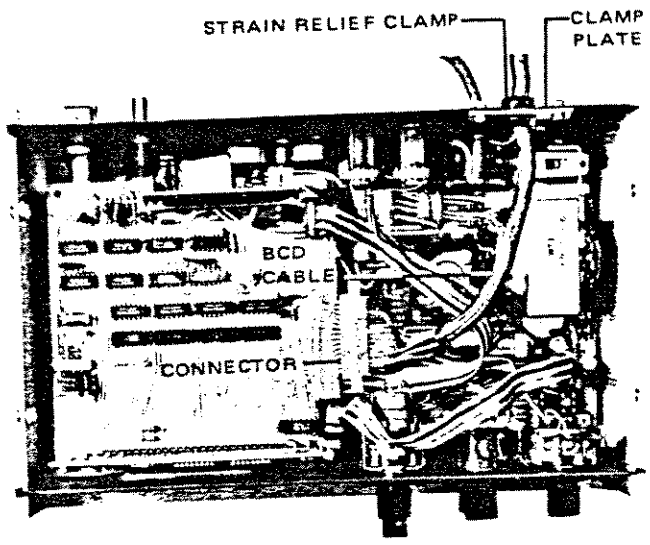


Figure 11. Overall View of Completed Installation

FUNCTION	WIRE NO.	COLOR	CONNECTOR PIN NO.
RESET	22	W/BLK/BLU	24
(–)	21	W/BLK/GRN	4
DATA READY	20	W/BLK/YEL	19
INHIBIT	19	W/BLK/ORN	2
GND	18	GRN	21
1	17	W/BLK/RED	36
2	16	W/BLK/BLK	35
4	15	W/BLK/BRN	18
8	14	W/BLU	17
10	13	W/ORN	34
20	12	W/RED	33
40	11	W/BLK	16
80	10	W/BRN	15
100	9	GRY	32
200	8	PUR	31
400	7	BLU	14
800	6	WHT	13
1000	5	YEL	12
2000	4	ORN	28
4000	3	RED	11
8000	2	BLK	10
10 000	1	BRN	8

Figure 12. Connector Wiring Diagram (Printer End of Cable)

SECTION ELEVEN TROUBLESHOOTING

No periodic service, other than that mentioned in Section Ten, is recommended. If problems occur, follow the procedure described below:

1. Put instrument in Standby by depressing the STANDBY Pushbutton.
2. Depress pH Pushbutton.

The capability of displaying a reading of 4 to 10 by changing zero adjustment will negate problems associated with display circuitry (DPM Board). Model 3550 *Only*: If the input is shorted and AUTO STD Pushbutton is depressed, Digital Display should indicate the value set with ZERO Control. Return to pH 7.00.

3. Set TEMP °C Control to 25°C.
4. Put instrument in Read by releasing STANDBY Pushbutton.
5. Activate Test Function by depressing TEST Pushbutton.

If the test number is displayed when the TEST Pushbutton is depressed, problems associated with the analog board are negated. This indicates that problems are related to the cables or electrode pair. Refer to electrode instructions for further testing of electrode pair. Should this fail to solve the problem, contact the nearest Beckman Service Office for assistance.

SECTION TWELVE HAZARDS

The following hazards are identified for maximum safety of the operator:

1. DO NOT remove meter cover. Equipment inside meter is not user-serviceable and presents electrical shock hazard. Refer servicing needs to qualified service personnel.

SECTION THIRTEEN MISCELLANEOUS SUPPLIES

Beckman Part No.	Description	pH Value (at 25°C)	Quantity
3005	Instant Buffer Powder	4.01 ±0.01	12
3006	Instant Buffer Powder	6.86 ±0.01	12
3007	Instant Buffer Powder	7.00 ±0.03	12
3008	Instant Buffer Powder	7.413 ±0.01	12
3009	Instant Buffer Powder	9.18 ±0.01	12
3019	Instant Buffer Powder	10.01 ±0.01	12
3010	Instant Buffer Powder	12.45 ±0.05	12
3011	Assortment Pack	(2 each of 7 above)	14
582525	pH 10 Color-Coded Buffer		6-Pack/Pts (473 ml)
582517	pH 4.01 Color-Coded Buffer		6-Pack/Pts (473 ml)
582521	pH 7.00 Color-Coded Buffer		6-Pack/Pts (473 ml)
700	Terminal Connector		1
8980	Shorting Strap		1
93583	Recorder Cable		1
587439	BCD Output Cable Accessory		1
39095	Automatic Temperature Compensating Probe		1
573954	Test Resistor		1
5083	Polarizing Jumper		1
586342	Electrode Stand		1
14880	Electrode Holder		1
566467	4M KCl Saturated with AgCl		4-Pack/100 ml
566468	Saturated KCl Solution		4-Pack/100 ml
16740	Electrode Rod		1
583540	Multiple Electrode Selector		1
566576	Electrode Storage Solution		4-Pack/100 ml

SECTION FOURTEEN LITERATURE

The following items may be obtained from Beckman Instruments, Inc.

BULLETINS

7686	Beckman Supplies for pH Meters
7222	An Introduction to pH

TECHNICAL INFORMATION

1085-EC	pH Measurement Technique
920-EC	Biomedical pH Measurements
952-EC	Oxidation-Reduction Potential Measurements With Metallic Electrodes
987-EC	Selection of a Reference Electrode
pH-8053	Buffers for Accurate pH Measurements
pH-8115	Standard Techniques for pH Measurements With Troublesome Samples

INSTRUCTION SHEET

015-081618	The Use and Care of Futura Electrodes