Division 17

Section 17A

Instruments and Controls

DIVISION 17

SECTION 17A

INSTRUMENTATION

1.0 SCOPE

This Specification Section includes furnishing, installing, testing and placing in satisfactory operation all instrumentation required for monitoring, recording and control of the water treatment plant, as indicated on the drawings and described in this specification.

2.0 GENERAL

2.1 Process Variables, Components and Abbreviations

The following process variables shall be measured and controlled as specified in the plans.

	Variable	Abbreviation
.1	Flow	F
.2	Level	L
.3	Diff. Pressure	dP
.4	Hydrogen Ion Concentration	pH
.5	Pressure	P
.6	Specific Conductivity	SC
.7	Temperature	T

The following components of instrumentation channels shall be used as specified in the plans.

	Component	Abbreviation
.1	Primary Element	E
.2	Transmitter	T
.3	Recorder	R
.4	Controller	C
.5	Meter	M
.6	Totalizing	Q

	Component	Abbreviation
.7	Indicating Receiver	I
.8	Alarm	A
.9	Control Valve	V

2.2 Service Classifications

All instrumentation furnished under this specification shall be constructed of materials suitable for the service conditions encountered. The service conditions that will be encountered in the treatment plant are as follows:

Service Conditions

pH	No Solids	6% to 10% Solids
2.5-4.0	A	-
6.0-9.0	B	B_1
7.0-9.0	C	-
11.0-12.0	D	D_1
12.0-14.0	E	-

Unless specified, all temperatures are ambient, specific gravity 1.0 - 1.1, and viscosity 1.0 centipoise.

2.3 Substitutions

The instrumentation is shown schematically on the drawings. Contractor shall be responsible for matching all components so that the system meets the specified requirements and performs the specified functions.

For each process variable, the instrumentation channels are described in Article 3.0, DETAILED REQUIREMENTS. All references to specific manufacturers and model numbers are for identification only. Equivalent units by other manufacturers may be substituted, subject to approval by Engineer. Any substitute components shall meet all of the functional requirements of this specification.

All similar components shall be of the same manufacturer and model.

2.4 Control Channels

2.4.1 Flow Measurements

The following flow measurements shall be monitored and controlled as shown below.

Tag No.	Location	Function
F-1	Raw Water	E T I Q R C V
F-2,3,4,5	Ion Exchange	M I Q A
F-6,7,8	Filter Effluent	E T C V
F-9	Filter Backwash	E T I C V
F-10	Product Water	E T I Q R
F-11	Regeneration	E T I C V
F-12	Lagoon	E T R
F-13	Carbon Dioxide(gas)	M Q
F-14	Ammonia - Anhydrous	M I
F-15	Ammonia Dilution Water	M I
F-16	Mine Hole Overflow	E T R

2.4.2 Level Measurements

Tag No.	Location	Function
L-1	Raw Water Sump	E C A
L-2	Settling Basin SB-1	E A
L-3	Settling Basin SB-2	E A
L-4	Clarifier SF-1	E A
L-5	Product Water TK-1	E A
L-6	Precipitator CP-1	E I*C A
L-7	Precipitator CP-2	E I*C A
L-8	Lime Silo TK-1	E I A
L-9	Lime Slurry TK-2	E I C A *
L-10	Stripper Feed TK-4	E C A *
L-11	Backwash Storage TK-11	E C A
L-12	Distillate Collection TK-5	E C A *
L-13	Regenerant Day TK-6	E I C A
L-14	Backwash Sump	E C A
L-15	Pneumatic Tank	E C
L-16	Ion Exchanger IE-1	E C
L-17	Ion Exchanger IE-2	E C
L-18	Ion Exchanger IE-3	E C
L-19	Ion Exchanger IE-4	E C

* Located on Ammonia Recovery System control board.

2.4.3 Pressure Measurements

The pressure of the following streams shall be measured as shown below.

Tag No.	Location	Function
P-1	Ion Exchange Effluent	I
P-2	Ion Exchanger IE-1	I
P-3	Ion Exchanger IE-2	I
P-4	Ion Exchanger IE-3	I
P-5	Ion Exchanger IE-4	I
P-6	Service Air CM-1	I

2.4.4 Differential Pressure

The pressure of the following streams shall be measured and controlled as shown below.

Tag No.	Location	Function
dP-1	Filter FT-1	E T I
dP-2	Filter FT-2	E T I
dP-3	Filter FT-3	E T I

2.4.5 Hydrogen Ion Concentration

The following streams shall be monitored for hydrogen ion concentration as shown below.

Tag No.	Location	Function
pH-1	Ion Exchange Influent	E T R
pH-2	Ion Exchange Effluent IE-1	E T R A
pH-3	Ion Exchange Effluent IE-2	E T R A
pH-4	Ion Exchange Effluent IE-3	E T R A
pH-5	Ion Exchange Effluent IE-4	E T R A
pH-6	Settling Basin Effluent	E T R
pH-7	Clarifier SF-1	E T R
pH-8	Recarbonation	E T R C V
pH-9	Product Water	E T R

2.4.6 Specific Conductivity

The specific conductivity of the following streams shall be monitored as shown below.

Tag No.	Location	Function
SC-1	Ion Exchange Influent	E T R
SC-2	Ion Exchange Effluent IE-1	E T R
SC-3	Ion Exchange Effluent IE-2	E T R
SC-4	Ion Exchange Effluent IE-3	E T R
SC-5	Ion Exchange Effluent IE-4	E T R
SC-6	Settling Basin Effluent	E T R
SC-7	Recarbonation	E T R
SC-8	Product Water	E T R

2.4.7 Temperature

The temperature of the following streams shall be monitored as shown below.

Tag No.	Location	Function
T-1	Ion Exchange Influent	E I

3.0 DETAILED REQUIREMENTS AND MATERIALS OF CONSTRUCTION

3.1 Flow Measurements

3.1.1 Elements

3.1.1.1 Insert Venturi

Flow elements listed in the following table shall be of the insert venturi differential producing type, constructed of fiberglass reinforced plastic, with metallic throats and holding flanges of the materials indicated. The head loss through the primary elements shall not exceed 12% of maximum differential. Accuracy shall be $\pm$1%. Insert Venturis shall be Penn Meter Co. Type PMT, BIF Model 122 or approved equal.

Insert Venturis

Tag No.	Max Flow gpm	Line Size, in.	Service Class.	Max. Diff. in. H_2O	Materials Throat	Flange
FE-1	1000	8	A	80	316SS	316SS
FE-6	500	6	A	80	Bronze	Steel
FE-7	500	6	A	80	Bronze	Steel
FE-8	500	6	A	80	Bronze	Steel
FE-9	1500	8	A	80	Bronze	Steel
FE-10	1000	10	C	40	Bronze	Steel
FE-11	500	4	A	80	316SS	316SS

3.1.1.2 In Line Liquid Flow Meter

Flow elements listed in the following table shall be of the in line propeller meter type. They shall be constructed of stainless steel with polypropylene impellers. Each meter shall be equipped with a 6-digit cyclometer and a pulse transmitter, emitting one pulse every 1000 gal. Meters shall be Rockwell Mfg. Co. Model 101 with Model 506 pulse transmitter or equal.

In-Line Flow Meters

Tag No.	Max. Flow gpm	Line Size in.	Service Class.	Remarks
FM-2	500	4	A	
FM-3	500	4	A	
FM-4	500	4	A	
FM-5	500	4	A	

3.1.1.3 In Line Gas Flow Meter

The following flow elements shall be of the in line positive displacement diaphragm type, suitable for service to measure carbon dioxide gas flow. They shall be constructed with aluminum bodies, rated at 100 psig. Output shall be 10-50 ma dc for panel mounted flow totalizer. Meters shall be American Meter Co. models as shown below or equal.

In-Line Gas Flow Meters

Tag No.	Max Flow lb/hr	Line Size in.	Remarks
FM-13A	1,000	4	Model AL-2300
FM-13B	50	1½	Model AL- 800

The following flow elements shall be of the type, suitable for the service as indicated below. Rotameters shall be as manufactured by Wallace and Tiernan models as shown below or equal.

Rotameters

Tag No.	Max. Flow gpm	Line Size in.	Pressure Rating, psig	Remarks
FM-14	12	1½	200	Liquid Anhydrous Ammonia - WT-1½38G5-1½G-ZVI
FM-15	80	2	100	Service Water WT-240G10-ZG-14VI

3.1.1.5 Float Type Elements

The following flow elements shall be of the float type. Floats shall be pancaked shaped, constructed of polyester plastic, not less than 11 inches in diameter. Floats shall be furnished with corrosion resistant cable attached to counterweight. Float travel for full range shall be 6 inches.

Tag No.	Application
FE-12	Lagoon
FE-16	Mine hole overflow

3.1.2 Transmitters

3.1.2.1 Differential Pressure

Transmitters for transmitting signals from differential producing primary elements shall be of the differential pressure cell type. Output of the transmitter shall be either 1-5 volt dc or 10-50 ma dc, and shall be compatible with all instruments receiving the signal. The signal shall be linear with flow through use of appropriate square root extractors. Transmitters shall be BIF Model 251-01 or equal.

Transmitters shall have an accuracy of ± 1% of output span and repeatability of ± 0.5% of output span, with temperature compensation over a range of 40°F to 120°F.

Cells shall be constructed of corrosion proof metal, type 316SS or equal; cell housing shall be forged brass. The entire transmitter shall be housed in a corrosion resistant case with gasketed cover, meeting all requirements of a NEMA IV enclosure.

The following transmitters shall be furnished under this section:

Tag No.	Receiver	Functions
FT-1	FR-1	I Q R C V
FT-6,7,8	FC-6,7,8	I C V
FT-9	FC-9	I C V
FT-10	FR-10	I Q R
FT-11	FC-11	I C V

3.1.2.2 Float Type

Transmitters from float type primary elements shall be similar to those transmitting signals from differential producers, except that square root extraction will not be required. Transmitters listed below shall be BIF Model 251-02 or equal.

Tag No.	Receiver	Function
FT-12	FR-12	R
FT-16	FR-16	R

3.1.3 Recorders

3.1.3.1 Strip Chart Recorder

The following recorders shall be of the 4-inch strip chart type with indicating scale. They shall be compatible with the transmitters and all other units specified herein. Chart drive shall be electric at a rate of 3/4" - 1" per hour. The recorders shall be suitable for mounting on the main control panel. Recorders shall be BIF Model 257-01 or equal. Contractor may offer a joint recorder in place of individual recorders.

Tag No.	Scale Graduation
FR-1	0 - 1000 gpm
FR-10	0 - 1000 gpm

3.1.3.2 Circular Chart Recorder

The following recorders shall be of the 12-inch diameter circular chart type. The chart shall make one revolution each 7 days. Mechanism shall be contained in a steel case. Indicating scales shall be 10 in. nominally long with equally spaced, machine engraved graduations.

Tag No.	Scale Graduation	Mounting	Nema Rating
FR-12	0 - 1000	Local	4
FR-16	0 - 100	Local	4

3.1. 4 Totalizers

Totalizers shall be of the cyclometer type driven by a synchronous motor. They may be either supplied as separate instruments or mounted in a receiver case. Totalizers shall be of the 7-digit non-reset type with white numerals not less than 1/4 inch high on a black background, and shall show total quantities in units shown below without requiring a multiplier. The following totalizers shall be furnished:

Tag No.	Unit	Input from	Remarks
FQ-1	100 gal	FT-1	pulse output
FQ-2	100 gal	FM-2	with alarm
FQ-3	100 gal	FM-3	with alarm
FQ-4	100 gal	FM-4	with alarm
FQ-5	100 gal	FM-5	with alarm
FQ-10	100 gal	FM-10	
FQ-13	100 scf	FM-13A	

3.1.5 Controllers

Controllers shall be of the electronic type and shall contain means of manually selecting a specific flow rate, which rate shall then be automatically maintained by the controller by comparing the set rate with an incoming electric signal from a transmitter and emitting a signal which can be used to operate a control valve to correct the flow to the selected flow rate.

The controllers shall employ solid state circuitry. It shall contain a set rate indicator dial, a rate setting knob, a power control knob, and a manual - automatic switch. The controllers shall be BIF Model 252 or equal.

The following controllers shall be provided:

Tag No.	Application	Max. Flow gpm	Control Valve
FC-1	Ion Exchange	1000	FCV-1
FC-6,7,8	Filter Effluent	500	FCV-6,7,8
FC-9	Backwash	1500	FCV-9
FC-11	Regeneration	500	FCV-11

3.2 Level Measurements

3.2.1 Elements

3.2.1.1 Electrode Elements

Level measuring systems listed in the following table shall be of the suspended electrode type as manufactured by B/W Controller Corporation or approved equal. Each level control system shall consist of the number of electrodes as indicated.

All systems shall be furnished with locally mounted relays for 110 volt 60 cycle single phase operation. Relays shall be suitable for the functions specified. All relays shall be housed in NEMA IV enclosures. All relays shall be properly grounded.

Electrodes shall be Type E-1P, shielded; suspension wire shall be Type SW; electrode holders shall be flanged, and made of 316 SS.

Suspended Electrode Level Functions

Tag No.	No. of Electrodes	Control Functions High	Low
L-1	3		Stop P1A & P1B Panel Alarm Manual Pump Reset
L-2	1	Panel Alarm	
L-3	1	Panel Alarm	
L-4	1	Panel Alarm	
L-10	2	Stop P12 and P17 Panel Alarm*	Stop P16A or P16B Panel Alarm* Panel Alarm*
L-11	1		Stop P-24
L-12	1		Stop Ammonia Distillate Pump Panel Alarm*
L-14	2	Panel Alarm	

Note: *Mount on Ammonia Recovery System Panel Board.

3.2.1.2 Electro-Mechanical Detectors

Level detection of dry chemical solids shall be of the rotating paddle type. The device shall consist of a rotating vane paddle with an extended shaft, and a slip clutch. The vanes shall be rotated by a low torque, low speed motor mounted locally on the tank.

3.2.1.2.1 L8A - Lime Silo High Level

The level detector shall be mounted on the top of the bin as indicated on plans and shall be provided with an extended shaft to provide proper detection of high solids level. The detector shall be equipped with SPDT switch rated 15A at 125v-AC service wire for NO circuit. Upon high level detection, paddle will stop rotation closing switch and sounding high level alarm.

3.2.1.2.2 Lime Silo Low Level

The level detector shall be mounted on the side wall of the bin as indicated on plans and shall be provided with a protective baffle. The detector shall be equipped with a SPDT switch rated 15A at 125 v.A.C. service wired for N.O. circuit. Upon low level detection, paddle will rotate and close switch sounding a low level alarm.

3.2.2 Differential Pressure

The following level measurements shall be detected by differential pressure measurement.

Tag No.	Material	Function	Differential Pressure Range
L-5	Product Water	Product Inventory	0-240 in. H_2O
L-6	$CaSO_4$ Slurry[1]	Product Inventory	0-600 in. H_2O
L-7	$CaSO_4$ Slurry[1]	Product Inventory	0-600 in. H_2O
L-9	$Ca(OH)_2$ Slurry[2]	Product Inventory	0-600 in. H_2O
L-13	Aqueous Ammonia	Product Inventory	0-200 in. H_2O
L-16	pH: 4-6 water	Liquid Draindown	0-12 in. H_2O
L-17	pH: 4-6 water	Liquid Draindown	0-12 in. H_2O
L-18	pH: 4-6 water	Liquid Draindown	0-12 in. H_2O
L-19	pH: 4-6 water	Liquid Draindown	0-12 in. H_2O

3.2.2.1 The slurry at L6 and L7 will contain 5-10% wt. calcium sulfate (gypsum) in aqueous ammonia solution. The slurry at L-9 will contain 10% wt. calcium hydroxide (hydrated lime). The slurry at L16, L17, L18 and L19 will contain ion exchange resin.

3.2.3 Diaphragm Activated Switch

The water air interface level in the hydro-pneumatic tank, TK-12, shall be sensed by a pressure activated diaphragm switch. The diaphragm activated switch may be supplied as a unit of a preassembled system.

3.2.4 Transmitters

Transmitters for transmitting signals from differential producing elements shall be of the differential pressure cell type. Output of the transmitter shall be either 1-5 volt dc or 10-50 ma dc and shall be compatible with all instruments receiving the signal. The signal shall be linear with level. Transmitters shall have an accuracy of $\pm$ 0.5% of output span and repeatability of $\pm$ 0.15% of output span with temperature compensation over a range of -40 to +250^{o}F.

Cells shall be constructed of corrosion proof metal, type 316 stainless steel or equal; cell housing shall be cadmium plated carbon steel. The entire transmitter shall be housed in a corrosion resistant case with gasketed cover, meeting all requirements of a NEMA IV enclosure. Equivalent units by other manufacturers may be substituted, subject to approval by Engineer.

Tag No.	Model No.
L5, L13	Foxboro #613
L6, L7, L9	Foxboro #617FEM
L16, L17, L18, L19	Foxboro # 613 DL

3.2.5 Controls Programs and Alarms

3.2.5.1 Chemical Precipitator - CP-1 & CP-2

The level indicator shall indicate the level of inventory in the chemical precipitator. The controller upon high level signal shall shut down P-12 and P-17. The controller upon low level signal shall shut down P-16A or P-16B. The programmer shall be capable of shut down either or both operationg pumps. Alarm shall sound upon low level or high level signal.

3.2.5.2 Lime Slurry Tank - TK-2

The level indicator shall indicate the level of 10% lime slurry inventory in the tank. Upon high level signal, the controller shall shut down the lime feeder LF-1, lime slaker LS-1 and the transfer pump, P-10. Upon low level signal the controller shall shutdown the lime slurry feed pumps, P-11 & P-12. Alarms shall sound upon either low level or high level signal.

3.2.5.3 Ion Exchange Units - IE-1, IE-2, IE-3, IE-4

The level controller shall upon signal close the drain-down valves as described in Specification Section 3.10.1 Automatic Sequence Program - Ion Exchange Regeneration Cycle.

3.3 Loss of Head Measurement

3.3.1 Differential Pressure Cells

Transmitters for transmitting signals from differential producing primary elements shall be of the differential pressure cell type. Output of the transmitter shall be either 1-5 volt dc or 10-50 ma dc and shall be compatiable with all instruments receiving the signals. The signal shall be linear with pressure drops. Transmitters shall have an accuracy of $\pm$ 0.5% of output span and repeatability of $\pm$0.15% output span with temperature compensation over a range of -40 to 250^{o}F. Cells shall be constructed of corrosion proof metal, type 316 stainless steel or equal; cell housing shall be cadmium plated carbon steel. The entire transmitter shall be housed in a corrosion resistant case with gasketed cover, meeting all requirements of NEMA I enclosure.

3.3.2 Loss of Head Indicator

The indicator shall be activated by a 1 to 5 volt signal or 10-50 ma dc signal. The meter module shall include precision series resistance circuit, a range adjusting resistor, a terminal strip and a 3½ in. by 2½ in. indicating scale graduated over an arc of 100^{o}. The indicator shall be adjustable from the front. The accuracy shall be within $\pm$ 2% of maximum scale reading.

3.4 Pressure Measurements

3.4.1 Indicators

The pressure indicators shall be 4½ inch diameter with white numerals on black background. The scale shall be 0-100 psi with 10 psi major divisions and 1 psi minor divisions. The elements shall be of the bourdon tube type constructed of Type 316 stainless steel for Class A pipe service as specified in Specification Section 15C - Piping Systems. The pressure indicators shall be installed as shown on Drawing No. 2009.

3.5 Temperature Measurements

3.5.1 Indicators

The temperature element and indicator shall consist of a bimetallic element with indicating scale. The indicating scale shall have a range of 0-100°F. The indicating scale shall have black numerals on a white background.

3.6 Hydrogen Ion Concentration

The following table shows the expected water composition at each monitoring station.

Tag No.	Stream	pH
pH-1	Raw Water	2.5-4.0
pH-2	IE-1 Effluent	5.0-6.0
pH-3	IE-2 Effluent	5.0-6.0
pH-4	IE-3 Effluent	5.0-6.0
pH-5	IE-4 Effluent	5.0-6.0
pH-6	Settling Basin Effluent	6.0-8.0
pH-7	Clarifier Effluent	10.0-12.0
pH-8	Recarbonated Water	7.0-9.0
pH-9	Product Water	7.0-9.0

3.6.1 Cell Assemblv

The cell assembly shall consist of a measuring electrode, a reference electrode and a thermal compensator, all mounted in a flow through chamber. The reference electrodes shall be made of low resistance, pH sensitive, good abrasion resistant glass. The electrodes shall have a temperature operating range of 32-85°F. Cells for monitoring stations pH-1 to pH-5 shall be for high pressure duty (shut off pressure - 100 psig) and require compressed air for pressure balance. The cell chamber shall be constructed of type 316 stainless steel in contact with sample fluid, contain teflon gasket and neoprene rubber electrode grommets.

3.6.2 Junction Boxes and Cable

The leadwire from the electrode assemblies shall run to junction boxes which are supplied with electrode assembly. From the junction box, single conductor leadwire shall be used for the reference electrode connection. Two conductor leadwire shall be used to connnect temperature compensator to the transmitter converter. Shielded single conductor leadwire shall be used to connect the measuring electrode to the transmitter converter. Three conductor leadwire shall be used to connect the transmitter converter to the recorder.

3.6.3 Transmitter Converter

The potential signal from the electrode assembly junction box shall be converted to either 1-5 volt dc or 10-50 ma dc signal by a converter transmitter and shall be compatible with all instruments receiving the signal. Temperature compensation shall be located in the electrode assembly.

3.6.4 Multipoint Recorder

The multipoint recorder shall have provision for 12 point recording. The input signal shall be an automatically balanced signal from the transmitter converter. The range span shall be 2 to 12 pH units. The recorder shall be recorded by curve printing of numbered dots. The chart speed shall be 2 inches per hour. The chart width shall be 10 inches nominal width. Temperature compensation shall be automatic by use of temperature compensation located in pH electrode assembly. Power supply shall be 120 volts, 60 hertz current.

3.6.5 Controller

A controller shall be provided for monitoring station pH-8. The controller shall be capable of varying the output pressure of an electro-pneumatic converter to accurately position a pneumatic valve. The controller shall contain on the front panel a meter showing the deviation of process variable from the set point, a circular set point dial calibrated in the required range, a current output indicator calibrated in percent of full current output, automatic and manual pushbuttons including a decrease button, an auto button and an increase button. The two manual buttons shall provide manual control of signal output by depressing one of the buttons until the meter indicates the correct output signal. Depression of the auto button shall provide complete automatic control of the process.

The input signal shall be the dc volt or dc milliamp signal from the converter transmitter. The output signal shall be 1-5 milliamp dc signal. The power required shall be 107 to 127 volt a.c. 60 hertz.

3.6.6 Electro-Pneumatic Converter

An electro-pneumatic converter shall be provided for monitoring station pH-8. The electro-pneumatic converter shall be capable of converting the electronic signal from the controller to a 3-15 psig pneumatic signal capable of operating a valve. The air supply to the converter shall be 20 psig filtered and regulated air. The converter shall have one ¼" NPT air supply connection and two ¼" NPT output supply connections. The electro-pneumatic converter case shall be constructed of cast aluminum and shall be gasketed and weatherproof.

3.6.7 Alarm and Control Function

The hydrogen ion concentration alarm and control functions shall be as shown below.

Tag No.	Control Function		Alarm	
	#1	#2	#1	#2
pH-1	None	None	None	None
pH-2	Signal Alarm Shut pHCV-2		End of IE Cycle	End of Regen Cycle
pH-3	Signal Alarm Shut pHCV-2		End of IE Cycle	End of Regen Cycle
pH-4	Signal Alarm Shut pHCV-2		End of IE Cycle	End of Regen Cycle
pH-5	Signal Alarm Shut pHCV-2		End of IE Cycle	End of Regen Cycle
pH-6	None	None	None	None
pH-7	None	None	None	None
pH-8	Proportion CO_2 Gas to Maintain pH Control		To sound alarm on low pH signal	
pH-9	None	None	None	None

3.7 Specific Conductivity

3.7.1 Cells

The specific conductivity cells shall have cell constants to record the specific conductivity for the monitoring point. The cells shall be inserted directly into the flow pipe line as shown on the plans. The cells shall be constructed of platinum electrodes. The cell body shall be constructed of teflon or penton body material and Carpenter 20 or type 316 stainless steel mounting fitting material which is in contact with fluid.

3.7.2 Multipoint Recorder

The recorder shall be an indicating recorder with a 12 point strip chart and electronic amplification of error signal and reversing motor to effect automatic balancing action. The measuring circuit shall be automatic balanced a.c. Wheatstone Bridge. The recorder shall have a range span of 0-2000 micromho. The strip chart width shall be 10 inch nominial width and travel at 1 inch per hour. The points shall be printed once every 30 seconds, in a cycle order. The recorder shall have automatic temperature compensation. The power supply for the recorder shall be 120 volts, 60 hertz. The recorder shall record the functions as specified in Specification Section 17-2.4.6.

3.8 Control Valves

3.8.1 Flow Control Valves

Tag No.	FCV-1	FCV-6,7&8	FCV-9	FCV-11.1	FCV-11.2
Liquid	Raw Water	Filtered Water	Service Water	8% Aqua Ammonia & Service Water	8% Aqueous Ammonia
Design Flow GPM	475	250	1,000	250	250
Shut Off Pressure psi	100	30	30	100	20
C_V @60°	770	515	235	70	159
Size, In.	6	5	4	2½	3
Type	Butterfly	Butterfly	Butterfly	Butterfly	Butterfly
Material	Cast Iron Rubber Lined	Cast Iron Rubber Lined	Cast Iron Rubber Lined	Aluminum	Aluminum
Ends	125#Flgd	125#Flgd	125#Flgd	125#Flgd	125#Flgd
Failure Position	Closed	Closed	Closed	Closed	Closed
Operator	I/P	I/P	I/P	I/P Note 1	I/P Note 1

Note 1: FCV-11.1 and FCV-11.2 are operated by FC-11.

3.8.2 Ammonia Makeup System

Control valves for ammonia makeup system shall be as shown on the plans and herewith specified.

Tag No.	FV-14	FV-15
Liquid	Anhyorous Ammonia	Service Water
Design Flow	10 GPM	70 GPM
Shut Off Pressure	300 psi	100 psi
C_v	3.5(100% Open)	101(60^{o} Open)
Size	½ in.	2½ in.
Type	Diaphragm	Butterfly
Material	Steel: Buna N	CI: Rubber line

3.8.3 pH Control Valve

Control valves for recarbonation service shall be installed as shown on the plans and as herewith specified.

Tag No.	pHCV-1	pHCV-2
Service	Carbon Dioxide Recarbonation	Carbon Dioxide I.E. Recarbonation
Design Flow	10 lb/hr	190 lb/hr
Shut Off Pressure	300 psi	300 psi
C_v	2.6	407
Plug Size	¼ in.	1½ in.
Body Size	1 in.	1½ in.
Type	Needle Valve	Single Port
Material	Aluminum Needle & Body	Aluminum Plug & Body

3.9 Control Panel

3.9.1 Design Requirements

A control panel shall be furnished, constructed of 12-gauge steel, cubicle type, suitable for floor mounting.

The control panel shall be mounted on suitable vibration dampers and shall have hinged doors on the back to allow ease of access to the instruments. The doors shall have locks in the handles. The panel shall form part of the interior wall. The arrangement, dimensions, and graphic section shall be as shown on the drawings.

The spare light boxes nameplates will be left blank.

The panel shall also contain a horn, an acknowledge button, a reset button for alarms, and a lamp and audible test button.

The annunciator sequence shall start when the operating contact goes off normal. The horn shall sound, and the appropriate nameplate light shall start flashing. This shall continue until the acknowledge button is depressed, which shall silence the horn and cause the light box to glow steadily.

The light shall continue to glow until the operating contact returns to normal. For level alarms, this shall occur when the level returns to within limits. For pH alarms, this shall occur when the reset button is depressed.

The panel board shall be painted with gray corrosion resistant paint suitable for normal damp atmosphere.

3.9.2 Graphic Panel

The graphic panel shall be color coded as shown on the plans. The graphics of the ion exchangers shall contain three indicating lights to represent the three conditions of service. The conditions are:

1.	Red	Regeneration
2.	Yellow	Stand by
3.	Green	Service

The graphics of the filters shall contain three indicating lights to represent the three conditions of service. The conditions are:

1.	Red	Backwash
2.	Yellow	Stand by
3.	Green	Service

All other graphics shall have one or two indicating lights as shown on the plans. These will indicate as follows:

1.	Red	Equipment on, valve open, motor or circuit energized.
2.	Green	Equipment off, valve closed, motor or circuit de-energized.

3.9.3 Annunciator Panel

The annunciator panel shall consist of 24 light panels with translucent white nameplates and operating relays mounted in the control panel. The nameplates shall be 3 inch by 2 inch for single function windows; and 1½ inch by 2 inch for two function windows. The nameplates and functions are as indicated below.

Tag No.	Inscription	Function
L-1	Mine Water Sump	High Level
L-2	Settling Basin #1	High Level
L-3	Settling Basin #2	High Level
L-4	Clarifier	High Level
L-5	Product Water Storage Tank	High/Low Level
L-6	Precipitator #1	High/Low Level
L-7	Precipitator #2	High/Low Level
L-8	Lime Silo	High/Low Level
L-9	Lime Slurry Tank	High/Low Level
L-10	Ammonia Recovery Feed Tank	High/Low Level
L-11	Distillate Collection Tank	High/Low Level
L-12	Regenerant Day Tank	Low Level
L-13	Backwash Storage Tank	Low Level
L-14	Backwash Water Sump	High Level
pH	Recarbonation pH	High Level
FA-2,3,4,5	Ion Exchange Volume Exceeded	
pH-2,3,4,5	Ion Exchange Low pH	

The panel shall also contain a horn, an acknowledge button, a reset button and a lamp and audible test button.

The annunciator sequence shall start when the operation is off contact goes off the normal. The horn shall sound, and the appropriate nameplate light window to glow steadily.

The light shall continue to glow until the operation returns to normal. For level alarms, this shall occur when the level returns to within limits. For chemical content, this shall occur when the reset button is depressed.

3.9.4 Electrical Requirements

All instrument leads shall be wired to clearly identified terminal strips.

The control panel power supply shall consist of two 120-volt, a-c,20-ampere circuits with final disconnect switches for each circuit mounted on the back of panel. Fuses shall be rated 15-ampere, 240 volts. All circuits to instruments shall be properly fused; neutral shall not be fused.

The indicating lights for the electropneumatic valves shall be controlled by the filter backwash system.

3.9.5 Control Switches

Rotary-type, panel-mounted control switches shall be provided with contacts rated for 20 amperes continuous at 600 volts. The number of positions shall be as specified. The switches shall have a throw of 30 degrees between positions regardless of the number of positions up to 12. Each switch shall have a dial plate clearly indicating the switch position, the control action at each position and the device being controlled by the switch. Lettering shall be black on white.

Operating handles shall be of pistol grip shape and have a recessed arrow molded into it to aid in positioning. They shall be made of black insulating pheonolic composition and fastened to the switch shaft by a screw through the front of the handle into the front end of the shaft.

Selector switches shall be heavy-duty, lever-operated, oil-tight type. They shall be three-position, maintained-contact type. Contacts shall be rated 10 amperes at 600 volts. Each switch shall have a permanently attached nameplate clearly indicating the switch position and the device controlled by the switch. Nameplates and contact arrangement shall be as shown on the drawings.

3.9.6 Push Buttons

Push buttons shall be of the heavy-duty, oil-tight, momentary-contact type. Contacts shall be of the convertible type rated 10 amperes at 600 volts. Push-button operator shall be standard button. The color of those push buttons which function to stop a motor shall be red. On all single-row push-button arrangements, the stop button shall be located below or to the right of all other associated buttons, indicating pilot lights and selector switches. Each push button shall have a permanently attached nameplate clearly indicating the function of the push button.

Pilot lights shall be of the heavy-duty, oil-tight transformer type for 120 volts, ac, 60 cycles. The Contractor shall provide all required bulbs as recommended by the manufacturer. Each pilot light shall be provided with a lens of a color as indicated on the drawing.

3.10 Automatic Sequence Program

3.10.1 Ion Exchange Regeneration Cycle

.1 Regeneration of the ion exchange vessels shall be on a fixed time cycle, where all modes are automatic except the last rinse mode which will be ended by the pH monitor. Sequence of operation shall be in accordance with Table 4.

.2 Alarms shall be provided to:

a. Annunciate exhaustion of the resin when the pH of the effluent exceeds a preset limit.

b. Annunciate the completion of the second rinse mode when the pH monitor of the effluent indicates completion of the alkalization step by the lowering of the pH to below 5.0.

c. When the total volume throughput between regenerations exceeds a preset limiting value.

.3 Regeneration shall be initiated manually for each unit by depressing the appropriate pushbutton, thereafter all steps of the regeneration cycle shall be initiated automatically under control of a regeneration program.

.4 The return to service shall be manual.

.5 The controls shall be interlocked to prevent regeneration of more than one I.E. Unit simultaneous.

.6 Depression of the appropriate I.E. Unit push button shall initiate the automatic sequence cycle as follows:

a. The unit shall be drained to a level 6 inches above the top of the resin bed by opening the drain valve (V-24,30,36 or 42) and the automatic vent valve, (V-45,46,47,48). Valve V-5 will open permitting the drainage to return to the raw mine water sump. Level control (LLC-16,17,18 and 19) will close valves (V-5, and V-24,30,36 or 42) when the water level in the appropriate ion exchange unit is 6 inches above the resin bed.

b. The regenerant inlet valves (V-49,50,51 or 52) shall open. The fresh regenerant pump (P-18) shall start. The spent regenerant valves (V-24,30,36 or 42) shall open. The spent regenerant valves at the chemical precipitators (V-204, 210 and 218) shall open. The spent regenerant pump (P-17) shall start. Flow control valve (FCV-11.2) will control the regenerant flow rate and time will yield predetermined volume.

c. After a predetermined time, the regenerant pump (P-18) shall stop. The rinse water pump (P-21) shall start. Flow control valve (FCV-11.1) will control the rinse flow rate and time will yield predetermined volume.

d. The regenerant inlet valves (V-49,50,51 or 52) shall close. The spent regenerant valves (V-24,30,36 or 42) shall close. The chemical precipitator valves (V-204,210 and 218) shall close. The spent regenerant pump (P-17) shall stop. The rinse valves (V-23,29,35 or 41) shall open. The carbon dioxide valves (V-248 and pHCV-2) shall open. The rinse water pump (P-21) shall be operating and flow control valve (FCV-11.1) shall control the rinse water flow rate. The predetermine volume will be determined by time. The volume of carbon dioxide addition will be determined by pHCV-2. At the end of the carbon dioxide addition, the carbon dioxide valves (V-248 and pH CV-2) shall close. The rinse water pump (P-21) and valves V-23, 29, 35 or 41 shall close upon manual operation.

Table
Time Schedule of Ion Exchange Operation Sequence

Time From	To	IE#1	IE#2	IE#3	IE#4
00:00	08:00	Off	Off	On	On
08:00	08:10	Reg.	Off	On	On
08:10	08:30	1st Rinse	Off	On	On
08:30	10:00	2nd Rinse	Off	Off	On
10:00	10:10	Off	Reg	On	On
10:10	10:30	Off	1st Rinse	On	On
10:30	12:00	Off	2nd Rinse	On	Off
12:00	12:10	On	On	Reg.	Off
12:10	12:30	On	On	1st Rinse	Off
12:30	14:00	On	Off	2nd Rinse	Off
14:00	14:10	On	On	Off	Reg.
14:10	14:30	On	On	Off	1st Rinse
14:30	16:00	Off	On	Off	2nd Rinse
16:00	24:00	On	On	Off	Off

3.10.2 Filter Controls and Backwash Cycle

The filter control system shall include rate of flow controllers, automatic backwash system and all necessary instrumentation and valve operators. The controls shall be mounted on the control panel conforming to the arrangement shown on the drawings.

The filter control system is shown on the drawings to be of the electro-pneumatic type in which all valves are pneumatically operated. This may be substituted by the electro-hydraulic type, subject to Engineer's approval. Valves shall be equipped with manual operating levers for emergency operation. Pilot circuits between the valve and the control panel shall be electric. All components within the panel shall be electric and no water or air shall be brought into the control panel.

All panel operated valves shall have limit switches on the valve stem, and indicating lights on the control panel. Lights shall indicate open if the valve is not tightly closed. Lights shall also be provided to show filter in service, under backwash, and ready to return to service. Nameplates shall be provided to show the function of each item mounted on the control panel. All equipment insofar as practical shall be the product of one manufacturer who has adequate design experience on installations of similar type. It is the intent of these specifications that all necessary components for a complete operating system be furnished.

3.10.2.1 Filtration Control

The rate-of-filtration controllers located in the effluent line of each filter shall consist of an electro-pneumatic butterfly valve with a Dall-type venturi flow tube. A transmitter shall convert differential pressure input into a d-c milliamp signal which shall be transmitted to a controller on the control panel. Each of the controllers shall contain a rate setting dial and a flow indicator. The range of the controllers shall be 0-500 gpm. Valve and flow tube shall be suitable for installation in a 6 inch-diameter pipe.

3.10.2.2 Filter Backwash

Filters shall be backwashed under the automatic control of a filter backwash program. Normally, backwashing of the filters will be on a fixed time cycle. The backwash cycle shall be initiated manually by depression of a push button, one for each filter, located on the control panel. Thereafter all steps in the backwash cycle shall be initiated automatically under control of the backwash program. The program shall operate in the following sequence:

a. Upon depression of the initiating push button, the "in service" light shall be turned off and the "Backwash" light shall be lit.

b. The influent valve shall be closed. (V-69,71 or 73)

c. After a predetermined time when the water level in the filter has fallen to a level 6" above the filter bed the effluent valve (FCV- 6,7 or 8) shall close.

d. The waste wash water valve (V-70,72 or 74) shall open.

e. The backwash pump (P-23) shall be started with the control valve (FCV-9) in the closed position.

f. The air compressor (BL-2) shall be started.

g. The backwash control valve (FCV-9) shall open to the preset low backwash rate. The backwash inlet valve (V-77, 80 or 83) shall also be opened.

h. The air scour valve (V-75, 78 or 81) shall open for a predetermined period of time and then close.

i. The backwash control valve (FCV-9) shall open to the preset high backwash rate.

j. During the last 60 seconds of the preset high rate backwash period, warning light shall light. While this light is lit, it shall be possible to manually extend the high rate backwash cycle by depression of an extended backwash push button. Upon release of this pushbutton, the 60 second warning light shall complete its cycle and upon completion reduce the flow to the low backwash rate by partially closing the backwash control valve. (FCV-9)

k. After completion of the second low rate backwash period the backwash inlet valve (V-77, 80 or 83) shall be closed. The waste wash water valve (V-70,72 or 74) shall be closed, the backwash control valve (FCV-9) shall be closed, and the backwash pump (P-23) shut down.

l. The filter inlet valve (V-69,71 or 73) shall open, causing the level in the filter to rise to the normal operating level. After a predetermined time when this level is reached, the filter-to-waste valve (V-116, 115 or 114) shall open and the filter shall operate in the rewash mode for a preset period.

m. At the end of this period, the filter-to-waste valve (V-116, 115 or 114) shall close, the filter inlet valve (V-69, 71 or 73) shall close and a light shall indicate that the filter is ready to return to service.

n. The filter shall be returned to normal operation manually by opening the inlet valve (V-69, 71 or 73) and resetting the effluent controller to automatic control. (FCV-2, 3 or 4)

Should power failure occur while the equipment is automatically backwashing a filter, all of the valves shall reset themselves to put the filter back into a filter to waste operation for the duration of the power failure.

No action of the backwash program shall take place unless the preceding step has been completed. Failure of a particular step to be completed shall cause the sequence of operation to be interrupted and thus fail safe.

An interlock shall be provided to prevent backwashing more than one filter at any time. Timers will be furnished to adjust the periods of surface wash, initial low backwash, high backwash, terminal low backwash and air scour.

The rate of discharge of the wash water pump shall be controlled by an electrohypneumatic butterfly valve. The flow shall be measured by a Dall-type venturi flow tube. Valve and flow tube shall be suitable for installation in a 8 inch-diameter pipe. The differential pressure output of the flow tube shall be converted into a d-c milliamp signal, which shall be transmitted to a controller mounted on the control panel. The controller shall be capable of maintaining the flow at two set rates without manual adjustment, a low rate for initial and terminal backwash and a high rate for the main backwash period. The flow range of the controller shall be 0-1500 gpm.

3.10.3 Chemical Precipitation Cycle

The Chemical Precipitation Cycle shall be manually operated, but the equipment shall be so interlocked for safety purposes. The chemical precipitation consists of the lime slurry feed pump (P-12) and the chemical precipitators (CP-1, CP-2). The operating sequence shall be as follows:

a. At the beginning of the regeneration cycle both chemical precipitators shall be empty. The spent regenerant shall be pumped into one of the two precipitators. Simultaneously lime slurry shall be added by mannually operating pump (P-12). The agitator in the operating chemical precipitator shall be so interlocked that it is operating when the lime slurry feed pump (P-12) is operating, the spent regenerant pump (P-17) is operating and when the chemical slurry pump (P-16A or P-16B) is operating. When CP-1 has reached

a predetermined level as determined by LHLA-6; flow shall be diverted to CP-a by closing valve V-204 and opening valve V-210. The valves shall be so interlocked that the high level alarm diverts the flow to the other chemical precipitator.

b. Lime slurry will be added by manual operation of pump (P-12) until the reaction is completed.

c. After the reaction in CP-1 is completed, the lime slurry flow shall be manually diverted to CP-2. Lime slurry shall be added to chemical precipitator (CP-2) until the reaction is completed.

d. Operation of the lime slurry pump (P-12) shall be interlocked with the level alarm (LHLA-9) in the lime slurry tank (TK-2) to prevent operation unless the level in the tank exceeds a preset minimum.

e. The operator at the central control panel shall have visual indication of the levels in TK-2, CP-1, and CP-2; operating lights on P-17 and P-12; and lights indicating the positions of valves V-204, V-205, V-210 and V-211.

4.0 INSTALLATION

4.1 Assembly and Installation

The instrumentation and equipment and controls shall be shipped completely assembled, ready for installation. Installation shall conform to all applicable NEMA, ANSI and IEEE standards. Contractor shall provide the services of a competent engineer for consultation during the installation and checkout.

4.2 Inspection

Contractor shall provide the services of a factory-trained technician to inspect the installation, testing and operation of the equipment, not less than three(3) months nor more than six(6) months after notification by owner that the equipment is installed.

5.0 TESTING

5.1 Shop Tests

All instrumentation system components, such as transmitters, amplifiers, receivers, recorders, controllers and the like, shall be calibrated by manufacturer prior to shipment of equipment. Contractor's calibration procedures shall be sub-

mitted to Engineer prior to running any calibration checks. After calibration all instruments shall be sealed before shipment. A calibration sticker shall be affixed to the instrument showing date of calibration with a warning that instrument must not be tampered with.

5.2 Field Tests

5.2.1 Electrical Insulation, Continuity and Wiring Diagram Conformity Tests

After complete assembly of the control boards and panels, tests shall be conducted by Contractor to demonstrate integrity of all electrical insulation, the continuity of all connected circuits and conformity with approved wiring diagrams.

Tests shall comprise (but not be limited to) the following:

.1 Each circuit shall be tested to ascertain the value of ground resistance using a 1000 volt Megger. Minimum resistance shall be one megohms.

.2 Each switch shall be checked for conformity to the switch development diagrams.

.3 Each annunciator window shall be tested functionally.

.4 All manually-actuated control devices and associated wiring shall be checked for function and correctness of wiring.

.5 All indicating lamps shall be tested by applying rated voltage to lamp circuits.

.6 All indicator and meters shall be checked by applying actual or simulated input signals to verify normal full-scale deflection.

5.2.2 Pneumatic Tests

After complete assembly of the control boards and panels; and all other valves, fittings, piping, tubing and connections, a mechanical pressure test shall be made on all valves, fittings, piping, tubing and connections. These shall be carefully inspected and checked for leaks. In accordance with I.S.A. RP7.1, "Pneumatic Control Circuit Pressure Test" using air with a dew point of 10°F below the minimum ambient test temperature but not below -40°F. All lines shall be blown free of foreign matter before test. After testing, all lines shall be sealed against dust and dirt until final installation. Dry gas shall be used for the pressure testing.

5.2.3 Operational Tests

After installation in the field, and pneumatic tests are completed, all control indication and alarm circuits shall be tested to ensure proper operation in order to complete control loops that will be closed in the field. Suitable test inputs and loads shall be provided by Contractor external to the specified system in order to test performance of Contractor-supplied equipment in a complete loop. Contractor shall submit to Engineer a complete description of his test facilities and proposed test procedures for approval prior to running any acceptance tests.

6.0 INFORMATION TO BE SUBMITTED

6.1 With Bid

The technical information and data sheet included in the Bid Form shall be submitted completely filled out by Bidder. After acceptance by Engineer, this data in the Bid Form shall become part of the Technical Specification for this equipment.

6.2 After Award

The following information and data shall be submitted after award.

6.2.1 Drawings

a. Control board layouts showing arrangement of face mounted instruments, control devices and other equipment.

b. Foundation Requirements.

c. Assembly drawings depicting general construction of panels and instruments with section views, details, and framing with complete parts list for each panel (including owner-furnished items) and material designations.

d. Detail drawings depicting nameplates and switch markings showing the exact numbering and/or lettering used. Also equipment mounting details, locations of raceways and outlet and installation details.

e. Instrument and control system loop diagrams.

f. Piping and tubing layout diagrams.

g. Tubing connection, mounting and wiring connection diagrams, covering all instrumentation and control system components.

h. Elementary diagrams of all electrical equipment.

i. Interconnection wiring diagrams for the complete system:
Note: Wiring diagrams shall be of the physical point-to-point type and shall show physical arrangement of all terminal blocks. All external wiring groups shall be identified on the diagrams with the Engineer's cable number and wire identification of each wire. Wire tabulations will NOT be accepted in lieu of wiring diagrams.

j. Drawings and diagrams as defined above, which have to be furnished to Contractor by manufacturer for equipment and/or material purchased by Contractor to fulfill the requirements of this Specification.

The above information and data shall be submitted within 60 days after award of contract.

6.2.2 Instruction Manuals

a. See General Conditions for number of copies to be submitted.

b. Installation, operating and maintenance manuals are to be forwarded 30 days prior to final shipment.

6.2.3 Photographs

Contractor shall furnish Engineer with 8½" x 11" glossy print photographs of the front and back of each panel. Photographs shall consist of overall views, plus detail views enabling complete identification of all panel equipment. Photographs shall be forwarded within ten(10) days after completion of control panels.

6.2.4 Painting

Details of Contractor's painting procedures including details of temporary protective coating procedures and coating removal procedures. Data to be forwarded to Engineer within 30 days prior to painting and coating of equipment.

6.2.5 Spare Parts

Contractor shall submit to Engineer within 60 days after award of contract, a list of recommended spare parts for one years operation complete with individual prices. Contractor shall also submit, a list of all charts and graphs required for the equipment, complete with individual prices.