NERT Perchlorate Treatment System

Henderson, NV

ENVIROGEN TECHNOLOGIES

Operations Manual

Originally Issued: November 2004

Revision 3 - April 2015

CONFIDENTIALITY STATEMENT

Revisions Log

Revision General Notes:

Manual Revision	Date	Notes/Comments	Apprv. by.
3	4/17/2015	Revised 2014 manual to add chapter and appendices on spill control and testing • *Remove and replace previous Cover, Revision Log and Table of Contents* • *Add New Chapter 17 after current Chapter 16* • *Add New Appendices P – S after current Appendix O*	MD
2	04/28/2014	Revised and updated 2006 manual to reflect operations at the NERT facility at the time Envirogen assumed operations of the plant. Shading section of the text are considered obsolete processes or equipment not in use. The text was shaded to preserve for historical reference.	MD
1	Sept 2006	Issued By Veolia/Shaw for AP5 Upgrade	--
0	Nov 2004	Initial Issue	--

See the chapter list below as reference to the revision level of the chapters that comprise the current version of this manual.

The current Rev 3 manual consists of the following chapters

Chapter	***Rev***	***Date Issued***
1	2	April 2014
2	2	April 2014
3	2	April 2014
4	2	April 2014
5	2	April 2014
6	2	April 2014
7	2	April 2014
8	2	April 2014
9	2	April 2014
10	2	April 2014
11	2	April 2014
12	2	April 2014
13	2	April 2014
14	2	April 2014
15	2	April 2014
16	2	April 2014
17	3	April 2015
Appendix A	2	April 2014
Appendix B	2	April 2014
Appendix C	2	April 2014
Appendix D	2	April 2014
Appendix E	2	April 2014
Appendix F	2	April 2014
Appendix G	2	April 2014
Appendix H	2	April 2014
Appendix I	2	April 2014
Appendix J	2	April 2014
Appendix K	2	April 2014
Appendix L	2	April 2014
Appendix M	2	April 2014
Appendix N	3	April 2015
Appendix O	2	April 2014
Appendix P	3	April 2015
Appendix Q	3	April 2015
Appendix R	3	April 2015
Appendix S	3	April 2015

NERT GWETS Perchlorate Treatment System
Table of Contents

APPENDICES

CHAPTER 1
INTRODUCTION

OVERVIEW

This manual is intended to furnish the information required for the proper operation of the Nevada Environmental Response Trust Perchlorate Removal System located in Henderson, Nevada. The manual is for use by operating personnel as the primary source of reference with regard to the design and workings of the treatment processes involved.

PURPOSE OF THE MANUAL

This manual is intended to provide a summary of the plant goals and an explanation of how the system was designed to meet those goals. Most importantly, the manual gives a detailed explanation of how to safely operate the equipment. An operator reading this manual should focus on the following:

- The purpose of each piece of equipment.
- The procedure for safe operation of each piece of equipment.

To achieve the treatment process goals, the system must be operated according to the procedures stated in this manual in accordance with the intent of the design. The procedures in this manual are intended for use under normal operating conditions. A change in operating conditions may require a change in operating procedures. Variable operating conditions or problems may arise that will require the skill and judgment of the operating personnel.

FORMAT OF THE MANUAL

This Operations Manual covers the design and operation of the treatment processes. The manual is of primary interest to those responsible for achieving the degree of water treatment required, and the satisfactory disposal of the residual solids, which will be produced. This manual also addresses the auxiliary systems, which provide a support function for the System.

This manual is not intended to replace Operation and Maintenance Manuals prepared and provided by the various equipment manufacturers. Those equipment manuals are more detailed and contain specific maintenance and repair information and, therefore, should be used as supplements to this manual. The manufacturer’s Operation and Maintenance Manuals are bound separately and are located in the Operations Office Trailer.

The "Table of Contents", presented in the front of this manual, sets forth the page numbers where each chapter starts and ends and the pages, which cover each subtitle. For convenience, new page numbering is begun for each chapter with each page number preceded by the chapter number. Operating personnel are urged to familiarize themselves with the format and "Table of Contents" so that any specific subject matter can be located readily.

In this manual, the descriptions and operating procedures for each unit operation is presented in the same sequence that the operator would encounter following the water as it flows through the normal treatment scheme of the system.

Each major piece of equipment has been assigned a unique three-digit equipment number. The unique equipment number appears on equipment labels in the plant and the number also appears on equipment drawings. The equipment number is also used in this Operations Manual to help the operators associate a description in the Operations Manual with a piece of equipment in the plant. In addition, all valves have been tagged to match the P&ID's.

Throughout this document, start and stop set points, high and low alarm set points, and other parameters that the programmer or operator can change may be somewhat different from what is described herein. This is due to the ongoing fine tuning of the Water Treatment System.

OPERATIONAL RESPONSIBILITY

Proper operation and maintenance is absolutely essential if the System is to consistently meet the performance requirements imposed. The primary purpose of the facility is to adequately treat the groundwater for discharge to the receiving system. The System was designed to meet these objectives, and it is the responsibility of the plant personnel to assure that these objectives are met.

Regardless of how well the system is designed and constructed, these requirements cannot be achieved if it is not properly operated and maintained.

The maintenance requirements for all equipment are covered in the individual equipment operation and maintenance manuals.

A clear understanding of the workings of the equipment and the treatment processes by those who are responsible for operating the facility is necessary in order to ensure successful performance of the system. The more knowledgeable the personnel, the more efficient the operation of the treatment system will be. Therefore, it is the responsibility of the operations personnel to acquire a clear understanding of the workings of the equipment and treatment processes by studying this manual, the manufacturer's manuals and any suggested references.

The System must be kept clean and organized at all times. A good housekeeping program must be a continuing effort on the part of all personnel to be fully effective.

ORIGINAL INFLUENT WATER DESIGN SPECIFICATION

The Perchlorate Treatment System located in Henderson, Nevada was designed based on specific influent water quality requirements. The original Influent Water Design Specifications are presented in Table 1-1.

Table 1-1 Influent Water Quality Specifications

Constituent	Units	Concentrations
Perchlorate as ion	Mg/L as ion	Influent Specifications Function Below
Chlorate as ion	Mg/L as ion	Influent Specifications Function Below
Nitrate, as N ion	Mg/L as ion	Influent Specifications Function Below
Chloride	Mg/L as ion	< 2500
Sulfate	Mg/L as ion	< 2100
Total Alkalinity	Mg/L as $CaCO_3$	< 500
Ammonia	Mg/L as ion	< 10 ppm
Phosphorus	Mg/L as ion	< 1
Calcium	Mg/L as ion	< 800
Total Chromium	Mg/L as ion	0.1
Hexavalent Chromium	Mg/L as ion	0.01
Iron	Mg/L as ion	< 5
TDS	Mg/L as ion	< 10,500
TSS	Mg/L as ion	< 10
PH	Standard Unit	6.95 – 7.85
Temperature	°F	55-75
Flow Rate	GPM	950 (Annual Average) 1000 (30-Day Average Maximum)
Biologically Substances Toxic	NA	Water not to contain biologically toxic substances per Perchlorate Reduction Bottle Assay.

Influent Specifications Function:

[(0.90 x NO3-N) + (0.17 x Cl03) + (0.18 x Cl04)] x flow x 1440/1,000,000 x 8.34 < 1514

where:

NO3-N = Influent (i.e. feed to system) Nitrate-nitrogen concentration, measured in mg/L as N;

Cl03 = Influent (i.e. feed to system) Chlorate concentration, measured in mg/L;

Cl04 = Influent (i.e. feed to system) perchlorate concentration, measured in mg/L;

Flow = Influent flow, daily average in gpm

"<" Signifies "Less Than"

The influent specification function is based on daily flow-proportioned composite samples, which will be monitored individually or averaged over a thirty-day period. In addition, the following values are not to be exceeded individually at any time (instantaneously):

NO3-N limit = 50 mg/l

Cl03 limit = 500 mg/l

Cl04 limit = 400 mg/l

CURRENT EFFLUENT WATER QUALITY REQUIREMENTS

The treated effluent from the Perchlorate Treatment System must meet the following criteria as per NPDES permit NV0023060 issued December 2011.

Table 1-2 Effluent Water Quality Requirements

Effluent	30 Day Average
Perchlorate Concentration, ug/L	< 18[a]
Ammonia-N, lb/day	< 40
Total P, lb/d	< 20
TSS, mg/l	< 135
BOD, mg/l	< 25
pH	6.5-9 SU

Note [a] or less than the minimum reporting level "MRL", as measured by the current EPA Method 314.0, Revision 1, November, 1999, whichever is greater. For not detect samples, daily composite values will be assigned a value of zero for calculating 30 day average. Maximum perchlorate concentration is based on maximum flow of 1000 gpm.

Values are based on discrete samples, which are averaged over a thirty-day period.

APPENDICES

Located in the back of this Operations Manual, there are several appendices that are intended to further assist the system operators. These items include:

A. Glossary
B. Arithmetic for Water Treatment
C. Abbreviations
D. Jar Test Procedures
E. pH/Orp Calibration
F. List of Vendor Operation and Maintenance Manuals
G. Final Drawing List
H. P&ID's
I. Engineering Lists
J. Lubrication Schedule
K. Spare Parts List
L. FBR Valve Schedules
M. FBR Loading Equation
N. FBR System Startup
O. Sludge Conditioning Procedures

Chapter 2
SYSTEM DESCRIPTION

INTRODUCTION

The system is designed to remove perchlorate from contaminated water at the site. The reader is referred to the system Piping and Instrumentation Drawings and the Process Flow diagram for additional general descriptive information. The major unit operations/treatment vessels included in the system are:

1. (5) First stage fluidized bed reactors – 14 ft. diameter X 30 ft. straight side with sand media (FBRs 1, 2, 3, 4, and A).
2. (2) First stage separation tanks – 14 ft. diameter X 30 ft. overall height (T-2011 and T-2012).
3. (1) Separator for FBR-A, 10 ft. diameter X 30 ft. overall height (T-1401)
4. (4) Second stage fluidized bed reactors – 14 ft. diameter X 26 ft. straight side with granular activated carbon media (FBRs 5, 6, 7, and 8).
5. (2) Second stage separation tanks – 14 ft. diameter X 26 ft. overall height (T-3011 and T-3012).
6. (1) Aeration tank – 14 ft. diameter X 24.5 ft. straight side (T-401).
7. (2) biofiltration vessels – 120 cu. ft. of media each (T-402A, and T-402B)
8. (2) DAF vessel assemblies – 10.5 ft. W X 10.5 ft. H X 40 ft. overall length (D-501 and D-551).
9. (1) UV disinfection system (X-621).
10. (1) Gravity thickener – 20 ft. diameter X 18 ft. straight (T-602).
11. (2) Filter press assemblies, 80 cu. ft. each (X-901 and X-902).
12. (1) Sludge storage tank, 10 ft. diameter X 16.25 ft. straight side ht (T-1601).
13. (1) Sand Filter, 300 ft^2, T-1702.

MAIN FEED STREAM TREATMENT

Feed Flow Control

The system is designed to accept feed water at up to 1,000 gpm maximum hydraulic loading. Equalized feed enters the system at the three first stage fluidization pump skids (P-1011 and P-1012, spare P-101A for FBRs 1 and 2; P-1013 and P-1014, spare P-102A for FBRs 3 and 4, and P-1401A and P-1401B for FBR A). Individual flow control valves control feed flow splitting to each of the operating first stage FBR vessels. Under normal steady state operating conditions, it is expected that the total feed flow will be equally split between the operating first stage FBR vessels. It will, however, be possible to operate with unequal flow splitting or with one or more of the first stage FBRs off-line. Operation with more than one FBR off line is an abnormal condition that is expected to occur at start-up.

The system controls will provide the ability to set the system feed flow at a constant rate or to control based on maintaining level in the equalization tanks.

A trace element solution will be metered into the system feed. The mixture is fed into the feed stream from a separate tank (T-753) using a metering pump (either P-753A or P-753B). The trace element feed rate is automatically controlled in proportion to the total feed flow to the system, and is operator-adjustable.

<u>First Stage FBR Treatment</u>

Feeds to each operating first stage FBR vessel are combined with recycle flow, ethanol (i.e. ethanol) solution, nutrients solution, phosphoric acid solution, and pH control solution (25% caustic). The pH and ethanol solutions are, respectively, controlled by pH and optional ORP control systems. The ethanol flow may also be automatically controlled individually to each FBR in proportion to the feed flow to each FBR. The pH control solution from tank T-701 is added to the first stage FBRs 1, 2, 3, 4, and A via pumps P-711, 712, 713, 714, and 71A respectively. The ethanol solution from tank T-703 is added to the first stage FBRs 1, 2, 3, 4, and A via pumps P-731, 732, 733, 734, and 73A respectively. Nutrient solution flow from tank T-702 is controlled to each FBR in proportion to the feed flow to each FBR (via pumps P-721, 722, 723, 724, and 72A for FBRs 1, 2, 3, 4, and A, respectively). The FBR vessels contain integral fluidization distribution and effluent collection systems. These internal components are designed to enhance uniform flow distribution. Microorganisms metabolize the ethanol solution and utilize the perchlorate, chlorate, nitrate and oxygen contained in the feed water. These contaminants are converted to harmless minerals in the process. The microbes form a film on the fluidized sand media.

As with virtually all biological processes, an excess biomass byproduct is produced. As biomass accumulates on the FBR media, the fluidized bed height expands. Some excess biomass is removed by the shear that is caused by the normal flow through the bed. Additional excess biomass is removed from the fluidized beds by operation of the Bed Height Controls. A second set of Bed Height Controls has been installed and is now in use. The original set of Bed Height Controls remains in place and is available for use when desired.

The new set of Bed Height Controls includes two Biomass Separators installed in each primary FBR and a Biomass Separator Control Panel. The Biomass separator is comprised of a lift pipe and a splash shield. The bottom of the lift pipe is located at the top of the expanded bed, and is run to pipe mount above the water level. A "window" in the lift pipe allows water, biomass, and media to exit the lift pipe at the water surface level in the FBR. The lift pipe passes through a larger diameter pipe, which acts as a splash shield, and directs the lifted water, biomass, and media back into the FBR. An air line connected near the bottom of the lift tube provides the air needed to raise the media up the lift tube. The air stream also imparts the shear forces needed to separate the biomass from the media.

A Biomass Control Panel is used to control the air flow rate delivered to the base of the lift tube. Each Biomass Control Panel controls the air flow rate to both Biomass Separators installed in each First Stage FBR, and includes an air pressure regulator and two rotameters with needle valves.

The original set of Bed Height Controls includes Pumps (P-1021, 1022, 1023, and 1024 for FBRs-1, 2, 3, and 4, respectively). These pumps are intended to operate continuously, taking suction from the top of the FBR media bed at the control bed height. The pumping action and flow through a throttling pinch valve at the pump discharge provide sheer to remove excess biomass from the pumped media.

The separated biomass from either Bed Height Control system exits the FBR vessels with the effluent and recycles streams.

FBR-A has two biomass separators identical in design and function to the biomass separators on the second stage FBRs. These internal devices collect and remove excess biomass. Additionally, the biomass control system also includes provisions for removal of excess biomass from a lower level within the fluidized bed. This system will be operator-controlled based on the measured FBR bed heights and instructions provided in the system operating manual.

Media Separation

First stage FBR effluent flows to centrifugal cone bottom separator vessels (T-2011 for FBRs-1 and 2; T-2012 for FBRs-3 and 4, T-1401 for FBR-A). These vessels are designed to capture any media in the first stage effluent and recycle streams. The media return pumps (P-2011 for T-2011, P-2012 for T-2012, and P-1410 for T-1401) operate on an automated cyclical basis to transfer captured media back to the FBR vessels. The bulk of the water entering the first stage separators is returned to the first stage FBR vessels as recycle (via recycle pumps P-1011 and 1012, spare P-101A for FBRs 1 and 2, respectively; P-1013 and 1014, spare P-102A for FBRs 3 and 4, and P-1401A/B for FBR-A respectively). The balance of the water that enters the separator vessels exits to the second stage FBRs.

Second Stage FBR Treatment

Flow from the first stage system is typically expected to be equally split between the four-second stage FBR vessels. It is, however, possible to operate automatically with unequal flow split or with one of the four units off-line. Flow control valves on the feed lines to each FBR vessel will be automatically trimmed by the system to proportion the feed flow based on operator set values.

The second stage FBR vessels (FBRs 5, 6, 7 and 8) contain granular activated carbon (GAC) media. Internal components include a fluidization flow distribution system, recycle and effluent collection systems, biomass separators and an "in-bed biomass control system". Operation of the biomass control systems will be based on bed height and bed sampling data, as well as instructions provided in this operating manual. Excess biomass will leave the second stage FBRs with the FBR effluent stream.

Second Stage Separators

Second stage FBR effluent flows to centrifugal cone bottom separator vessels (from FBRs 5 and 6 to T-3011; from FBRs 7 and 8 to T-3012). These vessels are designed to capture any media in the second stage effluent and recycle streams. Media return pumps (P-3011 for T-3011; P-3012 for T-3012) transfer captured media back to the FBR vessels. The bulk of the water entering the second stage separators is returned to the second stage FBR vessels as recycle (via recycle pumps P-3015 and 3016, spare P-301A for FBRs 5 and 6, respectively; P-3017 and

3018, spare P-302A for FBRs 7 and 8, respectively). The balance of the water that enters the separator vessels exits to the Aeration vessel (T-401).

Second stage treated effluent is removed from the second stage system through level control valves that maintain the separators' water level at the design set points.

Aeration

Nitrate, chlorate, and perchlorate are expected to be reduced to effluent design concentrations in the effluent of the second stage FBRs. This stream flows to the aeration tank (T-401) where fine bubble aeration is used to approach saturation concentrations of dissolved oxygen. The benefits of this aeration process include a reduction in the amount of high-pressure air required in the downstream DAF and partial oxidation of trace amounts of reduced sulfur that may be present in the second stage FBR effluent.

Dissolved Air Floatation (DAF)

Aerated water flows to the DAF systems(s) (D-501 and D-551). The two systems are each capable of hydraulically treating the full system flow rate. It is possible to operate one or both of the systems in parallel, although both units may need to be operated to meet the turbidity requirements of the agency. A portion of the DAF effluent is pumped (via pumps P-501 and P-551) to the feed side of the DAF system(s). Compressed air is added to this pumped re-circulating stream as it passes through the DAF pressure tank(s) (T-501 and T-551). Sufficient air is dissolved into this stream under pressure to produce the design volumetric flow of fine bubbles within the DAF vessel(s). The pressurized re-circulating stream passes through a throttling valve as it enters the DAF vessel(s). The pressure reduction across the throttling valve results in an air supersaturated condition at the liquid entrance to the DAF vessel(s). This produces many fine bubbles that enhance flocculation and adhere to suspended solids in the liquid, resulting in floatation. Flocculation is further enhanced by use of a polymer solution from T-705 that is metered into the liquid upstream of the DAF vessel(s) via the polymer feed pump, P-742. There are also provisions for adding the polymer solution directly to the aeration tank T-401. This provides operational flexibility to optimize TSS removal efficiency within the DAF system(s). Polymer solution flow is automatically controlled in proportion to the total system feed flow as measured by the first stage FBR flow meters.

Float material is collected by a skimming mechanism that conveys the skimmed solids stream into a compartment within the DAF vessel(s) (M-503 and M-553). The accumulated skimmed solids are removed by automated cyclical operation of DAF float pumps P-502 and P-552. Settled material at the bottom of the DAF vessels is also periodically removed by use of the same pumps. All float and settled solids are pumped to the sludge storage tank or to the thickener (T-602) for further gravity dewatering. The thickener is currently off-line, but remains available for use

Sand Filter and Effluent Disinfection

DAF effluent flows by gravity into the effluent tank (T-601). From there it is pumped via pumps P-601 and P-602 through the sand filter for additional solids removal. The sand filter improves the biosolids removal and further reduces the turbidity in the effluent. The effluent water flows via gravity from the sand filter to the existing effluent booster pumps for discharge to the seep. The UV disinfection system (X-

621) is currently off-line, but remains available for use. . The UV system utilizes low-pressure mercury vapor lamps and includes provisions for automated cleaning of the lamps with a quartz sleeve wiper system. The UV system is controlled by a dedicated control system. These controls include a separate LED control interface along with UV dosage monitoring. The UV system interface with the main system controls includes monitoring of various alarm and status conditions by the main control system and a treatment flow input to the UV system.

SECONDARY STREAMS

Thickening

The thickener (T-602) is available for use, but is currently bypassed. Solids from the second stage FBRs currently leave with the FBR effluent stream, flow through the aeration tanks on their way to the dissolved air floatation vessel. The sand filter reject stream joins with the FBR effluent stream downstream of the aeration tanks and is also fed to the dissolved air floatation vessel.

The thickener can receive excess biomass stream from the second stage FBRs and the float and underflow streams from the DAF float pumps, and the sand filter reject.

Thickener feed enters a central flocculation zone or detention hood within the thickener. Flocculation is enhanced within the detention hood by variable speed flocculation mixers (M-612 and 613) and provisions for polymer solution feed (from T-704 via polymer feeder P-741) and also ferric chloride from P-751. If required, polymer may be automatically added at a flow rate in proportion to the system feed flow as measured by the first stage FBR flow meters although generally it will be controlled manually at the preset rate. Water exits the detention hood at a hydraulically controlled low velocity into the thickener settling zone. Sufficient area is provided in the settling zone to effect gravity separation of flocculated suspended solids and clarified liquid. Clarified liquid is recycled by gravity to the head of the DAF system. Settled solids accumulate in the lower section of the thickener. This gravity-thickened stream is periodically pumped out by the thickener underflow pump (P-603) to the sludge storage tank. The solids are continuously mixed in the sludge storage tank until the operator is ready to process the sludge through the sludge conditioning tank and then to the filter presses (X-901 and X-902) for further dewatering, or optionally to a truck loading connection for removal as a liquid suspension.

A thickening rake system is utilized to further de-water the settled solids and to direct the thickened sludge to the central sump where thickened solids are pumped to the sludge storage tank. The thickening rake/scraper drive (M-611) torque is monitored by the dedicated thickener controls. Alarm and status conditions are also monitored by the main controls.

Solids Conditioning and Filter Press

The filter presses (X-901 and X-902) operate as a batch system on a schedule established by the system operators. It is generally preferable to operate both presses in parallel during the batch process. However, it is also possible to operate with only one of the two presses.

At the start of the batch, a sufficient thickened solids volume exits the sludge storage tank to be processed in one or two filter press runs. A predetermined volume of sludge is pumped from the sludge storage tank to the conditioning tank (T-901).

The sludge can be conditioned with powdered lime from the hydrated lime storage silo (T-752) and ferric chloride solution from T-751. These two sludge conditioners are available but are no longer being used. If used, lime is added to the conditioning tank at predetermined dosages via screw conveyer M-755 and ferric chloride can be added with pump P-751.

A predetermined volume of polymer solution prepared on the dry polymer skid is currently added to the solids conditioning tank. The conditioning tank agitator (M-901) mixes the suspension. The chemical addition and mixing creates a filterable material that can form a permeable cake under pressure within the filter presses.

The conditioned suspension is pumped to the filter presses during the press operation cycle via pump P-901 and P-902. Filtrate flows by gravity from the presses to the filtrate tank (T-902). This filtrate is recovered periodically by automated pumping from the filtrate tank to the head of the DAF system via pump P-903. At the end of the press operation cycle, an automated plate shifting system is used to discharge pressed cake to roll-off containers below the press.

CHEMICAL FEED SYSTEMS

Trace Elements

A trace elements mixture (see Table 2-1) will be added to the feed to optimize the performance of the system. The mixture is fed into the feed stream from a separate tank (T-753). The mixture will be supplied as a solution. A peristaltic pump (either P-753A or P-753B) is used to pump the mixture into the feed. The rate of addition is in proportion to the feed flow to the system, and is operator-adjustable.

Caustic Soda

Caustic soda will be used for pH control within the FBRs. The caustic soda will be supplied via tanker truck to the new pH solution tank (T-701). The 20% caustic soda has a freezing point of approximately minus 15 degrees F, so freeze protection is not required. Five electric operated diaphragm-metering pumps, P-711 through P-714 and P-71A, are used to pump the caustic to the five first stage FBRs. Four electric operated diaphragm-metering pumps, P-715 through P-718, are currently not used, but are available to pump caustic to the second stage FBRs. The caustic soda flow to each FBR is controlled by pH sensors located in each FBR influent (i.e. combined feed and recycle) line. A dedicated containment structure is provided around the pH solution tank to contain spills.

P-720, an electric operated diaphragm-metering pump, pumps caustic to the DAF effluent tank T-601.

Polymers

The DAFs, the sludge thickener, and conditioning tank use polymers for assistance in separating solids from the liquid stream. A dedicated polymer feed system serves each point of use. For the DAFs, neat polymer is stored in a plastic tote, T-705, which is supplied by the polymer vendor. A plastic containment is provided to capture spills from the tote. A polymer feeder, P-742, is used to mix the polymer with service water and to transfer the resulting polymer mix to the DAFs. The polymer feed to the DAFs is controlled based on the flow of water to the DAFs, as measured by the first stage FBR flow meters, and is operator-adjustable.

The polymer feed system for the sludge thickener is not in use, but is available. This feed system is similar to that for the DAFs. Neat polymer is stored in a plastic tote, T-704, which is supplied by the polymer vendor. A plastic containment is provided to capture spills from the tote. A polymer feeder, P-741, is used to mix the polymer with service water and to transfer the resulting polymer mix to the thickener. The polymer feed to the thickener is controlled based on the flow of water to the DAFs, as measured by the first stage FBR flow meters, and is operator-adjustable.

The dry polymer skids blend dry polymer with water using a calibrated screw conveyor to make a predetermined concentration of polymer solution in a storage tote. The polymer application pump feeds the polymer to the conditioning tank.

Nutrients- Urea Solution and Phosphoric Acid

To improve control of nitrogen and phosphorus addition, the nutrients have been separated into feed solutions containing urea (for nitrogen) and a phosphoric acid solution (for phosphorus) addition. The urea solution consists of 1.8 lbs. of urea per gallon of water and is stored in a 4,100-gallon FRP tank, T-702. The tank will be refilled from trucks. Nine electric operated peristaltic pumps, P-721 through P-728, and P-72A are used to pump the urea nutrient to the all nine FBRs. A 75% phosphoric acid solution will be fed by five peristaltic pumps to FBRs 1, 2, 3, 4, and FBR-A. The rate of nutrient addition to each FBR is in proportion to the feed flow to each FBR, and is operator-adjustable. These levels also will be adjusted based on residual phosphorus in the effluent in order to maintain effluent levels within permitted values.

Electron Donor

Denatured ethanol will be used as the electron donor for the treatment system. The ethanol will be purchased in 95% concentration (190 proof) and delivered via tanker truck. The ethanol will be stored in a 20,000-gallon double wall tank (T-703) located on the south side of the treatmentsystem. Eight electric operated diaphragm-metering pumps, P- 731 through P- 738 and P-73A, are used to pump the ethanol to the nine FBRs. The rate of ethanol addition to each FBR is in proportion to the feed flow to each FBR, and is operator-adjustable. The rate of ethanol addition can also be tuned using ORP.

Ferric Chloride

The entire ferric chloride feed system, including the ferric chloride storage tank and chemical feed pumps, is no longer in use, but remains available. Ferric chloride can be injected into a static mixer on the discharge piping of the aeration tank for the purpose of coagulating the small particles in the wastewater. The ferric chloride and wastewater are thoroughly mixed in the static mixer. The wastewater along with the coagulated particles exit the static mixer and flow into the DAF units. Prior to the DAF units, the wastewater is dosed with a cationic polymer to flocculate the coagulated particles. The ferric chloride feed system consists of two metering pumps (P-758A/B), a calibration column, and a flow switch (FS-758).

Hydrated Lime

The hydrated lime system, including the lime storage silo and conveyors is no longer used to condition sludge, but remains available when needed. Hydrated lime can be used for sludge conditioning. Hydrated lime can be purchased in bulk and delivered to the site by truck. The lime is stored on site in a 30-ton lime silo, T-752. Trucks will fill the lime silo using their own on-board blowers. The lime silo is equipped with a dust collector on the vent to control the escape of lime dust to the environment.

The hydrated lime is fed to the conditioning tank in dry form using a screw conveyor, M-755. A volumetric feeder, M-754, controls the amount of lime fed to the screw conveyor. The dry lime is netted with a water spray as it enters T-901 to minimize dusting.

Hydrogen Peroxide

Hydrogen Peroxide is injected into the 10-inch feed line to the Aeration Tank for the purpose of oxidizing the dissolved sulfide ion in the waste stream leaving the second stage separators. The hydrogen peroxide used at the site is at a strength of approximately 35%. By manually manipulating valves, hydrogen peroxide can also be base loaded to the 2-inch Biomass Separator Line feeding the Thickener. This option is no longer in use, but is available to be utilized during high sulfide events with the purpose of minimizing the amount of sulfide sent to the Thickener. High sulfide concentration in the Thickener can degrade the effluent quality and can create sludge dewatering problems.

The Hydrogen Peroxide Feed System consists of two peristaltic metering pumps (P754 A/B), a calibration column for each pump, a common flow switch (FS-758) on the feed line to the Aeration Tank, and a Dissolved Sulfide Analyzer (AIT-402). The feed line to the Thickener does not include a low flow switch.

Defoamer

A Defoaming agent is injected into the 8-inch effluent line of the bio-system downstream of the UV System. The Defoamer is used to minimize the amount of white fluffy foam that is generated at thesystem's outfall location of the Las Vegas Wash. This Defoamer Feed System consists of two peristaltic metering pumps (P755 A/B), a calibration column, and a flow switch (FS-755)

UTILITIES

Compressed Air

Compressed air is necessary to operate equipment and instrumentation. Two new rotary screw compressors, P-801 and P-802, located inside Building D-l, provide this air. These 50-HP compressors can provide 240 ICFM at 110 psig each. The two compressor systems will permit one compressor to operate and the other to be used as a connected spare; or both can be operated simultaneously to satisfy peak loads. All air generated by the compressors flows into a 660-gallon air receiver, T-801. Two filters, F-802 and F-803, remove remaining water droplets and oil from the air exiting the air receiver. Taking a portion of the total air and drying it with a desiccant type regenerative air dryer, T-802, provides instrument air.

Process Air

A dedicated blower, B-401, provides the process air required for the aeration tank T-401.

Service Water

Treated effluent will be the main source of service water for the treatmentsystem. The service water will be tapped on the pressure side of effluent pumps P-601 and P-602 prior to the UV disinfection system, X-601. This will provide a service water loop at approximately 30 psig. Stabilized lake water will be used as makeup to the service water loop. Stabilized lake water will be used for the eyewash stations and safety showers within the treatmentsystem. The safety showers and eyewash stations will have scald and freeze protection, but no additional temperature controls (i.e. tepid water). The stabilized water is non-potable.

Drinking Water

The Company facility does not have potable water. Bottled water will be used for drinking purposes.

Electric Power

Power to run the equipment for the FBR treatment facilities will come a motor control center (MCC) located in a climate-controlled enclosure in the treatment system area. Equipment relating to the Equalization Area is fed from MCC-3. MCC-3 is fed from existing MCC-1 located in D-1 building electrical room. Additionally, power for equipment associated with the AP-5 system upgrade is located in the electrical room in Building D-1 in MCC-1 and MCC-2.

CONTROL SYSTEM OVERVIEW

A complete electrical control system has been furnished for the fluidized bed system. It will contain a Siemens PCS7 system with Siemens PLC components as required and as specified below. All I/O will be contained in a cabinet with NEMA rated terminals for connection of field wiring. The PCS7 system will be programmed with all applicable screens as required.

All automatic electrical devices (including motors) will be controlled through the PLC, and displayed on screen. This will include approximately (70) motors, approximately (45) 4-20 mA transmitters, and (13) 4-20 mA control valves. Manual controls will be provided where required.

The following hardware will be provided:

- (2) Siemens 6ES7650-0BAI5-0BXO -PCS7 IPC (Pentium III Windows
- NT) (One main operator station and one remote supervisory station).
- (2) Siemens 16055-596 -Color Monitor.
- Simatic S7-400 automation system for the following approximate I/O count: 120
- Digital inputs, 120 digital outputs, 22 analog inputs, and 11 analog outputs.
- Simatic ET200M distributed I/O devices.
- Fiber Optic Industrial Ethernet communication network.

The following software will be supplied:

- Siemens PCS7 runtime single station V5.2 for 64K variables.
- Siemens PCS7 Engineering station V5.2 runtime and engineering for 64K variables.
- Siemens PCS7 engineering toolset V5.2, max. 3000 function blocks.

The following spare control parts will be supplied:

- 16-point digital input card.
- 16-point digital output card.
- 8-point analog input card.
- 8-point analog output card.
- 24-volt PLC power supply.
- Profibus communication module.

The system will be supplied with Ethernet (fiber-optic) communications. The system will be designed with the same software as the existing system. Once installed, it can be integrated with the existing system so that control can be from either the existing operator station or the new operator station. All that will be required is the fiber-optic cabling from the existing control system to the new control system and programming.

Additional PLC I/O modules for the AP-5 treatment system upgrade have been connected and configured in unused PLC racks in the MCC building and the Electrical room in the D-1 building.

TREATMENT SITE SYSTEM

A significant portion of the treatment system is located on an area approximately 34 feet west of existing building D-1. Most of the equipment including FBR-A equipment, are installed outside on a concrete slab. Additional equipment is installed inside the existing building D-l, and the sand filter and filter reject skid are on the opposite side of the building D-1. An overall plant arrangement is shown in Drawing M-2.

OUTDOOR EQUIPMENT

The treatment plant equipment is installed on a concrete slab with the east edge located approximately 34 feet west of Building D-l. The separation between the building and the new treatment plant area provides clearance for the foundations of the existing building and provides a driving area for firefighting equipment.

The equipment will be installed on one single concrete slab, approximately 85 ft. X 135 ft. The slab will have a 10" curb all around to provide 110% containment for the largest tank within the containment area. The slab will be sloped to one or more sumps.

The chemical storage tanks are located on the north side of the plant, along the road, to provide easy access by trucks. The polymer feed lines will be heat traced and insulated. Caustic soda lines will not be freeze-protected.

A bridge has been installed between the new treatment system and the existing building for support of piping and conduit between the building and the new site. The clearance under the bridge is a minimum of 13'-6", as required for fire protection equipment access.

INDOOR EQUIPMENT

The filter presses are installed inside the existing building in the area lying between column row G and the existing MCC room. The filter presses are located on structural steel platforms in order to provide clearance for the roll-off boxes. The filter presses are back-to-back. Access for the roll-off boxes will be from the east side of the building for one filter press and from the west side of the building for the other filter press. The air compressors and the filtrate tank are located inside the existing building in the area between column lines F and G. Additional Equipment for the perchlorate treatment system upgrade is located throughout the D-1 Building and includes a sludge storage tank, a UV disinfection system, a UV effluent tank, an oxygen generator, and a dry polymer feed skid.

Table 2-1

Chemical Name	Formula	Chemical Concentration (g/L)	Chemical Concentration (lbs per 250 gal)	Molecular Weight	Metal	Metal Molecular Weight	Metal Concentration (mg/L)	Metal Concentration (lbs per 250 gal)
ferrous sulfate	$FeSO_4 \cdot 7H_2O$	36.0	75.1	278.01	Fe	55.85	7,232	15.1
manganese sulfate	$MnSO_4 \cdot 7H_2O$	9.0	18.8	169.01	Mn	54.94	2,926	6.1
zinc sulfate	$ZnSO_4 \cdot 7H_2O$	9.0	18.8	287.54	Zn	65.37	2,046	4.3
cobalt chloride	$CoCl_2 \cdot 6H_2O$	3.0	6.3	237.93	Co	58.93	743	1.6
sodium molybdate	$Na_2MoO_4 \cdot 2H_2O$	36.0	75.1	241.95	Mo	95.94	14,275	29.8
aluminum potassium sulfate [1]	$AlK(SO_4)_2 \cdot 12H_2O$ [1]	11.1	23.2	474.4	Al	26.98	631	1.3
copper (II) chloride [1]	$CuCl_2$ [1]	1.5	3.1	134.45	Cu	63.55	709	1.5
nickel (II) chloride [1]	$NiCl_2$ [1]	1.5	3.1	129.62	Ni	58.71	679	1.4

Metal	Measured Concentration in On-site IX Water; Lab Pilot (ug/L)	Concentration in 6% GW-11 Water (in On-site IX Water); Lab Pilot (ug/L)	Concentration in 0% to 6% GW-11 Plus Trace Metals (ug/L)	% Increase in Metal With Added Trace Metals
Fe	< 22.2	< 22.2	129 to 151	> 582%
Mn	4.7	4.0	57	1201%
Zn	149	25.1	124	42%
Co	4.0	3.0	17	379%
Mo	62.4	60.4	316	415%
Al	< 18.4	< 18.4	11 to 30	> 61%
Cu	6.8	9.5	21	155%
Ni	9.5	7.6	21	142%

NOTE: NOT MUCH DIFFERENCE IN METALS COMPOSITION WITH AND WITHOUT GW-11; THEREFORE, METALS COMPOSITION OF GW-11 IS MINIMAL.

Feed Rate to Full-scale System at 1,000 GPM (gpd)	EDTA Concentration (lbs per 250 gallons)	Concentration of EDTA in Feed to FBR (mg/L)
30	125	1.2

EDTA MUST BE ADDED TO TRACE METALS SOLUTION OR METALS WILL NOT DISSOLVE!!

1. Aluminum sulfate, copper sulfate, and nickel sulfate may be substituted for aluminum potassium sulfate, copper (II) chloride, and nickel (II) chloride, respectively, AS LONG AS METAL CONCENTRATION IS NOT CHANGED.

CHAPTER 3
FBR SYSTEM EQUALIZATION AREA

OVERVIEW

The equalization area of the ground water treatment process provides a blended flow of water from the Chrome treatment process and the ground water wells to the Perchlorate Treatment System. Work in the equalization area of the process was completed in 2013 to increase the volume available for blending of water and thus reduce the amount of concentration change resulting from wells coming on line or off line. While providing new capacity to the equalization area, the historical water blending arrangement was preserved. A process description for both water-blending arrangements follows.

HISTORICAL WATER BLENDING ARRANGEMENT

The EQ Area also provides GW-11 (pond) water feed to the Groundwater Treatment System (GWTS) for removal of Hexavalent Chromium and incorporates treated GWTS effluent into the blended feed water for the Fluidized Bed Reactor (FBR) Perchlorate Treatment System.

Off-site groundwater from the Seep and Athens Road wells (Lift Stations #1 & #3) is combined at Lift Station #2 and pumped to the EQ Area. Water from Lift Station #2 is pumped directly to the GW-11 pond or Equalization Tank TK-101A.

Pond Water Transfer Pump (P-104) has the ability to send GW-11 water to the GWTS. While P-104 and spare P-104B are available, they are no longer used. When used, this stream is combined with groundwater from approximately 26 interceptor wells and treated at the GWTS.

Treated water from the GWTS is collected in tank (TK-6). From TK-6, the treated water from the GWTS can be sent to TK-7, TK-101A, or GW-11. In the past, the BT Tanks were used for additional flow equalization. The BT tanks, BT-40 and BT-45, have been abandoned in place, and are no longer used.

Tank TK-6 is equipped with a differential pressure level transmitter (LE-6). The Level Transmitter is used to indicate water level in TK-6 on the SCADA at the GWTS and ultimately control the VFD Drive for Feed Equalization Pump (P-1001) when level control is selected on the SCADA.

The Feed Equalization Pump (P-1001) has a 7.5 HP motor and is capable of delivering 70 GPM of water at 140 TDH. The pump draws suction from the bottom of TK-6. There is a local turbine style Flow Indicator (FI-16) located between TK-6 and P-1001 that is used to record and totals the water treated and the GWTS. P-1001 has a variable frequency drive that is controlled by the GWTS PLC with a PID Loop to maintain a set point level in TK-6. Discharge flow from P-1001 passes through

Flow Indicator (FI-1001) prior to being pumped to GW-11. There is valving and piping available to bypass FI-1001 for maintenance purposes

The BT Equalization Tanks (40, 45) are abandoned in place. The tanks are located on property formerly owned by Kerr McGee Chemical south of the GWTS. The normal flow pattern is for the water pumped from TK-6 by P-1001 to flow up the hill via a 3-inch underground line and feed into BT-40. As BT-40 fills, the water enters the overflow piping of BT-40 and is sent to BT-45. Once BT-45 is filled, the overflow from BT-45 is sent back to TK-7 at the GWTS via a 4-inch underground line. There is a Flow Indicator (FI-1002) at the GWTS just prior to the water entering TK-7. There is valving and piping available to bypass FI-1001 for maintenance purposes. At the BT Tanks, there is piping available that enables either tank to be bypassed for maintenance. However, these tanks cannot be operated in a parallel flow pattern. They must be operated in series with BT-40 feeding BT-45 or configured in such a fashion that one of the tanks is offline.

TK-7 is located at the GWTS directly beside TK-6. TK-7 serves a storage location for water discharged from TK-6. The water in TK-7 is pumped out by the Pond Water Auxiliary Pump (P-103) and sent to TK-101A. In the event that the water is not pulled out of TK-7 fast enough by pump (P-103), TK-7 is equipped with an overflow that will send the water back the pond (GW-11).

ALTERNATE (NEW) WATER BLENDING ARRANGEMENT

The perchlorate concentration of the on-site wells is substantially higher than the perchlorate concentration in off-site wells. When an on-site well pump energizes or de-energizes, a significant change in the perchlorate concentration would result in the blended FBR feed water stream. This change required the system operators to make the appropriate change in the FBR dosing rates of electron donor and nutrients. With the treatment system staffing level changing from 24 hours per day to one shift per day, a timely operator response to a change in influent perchlorate load is no longer guaranteed. Changes to the equalization portion of the treatment process were made to meet the needs of a smaller operating staff.

The capacity of the TK-101A / B feed tank is 23,500 gallons. The capacity of GW-11 at 50% capacity is 32,000,000 gallons. When GW-11 is used as the blending tank, changes in composition in response to an on-site well coming on or off-line is dampened to the point where a single operating shift per day can respond to changes in load.

Two sets of diverter valves are now in place to enable the use of GW-11 as the Perchlorate Treatment System feed blending tank. Well water from Lift Station 2 can be directed to GW-11 or TK-101A/B with HV-10 and HV-17. Water from the GWTS can be directed to GW-11 or TK-101A/B with HV-11 and HV-11A. When GW-11 is used as the blending tank, the Pond Water Feed Pump P-101A/B is used to deliver water from the GW-11 to TK-101A/B. When water from GW-11 is used to feed the

Perchlorate Treatment System, it is possible to introduce sediment from the pond bottom into the feed stream. The bulk of these solids are removed in the Pond Water Strainers F-101A/B.

Since the system can treat 1000 gpm, the process control system is used to change the configuration of the equalization portion of the process from the historical configuration to the alternate configuration, using 12" actuated butterfly valves.

When the equalization portion of the process is configured in the historical mode, well water from lift station 2 flows through HV-10 to TK-101A/B. The valve to divert the well water to GW-11, HV-17, is closed. Water from the GWTS flows through HV-11 to TK-101A/B. The valve to divert the water from the GWTS to GW-11, HV-11A, is closed. The operator then places an OIT configured switch to the GW-11 position to change the equalization area configuration. The PLC initiates the following sequence:

The flow control valves, HV-10 and HV-11, feeding water to TK-101A/B remain open. The diverter valves, HV-17 and HV-11A are opened.

When the PLC receives confirmation from both valve open limit switches, the PLC will close HV-10 and HV-17, stopping the flow of water to the Feed Tank TL-101A/B.

When the PLC receives confirmation from the valve closed limit switches, the PLC will energize the selected Pond Water Feed Pump P-101A or B.

The operator then will monitor the feed pump flow on FI-12 and position the manual 8" flow rate set valve to feed TK-101A/B at the approximate combined feed from the well pumps and the GWTS effluent flow into GW-11.

Restoring the equalization portion of the process back to the historical configuration, the operator changes the OIT switch to re-select TK-101A/B. The PLC then will reverse its procedure to shut down P-101 and change the valve positions.

Feed Tank (TK-101A) is interconnected to Feed Tank (TK-101B), so that they act as a single tank. The Raw Water is pumped from the Feed Tanks by the Raw Water Feed Pumps (P-102A, B) to the Granulated Activated Carbon Adsorbers (GC-201A, B, C) and eventually on to the FBR System. This flow rate is controlled by the set point value entered on the SCADA for Flow Controller (FIC-13).

EQUALIZATION AREA OPERATING PARAMETERS

PARAMETER	RANGE	TYPICAL
Lift Station #2 Flow Rate	500 – 1000 GPM	900 – 950 GPM
GW-11 Pond Flow Rate	0 – 20 GPM	20 GPM
GWTS Effluent Flow Rate	0 – 80 GPM	80 GPM

Lift Station #2 Perchlorate Concentration	45 - 400 PPM	250 – 350 PPM
GW-11 Pond Perchlorate Concentration	250 – 2500 PPM	1500 – 2000 PPM
Pond Water Strainer Delta P	0 – 15 PSIG	0.5 – 3.5 PSIG
GAC Column Delta P	0 – 15 PSIG	

GRANULATED ACTIVATED CARBON COLUMNS

The purpose of the Granular Activated Carbon Columns (GAC's) is to remove trace organics and solids from the raw water upstream of the perchlorate reduction process.

The Granular Activated Carbon Columns (GC-201A, B, C) are located in the same containment area as the equalization area equipment east of GW-11 Pond. Over time, organics are adsorbed onto the carbon in the GAC's until the carbon is all used up. Once this happens, the carbon will need to be replaced. The concentration of organics is extremely low, so the carbon's effective service life will be long. The GAC Units are operated in parallel to minimize the pressure drop on each unit.

Water is pumped from Feed Tank (TK-101B) to the GAC's by the Raw Water Feed Pumps (P-102A, B). Flow through the GAC's is in downflow fashion (top to bottom). From the bottom of the vessels, the water flows into the discharge line of the GAC's and to Raw Water Filter (F-201) located at the D-1 Building.

Due to the presence of solids in the water, the GAC pressure drop will increase over time. When the pressure drop (Delta P) increases to 20 PSIG, the bed must be backwashed.

Backwashing involves running clean water up through (bottom to top) the GAC adsorber. Stabilized Lake Water (SLW) is utilized for backwashing of the GAC adsorber beds. Backwashing a GAC adsorption bed is done during normal operations if abnormally high-pressure drop across the GAC beds is observed.

When the pressure drop across the GAC beds increases, the beds are backwashed to:

1. remove solids from the carbon bed,
2. remove carbon fines that may be plugging the underdrain nozzles, and
3. remove any air that may have accumulated and is blinding the bed.

Only one GAC can be backwashed at a time.

When the GAC is started after a backwashing, the initial 5 to 15 minutes of effluent flow will be discolored due to the small quantities of fines left over from the backwash. The fines are removed from the water by the Raw Water Filter (F-201) located just east of the D-1 Building. After each backwashing of the GAC beds, the Raw Water Filter should be checked for loading or clogging. This can be accomplished by checking the pressure drop on PDI-16.

GAC OPERATING PARAMETERS

PARAMETER	RANGE	TYPICAL
GAC Delta P	5 – 30 PSIG	10 – 20 PSIG
Flow Rate Per GAC (2 GAC's Operating)	250 – 1000 GPM	350 – 425 GPM
Flow Rate Per GAC (1 GAC Operating)	250 – 1000 GPM	700 – 850 GPM
GAC Inlet Pressure	10 – 100 PSIG	70 – 80 PSIG
Rupture Disc Pressure (PSE-201, 202)	N/A	125 PSIG

RAW WATER FILTER (F-201)

The Raw Water Filter consists of two side-by-side vessels in which water being filtered passes though one side while the other side is in STANDBY. Four butterfly valves connect the two housings and a mechanical linkage allows the flow to be directed to one side or the other. Filtration is provided by 52 pleated polypropylene filter cartridges per vessel. When the pressure drop across the filter reaches 5 PSIG or greater, the filter must be switched and the cartridges replaced.

RAW WATER FILTER OPERATING PARAMETERS

PARAMETER	RANGE	TYPICAL
Raw Water Filter Delta P	0 – 15 PSIG	1.0 – 5.0 PSIG

Chapter 4
FBR SYSTEM OPERATION

FBR CONTINUOUS OPERATION AT STEADY-STATE

This chapter describes the operation of the FBR system during continuous operation at steady-state conditions. For a general system description, refer to Chapter 2. For system startup instructions, refer to Chapter 15. For information pertaining to valve positions, operational logic regarding the FBR operation, and alarm conditions, refer to Chapter 11, 14, and the Appendices.

GENERAL FBR SYSTEM OPERATION PRECAUTIONS

The precautions listed below are to be carefully followed to ensure maximum system efficiency and equipment life.

Continuous Operation

For any biological process such as the FBR system, the health and efficiency of the biological activity that performs the waste contaminant conversion can only be maintained if the biomass receives a proper supply of electron acceptor (i.e. nitrate, chlorate and perchlorate in groundwater), electron donor substrate (ethanol), urea solution, and phosphoric acid solution on a continuous basis. As such, it is very important to minimize down time, and specifically, to limit down time to less than 24 hours if possible.

Bioreactor Media Bed Height

Excess bioreactor media and biological growth must be kept out of the bioreactor distribution and flow guide system to minimize the possibility of plugging. In a properly operating system, the bed height will increase (i.e. expand) as biological growth takes place. The first stage sand FBRs have each equipped with two pneumatic biomass separators in addition to the original (1) biomass separation pump and one (1) in-bed media cleaning system. The second stage GAC FBRs are equipped with two (2) biomass separation devices and one (1) in-bed media cleaning system. These are installed to help remove biological solids from the media and therefore limit bed expansion. If it is necessary to add or remove media from the bioreactor, the addition and removal procedures described later in this chapter must be followed explicitly.

Bioreactor Temperature

The biological perchlorate destruction process is temperature sensitive. A reactor temperature below 10°C may negatively affect the microbes and reactor performance temporarily. This effect is not permanent; returning to temperatures that are more moderate will restore performance. If the reactor temperature increases beyond 38°C for any reason (e.g. due to a severe pump malfunction or operation for an extended period of time in recycle on extremely hot days), steps should be taken to immediately lower the temperature. A long re-acclimation period may result if the temperature remains above 38°C for more than two hours. The temperature is alarmed. If running in recycle, the on/off time should be managed in order to keep temperature from rising above 38°C.

FBR OPERATING MODES

Each FBR has five distinct operating modes which are indicated at the Operator Interface Terminal (OIT).

Offline Mode

When an FBR is in the Offline mode, both the feed and recycle are off, but power is available. The OFFLINE mode should only be used if a long-term shutdown is required such as maintenance on reactor internal assemblies.

Recycle Mode

At startup, the operator shall change the mode from OFFLINE mode to RECYCLE mode by starting the associated fluidization pump. The operator should verify all manual valve positions in accordance with the Valve Position Chart (Refer to Appendix L) for the RECYCLE mode.

FBR Running Mode

Proceeding from the RECYCLE mode, the operator can initiate FBR feed to an FBR by opening the associated feed valve. The reactor will be in the FBR RUNNING mode. The operator must select one of three feed flow modes for the 1st Stage FBRs at the OIT, AUTOMATIC EQUALIZATION TANK CONTROL, FLOW SET POINT CONTROL, AND MANUAL FEED CONTROL. Selection of the feed flow modes will depend on operating requirements of the overall treatment system. The operator must also select one of two feed flow modes for the 2nd stage FBRs, either AUTO FLOW BALANCING OR MANUAL FEED CONTROL. Automatic flow balancing will be the preferred method for feeding the 2nd Stage FBRs. See Chapter 11 for more details.

Shutdown Modes

There are two shutdown modes, a SHUTDOWN and a FBR SHUTDOWN. The SHUTDOWN mode occurs when an alarm condition causes a feed shutdown and closes the feed control valve. The FBR SHUTDOWN mode occurs when an alarm condition stops both the feed and recycle. Various alarm conditions such as high or low pH, low urea solution and phosphoric acid solution flow, or low electron donor flow will trigger a SHUTDOWN. A table listing the alarm default set points which cause a feed shutdown are listed in Chapter 14. The operator must clear the alarm causing the feed shutdown condition before feed can be restarted to the FBR.

At the start of a SHUTDOWN with the wastewater feed discontinued, biological activity in the reactor will continue for some time. Therefore, the pH adjust system should continue to operate. The media will remain fluidized in the reactor since the fluidization pump will remain operational. A feed shutdown of 48 hours or less can be followed by an immediate restart of the feed to the previous flow. If a feed shutdown lasts between 48 hours and 7 days, the operator should restart the system with 50% influent load and gradually increase the feed rate by 10% increases per day. If a feed shutdown lasts longer than 7 days, the reactor will most likely require inoculation. However, if inoculation is not possible, the system could be restarted with the understanding that the effluent should be closely monitored and will not meet discharge requirements until a perchlorate-degrading microbial population can be reestablished.

An FBR SHUTDOWN is a when the feed and recycle are off. This includes automatic shutting-off of the following equipment: (1) the fluidization pump, (2) the pH adjust pump, (3) the electron donor substrate pump, (4) the urea solution, and phosphoric acid solution pumps, and (5) the micronutrient solution pump. An extended system shutdown (greater than 48 hours) could cause the media to compact at the bottom of the reactor clogging the nozzles, cause channeling in the bed, and bed loss during restart. The cause of an unexpected system shutdown must be identified quickly and remedied to prevent degradation in system performance.

If an FBR SHUTDOWN is desired due to site specific conditions, the fluidization pump must be started every 48 hours to fluidize the reactor bed for 1 hour.

Additionally, after 7 days, one reactor volume of feed should be passed through the reactor to wash out the biomass. The one reactor volume throughput should be repeated monthly during an extended system shutdown. During the 1-hour fluidization, the water level in the reactor should be monitored, fluidization flow recorded, and an expanded bed height measurement should be taken. The expanded bed height should be equal to or greater than the clean expanded bed height. If not, we suggest the operator contact Shaw Environmental, Inc. personnel to assist in troubleshooting the bed loss or compaction.

If an FBR SHUTDOWN (whether planned or unexpected) is less than 48 hours, the operator should gradually restart the feed starting at 1/2 the last feed flow for 1 day and returning feed flow to the desired setting the following day. If the system shutdown lasts between 48 hours and 7 days, the operator should perform a gradual restart of the feed with 10% increases daily in the feed rate. If a system shutdown lasts longer than 7 days, the reactor will most likely require inoculation. However, if inoculation is not possible, the system could be restarted with the understanding that the effluent should be closely monitored and will not meet discharge requirements until a perchlorate-degrading microbial population can be re-established.

FBR MONITORING AND MAINTENANCE

The operation of the FBR vessels involves monitoring mechanical, biological, and chemical parameters and maintaining the sand and carbon bed heights.

System Monitoring

To gauge the operational and process integrity of the FBRs while in operation, it is necessary to record operational data regularly. In this way, the operator should be aware of any trend changes in system operation that may be taking place, and should have early warnings of problems that may be starting to occur. With such early warnings in hand, corrective actions may be taken to prevent minor developing problems from becoming major problems that require lengthy system shutdowns.

During the normal operation of the FBR systems, these procedures should be followed:

1. Perform the required monitoring at the designated frequencies.

2. Perform routine maintenance procedures.

Table 4-1 provides the analytical monitoring required to assess the health and performance of the FBR system. In addition, Table 4-1 provides the various mechanical and operational data that should be recorded at the designated frequencies.

In addition to the daily analytical, mechanical, and operational data performed and recorded, numerous maintenance and monitoring tasks are required on a periodic basis when operating the FBR reactors. These items include:

(1) Establishing the electron donor, urea solution, phosphoric acid solution, and micronutrient solution delivery requirements for the FBR system (Daily).

(2) Routine check and standardization of all ORP probes (Bi-weekly).

(3) Routine check and calibration of all pH probes (monthly).

(4) Routine check of the hydrogen sulfide monitoring systems (monthly).

(5) Routine check of the ethanol delivery system (daily).

(6) Routine check of the urea solution, and phosphoric acid solution, micronutrient solution, and phosphoric acid solution, and caustic delivery systems (daily).

(7) Operation and maintenance of the biomass control devices (weekly).

(8) Measuring settled bed height (when needed).

(9) Routine check of the biofilter operation and the addition of the biofilter nutrient solution to the biofilter nutrient tank (weekly).

A copy of the Microsoft EXCEL® spreadsheet to be used as a guide to help determine the urea solution, phosphoric acid solution, trace elements solution (micronutrient solution), and electron donor (i.e., ethanol) requirements can be found on the main Operator computer in the office trailer.

Using the EXCEL® spreadsheet, the necessary trace element, electron donor (i.e., ethanol) and urea solution, and phosphoric acid solution dosages can be calculated for various feed flow rate and composition [i.e., the concentrations of dissolved oxygen (DO), nitrate-nitrogen (NO_3^--N), chlorate (ClO_3^-), and perchlorate (ClO_4^-)] conditions. The operator inserts the feed DO, nitrate-nitrogen, chlorate, perchlorate, and feed flow into the spreadsheet along with the excess ethanol (typically 15 to 30 percent) and excess urea solution, and phosphoric acid solutions desired (typically 50 to 100 percent). The spreadsheet then calculates the feed rates of ethanol, urea solution, and phosphoric acid solution TO EACH SAND FBR AND EACH GAC FBR, and the feed rate of trace elements to the entire system. These settings are provided to the operator as k-factors that need to be inputted into the OIT in the MCC or Building D-1. When the k-factors for the ethanol, urea solution, and phosphoric acid solution, and micronutrient solution are entered for all FBRs, the operator should check the newly established flows to ensure that they are close to the model predictions. If the actual flows are not within 5% of the predicted model, the k-factors should be rechecked for correct input and the pumps should be checked to ensure they are primed and operating correctly. The settings of the urea solution, phosphoric acid solution, micronutrient solution, and ethanol pumps should be adjusted to provide the required flows. Actual urea solution, and phosphoric acid solution flows should be verified using the calibration columns. Actual ethanol flows should be verified using the flow totalizer independently for each pump.

In terms of target parameter removal (i.e., nitrate, chlorate, and perchlorate), the urea solution, phosphoric acid solution, micronutrient solution, and ethanol dosages provided in the model should be used as a guideline only; actual requirements will be dictated by the concentrations of the target parameters in the sand and GAC FBR effluents, as well as the residual ammonia-N, ortho-phosphate, TOC, and sulfide in the effluent. Oxidation-Reduction potential and pH will also be of value in achieving the target parameters. For continuous, steady-state operation, Table 4-2 provides typical values and ranges for important chemical parameters. Values outside of these typical ranges may jeopardize the effluent discharge limitations or produce odorous, aesthetically poor quality effluent.

Complete removal of perchlorate and all TOC in the 1st FBR train is ideal. However, based on experience during the startup phase of operation, this result is not easy to achieve. Hence, k-factors for ethanol, urea solution, and phosphoric acid solution delivery should be set so that low levels of perchlorate at concentrations of 30 ppm (as an average) should pass the first stage separators to the 2nd train of FBRs. This will allow any residual TOC to be consumed by the perchlorate degrading population in the 2nd train of FBRs while minimizing the chance for odor generation. Based on experience, if more than 40 ppm passes through first stage separators to the 2nd train, possible perchlorate breakthrough may occur through Separator's 3 & 4 (with perchlorate concentrations ranging from 1.4 to 3 ppm). If such an event occurs, the ORPs for the back reactors will increase to greater than -250 mV. The operator must be diligent to add ethanol to the 2nd FBR train in batch-mode. . Such an action should produce an almost immediate decline in the ORPs in the 2nd stage. Following the batch addition of ethanol to the 2nd FBR train, the k-factors for the ethanol and urea solution, and phosphoric acid solution delivery will need to be increased accordingly to bring the average perchlorate concentration in the 1st FBR train down to less than 40 ppm of perchlorate.

In the event that no/minimal perchlorate is passed from the 1st FBR train to the 2nd FBR train, yet residual TOC does carry over, odors will likely ensue. ORPs in the 2nd FBR stage will decline dramatically to less than -350 mV. In this event, the k-factors for the ethanol and urea solution, and phosphoric acid solution delivery will need to be reduced to allow some perchlorate to breakthrough to the 2nd FBR stage. Consult Envirogen Technologies, Inc. personnel for assistance.

Note: The proportion of ethanol fed to the sand FBRs versus the GAC FBRs will be dictated by the pH change that occurs in each reactor. In the sand FBRs, the pH will have a tendency to go down due to: (a) the formation of carbon dioxide, and (b) formation of acidic intermediates from ethanol. In the GAC FBRs, the pH may have a tendency to go up due to: (a) release of carbon dioxide, and (b) degradation of the acid intermediates (which also support perchlorate reduction). The proportion of ethanol fed to the sand versus the GAC FBRs must be adjusted so that the pH in the FBRs stays below the pH of the feed (or hardness will precipitate), but above a pH of approximately 6.5.

ORP can also be used as a guide to establishing ethanol feed rates. However, caution should be employed when using ORP values tied to a process control feedback loop for ethanol addition. Water chemistry and specific microbiology can affect ORP measurements; as such, ORP set points and control schemes should only be established after a long history of correlated performance with ORP has been developed.

(2) Standardization of ORP Probes

Based on past experience, the ORP probes should be removed on a bi-monthly basis, cleaned, and standardized. Before removing an ORP probe, it is imperative that the ORP transmitter be placed in “stand-by” mode, such that changes in ORP while standardizing the unit do not affect FBR process control. This can be accomplished by clicking on the calibration menu of the screen and entering the editing screen. From this screen, the “stand-by” mode can be accessed and turned “ON”. Once this is complete, the operator can continue to the standardization screen. The ORP will need to be electrically disconnected from the transmitter (separation of the BNC cable from the probe). The ball-valves surrounding the ORP probe will need to be closed to prevent high-pressure water from being discharged when the probe is removed. The probe can then be unscrewed from the casing and reconnected to the transmitter. The probe should be gently cleaned with stabilized lake water to remove any debris or biomass that has accumulated on the tip. Then, a one-point standardization of the ORP probe using a 200 mV solution can be conducted by placing the tip of the probe in the ORP standard solution. After a period of a minute, providing the instrument sufficient time to acclimate to the ORP solution, the operator can adjust the ORP value to meet the standard solution value by inputting the standard solution value via the numeric keypad. The probe can then be disconnected from the BNC cable and screwed back into the casing. The BNC cable can then be reconnected. The transmitter should be released from “stand-by” mode. The ball-valves surrounding the ORP probe should be opened. Up to one hour may be necessary before the probe accurately reads ORP values from the FBR. Consult the manufacturer’s literature or Shaw Environmental, Inc. personnel for more information.

(3) Calibration of pH probes

Based on past experience, the pH probes should be removed on a monthly basis, cleaned, and calibrated. Like the ORP probes, before removing a pH probe, it is imperative that the pH transmitter be placed in “stand-by” mode, such that changes in pH while calibrating the unit do not affect FBR process control. This can be accomplished by clicking on the calibration menu of the screen and entering the editing screen. From this screen, the “stand-by” mode can be accessed and turned “ON”. Once this is complete, the operator can continue to the calibration mode screen. The pH probe will need to be carefully removed from its casing. Great care should be taken when removing the pH probe so as not to crack the housing case.

There is one locking nut that should be loosened on the pH probe shaft, releasing the probe away from its casing. Once this is accomplished, a ball-valve between the casing and the probe can be closed. This will prevent high-pressure water from being discharged when the probe is removed. Using a wrench, a male adaptor can be loosened, allowing the pH probe to be completely removed from the casing. The tip of the probe should be inspected for any damage or debris. The probe should be gently cleaned with stabilized lake water to remove any debris or biomass that has accumulated on the tip. Then, while in the calibration mode on the transmitter, the pH probe can be calibrated using a two point calibration procedure. pH buffer solutions of 4.00 and 7.00 should be used as buffers 1 & 2. The screen will lead the operator through the calibration sequence. It may be necessary to adjust the indicated value to the buffer value using the numeric keyboard. After calibrating to both buffer solutions, it is important that the operator recheck the pH probe accuracy for both buffer solutions while the probe is in the standard operating mode. If either solution does not read within 0.1 pH unit for either buffer solution, the probe should be recalibrated again. This procedure may need to be repeated up to three times. Once the operator feels comfortable that the pH probe is reading accurately, the probe can be reinserted into the casing and the steps required to remove it can be applied in reverse.

CAUTION: DO NOT FORCE THE pH PROBE INTO THE CASING SUCH THAT THE TIP MAY HIT THE BACKSIDE OF THE CROSSING PIPE. THIS WILL DAMGE THE PROBE TIP.

Once the pH probe is in the casing and locked in place, the transmitter should be released from “stand-by” mode. The ball-valves surrounding the pH probe should be opened. Consult the manufacturer’s literature or Shaw Environmental, Inc. personnel for more information.

(4) Hydrogen Sulfide Monitoring Systems

The hydrogen sulfide monitoring systems should be manually checked every month, or whenever a “trouble” and an “alarm” signal are generated (flashing). A “trouble” light flashes when there is an electrical or sensor problem. The “alarm” light flashes when the hydrogen sulfide alarm condition (> 10 ppm) is exceeded or a failure of the auto-calibration test. The auto test occurs every 24 hours. The process involves a signal being generated to test the sensor’s ability to read hydrogen sulfide. As long as the signal generator works and the sensor gives a reading above 2.0 ppm of hydrogen sulfide, then no “trouble” or “alarm” lights will be illuminated.

The auto-test can be performed manually, so as to test the sensor of the instrument to ensure that it is working properly. The operator should touch and hold down the “A/R” button on the keyboard. After a few seconds, the operator will see all of the system lights illuminate. Continue to hold the A/R button. Approximately 3 seconds later, a beep will occur and the screen will show the number of hours passed since the last automatic calibration has occurred. Release the A/R button. At this time, the “trouble” and “alarm” lights will flicker in an alternating flashing. The operator should push the A/R button again, beginning the manual test of the sensor. A value of 0.0 ppm will appear on the digital screen. After approximately three to five minutes, the value on the screen will increase to above 2.0 ppm. When this occurs, the instrument will then shut off the signal generator and the value on the screen will decrease slowly to 0.0 ppm. A ten-minute warm-down period occurs. In the event that the sensor does not reach 2.0 ppm, the instrument will continue to generate a signal for ten minutes. After ten minutes, if there is still no sensor indication above

2.0 ppm, the instrument will flash the “trouble” and “alarm” lights. The process may need to be repeated. If further testing does not clarify the problem, then the signal generator and/or the sensor may be bad, requiring replacement Contact the manufacturer for assistance. Consult the manufacturer’s literature or Shaw Environmental, Inc. personnel for more information.

(5) Ethanol Delivery System

On a daily basis, or whenever a change is made to the ethanol dosing rate, the ethanol pumps should be monitored for proper operation. Adequate ethanol delivery to the FBRs is essential in achieving optimal performance. The pumping rate is displayed on the screen in the MCC and D1 buildings. This value should be near the value established by the model (within 0.3 gph). In addition, the ethanol delivery pumps should be individually checked for operation. A significant rattle noise generated by any of the ethanol delivery pumps is indicative that the pump has lost prime. In order to reestablish the pump prime, the pump discharge and suction lines should be checked for plugging. This may require that the discharge line be disconnected at the injection point of the FBR. If ethanol will not pump through the disconnected line, the operator should work back towards the pump to determine where the clog in the line is occurring (checking check valves, ball valves, etc.). If no clog is determined on the discharge side, the pump operation will need to be addressed. It is possible that the pump could need a diaphragm replacement. Consult the manufacturer's literature or Shaw Environmental, Inc. personnel for more information.

The FBR ethanol delivery pumps have been calibrated and set-up for operation during the start-up phase of operation. However, such pumps have the capacity to lose efficiency over time and may require periodic calibration. However, due to the fact that the ethanol delivery system uses a booster pump to feed the FBR ethanol delivery pumps, generating a positive head at the suction side of the FBR ethanol delivery pumps, the calibration columns should not be used to calibrate the FBR ethanol delivery pumps. The provided calibration columns will not provide an accurate flow measurement because they do not have a positive pressure provided by the booster pump. The only manner in which to calibrate each FBR ethanol delivery pump is to turn each ethanol pump off and independently check each pump flow using the in-line flow meter/transmitter. Since a shutdown to all the ethanol pumps is not advisable when feed water is being delivered to the FBR system, such a calibration should only occur when feed water is shut off to the system or when the accuracy of a pumping rate is severely questioned. In the latter case, the pumps should be shut down for as minimal time as possible. Ethanol may need to be fed batch-wise to the top of the reactors during such a calibration procedure. In general, the accuracy of the calibration of the FBR ethanol delivery pumps should only be questioned when the ethanol flow on the OIT is significantly different than the predicted flow of ethanol by the model. Consult with Shaw Environmental, Inc. personnel for assistance.

(6) Urea solution/Phosphoric acid solution/Micronutrient solution/Caustic Delivery Systems

Like the ethanol delivery system, adequate urea solution/phosphoric acid solution/micronutrient solution/caustic delivery to the FBRs is critical in achieving optimal performance. On a daily basis, or whenever a change is made to the urea solution/phosphoric acid solution/micronutrient solution/caustic dosing rate, the respective pumps should be monitored for proper operation. At the base of each of the urea solution/phosphoric acid solution/micronutrient solution/caustic pumps, are flow indicators. The micronutrient solution and phosphoric acid solution/caustic flow indicator should show a positive reading to indicate proper operation. For the urea solution, and phosphoric acid solution pumps, the flow indicators should all read approximately the same value (though change together at different pumping speeds). If one or more urea solution or phosphoric acid solution delivery pumps does not appear to be providing similar flow as the others, the discharge line should be disconnected at the injection point of the FBR. Over a period of months, urea solution may precipitate and cause some clogging at the injection point. This clog should be removed and the pump flow rate compared with that of the other urea solution delivery pumps. If the pump flow rate still does not compare well to the others, the tubing may require changing within the casing of the peristaltic pump. In any respect, this tubing should be checked every four to six months for normal degradation. It is also advantageous to regularly check (i.e. every week) the flows for all of the urea solution/phosphoric acid solution/micronutrient solution/caustic pumps using the provided calibration columns. This will ensure that a tubing failure may be predicted before it happens. Consult the manufacturer's literature or Shaw Environmental, Inc. personnel for more information.

(7) BIOMASS CONTROL SYSTEMS

1stStage FBRs (except FBR-A) Bed Height Control System

The original four 1st stage FBR vessels have a two level bed height control system to control bed growth and limit media carryover. Measurement of bed height, experience, and media samples will dictate the frequency of operation and location of bed height control. The operator will measure bed height on a routine basis in all the reactors using a probe from the top catwalk of the reactor. Maximum bed growth should not exceed 24 feet.

A revised design for the first stage FBR bed height control devices has been added to each first stage FBR. The previous set of bed height control devices remains in place and available for use. The revised design for the bed height control system is very similar to the Biomass Separator design that is in use for the second stage FBRs. The purpose of the bed height control system or biomass separator is to remove excess biomass accumulation on media located at the top of the fluidized bed in the FBR. Each first stage FBR now is equipped with two biomass separation devices, along with the original bed height control.

The first stage biomass separators may be operated on a continuous or intermittent basis, as dictated by the system operating conditions. Normally, they will be operated continuously. The separators maintain the top of the fluidized media bed at 21'-9" using an air lift tube (pipe). Media with attached biomass and water is directed through the lift tubes into the mixing chamber located at the water surface. Both lifting and mixing are controlled by airflow to the biomass separator. The biomass separator elevation is set to position the bottom of the lift tube discharge slot at the liquid level in the reactor when operating at the design flow rate.

The sand and biomass are separated in the mixing chamber. The media and biomass fall in the 6" pipe (splash shield) and return to the reactor. The sheared biomass will float and leave the reactor with the effluent stream. The media will settle back to the bed.

The air flow rate to the biomass separator is operator-adjustable. The air flow rate range is 1 to 100 standard cubic feet per hour (SCFH). The airflow will determine the media lift rate and the degree of mixing imparted. **A normal setting is 15-40 SCFH**. To control bed height more effectively, increase air lift flow while closely monitoring the effluent biomass.

The optimum adjustment of the aforementioned parameters will yield effective biomass removal. If the bed height exceeds the 21'-9" expanded bed elevation in the reactor, the biomass separation devices should be inspected and if nothing is found to be wrong, the airflow should be increased and/or the elevation adjusted. If the bed expansion cannot be controlled with the biomass separation devices alone, then the in-bed cleaning system should be put into service.

Upper Bed Height Control

To control bed growth in the upper portion of the reactor, the operator will open the suction valve on the shorter pipe and open the pump discharge valve. Verify valve position on the Valve Position Chart in Appendix L. Start the bed height control pump at the operator interface terminal and observe pressure at the discharge pressure gauge and effluent/recycle water clarity.

Lower Bed Height Control

To control bed growth in the lower portion of the reactor, the operator will open the suction valve on the longer pipe and open the pump discharge valve. Verify valve position on the Valve Position Chart in Appendix L. Start the bed height control pump at the operator interface terminal and observe pressure at the discharge pressure gauge and effluent/recycle water clarity.

2nd Stage FBRs and FBR-A Bed Height Control System

In the four 2nd Stage FBR vessels and FBR-A, bed expansion is caused by biomass growth and may be controlled by the Biomass Separation Devices and/or the In-bed Cleaning System.

Biomass Separator

The purpose of the biomass separator is to remove excess biomass accumulation on media located at the top of the fluidized bed in the FBR. Each FBR is equipped with two biomass separation devices.

The biomass separators may be operated on a continuous or intermittent basis, as dictated by the system operating conditions. Normally, they will be operated continuously. The separators lift media from the top of the fluidized media bed at 18' 9" using a 2" diameter air lift tube (pipe). Media with attached biomass and water is directed through the lift tubes into the mixing chamber located at the water surface. Both lifting and mixing are controlled by airflow to the biomass separator. The mixing chamber consists of the 2" air lift pipe with 3" long slot openings inside a 4" pipe section.

The carbon and biomass are separated in the mixing chamber. The media and biomass fall in the 4" pipe into an outer 10" diameter pipe. At the water level, the 10" pipe has (8) slots which allow water and biomass to flow into an outer 12" diameter pipe which is sealed at the bottom except for a drain fitting which is connected by hose to a nozzle connection on the side of the reactor.

The following parameters are operator-adjustable:

1. Airflow rate 0 to 100 standard cubic feet per hour (SCFH). The airflow will determine the media lift rate and the degree of mixing imparted. **A normal setting is 15-40 SCFH**. To control bed height more effectively, increase air lift flow while closely monitoring the effluent biomass.

2. Separator elevation is adjustable using the nuts and threaded rod which hold the biomass separator in place. The biomass separator elevation should be set so that the bottom of the 1/16" slots in the 10" pipe are 2" below the water level during normal operating conditions. Raising the 10" pipe in the separator will reduce the biomass overflow flow rate and increases the retention time of media particles in the separator, thus increasing the mixing intensity while decreasing flow.

The optimum adjustment of the aforementioned parameters will yield effective biomass removal. If the bed height exceeds the 18’ 9” expanded bed elevation in the reactor, the biomass separation devices should be inspected and if nothing is found to be wrong, the airflow should be increased and/or the elevation adjusted. If the bed expansion cannot be controlled with the biomass separation devices alone, then the in-bed cleaning system should be put into service.

In-Bed Cleaning System

The in-bed cleaning system is a bed height control device that is intended to agitate and mix media at lower levels in the reactor and shear biomass from the media. Service water provides the energy to an eductor, which circulates and agitates the media. The agitation of the media separates the biomass from the media. Use of the in-bed cleaning system is accomplished by an operator manually opening the service water isolation valve and adjusting a globe valve to produce sufficient mixing.

The in-bed device should be fed with a pressure source of clean water at 15-40 psi for a period of 1 hour. A globe valve located on top of the 2nd Stage FBR and FBR-A control the flow of water to the eductor. The more the valve is open the greater the mixing by the eductor. Repeat the 1-hour cleaning procedure as necessary after measuring the bed height with a probe or media-sampling device.

When the expanded bed elevation falls below the design value, use of the In-Bed Cleaning system can be discontinued.

(8) Determining Settled Bed Height

Occasionally, it is necessary to check the amount of media in the bioreactors. This may be done by measuring the height of the settled media bed. Because measuring the settled bed height involves a system shutdown procedure and restarting, it should only be done if a question arises about the amount of media in the bioreactors or the degree of fluidization being achieved.

Perform the measuring procedure as carefully and quickly as possible to minimize damage to the biological growth that is present. Perform the procedure as follows:

1. Perform a System Shutdown that will stop fluidization.
2. Allow the bioreactor media to settle for approximately 30 minutes.
3. Measure the distance (in inches) down from the top of the reactor vessel to the top of the settled bed using the portable bed height indicator (weighted probe at the end of a rope). The settled bed height should be equal to or greater than the initial settled bed height at startup.
4. Immediately restart the bioreactor system after completion of measurement.

<u>Media Addition and Removal</u>

The following procedures are to be used when adding or removing media from the bioreactors.

Media Addition

If it is determined that sand or carbon addition is necessary, follow the steps below:

1. Perform a System Shutdown that will stop fluidization.
2. Determine how much media is required.
3. Add pre-wetted (pre-soaked in water for at least 24 hours) sand or carbon through the top of the reactor vessel.
4. Restart the system.

Media Removal

If there is a need to remove sand or carbon, follow the steps below:

1. Place reactor system in the recycle mode.

2. Use a siphon hose or ejector to remove excess media.

3. Transfer and store the media in a holding tank on site or transfer the media to the other FBRs. Check integrity of tank to ensure no spillage of media. Ensure tank is cleaned of any contaminants prior to usage.

4. Ensure supply of clean water to replenish any water lost from the reactor during the transfer process so as not to run dry the fluidization pumps.

(9) Biofilter Operation and Biofilter Nutrient Solution

See Chapter 7 for specific biofilter operating instructions. The biofilter reactors, T-402A and T-402B, should be checked once a week for proper operation. The main power, the blower, and the water discharge pump should be temporarily shut down (no more than 10 minutes) and a lock-out tag placed on the main disconnect switch. Along the side of each tank, there is a small media port (approximately 3 inches in diameter). This port should be opened and a sample of media should be inspected for moisture. The media should be damp to the touch, but not over saturated. If the media is oversaturated, the water addition and frequency require a decrease. If the media is overly dry, then the water addition and frequency require an increase. The water addition settings during start-up of the biofilters have been set to operate every 20 minutes for 35 seconds. During continuous operation, these settings should be maintained unless a change in media moisture has been detected. Based on prior operation of similar biofilters, the media moisture content should be in the range of 50-70% moisture content. Though not necessary, a laboratory can perform a media moisture analysis than can be used as a standard for future media observation. Consult Envirogen Technologies' personnel for additional details. The media sample can be returned to the reactor through the port. Once the port cap has been reinserted into the biofilter, the main power, the blower, and the discharge pump should be restarted.

Approximately every 30 days, the biofilter nutrient solution requires replenishment. With the biofilter nutrient solution tank at or near zero volume of solution, add 2.5

liters of the nutrient solution (obtained from the FBR nutrient solution tank T-702) to the biofilter nutrient solution tank T-403. In addition, add 25 ml of the micronutrient solution to T-403. Following the addition of the nutrient solution and micronutrient solution, T-403 should be filled to the 50 gallon mark with stabilized lake water. In the event that T-403 is not empty prior to filling, a proportional volume of nutrient solution, and micronutrient solution, and stabilized lake water will need to be added to the existing solution. Place the lid back on the tank and check the tank over the next few days to ensure that liquid is flowing from T-403 into the biofilters (a drop in depth of about an inch in water level will occur every day). If the water level is not decreasing in T-403, the operator should check the nutrient solution metering pump (P-401) and/or the timer/solenoids for proper operation. If the problem continues to persist, contact Envirogen Technologies, Inc. personnel for assistance.

Once a week, the biofilter nutrient solution tank (T-403) volume should be monitored to ensure that water and nutrient solution are continually being added to the biofilter reactors. If the nutrient solution tank volume does not decrease, then the nutrient solution metering pump (P401) and/or the timer/solenoids should be checked for proper operation. If the problem continues to persist, contact Envirogen Technologies, Inc. personnel for assistance.

Table 4-1. Monitoring Program for Fluidized Bed Reactor System

Perchlorate Treatment Plant

Parameter	Typical Measurement Location	Method	Frequency (Startup)	Frequency (Normal Operation)	Sample Location [2]	Reason for Monitoring Parameter
Oxidation-Reduction Potential (ORP)	Field	Probe	Daily (5x per week)	Online Continuous	FBR Effluents	Used to help estimate ethanol dosage. Measurement below negative (-) 100 mV is usually good.
Temperature	Field	Thermometer	Daily (5x per week)	Daily	FBR Feeds FBR Effluents	Used to monitor system temperature.
Chloride	On-site Laboratory	Hach Method (Mercuric Thiocyanate)	3x per week	Quarterly	FBR Feeds FBR Effluents	Used to determine if water is within design specifications.
Sulfate	On-site Laboratory	Hach Method 8051 (SulfaVer® 4) [1]	3x per week	Quarterly	FBR Feeds FBR Effluents	Used to determine if water is within design specifications.
Sulfide	Field	Probe	Daily (5x per week)	Online Continuous	FBR Effluents	Used to determine ethanol dosage.
Sulfide	On-site Laboratory	Hach Method 8131 (Methylene Blue)	3x per week	Daily	FBR Effluents	Used to determine ethanol dosage.

Parameter	Typical Measurement Location	Method	Frequency (Startup)	Frequency (Normal Operation)	Sample Location [2]	Reason for Monitoring Parameter
Ammonia-N	On-site Laboratory	Hach Method 8038 (Nessler) [1]	3x per week	Daily	FBR Effluents	Used to determine if adequate nutrients are available.
Ortho-phosphate (reactive)	On-site Laboratory	Hach Method 8048 (Ascorbic Acid) [1]	3x per week	Daily	FBR Effluents	Used to determine if adequate nutrients are available. Measurement greater than 1 mg/L is usually good, taking care not to exceed effluent limitations.
Nitrate-N	On-site Laboratory	Hach Method (Cadmium Reduction)	3x per week	Weekly	FBR Feeds	Used to determine ethanol dosage.
Nitrite-N	On-site Laboratory	Hach Method 8507 (Diazotization) [1]	2x per week	Quarterly	FBR Feeds	Used to confirm nitrite-N not present; if present at > 2 mg/l, ethanol requirement spreadsheet requires modification.
Nitrate-N	Off-site Laboratory	EPA 300.0	3x per week	Quarterly	FBR Feeds FBR Effluents	Influent analyses used to set ethanol dosage.

Parameter	Typical Measurement Location	Method	Frequency (Startup)	Frequency (Normal Operation)	Sample Location [2]	Reason for Monitoring Parameter
Chlorate	Off-site Laboratory	EPA 300.0	3x per week	Quarterly	FBR Feeds FBR Effluents	Influent analyses used to set ethanol dosage.
Perchlorate	Field	Probe	Daily (5x per week)	Daily	FBR Feeds FBR Effluents	Influent analyses used to set ethanol dosage. Effluent analyses used to screen (only) for perchlorate treatment.
Perchlorate	Off-site Laboratory	EPA 314.0	3x per week	Daily	FBR Feeds FBR Effluents	Influent analyses used to set ethanol dosage. Objective of FBR operation is to remove perchlorate to < 4 ug/l.
Total Organic Carbon (TOC)	On-site Laboratory	Hach Method (Digestion, Persulfate, Sulfuric Acid)	3x per week	Daily	FBR Effluents (filtered samples – 0.45 um filter)	Used to confirm reactor operation – residual ethanol. Slight residual filtered TOC expected from "old" cell debris.
Alkalinity	Off-site Laboratory	EPA 310.1	Weekly	Quarterly	FBR Feeds	Used to determine if water is within design specifications.
Total Hardness	Off-site Laboratory	EPA 130.2	Weekly	Quarterly	FBR Feeds FBR Effluents	Used to determine potential of water to scale.

Parameter	Typical Measurement Location	Method	Frequency (Startup)	Frequency (Normal Operation)	Sample Location [2]	Reason for Monitoring Parameter
Total Dissolved Solids (TDS)	Off-site Laboratory	EPA 160.1	Weekly	Quarterly	FBR Feeds	Used to determine if water is within design specifications.
Calcium	Off-site Laboratory	EPA 215.1	Weekly	Quarterly	FBR Feeds	Used to determine if water is within design specifications and to support hardness analyses.
Magnesium	Off-site Laboratory	EPA 242.1	Weekly	Quarterly	FBR Feeds	Used to determine if water is within design specifications and to support hardness analyses.
Sulfate	Off-site Laboratory	EPA 300.0	Weekly	Quarterly	FBR Feeds	Used to determine if water is within design specifications.
Chromium	Off-site Laboratory	EPA 200.7	Weekly	Quarterly	FBR Feeds	Used to determine if water is within design specifications.
Microscopic Analysis (Media)	Off-site Laboratory	Envirogen Laboratory	1x per month	2x per year	FBR Sand and GAC	Used to determine health of biomass.
FBR Bed Height	Field	Portable Sounding Device	Daily (5x per week)	Daily	FBR Vessels	Used to determine FBR bed height.

Parameter	Typical Measurement Location	Method	Frequency (Startup)	Frequency (Normal Operation)	Sample Location [2]	Reason for Monitoring Parameter
System Feed Flow	Field	Feed Flow Indicator	Daily (5x per week)	Daily	FBR Skids	Used to determine load on reactor.
pH - Fluidization	Field	Probe	3x per week	2x per month	FBR Fluidization	Used to determine if system pH probe is out of calibration.
pH - Fluidization	Field	System pH Analyzer	3x per week	Online Continuous	FBR Skids	Used to determine operating pH.
Nutrient Flow	Field	Calibration Columns	3x per week	Weekly	FBR Skids	Used to determine amount of inorganic nutrients (N and P) fed to FBRs.
Trace Elements Flow	Field	Calibration Column	3x per week	Weekly	System Feed	Used to determine amount of trace elements fed to system.
Fluidization Flow	Field	System Flow Indicators	Daily (5x per week)	Online Continuous	FBR Skids	Used to determine bed expansion vs. recycle flow.

1. USEPA-Accepted or Approved Hach Methods Used for Wastewater Reporting
2. **Caution should be exercised if sampling the FRB Effluents at the top of the FBRs; hydrogen sulfide may be present. Appropriate personal protective equipment (PPE) should be used.**

Table 4-2. Typical Chemical Operating Parameters for FBR System

Parameter	Typical Value (mg/l)	Range (mg/l)
Ammonia-N	**2.0**	**1.0 – 4.0**
Ortho-phosphate	**1.0**	**0.5 – 2.0**
TOC	**30.0**	**20.0 – 50.0**
Sulfide	**<1**	**0.0 – 5.0**
ORP (in MV)	**-300 mV (1st Stage)** **-350 mV (2nd Stage)**	**-250 to -350 mV** **-300 to -400 mV**
pH	**6.3 (1st Stage)** **6.5 (2nd Stage)**	**6.0 – 7.0** **6.0 – 7.0**

Chapter 5
DISSOLVED AIR FLOTATION SEPARATORS

OVERVIEW

Following the FBR and Aeration process, the wastewater is coagulated with ferric chloride, passed through a static mixer, flocculated with a cationic polymer, and then processed through the Dissolved Air Flotation Separators. The process of dissolved air flotation involves the separation of biomass from the wastewater stream. It is basically the reverse of gravity sedimentation. Dissolved air flotation is accomplished by attaching small air bubbles to the solids resulting in a combined specific gravity of the solids-air mixture of less than the liquid. Since biomass has a specific gravity less than water and will float on the water surface, clarification is usually more effective using flotation than gravity settling. Therefore, two dissolved air flotation units have been installed for clarification of the aeration tank effluent, each hydraulically designed to treat 1000 GPM. In order to meet the turbidity requirement is imposed after the system was designed, both units must be operated in parallel.

The air bubbles are supplied to the process by dissolved air in the process liquid at an elevated pressure so that when the pressure is released, a supersaturated condition results and air is released as micron size air bubbles. The flotation process consists of pressurizing a portion of the treated wastewater flow and a dissolving gas such as air, at elevated pressures up to 55 psig, followed by release to atmospheric pressure. When reduced to atmospheric pressure, the dissolved gas (in excess of saturation at atmospheric pressure) is released in the waste stream in extremely fine bubbles. These bubbles attach themselves to suspended matter (biomass) and lift them to the surface.

The attachment of the micron-sized gas bubbles to suspended solids or oily material occurs by several mechanisms. Some or all of these mechanisms may occur during the flotation process. The suspended solids-gas mixture are carried to the surface of the flotation vessel after:

1. Adhesion of a gas bubble to the suspended solids by precipitation of the gas on the particle or by collision of the rising gas bubble with a particle.
2. Trapping of gas bubbles under a floc as the bubble is rising.
3. Adsorption of the gas by a floc formed or precipitated around the gas bubble.

Dissolved Air Flotation Separators

The Nevada Environmental Response Trust Perchlorate Removal System uses two Dissolved Air Flotation Separators (DAF-501 and DAF-551) to clarify the wastewater stream exiting the aeration tank. The chemically conditioned wastewater is combined with a recycle stream of clarified DAF effluent that has been saturated with air in the pressurization system. The super-saturated effluent passes through a pressure reduction valve just before entry into the DAF. As pressure is reduced, the air is released from the water as fine bubbles. The air/water mixture is introduced into the flotation chamber through a perforated pipe header and is combined with the influent flow. The rising air bubbles float the waste particles to the surface where they can be removed with the surface skimmer.

The Dissolved Air Flotation Separators (DAF-501 and DAF-551) can be broken down into four major components these are as follows:

1. Flotation Chamber
2. Recycle Pressurization System
3. Surface Skimmer
4. Settled Sludge Screw Conveyor

Flotation Chamber

The flotation chamber is the largest component of the Dissolved Air Flotation Separators (DAF-501 and DAF-551). This steel flotation chamber provides the retention time required for the micro-bubbles to rise and float the solids and oil to the surface of the DAF's. Each of the Flotation Chambers has a total length of 40-feet 0-inches and an effective flotation area of approximately 350 square feet surface area. The first 2-feet 6-inchs of the flotation chamber is used for air saturation of the wastewater stream. A perforated pipe located on the influent in this saturation section of the Flotation Chamber provides mixing and prevents short-circuiting of the wastewater and saturated air recycle stream.

Wastewater flow enters the tank in the inlet mixing assembly, which provide adequate mixing of the wastewater and pressurized recycle to allow flotation of the flocculated particles. In theory, the water travels the length of the DAF, then back while these particles float to the surface. This results in the folded flow concept. Effluent is removed from the feed end of the DAF. At the effluent end of the separator, the water must pass under an underflow baffle before overflowing an adjustable weir and entering the effluent pipe.

The width of each Dissolved Air Flotation Separator (DAF-501 and DAF-551) is 10-feet 5-inches and the effective water depth is 6-feet 3 inches. The Flotation Chamber has a coned bottom for the storage of sludge solids, which are too heavy to float in the flotation chamber.

The Dissolved Air Flotation Separators are each designed for an average influent flow rate of 1000 GPM. Note that improved solids removal efficiency will result if both DAF's are operated in parallel. The average influent TSS concentration is estimated at 100-200 mg/l. The DAF's are expected to produce an effluent with a TSS concentration of less than 20 mg/l (80-90% removal efficiency).

Recycle Pressurization System

The recycle pressurization system consists of a pressure tank (T-501 & T551); recycle pump (P501 & P551), pressure reduction valve, flow control valve, flow transmitter (FIT 502 & FIT 506) and an air assembly to provide air to the pressure tank, pressure tank level controller (LT 501 & LT 551) and solenoid valve. This system is designed to produce the micro-bubbles used to float the solids and oil by dissolving air in a stream of recycled effluent. This pressurized flow/air stream passes through a pressure reduction valve and combines with the influent wastewater.

The two pressure tanks, one for each unit, are 24-inch diameter steel vessels, with a 10-feet 4-inch straight side. Water from the recirculation pumps is saturated with air in these tanks. The operating pressure for the pressure tanks is 50 - 55 PSI and they are designed to receive a recycle flow rate up to 200 GPM. The recycle pressurization system must be operating properly and correctly balanced to float the solids in the flotation chamber. There are four main parameters that must be monitored and controlled to achieve optimum performance. These are as follows:

1. Pressurized water flow rate
2. Pressure tank level
3. System operating pressure
4. Pressurized Air Flow Rate

Pressurized water flow rate

The pressurized flow system is pressurized water pumped through an air chamber causing the air to become dissolved in the water. The pressured water flow rate, not the airflow rate, is the key to amount of air that can be dissolved in the water. The recirculation pump is a fiberglass, horizontal centrifugal pump with a discharge capacity of 206 GPM at 140 feet total dynamic head. The recirculation pump is driven by a 25 HP, 460-volt, 3-phase motor. The pumps draw suction from the effluent end of the DAF through a 4-inch CPVC line, which reduces to a 3-inch CPVC line. The recirculation pump discharges to a 2-inch CPVC line, which increases to a 4-inch CPVC line that feeds the pressure vessel. Each pump has a local suction and discharge pressure gauge, a check valve, flow control valve and a flow meter on the discharge piping. The recirculation pumps are equipped with an HAND, OFF, AUTO selector switches. These switches are located on a control panel next to the pump.

A flow control valve and flow meter are used to control the discharge flow rate from the recirculation pumps to the pressure vessel. The flow meter and the flow control valve are installed on the discharge line of the pumps. This flow control is designed to maintain a constant flow rate to the pressure vessel. The operator must manually set the flow control valve to set the desired flow rate. The flow control valve is a diaphragm valve that is specifically designed for flow control. The valve is also equipped with a position indicator so that the percent open/closed can easily be established. The desired flow rate from the Recirculation Pumps at Kerr McGee is 200 GPM. However, it is more important to maintain a recirculation pressure of 50 - 55 psig. The flow rate can be altered if needed to maintain the 50 psig.

Pressure tank level

Controlling the pressure tank level is important because it insures that there is an air pocket in the chamber so that air can dissolve into the water at the required rate. If the tank is filled with water, the air will not dissolve into the water efficiently and performance of the DAF will decrease. Likewise, if the water level is too low the air will not dissolve in the water efficiently and DAF performance will decrease. To control the level in the pressure tank, a bleed off piping assembly, a bleed off throttling valve, a solenoid valve, a sight tube and a float switch assembly have been installed on the pressure tank. Under normal operating conditions, the level in the pressure tank will rise and fall but will be maintained within the sight tube. The sight tube provides easy level determination for the operator.

The solenoid valve is equipped with a HAND, OFF, AUTO selector switch. In the HAND position, the valve opens regardless of level and other interlocks. In the OFF position, the valve remains closed. In the AUTO position, the level switch installed in the pressure vessel controls the function of the valve. In AUTO, if the water level in the pressure tank drops, the low level float switch closes and energizes the solenoid. This causes air to bleed off which allows the water level to rise to maintain the desired air pocket in the tank to again maximize the air to water transfer efficiency. Once the level rises to the normal operating level, the level switch causes the solenoid valve to close and stops the air bleed off. By opening and closing the solenoid valve and bleeding off air, the level in the pressure tank is maintained. The bleed off throttling valve regulates the rate at which the excess air is removed from the system.

For the best performance of the Pressurization System, it is recommended that the Throttling Valve be maintained at approximately 50% open, not 100% open. The bleed off of air should be at a controlled rate, which enables the level to change and correct itself slowly preventing upsets of the Pressurization System and wild swings in the level of the Pressure Tank. Since the airflow rate is set higher than the water flow rate, it is not usual for the water level to rise above the bleed off stop level. However, if the water level rises above this point a high water level alarm is activated.

System operating pressure

System operating pressure is not a function of the air pressure. It is determined by the head of water at the top of the pressure tank and the head loss at the pressure regulation valve. This valve is located on the discharge of the pressure tank just before the air-saturated water enters the DAF. Process air pressure has no direct effect on the operating pressure but the pressure must be set high enough to overcome the dynamic head of the water at the air injection point.

The system operating pressure is 50 - 55 PSI. It is more important to maintain this pressure setting than the 200 GPM recycle flow. The 50 - 55 psig gives the optimum release of fine air bubbles into this particular waste stream.

Although the system pressure is not a function of air pressure as stated above, the air pressure must be higher than the water pressure at the injection point. More importantly, to prevent filling the pressure vessel with water, the airflow rate must be higher than the water flow rate. The air injection system consists of a shutoff valve, supply pressure gauge, pressure regulator, an air line filter with automatic drain, regulated pressure gauge, throttling valve, flow meter, flow meter isolation valves, flow meter bypass valve and check valve. The airflow rate through the flow meter should be set at approximately 1.5 CFM for every 100 GPM of recycled water flow. For example, if the recycle water flow rate is 200 GPM the airflow rate is set at 3.0 CFM. The throttling valve located before the flow meter is used to adjust the airflow rate as specified above.

Air Flow Rate

The airflow rate should be adjusted to approximately 2 - 3 cfm and should be set to produce a “quiet” appearance on the surface of the DAF. Solids carry over can be caused by excessive airflow rates.

Surface Skimmer M-503 & M-553

A concentrated solids/oil layer called the float forms at the tank surface due to properties discussed earlier in this section. This top sludge is removed by a float removal system which consists of skimming blades, blade guards, blade scrapers, drive and tail sprockets, roller chains, drive motor and gear reducer, beaching plate and trough, and a fabricated steel support frame for the roller chain. The roller chains with skimming blades attached to it are driven by a ½-HP motor. The blades are vertical during the skimming cycle and penetrate into the float blanket. Penetration into the float blanket can be adjusted by the adjustable effluent and rubber wipers. As the blades skim through the float blanket, the sludge is pushed up the dewatering beach and into the scum collection trough. From the collection trough, the float is pumped by the DAF Float Pumps via a 3-inch CPVC line to the center well of the Thickener Tank (T-602).

The Surface Skimmer is equipped with a HAND, OFF, AUTO selector switch. In the HAND position, the skimmer runs continuously. In the OFF position, the skimmer will not operate. In the AUTO position, the skimmer is controlled by a cycle timer that starts and stops the skimmer based on the operator-entered set points. The on-off timer set points will have to be adjusted at startup to maximize the float concentration and minimize the concentration of water skimmed from the DAF surface. Normally, the surface skimmer is operated in automatic operation so that the timer controls the skimmer on-off operation. If the skimmer fails to start, a blinking yellow FAILED indication will appear for the skimmer, which will activate the alarm horn and cause an alarm message to be displayed at the operators interface screen.

Settled Sludge Screw Conveyor M-502 & M-552

All of the solids that enter the DAF will not float. Therefore, a bottom sludge removal system is installed. The settled sludge screw conveyor travels in the same direction as the skimmer and is used to move the non-floatable solids along the hopper bottom of the tank to the discharge. The settled sludge screw conveyor is a 6-inch diameter screw and is driven by a ¾ -HP, constant speed motor. From the DAF outlet, the settled solids are pumped by the DAF Float Pumps (P-502 & P-552), through a 3-inch CPVC line, to the Thickener Tank (T-602).

The Settled Sludge Screw Conveyor is equipped with an ON, OFF switch. In the ON position, the screw runs continuously. In the OFF position, the screw will not operate. The Settled Sludge Screw Conveyor is only operated intermittently by the operator. The frequency and duration of operation depends on the concentration of non-floatable material in the influent stream. The operator must start and stop the conveyor to prevent the buildup of solids in the bottom of the DAF.

Operation of the DAF Screw Conveyor's also requires the manual isolation of the DAF Float Boxes. The sludge that is collected in the float boxes and the sludge that settles on the bottom of the DAF's is removed by a common Sludge Pump for each DAF Unit. Under normal operation, the Sludge pump will be in AUTO and isolation valve on the DAF Float Box will be opened while the isolation valve for the DAF Screw will be closed. When the sludge needs to be pumped from the bottom of the DAF's, the isolation valve on the DAF Float Box must be closed, the isolation valve for the DAF Screw must be opened and the DAF Sludge Pump and DAF Screw turned on in HAND mode. The screw conveyors need to be operated for approximately 20 – 30 minutes every shift to remove all of the solids from the bottom of the DAF's. It is important that the valves be switched back once the DAF Screw has been turn OFF and the Sludge Pump has been placed back into AUTO mode.

The sludge becomes septic very quickly and will begin to pop up and float to the surface of the DAF's. Due to the folded flow design, if the sludge is not removed frequently enough, DAF effluent water quality may become affected by the floating septic sludge as it rises to the surface.

<u>DAF Operating Parameters</u>

The major variables affecting the operation and performance of the Dissolved Air Flotation Separators (DAF-501 and DAF-551) are:

1. Pressurized Water Flow Rate
2. System Operating Pressure
3. Pressure Tank Water Level
4. Air Flow Rate
5. Surface Loading
6. Chemical Conditioning
7. Float Skimming & Settled Sludge Removal

Pressurized Water Flow Rate and System Operating Pressure

To float the solids in the DAF there must be sufficient air dissolved in the recycle stream. The amount of air in the recycle stream is partially dependent on the amount of recycle flow through the pressure vessel. In most applications, the recycle flow rate is 25 % of the influent flow rate. For this system, the maximum recycle flow is 200 gpm, or approximately 20% of the forward flow.

A second and more important method for adjusting the available air is to change the system operating pressure. By increasing the system operating pressure, the solubility of the gas in water increases. Therefore, at higher operating pressure the recycle flow rate will contain more air and will release more air in the DAF. Remember though, increasing the system operating pressure will decrease the recycle flow rate. However, the bubble size is also related to the system operating pressure. To obtain the optimum bubble size (80 to 100 microns) the system operating pressure must be maintained between 45-55 psi. At higher pressures, the bubble size decreases and these smaller bubbles tend to agglomerate to form large bubbles. Smaller bubbles result in a decreased rise rate and the larger agglomerated bubbles are not efficient for DAF operation. System operating pressures less than 40 psi generates a large bubble that is inefficient and can break up the float layer.

Pressure Tank Water Level and Air Flow Rate

The pressure tank water level and airflow rates and the relationship between the two have been discussed above. Controlling the pressure tank level is important because it ensures that there is an air pocket in the chamber so that air can dissolve into the water at the required rate. If the tank is filled with water, the air will not dissolve into the water efficiently and performance of the DAF will decrease. Likewise, it the water level is too low the air will not dissolve in the water efficiently and DAF performance will decrease.

As stated above, the air pressure must be higher than the water pressure at the injection point. More importantly, to prevent filling the pressure vessel with water, the airflow rate must be higher than the water flow rate. The airflow rate through the flow meter should be set at approximately 0.10 SCFM for every 100 GPM of recycled water flow. For example, if the recycle water flow rate is 200 GPM the airflow rate is set at 0.20 SCFM.

Surface Loading

Surface loading is measured in terms of GPM/ft^2. The surface area of the Dissolved Air Flotation Separators (DAF-501 and DAF-551) is approximately 350 ft^2 each. The average flow per DAF is estimated at 1000 GPM. This results in a surface loading of 3.4 when the recycle flow rate is factored into the equation.

The surface-loading rate is dependent on the particle rise rate and the stability of the floc. If the rise rate is high, the particles will overcome the downward pull of the water passing through the DAF. If the surface-settling rate is too high, particles will be trapped in the water flow and exit with the effluent.

Flow stability is very important if the surface-loading rate is high. If the floc is fragile, it may break during high flow rates due to shearing forces. Additionally, smaller floc generally collects less air and is therefore less buoyant. These smaller, less buoyant floc particles tend to become trapped in the downward pull of the water passing through the DAF and end up in the effluent flow.

Chemical Conditioning

Jar testing provides a means to determine the optimum type and quantity of chemical conditioning agent. A jar testing procedure is presented in Appendix D. Ferric Chloride is added and mixed in the Aeration Tank to aid in the coagulation of the fine particles in the waste stream. A Cationic Polymer is then added to the DAF influent stream to flocculate the coagulated particles and form a large enough floc particle that easily entraps the fine air bubbles released by the DAF Recycle System. The typical chemical rates are expected to be in the range of 20 – 30 PPM of ferric chloride and 3 – 6 PPM of cationic polymer.

Float Skimming

Proper operation of the skimming operation is important to remove the float before the layer gets too thick that it carries out with the effluent. Because the float must be removed intermittently, a cycle timer is installed. Its function is to start and stop the skimming mechanism even when the system is unmanned. If the skimmer is not keeping up to the float formation, the OFF cycle should be decreased or the ON cycle should be increased. The longer the OFF cycle the higher the float concentration because of the thickening effect of the solids rising from below. However, a longer OFF cycle will require a longer skimming cycle.

TROUBLESHOOTING

Dissolved Air Flotation Units

CONDITION	PROBABLE CAUSE	REMEDY
Turbulent water surface	• Excessive air flow to the Pressurization system	• Reduce air flow as necessary, but no lower than a ratio of 1.5 cfm of air per 100 gallons of recycle flow
Solids carryover of the weirs	• Excessive air flow to the Pressurization system • Buildup of solids on DAF bottom • Lack of fine bubble dispersion on the DAF surface	• Reduce air flow as necessary, but no lower than a ratio of 1.5 cfm of air per 100 gallons of recycle flow • Check System operating pressure to verify that it is between 50 – 55 psig. • Pump DAF bottoms while operating screw conveyor • Check for level of air/water interface in the Pressurization Tank. Water level may be too high.
Small floc size at influent of DAF (1/8-inch or smaller)	• Check Polymer Feed	• Prime Polyblend LMI Pump • Clean or/replace LMI Pump head as necessary

CHAPTER 6
SAND FILTER AND EFFLUENT

GENERAL

Treated effluent from the DAF's flows via a 10-inch pipe into the Effluent Tank (T-601). The purpose of the tank is to act as the storage vessel for the Effluent Pumps. The Effluent Pumps pull water from the Effluent Tank and either direct flow to the front of the system, (System Recycle) for reuse or to the Sand Filter for further solids removal. From the Sand Filter, the treated water is pumped to the Las Vegas Wash. The UV disinfection system is available as a final disinfection step, but is not presently used.

EFFLUENT TANK (T-601)

Gravity flow of treated wastewater comes from the DAF's and enters the Effluent Pump Tank through a drop into the tank. The tank is 14-feet 0-inches in diameter with a 13-feet STR for a working volume of 15,200 gallons. The purpose is to temporally store treated wastewater prior to sand filtration, and final discharge to the Las Vegas Wash. A small portion of the effluent flow is used for service water.

The Effluent Pump Tank is constructed of fiberglass-reinforced plastic with a flat bottom, a drain, and it is equipped with a level transmitter (LIT-601). Discharge from the tank is through an isolation valve into an 8-inch CPVC pipe.

The design data for the Effluent Tank (T-601) is:

- 14 ft diameter
- 13 ft straight wall side
- 15,200 gallons

Detention time refers to the amount of time the water remains in the Effluent Tank. The approximate detention time for this tank at normal flow of 998 GPM is:

Detention Time min = Tank Volume (working volume) x 1 min/ Flow gal

= (14,200 gal) x 1 min/ 998 gal

= 14.2 min

EFFLUENT PUMPS (P- 601 & P - 602)

The fixed speed Effluent Pumps (P–601 / 602) draw water from the Effluent Tank and discharge to the front of the system(System Recycle) or to the Sand Filter (T-1702). The pumps are horizontal centrifugal pumps, rated at 1000 GPM at 93 feet TDH and are driven by 30 HP electric motors.

Normal operation calls for a flow of 900 – 1000 GPM discharge to the Sand Filter.

The Effluent Pumps draw suction from a common 10-inch suction header. The suction line for each pump has an 8-inch butterfly valve and an 8-inch x 6-inch expansion joint. Fixed speed motors drive the pump wet ends. Normally one pump will run continuously and the other pump will be in standby. The pumps are not intended to be run lead/lag, since there are no check valves.

Each Effluent Pump discharge passes through a 4-inch x 8-inch expansion joint to a 8-inch pipe with a pressure tap for a local pressure gauge (PI – 602), through a butterfly isolation valve. Both pump discharges then flow into a header followed by a check valve. Manual butterfly valves direct the flow to the System Recycle or the Sand filter. The operator sets the flow to the sand filter, at the human machine interface, HMI. Normal flow to the sand filter will be set at 1000 gpm.

SAND FILTER (T-1702)

The Parkson Dynasand Filter provides a unique filtration system since it continuously cleans the sand bed while filtering liquid suspensions to the designed effluent quality. Feed water is passed upwards through the sand bed, exiting from the top of the filter as clean water. At the same time, sand is continuously removed from the bottom, cleaned, and returned to the top. A small portion of the filtered water is used to wash the sand and leaves the filter as the filter reject stream.

The continuous sand filter with its associated solenoid valves is controlled by an independent control system. The interface with the main control system is limited to the filter high and high-high feed pressure alarms PAH-1702 and PAHH-1702. These are indicated and interlocked on the main control system. A high filter feed pressure is an indication that the filter is dirty. When PAH-1702 is activated, the filter air burst lines will open to increase the filter cleaning operation. Activation of PAHH-1702 causes a feed shutdown to the Perchlorate Treatment System (the FBRs continue to operate in recycle).

Once the water level in the continuous sand filter basin rises to the position of LSL-1702, air flow to the internal washing system commences. Level switch LSL-1702 also prevents the filter from dewatering after a process shutdown. PIT-1702, the continuous sand filter influent line pressure, detects a high filter inlet pressure, indicating a dirty filter. When PAHH-1702 becomes energized, burst air valves are opened for three seconds to increase the amount of air being delivered to the internal washing system to remove unwanted solids.

The unwanted solids removed by the sand filter leave the filter in the filter reject line, and are accumulated in the filter reject tank (T-1701). P-1701A/B pumps the filter reject water and solids to the thickener (T-602) under pump-down level control.

OXYGEN ADDITION

Clean water from the sand filter flows via gravity to the UV Effluent tank (T-621). FI-1601 controls the flow of 95% pure oxygen to the Perchlorate Treatment System effluent and should be initially set at ~60 standard cubic feet per hour (scfh). Adjustments to this rate should be made based on dissolved oxygen concentration readings at AP 10B using a hand-held dissolved oxygen meter and at other locations along the effluent discharge line.

BOOSTER PUMPS (P-1302A AND P-1302B)

Two (2) variable speed pumps (one standby) are used to increase the pressure of the effluent stream to enable the conveyance through the 3-4 mile effluent force main to the outfall. The pumps are located within Building D-1 and take suction from the UV effluent tank inside of Building D-1. The pump speed is controlled through the FBR control system based on the level in the UV Effluent Tank. During operation, the pumps speed up or slow down to maintain the UV Effluent Tank level constant.

The Booster Pumps transfer the effluent 4 miles to the system outfall near the Las Vegas Wash. The option exists to bypass the effluent to the GW-11 Pond. Compliance samples are taken at the discharge from the Booster Pumps.

EFFLUENT SAMPLING

The type of sample to be collected depends on the time available for the test to be performed and the test objective. One sample type is the “grab” sample, which consists of a portion of wastewater taken at one time. The other type is a "composite" sample, which consists of grab portions of wastewater collected in proportion to the flow volume and mixed in one vessel. The composite will be representative if the waste over the entire period under consideration. Uses of both types of samples are discussed below.

Grab samples may or may not be representative of average conditions, since they reflect only the condition at the instant of sampling. When grab samples are used to determine the efficiency of a treatment process, the effluent sample should be collected after a period of time corresponding to the flow through the period so that approximately the same waste is sampled.

For some tests, grab samples must be used. Such is the case if one wishes to determine conditions at a given time such as pH and dissolved oxygen or the sample cannot be preserved with respect to the constituent to be tested. Sometimes the object is to determine the effect of a substance on the treatment process. It can happen that the substance is present in high concentrations for only a short period of time. If individual portions were composted, an average concentration would be obtained. Thus, to determine the high concentration, grab samples should be examined.

Composite samples indicated the average character of a wastewater over a period of time, some samples to be composted should be collected with sufficient frequency that effects of intermittent changes in strength and flow are eliminated.

If the strength and flow do not fluctuate rapidly, hourly portions over a 24-hour period are satisfactory. If the fluctuations are rapid, half or quarter hours samples may be required. The period of sampling may vary from 4, 8, or 12 hours, depending on the personnel available and the use to be made of the result. Generally, composite samples are used to determine the character of the waste and the efficiency of the treatment units and the total treatment process.

CHAPTER 7
AERATION SYSTEM AND BIOFILTER SYSTEM

The biological treatment of perchlorate in the groundwater removes the dissolved oxygen from the water. To restore the dissolved oxygen, the treated water enters an Aeration Tank, T-401. A blower pushes air through diffusers in the bottom of the aeration tank that dissolve oxygen into the treated water. As the air passes through the water, it strips compounds from the water that can cause an odor. The biofilter captures the air stream from the aeration tank and removes the odor.

AERATION SYSTEM OPERATION

The aeration system operates continuously when water is being treated in the FBRs. Water exits the second stage separators and flows through the inlet valve, V-417 to the aeration tank. Under normal operating conditions the Second Stage Bypass Valve, V-3020, should be closed. Aeration of the treated water occurs in the aeration tank (T-401). Water overflows from the top of the aeration tank and into the selected DAF.

The operator must verify aeration blower (B-401) discharge valve V-411 is open and the biofilter prepared for startup. After the operator starts the Biofilter, the aeration blower can be started at the Aeration Tank SCADA screen. Then, treated water from the 2nd Stage separators can be sent to T-401 for aeration.

BIOFILTRATION SYSTEM DESCRIPTION

The H-120 Biofilter system, utilizing Envirogen's Biofilter Media, removes contaminant chemicals, such as hydrocarbons and reduced sulfur compounds, from the air in the aeration tank headspace. In the biofilter bed, microbes are responsible for degrading and eliminating the contaminants. Therefore, it is critical that the biofilter provide an optimal growth environment to enhance microbial development. This environment is created by maintaining proper temperature, pH, moisture, and nutrient levels. Specific optimal conditions will be further described in the subsequent sections of this manual.

Warm, moist, contaminated air enters the biofilter through the chamber below the media. Its velocity decreases as it enters the large media chamber, and it slowly flows upward through the biofilter media. While passing through the media, the contaminants in the air stream are metabolized and removed. The purified air passes through the upper chamber of the biofilter and out via a flange.

The mechanism of the biofiltration process includes a combination of absorption, adsorption, and biological degradation. A portion of the contaminants from the influent air are adsorbed on the surface of the media while the rest of the contaminants are absorbed into the thin film of water surrounding individual media particles. Microorganisms on the surface of the particles and in the water continuously metabolize the contaminants, converting them to water, carbon dioxide, and salts. For treatment of reduced sulfur odors, sulfate (i.e., sulfuric acid) is generated; for treatment of ammonia and other nitrogen-containing compounds, nitrate (i.e., nitric acid) is generated. In this sense, a biofilter may be described as a combination absorber and low-temperature oxidizer.

Important Considerations for Biofiltration

The following three conditions are essential for the operation of an Envirogen H-120 Biofilter.

1. The incoming air stream must be maintained as close to the dew point as possible (i.e., 100% relative humidity) prior to entering the biological treatment zone to prevent the media from drying out.

2. The incoming air stream should be set to maintain the filter bed temperature between 55 and 95°F (50 and 95°F if the vapor contact time is 28 seconds or higher), and preferably between 58 and 95°F. Optimal temperatures for the bed vary depending on the contaminants to be metabolized, the size of the bed and the flow rate of the air. Temperatures in excess of 100°F may severely affect biological activity.

3. Media moisture, pH, and nutrient levels must be maintained at appropriate levels.

The H-120 Biofilter System

Incoming air from the Aeration Tank enters the Shaw Environmental and Infrastructure H-120 Biofilter through a penetration in the inlet air plenum below the media chamber, and flows upward uniformly through the media. The first elements in the media chamber are the biofilter media support grating and mat. The support grating is constructed of FRP, and is designed to have an effective open area of 33% or greater. In order to prevent small media particles from passing through the grating, a PVC mesh mat is placed on top of the grating. Once the air has been treated in the biofilter media bed, the purified air passes through the upper chamber of the biofilter and out via a flange.

Envirogen's proprietary irrigation systems are placed within and above the media, thereby assuring that moisture and nutrients are directed to the specific locations within the biofilter where they will provide optimum benefit with minimum consumption of utilities. This internal approach to irrigation and nutrient addition provides a significant improvement in the efficiency and capacity of Envirogen's biofilters compared to conventional biofilters.

A layer of a porous, inorganic, granular media (SCORFIL) is placed on top of the mesh mat. Above this layer, an Envirogen Technologies internal irrigation system is placed. This irrigation system is used to periodically saturate the humidification media, thereby assuring that the air moving through the media will be close to 100% saturated with water before entering the biologically active layer(s) of the biofilter. The irrigation system is pre-manufactured and constructed of pressure-compensating polyethylene hose and fittings.

The biologically active layer(s) consist of Envirogen's proprietary biofiltration media (one or more layers of EnviroFil, and/or VAMFIL). A second pop-up spray irrigation system for the supply of nutrients and moisture is installed at the top of the media. This irrigation system is also used to flush out accumulated salts and acids as required to maintain the performance of the biofilter.

Envirogen's ScorFIL media is a proprietary mixture of lava rock nuggets. Envirogen's EnviroFil a media are proprietary mixtures of select tree barks and compost that have been treated to provide a maximum level of porosity and biological activity, low pressure drop, a high level of physical stability and predictable long life. The upper media layer is also amended with chemical fertilizer(s) that are washed into the lower sections of the bed with the water from the upper spray irrigation system during start-up.

The Blower and Inlet Ducting

The H-120 Biofilter operates with the blower, B-402, on the upstream side of the biofilter module(s); therefore, the system operates under positive pressure. The blower is sized for a head loss of 5 inches of water column at the design flow of 200 cfm.

The inlet ducting connects the blower discharge with the inlet air plenum(s). Butterfly dampers, V-404 and V-405, are used to balance the air flow to each module. The ducting includes plugged openings to allow for direct measurement of air flow.

Water and Nutrient Supply and Discharge

Water Supply

The water source for the biofilter is stabilized Lake Mead water. The water should be free of suspended solids and iron to prevent clogging of spray nozzles and irrigation hoses. Manually open V-401 to provide water.

For each biofilter, there are two branches - one for the lower humidification layer and one for the upper biologically active layer(s). Each branch enters the biofilter through the sidewall. The biofilter irrigation system will require an instantaneous flow rate of 4 gpm at 50 to 60 psig.

Irrigation Control

The upper and lower irrigation systems function independently. Each system has two timers, one for control of the irrigation cycle frequency and a second one for control of the irrigation cycle duration (i.e., two sets of two timers; four timers total). The upper irrigation systems function simultaneously (i.e., the upper irrigation systems are tied to a common control solenoid valve) and the lower irrigation systems function simultaneously (i.e., the lower irrigation systems are tied to a common control solenoid valve). Irrigation controls should be set based on the system flow rate, the inlet air temperature, the inlet air relative humidity, and the expected maximum inlet reduced sulfur (primarily H_2S) concentration. Guidelines for setting the irrigation timers can be found later in this Section 2.3 of this manual. Each irrigation leg also includes a rotameter, and a flow control valve (attached to the rotameters). Guidelines for setting the flow control valves can also be later in this Section 2.3 of this manual.

Nutrient Addition

The upper irrigation branch includes a nutrient injection system that delivers a nutrient solution to the top of the media whenever the upper irrigation system is activated. The nutrient injection system is composed of a flow-driven fertilizer injector, P-401, and a 55-gallon covered plastic tank, T-403. The nutrient tank requires periodic replenishment (every one to two months) with water from the irrigation supply line and a concentrated fertilizer stock solution (purchased from Shaw Environmental and Infrastructure or a local fertilizer supplier). The amount of concentrated nutrient solution required and the injection ratio setting depend on the sulfur load to the biofilter system and the upper irrigation system water requirement. Section 2.3 provides recommended guidelines for injector ratio setting and nutrient solution requirements.

Filtrate Discharge to Pump Transfer Station

Filtrate water generated by the biofilter drains by gravity from the inlet plenum to the filtrate discharge port where it will be collected and discharged through a loop seal prior to the Pump Transfer Station. The maximum amount of wastewater is an instantaneous flow of 2 gpm per H-120 module. The transfer pump, P-402, should be placed in Auto at the Aeration Tank SCADA screen. The water is returned to the treated water going to the DAF.

Control Panel

The H-120 Biofilter system includes a control panel that contains the irrigation timers and the blower motor starter. The control panel includes an indicator light and hand switch for blower operation.

Air Volume Control

The flow rate through the biofilter system should be measured using the discharge blower pressure and the blower curve provided by the manufacturer (see Appendix D). A 1-inch sample tap for a pressure gauge is provided on the downstream side of the blower. If the materials of the pressure gauge are not compatible with the contaminants in the air stream, the pressure gauge should not be installed permanently. The inlet damper(s) should be manually adjusted until the design flow is obtained. Excessive air flow can create voids in the media and also allow untreated air to pass through the system without sufficient contact time.

If more than one H-120 module is provided, the air flow rate to each of the units must be balanced (to within ± 10 percent) using the inlet dampers. The system may not perform as designed if the flows are not balanced. The ducting includes plugged openings to allow for direct measurement of air flow to the modules using an anemometer, pitot tube, or other flow measuring device. A plugged opening is not included for direct flow measurement to the module closest to the blower because the duct length is not long enough for an accurate measurement to be made. Flow to this unit can be determined by subtracting the flow to the other unit from the total flow to the system (determined from the blower curve).

Water Irrigation Control

Shaw Environmental and Infrastructure biofilter systems are equipped with two water irrigation control systems – a lower system for providing water to a humidification zone and an upper system for providing water and nutrients to the biologically active media layer(s). Each system has two timers, one for control of the irrigation cycle frequency and a second one for control of the irrigation cycle duration. If the biofilter system includes more than one module, the upper irrigation systems function simultaneously (i.e., the upper irrigation systems are tied to a common control solenoid valve) and the lower irrigation systems function simultaneously (i.e., the lower irrigation systems are tied to a common control solenoid valve). Each irrigation leg also includes a flow meter and a flow control valve.

The water irrigation control system requires a water pressure of 50 to 60 psig. Do not exceed a maximum of 60 psig pressure water supply. A regulator is recommended to maintain the desired water pressure.

Timer Operation

Both the upper and lower irrigation systems work on the basis of a cycle frequency and duration timer set. The timers are located inside the local biofilter system control panel. For operation of the irrigation timers, refer to the manufacturer's instructions.

The cycle frequency of the irrigation sequence is controlled by a repeat cycle timer (i.e., cycle contact closed for same time period as contact is open). The value of the cycle frequency F is input into the timer as ½ F (i.e., if you want the irrigation sequence to operate once every 30 minutes, the value input into the timer would be 15 minutes).

The duration of the irrigation sequence is controlled by an on-delay (i.e., one shot) duration timer. When the contact of the cycle timer is closed, it energizes the duration timer, which opens the solenoid. The duration timer contact remains closed until it is timed out, at which time the contact opens and the solenoid valve shuts. The process is automatically repeated during the next cycle timer irrigation sequence.

Lower SCORFIL Humidification Layer (Irrigation Hose)

The inert SCORFIL humidification layer at the bottom of each module ensures good air distribution of the incoming air. An irrigation network above this humidification layer meters water evenly over the inert under-layer at an instantaneous rate of 0.4 gallons per minute (gpm) per module. The combination of the SCORFIL layer and the irrigation network ensures that the air is as close to 100% relative humidity as possible prior to contact with the biologically active media. Heat created by the decomposition of organic and odorous compounds will vaporize some of the moisture in the filter material. A fully water-saturated air stream is necessary to compensate for the removal of water from the media by exothermic heat generation.

Since the lower irrigation hoses are pressure-compensating, changes in the delivery pressure will **not** alter the volume flow of water (i.e., 0.4 gpm per module) delivered via these hoses, provided the lower irrigation pressure is at least 20 psig (at PI-101; see Piping and Instrumentation Drawing PID-4) when water is flowing through the lower hose(s). Routine checks of the biofilter system should include measurement of delivery pressure (PI-101; see Piping and Instrumentation Drawing, PID-1 in Appendix B) and water flow [via rotameter FI-102]. Flowing water pressures significantly lower than 15 psig and water flow rates significantly higher than [1 gpm (if 2 modules)] [0.5 gpm (if 1 module)] may indicate an irrigation hose system rupture.

The guidelines provided in this section assume that the incoming air to the biofilter system is at a relative humidity of 75%. If actual measured relative humidity values are different than these assumptions, the SCORFIL irrigation controls should be adjusted accordingly. Table 7.1 below provides guidelines for the SCORFIL irrigation timer settings if a humidifier is not included.

The water volume supplied to the SCORFIL humidification layer via the lower irrigation system must be sufficient to maintain the SCORFIL in a saturated state. If it appears that the volume of water delivered exceeds the media's capacity (this will be evident by excessive drainage from the base of the module), the humidification layer duration timer setting (TMR-102B) may be decreased. Increasing the amount of water to be delivered can be accomplished by increasing the duration time (TMR-102B), and/or by decreasing the cycle frequency timer setting (TMR-102A). Adding excessive water to the SCORFIL will **not** damage the biofilter or compromise the system's performance. It is better to err on the side of too much water than not enough.

Table 7-1 SCORFIL Irrigation Timer Setting Guidelines

(Humidifier NOT Provided)

	Cycle Frequency TMR-102A Timer Setting (½ F) = 10 min			
	Air Flow per H-120 Module (acfm)			
	100	200	300	400
Inlet Air Temp. (°F) [1]	*ON Duration TMR-102B Timer Setting (sec)*			
60	35	70	100	130
70	35	70	100	130
80	35	70	115	150
90	40	75	115	150
100	40	75	115	150

[1] Inlet air temperatures less than 55°F (50°F if the vapor contact time is 28 seconds or greater) may require that the air be heated or that the system include provisions for adding caustic to the SCORFIL layer on cold days (US Patent #5,861,303). Consult Envirogen Technologies.

Upper Media Irrigation (Sprays)

The upper irrigation spray system is designed to provide water evenly to the top of the biofilter bed at an instantaneous flow rate of 1.4 gpm per module (at a spray nozzle pressure of 30 to 40 psig) to make up for moisture losses caused by biological heat generation and to flush acidic byproducts from the biofilter system. When treating air containing reduced sulfur compounds, the reduced sulfur compounds are converted into sulfuric acid, thus acidifying the media and potentially reducing the media life. Rinsing with water reduces the acidity level within the media. The upper spray irrigation network is also used to provide nutrients to the biofilter.

Since the upper spray nozzles are pressure-compensating only over the range of 30 to 40 psig, significant changes in the delivery pressure **will** alter the volume flow of water delivered via these nozzles (see the manufacturer's literature in Appendix D for more details). The spray nozzles will deliver a combined instantaneous water flow of 1.4 gpm per module at a nozzle pressure between 30 and 40 psig when **water is flowing**. Taking into account pressure losses through the nutrient injection system, the rotameter (FI-101), and other line losses, the pressure at pressure gauge PI-101 (see Piping and Instrumentation Drawing PID-4) should read at least 40 psig when water is flowing through the upper irrigation system. Flow through FI-101, the upper irrigation system rotameter, must be adjusted using ball valve [V-110 (if 2 modules)] [V-102 (if 1 module)] to provide a flow of approximately 1.4 gpm per module when water is flowing through the upper irrigation system. At this flow, the delivery pressure at the spray nozzles should be 30 to 40 psig. A flowing water pressure at PI-101 significantly lower than 40 psig could cause uneven water distribution. Routine checks of the biofilter system should include measurement of flowing water pressure (via PI-101) and water flow (via FI-101). Flowing water pressures significantly lower than 40 psig and water flow rates significantly higher than [2.8 gpm (if 2 modules)] [1.4 gpm (if 1 module)] may indicate an irrigation system rupture.

When treating reduced sulfur compounds, the water needed for removal of acidic byproducts usually far exceeds the water needed to make up for media moisture loss. Figure 1 provides guidelines for the upper irrigation system timer settings as a function of the sulfur load to an H-120 Biofilter system.

The water volume supplied to the upper irrigation system must be sufficient, at a minimum, to maintain the media very close to its moisture holding capacity. If it appears that the volume of water delivered exceeds the media's capacity (this will be evident by excessive drainage from the base of the module), the upper irrigation system duration timer setting (TMR-101B) may be decreased. Increasing the amount of water to be delivered can be accomplished by increasing the duration time (TMR-101B), and/or by decreasing the cycle frequency timer setting (TMR-101A).

Adding excessive water to the media will generally **not** damage the biofilter or compromise the system's performance. It is better to err on the side of too much water than not enough, *especially if the inlet air relative humidity is lower than anticipated, and the lower SCORFIL irrigation system is not able to sufficiently humidify the air (See Section 2.3)*.

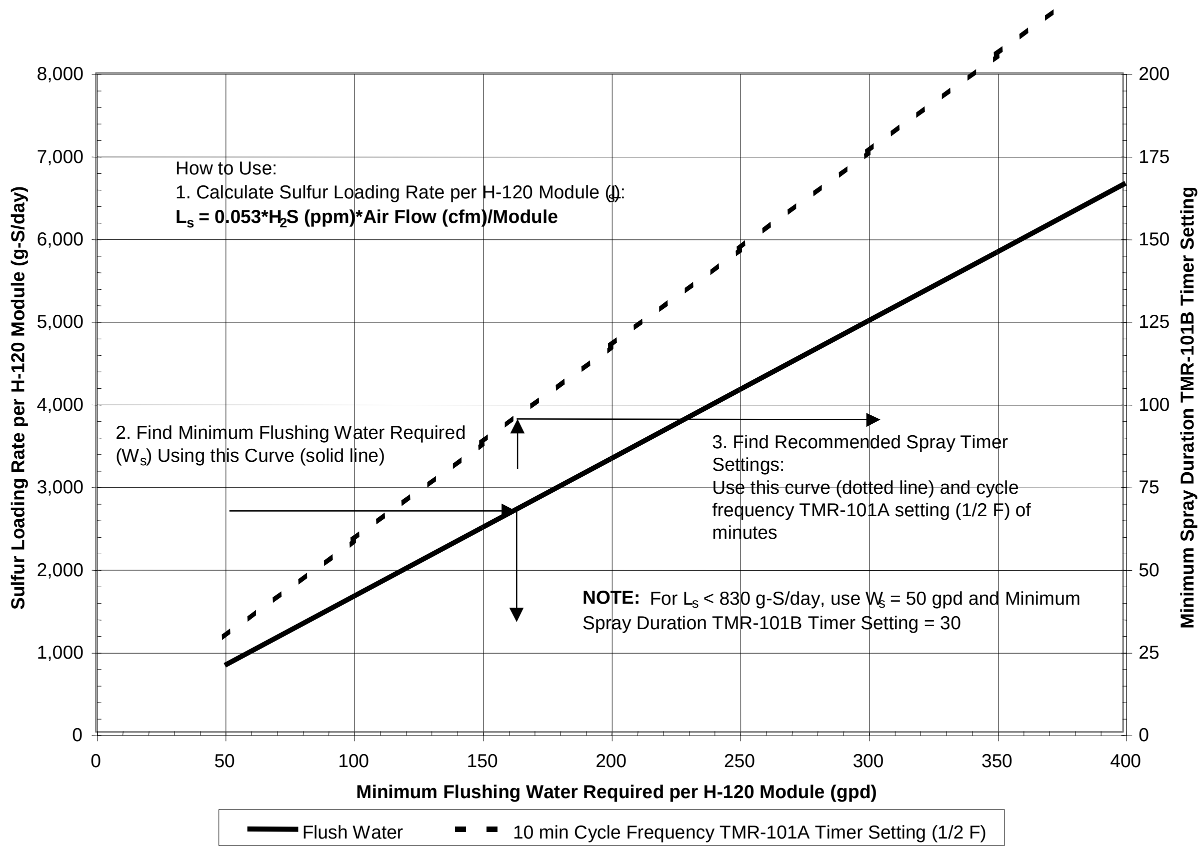


Figure 7-1 Upper Media Spray Irrigation Timer Setting Guidelines (Reduced Sulfur Compounds)

<u>Nutrient Injector Control</u>

The upper irrigation branch includes a nutrient injection system that delivers a small amount of a concentrated nutrient solution to the top of the media whenever the upper irrigation system is activated (see General Arrangement Drawing M-1 in Appendix B). The nutrient injection system is composed of a flow-driven fertilizer injector and a 55-gallon covered tank (liquid capacity of 50 gallons). The tank requires periodic refilling (every one to two months, depending on the number of H-

120 modules included with the system) with water from the irrigation supply (using valve V-103) and a concentrated fertilizer stock solution (purchased from an approved Shaw Environmental and Infrastructure list or a local fertilizer supplier).

Table 7-2 below provides guidelines for the nutrient injector ratio setting. The injector ratio is the ratio of nutrient solution flow to water flow through the injector. Table 7-3 shows the recommended minimum volume of nutrient concentrate to add to the feed tank if the upper irrigation timer settings recommended in Figure 7-1 and the injector settings recommended in Table 7-2 are utilized.

Table 7-2 Guidelines for Nutrient Injector Ratio Setting

Flushing Water per H-120 Module (gpd) [From Fig.1]	For One H-120 Module (Refill Every 60 Days)	For Two H-120 Modules (Refill Every 30 Days)
50	1/64	1/64
100	1/120	1/120
150	1/180	1/180
200	1/240	1/240
250	1/300	1/300
300	1/360	1/360
350	1/420	1/420
400	1/500	1/500

Table 7-3 Guidelines for Nutrient Solution Addition

	Minimum Gallons of Nutrient Concentrate Added to the Nutrient Tank When Nutrient Tank Contents are Refilled [1]	
Flushing Water per H-120 Module (gpd) [From Fig.1]	**For One H-120 Module (Refill Every 60 Days)**	**For Two H-120 Modules (Refill Every 30 Days)**
50	0.7	0.7
100	1.3	1.3
150	2.0	2.0
200	2.6	2.6
250	3.3	3.3
300	4.0	4.0
350	4.6	4.6
400	5.3	5.3

[1] Assumes the entire 50-gallon tank contents (liquid capacity) are replaced. Ratio accordingly if a partial refilling is conducted. The formulation for the nutrient concentrate solution is found below.

Nutrient Concentrate Formulation

A sufficient quantity of inorganic nutrients [i.e. primarily nitrogen (N) and phosphorus (P), but also smaller quantities of potassium (K) and other micronutrients] must be supplied to the microorganisms within the biofilter to efficiently degrade the constituents in the waste air stream. The nutrient injection system provides these inorganic nutrients to the biofilter system. If the feed water to the system contains N (in the form of ammonia-nitrogen or nitrate-nitrogen) and P (in the form of ortho-phosphate or low molecular weight polyphosphates), lower quantities of N and P can be supplied.

The materials making up the nutrient concentrate solution (i.e., liquid fertilizer) should contain nitrogen in the form of nitrate, ammonia, or urea. The phosphorus source should be in the form of low molecular weight polyphosphates. The liquid fertilizer should contain micronutrients (i.e., minor elements) and a minimum of 10 percent total nitrogen (N), 6 percent available phosphate (P_2O_5), and 2 percent soluble potash (K_2O), by weight. Local fertilizer suppliers should be able to meet the above specification. Upon request, Shaw Environmental and Infrastructure will provide a list of approved liquid fertilizers and suppliers. The nutrient (3.6 lb/gal urea & 1.8 lb/gal di-ammonium phosphate) and trace elements solutions used for the operation of the FBRs, in a ratio of 100 parts nutrient solution to 1 part trace elements solution (by volume), is acceptable, provided the water used for irrigation contains a sufficient amount of potassium (K).

BIOFILTER SYSTEM OPERATION

A 1/4" tap must be drilled into the inlet ducting on the downstream side of each butterfly damper as close as possible to the biofilter vessel(s) in order to measure the pressure drop across the media in each vessel. When not in use, the taps should be plugged.

Start-Up Program for the Biofilter

Smooth biofilter start-up is essential to develop a healthy microbial population and reduce possible future operational problems. It is recommended that start-up be performed by a technician familiar with Envirogen's biofilter operations and start-up procedures.

The operation is defined as "start-up" until the microbial culture fully develops in the media and is able to reduce contaminants in the inlet air to the desired level. Start-up may require between one and six weeks, depending on the contaminants, flow rates, and characteristics of the biofilter system.

During the start-up, the following steps should be taken.

- Inoculate the top of the media with a solid or liquid inoculum (provided by Envirogen) to boost bioactivity.
- Maintain appropriate media bed temperature [55 to 95°F; 50 to 95°F if the vapor contact time is 28 seconds or greater (preferably 58 to 95°F)].
- Monitor inlet, outlet, and internal (i.e., media) conditions.

Blower Start-up

Turn on the blower at the local control panel and confirm proper air flow from the source and discharge from the biofilter. Balance the air flow to each module using the inlet dampers.

Irrigation

During start-up and thereafter, the biofilter bed should be irrigated sufficiently to maintain the media very close to its water holding capacity (60% to 75% by weight for the organic VAMFIL and EnviroFil media; 30% to 35% by weight for ScorFIL media). Envirogen recommends that the media be visually inspected weekly during the first two weeks of operation. Irrigation rates should be adjusted as necessary based on these visual observations. The water used for irrigation must be free of excessive treatment chemicals (such as chlorine).

Irrigation Controls

Irrigation controls should be set based on the system flow rate, inlet air temperature, inlet air relative humidity, and the expected maximum inlet hydrogen sulfide concentration (see Section 2.3 of this manual for guidelines). The default settings are as follows:

- Upper Irrigation – 60 seconds every 20 minutes (1/2 F = 10 minutes)

- Lower Irrigation – 60 seconds every 20 minutes (1/2 F = 10 minutes)

These settings will be set in the control panel prior to shipment. If necessary, the settings should be adjusted during the start-up according to the guidelines in Section 2.3 of this manual.

Inoculation

Envirogen personnel will inoculate the biofiltration media bed prior to start-up.

Monitoring

The following parameters should be measured and closely monitored for the first two (2) weeks after introducing or increasing the inlet air flow:

- Flow rate(s)
- Inlet and outlet concentrations
- Inlet and outlet temperatures
- Inlet relative humidity
- Pressure drop across the bed(s)
- Drain water pH (from each module)

Biofiltration Bed Temperature

The optimal operating temperature range for the biofilter media is 55 to 95°F (50 to 95°F if the vapor contact time is 28 seconds or greater). In order to maintain this media temperature, the influent temperature may need to be heated in extremely cold environments. Cooling of the air is seldom necessary. During the start-up phase, Shaw Environmental and Infrastructure recommends monitoring the inlet air, outlet air, and biofilter bed temperatures. Lower temperatures will cause a longer start-up period. **Temperatures in excess of 100ºF may damage the media. Temperatures below 50ºF may render the microbes dormant.**

Biofilter Start-up Checklist

Table 7-4 Biofilter Start-up Checklist

MEASUREMENT	FREQUENCY [1]	RANGE
Flow rate	Daily	See job specific data

Inlet concentration	Daily	See job specific data
Outlet concentration	Daily	See job specific data
Inlet temperature	Daily	55 - 95°F range [2]
Outlet temperature	Daily	55 - 95°F range [2]
Inlet relative humidity	Daily	> 75% [2]
Pressure drop	Daily	0.75 - 1.50 inches w.c.
Drain water pH	Weekly	1.0 – 5.0 (for reduced sulfur)

[1] Sampling frequency should be adjusted depending on application, level of system controls, and position within the start-up schedule.

[2] 50 - 95°F if the vapor contact time is 28 seconds or greater.

GENERAL CONDITIONS FOR BIOFILTER OPERATION

Moisture Content of the Media

The biofilter bed moisture content should be maintained very close to its water holding capacity (60% to 75% by weight for the organic EnviroFil media; 30% to 35% by weight for ScorFIL media). It has been clearly demonstrated in the laboratory that biological activity declines rapidly when moisture content falls below 50% of the water holding capacity. Similarly, it has been demonstrated that a media moisture level at the water holding capacity can lead to the establishment of anaerobic microbial populations that can, in some circumstances, create objectionable odors. All of Envirogen's biofilter media formulations are designed to freely drain water, preventing the moisture content from reaching these high levels.

pH of the Media

If water is provided to the biofilter bed in accordance Section 2.3 of this manual, the media pH should be maintained within the range of 1.0 to 5.0 (when treating air containing reduced sulfur compounds). This media pH range is acceptable to sulfur-oxidizing microorganisms. A media pH level significantly below 1.0 may lead to accelerated media degradation. Since the water that drains from the biofilter bed is in equilibrium with the biofilter media, the drain water pH can be used as an indicator of media pH.

Nutrient Levels of the Media

Media nutrient levels must be maintained above certain minimum values to achieve optimal biofilter performance. As nutrient levels are a critical factor, the addition rate and formulation of the nutrient solution added to the biofilter media should be carried out in accordance with the instructions in Section 2.3 of this manual.

Byproduct Accumulations in the Media

The byproducts of biodegradation are treatment of reduced sulfur compounds, ammonia, other nitrogen-containing compounds, and halogenated hydrocarbons, result in production of biodegradation byproducts that include salts and/or acids. In order to assure the long-term operation of the biofilter, these materials must be periodically flushed from the biofiltration media when their levels become excessive. If water is provided to the biofilter bed in accordance with Section 2.3 of this manual, these byproducts will not accumulate in the biofilter media at levels that will be harmful to either the microorganisms or the media.

Temperature of the Inlet Air

The inlet air temperature to the biofilter media should be maintained between 55 and 95ºF (50 and 95°F if the vapor contact time is 28 seconds or greater) to assure both the desired operating efficiency and the long life of the media. Although the biofilter will operate at temperatures below this range, it has been demonstrated that, in certain applications, removal efficiencies decline at temperatures below 50ºF.

It has also been shown that in many applications removal efficiencies will remain at the targeted level at temperatures up to 100ºF. However, temperatures in excess of 100ºF will lead to accelerated deterioration of the media.

Temperature of the Outlet Air

Although the temperature of the outlet air is not, in itself, a concern, it should be periodically measured and compared with the temperature of the inlet air. Although certain Shaw Environmental and Infrastructure biofilters are designed to operate with a temperature increase across the media, most are not. For those that are not so designed, a temperature increase across the media is a significant indication that a problem exists. Failure to locate the source of the problem and address it in a timely fashion will result in severe and irreparable damage to the media.

Relative Humidity of the Inlet Air

In order to prevent drying out of the Biofilter Media, it is essential that the air that contacts the media be as fully saturated with moisture as possible (i.e., close to 100% relative humidity). Envirogen's proprietary humidification layer and its internal irrigation system allow Envirogen's biofilters to accept inlet air below the 100%

relative humidity level. It is anticipated that the air will be entering very close to 100% relative humidity.

Contaminant Concentration in the Inlet Air

Excessive inlet air concentrations of contaminant(s) may exceed the biofilter's removal capacity, while low concentrations may also result in lower than design removal efficiencies. Typically, excursions in inlet concentrations above the design capacity of the system are only transient in nature; when concentrations return to the design range, the design removal efficiencies are usually quickly achieved. Even during these excursions, removal efficiencies are typically very close to design values. Likewise, the lower removal efficiencies that may occur as a result of low inlet concentrations are not usually problematic because outlet concentrations during these periods are typically below problematic levels.

Inlet Air Flow Rate

Inlet air flow rate should be maintained within the range for which the biofilter was designed. Excessive air flow rate may exceed the biofilter's capacity, while low air flow rate may result in poor flow distribution within the media and the associated possibility of media drying.

Variations in Inlet Air Conditions

Variations in inlet conditions should be avoided unless the biofilter was specifically designed to handle them. Any substantial change in air flow rate, temperature, or contaminant concentrations may result in a period of sub-par performance during which the biofilter will establish a new equilibrium.

It is recommended that Envirogen be consulted before any substantial changes are made to the operating conditions of an Envirogen biofilter.

OPERATING GUIDELINES

GENERAL

Throughout the operation of the biofilter, a monitoring and maintenance program is required in order to maintain maximum system performance.

Envirogen recommends that experienced professionals inspect the biofilter system and operation at least once each year to assess general media health and the condition of system components.

The following should be regularly monitored and maintained as necessary:

- Moisture level of the media;
- Temperature of the media;
- Volumetric air flow rate;
- Contaminant concentration of the inlet and outlet air;
- Temperature of the inlet and outlet air;
- Relative humidity of the inlet air;
- Media pressure drop;
- pH of the drain water;
- Nutrient levels of the drain water.

Media Moisture Level

Measurement and Frequency:

Envirogen recommends a visual inspection of the media surface and six (6) to twelve (12) inches below the surface on a quarterly basis, or when system performance is not as expected. This is accomplished by removing the H-120 module cover(s) and physically climbing into the biofilter(s) (see Site Specific Health and Safety Plan and Section 1.2.3 for safety precautions). Care should be taken not to walk or stand directly on the media. Doing this may compact the media and could cause uneven gas distribution. A minimum 3'x3' plywood sheet should be placed on top of the media as a support for standing. If using VAMFIL or EnviroFil media (i.e., organic media), Envirogen recommends additional core sampling at different depths throughout the media. Once the media samples have been obtained, the moisture content should be determined by weight loss during a twenty-four (24) to forty-eight (48) hour oven drying at 100°F to 105°F using the following formula:

$$\% \text{ Moisture} = (W_1 - W_2)/W_1 \times 100\%$$

where: W_1 = weight of sample before drying;

W_2 = weight of sample after drying.

If the samples cannot be analyzed immediately, they should be stored in sealed containers and refrigerated.

Following procurement of the media samples, any holes in the media bed should be carefully filled with media and watered.

Maintenance and Troubleshooting:

If dry areas are observed, they should be packed down and watered. All spray nozzles should be checked and cleared of debris if plugged. If the analyses indicate excessive or inadequate moisture levels, the irrigation schedule should be adjusted accordingly.

When using exclusively VAMFIL or EnviroFil, if the moisture content drops below 60%, in addition to adjusting irrigation timer settings, water should be immediately added batch wise as follows, 5-10 gallons at a time, with 10 minutes between additions for best absorption:

VAMFIL or EnviroFil Moisture Content (%)	Quantity of Water Added (Gallons per H-120 Module)
40%	28
45%	24
50%	20
55%	15
60%	9

<u>Media Bed Temperature</u>

The biofilter media temperature should be maintained between 55°F and 95°F (between 50°F and 95°F if the vapor contact time is 28 seconds or greater). Lower operating temperatures may reduce microbial activity while higher temperatures can damage the media, or contribute to accelerated physical degradation.

Measurement and Frequency:

After start-up, the media temperature should be checked quarterly at a minimum, or when system performance is not as expected. The media temperature should be checked at several locations and media depths by carefully inserting a compost thermometer (with 3-foot length or greater) into the media through the 4" inspection port neat the top of each unit. Care should be taken not to damage the thermometer, especially if inserting through ScorFIL media. Never force the thermometer through the media. Instead, if resistance is encountered, gently wiggle the thermometer around until a less obstructed area is found, or pull out the thermometer and insert it in a different location.

Maintenance and Troubleshooting:

If monitoring indicates consistent media temperatures above 95°F, the pressure drop across the system should be checked, the ducting should be inspected for blockage, and the blower should be inspected for proper operation. If the high media temperature is due to a high feed air temperature, methods for cooling the air should be considered (i.e., by diluting the feed air with fresh air or by placing a humidifier upstream to promote evaporative cooling). If the media temperature is consistently lower than specified and system performance is not as expected, methods for heating the air should be considered (i.e., by placing a heater/humidifier upstream).

<u>Volumetric Air Flow Rate</u>

Excessive flow can create voids in the media and can also allow untreated air to pass through the system without sufficient contact time. In contrast, very low air flow rate may not create enough pressure drop across the media, resulting in uneven air distribution across the media.

Measurement and Frequency:

The measurement of air flow through the biofilter module(s) is described in Section 2.2. The air flow through the module(s) should be monitored on a quarterly basis or when biofilter performance is not as expected.

Maintenance and Troubleshooting:

If the total air flow through the system or the air flow through the individual modules (if more than one module is provided) is not within ± 10 percent of the design value(s), adjust the air flow using the butterfly dampers as described in section 2.2. If the design air flow cannot be attained, the pressure drop across the system should be checked, the ducting should be inspected for blockage, and the blower should be inspected for proper operation. If the pressure drop across the biofilter media is less than 6 inches of water column and the ducting is not blocked by debris, the blower fan blades and motor should be inspected; consult the blower manufacturer (Appendix D). If the pressure drop across the media is greater than 6 inches of water column, the media should be replaced.

Contaminant Concentrations

Measurement and Frequency:

The influent and effluent gas contaminant concentrations should be monitored monthly during normal operation. If possible, measurements should be taken every 1 to 2 hours during a full twenty-four (24) hour day to determine both the average contaminant concentration as well as the maximum and minimum values. If the primary contaminant of concern is hydrogen sulfide (H_2S), a hand-held H_2S analyzer and/or H_2S detection tubes can be utilized. The feed H_2S concentration can be determined by withdrawing samples on the downstream side of the blower using the 1-inch sample tap (see Piping and Instrumentation Diagram Drawing PID-1 in Appendix B). Effluent concentrations should be withdrawn by inserting a thin sample line (i.e., Teflon® tubing or equivalent) into the space above the media through the 4" inspection port of each unit.

An increase in outlet contaminant concentrations may indicate a decrease in biological activity (provided the inlet concentrations are within design specifications). If this occurs, Shaw Environmental and Infrastructure recommends that the bed be visually checked for dry spots, samples of media be analyzed for moisture (if the media is composed of only VAMFIL or EnviroFil), and that the pH and nutrient levels of the drain water be checked. Based on the results of this monitoring, actions such as additional irrigation, nutrient addition and/or inoculation should be taken.

Abnormally high inlet concentrations may overload the biofilter beyond its capacity to remove all contaminants efficiently. Inlet concentrations in excess of design may cause an "overloading condition". If this is observed, repeated inlet samples should be collected to document loading for possible re-sizing.

Inlet and Outlet Air Temperature

Measurement and Frequency:

The inlet air temperature is used to set the timer settings for the lower irrigation system (See Section 2.3.2). After start-up, the inlet and outlet air temperatures should be checked monthly at a minimum, or when system performance is not as expected. The inlet temperature should be checked by inserting a thermometer or thermocouple into the 1-inch sample tap (see Piping and Instrumentation Diagram Drawing PID-1 in Appendix B) on the downstream side of the blower. The effluent air temperature should be checked by inserting a thermometer or thermocouple into the space above the media through the 4" inspection port of each unit.

Troubleshooting:

If monitoring indicates consistent inlet temperatures above 95°F, methods for cooling the air should be considered (i.e., by diluting the feed air with fresh air or by placing a humidifier upstream to promote evaporative cooling). If the inlet air temperature is consistently lower than 55°F and system performance is not as expected, methods for heating the air should be considered (i.e., by placing a heater/humidifier upstream).

The microbial activity inside the media tends to generate heat, which tends to warm the air as it passes through the biofilter. In addition, the incoming air may cool slightly as its velocity is decreased entering the plenum below the biofilter. Other factors, such as the difference in temperature between the biofilter and its surroundings, may alter the temperature of the air passing through the biofilter media.

A slight temperature decrease across the biofilter will tend to increase moisture levels in the biofilter media, and therefore, decrease the need for irrigation. This is not a threat to the performance of the biofilter.

An increase in air temperature through the biofilter media of even 1°F or 2°F may result in evaporative losses of moisture that could dry the biofilter media and threaten its performance. Therefore, if a consistent temperature increase is found in the air passing through the biofilter media, Envirogen recommends that careful attention be given to the moisture content of the biofilter media and additional irrigation be performed to ensure that the media does not dry out.

Relative Humidity of the Inlet Air

The inlet air relative humidity (RH) is used to set the timer settings for the lower irrigation system (see Section 2.3.2). The inlet RH should be 75 percent or greater. If the RH is less than 75 percent, the lower irrigation timer settings should be changed to provide more water to the SCORFIL layer. If the RH is significantly less than 75 percent (i.e., less than 60 percent), the lower irrigation system may not be effective in providing enough moisture to the air (i.e., as close to 100 percent RH) prior to contact with the biologically active media layers. This may result in the media drying out and becoming permanently damaged.

Measurement and Frequency:

After start-up, the inlet RH should be checked monthly at a minimum, or when system performance is not as expected. The RH should be checked by inserting a wet bulb/dry bulb thermometer or similar RH-measuring device into the 1-inch sample tap (see Piping and Instrumentation Diagram Drawing PID-1 in Appendix B) on the downstream side of the blower.

If monitoring indicates consistent inlet RH values below 75 percent and the media consistently appears (or is measured) to be below its water-holding capacity, methods for increasing the relative humidity of the inlet air should be considered (i.e., by placing a humidifier upstream).

Pressure Drop Across Biofiltration Media

As the media ages, its average particle size will decrease. The smaller particles cause an increase in the pressure drop across the media bed. Eventually, the particle sizes decrease to the point at which air no longer easily passes through the biofilter bed. At that time the media must be replaced.

Measurement and Frequency:

The pressure drop across the biofilter media in each module should be monitored on a quarterly basis. To measure this parameter, a water manometer or pressure gauge (0 to 10 inches of water column) should be inserted into a 1/4" tap in the inlet ducting on the downstream side of the butterfly damper of each module. The pressure at the effluent of each module is assumed to be one atmosphere. The taps are not pre-drilled; they must be drilled in the field (see Section 3.2.7). When not in use, the taps should be plugged.

If the pressure drop across the media increases to 6 inches of water column at the design air flow rate, Envirogen recommends that the media be replaced.

pH of the Drain Water

Measurement and Frequency:

The pH of the drain water should be measured on a monthly basis or when system performance is not as expected. Remove the cover from the drain water sump and collect a grab sample. The sample should be measured using a pH probe or pH paper.

The pH level of the biofilter drain water should be above 1.0. If drain water pH is less than 1.0, change the upper irrigation timer settings to allow for increased water addition to the media.

Nutrient Levels of the Drain Water

If nutrients are supplied to the biofilter in accordance with Section 2.4, the microorganisms within the media should have an ample supply of nitrogen (N), phosphorus (P), and trace elements. However, by tracking historical nutrient levels in the drain water, one can better diagnose if a nutrient deficiency is a possible cause of deteriorating system performance.

Measurement and Frequency:

The nutrient levels of the drain water should be measured on a quarterly basis or when system performance is not as expected. Drain water samples should be collected (from one of the modules on a rotating basis if more than one module is provided) by removing the cap from the loop seal and inserting a Teflon® sample line connected to a syringe. The samples should be sent to a laboratory for measurement of ammonia-N (using EPA Method 350.2 or equivalent), nitrate-N (using EPA Method 300.0 or equivalent), total Kjeldahl nitrogen (using EPA Method 351.3 or equivalent), phosphate-P (using EPA Method 365.2 or equivalent), and total phosphorus (using EPA Method 365.2 or equivalent).

The nutrient feed tank should be replenished regularly according to the instructions in Section 2.4. If the nutrient feed tank is not being emptied at the anticipated rate, the nutrient injector should be checked for proper operation and leakage. If the nutrient injector is working properly and no leakage is observed, the nutrient injection ratio setting should be increased (see Section 2.4 for details on how to set the injection ratio). If the tank is being emptied at the anticipated rate, and the performance is not as expected, check the nutrient levels in the drain water against historical values. If nutrient levels are lower than historical values, there may be a leak in the nutrient injection line. If a leak is identified, it should be repaired immediately.

CHAPTER 8
EFFLUENT DISINFECTION

OVERVIEW

A UV system is available, but no longer used for germicidal disinfection of system effluent at the Nevada Environmental Response Trust Perchlorate Removal System.

The system used is a WEDECO IH - 40L – R, Ultraviolet Treatment Unit. The UV unit is designed to destroy microorganisms for industrial water systems. UV light is defined as electromagnetic radiation having a wavelength less than that of visible light (400 nm) and greater than that of x-rays (100 nm). The unit of wavelength used is a nanometer (nm) equal to 10-9 meters. The optimum UV wavelength for germicidal effect is 254 nm, which is found only in small amounts in solar radiation because energy at these wavelengths is absorbed by the atmosphere.

The primary source of UV energy in current technology is the low pressure mercury arc lamp. The low-pressure UV lamp is universally accepted as the most efficient and effective source for disinfection systems application. The primary reason for its widespread use is that approximately 85% of its UV energy output occurs at the wavelength of 254 nm. The radiation is generated by striking an electric arc through mercury vapor; discharge of the energy generated by excitation of the mercury results in the emission of the UV light. UV light with a wavelength of 254 nm causes a rearrangement in the genetic code of microorganisms, preventing them from reproducing. The Ultraviolet lamp peak radiation of 254nanometer (nm) wavelength destroys or inactivates the DNA (deoxyribonucleic acid), which absorbs the Ultraviolet radiation. DNA is the major constituent of all microorganisms. The UV unit provides a minimum dosage of 30,000 microwatt seconds per square centimeter @ End of Lamp Life (EOL).

UV Transmittance is defined as the percentage of UV light at 254 nm not absorbed after passing through 1 cm of effluent sample. The percent transmittance depends on the amount and type of dissolved and suspended matter in the water. Reduced transmittance lowers the intensity of the light in the liquid, thus requiring longer exposure time in order to deliver the proper UV dose. The visual clarity of a water sample is not always a good indicator of its UV transmittance since water that is clear to visible light may absorb invisible ultraviolet wavelengths.

The UV Disinfection Unit is manufactured out of 316L stainless steel with removable gaskets and end plates. The end plates have stainless steel threaded connections that the quartz sleeve is inserted through and then sealed by the use of O-rings and gland nuts. The ultraviolet lamp has watertight and vibration - resistant lamp sockets that lie inside the quartz sleeve. There are quartz lamp covers located on both ends providing protection for the lamp/quartz and lamp socket assembly.

The model IH – 40 – R unit has a 6-inch inlet and outlet flange connection and will provide a water disinfection flow rate of 1000 GPM maximum. The unit has a remote electrical enclosure for control of the system operation. There is a LED Display panel located on the front of the enclosure. Each LED connects electronically to the ultraviolet lamp circuitry of the corresponding lamp. When the led is “on” the corresponding UV lamp is on. When the led is “off” the corresponding UV lamp is off. Numbers at each UV lamp position, on both ends of the vessel, correspond with LEDs on the display panel. This numbering system allows the operator to easily determine which specific lamp requires attention. Daily monitoring of the LED Display is essential to ensure proper performance. There is a non-resettable elapsed running time meter that counts up to 99,999 hours to alert the operator for scheduled maintenance.

There is an Automatic Quartz Sleeve Wiper assembly on this unit. The wiper is a pneumatically driven cylinder attached to wiper rod assembly through the end plate of the unit. The wiper rod assembly is a series of wiper plate discs with EPDM wiper rings. The quartz sleeves are inserted through the wiper rings. A solid-state autotimer, preset at the factory for every 6 hours that automatically actuates the wipe assembly to wipe the length of the quartz sleeves. The wiper system completes a full stroke in less than 30 seconds. The wiper system recommended operating pressure ranges from 45 to 50 PSI.

Operational interface from the Remote panel is provided by three dry contacts and one 4-20mA DC isolated signal output.

The dry contact monitoring is for:

- High Temperature Alarm

- Low UV Intensity Alarm
- Lamp Out Alarm

The 4-20mA signal is to monitor the relative ultraviolet intensity. Note: Periodic field calibration adjustments may be necessary.

SAFETY PRECAUTIONS

- Never look at the ultraviolet light with the naked eye. The light will cause burning and irritation to unprotected eyes and skin.
- Always disconnect power before servicing the unit.
- Make sure the unit is properly grounded.
- Only qualified personnel should attempt to work on this unit.
- Contact the factory before servicing the unit.

OPERATIONAL REQUIREMENTS

- Operating pressure should not exceed 150PSI
- Maintain air pressure to the automatic wiping system at 70-80 psi
- Minimize water hammers
- Inlet water temperature should not exceed 100 degrees F
- Effluent water meets acceptable standards. Water levels less than 20 NTU of turbidity, less than 15 TCU color, and 0.2 ppm of iron or other organic matter.
- Do not leave the UV unit on with no water running through it for over an hour.
- Do not cycle the UV unit more than 6 times in a 24 hour period.
- Do not exceed the system flow rate.
- A water-sampling program should be followed to ensure delivery of the desired water quality.

PROCESS DESCRIPTION

Effluent Disinfection

Sand filter effluent flows via gravity to the UV effluent tank (T-621). The UV system utilizes low-pressure mercury vapor lamps and includes provisions for automated cleaning of the lamps with a quartz sleeve wiper system. These controls include a separate LED control interface along with UV dosage monitoring. After UV disinfection there is an independent turbidity sensor that monitors the quality of the effluent water. The UV system interface with the main system controls includes the monitoring of various alarm and status conditions and treatment flow through the UV system.

UV Disinfection Unit (X-621)

Effluent from the sand filter feeds the UV unit through a 10" CPVC pipe. There are three 10" butterfly valves, one each on the inlet and outlet flanges of the UV unit, and there is one on the main line allowing for bypass of the UV Unit. On the inlet side of the UV unit there is a 10" by 6" concentric reducer. Water flows through the UV system where it exposed to UV light and exits the outlet side by a 10" by 6" concentric reducer at treated effluent. Flow out of the UV unit continues in a 10 inch CPVC pipe to the UV effluent tank. Flow indicator/transmitter FI/FT-622 measures treated water flow where that is discharged through several miles of underground piping to the Las Vegas wash. A bypass exists to direct the treated water to the GW-11 pond. The UV disinfection system is constructed of 316L stainless steel and has 40 lamps used for water disinfection. The unit has a remote control panel mounted next to the unit. The remote control panel controls the operation of the UV unit and reports status back to the HMI/PLC.

CHAPTER 9
SOLIDS HANDLING SYSTEM

GRAVITY THICKENING

The biological solids removed from the DAF's and the excess biomass from the FBRs is in the form of very dilute sludges. The stabilization and dewatering facilities are used to remove solids from the perchlorate process. A gravity thickener is available to increase the concentration of solids prior to the conditioning solids for removal in the filter press, but the thickener is no longer used. required to treat this dilute sludge would have to be rather large and inefficient. Experience has shown that it is much less expensive to thicken the sludge beforehand to reduce the liquid volume to be treated. This reduces the size required for the subsequent sludge treatment facilities and enhances the efficiency of most processes.

PROCESS DESCRIPTION

The most common sludge thickening process is the type utilized at the Nevada Environmental Response Trust Perchlorate Removal System, a gravity thickener. The primary purpose of the gravity thickener is to concentrate the total solids content of the waste sludge to a higher percent solids concentration. This has the effect of reducing the sludge volume that must be stabilized and dewatered prior to disposal.

The gravity thickener is circular in shape with an average sidewall depth of about 18 feet. Dilute sludge from the DAF Float Box, the second stage FBR Biomass separators, and the sand filter reject is continuously fed to a stilling well in the center of the tank. A Cationic Polymer is continuously added to the stilling well and the Thickener Flocculation Mixers gently mix the contents of the stilling well. This aids in forming a solid floc particle that will rapidly settle to the bottom of the Thickener. Stabilized Lake Water is also added to the Center Well of the Gravity Thickener to maintain a constant steady hydraulic loading to the Thickener. This serves to make up hydraulic loading to the Thickener during the intermittent times that the DAF Float Pumps are not being called for operation based on their ON/OFF Timers.

It is imperative that the cationic polymer flow be stopped if sludge flow to the thickener is discontinued. The liquid-solids mixture passes under the baffles forming the stilling well and begins to flow radially upward through the tank. As the mixture rises, the solids separate from the liquid phase and settle to the bottom of the tank by gravity. The liquid fraction or supernatant rises to the surface and is removed from the tank by an effluent trough with V-notched weirs located around the perimeter of the tank. The supernatant is recycled to the Aeration Tank via a gravity line that feeds the suction of an air diaphragm pump. The diaphragm pump is needed to give the Thickener overflow the necessary head pressure to overcome the water column in the Aeration Tank.

The solids that settle to the bottom of the tank are allowed to accumulate and form a sludge blanket. The weight of the solids in the sludge blanket exerts a continuous squeezing or compressing force on the solids in the lower layers that aids compaction. A circular sludge scraper or collector continuously rakes the solids along the sloped bottom of the tank to a central sludge hopper. To further aid the compacting of the settled sludge, vertical pickets or arms attached to the sludge collectors gently agitate the sludge blanket as the collector rotates. This gentle stirring increases the sludge compaction by breaking up flocculated sludge particles and releasing entrapped moisture from the sludge blanket.

Optimum performance of the biological treatment processes and the filter press process are closely related to the performance of the gravity sludge thickener. Poor performance of the gravity thickener may result in a sludge of a low percent solids going to the conditioning tank and filter press, as well as solids carryover to the Aeration Tank. The efficiency of the filter press is optimized at higher feed sludge solids concentrations. If the thickener is producing a sludge with a lower solids content, the solids holding capacity of the conditioning tank is reduced. The organic load contained in the thickener effluent is increased, if solids carryover occurs. Recycling this flow to the Aeration Tank can place an excessive solids loading on the process. This disrupts the air to solids balance in the DAF’s and reduces the efficiency of the process.

PROCESS CONTROLS

The major variables affecting the operation and performance of the gravity thickener are:

1. Sludge Blanket Depth
2. Solids Detention Time
3. Influent Solids Concentration
4. Hydraulic Loading Rate
5. Solids Loading Rate
6. Temperature
7. Type of Sludge

The operator has very little control over the last three variables. The other variables may all be controlled either directly or indirectly by the thickened sludge pumping rate and the amount of flow admitted to the thickener.

Operating experience has indicated the need to maintain a sludge blanket in the thickener to assist in the compaction of the sludge solids. This compaction results from the layers of solids exerting a squeezing or compressing force on those below. The sludge blanket depth should be maintained at 3-feet or less in depth. The sludge blanket depth is generally controlled by the thickened sludge withdrawal rate. The pumping rate should be adjusted to maintain the sludge blanket depth at 3-feet or less. The pumping rate for the sludge from the Thickener is adjusted by the operator adjusting the P-603 Pump Timers on the SCADA System. Sludge blanket depths greater than this will only increase the likelihood of septic conditions and/or solids washout developing.

The length of time that the solids remain in the thickener is also controlled by the thickened sludge pumping rate. The pumping rate for the sludge from the Thickener is adjusted by the operator adjusting the P-603 Pump Timers on the SCADA System. The longer the solids detention time in the thickener, the greater is the thickened sludge concentration. However, if the solids detention time is too long, septic conditions will develop. Thus, the thickened sludge withdrawal rate must be adjusted to maintain the solids detention time at a point somewhere in between.

Generally, a solids detention time of less than 24 hours will achieve maximum compaction and prevent septic conditions.

The influent solids concentration can vary depending on the source of the wasted solids, waste biomass versus DAF float. In general, it has been found that optimum results are achieved when the influent solids concentration is between 0.5 and 1.0 percent solids. Within this range, sludge compaction and supernatant clarity are optimized. Generally, a thicker sludge will be obtained as the influent sludge volatile solids content decreases.

The hydraulic loading rate also depends on the source of the waste solids and solids wasting practices. **Ideally, the operator should maintain a continuous rate of flow through the thickener by having the Biomass Separators online.** Maintaining a relatively constant hydraulic loading also provides a means of estimating the thickened sludge withdrawal rate and enables continuous feed of polymer to the thickener.

The solids loading rate or pounds of solids applied to the thickener surface per day is largely determined by the solids wasting requirements of the other treatment processes. It is estimated that solids loading to the thickener will be 1350 pounds per day. The solids wasting practices may be modified to enhance the performance of the thickener, but in terms of the total pounds of solids, there is little the operator can control. Optimum performance of the other processes, such as the fluid bed reactor process, requires wasting certain amounts of solids per day as needed to maintain proper conditions in the tanks. Therefore, these other processes will generally determine the total amount of solids, which must be wasted to the thickener each day or the solids loading on the thickener. However, the operator can control the rate at which the solids are applied to the thickener to optimize its performance. The performance and process control of both the fluid bed reactor process and the sludge thickening process can benefit by wasting smaller amounts of solids several times each day rather than large amounts once a day. This maintains a relatively constant loading rate on the thickener and produces a less dramatic change in the FBR tank conditions, both of which will enhance the control of each process. In addition, this applies to solids removed from the DAF's. It is better if the sludge is pumped from the DAF's several times a day in small quantities rather than once a day in large volumes.

Note: The system was originally designed to operate one DAF Sludge Pump for a sustained amount of time. Running both DAF Sludge Pumps at the same time will eventually surcharge the Thickener and ultimately overflow the Stilling Well in the center resulting in the short-circuiting of solids through the Thickener and increased loading back to the DAF's. Timer settings within the SCADA System should be configured so that operation of the two Float Pumps is staggered.

MAJOR COMPONENTS

Thickener Tank

The major structural component of the sludge thickening is the Thickener Tank (T-602). The bottom of the tank is sloped towards the center of the tank to form an inverted cone to accommodate the sludge collector mechanism. The sidewall water depth is about 18 feet and the center tank depth is 16 feet. The tank has a volume of about 47,300 gallons.

Feed sludge enters the tank through a 2-inch CVPC inlet pipe from the DAF's and the FBRs. Sludge flow from the FBRs is by gravity while, Sludge from the DAF's is pumped over by the DAF Float Pumps (P-502 & P-552). The influent sludge pipe discharges to a central stilling well formed by a 6-foot diameter circular baffle. Here, flocculent (Cationic Polymer) and ferric chloride can be introduced to aid in solids separation. The baffle forces the flow downward and under the baffle to depth of about 4 feet. Once under the baffle, the dilute sludge flows radially outward from the center and upward allowing the solids to settle out. An effluent trough with V—notched weirs located around the perimeter of the tank surface collects the thickener effluent or supernatant, which is discharged to the Aeration Tank. The thickened sludge is raked by the sludge collector mechanisms to a sludge hopper at the center of the tank bottom. A 4-inch diameter thickened sludge draw-off pipe connects the sludge hopper to the sludge thickener underflow pump.

Sludge Collection Mechanism

The gravity thickener utilizes a motor driven circular sludge scraper mechanism to move the settled solids along the sloped tank bottom to the sludge hopper.

The collectors consist of numerous steel rakes or plows attached to two radially mounted arms supported from a rotating drive cage around the center support pier.

The vertical pickets gently agitate the settling sludge as the collector arms rotate allowing entrapped moisture to escape enhancing the solids compression.

The collector arms move the solids along the conical tank bottom towards the sludge hopper and sludge draw-off pipe at the center of the tank. The collector arms are designed to sweep the entire tank bottom twice every revolution. The Scraper / Rake collector mechanism (M-611) is driven by a 1/2 hp 460 VAC 3 PH electric motor mounted on the walkway over the center support pier. The sludge thickener collection equipment is provided with an overload device to protect it from damage due to being jammed by foreign objects or overloaded by excessive accumulations of solids in the tank. A local torque alarm will shut down the rake drive motor under preset conditions.

Underflow Pump (P-603)

The fixed speed Underflow Pump (P–603) draws sludge from the Gravity thickener Tank and discharges it to the Sludge Storage Tank (T-1603). The underflow pump is a Penn Valley 3” double Disc Electric Diaphragm pump, rated at 150 GPM at 15 feet TDH and is driven by a 7.5 HP electric motor.

The Underflow Pump draws suction from the bottom of the thickener tank through a 4 - inch CVPC line. The suction line for the pump has a 4-inch plug valve and a 4-inch x 3-inch expansion joint. The pump discharge is a 3-inch CVPC pipe through a 3 - inch plug valve to the Conditioning Tank (T-901).

The pump is equipped with a HAND/OFF/AUTO switch located in close proximity of the pump. With the switch In the Manual mode, the pump is started and stopped locally. With the switch in the OFF mode, the pump start is disabled. (Note: use proper lock out tag out procedures when performing maintenance on the pump). When the switch is in AUTO, the pump will start automatically from the HMI screen and the PLC based on ON/OFF Timers. The operator is required to enter both an On Time in minutes and an OFF Time in Minutes to effectively control the pump in AUTO.

Sludge Storage Tank (T-1603)

Divert the thickener (T-602) underflow to T-1603 by closing valve V-623 and opening valves V-4910 and V-4820. The timer settings for the thickener underflow pump (P-603) should be set to deliver a steady flow of sludge from T-602 to T-1603. The sludge level in the thickener should be monitored frequently initially to maintain a "steady-state" sludge interface. Biological solids from the FBRs are concentrated in the dissolved air floatation vessels D-501 and D-551. The DAF reject stream is pumped by P-502 and P-552 to the Sludge Storage Tank T-1603. Once the sludge reaches the "Lo-Lo Sludge Storage Tank Level" in T-1603, the sludge pump (P-1601) can be operated and 95% pure oxygen from the oxygen receiver (T-1602) can be added to the sludge. Initially, the flow of oxygen at FI-1602 should be set to ~150 standard cubic feet per hour (scfh), but should be increased to ~420 scfh as the tank fills with solids. Adjustments to the flow of 95% oxygen should be made based on dissolved oxygen concentration readings at AP 477 using a hand-held dissolved oxygen meter and T-1603 oxygen requirements as determined by the general odor from the T-1603 headspace. As a check of the oxidation/reduction (i.e., "redox") conditions in T-1603, the lower explosion limit (LEL) of the T-1603 headspace and the hydrogen sulfide (H_2S) concentration should be periodically measured using hand-held meters. Care should be taken not to add a large excess of 95% pure oxygen to T-1603 since the flow of 95% pure oxygen to the Perchlorate Treatment system effluent may then be reduced. The oxygen generator is located in Building D-1 adjacent to the air compressor.

Equalized sludge from T-1603 is transferred to the conditioning tank (T-901) by opening valve V-4780 and partly closing off valve V-4775 if necessary. Care should be taken to maintain some sludge flow through the eductor (E-1603) during the transfer, or else the flow of oxygen should be temporarily stopped by closing valve V-4761. P-1601 has a capacity of 160 gpm at 60 feet of water head pressure. Assuming a flow of ~100 gpm during a transfer sequence, it will take approximately 1 hour to transfer 6,000 gallons of equalized sludge from T-1603 to T-901. The biological solids in T-901 are conditioned with a polymer solution following the transfer, valve V-4780 should be closed and valve V-4775 fully opened. Valve V-4761 should also be opened if it was closed during the transfer.

Flocculation Mixers (M-612 &M613)

There are two Flocculation mixers in the Thickener Tank. These mixes are used to aid in the formation of the floc in the tank. The flocculation mixers are variable speed. 1 HP 460 VAC 3 PH motors.

The mixers are equipped with a HAND/OFF/AUTO switches located in close proximity of the mixer. With the switch In the Manual mode, the mixer is started and stopped locally. With the switch in the OFF mode, the mixer start is disabled. (Note: use proper lock out tag out procedures when performing maintenance on the mixers) When the switch is in AUTO, the mixer will start automatically from the HMI screen and the PLC. The mixers speed is adjusted by the frequency setting on the Smart Motor Controller mounted in the MCC room.

Polymer Addition (T-704 & P-741)

Cationic Polymer is added to the center well of the Thickener tank to aid in the flocculation process. There is a polymer tote located at the south base of the Thickener mounted on a Tote Containment Tub. Tote T-704 is used to supply Polymer to the Thickener Tank (T-602). Polymer is made down by a Polymer Feed Unit (P-741). Concentrated liquid polymer, called neat polymer, and service water are mixed by the Polymer Feed System to produce a dilute polymer solution. The Polymer Feed Unit is rated at 1.0 GPH of neat polymer. Specific operation of the Polymer unit can be found in the Chemicals chapter of this manual

Ferric Chloride Addition (P-751)

Ferric Chloride can also be added to the Thickener Feed Well, should it be required to separate the solids from the water phase. The ferric chloride is provided using Pump P-751, a fixed speed centrifugal pump. The rate of addition is manually controlled using a ball valve located at the top of the Thickener. Specific operation of the ferric chloride system can be found in the Chemicals chapter of this manual.

Note – Ferric should not be added to the thickener unless directed by the Process Control Team. If it is added, close monitoring must be done to assure that Ferric Sulfide is not precipitated and overflowed to the Aeration Tank and/or pumped to the Conditioning Tank where it will have negative effects on the performance of the Filter Presses.

SOLIDS CONDITIONING

Process Description

Wastewater sludges consist of a mixture of solid particles suspended in an aqueous solution of dissolved substances. The solid particles of biological sludges characteristically have a negative surface charge acquired by preferential adsorption of ions from the solution. Because of this negative charge, the solid particles have a powerful affinity for water molecules and a pronounced tendency to remain dispersed due to electrostatic repulsion. In addition to the surface charge, other surface effects can also cause the solid particles to adsorb film layers of water (hydration). This “bound water” and the tendency of the particles to remain dispersed adversely affects sludge dewatering processes. The chemical activity of the sludge particle surfaces in sludges with a high volatile solids content, such as sludges from biological treatment processes, is especially high, resulting in a reputation as being the most difficult sludges to dewater. It is an unfortunate fact that essentially all biologically treated wastewater sludges require some form of conditioning prior to dewatering to achieve sufficient water removal.

The most common method of sludge conditioning is the addition of chemical substances such as coagulants to improve the dewatering characteristics of the sludge. The principal objectives of chemical conditioning are to adjust the chemical and physical conditions of the sludge so as to reduce the surface charge on the sludge particles and to promote aggregation of the dispersed particles into large floc particles. This releases some of the bound water and results in a sludge in which the water phase is free to move through the pore spaces created between the larger aggregates of solid particles.

A variety of chemical substances have been used as conditioning agents for wastewater sludges. These chemicals may be used alone or in combination, but because the mechanism of their action is often different, the best results may be obtained when their combined actions are utilized. The only way to determine the best combinations and dosages for a particular sludge is by experimentation using bench testing. The principal chemical conditioning agents are coagulants such as, lime, and iron salts.

Lime has been used alone, but in almost all cases, it is used in conjunction with other chemical agents such as metal salts for sludge conditioning. Lime is used primarily to react with excess alkalinity in the sludge to reduce the dosages of iron or metal salts required. Lime also has a limited dehydrating action on colloids and the calcium ions are effective in precipitating carbonates, phosphates, and soaps in the sludge. The principle use of lime is for pH control, odor reduction, disinfection, and as a filter aid.

Iron salts, notably ferric chloride ($FeCl_3$), are the most commonly used conditioning agent. Ferric chloride is used alone or frequently in combination with lime. Ferric chloride releases highly reactive trivalent ferric ion when dissolved in water. Ferric ion reacts to form slightly soluble precipitates with hydroxides, carbonates, phosphates, and soaps. These compounds increase the inorganic solids fractions in the sludge and change the pH that shifts the ionization and adsorption equilibrium of the sludge particle surfaces towards electrostatic neutrality. Typical lime to ferric chloride dosage ratios of 3:1 or 4:1 has produced good dewatering results.

The chemical conditioning of the sludge is accomplished in the Conditioning Tank. The feed sludge and conditioning agents are introduced separately to the conditioning tank. A mechanical agitator mixes the chemicals and sludge to provide uniform distribution of the conditioner throughout the sludge. Close visual observation of the conditioning tank mixing and the appearance of the filter cake are necessary to control the process.

When adding two or more conditioner chemicals, the sequence of addition is important. Ferric chloride is added first when used in conjunction with lime. When used, the ferric chloride is added first to lower the pH of the sludge to approximately 2.5 S.U. Lime is then added to raise the pH of the sludge to approximately 11.5 S.U. Nevada Environmental Response Trust Perchlorate Removal System sludge is no longer conditioned with ferric chloride and lime.

The effectiveness of the chemical conditioning practices, such as mixing, chemical combinations, and dosages, can only be evaluated in terms of the performance of the dewatering units. The best chemical conditioning program is the one, which produces the optimum dewatering performance.

<u>Major Components</u>

The major components of the chemical sludge conditioning system include two (2) sludge transfer pumps, three chemical addition systems (Polymer, Ferric Chloride, & Lime), a conditioning tank and mixer. The following sections describe the major components of the system and their operation and control. Nevada Environmental Response Trust Perchlorate Removal System, sludge is no longer conditioned with ferric chloride and lime. The ferric chloride and lime dosing systems do remain available for use.

Conditioning Tank (T-901)

The major structural component of the sludge conditioning is the Conditioning Tank (T-901). The bottom of the tank is sloped towards the center of the tank to form an inverted cone to accommodate the sludge collection. The sidewall water depth is about 9.5 feet and the center tank depth is 8 feet. The tank has a volume of about 13,500 gallons.

Feed sludge enters the tank through a 3- inch CVPC inlet pipe from the Thickener Tank. Sludge flow from the Thickener is pumped over by the Thickener Underflow Pump (P-603). 4-inch CPVC inlet pipe from the Sludge Storage Tank. Sludge flow from the Sludge Storage Tank is pumped over by the Sludge Pump (P-1601). A 3-inch diameter conditioned sludge draw-off pipe connects the conditioning tank to the filter press feed pumps.

Conditioning Tank Agitator (M-901)

There is one mixer in the Conditioning Tank used to keep the tank mixed during the treatment process. The Agitator is a constant speed 45 RPM, 5 HP 480 VAC 3 PH motor. The Mixer will only be operated when polymer is being added to the Conditioning Tank and/or to mix the contents of the Conditioning Tank to acquire a representative grab samples from the tank.

The agitator is equipped with a HAND/OFF/AUTO switch located next to the agitator motor on the top of the Conditioning Tank. With the switch In the Manual mode, the agitator is started and stopped locally. With the switch in the OFF mode, the agitator start is disabled. (Note: use proper lock out tag out procedures when performing maintenance on the agitator). When the switch is in AUTO, the agitator will start automatically from the HMI screen.

Ferric Chloride Addition (T-901 & P-751)

Ferric Chloride is added to the Conditioning tank to aid in the flocculation process. There is one Ferric Chloride Feed / Mix Pump (P-751) supplying ferric chloride solution to the Conditioning Tank. The Feed / Mix pump is a Fybroc 1500 series Horizontal Centrifugal 15HP 460 volt 3 phase with a capacity of 40 GPM @ 40 FTDH. **(Note: actual delivery of Ferric Chloride to the Conditioning Tank is approximately 4.4 GPM since the majority of the fluid is recycled back to the Storage Tank. However, if the Ferric Recycle Valve is pinched closed, it will increase the delivery of Ferric to the Conditioning Tank.)** The Ferric chloride pump draws suction from the storage tank through a 2-inch CVCP line to the Conditioning Tank (T-901). Ferric Chloride is added to the conditioning tank in predetermined doses. A portion of the pumped ferric chloride is continuously recycled back to the storage tank through a mixing eductor to keep the ferric solution homogenous, with the balance directed through an automatic valve (on/off). The use of a timer function within the SCADA System allows for the introduction of a fixed amount of ferric chloride to be automatically delivered to the Conditioning Tank based on jar testing results. It is estimated that approximately 100 gallons of Ferric Chloride will be required per day to condition the sludge.

The pump is equipped with a HAND/OFF/AUTO switch located in close proximity of the pump. With the switch In the Manual mode, the pump is started and stopped locally. With the switch in the OFF mode, the pump start is disabled. (Note: use proper lock out tag out procedures when performing maintenance on the pump). When the switch is in AUTO, the pump will start automatically from the HMI screen and the PLC.

Specific operation of the Ferric Chloride unit can be found in the Chemicals chapter of this manual.

Lime Addition (T-752)

The lime addition system consists of a 1500 CU. FT (30 Ton) storage silo (T-752). The lime storage silo is 12-feet 0-inches in diameter and has a wall depth of 28-feet 0-inches. A 15 HP bin activator (M-753), a 10 HP Volumetric Feeder (M-754), a 3 HP Screw Conveyor (M-755) with a capacity of 40-50 CU. FT/HR, a Truck fill panel, and integral System Control panel make up the rest of the Lime Addition System. Hydrated lime is received in bulk pneumatic delivery trucks (i.e. closed tank trucks with integral blowers for conveying the contents pneumatically into a storage bin). Lime is fed to the conditioning Tank in dry form using a screw conveyor and a volumetric feeder. This is a batch operation set up and operated from the System Control Panel located inside the Lime Silo building. It is estimated that approximately 1500 pounds of lime will be required per day to condition the sludge.

Specific operation of the Lime Addition unit can be found in the Chemicals chapter of this manual, as well as the vendor Operations and Maintenance Manual.

Dry Polymer Feed Assembly

A dry polymer feed assembly is provided to condition the biological solids in T-901 with a polymer solution. A metered amount of dry polymer is mixed with service water in the polymer mix tank (T-920) via the volumetric feeder (H-920) and mixer (M-920). The mixed polymer is transferred to a polymer application tank (T-930) via the polymer transfer pump (P-920). The polymer solution in T-930 is added to T-901 using the polymer feed pump (P-930). The sludge storage tank (T-1603), oxygenation system, and dry polymer system are installed in Building D-1.

FILTER PRESS FEED PUMPS (P901 & P902)

Sludge is pumped from the bottom of the conditioning tank T-901 to two plate and frame Filter Presses (X901 & X902) for final dewatering. It is estimated that 1 to 2 press loads of sludge will have to be processed each day to prevent a build-up of solids. The Filter Presses (X901 & X902), with 80-ft^3 of capacity, receive the sludge for dewatering. The cake produced by the filter presses are dropped into roll-off boxes located below each Filter Press. Each roll-off box will hold approximately 4 – 5 press loads. The sludge cake will be approximately 35% solids and will be hauled off site for disposal as residual waste, which will be alkaline (pH of 11 – 11.5). The filtrate is routed to the Filtrate Tank (T902), and subsequently returned to the DAF's to be reprocessed.

The Filter Press Feed Pumps (P901 & P902) are air driven diaphragm pumps and are provided for the purpose of transferring sludge from the Conditioning Tank (T-901) to the Filter Presses (X901 & X902). The pumps are rated at 150 GPM at 40 PSIG. The pumps are constructed of polypropylene with neoprene elastomer diaphragms. The pumps are installed with sections of flex connection connecting the pump to the suction and discharge piping. This reduces vibration on the hard piping during operation and simplifies pump removal for maintenance.

Sludge flows by gravity to the Filter Press Feed Pumps (P901 & P902) by opening a manually operated plug valve at the bottom of the Conditioning Tank (T901). The sludge flows through a 3-inch CVCP line to a 3-inch manual diaphragm valve connected to the flex hose at the pump suction piping of each pump. The flow continues through the pump discharge piping, flex hose, 3–inch manual plug valve, and finally to a 3-inch CVCP line. The 3-inch CVCP line is connected to the feed port of the Filter Presses (x901 & x902). One pump normally directs the sludge to the filter press during a press cycle. The control of each pump is dedicated to a particular Filter Press. If necessary for maintenance purposes, there is piping and valving in place that enable the Feed Pumps to be directed to either Filter Press, but the control of the pump **must** still be accomplished by the pumps dedicated Filter Press Control Panel. System air is used to operate the pumps. The filter press local control panel is used to control the pumps. The pumps are operated from the control panel by regulating the air supply solenoid valves. Energizing the valves causes air to flow through the air hose to the air diaphragm, thereby starting the pumping action. The air supply line to each pump has flow switch installed on it that tracks the strokes of the air diaphragm pump. Each time the pump strokes, the piston in the flow switch is forced back and forth causing it to loose contact with the magnetic sensor and return to its resting position back in contact with the magnetic sensor. The magnetic sensor is mounted to the outside surface of the flow switch and is used in conjunction with the stage timers on the Filter Press Control Panels to keep track of the pumping frequency of the Feed Pumps for a particular stage. The magnetic sensors are equipped with a small local LED light that will flash off when the Feed Pump strokes. **(Note: it is important to remember that when the LED light on the magnetic sensor is "ON", the pump is in the resting position. The LED light should temporarily go out each time the Feed Pump strokes).**

FILTER PRESSES (X901 & X902)

The Filter Presses (X901 & X902), with 80-ft^3 of capacity, receive the sludge for dewatering from the Feed Pumps. The press consists of filter plates that are covered with a gasketed filter cloth and pressed together by a hydraulic ram under hydraulic pressure.

There are three types of plates on the Filter Presses. The first type is the head plate, which is permanently mounted to the feed end of the press. The feed end of the press is connected to the 3-inch CVPC line to the Filter Press Feed Pumps (P901 & P902) discharge pipe, which transfers the sludge to the Filter Press. There is one head plate on the filter press.

The next plate type is the end plate. This plate is usually placed next to the hydraulic ram. The end plate has no center feed hole; consequently, any sludge fed to the press cannot get beyond this plate. There is one end plate on the filter press.

The third type of plate is the intermediate plates. The intermediate plates are located between the head plate and the end plate. Each intermediate filter plate has a recessed surface on the front and backside of the plate. A chamber is created between two filter plates when the filter plates are stacked together. The combined capacity of all chambers is 80 cubic feet when the press is closed. The plates are constructed of non-gasketed polypropylene fabric with center feed ports and four (4) corner filtrate outlet ports.

NOTE: Sludge can flow through the Filter Press Feed Pump to the Filter Press if there is sufficient head pressure supplied by the Conditioning Tank contents. The manual gate valve at the pump discharge should be closed to prevent sludge flow and spillage to the Filter Press frame when the Filter Press is not in use.

FILTER PRESS CYCLE

WARNING: READ THE MANUFACTURER'S OPERATING MANUAL

WARNING: OBSERVE ALL SAFETY INSTRUCTIONS

WARNING: WEAR EYE PROTECTION

WARNING: WEAR PROTECTIVE CLOTHING

Switch POWER to ON at Filter Presses (X901 & X902) control panel.

NOTE: Operation of the valves and starting/stopping of the equipment associated with the filter press operation can only be performed at the filter press control panel.

To start the filter press cycle the operator presses the control power on push button on the filter press control panel. When the control panel light is illuminated, the operator presses the press control button. The drip trays will automatically close if selected in AUTO or the operator can close the drip trays by selecting MANUAL. Next, the Follower Selector Switch should be put into the “CLOSE” position and the “Close Press” button pushed. The Follower should begin to close. Align the manual valving so that the Filter Press is set up to accept sludge from the Feed Pumps. At first, the Filtrate Valving should be set up for “Even Fill”. This refers to closing the bottom Filtrate Valves initially until filtrate begins to discharge from the top two Filtrate Valves (at this point, all of the Filtrate Valves can be opened). Even Fill ensures that the Filter Press is receiving and even distribution of sludge throughout the individual chambers through the entire Filter Press Cycle. Next, the operator presses the press feed push button. The filtration cycle will begin with starting the Filter Presses (X901 & X902) feed system. The sludge enters the Filter Press through the 3-inch CVPC feed inlet pipe in the center of the head plate assembly. The cavities of the filter plate chambers begin to fill with sludge quickly. The rate of sludge fed to the press decreases during the cycle as the chambers fill with solids and the flow rate of the feed system reduces correspondingly. After a short period of time, the filtrate starts to discharge through the filtrate corner ports. Leakage around the filter cloths and cloudy filtrate might appear during the first few minutes. This is a normal occurrence and should disappear after a short time as solids build-up in the press. The filtrate and any water removed during the air blow down cycles are directed to the Filtrate Tank (T-902) and eventually returned to the DAF’s (D-501 & D-551) by the Filtrate Recycle Pump (P903).

With the increase of the solids concentration in the filter press chambers, the filtration pressure at the inlet will increase. The maximum operating pressure for the Filter Presses (X901 & X902) is approximately 100 PSI.

The solids concentration of the filter cakes depend on the following parameters:

1. Selection of filter cloth material.
2. Condition of the filter cloths. The filter cloths have to be cleaned after a period of use depending on the application.
3. Flow control and operating pressure of the feed system.
4. The time of the dewatering cycle.
5. The pretreatment and condition of the sludge.

The Filter Presses operate on the principal of gradually increasing the feed pressure over the course of the filtration cycle. This is accomplished with the combination of the flow switches mounted on each Feed Pump and the timers for each of the four stages mounted on the front of the Filter Press Control Panel.

There are four stages to each filter press cycle. Each stage has a timer and an air solenoid valve that control air pressure to the Feed Pump for that particular stage. The air pressure for the four stages is adjustable, but the original settings were:

- Stage #1 = 25 psig
- Stage #2 = 45 psig
- Stage #3 = 65 psig
- Stage #4 = 85 psig

Once the filtration cycle is started by the operator by pushing the “Start Feed” button on the control panel, the pump starts pumping at 25 psig in stage #1. As solids begin to build on the surface of the filter cloths, the pump stroke frequency will decrease creating pauses between each pump stroke. As previously mentioned above, these pauses in pump strokes will cause the magnetic sensor on the Feed Pump flow switch to light the LED light on the sensor. When this happens, a signal is sent to the Filter Press Control Panel that starts the timer for Stage #1. The timer will begin to count until there is another pump stroke, resetting the timer. The timers are adjustable, but it is recommended that the setting for each stage remain between 5 – 10 seconds. Once the Feed Pump slows enough that the timer reaches its setting and times out, the Filter Press automatically advances to the next stage, which has a higher air pressure and ultimately increasing the Feed Pump stroke frequency. This process continues throughout the four stages. Once the timer for stage #4 times out, the Feed Pump is automatically shut off and an orange light is illuminated on the Filter Press Control Panel indicating that the cycle is complete. It is now time to perform the Core Blow and Air Blow sequences that remove excess water from the chambers and associated piping.

DESCRIPTION OF FILTER CLOTHS

The Filter Press is equipped with a filter media, called a filter cloth. Each Filter Press has one head and one end cloth. Each chamber plate is equipped with a barrel-neck filter cloth, which covers both sides of the plate.

The filter cloth media is determined by the slurry application based upon the following characteristics:

1. Filtration efficiency
2. Good cake discharge
3. Low blinding
4. Mechanical resistance
5. Chemical resistance

It is recommended that treatment system operators clean the filter cloths regularly after several press cycles or when they are exceptionally dirty. The cloths can remain on the plate during this procedure.

The following is a list of common operational problems associated with the filter plates:

Problem	Remedy
1. Slurry leaking from plates	Check run hydraulic system for leaks
	Sealing surface of filter plates dirty: Clean
	Possible plate warpage.
2. Plate breakage	Solids buildup along filtration pipe, causing pressure differential: Clean.
3. Filter plate pack off side rails	Filter plates not aligned properly: Reshift plates. Sealing surface of filter plates, and or, cloths dirty: Clean

CORE BLOW

Core Blow is the process of removing liquid sludge and partially formed cake from the center feed hole of each filter chamber. This step must be initiated by the operator after the filtration cycle is complete, but prior to initiating the Air Blow.

The Filter Press should still be closed and now the operator must close the four filtrate valves. The sludge feed from the Feed Pumps must be closed and the large valve to the Filtrate Tank. At this point, the only valves that should be open are the 3-inch inlet valve to the Filter Press and the 3-inch valve to the Conditioning Tank. Now open the Core Blow Air Valve for 1 – 3 minutes. Do not rush this, but if the core is not blown out within 3 minutes, most likely it will not. Close the Core Blow Air Valve and continue to the Air Blow step.

AIR BLOW DEVICE

Air blow refers to the process of removing excess water from the cloth, cake, and discharge eyes. Following a filtration cycle, the feed line valves are closed, and the manifold valves are closed in such a way that discharge can only exit from the lower right filtrate valve. System air is supplied to the air blow through a 1/2-inch galvanized pipe. The air valve is then opened and air enters the press through the upper left port and fills the drainage area. The air passes from the backside of the cloth, through the cake, and the opposite cloth, and then out the lower right port, leaving the press via the piping system and is sent to the Filtrate Tank. The air forces the excess water from the cake and on the drainage surface. This helps loosen the filter cake, improves cake dryness, and drains the remaining liquid in the bottom discharge eyes.

The air blow procedure is as follows:

1. Shut off the Filter Press Feed Pumps (P901 & P902).
2. Close the feed valve(s).
3. Open only the lower right Filtrate Valve.
4. Open the air valve. Run air through the press for at least 5 minutes. If this does not remove all the water, longer filtration times should be performed.
5. Open all the filtrate discharge valves except for the upper left one and then close the Air Blow Valve. Gravity will drain the press. Allow several minutes for complete drainage. The press can now be opened.

SOLIDS COLLECTION

A collection box must be located directly beneath Filter Presses (X901 & X902). Following a press cycle, the press is opened and the operator must take care in cleaning any sludge from the cloths and plates. (Note: make sure that the center sludge feed port of each plate is free of cake if the Core Blow was not able to remove it. No solids should be allowed to remain in the feed port, as it will impact performance of the Filter Press Cycle). If clumps of sludge are allowed to remain stuck to the cloths or plates, they can cause gaps in sealing the plates and provide a potential source for sludge leaks during the filling of the next cycle or actually crack the plate. The dewatered solids are released directly into the collection box. Here the solids are collected until the time of disposal

OPENING THE PRESS

To open the filter press for cleaning the operator presses the open press pushbutton. Be careful not to fully open the press and/or move the filter plates with the tray in the upright position. Open the press slightly to allow any excess water to drain on to the tray for approximately 1-2 minutes. Lower the tray before fully opening the press to allow any heavy sludge cakes to drop into the dumpster below the filter press. **(Note:**

The operator must make sure that the Filtrate Valves are left open before opening the Filter Press. IF not, the Filter Press could still be pressurized from the Air Blow Step).

FILTRATE RECYCLE

Overview

The filtrate is routed to the Filtrate Tank (T-902), and subsequently returned to the DAF's (D-501 & D-551) to be reprocessed. The Filtrate recycle system consists of the Filtrate Tank (T-902), Filtrate Recycle Pump (P-903) and tank level & control switches (LS-902). In the automatic mode, the Filtrate Tank level controls can impact the operation of the filter presses. If the filtrate tank level is HIGH HIGH, the filter presses cannot be started. The normal operation of the filtrate tank level control is for the operator to manually start the Filtrate Recycle Pump when once the Low Level Alarm has cleared. The Filtrate Recycle pump runs until the filtrate tank level is LOW. When the low level is detected, the pump shuts off. It is important to remember that the Filtrate Recycle Pump does not turn on automatically. It only turns off automatically. The operator must start the Filtrate Recycle Pump from the SCADA System.

MAJOR COMPONENTS

Filtrate Tank (T-902)

The Filtrate Tank (T-902) is constructed of fiberglass-reinforced plastic with a flat bottom, a drain a 24-inch manway access and is equipped with three level indicators (LOW, HIGH & HIGH HIGH). Discharge from the tank is through a 2-inch ball valve into a 2-inch CVCP pipe.

The design data for the Filtrate Tank (T-601) is:

- 14 ft diameter
- 8 ft straight wall side
- 8000 gallons

FILTRATE RECYCLE PUMP (P- 903)

The fixed speed Filtrate Transfer Pump (P–903) draws water from the Filtrate Tank and discharges to the front of the DAF's (D-501 & D-551). The pump is a horizontal centrifugal pump, rated at 20 GPM at 46 feet TDH and is driven by a 1.5 HP, 480VAC 3-phase electric motor. Filtrate Recycle Pump suction line has a 2-inch ball valve and a 2-inch x 1.5-inch reducing expansion joint. A fixed speed motor drives the pump's wet end. The Filtrate Recycle Pump discharge passes through a 1-inch check valve through a 1-inch ball valve to a 1-inch CVPC pipe that can be directed to either the Thickener Overflow Weir or upstream of the Static Mixer. The pump is equipped with a HAND/OFF/AUTO switch located in close proximity of the pump. With the switch In the Manual mode, the pump is started and stopped locally. With the switch in the OFF mode, the pump start is disabled. (Note: use proper lock out tag out procedures when performing maintenance on the pump). When the switch is in AUTO, the pump can be started by the operator from the HMI screen and will automatically turn off on a LOW Level Alarm in the Filtrate Tank.

TROUBLESHOOTING

Thickener

CONDITION	PROBABLE CAUSE	REMEDY
Pin-floc discharging in overflow	• Check Polymer Feed • Check sulfide levels in the Thickener	• Prime Polyblend LMI Pump • Clean or/replace LMI Pump head as necessary • Reduce sulfide levels at the source • Verify adequate water flow from the Biomass Separators • Verify adequate water flow from the Service Water Line
Sludge Bulking to the surface	• Check sludge depth • Check sulfide levels in the Thickener	• Pump sludge to Conditioning Tank to reduce sludge blanket • Reduce sulfide levels at the source • Manually add hydrogen peroxide to the Biomass Separator Line • Verify adequate water flow from the Biomass Separators • Verify adequate water flow from the Service Water Line

CONDITION	**PROBABLE CAUSE**	**REMEDY**
Surcharging of Overflow Weir	• Check Overflow Air Diaphragm Pump • Check for solids build up on the bottom plate of the Center Well.	• Verify that the pump is operating and increase air pressure to pump as necessary. • Remove solids from bottom plate with a Fire Hose.

Filter Presses

CONDITION	PROBABLE CAUSE	REMEDY
Press Cycle Too Short	• Flow switch not reading correctly at Feed Pump • Blinded filter cloths	• Adjust flow switch position • Open Filter Press an inspect sludge cake quality and filter cloths
Press Cycle Too Long	• Flow switch not reading correctly at Feed Pump • Check feed pressure for filtration cycles	• Adjust flow switch position. • Set cycle pressure to 25, 35, 65, 85 psig respectively

CHAPTER 10
CHEMICAL FEED SYSTEMS

OVERVIEW

A variety of chemicals are used to provide the necessary treatment of the contaminated water at the Nevada Environmental Response Trust Perchlorate Removal System located in Henderson, Nevada. These chemicals include ferric chloride, sodium hydroxide, phosphoric acid, urea solution, and polymer, and lime. Most chemicals are supplied in liquid form and are stored in the bulk chemical tanks or totes, located on the equipment pad. Polymer for the solids conditioning tank is supplied in dry form and mixed with water in the Polymer feed assembly. In addition, lime is in dry form and stored in the Lime Silo on the equipment pad. The systems were designed to provide an adequate inventory of chemical and also to safely transport the chemical from the storage tank to the treatment processes.

WARNING: Coming in contact with these chemicals or fumes from these chemicals may cause injury or death. The dangers associated with each chemical are stated in the specific subsection. A Material Safety Data Sheet (MSDS) for that chemical in use is maintained in the Operations Trailer. All persons handling any chemical must read and understand the MSDS for that chemical before using the chemical. Individuals working with chemicals must be familiar with the standard safety procedures developed for the site.

FERRIC CHLORIDE SYSTEM

General

The ferric chloride addition system consists of a 4,400-gallon double-walled storage tank and one chemical feed / mix pump. The Ferric Chloride storage tank is 10-feet 2-inches in diameter and has a straight wall depth of 9-feet 10-inches with a resulting nominal capacity of 4,400 gallons.

WARNING: Ferric chloride chemical solution is an orange-brown liquid of specific gravity between 1.3 and 1.4 depending upon the percentage solution purchased. These specific gravities correspond to 28% ferric chloride by weight to 36% ferric chloride by weight. The chemical is acidic and may cause eye burns. Avoid contact with the eyes by wearing acid goggles when handling any ferric chloride solution. In case of contact, the eyes must be immediately flushed with flowing water for at least 15 minutes. A physician should be called without delay. All persons handling ferric chloride solution must read and understand the MSDS for ferric chloride solution before using the chemical. Individuals working with chemicals must be familiar with the standard safety procedures developed for chemical usage at their site.

Although brief skin contact with ferric chloride solution may cause a slight irritation, prolonged exposure could cause burns. Prevent contact with skin and clothing by the use of rubber gloves, rubber boots, rubber jacket or rubber bib apron, and rubber pants. In the case of contact, any contaminated skin must be washed thoroughly. Ferric chloride solution will stain skin and clothing and cause deterioration of leather and fabrics. Immediately remove contaminated clothing and have the clothing thoroughly washed before reuse. Consult with a physician if any irritation or burns are evident.

Ferric chloride solution can be added to both the sludge thickener and/or the Conditioning Tank (T901). The addition of ferric chloride to the water sludge produces an iron hydroxide precipitate, which will settle out in either the thickener or the Conditioning Tank.

One 4,400-gallon tank is located on the equipment deck next to the Conditioning Tank, for the storage and feeding of the ferric chloride solution. The tank is made of high-density cross-linked polyethylene (XLHDPE) and is 10-feet 2-inches in diameter with a straight side depth of 9-feet 10-inches. The domed top of each tank is equipped with a 24-inch manway, U-vent, and top gusseted nozzles for drain, fill, and tank outlet connections. No chemical containment basin is needed, as the tank is a double wall. A leak detection sensor monitors for liquid in the secondary tank and alarms if detected.

FERRIC CHLORIDE FEED / MIX PUMP

There is one Ferric Chloride Feed / Mix Pump (P-751) supplying ferric chloride solution to the Conditioning Tank. The Feed / Mix pump is a Fybroc 1500 series Horizontal Centrifugal 15HP 460 volt 3 phase with a capacity of 40 GPM @ 40 FTDH. (Note: The actual amount of ferric chloride that is delivered to the Conditioning Tank is approximately 4.4 GPM, since the majority of the pump chemical is returned to the Storage Tank if the recycle valve is 100% open. If the recycle valve is pinched back, the ferric chloride flow will increase based upon how much the valve is pinched back and head pressure from the Storage Tank)

The Ferric chloride pump draw suction from the storage tank through a 2-inch CVCP line to a 2-inch X 1.5- inch expansion joint. A fixed speed motor drives the pump wet ends. The Feed / Mix Pump discharge passes through a 2-inch x 1-inch expansion joint to a 2-inch CVCP pipe with a pressure tap for a local pressure gauge (PI – 751), through a 2-inch x 1-inch expansion joint to a 1-inch CVCP pipe through a flow control valve FV – 751E to the Conditioning Tank (T-901). Ferric Chloride is added to the conditioning tank in predetermined doses using a SCADA timer function. A portion of the pumped ferric chloride is continuously recycled back to the storage tank through a mixing eductor to keep the ferric solution homogenous. In addition, ferric chloride can be added to the Sludge Thickener through a ¾" line tapped from the pump discharge prior to FV-751 E. If addition to the sludge thickener is deemed necessary, will be done on a fixed rate established in jar tests and monitored by throttling the flow using a ball valve at the point of injection.

A HAND/OFF/AUTO pump control selector switch is mounted next to the pump.

Through the use of jar testing in the laboratory, the operator will determine how much ferric chloride is necessary to add to the Conditioning Tank for sludge conditioning. Once the total gallons of ferric to be added is determined, the total gallons should be divides by 4.4 GPM to determine how long (in minutes) to add the ferric chloride to the Conditioning Tank. The time is entered on the HMI screen and Control Valve (751E) is place into AUTO mode. The operator will then initial the addition of ferric chloride by clicking the button the HMI screen and the timer will begin to count up to the operator entered minutes. Once the timer is complete, Valve (751E) will automatically close stopping the addition of ferric chloride. (Note: The timer does not stop the pump, so the manual recycle valve must always be left open).

Unloading Ferric Chloride Solution from a Tank Truck

Ferric chloride solution will be delivered to the treatment system by a tank truck.

IMPORTANT: THE TANK TRUCK DRIVER IS CERTIFIED FOR UNLOADING OF THE FERRIC CHLORIDE SOLUTION. IT IS THE DRIVER WHO IS RESPONSIBLE FOR UNLOADING FERRIC CHLORIDE SOLUTION DIRECTLY INTO THE FERRIC CHLORIDE STORAGE TANK. TRUCK DRIVERS MUST BE INSTRUCTED TO

CONTACT A MEMBER OF THE OPERATIONS STAFF PRIOR TO OFF LOADING A CHEMICAL. THIS WILL PROVIDE THE OPPORTUNITY FOR SYSTEM STAFF TO CONFIRM THAT PROPER CONNECTIONS AND SAFETY PROCEDURES ARE FOLLOWED. TREATMENT SYSTEM OPERATORS SHOULD NOT ATTEMPT TO UNLOAD THE TANK TRUCK.

A local truck fill connection is available to the tank truck driver for chemical unloading. This chemical fill connection is a 3 – inch Cam lock connection. There is a local tank level indicator on the side of the tank. The truck driver can visually observe the tank level during filling to prevent over filling the tank. If the tank becomes overfilled, an alarm is generated on the HMI screen to alert the operator.

FERRIC CHLORIDE FEED SYSTEM TO THE DAF'S

Ferric Chloride is injected into a Static Mixer on the discharge piping of the Aeration Tank for the purpose of coagulating the small particles in the wastewater. The Ferric Chloride and wastewater are thoroughly mixed by the Static Mixer. The wastewater along with the coagulated particles exits the Static Mixer and flows to the DAF Units. Prior to the DAF Units, the wastewater is dosed with a cationic polymer to flocculate the coagulated particles.

This Ferric Chloride Feed System consists of two peristaltic metering pumps (P758 A/B), a calibration column, and a flow switch (FS-758). The Ferric Chloride Metering Pumps sit on top of a pump stand located on the North Side of the bulk Ferric Chloride Storage Tank (T-751). The operational intent of the system is to continuously operate one of the Metering Pumps while the other is an installed spare. The Ferric Chloride Metering Pumps are flow pace in relationship to the total feed flow signal for the First Stage Reactors via the PLC. The Ferric Chloride Pump System has a common Flow Switch installed in the common discharge line of the pumps. This flow switch will detect a loss of ferric chloride flow, send an alarm to the PLC, which will generate an alarm on the SCADA System and attempt to start the spare Metering Pump if it is in AUTO. This event has some conditions applied to it though. There is a 30-second delay built into the program before the PLC will attempt to start the second Ferric Pump in the event of a Low Ferric Flow Alarm. In addition, if the PLC output to the Ferric Pumps, whether they are in HAND or AUTO at the SCADA, is less than 15%, the PLC will alarm only. It will not attempt to start the second pump.

The Ferric Chloride Metering Pumps can be operated locally or remotely and in AUTO or MANUAL. A switch on the back of the pumps toggles the control of the pumps from local control to remote control. If local control is selected, the speed must be adjusted locally at the pump. If remote control is selected, the speed is adjusted manually by the operator on the Aeration Screen of the SCADA System or automatically via flow-paced control of the PLC. In the even that remote manual operation is selected, the operator enters a pump speed on the SCADA System and the speed remains at that operator selected speed until manually changed by the operator or the pump is switched to automatic control. Remote automatic control automatically adjusts the pump speed based on the total flow signal for the feed to the First Stage Reactors of the FBR System.

It should also be noted that if the Ferric Chloride Pumps are in AUTO and a High Sulfide Alarm is generated, the PLC will shut off the Ferric Chloride Pumps until the High Sulfide Alarm clears. Once the alarm clears, the PLC will automatically start the Ferric Chloride Pumps.

HYDROGEN PEROXIDE FEED SYSTEM

Hydrogen Peroxide is injected into the 10-inch feed line to the Aeration Tank for the purpose of oxidizing the dissolved sulfide ion in the waste stream leaving the second stage separators. The hydrogen peroxide is used at the site is at a strength of approximately 35%. By manually manipulating valves, hydrogen peroxide can also be base loaded to the 2-inch Biomass Separator Line feeding the Thickener. This option is to be utilized during high sulfide events with the purpose of minimizing the amount of sulfide sent to the Thickener resulting in eventual effluent quality and sludge dewatering problems.

This Hydrogen Peroxide Feed System consists of two peristaltic metering pumps (P754 A/B), a calibration column for each pump, a common flow switch (FS-754) on the feed line to the Aeration Tank, and a Dissolved Sulfide Analyzer (AIT-402). There is not a Flow Switch located on the feed line to the Thickener. The Hydrogen Peroxide Metering Pumps sit on top of a pump stand located on the North Side of the overall bio-system containment pad just west of the access stairs leading to the top of the reactors. The operational intent of the system is to operate one of the Metering Pumps as needed to oxidize dissolved sulfide while the other is an installed spare. The spare pump can be valved to manually add hydrogen peroxide to the

Thickener if needed via the Biomass Separator Line. The Hydrogen Peroxide Metering Pumps are intended to be automatically controlled by the PLC based on a PID Loop. The PID Loop maintains a dissolved sulfide concentration set point entered on the SCADA by the operator based on the feedback to the PLC from the Dissolved Sulfide Analyzer. The Hydrogen Peroxide Pump System has a common Flow Switch installed in the common discharge line of the pumps to the Aeration Tank. This flow switch will detect a loss of hydrogen peroxide flow, send an alarm to the PLC, which will generate an alarm on the SCADA System and attempt to start the spare Metering Pump if it is in AUTO. This event has some conditions applied to it though. There is a 30-second delay built into the program before the PLC will attempt to start the second Hydrogen Peroxide Pump in the event of a Low Hydrogen Peroxide Flow Alarm. In addition, if the PLC output to the Hydrogen Peroxide Pumps, whether they are in HAND or AUTO at the SCADA, is less than 15%, the PLC will alarm only. It will not attempt to start the second pump.

The Hydrogen Peroxide Metering Pumps can be operated locally or remotely and in AUTO or MANUAL. A switch on the back of the pumps toggles the control of the pumps from local control to remote control. If local control is selected, the speed must be adjusted locally at the pump. If remote control is selected, the speed is adjusted manually by the operator on the Aeration Screen of the SCADA System or automatically via PID Loop control of the PLC. In the even that remote manual operation is selected, the operators enter a pump speed on the SCADA System and the speed remains at that operator selected speed until manually changed by the operator or the pump is switched to automatic control. Remote automatic control automatically adjusts the pump speed based on the PID Control Loop.

The Hydrogen Peroxide System is also supported with two separate adjustable Sulfide Alarms. There is a High Sulfide Alarm and a High High Sulfide Alarm. If a High Sulfide Alarm is generated, the PLC will shut off the Ferric Chloride Pumps until the High Sulfide Alarm clears if the Ferric Chloride Pumps are in AUTO. Once the alarm clears, the PLC will automatically start the Ferric Chloride Pumps. If a High High Sulfide Alarm is generated, the autodialer will call the on duty operator and notify the operator of the alarm.

DEFOAMER FEED SYSTEM

A Defoaming agent is injected into the 8-inch effluent line of the bio-system downstream of the UV System. The Defoamer is used to minimize the amount of white fluffy foam that is generated at thesystem's outfall location of the Las Vegas Wash.

This Defoamer Feed System consists of two peristaltic metering pumps (P755 A/B), a calibration column, and a flow switch (FS-755). The Defoamer Metering Pumps sit on top of a pump stand located on the Southeast Corner of the Effluent Tank (T601). The operational intent of the system is to continuously operate one of the Metering Pumps while the other is an installed spare. The Defoamer Metering Pumps are flow pace in relationship to the total feed flow signal for the First Stage Reactors via the PLC. The Defoamer Pump System has a common Flow Switch installed in the common discharge line of the pumps. This flow switch will detect a loss of Defoamer flow, send an alarm to the PLC, which will generate an alarm on the SCADA System and attempt to start the spare Metering Pump if it is in AUTO. This event has some conditions applied to it though. There is a 30-second delay built into the program before the PLC will attempt to start the second Defoamer Pump in the event of a Low Defoamer Flow Alarm. In addition, if the PLC output to the Defoamer Pumps, whether they are in HAND or AUTO at the SCADA, is less than 15%, the PLC will alarm only. It will not attempt to start the second pump.

The Defoamer Metering Pumps can be operated locally or remotely and in AUTO or MANUAL. A switch on the back of the pumps toggles the control of the pumps from local control to remote control. If local control is selected, the speed must be adjusted locally at the pump. If remote control is selected, the speed is adjusted manually by the operator on the Aeration Screen of the SCADA System or automatically via flow-paced control of the PLC. In the even that remote manual operation is selected, the operator enters a pump speed on the SCADA System and the speed remains at that operator selected speed until manually changed by the operator or the pump is switched to automatic control. Remote automatic control automatically adjusts the pump speed based on the total flow signal for the feed to the First Stage Reactors of the FBR System.

SODIUM HYDROXIDE FEED SYSTEM

General

The chemical name for Caustic is Sodium Hydroxide and either name may be used. Caustic is a solution of sodium hydroxide and water, which is added to the FBRs to raise the alkalinity in the feed water to levels suitable for the FBRs process. Sodium hydroxide solution or caustic soda solution is a severe poisonous corrosive liquid with a high pH value. Wear protective rubber gloves, chemical goggles, a face shield, rubber apron, and rubber boots when handling this chemical. Contact with this chemical can cause irritation or severe burns and even scarring. If contacted on skin or in eyes, immediately flush with plenty of running water. In the case of eye contact, flush for 15 minutes. Obtain medical attention in all cases.

WARNING: Caustic solution may cause eye burns. Wear goggles when handling caustic solution. Brief skin contact with caustic solution may cause irritation. The use of rubber gloves, boots, jacket, and pants are recommended. In case of contact, the contaminated skin should be washed thoroughly. Caustic solution will stain clothing and cause deterioration of fabrics and leather. Contaminated clothing should be removed immediately and thoroughly washed before reuse. All persons handling sodium hydroxide solution must read and understand the MSDS for sodium hydroxide solution before using the chemical. Individuals working with chemicals must be familiar with the standard safety procedures developed for chemical usage at their site.

Sodium Hydroxide Tank

A pH feed tank (T-701) has replaced a tote for supplying caustic and is located adjacent to the Equipment Pad. This 6,650 gallon tank has double wall containment and is made of polyethylene (XLHDPE). This chemical fill connection is a 3 – inch Cam lock connection. There is a level indicator/transmitter located at the top of the tank. The tank will be refilled as required when low. The operator can monitor tank level during filling with the local digital readout to prevent over filling the tank.

pH Feed Pumps

There are nine pH Feed Pumps (P-711 thru P-718 and P-71A) supplying sodium hydroxide solution to FBRs 1 -8 and FBR-A. The chemical metering pumps are Masterflex (Model VA-975-3000) for the first stage FBRs 1 through 4 and FBR A which delivers a max flow of 7.6 GPH. The second stage FBRs have a Stenner (model SVP4L3A4S) Electric Peristaltic 1/30 HP, 120 VAC which can deliver a maximum flow of 1.675 GPH. The four pH Feed Pumps, P-715 thru P-718 are available for feeding sodium hydroxide to the second stage FBRs, but are no longer used. These chemical metering pumps are controlled by a PLC/HMI automatic milliamp signal referenced to a pH sensor located in each FBRs influent.

Sodium Hydroxide solution is gravity fed from the tank through a 2-inch CPVC line through a 2-inch X 1- inch expansion joint. The metering pumps are connected by a common 1 – inch header. Flow to each pump is through a 1-inch ball valve to a 1-inch X 3/8 -inch expansion joint through a 3/8 – inch ball valve to a 3/8 (POPT) polypropylene hose to the suction side of the pump. There is a Calibration column and a ball valve on the suction side for calibration. Installed on the discharge line is a ball valve and 3/8 – inch POPT hose is connected to the appropriate FBRs influent.

During automatic operation, the metering pump is controlled by a milliamp signal from the HMI / PLC. PH sensors located in each FBR influent line control the speed of the pump.

A calibration chamber (also known as a “Draw Down Tube”) is installed in the suction line for each metering pump. This chamber can be filled with sodium hydroxide solution from the storage tank and then isolated from the storage tank so that the chemical metering pump pulls from this chamber. The chamber is calibrated with milliliters units. To monitor the chemical flow being pumped into the system using a Draw Down Tube, take a stopwatch out to the Draw Down Tube, and turn off the valve to the tank. The distance the chemical solution level drops in the Draw Down Tube in 60 seconds is the amount in mL/minute being pumped into the system.

Before working on any part of the Sodium Hydroxide Feed System, the operator should read and understand the MSDS for sodium hydroxide. Aqueous solutions of sodium hydroxide have widely varying freezing points based upon their concentration. The following table provides a brief list of different sodium hydroxide solution strengths and their corresponding freezing points:

Freezing Points of Caustic Solutions

Solution Strength, by Weight	Freezing Point
73 % Solution	141 F
50 % Solution	53 F
25 % Solution	- 4 F
19 % Solution	- 18 F

The Nevada Environmental Response Trust Perchlorate Removal System Process will use 20% caustic soda, which will not freeze under any weather conditions. When sodium hydroxide solutions dry out, a white crusty deposit forms. This presence of white deposits upon drying can be used as an indication of leaks, drips or other spills of caustic.

NUTRIENT FEED SYSTEM

General

The additional treatment of water from AP-5 contains ammonia-N and increases the amount of available nitrogen for biological growth in the water fed to the Perchlorate Treatment System. Nutrient dosing flexibility has therefore been added to the Perchlorate Treatment System by supplying separate chemical feeds for the nitrogen and phosphorus supplements. Previously, nitrogen and phosphorus were supplied to each FBR as a 39% urea/di-ammonium phosphate (DAP) “nutrient” mixture from the 4,100-gallon nutrient tank (T-702). A phosphoric acid feed assembly has been added to separately supply phosphoric acid. The nitrogen required for growth can now also be independently supplied to each of the (5) first stage FBRs in the form of a urea (or another reduced nitrogen) solution from T-702 (replacing the 39% urea/DAP mixture) using peristaltic pumps P-72A, 721, 722, 723, and 724. The system will maintain the ability to feed the nitrogen solution from T-702 to the second stage FBRs via peristaltic pumps P-725, 726, 727, and 728, although it is anticipated that these pumps will not normally be used. The rate of urea and phosphoric acid addition to each FBR is in proportion to the feed flow to each FBR, and is operator-adjustable.

Nutrient is added to the FBRs to enhance the biological reaction. The rate of nutrient addition to each FBR is in proportion to the feed flow to each FBR and is operator adjustable through the HMI.

Nutrient Tanks

A 4,300-gallon tank is located on the equipment deck next to MCC room, for the storage and feeding of the urea solution. The tank is made of FRP and is 8-feet in diameter with a straight side depth of 12-feet. The domed top of the tank is equipped with a U-vent. A 24-inch manway is accessible on the side of the tank.

A local fill connection is available to the operator for chemical loading. This chemical fill connection is a 3 – inch Cam lock connection. There is a local tank level indicator on the side of the tank. The operator can visually observe the level during filling to prevent over filling the tank.

Nutrient Metering Pumps

There are nine Nutrient Metering Pumps (P-721 thru P-728 and P-72A) supplying urea solution to FBRs 1 -8 and FBR-A. The chemical metering pumps are Stenner (model SVP4L3A4S) Electric Peristaltic 1/30 HP, 120 VAC. The pumps can deliver a maximum flow of 1.675 GPH. These chemical metering pumps are controlled by a PLC/HMI automatic milliamp signal, referenced to the feed flow in each FBRs influent. This feed flow rate is adjustable through the HMI.

Nutrient solution is gravity fed from the tank through a 2-inch CVCP line through a 2-inch X 1- inch expansion joint. The metering pumps are connected by a common 1 – inch header. Flow to each pump is through a 1-inch ball valve to a 1-inch X 3/8 - inch expansion joint through a 3/8 – inch ball valve to a 3/8 POPT hose to the suction side of the pump. There is a Calibration column and a ball valve on the suction side for calibration. Installed on the discharge line is a ball valve and 3/8 – inch POPT hose is connected to the appropriate FBRs influent.

For phosphoric acid feed a tote (T-1520) supplies phosphoric acid to a skidded assembly of pumps P-1520A, 1521, 1522, 1523, and 1524 to feed each of the (5) first stage FBRs independently. During automatic operation, the nutrient metering pump is controlled by a milliamp signal from the HMI / PLC. The feed flow of each FBR influent line determines the speed of the pump.

POLYMER FEED SYSTEM

General

Polymer is a water treatment chemical used in water treatment to pull coagulated, suspended, and flocculated solids together by building particles large enough to settle. This treatment system uses polymer to agglomerate the suspended solids. Suspended solids form floc, which settles to the bottom of the Thickener Tank (T-602), Solids Conditioning Tank (T-901), and the DAF's and/or float in the DAF's. This section will discuss the mechanics of polymer delivery and control.

WARNING: Polymer is extremely dangerous because of the slips and falls that can occur when stepping in the substance. A more subtle danger is getting the substance on your shoes and a while later getting your shoes wet and falling due to the dry polymer that went into solution. After all visible evidence of polymer is gone; continue to wash down for several minutes. Clean bulk spills with oil dry or kitty litter and shovel the waste up before starting to wash the area down. Zep Citrusolv is a good cleaning agent. All persons handling polymer solution must read and understand the MSDS for polymer solution before using the chemical. Individuals working with chemicals must be familiar with the standard safety procedures developed for chemical usage at their site.

Polymer Totes

There is a polymer tote (or drums) located on the equipment pad adjacent to the Polyblend units and the ferric chloride tank.

Tote T-704 is used to supply Polymer to the Thickener Tank (T-602) and to the DAF's (D-501 & D-551). The thickener is no longer used, so the use of T-704 and P-741 has been discontinued as well.

A dedicated plastic containment structure is provided under the tote to contain spills. The tote or drums will be replaced when empty.

Polymer Feed Units

Polymer is made down by a Polymer Feed Units (P-741) or (P-742). Concentrated liquid polymer, called neat polymer, and clean service water are mixed by the Polymer Feed Systems to produce a dilute polymer solution. There are two Polymer Feed Units rated at 1.0 GPH of neat polymer flow. The feed pump delivers neat polymer to a mixing chamber while service water pressure conveys water to the mixing chambers.

NOTE: This system requires a minimum of 38-psig dilution water pressure for the dilution water to overcome the pressure loss within the system. In addition, the highest water pressure supplied to these units must be under 100 psi.

The liquid polymer make down systems use dilution water and mechanical mixing to produce a dilute solution. The system injects the neat polymer with chemical feed pumps into a flash mix zone where an impeller mixes the polymer with a low volume of dilution water (primary dilution). Next, water and polymer solution is moved to the low shear mixing zone where baffle plates continue the agitation. This mix chamber is enclosed in an acrylic tube. The dilute solution targeted to be 0.1% polymer by weight, is then applied to the treatment process. This dilution/mixing process is necessary to provide uniform dilution, provide polymer activation, and allow the polymer to flow smoothly to the point of application. Polymer alone in the discharge plumbing can cause plugging.

Polymer Feed Units (P-741 & P-742)

The chemical feed pump in the Polymer Feed Units is a variable speed diaphragm pump with a manually adjustable volume control. Neat polymer rates are adjustable over the range of 0.05 - 1.0 GPH. The Polyblend Unit Polymer Feed Unit for the DAF's can be stroke rate controlled by automatic or manual adjustments, however, the Polyblend Unit for the Thickener is manual control at the unit only.

NOTE: Only turn the stroke length control knob in the center of the pump housing slowly when the pump is running and the diaphragm is going through a stroke. Do not force it, the % stroke volume knob will move freely during the stroke cycle.

The pump stroke rate for the DAF Polyblend Unit can be set manually or by using a digital display pump controller where the pump stroke rate can be proportionally controlled with a 4-20 mA signal from the PLC. This PLC signal is based on the First stage total feed flow. Pump stroke rate is either 0-100 strokes per hour or 0-100 strokes per minute proportional to the 4-20 mA analog input signal. The mix chamber assembly impeller is driven by a 1/6 HP, 120 VAC, 6 Amps motor. An individual globe valve controls primary dilution water (0 – 100 GPH). The pump stroke length can only be adjusted manually at the pump.

The best way to prime and check out a polymer make down system is by operating it in manual. The goal is to keep the system stable. In order to operate this system manually, the HOA switch can be placed in the Hand position in the field or the flow-paced output to the Polymer System can placed in manual at the HMI. Pump calibration can be performed on the Polymer Feed Unit (PFU-1) using a stopwatch, a length of tubing, and a calibrated cylinder. All connections on the Polymer Feed Unit are maintained except the pump input suction line. The length of tubing is connected to the pump input with the other end of the tubing placed in the graduated cylinder. Fill the graduated cylinder with neat polymer and run the metering pump until all air is exhausted from the tubing and the polymer is being discharged from the pump. Stop the metering pump and refill the graduated cylinder with neat polymer. Note the starting volume and start the pump. Start the stopwatch when the pump starts. After pumping out an appropriately large enough volume of polymer, stop the pump and the stopwatch. Record the time and the volume remaining in the graduated cylinder. Calculate the volume pumped in milliliters per minute by:

$$\frac{\text{Starting ml} - \text{Remaining ml}}{\text{Minutes pumping}}$$

Compare the actual rate of pumping to the desired rate of pumping. If the actual rate differs from the desired rate, make the necessary adjustments to the pump controls and re-measure the pumping rate. Repeat the process until you get the actual rate to match the desired rate. Disconnect the tubing and re-install the polymer tank feed line to the pump suction.

Polymer System Concerns

NOTE: The Polymer System should provide trouble free delivery of polymer to the DAF's and/or the Thickener. If you are having difficulty with the system or if you are learning how to use the system properly, contact the polymer sales account representative or refer to the operating manual.

When the Polymer System is going to be taken out of service for a few hours, the output to the Polymer Feed Pump from the PLC will be set to zero. That means that the stroke volume of the pump will be zero and no neat polymer will be added to the system. The dilution water remains on when the Polymer System is on to permit the system to self-clean the static mixer in the system and the delivery piping to the tanks. Unless there is a specific reason for shutting down the dilution water, keep it on in order to flush the system clean. If the Polymer System must be taken out of service, the polymer must be cleaned from the Polymer Feed Pump, static mixer, and the system tubing. A good cleaning agent for polymer is Citrusolv made by Zep.

The dose of polymer varies dependent upon the stroke volume and the strokes per minute. To accurately know the dose of neat polymer that is being delivered, a field calibration must be done. This is due to the different viscosity of neat polymer and dilute polymer solutions, head pressure within the delivery piping, and internal pressure drop within the make down system.

Operational Help

- Never put water into a tank of neat polymer. It will partially activate the polymer, which will cause the pump, static mixer, or piping to clog.
- Never add neat polymer to the system from a bucket or priming collection bucket.
- Dilute the polymer within the Polymer Feed Unit; it typically yields better performance than concentrated polymers.
- Typical concentrations for dilute polymer in this type of application ranges from 0.1 to 0.75 %. Attempt to deliver the most dilute polymer as possible without adding excessive dilution water. It is necessary to dilute the polymer before application due to the neat polymer molecule behavior that is tight and non-reactive. During the make down process, the molecules relax exposing their long chain of active sites to become available to work as, “sticky” sites to take suspended solids to floc formed solids.
- Calibrate and confirm delivery of polymer. As an example, if the target dose of polymer is 9 parts per million, PPM, and the system total flow through the system is 525,000 gallons, how many pounds of polymer should be pumped for that day? How many gallons of polymer would that be?

  Assume for this example the neat polymer weighs 11.5 pounds per gallon.
  Given: 525,000 gallons flow 9 PPM target dose 1 gal polymer = 11.5 lbs

  Find: ? lbs polymer needed for treatment

  ? lbs of polymer = ?? gallons of polymer

Equation: delivered chemical lbs = target dose in PPM x (8.34 lb/gal) x (flow in million gallons)

delivered chemical lbs = (9 PPM) (8.34 lb/gal) x (0.525 Mgal)

delivered chemical lbs = 39.41 lbs (target)

Operator measured use of polymer from the polymer tote 40.5 lbs

Actual delivery 40.5 lbs vs. calculated target pounds of 39.41 yields,

40.5 lbs/ 39.41 lbs = 1.028, 1.028 x 100 = 102.8 %. This tells the operator that the feed of polymer is 2.8% high. This small deviation is not a problem. To calculate how many gallons of polymer has been used,

40.5 lbs of polymer used x one gallon/ 11.5 lbs polymer = 3.5 gallons polymer.

This is important to know so that chemical inventory and delivery can be predicted. Polymer delivery from order placement is typically two to three weeks.

<u>Overdose Check</u>.

One quick and dirty way to check if the water is mildly overdosed with polymer is to set up a vacuum set for measuring suspended solids. Pour clear primary effluent through the filter paper. If the clear effluent causes the filter paper to clog, the dosage of polymer is probably too high. Severe overdose of polymer will cause the surface of the water to change in appearance and to the touch the water is slippery. In addition, polymer can coat the filter cloths in the filter press causing the unit to perform poorly or not at all.

In review, feed as little, dilute polymer as possible while achieving good system performance.

After reading this and reviewing the operation manual for the Polymer System and if you have never worked with polymer, ask one of your co-workers that is familiar with the system to walk you through it. Polymer Systems work better when they are used within the pump curve. With both of the systems on, the stroke volume at the pump would have to be very low. Notice that there are red warning areas for stroke volume and speed. This is to indicate to the operator that the system should be operated above this range.

Dry Polymer Feed Assembly

A dry Polymer feed assembly has been added in Building D-1. It allows system operating personnel to condition the biological solids in T-901 using a polymer solution rather than powdered lime and ferric chloride. A metered amount of dry polymer is mixed with service water in the polymer mix tank (T-920) via the volumetric feeder (H-920) and mixer (M-920). The mixed polymer is transferred to a polymer application tank (T-930) via the polymer transfer pump (P-920). The polymer solution in T-930 is added to T-901 using the polymer feed pump (P-930). The operator will start the polymer application pump manually for a predetermined number of minutes based on the desired polymer dosage required for optimal conditioning of solids.

Reminder Note: Polymer is extremely dangerous because of the slips and falls that can occur when stepping in the substance. A more subtle danger is getting the substance on your shoes and a few days later getting your shoes wet and falling due to the dry polymer that went into solution. After all visible evidence of polymer is gone, continue to wash down for several minutes. Clean bulk spills with oil dry or kitty litter and shovel the waste up before starting to wash the area down. Zep Citrusolv is a good cleaning agent. Keep polymer areas clean and dry!

LIME SYSTEM

General

The lime addition system consists of a 1500 CU. FT (30 Ton) storage silo (T-752). The lime storage silo is 12-feet in diameter and has a wall depth of 28-feet. A 15 HP bin activator (M-753), 10 HP Volumetric Feeder (M-754), 3 HP Screw Conveyor (M-755) with a capacity of 40-50 CU. FT/HR, a Truck fill panel, and a System Control panel comprise the balance of the system. Hydrated lime is received in bulk pneumatic delivery trucks (i.e. closed tank trucks with integral blowers for conveying the contents pneumatically into a storage bin). Lime is fed to the conditioning Tank in dry form using a screw conveyor and a volumetric feeder. A water spray is used to mist the lime as it is delivered to Conditioning Tank in order to minimize dusting.

This is a batch operation set up and operated from the System Control Panel located inside the Lime Silo building.

SILO SYSTEM - TRUCK FILL OPERATIONS

The truck fill operations are monitored and controlled from the PLC located in the Lime system control panel located inside the lime silo building. Before commencing any operations from the Truck Fill Panel, the operator is required to set the following:

- Silo Dust Filter Blower — Selector switch to AUTO
- Silo Dust Filter Shaker — Selector switch to AUTO
- Bin Valve — Manually close valve (first fill only)
- Hose Connection — Remove fill cap and connect fill hose to pipe on silo

After detection of removal of the fill cap by the limit switch, the following automatic control actions are carried out.

- Dust Filter Blower — Runs
- Dust Filter Blower — On light illuminated

The operator commences pneumatic filling. Filling will continue until interrupted by the operator. If high level is detected in the silo filling during filling, the following automatic control actions are carried out.

- Truck Fill — Alarm Horn Alarm Horn sounds
- Bin Level High — Alarm light illuminated

When the high level alarm actuates, the operator is required to perform the following actions:

- Truck — Stop pneumatic filling
- Truck Fill Panel — Press Alarm silence button (Truck fill panel)
- Hose Connection — Disconnect fill hose from pipe on silo
- Bin Valve — Manually open valve (first fill only)
- Hose Connection — Attach fill cap to pipe on silo

After detection of the fill cap by the limit switch, the following automatic control actions are carried out.

- Dust Filter Blower — Stops
- Dust Filter Blower — On light not illuminated
- Dust Filter Shaker — Runs for preset time and stops.
- Dust Filter Shaker — On light illuminated while shaker is running.

LIME SYSTEM CONDITIONING TANK FEED

The conditioning tank feed operations are monitored and controlled from the PLC located in the Lime system control panel located inside the lime silo building. Before commencing any operations the operator must set up the batch parameters needed to treat the sludge in the Conditioning Tank.

Before commencing the treatment of the Conditioning Tank with lime the operator is required to set up the following.

- Bin Valve — Check that the valve is open
- Control Power — Control power light is illuminated
- Bin Activator — HOA Switch in Auto
- Volumetric Feeder — HOA Switch in Auto

- Screw Conveyor HOA Switch in Auto
- Batch Timer Enter length of time to feed lime to Hopper

The operator initiates the lime feed to the conditioning tank and checks the following.

- Batch mode Batch mode switch to ON
- Bin Activator Cycles ON and OFF
- Volumetric Feeder Turns ON
- Screw Conveyor Turns ON
- Batch Timer Timer STARTS and displays time left
- Operator Visually verify that lime is entering the Cond. Tank

The system continues to operate until the batch mode timer times out.

- Bin Activator Turns OFF
- Volumetric Feeder Turns OFF
- Screw Conveyor Turns OFF (once low level is reached in the Hopper)
- Batch Timer Timer Done light is ON

The operator disables the lime feed to the conditioning tank and checks the following.

- Batch mode Batch mode switch to OFF
- Operator Visually verify no lime is entering the Cond. Tank

Chemical Testing Protocol

Bench-scale jar testing is conducted bi-monthly to check chemical product performance and dosage requirements. Chemical dosage rates are monitored and adjusted as required to satisfy changes in flow and sludge characteristics. (Note: Jar testing of the sludge in the Conditioning Tank will need to be done per batch) These tests provide the best performance along with the most cost-effective dosage rate of the chosen chemicals.

ELECTRON DONOR SYSTEM

The Electron Donor System is designed to feed ethanol (electron donor) to four (4) first-stage fluidized bed reactors (FBRs-1, -2, -3 , 4, and FBR-A) and four (4) second-stage fluidized bed reactors (FBRs-5, -6, -7 and -8) that are designed to treat perchlorate at the site. The reader is referred to the Piping and Instrumentation Drawings, Process Flow Diagram and Chapter 3 for descriptive information about the FBR treatment system. The major equipment included in the electron donor system are:

(1) – 10’-1” outside diameter X 38’-8” long, horizontal, 20,000 gallon, electron donor (i.e., ethanol) storage tank (T-703) and related hardware.

(2) – 10 GPM tank mounted electron donor booster pumps (P-739 A/B) and piping.

(4) – 20 GPH skid mounted electron donor metering pumps (P-731, -732, -733 and 734), piping and calibration columns.

(4) – 8 GPH skid mounted electron donor metering pumps (P-735, -736, -737 and -738), piping and calibration columns.

(1) – Spill Containment Pan.

ELECTRON DONOR SYSTEM LOCATION

The electron donor system is located outdoors west of existing Building D-1 and south of the 1st stage FBRs. Refer to an overall system arrangement drawing M-2 for the overall treatment system. The electron donor storage tank and pumps are accessible by truck for filling.

SYSTEM DESCRIPTION

Feed Flow Control

The system is designed to feed ethanol (SDA 35A 190 Proof or similar) to the discharge side of fluidization pumps that provide feed to the FBRs. One metering pump is provided for each FBR. The system controls provide the ability to set the system feed flow at a rate proportional to the flow to each FBR. Each metering pump can be started and shutoff manually by a hand switch provided at the pump.

ORP will be used as a guide to establishing electron donor feed rates. However, caution should be employed when using ORP values tied to a process control feedback loop for electron donor addition. Water chemistry and specific microbiology can affect ORP measurements; as such, ORP set points and control schemes should be set initially by SHAW E & I and adjusted only after a long history of correlated performance with ORP has been developed.

Electron Donor Storage Tank

Denatured ethanol will be used as the electron donor for the treatment system. The ethanol will be purchased in 95% concentration (190 proof) and stored in a 20,000-gallon tank (T-703) located north of the treatmentsystem.

The tank is double walled carbon steel with a fill station, an integral ethanol metering pump skid, a canopy to shelter the pump skid from rain and snow, a spill containment enclosure for the fill station, one tank top mounted manway, an interstitial leak monitoring system, and nozzles for pipes and appurtenances.

Electron Donor Tank Fill System

The tank is provided with a 3-inch fill line that will receive ethanol delivery from a commercial supply tank truck. The delivery connection, isolation valve (V-751) and check valve (V-750) are contained inside a spill containment to catch ethanol leaks during fill operations. The operator can monitor the tank level at the SCADA screen on LI-703 or at the locally at the tank. The maximum tank liquid depth is 114 inches and the minimum is 0 inches. A tank calibration table at the end of this chapter provides depth to tank capacity. As the tank depth passes 100 during filling the operator should prepare to stop the tank filling process.

Tank Safety Controls

A tank gauging leak detection system is provided that monitors tank levels, temperatures and leaks in the tank. The OMNTEC analyzer will alarm at the Truck Fill Station only on High level and High-High Level in the Ethanol tank.

The top of the tank is provided with two automatic emergency vents (PSV-704 and PSV-705) that are set at 8 oz. to relieve tank internal pressure. The top of the tank is provided with a flame arrester in combination with a pressure relief valve (PSV-703) that is set at +4 in w.c./-1 w.c. internal tank pressure. The flame arrester is designed to prevent transmission of heat and or an ignition source into the tank. A Tank Level Gauge. A Morrison Fig 818 Clock Tank Level Gauge is provided for local measurement of liquid level in the tank.

Electron Donor Booster Pumps

Two (2) booster pumps (P-739 A/B, one operating, one standby) are provided to ensure positive inlet pressure to any number of operating metering pumps. The booster pumps are Viking Mag Drive pumps, Model No. GG-895 with cast iron internals and are rated at 10 GPM @ 10 psi.

The common discharge line of the two booster pumps is provided with a product return line to the tank. A Pulsation Dampener is provided on the common discharge line of Pumps 739-A/B. The pressure control valve (PCV-739) in the return line is set between 5-15 psig. Tank T-703 low level or containment leak detection causes Electron Donor Booster Pump to shut down.

Electron Donor Skid Assembly

Ethanol feed from the booster pump is measured on the Electron Donor Skid Assembly at FE-739. The Mass Flow Element measures total ethanol flow from the storage tank to the reactors.

Eight (8) electric operated diaphragm metering pumps, P- 731 through P- 738, are provided to pump ethanol to the eight FBRs. The rate of ethanol addition to each FBR is in proportion to the feed flow to each FBR, and is operator-adjustable. The rate of ethanol addition can also be tuned using ORP. See Appendix C in the Operation & Maintenance Manual for the Fluidized Bed Perchlorate Treatment System for guidance in setting the ethanol addition rates.

Each pump is provided with a calibration column and a common return line to the electron donor tank, Kenco Engineering Calibration Pot Model No. 15848-SS-T-GPH.

ELECTRON DONOR OPERATING REQUIREMENTS

The operator will use the Electron Donor Tank & Pumps SCADA screen to control the electron donor feed system. First, select one of the two electron donor booster pumps. One booster pump will be used and the second is a spare. The operator will verify the manual valves at the selected booster pump are open prior to starting the pump. At startup, the electron donor feed metering pumps will be used in hand mode making adjustment to pump output percentages based on operator observation of system performance. When the FBR system has steady and established operating conditions, the electron donor metering feed pumps should be placed in Auto mode.

The automatic feed control of the electron donor is based on flow proportional control. As the FBR feed flow changes the flow of electron donor automatically changes. Proportionality constant, K1, is adjustable on the FBR set points SCADA screen. This constant, K1 has been set by Shaw engineers based on anticipated operating conditions and should only be adjusted with guidance from Shaw E&I engineers.

The operator should verify all valves are open on each electron donor feed line as well as the electron booster pump in use. The inlet and outlet valve on the offline booster pump should be closed.

Use the calibration column to measure electron donor flow to each FBR and confirm that the flow equals the flow calculated on the electron donor spreadsheet. The operator will need a stopwatch to time the calibration column draw down. Fill the calibration column using the manual valves. Then, close the valve on the ethanol booster pump feed and open the valve on the calibration column. Time the draw down. Return all valves to the normal operating positions.

ETHANOL TANK (T-703) CALIBRATION CHART

Depth In.	VOL. Gals.	Depth In.	VOL. Gals.	Depth In.	VOL. Gals.	Depth In.	VOL. Gals.
1	39	30	4283	59	10580	88	16736
2	94	31	4483	60	10850	89	16922
3	163	32	4685	61	11039	90	17107
4	243	33	4888	62	11253	91	17288
5	333	34	5094	63	11477	92	17466
6	432	35	5301	64	11701	93	17642
7	538	36	5510	65	11924	94	17814
8	651	37	5730	66	12146	95	17982
9	771	38	5932	67	12638	96	18147
10	897	39	6145	68	12589	97	18308
11	1028	40	6360	69	12809	98	18466
12	1165	41	6575	70	13038	99	18619
13	1307	42	6792	71	13247	100	18768
14	1454	43	7010	72	13464	101	18912
15	1605	44	7339	73	13680	102	19051
16	1760	45	7449	74	13895	103	19186
17	1919	46	7669	75	14109	104	19314
18	2082	47	7891	76	14322	105	19437
19	2249	48	8113	77	14533	106	19554
20	2430	49	8335	78	14742	107	19664
21	2593	50	8558	79	14950	108	19766
22	2770	51	8782	80	15157	109	19860
23	2950	52	9006	81	15361	110	19945
24	3135	53	9231	82	15564	111	20020
25	3318	54	9465	83	15765	112	20083
26	3506	55	9680	84	15963	113	20129
27	3697	56	9905	85	16160	114	20150
28	3890	57	10150	86	16354		
29	4086	58	10355	87	16546		

TROUBLESHOOTING

Ferric Chloride System (Sludge Conditioning)

CONDITION	PROBABLE CAUSE	REMEDY
No chemical delivery to the Conditioning Tank	• Check Chemical Storage Tank Level • Check pump operation • Check the operation of automatic valve (FV-751E)	• Fill Chemical Storage Tank • Restart or repair Ferric Feed Pump • Operate automatic valve (FV-751E) in HAND if necessary.
Low chemical delivery to the Conditioning Tank	• Check Chemical Storage Tank Level • Check pump operation	• Fill Chemical Storage Tank • Close down on the manual Ferric Recycle Valve (do not close all the way)

Dry Polymer Feed Assembly (Solids Conditioning)

CONDITION	PROBABLE CAUSE	REMEDY
No chemical delivery to the Conditioning Tank	• Check Polymer Application Tank Level • No dry polymer	• Verify polymer in dry Polymer Hopper, H-920 and proper addition of polymer to mix tote • Restart or repair Polymer Application Pump • Check operation of automated fill valve FV-920 and check water flow

Ferric Chloride System (Coagulant for the Dissolved Air Flotation)

CONDITION	PROBABLE CAUSE	REMEDY
Low Flow Alarm	• Check Chemical Storage Tank Level • Check pump operation • Check peristaltic tubing	• Fill Chemical Storage Tank • Restart or repair Ferric Feed Pump • Replace peristaltic tubing

Hydrogen Peroxide System

CONDITION	PROBABLE CAUSE	REMEDY
Low Flow Alarm	• Check Chemical Storage Tote Level • Check pump operation • Check peristaltic tubing	• Change Chemical Storage Tote • Restart or repair Hydrogen Peroxide Feed Pump • Replace peristaltic tubing

Defoamer System

CONDITION	PROBABLE CAUSE	REMEDY
Low Flow Alarm	• Check Chemical Storage Drum Level • Check pump operation • Check peristaltic tubing	• Fill Chemical Storage Drum • Restart or repair Defoamer Feed Pump • Replace peristaltic tubing

Polymer Unit

CONDITION	PROBABLE CAUSE	REMEDY
Unit shut down on high differential pressure	• Closed or blocked discharge pipe • Too much service water flow	• Verify that all downstream valves are open • Flush discharge piping out • Adjust setting on D/P switch • Decrease service water flow.
Loss of prime on polymer pump	• Check tote volume • Verify that tote mixer is on • Debris lodged in LMI pump head	• Replace polymer tote • Check for solidification of polymer due to lack of mixing and ambient temperature • Disassemble pump head, clean thoroughly, air dry, and reinstall

Bulk Lime System

CONDITION	PROBABLE CAUSE	REMEDY
Screw Conveyor Shuts down on High Hopper level	• Verify Lime is discharging to conditioning tank • Volumetric Feeder is adding more lime to the Hopper than the Screw Conveyor is removing	• If there is no discharge, open clean out cap on bottom of Screw Conveyor and reverse the direction of the Screw Conveyor in an attempt to clean out the conveyor tube. • Increase the speed of the Hopper Vibrator Motor
Screw Conveyor Shuts down on Low Hopper Level	• Verify Lime is discharging in to the Hopper • Volumetric Feeder is adding less lime to the Hopper than the Screw Conveyor is removing	• Unclog Volumetric Feeder as recommended in the Vendor's Literature • Decrease the speed of the Hopper Vibrator Motor

CHAPTER 11
PROCESS CONTROL SYSTEM

OVERVIEW

The next page shows an overview of the Nevada Environmental Response Trust Perchlorate Removal System.

The PLC (programmable logic controller) in the MCC Building (Electro Center) is what controls the entire system. It has Profibus ports for connecting to the I/O modules. These I/O modules are what turn on and off the starters, control valves and accept 4-20 mA signals from the instruments.

If the PLC loses communication with an I/O module, all outputs (motor starters, valves) controlled by that module will turn off. All other modules will continue to operate as normal.

Operators interface with the control system through the WinCC program that runs on the two personal computers (PC's). One of the PC's is installed on the control panel in the MCC. The other PC is in building D1.

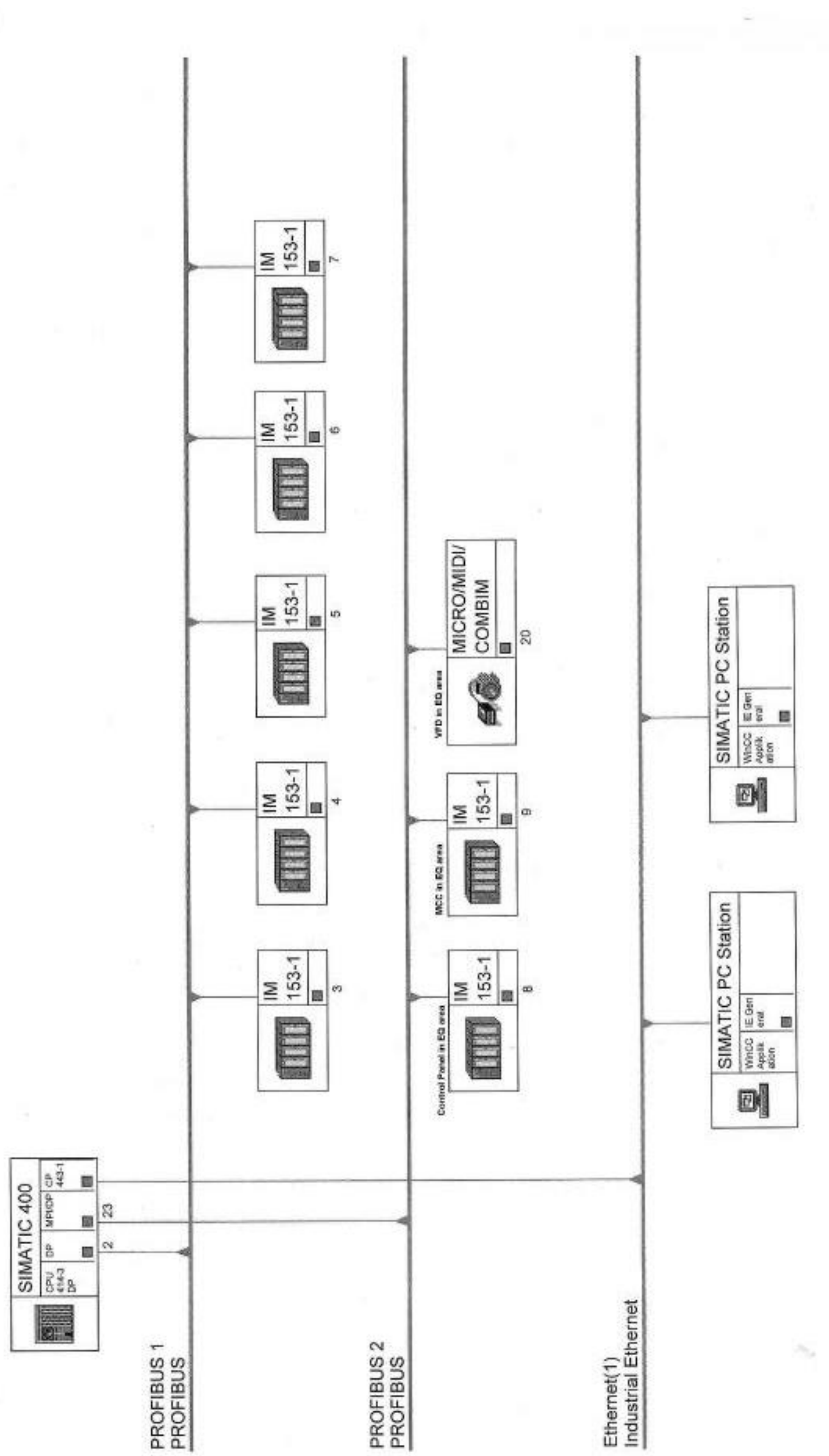
Both PC's are connected to the PLC through Ethernet. There is an Ethernet switch in the control panel and another switch installed in the control panel in building D1.

If the PLC loses communication with either or both P.C.'s, the system will continue to run with all set points last entered on the screen without any problems.

The WinCC program on the two PC's are set up as exact duplicates. If one of the PC's is lost, all functions are still accessible from the other PC.

The primary difference between the set up on the two PC's is that the PC in Building D1 has the Engineering software installed also. This computer can be used to modify the PLC program as well as the WinCC program.

All systems (motors, valves, etc.) which have control on the screen are designed to be run from the screen. If Hand/Off/Auto switches are provided at the motor or valve, they should always be in Auto unless there is repair or maintenance being performed on the motor or valve. Switches at the equipment always have priority over the selections on the screen.


SIMATIC 400
CPU 414-3 DP
DP
MPI/DP
CP 443-1
2
23
PROFIBUS 1
PROFIBUS
PROFIBUS 2
PROFIBUS
Ethernet(1)
Industrial Ethernet
IM 153-1
3
IM 153-1
4
IM 153-1
5
IM 153-1
6
IM 153-1
7
Control Panel in EQ area
IM 153-1
8
MCC in EQ area
IM 153-1
9
VFD in EQ area
MICRO/MIDI/ COMBIM
20
SIMATIC PC Station
SIMATIC PC Station

SCADA SCREENS

Below is a list of screens.

1. Main Screen
2. Equalization Area – Pumps and EQ tanks
3. Equalization Area – Carbon Absorbers & Effluent
4. Equalization Area Detail Settings
5. EQ Pressure, Flow and Level trending screen
6. EQ area Effluent pH and Perchlorate trending
7. Equalized Feed Pressure Control, Conductivity and Micronutrient
8. Equalized Feed Pressure Control Detail Settings
9. Influent Feed flow and Pressure trend
10. Influent Conductivity Trend
11. FBR’s 1 & 2
12. FBR’s 1 & 2 Detail settings
13. FBR’s 1 & 2 Flow trending
14. FBR’s 1 & 2 pH and ORP trending
15. Separator T-2011
16. Separator Detail Settings
17. Separator tank level trending
18. FBR’s 3 & 4
19. FBR’s 3 & 4 Detail settings
20. FBR’s 3 & 4 Flow trending
21. FBR’s 3 & 4 pH and ORP trending
22. Separator T-2012

23. Separator tank level trending
24. FBR’s 5 & 6
25. FBR’s 5 & 6 Detail Settings
26. FBR’s 5 & 6 Flow trending
27. FBR’s 5 & 6 pH and ORP trending
28. Separator T-3011
29. Separator tank level trending
30. FBR’s 7 & 8
31. FBR’s 7 & 8 Detail Settings
32. FBR’s 7 & 8 Flow trending
33. FBR’s 7 & 8 pH and ORP trending
34. Separator T-3012
35. Separator tank level trending
36. Aeration

DAF’S

1. Effluent
2. Effluent Level Detail Settings
3. Effluent Tank level trend
4. Solids
5. Ethanol/Electron Donor Tank & Pumps
6. Set points
7. Setpoints-2
8. Alarms (See attached list)

TROUBLESHOOTING

To be able to troubleshoot the control system several documents may be required. Below is a list in the order of importance.

1. Process Controls and Assembly Specification.
2. P&ID
3. Electrical schematic for Fluid Bed System
4. Electrical Single line diagrams
5. Specific instrument manuals
6. PLC program

If for instance the feed valve on FBR #1 isn't opening, the first step is to rule out that there isn't a process reason for the valve to not open.

If the process reason can be ruled out, then the P&ID should be checked for any interlocks related to the device that is not responding.

If all interlocks shown on the P&ID are made, then the electrical schematic should be used in conjunction with a multi-meter to narrow the problem to a specific instrument. Note that one of the checks should be to see if there are any error lights on the I/O modules. All modules normally have a green 'OK' light on them in addition to individual I/O point lights. The electrical single line diagram may be required to troubleshoot devices which terminate in the MCC. Specific instrument manuals (such as the Rosemount pH transmitter manual) may be required also.

If the problem is not related to an electrical fault, then the PLC program should be checked to see what (if any) interlocks could be disabling the device.

ALLEN BRADLEY TO FBR SYSTEM INTERFACE

AB – Rockwell Automation / Allen-Bradley

CAT5 – A standard 8-conductor unshielded twisted pair cable

D1 – A specific area within the KMG system perimeter

Ethernet – A type of Local Area Network

FBR – Fluidized Bed Reactor

GWTS – Ground Water Treatment System

F.O. or FO – Fiber Optics

HMI – Human Machine Interface (Graphics Computer)

LAN – Local Area Network S7 – Siemens Step 7 Application Suite

PC – Personal Computer

PLC – Programmable Logic Controller

RSView32 – Rockwell Software HMI Application Suite

SCADA – Supervisory Control and Data Acquisition

Trailer – Administrative Offices for Veolia Water

General Information

The system within the KMG system that supports the processes associated with the FBR, is a combination of Siemens S7 and AB PLC's and HMI's connected together on a common LAN. The Ethernet network uses a TCP/IP protocol and is connected between automation components and various PC's in the trailer by a combination of wired and optical media.

Specific Information

PLC Network

The PLC network is comprised of a combination of one Siemens S7 PLC and two AB PLC's within the system perimeter and three AB PLC's outside of the perimeter at the remote facilities. All AB PLC's are part of the SLC family of processors. The system processors are Ethernet enabled and the remote SLC processors are DH-485/DF1 enabled. The configuration of the AB PLC's segregates the use of the processors for the unit process at the GWTS (processor is local), and a data accumulator for the remote facilities PLC's located within the D1 control room. The GWTS is also provided with a monochrome non-PC based operator interface (AB PanelView 550), which provides a text and limited graphic interface to the AB, networked PLC's. Communication between the GWTS, the GWTS PanelView, and the D1 SLC CPU is through Ethernet.

The Siemens processor, although connected to the same Ethernet subnet, is not arranged for peer-to-peer communications, but the two AB SLC processors can pass data natively between the processors in a bi-directional configuration.

The main use for the two AB PLC's is the direct control of the GWTS, and for reception and transmission of data to, and from, the remote facilities SLC processors. The Data Accumulator PLC is referred to as the "D1 PLC" and both it and the GWTS are directly interfaced through Ethernet to a Rockwell Software RSView32 HMI PC. The RSView32 graphical suite provides process data display, trending, control commands, discrete information, alarming, and other functions commonly associated with SCADA systems. The D1 SLC handles sump pump controls within the old IPEC area adjacent to D1 and can perform any control function associated with SLC 500 processors.

Network Specifics (See image below)

All the administrative office trailer computers are connected to a 16-port Ethernet switch and then connected underground via CAT5 from the trailer to a network panel at the GWTS, where the CAT5 media is converted to a buried fiber optic leg that connects the GWTS network panel to the D1 building. At the D1 building the fiber optic leg is converted back to CAT5 Ethernet and then to an 8 port Ethernet switch which is then distributed to all Ethernet drops in the D1 building, including the FBR Siemens SCADA computer, the Dell Rockwell SCADA computer, and the Allen-Bradley D1 SLC. One of the connections from the Ethernet network switch in D1 is routed by CAT5 to the FBR MCC room where the second FBR Siemens HMI flat panel MCC-mounted View station is located. The Siemens S7 PLC is also directly connected to the same 8-port Ethernet switch in the D1 building by another CAT5 run from D1 to the FBR MCC room.

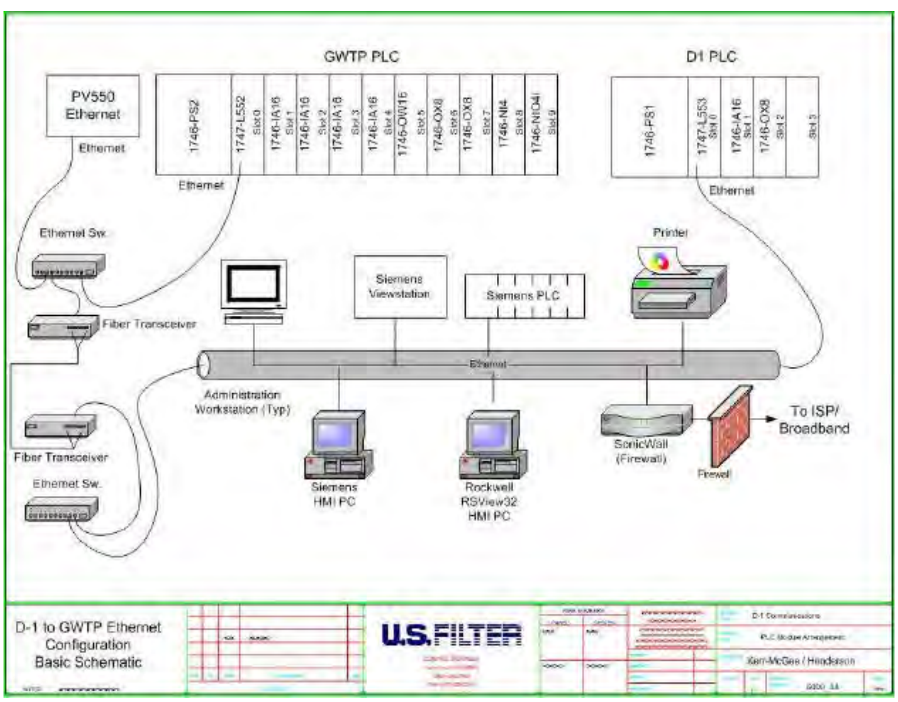
The FBR system at KMG, including the Siemens S7 PLC and two Siemens SCAD computers are on the same Ethernet subnet as the GWTS, the AB D1 SLC and the D1 Rockwell Software HMI Graphics computer.

The computers in the administrative office trailer are on the same subnet as the process computers and PLC's, but these computers do not have direct access to any of the process PLC's because they do not have the requisite software or OEM applications to do so. On occasion, it has been useful to use an office Ethernet port to connect an authorized, configured laptop to troubleshoot the network and PLC's, and the network topology fully supports this functionality.

There is a microwave broadband Internet connection via a strong firewall at the D1 building. This Internet connection is completely distributed to all Ethernet devices on the common LAN subnet. Any computer in the office trailer or D1 potentially has Internet access if so programmed.

The AB D1 SLC has a dedicated phone line (Voice-grade, switched on, no dial tone) connection to the remote lift stations. Any process data from the remote lift stations, which is required, has been mapped from this phone line connection to internal data registers in the D1 SLC. Since the data concentrating PLC is on Ethernet, the mapped data registers are accessible to any computer on the LAN, which has the requisite software to retrieve this data. At present the only computer, which has this software, is installed and implemented is the Dell Rockwell SCADA computer in D1.

Figure 11-1 Basic LAN Layout for D-1 and Main System

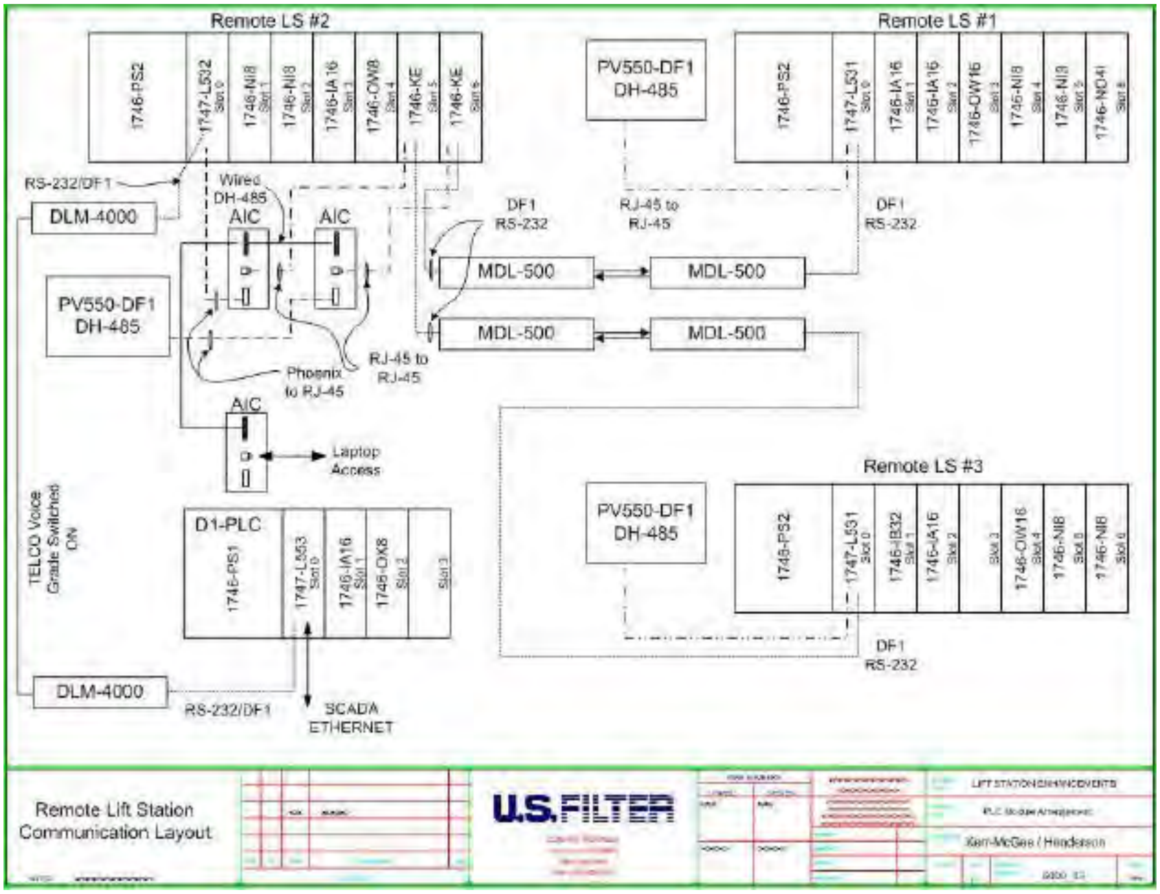


Remote Facilities (See Image Below)

The remote system network is comprised of three SLC processors, which share data and accumulate the data within one of the three to send and receive with D1. The connections are between remote lift stations numbered as 1, 2, and 3 with the central location being #2. The connections between #1 and #2, and #3 and #2 are cabled and use long-line modems to pass data bi-directionally. The connections to LS #2 from D1 are through a pair of specific modems that are connected in real time on the connection mentioned in the previous section. This provides a data pass at 19200 Baud, in a non-polled continuous data-packaging configuration.

The level of interface of the data from the remote facilities is complete at this time to the point of system monitoring at the D1. It is anticipated that bi-directional control will be implemented before the end of 2004 as a new and unprecedented level of control for these facilities and will provide operations in the Control Room at D1 with the ability to send control commands and relevant data to the remote locations as well as receive the data as provided in the current configuration.

Figure 11-2 Basic Remote Communication and PLC Layout



Additional Capabilities

The ability for the Siemens and the AB platforms to exchange data will be developed in the future and will be appended to this document as applicable.

CHAPTER 12
UTILITY SYSTEMS

AIR COMPRESSOR SYSTEM

Overview

Compressed air for the system is supplied by two Ingersoll Rand Air Compressors, (P-801 & P-802) that are located in the Filter Press building. The system has a 660-gallon air receiver tank (T-801), and an Instrument Air Dryer (T-802), two Oil Removal Filters (F-802 & F-803) and one Particulate Filter (F-804). One compressor will be on line while the other compressor will be in AUTO START MODE. While the unit is on line, the compressor motor will run continuously and the compressor will automatically load and unload as required to maintain 80 psig (+ or – 5 psi) air pressure in the air receiver tank. If the compressor that is on line does not maintain the 80 psig, the other compressor will automatically start and go on line. Compressor oil level should be checked regularly. Use the type of lubricating oil recommended by the manufacturer. The oil removal and particulate filters should be cleaned periodically as well.

Air from the two air compressors (P-801 & P-802) is fed through two 2 – inch CSTP40 carbon steel lines through a check and ball valve to the Compressed Air Receiver Tank (T-801). Air flow out of the tank is through a 1.5 – inch CSTP40 carbon steel line through a ball valve to the oil removal filter (F-802) through the Instrument Air Dryer (T- 802) to the particulate filter (F-804), out of the filter through a 1.5 – inch CSTP40 carbon steel line through a ball valve to a pressure control valve (PCV – 803) set at 100 PSI with a pressure indicator (PI-803). There is a low pressure switch (PSL - 802) set at 80 PSIG installed in 1.5 – inch CSTP40 carbon steel line that goes to the instrument air header. This switch is monitored by the PLC.

MAJOR COMPONENTS

Air Compressors (P-801 & P-802)

Ingersoll Rand Model EP50-PE with a capacity of 215 ICFM @ 125 PSIG Rotary Screw type with a 50HP 460VAC 3-phase motor.

Each Air Compressor has its own control panel on the front of the unit. These systems have the Intellisys Control & Instrumentation option. The touchscreen is used to start & stop the unit as well as for setup, displaying status and troubleshooting. See the Operation manual for additional information.

Compressed Air Receiver Tank (T-801)

The storage tank for the Air system a steel 660 gallon 42"OD x 120"HT with a maximum pressure of 137 PSIG. Both compressors feed the air tank. The tank has a local pressure indicator (PI-801) and a pressure relief valve (PSV-803) set at 150 PSI.

Instrument Air Dryer (T-801)

The instrument Air Dryer is a Regenerable Desiccant Dryer with an inlet flow rating of 160 SCFM (100PSIG) and a purge rating of 238 SCFM.

Oil Removal Filters (F-802 & F803)

The oil removal filters are rated for 275 SCFM 2 100 PSIG and a wet pressure drop of 6 PSI for liquid removal of 99.99% oil.

Particulate Filters (F-804)

The particulate filter is rated for 275 SCFM 2 100 PSIG and a wet pressure drop of 3 PSI for liquid removal of 100% water.

SERVICE WATER SYSTEM

Overview

The effluent water system furnishes a pressurized water supply for a variety of functions throughout the system that do not require a potable water supply. It provides pressurized seal flush water to the FBR pumps (P-1011, P-101A, P-1012, P-1013, P-102A, P-1014, P-3015, P-301A, P-3016, P-3017, P-302A & P-3018) through a 1 -inch CVPC line. Flush water for the Filter Press feed pumps (P-901 & P-902) through a 2 – inch CVPC line. Dilution water to the Polymer feed systems (P-741 & P-742) through a ½ - inch CVPC line. Make up water through a 1.5 – inch CVCP line to the Separator Tanks (T-2011, T-2012, T-3011 & T-3012)

ELECTRICAL SYSTEM

Overview

The FBR System motor control center is fed from an 800 Amp breaker located in the existing substation located to the west of Building D-1. Power to this process can be locked out at the substation breaker or at the MCC main circuit breaker. The equalization area equipment is fed from MCC-3, located in Building D-1 Electrical Room. MCC-3 is fed from a circuit breaker located in MCC-1 in the D-1 building electrical room. MCC-3 can be locked out at the feeder breaker in MCC-1.

Motor Control Center (MCC)

The FBR System motor control center controls the operation of all the system equipment with the exception of the Equalization Area equipment and the Building D-1 ISEP and raw water sumps and the booster pumps all of which receive power feed from the Building D-1 MCC. The MCC contains control transformers, motor starters, indicating lights and circuit switches for the various pieces of electrical equipment located throughout the plant. All of the equipment is provided with a disconnect switch safety lockout at the MCC. The operator must make certain that the power supply is disconnected at the motor control center or panel before any maintenance or repair is attempted on electrical equipment. This is necessary since many pieces of equipment are designed to start automatically or may be started remotely, and serious injury or death could occur if the circuits should be closed while the equipment is being serviced.

The control center is divided into smaller compartments containing the specific controls or switches for particular pieces of electrical equipment. Each compartment and every control switch are marked with a nameplate describing the function of the device and its identification. The MCC controls the power supply to the following equipment and circuits:

- First Stage FBR Fluidization Pump No. 1 (P-1011)
- First Stage FBR Fluidization Pump No. 2 (P-101A)
- First Stage FBR Fluidization Pump No. 3 (P-1012)
- First Stage FBR Fluidization Pump No. 4 (P-1013)
- First Stage FBR Fluidization Pump No. 5 (P-102A)
- First Stage FBR Fluidization Pump No. 6 (P-1014)
- Second Stage FBR Fluidization Pump No. 1 (P-3015)
- Second Stage FBR Fluidization Pump No. 2 (P-301A)
- Second Stage FBR Fluidization Pump No. 3 (P-3016)
- Second Stage FBR Fluidization Pump No. 4 (P-3017)
- Second Stage FBR Fluidization Pump No. 5 (P-302A)
- Second Stage FBR Fluidization Pump No. 6 (P-3018)
- Bed Height Control Pump No 1. (P-1021)
- Bed Height Control Pump No 2. (P-1022)
- Fluidized Bed Containment Area Sump Pump No 1 (P-1101)
- Bed Height Control Pump No 3. (P-1023)
- Bed Height Control Pump No 4. (P-1024)
- Thickener Underflow Pump (P-603)
- Scraper / Rake (M-611)
- Media Return Pump No 1 (P-2011)

- Media Return Pump No 2 (P-2012)
- Media Return Pump No 3 (P-3011)
- Media Return Pump No 4 (P-3012)
- Air Compressor Control Panel No 1 (P-801)
- Filtrate Recycle Pump (P-903)
- Aeration Blower (B-401)
- Sludge Conditioning Tank Agitator (M-901)
- DAF Pressure Pump No 1 (P-501)
- DAF Pressure Pump No 2 (P-551)
- Fluidized Bed Containment Area Sump Pump No 2 (P-1102)
- DAF Skimmer Drive No 1 (M-503)
- DAF Skimmer Drive No 2 (M-553)
- DAF Screw Conveyor Drive No 1 (M-502)
- DAF Screw Conveyor Drive No 2 (M-552)
- Ferric Chloride Feed / Mix Pump (P-751)
- Hydrated Lime Silo Control Panel (T-752)
- Effluent Pump No 1 (P-601)
- Effluent Pump No 2 (P-602)
- (Spare Breaker)
- Air Compressor Control Panel No 2 (P-802)
- Flocculation Mixer No 1 (M-612)
- Flocculation Mixer No 2 (M-613)
- Electron Donor Booster Pump No 1 (P-739A)
- Branch Circuit Panel board BCP-A (BCP-A)

- Control Panel Raychem HTPG (HPCP)
- Filter Press Control Panel No 1 (X-901)
- Filter Press Control Panel No 2 (X-902)
- DAF Float Pump No 1 (P-502)
- DAF Float Pump No 2 (P-552)
- (Spare Size 2 Starter)
- Electron Donor Booster Pump No 2 (P-739B)
- (Spare Size 1 Starter)
- Biofilter Control Panel
- (Spare Breaker)
- Branch Circuit Mini Power Zone BCP-B (BCP-B)
- (Spare Breaker)

Remote Safety Disconnects

Safety disconnect switch or field mounted lockout control station are located near each piece of electrical equipment. These devices may consist of HAND-OFF-AUTO switches for turning off the equipment. However, whenever it is necessary to work on the wiring of a motor or other piece of equipment, the power must be shut-off at the line disconnect at the MCC. The shut-off switches are designed so that they may be locked out with small padlocks to assure that no equipment is started while maintenance procedures are being performed. Detailed wiring schematics of both the remote field-mounted controls and motor control center controls are presented in the construction drawings.

EQUIPMENT PAD SUMPS

Overview

The equipment pad has two sumps with one pump installed in each sump (P-1101 & P-1102). These pumps are used for the removal of liquids from the equipment area. One sump is located between FBR – 1 Tank and FBR – 5 Tank and the other located by the Aeration Tank (T-401). There is a third existing sump pump adjacent to the D-1 Building (P-1202). The sump pumps (P-1101 & P-1102) are submersible centrifugal with a capacity of 85 GPM @ 27' TDH driven by a 1 HP 460VAC 3-Phase 60 Hertz motor. Fluids are pumped from the pad sumps to the Existing D – 1 sump, which transfers the water to GW-11 pond. The sump pumps in the equipment pad area have a level switch (LS -1101 & LS -1102), a High Level Alarm (LAH-1101 & LAH-1102) and Local Indicator (YI -1101 & YI -1102).

Liquids from the sumps are automatically pumped through a 3–inch CVCP line through a check valve and a ball valve to the ISEP sump outside the D-1 building. The ISEP pumps are controlled using the Building D-1 Allen Bradley System.

Safety Showers

There are 5 safety showers on the equipment pad (SS – 1202, SS – 1203, SS - 1204, SS – 1205 & SS – 1206) and 2 existing showers in the D -1 Building. Each shower is equipped with a pull chain to activate the shower, a handle to activate the eyewash, a temperature valve, an event alarm and SS-1202 through 1206 contain an alarm output to the PLC to indicate they are in use. The safety showers in Building D-1 do not have an alarm output. Stabilized lake water is fed to each safety shower through a 1.5 – inch CVPC line through a ball valve. The safety shower drains to the equipment pad sumps.

Fire Suppression System (Ethanol Storage)

The Ethanol Storage Vessel is provided with a fire protection system in accordance with NFPA and the following guidelines from Factory Mutual for water-spray application for “spill” hazard control and dilution.

The fixed fire protection uses a deluge control valve operating automatically by “pilothead” detection. The detection system consists of standard sprinkler devices installed on a closed network of pressurized pipe (air pressure supplied by a compressor in valve house). If a fire occurs, the heat from the fire should “fuse” (or melt) the mechanical linkage (bulb) within the detecting sprinkler allowing the pressurized air to escape and mechanically tripping the deluge valve to open and water to flow through the main pipe system and discharge uniformly around the vessel with a specific design density application (0.30 gpm/sq. ft.).

The control valve can also be manually operated by actuating the “emergency pull” that is located on the valve trim.

Devices associated on the deluge control trim to allow for monitoring the system condition are wired to the local control panel in the MCC Area (refer to Simplex Panel Model 4010). The devices include:

- A tamper switch mounted on the main isolation valve in the valve house below the deluge control valve to show position of open (normal) or closed (supervisory trouble).
- A pressure switch mounted on the deluge control trim to indicate a “flow” condition if the valve is operated or if a “test” is performed on switch to simulate flow.
- A pressure switch on the “pilot-detection” line to monitor that sufficient pressure is maintained on the system.

The monitoring of the system functions are wired from the valve enclosure to the Simplex panel mounted within the MCC Room. Should an alarm or trouble condition occur with the ethanol fixed water system, alarms will be annunciated locally at panel and also be directed through the Simplex panel to a monitor station that is serviced 24-hours a day.

Recommendations for weekly visual inspections, quarterly, and annual inspections are outlined within NFPA documents. The system operating personnel shall determine any planned maintenance program. Routine housekeeping and monitoring of power interruptions or physical damage to the system components is necessary to be included in a comprehensive maintenance schedule.

Information regarding the resetting of valves after operation is described within the equipment brochures. Should any condition arise that may warrant service work, please contact the local SimplexGrinnell office.

Fire Suppression System (D-1 Building MCC Room)

The D-1 Building MCC Room area is protected by a Dry Pre-Action Sprinkler System. Activation of two smoke detectors, simultaneously sets off the water sprinkler system and the fire alarm. The Simplex 4010 automatically calls in the fire alarm.

Fire Suppression System (D-1 Building Control Room)

The wet riser sprinkler system protects the D-1 Control Room and the remainder of the D-1 Building except for the MCC Room. This is a simple, single action system, which is activated by heat. If a single sprinkler is heated, the sprinklers in the control room and the building are activated. The Simplex 4010 automatically calls in the fire alarm.

CHAPTER 13
EQUIPMENT LIST

CHAPTER 13 Equipment List

Customer: Nevada Environmental Response Trust
Location: Henderson,NV
Date: 4/28/2014

Drawing Number	Equipment Number	Equipment Name	Description	Materials of Construction	Vendor
PID-1A	P-101A	First Stage FBR Fluidization Pump	2,000 gpm @ 40' TDH, 30 HP, centrifugal	Wetted material: FRP	Fybroc
PID-1A	P-1011	First Stage FBR Fluidization Pump	2,000 gpm @ 40' TDH, 30 HP, centrifugal	Wetted material: FRP	Fybroc
PID-1A	P-1012	First Stage FBR Fluidization Pump	2,000 gpm @ 40' TDH, 30 HP, centrifugal	Wetted material: FRP	Fybroc
PID-1A	FBR-1	First Stage Fluidized Bed Reactor	14' Dia. X 30' Str, 33,000 gallons, 2,010 cu. ft. sand	FRP	Palmer
PID-1A	P-1021	Bed Height Control Pump	40 gpm @ 40' TDH, 2 HP, electric diaphragm	Wetted material: PVC, neoprene	Penn Valley
PID-1A	FBR-2	First Stage Fluidized Bed Reactor	14' Dia. X 30' Str, 33,000 gallons, 2,010 cu. ft. sand	FRP	Palmer
PID-1A	P-1022	Bed Height Control Pump	40 gpm @ 40' TDH, 2 HP, electric diaphragm	Wetted material: PVC, neoprene	Penn Valley
PID-1B	P-102A	First Stage FBR Fluidization Pump	2,000 gpm @ 40' TDH, 30 HP, centrifugal	Wetted material: FRP	Fybroc
PID-1B	P-1013	First Stage FBR Fluidization Pump	2,000 gpm @ 40' TDH, 30 HP, centrifugal	Wetted material: FRP	Fybroc
PID-1B	P-1014	First Stage FBR Fluidization Pump	2,000 gpm @ 40' TDH, 30 HP, centrifugal	Wetted material: FRP	Fybroc
PID-1B	FBR-3	First Stage Fluidized Bed Reactor	14' Dia. X 30' Str, 33,000 gallons, 2,010 cu. ft. sand	FRP	Palmer
PID-1B	P-1023	Bed Height Control Pump	40 gpm @ 40' TDH, 2 HP, electric diaphragm	Wetted material: PVC, neoprene	Penn Valley
PID-1B	FBR-4	First Stage Fluidized Bed Reactor	14' Dia. X 30' Str, 33,000 gallons, 2,010 cu. ft. sand	FRP	Palmer
PID-1B	P-1024	Bed Height Control Pump	40 gpm @ 40' TDH, 2 HP, electric diaphragm	Wetted material: PVC, neoprene	Penn Valley
PID-2A	P-2011	Media Return Pump	30 gpm @ 40' TDH, 1 HP, electric diaphragm	Wetted material: PVC, neoprene	Penn Valley
PID-2A	T-2011	First Stage Separator Tank	14' Dia. X 30' H, 21,500 gallons	FRP	Palmer
PID-2B	P-2012	Media Return Pump	30 gpm @ 40' TDH, 1 HP, electric diaphragm	Wetted material: PVC, neoprene	Penn Valley
PID-2B	T-2012	First Stage Separator Tank	14' Dia. X 30' H, 21,500 gallons	FRP	Palmer
PID-3A	P-301A	Second Stage Fluidization Pump	2,000 gpm @ 40' TDH, 30 HP, centrifugal	Wetted material: FRP	Fybroc
PID-3A	P-3015	Second Stage Fluidization Pump	2,000 gpm @ 40' TDH, 30 HP, centrifugal	Wetted material: FRP	Fybroc
PID-3A	P-3016	Second Stage Fluidization Pump	2,000 gpm @ 40' TDH, 30 HP, centrifugal	Wetted material: FRP	Fybroc
PID-3A	FBR-5	Second Stage Fluidized Bed Reactor	14' Dia. X 26' Str, 28,800 gallons, 1,730 cu. ft. carbon	FRP	Palmer
PID-3A	FBR-6	Second Stage Fluidized Bed Reactor	14' Dia. X 26' Str, 28,800 gallons, 1,730 cu. ft. carbon	FRP	Palmer
PID-3B	P-302A	Second Stage Fluidization Pump	2,000 gpm @ 40' TDH, 30 HP, centrifugal	Wetted material: FRP	Fybroc
PID-3B	P-3017	Second Stage Fluidization Pump	2,000 gpm @ 40' TDH, 30 HP, centrifugal	Wetted material: FRP	Fybroc
PID-3B	P-3018	Second Stage Fluidization Pump	2,000 gpm @ 40' TDH, 30 HP, centrifugal	Wetted material: FRP	Fybroc
PID-3B	FBR-7	Second Stage Fluidized Bed Reactor	14' Dia. X 26' Str, 28,800 gallons, 1,730 cu. ft. carbon	FRP	Palmer
PID-3B	FBR-8	Second Stage Fluidized Bed Reactor	14' Dia. X 26' Str, 28,800 gallons, 1,730 cu. ft. carbon	FRP	Palmer
PID-3C	P-3011	Media Return Pump	30 gpm @ 40' TDH, 1 HP, electric diaphragm	Wetted material: PVC, neoprene	Penn Valley
PID-3C	T-3011	Second Stage Separator Tank	14' Dia. X 30' Ht, 21,500 gallons	FRP	Palmer
PID-3D	P-3012	Media Return Pump	30 gpm @ 40' TDH, 1 HP, electric diaphragm	Wetted material: PVC, neoprene	Penn Valley
PID-3D	T-3012	Second Stage Separator Tank	14' Dia. X 30' Ht, 21,500 gallons	FRP	Palmer
PID-4	B-401	Aeration Blower	50 SCFM @ 13 psi, 5 HP, rotary lobe type	cast Iron	Roots
PID-4	T-401	Aeration Tank	14' Dia. X 24' 6" Str., 28,000 gallons	FRP	Palmer

CHAPTER 13 Equipment List

Customer: Nevada Environmental Response Trust
Location: Henderson,NV
Date: 4/28/2014

Drawing Number	Equipment Number	Equipment Name	Description	Materials of Construction	Vendor
PID-4	X-401	Aeration Diffusers	24 diffuser assemblies, 1.4 SCFM per diffuser	CPVC air pipe, EPDM diffusers, FRP pipe supports	USF / Envirex
PID-4	S-401	Biofilter Strainer Filter	25 gpm capacity, 50 micron size		
PID-4	P-401	Biofilter Nutrient Pump	11 gpm chemical metering pump	polypropylene and stainless steel	Dosatron, DI-16HG
PID-4	T-403	Biofilter Nutrient Tank	55 gallon capacity, 22" diameter x 36" high	polyethylene	
PID-4	B-402	Biofilter Aeration Blower	50 scfm at 13 psig, rotary lobe type, 5 hp	cast iron	
PID-4	T-402A	Biofilter	120 cubic feet, 6' diameter x 6.5' high,	FRP	Shaw
PID-4	T-402B	Biofilter	120 cubic feet, 6' diameter x 6.5' high,	FRP	Shaw
PID-4	T-404	Biofilter Sump	50 gallon capacity	Polypropylene	
PID-4	P-402	Biofilter Sump Pump	10 gpm at 32' tdh, 0.75 hp		
PID-4	P-403	Thickener Overflow Booster Pump	100 gpm @ 50 psi	Polypropylene Wetted Parts	TEC
PID-5	M-401	Static Mixer	10"	PVC	Lightnin
PID-5	T-501	DAF Pressure Tank	24" Dia. X 10' 4" H, 230 gallons, 100 psi	Lined Carbon steel	USF / Envirex
PID-5	P-501	DAF Pressure Pump	206 gpm @ 140' TDH, 25 HP, centrifugal	Wetted material: FRP	Fybroc
PID-5	D-501	DAF Vessel	1,000 gpm, 10' 6" W x 10' 6" H x 40' 0" L	Lined Carbon steel	USF / Envirex
PID-5	M-502	DAF Screw Conveyor	3/4 HP drive with gear reduction	Carbon steel screw	USF / Envirex
PID-5	P-502	DAF Float Pump	20 gpm @ 20 psi, electric diaphragm type	Wetted material: polypropylene, santoprene & ceramic	Warren Rupp
PID-5	M-503	DAF Skimmer Drive	1/2 HP drive with gear reduction	FRP flights, polyurethane sprockets, non-metallic chains	USF / Envirex
PID-5	T-551	DAF Pressure Tank	24" Dia. X 10' 4" H, 230 gallons, 100 psi	Lined Carbon steel	USF / Envirex
PID-5	P-551	DAF Pressure Pump	206 gpm @ 140' TDH, 25 HP, centrifugal	Wetted material: FRP	Fybroc
PID-5	D-551	DAF Vessel	1,000 gpm, 10' 6" W x 10' 6" H x 40' 0" L	Lined Carbon steel	USF / Envirex
PID-5	M-552	DAF Screw Conveyor	3/4 HP drive with gear reduction	Carbon steel screw	USF / Envirex
PID-5	M-553	DAF Skimmer Drive	1/2 HP drive with gear reduction	FRP flights, polyurethane sprockets, non-metallic chains	USF / Envirex
PID-5	P-552	DAF Float Pump	20 gpm @ 20 psi, electric diaphragm type	Wetted materials: polypropylene, santoprene & ceramic	Warren Rupp
PID-6	T-601	Effluent Tank	14' Dia. X 13' Str., 15,200 gallons	FRP	Palmer
PID-6	P-601	Effluent Pump	1,000 gpm @ 93' TDH, 30 HP, horizontal centrifugal	FRP	Fybroc
PID-6	P-602	Effluent Pump	1,000 gpm @ 93' TDH, 30 HP, horizontal centrifugal	FRP	Fybroc
PID-6	X-621	UV Disinfection System	1,000 gpm, 99.9% bacterial reduction at 80% UVT	316L SS, pickled, passivated, and electropolished	Wedeco Ideal Horizons E&C
PID-6	T-602	Thickener	20' Dia. X 18' Str., 42,000 gallons	Lined carbon steel with flat steel bottom, internal grout	USF / DAVCO
PID-6	M-611	Scraper / Rake	1/2 HP TEFC, mill and chemical duty	Carbon steel drive shaft and arms, neoprene squeeges	USF / DAVCO
PID-6	M-612	Flocculation Mixer	1 HP TEFC, wash-down duty motor	Rubber coated steel shaft and impeller	USF / DAVCO
PID-6	M-613	Flocculation Mixer	1 HP TEFC, wash-down duty motor	Rubber coated steel shaft and impeller	USF / DAVCO
PID-6	P-603	Thickener Underflow Pump	150 gpm @ 15' TDH, 7.5 HP, diaphragm type	Wetted materials: polypropylene, santoprene & ceramic	Penn Valley
PID-7A	T-701	pH Tank	550 gallon tote	Carbon steel	By Chem. Vendor
PID-7A	P-711	pH Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-712	pH Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-713	pH Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-714	pH Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-715	pH Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-716	pH Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-717	pH Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-718	pH Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner

CHAPTER 13 Equipment List

Customer: Nevada Environmental Response Trust
Location: Henderson,NV
Date: 4/28/2014

Drawing Number	Equipment Number	Equipment Name	Description	Materials of Construction	Vendor
PID-7A	T-702	Nutrient Tank	8' Dia. X 12' Str., 4,300 gallons	FRP	Palmer
PID-7A	P-721	Nutrient Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-722	Nutrient Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-723	Nutrient Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-724	Nutrient Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-725	Nutrient Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-726	Nutrient Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-727	Nutrient Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7A	P-728	Nutrient Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7B	T-703	Electron Donor Tank	10' Dia. X 34' Str., 20,000 gallons	Carbon steel, double walled	Modern Welding
PID-7B	P-739A	Electron Donor Booster Pump	10 gpm @ 10 psi, 1/2 HP, centrifugal	Wetted material: 316 SS	Goulds
PID-7B	P-739B	Electron Donor Booster Pump	10 gpm @ 10 psi, 1/2 HP, centrifugal	Wetted material: 316 SS	Goulds
PID-7B	P-731	Electron Donor Metering Pump	20 gal / hr, 44 watts, 120V, electric diaphragm	Wetted material: 316 SS	LMI
PID-7B	P-732	Electron Donor Metering Pump	20 gal / hr, 44 watts, 120V, electric diaphragm	Wetted material: 316 SS	LMI
PID-7B	P-733	Electron Donor Metering Pump	20 gal / hr, 44 watts, 120V, electric diaphragm	Wetted material: 316 SS	LMI
PID-7B	P-734	Electron Donor Metering Pump	20 gal / hr, 44 watts, 120V, electric diaphragm	Wetted material: 316 SS	LMI
PID-7B	P-735	Electron Donor Metering Pump	8 gal / hr, 44 watts, 120V, electric diaphragm	Wetted material: 316 SS	LMI
PID-7B	P-736	Electron Donor Metering Pump	8 gal / hr, 44 watts, 120V, electric diaphragm	Wetted material: 316 SS	LMI
PID-7B	P-737	Electron Donor Metering Pump	8 gal / hr, 44 watts, 120V, electric diaphragm	Wetted material: 316 SS	LMI
PID-7B	P-738	Electron Donor Metering Pump	8 gal / hr, 44 watts, 120V, electric diaphragm	Wetted material: 316 SS	LMI
PID-7B	T-704	Polymer Feed Tank	550 gallon tote	Polyethylene	By Chem. Vendor
PID-7B	T-705	Polymer Feed Tank	550 gallon tote	Polyethylene	By Chem. Vendor
PID-7B	P-741	Polymer Feed System	1.0 gal / hr, 1/6 HP, 120V	Wetted materials: polypropylene, ceramic, PTFE	USF / Stranco
PID-7B	P-742	Polymer Feed System	1.0 gal / hr, 1/6 HP, 120V	Wetted materials: polypropylene, ceramic, PTFE	USF / Stranco
PID-7C	T-751	Ferric Chloride Storage Tank	10' 2" Dia. X 9' 10" Str., 4,400 gallons	Linear polyethylene, double wall containment	Polyprocessing Co.
PID-7C	P-751	Ferric Chloride Feed / Mix Pump	40 gpm @ 40' TDH, 1.5 HP, horizontal centrifugal	Wetted material: FRP	Fybroc
PID-7C	P-758A	Ferric Chloride Metering Pump	3-65 gpd, 115 volt	Wetted materials, PVDF, PTFE	Master Flex
PID-7C	P-758B	Ferric Chloride Metering Pump	3-65 gpd, 115 volt	Wetted materials, PVDF, PTFE	Master Flex
PID-7C	P-754A	Peroxide Metering Pump	3-65 gpd, 115 volt	Wetted materials, PVDF, PTFE	Master Flex
PID-7C	P-754B	Peroxide Metering Pump	3-65 gpd, 115 volt	Wetted materials, PVDF, PTFE	Master Flex
PID-7C	P-755A	Anti Foam Metering Pump	3-65 gpd, 115 volt	Wetted materials, PVDF, PTFE	Master Flex
PID-7C	P-755B	Anti Foam Metering Pump	3-65 gpd, 115 volt	Wetted materials, PVDF, PTFE	Master Flex
PID-7C	T-752	Hydrated Lime Storage Silo	12' Dia. X 28' High, 1,500 cubic feet capacity	Painted carbon steel	USF Zimpro / Imperial
PID-7C	M-756	Dust Filter	Mechanical shaker-type, 1/3 HP TEFC motor	Carbon steel, polyester bags	USF Zimpro / CPEnv.
PID-7C	M-753	Bin Activator	5 ft. Dia.with primary amd secondary baffles, 1.5 HP	Carbon steel	USF Zimpro / Metalfab

CHAPTER 13 Equipment List

Customer: Nevada Environmental Response Trust
Location: Henderson,NV
Date: 4/28/2014

Drawing Number	Equipment Number	Equipment Name	Description	Materials of Construction	Vendor
PID-7C	M-754	Volumetric Feeder	48 cu. ft. / hr hyd lime (1440 lb/hr at 30 lb/cf density)	Stainless steel and teflon	USF Zimpro / Acrison
PID-7C	M-755	Screw Conveyor	35 cu. ft. / hr capacity, flexible screw, 3 HP	Flexible 304SS flat wire screw, UHMW polyethylene tube	USF Zimpro / Flexicon
PID-7C	T-753	Micronutrient Tote Tank	400 gallon tote, ~ 4' x 4'x 4'	Stainless steel	Chemical Vendor
PID-7C	M-753A	Micronutrient Tote Tank Mixer	1/3 hp, 110v, fixed speed, tote agitator	316 ss shaft and folding 4" propeller blade	Lightnin
PID-7C	P-753 A	Micro-Nutrient Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-7C	P-753 B	Micro-Nutrient Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner
PID-8	P-801	Air Compressor	240 ICFM @ 110 psi, 50 hp, rotary screw, sound encl	Carbon steel, skid mounted package unit	Ingersoll-Rand
PID-8	P-802	Air Compressor	240 ICFM @ 110 psi, 50 hp, rotary screw, sound encl	Carbon steel, skid mounted package unit	Ingersoll-Rand
PID-8	T-801	Compressed Air Receiver Tank	42" OD x 125" H, 660 gal., 137 psi max. pressure	Painted carbon steel	Ingersoll-Rand
PID-8	T-802	Instrument Air Dryer	Regen. dessicant dryer, 160 SCFM @ 100 psi	Carbon steel	Hankinson
PID-8	F-802	Oil Removal Filter	275 cfm @ 100 psi, 0.01 micron oil carry-over	aluminum / zinc / steel	Hankinson
PID-8	F-803	Oil Removal Filter	275 cfm @ 100 psi, 0.01 micron oil carry-over	aluminum / zinc / steel	Hankinson
PID-8	F-804	Particulate Filter	275 cfm @ 100 psi, 1 micron	aluminum / zinc / steel	Hankinson
PID-9	T-901	Conditioning Tank	14' Dia. X 9' 6" Str., 13,500 gallons	FRP	TBD later
PID-9	M-901	Conditioning Tank Agitator	45 rpm, 3 HP, axial flow impeller	wetted parts - rubber coated steel	Philadelphia Mixers
PID-9	P-901	Press Feed Pump	150 gpm @ 40 psi, AOD, 150 SCFM @ 100 psi max.	cast iron	Warren Rupp
PID-9	P-902	Press Feed Pump	150 gpm @ 40 psi, AOD, 150 SCFM @ 100 psi max.	cast iron	Warren Rupp
PID-9	X-901	Filter Press	80 cu. ft., plate and frame, includes elevated platform	Carbon steel frame, polypropylene filter plates	USF / JWI
PID-9	X-902	Filter Press	80 cu. ft., plate and frame, includes elevated platform	Carbon steel frame, polypropylene filter plates	USF / JWI
PID-9	T-902	Filtrate Tank	14' Dia. X 8' Str., 8,000 gallons	FRP	Palmer
PID-9	P-903	Filtrate Recycle Pump	20 gpm @ 46' TDH, 1.5 HP, centrifugal	Wetted material: FRP	Polyprocessing Co.
PID-10A	TK-7	GWTP Equalization Tank	10,000 gallons	Polypropylene	
PID-10A	P101A	Pond Water Transfer Pump	1,000 gpm @ 43' TDH, 20HP	Wetted parts, Monel	Corcoran
PID-10A	P101B	Pond Water Transfer Pump	1,000 gpm @ 43' TDH, 20HP	Wetted parts, Monel	Corcoran
PID-10A	P-104	Pond Water Transfer Pump	30 gpm @ 50' FDH, 3 HP	Wetted Material - teflon	Finish Thompson
PID-10A	P-1001	Feed Equalization Pump	70 gpm @ 140' THD, 7.5 HP	Wetted Material - teflon	Finish Thompson
PID-10B	GC-201C	3rd GAC Adsorber at EQ Area	10' dia pressure adsorber vessel, 20,000 lbs GAC	Carbon steel plasite lined, to match existing GACs	USF / Westates
PID-10C	P-1302A	Effluent Booster Pump	1000 gpm@90 psi, 100 HP	Wetted parts, Monel	Corcoran
PID-10C	P-1302B	Effluent Booster Pump	1000 gpm@90 psi, 100 HP	Wetted parts, Monel	Corcoran
PID-11	P-1101	Dike Sump Pump	85 gpm at 28' tdh, 2 hp, sbmer, level controls	cast iron case and impellers, model 3SEV-DS	Barnes
PID-11	P-1102	Dike Sump Pump	85 gpm at 28' tdh, 2 hp, sbmer, level controls	cast iron case and impellers, model 3SEV-DS	Barnes

CHAPTER 13 Equipment List
SPARES

Customer: Nevada Environmental Response Trust
Location: Henderson,NV
Date: 4/28/2014

Item	Qty	Equipment Name	Description	Materials of Construction	Vendor	Notes
1	1	Media Return Pump	30 gpm @ 40' TDH, 1 HP, electric diaphragm	Wetted material: PVC, neoprene	Penn Valley	
2	1	DAF Float Pump	20 gpm @ 20 psi, electric diaphragm type	Wetted material: polypropylene, santoprene & ceramic	Warren Rupp	
3	1	Sand FBR Electron Donor Metering Pump	20 gal / hr, 44 watts, 120V, electric diaphragm	Wetted material: 316 SS	LMI	
4	1	GAC FBR Electron Donor Metering Pump	8 gal / hr, 44 watts, 120V, electric diaphragm	Wetted material: 316 SS	LMI	
5	1	Ferric Chloride Feed / Mix Pump	40 gpm @ 40' TDH, 1.5 HP, horizontal centrifugal	Wetted material: FRP	Fybroc	
6	1	Press Feed Pump	150 gpm @ 40 psi, AOD, 150 SCFM @ 100 psi max.	cast iron	Warren Rupp	
7	2	Nutrient Feed Pump	1.0 gal / hr, 22 Watts, 120V, electric diaphragm	Wetted materials: polypropylene, ceramic, PTFE	Stenner	
8	1	Polymer Dosing Pump (DAF)	1.0 gal / hr, 1/6 HP, 120V	Wetted materials: polypropylene, ceramic, PTFE	USF / Stranco	
9	1	Polymer Dosing Pump (Thickener)	1.0 gal / hr, 1/6 HP, 120V	Wetted materials: polypropylene, ceramic, PTFE	USF / Stranco	
10	1	Aeration Blower	50 SCFM @ 13 psi, 5 HP, rotary lobe type	cast Iron	Roots	
11	1	Set of Lamps - UV Disinfection Unit	48, low pressure, low intensity lamps	mercury vapor, quartz sleeve	Wedeco/Ideal Horizions E&C	

CHAPTER 13 Equipment List
Bioplant Effluent Clarity and AP-5 Treatment/09-06

Customer: Nevada Environmental Response Trust
Location: Henderson,NV
Date: 4/28/2014

Drawing Number	Equipment Number	Equipment Name	Description	Materials of Construction	Vendor	Notes
PID-7A	P-711	pH Feed Pump	peristaltic, 0.12-7.6 GPH	Norprene tubing	Masterflex	pH feed Assy.
PID-7A	P-712	pH Feed Pump	peristaltic, 0.12-7.6 GPH	Norprene tubing	Masterflex	pH feed Assy.
PID-7A	P-713	pH Feed Pump	peristaltic, 0.12-7.6 GPH	Norprene tubing	Masterflex	pH feed Assy.
PID-7A	P-714	pH Feed Pump	peristaltic, 0.12-7.6 GPH	Norprene tubing	Masterflex	pH feed Assy.
PID-7A	P-71A	pH Feed Pump	peristaltic, 0.12-7.6 GPH	Norprene tubing	Masterflex	pH feed Assy.
PID-9	T-920	Polymer Mix Tank	275 Gal.	HDPE	SNF Floquip	Dry Polymer Assy.
PID-9	T-930	Polymer Appl. Tank	275 Gal.	HDPE	SNF Floquip	Dry Polymer Assy.
PID-9	P-920	Polymer Transfer Pump	22 GPM		SNF Floquip	Dry Polymer Assy.
PID-9	P-930	Polymer Appl. Pump	0.5 - 5 GPM, 1 HP		SNF Floquip	Dry Polymer Assy.
PID-9	H-920	Volumetric Feeder	0.000017 - 3.69 cu. ft/hr	304 SS	SNF Floquip	Dry Polymer Assy.
PID-14	P-1401A	Fluidization pump	2000 GPM @ 40 ft TDH	FRP (vinyl ester resin)	Sulzer	on fluid. Skid
PID-14	P-1401B	Fluidization pump	2000 GPM @ 40 ft TDH	FRP (vinyl ester resin)	Sulzer	on fluid. Skid
PID-14	FBR-A	Add'l 1st stage FBR vessel	14ft dia x 30ft H, 33,000 gals.	FRP (vinyl ester resin)	Palmer	
PID-14	T-1401	Separator Tank	10ft dia x 30ft H, 8,500 gals.	FRP (vinyl ester resin)	Palmer	
PID-14	P-1410	Media Return Pump	30 GPM @ 40' TDH	PVC, Neoprene	Penn Valley	
PID-14	P-1420	FBR-A Skimmer Pump	100 GPM @ 70' TDH	CPVC, viton	Hayward	REMOVED from Process
PID-15	P-1520A	Phosphoric Acid Pump	0.08 - 0.54 GPH	Norprene	Masterflex	Phos. Acid skid
PID-15	P-1521	Phosphoric Acid Pump	0.08 - 0.54 GPH	Norprene	Masterflex	Phos. Acid skid
PID-15	P-1522	Phosphoric Acid Pump	0.08 - 0.54 GPH	Norprene	Masterflex	Phos. Acid skid
PID-15	P-1523	Phosphoric Acid Pump	0.08 - 0.54 GPH	Norprene	Masterflex	Phos. Acid skid
PID-15	P-1524	Phosphoric Acid Pump	0.08 - 0.54 GPH	Norprene	Masterflex	Phos. Acid skid
PID-16	T-1601	Air Receiver	240 Gal.	steel	On-site	O2 skid
PID-16	T-1602	Oxygen Receiver	240 Gal.	steel	On-site	O2 skid
PID-16	PX-1601	PSA Oxygen Generator	750 SCFH @ 45 psig, 110 VAC		On-site	O2 skid
PID-16	C-1601	Compressor	166 SCFM @125 psig, 40 HP		On-site	O2 skid
PID-16	T-1603	Sludge Storage Tank	8,200 Gal.	FRP (vinyl ester resin)	existing	
PID-16	P-1601	Sludge Pump	213 gpm @ 58' TDH	CD-4MCU	Discflo	
PID-17	T-1702	Sand Filter	300 sq. ft, 6 basins	Concrete, FRP, CPVC	Parkson	
PID-17	P-1701A	Filter Reject Pump	150 GPM @ 50' TDH, 5 HP	FRP (vinyl ester resin)	Fybroc	Filter Rej. Skid
PID-17	P-1701B	Filter Reject Pump	150 GPM @ 50' TDH, 5 HP	FRP (vinyl ester resin)	Fybroc	Filter Rej. Skid
PID-17	T-1701	Filter Reject Tank	6' 2" H X 4' 9" Dia., 1,000 gal	HDPE	US Plastic	Filter Rej. Skid

CHAPTER 14
INSTRUMENT LOOP AND ALARM LISTING

ALARM LIST

PARAMETER	ALARM	RANGE	DEFAULT VALUE	RESULT OF ALARM	TIME DELAY
FAL-1010	Lo Feed Flow FBR 1	0 – 300 gpm	50 gpm	Feed Shutdown in Corresponding FBR,	30 sec
FAL-1020	Lo Feed Flow FBR 2	0 – 300 gpm	50 gpm	Feed Shutdown in Corresponding FBR,	30 sec
FAL-1110	Lo Feed Flow FBR 3	0 – 300 gpm	50 gpm	Feed Shutdown in Corresponding FBR,	30 sec
FAL-1120	Lo Feed Flow FBR 4	0 – 300 gpm	50 gpm	Feed Shutdown in Corresponding FBR,	30 sec
FAL-3010	Lo Feed Flow FBR 5	0 – 300 gpm	50 gpm	Feed Shutdown in Corresponding FBR,	30 sec
FAL-3020	Lo Feed Flow FBR 6	0 – 300 gpm	50 gpm	Feed Shutdown in Corresponding FBR,	30 sec
FAL-3030	Lo Feed Flow FBR 7	0 – 300 gpm	50 gpm	Feed Shutdown in Corresponding FBR,	30 sec
FAL-3040	Lo Feed Flow FBR 8	0 – 300 gpm	50 gpm	Feed Shutdown in Corresponding FBR,	30 sec
FAH-1010	Hi Feed Flow FBR 1	0 – 500 gpm	350 gpm	Alarm Only	30 sec
FAH-1020	Hi Feed Flow FBR 2	0 – 500 gpm	350 gpm	Alarm Only	30 sec
FAH-1110	Hi Feed Flow FBR 3	0 – 500 gpm	350 gpm	Alarm Only	30 sec
FAH-1120	Hi Feed Flow FBR 4	0 – 500 gpm	350 gpm	Alarm Only	30 sec
FAH-3010	Hi Feed Flow FBR 5	0 – 500 gpm	350 gpm	Alarm Only	30 sec
FAH-3020	Hi Feed Flow FBR 6	0 – 500 gpm	350 gpm	Alarm Only	30 sec
FAH-3030	Hi Feed Flow FBR 7	0 – 500 gpm	350 gpm	Alarm Only	30 sec
FAH-3040	Hi Feed Flow FBR 8	0 – 500 gpm	350 gpm	Alarm Only	30 sec
AAL-1021	Lo ORP FBR 1	(-1000) -0 mV	(-400) mV	Alarm Only	60 sec
AAL-1022	Lo ORP FBR 2	(-1000) -0 mV	(-400) mV	Alarm Only	60 sec

PARAMETER	ALARM	RANGE	DEFAULT VALUE	RESULT OF ALARM	TIME DELAY
AAL-1023	Lo ORP FBR 3	(-1000) -0 mV	(-400) mV	Alarm Only	60 sec
AAL-1024	Lo ORP FBR 4	(-1000) -0 mV	(-400) mV	Alarm Only	60 sec
AAL-3025	Lo ORP FBR 5	(-1000) -0 mV	(-400) mV	Alarm Only	60 sec
AAL-3026	Lo ORP FBR 6	(-1000) -0 mV	(-400) mV	Alarm Only	60 sec
AAL-3027	Lo ORP FBR 7	(-1000) -0 mV	(-400) mV	Alarm Only	60 sec
AAL-3028	Lo ORP FBR 8	(-1000) -0 mV	(-400) mV	Alarm Only	60 sec
AALL-1021	Lo Lo ORP FBR 1	(-1000) -0 mV	(-450) mV	Alarm Only	60 sec
AALL-1022	Lo Lo ORP FBR 2	(-1000) -0 mV	(-450) mV	Alarm Only	60 sec
AALL-1023	Lo Lo ORP FBR 3	(-1000) -0 mV	(-450) mV	Alarm Only	60 sec
AALL-1024	Lo Lo ORP FBR 4	(-1000) -0 mV	(-450) mV	Alarm Only	60 sec
AALL-3025	Lo Lo ORP FBR 5	(-1000) -0 mV	(-450) mV	Alarm Only	60 sec
AALL-3026	Lo Lo ORP FBR 6	(-1000) -0 mV	(-450) mV	Alarm Only	60 sec
AALL-3027	Lo Lo ORP FBR 7	(-1000) -0 mV	(-450) mV	Alarm Only	60 sec
AALL-3028	Lo Lo ORP FBR 8	(-1000) -0 mV	(-450) mV	Alarm Only	60 sec
AAH-1021	Hi RP FBR 1	(-1000) - 500 mV	(-50) mV	Alarm Only	60 sec
AAH-1022	Hi ORP FBR 2	(-1000) - 500 mV	(-50) mV	Alarm Only	60 sec
AAH-1023	Hi ORP FBR 3	(-1000) - 500 mV	(-50) mV	Alarm Only	60 sec
AAH-1024	Hi ORP FBR 4	(-1000) - 500 mV	(-50) mV	Alarm Only	60 sec
AAH-3025	Hi RP FBR 5	(-1000) - 500 mV	(-50) mV	Alarm Only	60 sec

PARAMETER	ALARM	RANGE	DEFAULT VALUE	RESULT OF ALARM	TIME DELAY
AAH-3026	Hi ORP FBR 6	(-1000) - 500 mV	(-50) mV	Alarm Only	60 sec
AAH-3027	Hi ORP FBR 7	(-1000) - 500 mV	(-50) mV	Alarm Only	60 sec
AAH-3028	Hi ORP FBR 8	(-1000) - 500 mV	(-50) mV	Alarm Only	60 sec
AAHH-1021	Hi ORP FBR 1	(-1000) - 500 mV	(-0) mV	Feed Shutdown in Corresponding FBR,	60 sec
AAHH-1022	Hi ORP FBR 2	(-1000) - 500 mV	(-0) mV	Feed Shutdown in Corresponding FBR,	60 sec
AAHH-1023	Hi ORP FBR 3	(-1000) - 500 mV	(-0) mV	Feed Shutdown in Corresponding FBR,	60 sec
AAHH-1024	Hi ORP FBR 4	(-1000) - 500 mV	(-0) mV	Feed Shutdown in Corresponding FBR,	60 sec
AAHH-3025	Hi ORP FBR 5	(-1000) - 500 mV	(-0) mV	Feed Shutdown in Corresponding FBR,	60 sec
AAHH-3026	Hi ORP FBR 6	(-1000) - 500 mV	(-0) mV	Feed Shutdown in Corresponding FBR,	60 sec
AAHH-3027	Hi ORP FBR 7	(-1000) - 500 mV	(-0) mV	Feed Shutdown in Corresponding FBR,	60 sec
AAHH-3028	Hi ORP FBR 8	(-1000) - 500 mV	(-0) mV	Feed Shutdown in Corresponding FBR,	60 sec
AAL-1011	Lo pH FBR 1	0 - 14	6.5	Feed Shutdown in Corresponding FBR	60 sec
AAL-1012	Lo pH FBR 2	0 - 14	6.5	Feed Shutdown in Corresponding FBR	60 sec
AAL-1013	Lo pH FBR 3	0 - 14	6.5	Feed Shutdown in Corresponding FBR	60 sec
AAL-1014	Lo pH FBR 4	0 - 14	6.5	Feed Shutdown in Corresponding FBR	60 sec
AAL-3015	Lo pH FBR 5	0 - 14	6.5	Feed Shutdown in Corresponding FBR	60 sec
AAL-3016	Lo pH FBR 6	0 - 14	6.5	Feed Shutdown in Corresponding FBR	60 sec
AAL-3017	Lo pH FBR 7	0 - 14	6.5	Feed Shutdown in Corresponding FBR	60 sec
AAL-3018	Lo pH FBR 8	0 - 14	6.5	Feed Shutdown in Corresponding FBR	60 sec

PARAMETER	ALARM	RANGE	DEFAULT VALUE	RESULT OF ALARM	TIME DELAY
AAH-1011	Hi pH FBR 1	0 - 14	8.0	Feed Shutdown in Corresponding FBR	60 sec
AAH-1012	Hi pH FBR 2	0 - 14	8.0	Feed Shutdown in Corresponding FBR	60 sec
AAH-1013	Hi pH FBR 3	0 - 14	8.0	Feed Shutdown in Corresponding FBR	60 sec
AAH-1014	Hi pH FBR 4	0 - 14	8.0	Feed Shutdown in Corresponding FBR	60 sec
AAH-3015	Hi pH FBR 5	0 - 14	8.0	Feed Shutdown in Corresponding FBR	60 sec
AAH-3016	Hi pH FBR 6	0 - 14	8.0	Feed Shutdown in Corresponding FBR	60 sec
AAH-3017	Hi pH FBR 7	0 - 14	8.0	Feed Shutdown in Corresponding FBR	60 sec
AAH-3018	Hi pH FBR 8	0 - 14	8.0	Feed Shutdown in Corresponding FBR	60 sec
TAH-1011	Hi Temp FBR 1	0 – 100 C	40	Alarm Only	60 sec
TAH-1012	Hi Temp FBR 2	0 – 100 C	40	Alarm Only	60 sec
TAH-1013	Hi Temp FBR 3	0 – 100 C	40	Alarm Only	60 sec
TAH-1014	Hi Temp FBR 4	0 – 100 C	40	Alarm Only	60 sec
TAH-3015	Hi Temp FBR 5	0 – 100 C	40	Alarm Only	60 sec
TAH-3016	Hi Temp FBR 6	0 – 100 C	40	Alarm Only	60 sec
TAH-3017	Hi Temp FBR 7	0 – 100 C	40	Alarm Only	60 sec
TAH-3018	Hi Temp FBR 8	0 – 100 C	40	Alarm Only	60 sec
PAL-1011	Lo Press FBR 1	Fixed Pt. Sw. (set at static head + 1.0 psi		System Shutdown in Corresponding FBR	0.25 sec
PAL-1012	Lo Press FBR 2	Fixed Pt. Sw. (set at static head + 1.0 psi		System Shutdown in Corresponding FBR	0.25 sec
PAL-1013	Lo Press FBR 3	Fixed Pt. Sw. (set at static head + 1.0 psi)		System Shutdown in Corresponding FBR	0.25 sec
PAL-1014	Lo Press FBR 4	Fixed Pt. Sw. (set at static head + 1.0 psi)		System Shutdown in Corresponding FBR	0.25 sec
PAL-3015	Lo Press FBR 5	Fixed Pt. Sw. (set at static head + 1.0 psi)		System Shutdown in Corresponding FBR	0.25 sec
PAL-3016	Lo Press FBR 6	Fixed Pt. Sw. (set at static head + 1.0 psi)		System Shutdown in Corresponding FBR	0.25 sec

PARAMETER	ALARM	RANGE	DEFAULT VALUE	RESULT OF ALARM	TIME DELAY
PAL-3017	Lo Press FBR 7	Fixed Pt. Sw. (set at static head + 1.0 psi)		System Shutdown in Corresponding FBR	0.25 sec
PAL-3018	Lo Press FBR 8	Fixed Pt. Sw. (set at static head + 1.0 psi)		System Shutdown in Corresponding FBR	0.25 sec
FAL-1011	Lo Flow FBR 1	0 – 2800 gpm	1000 gpm	System Shutdown in Corresponding FBR	0.25 sec
FAL-1012	Lo Flow FBR 2	0 – 2800 gpm	1000 gpm	System Shutdown in Corresponding FBR	0.25 sec
FAL-1013	Lo Flow FBR 3	0 – 2800 gpm	1000 gpm	System Shutdown in Corresponding FBR	0.25 sec
FAL-1014	Lo Flow FBR 4	0 – 2800 gpm	1000 gpm	System Shutdown in Corresponding FBR	0.25 sec
FAL-3015	Lo Flow FBR 5	0 – 2800 gpm	1000 gpm	System Shutdown in Corresponding FBR	0.25 sec
FAL-3016	Lo Flow FBR 6	0 – 2800 gpm	1000 gpm	System Shutdown in Corresponding FBR	0.25 sec
FAL-3017	Lo Flow FBR 7	0 – 2800 gpm	1000 gpm	System Shutdown in Corresponding FBR	0.25 sec
FAL-3018	Lo Flow FBR 8	0 – 2800 gpm	1000 gpm	System Shutdown in Corresponding FBR	0.25 sec
LAL-2011	Lo Level Separator 2011	0 – 25" (from top of tank)	12"	Alarm Only	1 sec
LAH-2011	Hi Level Separator 2011	0 – 25" (from top of tank)	4"	Feed Shutdown in Corresponding FBR	1 sec
LAL-2012	Lo Level Separator 2012	0 – 25" (from top of tank)	12"	Alarm Only	1 sec
LAH-2012	Hi Level Separator 2012	0 – 25" (from top of tank)	4"	Feed Shutdown in Corresponding FBR	1 sec
LAL-3011	Lo Level Separator 3011	0 – 25" (from top of tank)	12"	Alarm Only	1 sec
LAH-3011	Hi Level Separator 3011	0 – 25" (from top of tank)	4"	Feed Shutdown in Corresponding FBR	1 sec

PARAMETER	ALARM	RANGE	DEFAULT VALUE	RESULT OF ALARM	TIME DELAY
LAL-3012	Lo Level Separator 3012	0 – 25" (from top of tank)	12"	Alarm Only	1 sec
LAH-3012	Hi Level Separator 3012	0 – 25" (from top of tank)	4"	Feed Shutdown in Corresponding FBR	1 sec
PAL-401	Lo Press Aeration Blower	Fixed Pt. Sw. (set at 10 psi)		System Feed Shutdown	1 sec
LAH-401	Hi Level Aeration Tank	Fixed Point Switch		System Feed Shutdown	1 sec
AAH-401	Hi H2S	0 – 100 ppm	10	System Feed Shutdown	1 sec
FAL-502	Lo Flow D-501 DAF Recirc	0 – 290 GPM	100	Shutoff Corresponding DAF pump	5 sec
FAL-506	Lo Flow D-551 DAF Recirc	0 – 290 GPM	100	Shutoff Corresponding DAF pump	5 sec
LAL-501	Lo Level T-501 DAF Press Tank	34" - 48" (from tank bottom)	36	Alarm Only	1 sec
LAL-551	Lo Level T-551 DAF Press Tank	34" - 48" (from tank bottom)	36	Alarm Only	1 sec
LAH-501	Hi Level T-501 DAF Press Tank	34" - 48" (from tank bottom)	46	Alarm Only	1 sec
LAH-551	Hi Level T-551 DAF Press Tank	0 – 14" (level gauge)	46	Alarm Only	1 sec
LAL-601	Lo Level Effluent Tank	0 – 156 inches	24	Shutdown Operating Effluent Pump	1 sec
LAH-601	Hi Level Effluent Tank	0 – 156 inches	120	System Feed Shutdown	1 sec
TAH-601	Hi Temp UV	Fixed Point Switch		Alarm Only	1 sec
LAH-601	Lo UV Intensity	Fixed Point Switch		Alarm Only	1 sec
XAH-611	Hi Torque Thickener	Fixed Point Switch		Alarm Only	1 sec
XAHH-166	Hi Hi Torque Thickener	Fixed Point Switch		Shutdown Thickener Rake/Scraper Motor	1 sec

PARAMETER	ALARM	RANGE	DEFAULT VALUE	RESULT OF ALARM	TIME DELAY
LAL-701	Lo Level pH Tank	Fixed Point Switch		Feed Shutdown in Corresponding FBR	1 sec
LAL-717	Lo Level Nutrient Tank	Fixed Point Switch		Feed Shutdown in Corresponding FBR	1 sec
FAL-721	Lo Flow Nutrient to FBR 1	Fixed Point Switch		Feed Shutdown in Corresponding FBR	1 sec
FAL-722	Lo Flow Nutrient to FBR 2	Fixed Point Switch		Feed Shutdown in Corresponding FBR	1 sec
FAL-723	Lo Flow Nutrient to FBR 3	Fixed Point Switch		Feed Shutdown in Corresponding FBR	1 sec
FAL-724	Lo Flow Nutrient to FBR 4	Fixed Point Switch		Feed Shutdown in Corresponding FBR	1 sec
FAL-725	Lo Flow Nutrient to FBR 5	Fixed Point Switch		Feed Shutdown in Corresponding FBR	1 sec
FAL-726	Lo Flow Nutrient to FBR 6	Fixed Point Switch		Feed Shutdown in Corresponding FBR	1 sec
FAL-727	Lo Flow Nutrient to FBR7	Fixed Point Switch		Feed Shutdown in Corresponding FBR	1 sec
FAL-728	Lo Flow Nutrient to FBR 8	Fixed Point Switch		Feed Shutdown in Corresponding FBR	1 sec
LAH-703	Hi Level Electron Donor Tank	Truck Fill Station Alarm from OMNTEC Analyzer		Alarm at Truck Fill Station Only	N/A
LAHH-703	Hi Hi Level Electron Donor Tank	Truck Fill Station Alarm from OMNTEC Analyzer		Alarm at Truck Fill Station Only	N/A
LAL-703	Lo Level Electron Donor Tank	0 – 120”	20	Alarm only	1 sec

PARAMETER	ALARM	RANGE	DEFAULT VALUE	RESULT OF ALARM	TIME DELAY
LAH-706	Hi Level Electron Donor Containment	2 Fixed Point Switches – Tank Secondary Containment & Spill Containment Pan		Electron Donor Booster Pumps Shutdown and System Feed Shutdown	1 sec
LAL-704	Lo Level Thickener Polymer Tank	Fixed Point Switch		Alarm only	1 sec
LAL-705	Lo Level DAF Polymer Tank	Fixed Point Switch		Alarm only	1 sec
LAL-751	Lo Level Ferric Chloride Tank	0 – 120 "	20"	Alarm only	1 sec
LAH-751	Hi Level Ferric Chloride Containment	Fixed Point Switch		Alarm only	1 sec
UA-752	Trouble Lime Systems	Fixed Point Switch		Alarm only	1 sec
PAL-802	Lo Press Inst Air	Fixed Point Switch		System Shutdown	1 sec
LAL-901	Lo Level Conditioning Tank	Fixed Point Switch		Conditioning Tank Mixer Shutdown	1 sec
LALL-901	Lo Lo Level Conditioning Tank	Fixed Point Switch		Alarm only	1 sec
LAH-901	Hi Level Conditioning Tank	Fixed Point Switch		Alarm only	1 sec
LAH-902	Hi Level Filtrate Tank	Fixed Point Switch		Alarm only	1 sec
LAHH-902	Hi Hi Level Filtrate Tank	Fixed Point Switch		Press Feed Pumps Shutdown	1 sec
LAH-1101	Hi Level Sump 1101	Fixed Point Switch		Alarm only	90 sec
LAH-1102	Hi Level Sump 1102	Fixed Point Switch		Alarm only	90 sec
YA-1201	Status Alarm SS-1201 Safety Shower	Fixed Point Switch		Alarm only	5 sec

PARAMETER	ALARM	RANGE	DEFAULT VALUE	RESULT OF ALARM	TIME DELAY
YA-1202	Status Alarm SS-1202 Safety Shower	Fixed Point Switch		Alarm only	5 sec
YA-1203	Status Alarm SS-1203 Safety Shower	Fixed Point Switch		Alarm only	5 sec
YA-1204	Status Alarm SS-1204 Safety Shower	Fixed Point Switch		Alarm only	5 sec
YA-1205	Status Alarm SS-1205 Safety Shower	Fixed Point Switch		Alarm only	5 sec
YA-1206	Status Alarm SS-1206 Safety Shower	Fixed Point Switch		Alarm only	5 sec
ADDED PER AP5 2006 Project					
LAL-621	Lo UV Effluent Tank Level	20” – 24” from Tank Bottom	20”	Shutdown Operating Effluent Booster Pump P-1302A/B	5 sec
LAH-621	High UV Effluent Tank Level	150” – 180” from Tank Bottom	162”	FBR System Feed Shutdown	1 sec
FAL-72A	Lo Nutrient Feed Flow FBR-A	Fixed Point Switch		FBR-A Feed Shutdown	1 sec
YA-1208	Status Alarm SS-1208 Safety Shower	Fixed Point Switch		Alarm only	5 sec
YA-1210	Status Alarm SS-1210 Safety Shower	Fixed Point Switch		Alarm only	5 sec
YA-1211	Status Alarm SS-1211 Safety Shower	Fixed Point Switch		Alarm only	5 sec

PARAMETER	ALARM	RANGE	DEFAULT VALUE	RESULT OF ALARM	TIME DELAY
AAL-1401	Lo FBR-A pH	0 - 14	6.5	FBR-A Feed Shutdown	60 sec
AAH-1401	High FBR-A pH	0 - 14	8.0	FBR-A Feed Shutdown	60 sec
TAH-1401	High FBR-A Temperature	0 – 100 C	40	Alarm Only	60 sec
PAL-1401	Lo FBR-A Feed Pressure	Fixed Pt. Sw. (set at static head + 1.0 psi)		FBR-A System Shutdown	0.25 sec
FAL-1401	Lo FBR-A Feed Flow	Fixed Point Switch		FBR-A Feed Shutdown	30 sec
FAL-1440	Lo Feed Flow FBR-A	0 – 300 gpm	50 gpm	Feed Shutdown in Corresponding FBR,	30 sec
FAH-1440	Hi Feed Flow FBR-A	0 – 500 gpm	350 gpm	Alarm Only	30 sec
AALL-1440	Lo-Lo FBR-A ORP	(-1000) - 0 mV	(-450) mV	Alarm only	60 sec
AAL-1440	Lo FBR-A ORP	(-1000) - 0 mV	(-400) mV	Alarm only	60 sec
AAH-1440	High FBR-A ORP	(-1000) - 500 mV	(-50) mV	Alarm only	60 sec

PARAMETER	ALARM	RANGE	DEFAULT VALUE	RESULT OF ALARM	TIME DELAY
AAHH-1440	High-High FBR-A ORP	(-1000) - 500 mV	(-0) mV	FBR-A Feed Shutdown	60 sec
FAL-1520A	Lo Phosphoric Acid Feed Flow	Fixed Point Switch		FBR-A Feed Shutdown	5 sec
FAL-1521	Lo Phosphoric Acid Feed Flow	Fixed Point Switch		FBR-1 Feed Shutdown	5 sec
FAL-1522	Lo Phosphoric Acid Feed Flow	Fixed Point Switch		FBR-2 Feed Shutdown	5 sec
FAL-1523	Lo Phosphoric Acid Feed Flow	Fixed Point Switch		FBR-3 Feed Shutdown	5 sec
FAL-1524	Lo Phosphoric Acid Feed Flow	Fixed Point Switch		FBR-4 Feed Shutdown	5 sec
LALL-1603	Lo-Lo Sludge Storage Tank Level	20" – 24" from Tank Bottom	20"	Shutdown Sludge Pump P-1601	5 sec
LAL-1603	Lo Sludge Storage Tank Level	20" – 32" from Tank Bottom	24"	Close Oxygen Feed Valve FV-1602	5 sec
LAH-1603	High Sludge Storage Tank Level	150" – 164" from Tank Bottom	152"	Alarm only	1 sec
LAHH-1603	High-High Sludge Storage Tank Level	150" – 164" from Tank Bottom	156"	Shutdown Thickener Underflow Pump P-603	1 sec

PARAMETER	ALARM	RANGE	DEFAULT VALUE	RESULT OF ALARM	TIME DELAY
LAL-1701	Lo Filter Reject Tank Level	20" – 24" from Tank Bottom	20"	Shutdown P-1701A/B	5 sec
LAH-1701	Lo Filter Reject Tank Level	150" – 164" from Tank Bottom	156"	Alarm only	1 sec
PAH-1702	High Continuous Sand Filter Inlet Pressure	Fixed Point Switch		Alarm only	1 sec
PAHH-1702	High-High Continuous Sand Filter Inlet Pressure	Fixed Point Switch		Open Burst Air FVs for 3 seconds	1 sec

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 1 - FBR 1&2 REACTOR SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
1-01	AIT 1011	FBR 1 pH	0-14		Yes
1-02	AIT 1012	FBR 2 pH	0-14		Yes
1-03	AIT 1021	FBR 1 ORP	-1000 mV to +1000 mV		Yes
1-04	AIT 1022	FBR 2 ORP	-1000 mV to +1000 mV		Yes
1-05	FIT 1011	FBR 1 FLUIDIZATION FLOW	0-2800 gpm		Yes
	FAL-1011	LO FLUIDIZATION FLOW FBR 1	0-2800 gpm	1000 gpm	Yes
	I14	FBR 1 SYSTEM SHUTDOWN			Yes
	P-1011	FBR 1 FLUIDIZATION PUMP HAND/AUTO	Hand		Yes
	P-1011	FBR 1 FLUIDIZATION PUMP HAND/AUTO	Auto		Yes
	P-101A	SPARE FLUIDIZATION PUMP HAND/AUTO	Hand		Yes
	P-101A	SPARE FLUIDIZATION PUMP HAND/AUTO	Auto		Yes
1-06	PS-1011	FBR 1 INFLUENT PRESSURE SWITCH		12 PSIG	Yes
	PAL-1011	LO FLUIDIZATION PRESSURE FBR 1		12 PSIG	Yes
	FV-1011	FBR 1 REACTOR BLOCK VALVE			Yes
	I11	FBR 1 SYSTEM SHUTDOWN			Yes
1-07	FIT 1012	FBR 2 FLUIDIZATION FLOW	0-2800 gpm		Yes
	FAL-1012	LO FLUIDIZATION FLOW FBR 2	0-2800 gpm	1000 gpm	Yes
	I14	FBR 2 SYSTEM SHUTDOWN			Yes
	P-1012	FBR 2 FLUIDIZATION PUMP HAND/AUTO	Hand		Yes
	P-1012	FBR 2 FLUIDIZATION PUMP HAND/AUTO	Auto		Yes
1-08	PS-1012	FBR 2 INFLUENT PRESSURE SWITCH		12 PSIG	Yes
	PAL-1012	LO FLUIDIZATION PRESSURE FBR 2		12 PSIG	Yes
	FV-1012	FBR 2 REACTOR BLOCK VALVE			Yes
	I11	FBR 2 SYSTEM SHUTDOWN			Yes
1-09	FIT-1010	FBR 1 FEED FLOW			Yes
	FCV-1010	FBR 1 FEED FLOW CONTROL VALVE			Yes
	FC-1010	FBR 1 FEED FLOW CONTROL			Yes
	I12	FIRST STAGE FBR FLOW CONTROL	0-1000 gpm	proportional	Yes
	FAL-1010	LO FEED FLOW FBR 1	0-300 gpm	50 gpm	Yes
	FAH-1010	HI FEED FLOW FBR 1	0-500 GPM	350 gpm	Yes
	I16	FBR 1 FEED SHUTDOWN		50 gpm	Yes
1-10	FIT-1020	FBR 2 FEED FLOW			Yes
	FCV-1010	FBR 2 FEED FLOW CONTROL VALVE			Yes
	FC-1010	FBR 2 FEED FLOW CONTROL			Yes
	I12	FIRST STAGE FBR FLOW CONTROL	0-1000 gpm	proportional	Yes
	FAL-1010	LO FEED FLOW FBR 2	0-300 gpm	50 gpm	Yes
	FAH-1010	HI FEED FLOW FBR 2	0-500 gpm	350 gpm	Yes
	I16	FBR 2 FEED SHUTDOWN		50 gpm	Yes
1-11	P-1021	FBR 1 BED HEIGHT CONTROL PUMP HAND/AUTO	Hand		Yes
	P-1021	FBR 1 BED HEIGHT CONTROL PUMP HAND/AUTO	Auto		Yes
1-12	P-1022	FBR 2 BED HEIGHT CONTROL PUMP HAND/AUTO	Hand		Yes
	P-1022	FBR 2 BED HEIGHT CONTROL PUMP HAND/AUTO	Auto		Yes
1-13	LIT-2011	SEPARATOR T-2011 LEVEL			Yes
	LC-2011	SEPARATOR T-2011 LEVEL CONTROL			Yes
	LCV-2011	SEPARATOR T-2011 LEVEL CONTROL VALVE			Yes
	I23	SEPARATOR T-2011 LEVEL CONTROL		proportional	Yes
	LAL-2011	LO LEVEL SEPARATOR T-2011	0-25" (From Top of Tank)	12"	Yes
	LAH-2011	HI LEVEL SEPARATOR T-2011	0-25" (From Top of Tank)	4"	Yes
	I21	FBR 1 AND 2 FEED SHUTDOWN		4"	Yes
1-14	P-2011	MEDIA RETURN PUMP	Hand		Yes
	P-2012	MEDIA RETURN PUMP	Auto		Yes
	FV-2021	SERVICE WATER SUPPLY FOR MEDIA RETURN			Yes
	FV-2031	SERVICE WATER SUPPLY FOR MEDIA RETURN			Yes
	I22	SEPARATOR MEDIA RETURN CYCLE			Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 2 - FBR 3&4 REACTOR SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
2-01	AIT 1013	FBR 1 pH	0-14		Yes
2-02	AIT 1014	FBR 2 pH	0-14		Yes
2-03	AIT 1023	FBR 1 ORP	-1000 mV to +1000 mV		Yes
2-04	AIT 1024	FBR 2 ORP	-1000 mV to +1000 mV		Yes
2-05	FIT 1013	FBR 1 FLUIDIZATION FLOW	0-2800 gpm		Yes
	FAL-1013	LO FLUIDIZATION FLOW FBR 1	0-2800 gpm	1000 gpm	Yes
	I14	FBR 1 SYSTEM SHUTDOWN			Yes
	P-1013	FBR 1 FLUIDIZATION PUMP HAND/AUTO	Hand		Yes
	P-1013	FBR 1 FLUIDIZATION PUMP HAND/AUTO	Auto		Yes
	P-102A	SPARE FLUIDIZATION PUMP HAND/AUTO	Hand		Yes
	P-102A	SPARE FLUIDIZATION PUMP HAND/AUTO	Auto		Yes
2-06	PS-1013	FBR 3 INFLUENT PRESSURE SWITCH		12 PSIG	Yes
	PAL-1013	LO FLUIDIZATION PRESSURE FBR 3		12 PSIG	Yes
	FV-1013	FBR 3 REACTOR BLOCK VALVE			Yes
	I11	FBR 3 SYSTEM SHUTDOWN			Yes
2-07	FIT 1014	FBR 4 FLUIDIZATION FLOW	0-2800 gpm		Yes
	FAL-1014	LO FLUIDIZATION FLOW FBR 4	0-2800 gpm	1000 gpm	Yes
	I14	FBR 4 SYSTEM SHUTDOWN			Yes
	P-1014	FBR 4 FLUIDIZATION PUMP HAND/AUTO	Hand		Yes
	P-1014	FBR 4 FLUIDIZATION PUMP HAND/AUTO	Auto		Yes
2-08	PS-1014	FBR 4 INFLUENT PRESSURE SWITCH		12 PSIG	Yes
	PAL-1014	LO FLUIDIZATION PRESSURE FBR 4		12 PSIG	Yes
	FV-1014	FBR 4 REACTOR BLOCK VALVE			Yes
	I11	FBR 4 SYSTEM SHUTDOWN			Yes
2-09	FIT-1110	FBR 3 FEED FLOW			Yes
	FCV-1110	FBR 3 FEED FLOW CONTROL VALVE			Yes
	FC-1110	FBR 3 FEED FLOW CONTROL			Yes
	I12	FIRST STAGE FBR FLOW CONTROL	0-1000 gpm	proportional	Yes
	FAL-1110	LO FEED FLOW FBR 3	0-300 gpm	50 gpm	Yes
	FAH-1110	HI FEED FLOW FBR 3	0-500 GPM	350 gpm	Yes
	I16	FBR 3 FEED SHUTDOWN		50 gpm	Yes
2-10	FIT-1120	FBR 4 FEED FLOW			Yes
	FCV-1120	FBR 4 FEED FLOW CONTROL VALVE			Yes
	FC-1120	FBR 4 FEED FLOW CONTROL			Yes
	I12	FIRST STAGE FBR FLOW CONTROL	0-1000 gpm	proportional	Yes
	FAL-1120	LO FEED FLOW FBR 4	0-300 gpm	50 gpm	Yes
	FAH-1120	HI FEED FLOW FBR 4	0-500 gpm	350 gpm	Yes
	I16	FBR 4 FEED SHUTDOWN		50 gpm	Yes
2-11	P-1023	FBR 3 BED HEIGHT CONTROL PUMP HAND/AUTO	Hand		Yes
	P-1023	FBR 3 BED HEIGHT CONTROL PUMP HAND/AUTO	Auto		Yes
2-12	P-1024	FBR 4 BED HEIGHT CONTROL PUMP HAND/AUTO	Hand		Yes
	P-1024	FBR 4 BED HEIGHT CONTROL PUMP HAND/AUTO	Auto		Yes
2-13	LIT-2012	SEPARATOR T-2012 LEVEL			Yes
	LC-2012	SEPARATOR T-2012 LEVEL CONTROL			Yes
	LCV-2012	SEPARATOR T-2012 LEVEL CONTROL VALVE			Yes
	I23	SEPARATOR T-2012 LEVEL CONTROL		proportional	Yes
	LAL-2012	LO LEVEL SEPARATOR T-2012	0-25" (From Top of Tank)	12"	Yes
	LAH-2012	HI LEVEL SEPARATOR T-2012	0-25" (From Top of Tank)	4"	Yes
	I21	FBR 3 AND 4 FEED SHUTDOWN		4"	Yes
2-14	P-2012	MEDIA RETURN PUMP	Hand		Yes
	P-2012	MEDIA RETURN PUMP	Auto		Yes
	FV-2022	SERVICE WATER SUPPLY FOR MEDIA RETURN			Yes
	FV-2032	SERVICE WATER SUPPLY FOR MEDIA RETURN			Yes
	FV-2012	SERVICE WATER SUPPLY FOR MEDIA RETURN			Yes
	I22	SEPARATOR MEDIA RETURN CYCLE			Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 3 - FBR 5&6 REACTOR SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
3-01	AIT 3015	FBR 5 pH	0-14		Yes
3-02	AIT 3016	FBR 6 pH	0-14		Yes
3-03	AIT 3025	FBR 5 ORP	-1000 mV to +1000 mV		Yes
3-04	AIT 3026	FBR 6 ORP	-1000 mV to +1000 mV		Yes
3-05	FIT 3015	FBR 5 FLUIDIZATION FLOW	0-2800 gpm		Yes
	FAL-1011	LO FLUIDIZATION FLOW FBR 5	0-2800 gpm	1000 gpm	Yes
	I34	FBR 5 SYSTEM SHUTDOWN			Yes
	P-3015	FBR 5 FLUIDIZATION PUMP HAND/AUTO	Hand		Yes
	P-3015	FBR 5 FLUIDIZATION PUMP HAND/AUTO	Auto		Yes
	P-301A	SPARE FLUIDIZATION PUMP HAND/AUTO	Hand		Yes
	P-301A	SPARE FLUIDIZATION PUMP HAND/AUTO	Auto		Yes
3-06	PS-3015	FBR 5 INFLUENT PRESSURE SWITCH		10 PSIG	Yes
	PAL-3015	LO FLUIDIZATION PRESSURE FBR 5		10 PSIG	Yes
	FV-3011	FBR 5 REACTOR BLOCK VALVE			Yes
	I31	FBR 5 SYSTEM SHUTDOWN			Yes
3-07	FIT 3016	FBR 6 FLUIDIZATION FLOW	0-2800 gpm		Yes
	FAL-13016	LO FLUIDIZATION FLOW FBR 6	0-2800 gpm	1000 gpm	Yes
	I34	FBR 6 SYSTEM SHUTDOWN			Yes
	P-3016	FBR 6 FLUIDIZATION PUMP HAND/AUTO	Hand		Yes
	P-3016	FBR 6 FLUIDIZATION PUMP HAND/AUTO	Auto		Yes
3-08	PS-3016	FBR 6 INFLUENT PRESSURE SWITCH		10 PSIG	Yes
	PAL-3016	LO FLUIDIZATION PRESSURE FBR 6		10 PSIG	Yes
	FV-3016	FBR 6 REACTOR BLOCK VALVE			Yes
	I34	FBR 6 SYSTEM SHUTDOWN			Yes
3-09	FIT-3010	FBR 5 FEED FLOW			Yes
	FCV-3010	FBR 5 FEED FLOW CONTROL VALVE			Yes
	FC-3010	FBR 5 FEED FLOW CONTROL			Yes
	I32	SECOND STAGE FBR FLOW CONTROL	0-1000 gpm	proportional	Yes
	FAL-3010	LO FEED FLOW FBR 5	0-300 gpm	50 gpm	Yes
	FAH-3010	HI FEED FLOW FBR 5	0-500 GPM	350 gpm	Yes
	I36	FBR 5 FEED SHUTDOWN		50 gpm	Yes
3-10	FIT-3020	FBR 6 FEED FLOW			Yes
	FCV-3020	FBR 6 FEED FLOW CONTROL VALVE			Yes
	FC-3020	FBR 6 FEED FLOW CONTROL			Yes
	I32	SECOND STAGE FBR FLOW CONTROL	0-1000 gpm	proportional	Yes
	FAL-3020	LO FEED FLOW FBR 6	0-300 gpm	50 gpm	Yes
	FAH-3020	HI FEED FLOW FBR 6	0-500 gpm	350 gpm	Yes
	I36	FBR 6 FEED SHUTDOWN		50 gpm	Yes
3-11	LIT-3011	SEPARATOR T-3011 LEVEL			Yes
	LC-3011	SEPARATOR T-3011 LEVEL CONTROL			Yes
	LCV-3011	SEPARATOR T-3011 LEVEL CONTROL VALVE			Yes
	I38	SEPARATOR T-3011 LEVEL CONTROL		proportional	Yes
	LAL-3011	LO LEVEL SEPARATOR T-3011	0-25" (From Top of Tank)	12"	Yes
	LAH-3011	HI LEVEL SEPARATOR T-3011	0-25" (From Top of Tank)	4"	Yes
	I37	FBR 5 AND 6 FEED SHUTDOWN		4"	Yes
3-12	P-3011	MEDIA RETURN PUMP	Hand		Yes
	P-3011	MEDIA RETURN PUMP	Auto		Yes
	FV-3021	SERVICE WATER SUPPLY FOR MEDIA RETURN			Yes
	FV-3031	SERVICE WATER SUPPLY FOR MEDIA RETURN			Yes
	I38	SEPARATOR MEDIA RETURN CYCLE			Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 4 - FBR 7&8 REACTOR SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
4-01	AIT 3017	FBR 7 pH	0-14		Yes
4-02	AIT 3018	FBR 8 pH	0-14		Yes
4-03	AIT 3027	FBR 7 ORP	-1000 mV to +1000 mV		Yes
4-04	AIT 3028	FBR 8 ORP	-1000 mV to +1000 mV		Yes
4-05	FIT 3017	FBR 7 FLUIDIZATION FLOW	0-2800 gpm		Yes
	FAL-3017	LO FLUIDIZATION FLOW FBR 7	0-2800 gpm	1000 gpm	Yes
	I34	FBR 7 SYSTEM SHUTDOWN			Yes
	P-3017	FBR 7 FLUIDIZATION PUMP HAND/AUTO	Hand		Yes
	P-3017	FBR 7 FLUIDIZATION PUMP HAND/AUTO	Auto		Yes
	P-302A	SPARE FLUIDIZATION PUMP HAND/AUTO	Hand		Yes
	P-302A	SPARE FLUIDIZATION PUMP HAND/AUTO	Auto		Yes
4-06	PS-3017	FBR 7 INFLUENT PRESSURE SWITCH		10 PSIG	Yes
	PAL-3017	LO FLUIDIZATION PRESSURE FBR 7		10 PSIG	Yes
	FV-3017	FBR 7 REACTOR BLOCK VALVE			Yes
	I34	FBR 7 SYSTEM SHUTDOWN			Yes
4-07	FIT 3018	FBR 8 FLUIDIZATION FLOW	0-2800 gpm		Yes
	FAL-3018	LO FLUIDIZATION FLOW FBR 8	0-2800 gpm	1000 gpm	Yes
	I34	FBR 8 SYSTEM SHUTDOWN			Yes
	P-3018	FBR 8 FLUIDIZATION PUMP HAND/AUTO	Hand		Yes
	P-3018	FBR 8 FLUIDIZATION PUMP HAND/AUTO	Auto		Yes
4-08	PS-3018	FBR 8 INFLUENT PRESSURE SWITCH		10 PSIG	Yes
	PAL-3018	LO FLUIDIZATION PRESSURE FBR 8		10 PSIG	Yes
	FV-3018	FBR 8 REACTOR BLOCK VALVE			Yes
	I34	FBR 8 SYSTEM SHUTDOWN			Yes
4-09	FIT-3030	FBR 7 FEED FLOW			Yes
	FCV-3030	FBR 7 FEED FLOW CONTROL VALVE			Yes
	FC-3030	FBR 7 FEED FLOW CONTROL			Yes
	I32	SECOND STAGE FBR FLOW CONTROL	0-1000 gpm	proportional	Yes
	FAL-3030	LO FEED FLOW FBR 7	0-300 gpm	50 gpm	Yes
	FAH-3030	HI FEED FLOW FBR 7	0-500 GPM	350 gpm	Yes
	I36	FBR 7 FEED SHUTDOWN		50 gpm	Yes
4-10	FIT-3040	FBR 8 FEED FLOW			Yes
	FCV-3040	FBR 8 FEED FLOW CONTROL VALVE			Yes
	FC-3040	FBR 8 FEED FLOW CONTROL			Yes
	I32	SECOND STAGE FBR FLOW CONTROL	0-1000 gpm	proportional	Yes
	FAL-3040	LO FEED FLOW FBR 8	0-300 gpm	50 gpm	Yes
	FAH-3040	HI FEED FLOW FBR 8	0-500 gpm	350 gpm	Yes
	I36	FBR 8 FEED SHUTDOWN		50 gpm	Yes
4-11	LIT-3012	SEPARATOR T-3012 LEVEL			Yes
	LC-3012	SEPARATOR T-3012 LEVEL CONTROL			Yes
	LCV-3012	SEPARATOR T-3012 LEVEL CONTROL VALVE			Yes
	I38	SEPARATOR T-3012 LEVEL CONTROL		proportional	Yes
	LAL-3012	LO LEVEL SEPARATOR T-3012	0-25" (From Top of Tank)	12"	Yes
	LAH-3012	HI LEVEL SEPARATOR T-3012	0-25" (From Top of Tank)	4"	Yes
	I37	FBR 7 AND 8 FEED SHUTDOWN		4"	Yes
4-12	P-3012	MEDIA RETURN PUMP	Hand		Yes
	P-3012	MEDIA RETURN PUMP	Auto		Yes
	FV-3022	SERVICE WATER SUPPLY FOR MEDIA RETURN			Yes
	FV-3032	SERVICE WATER SUPPLY FOR MEDIA RETURN			Yes
	FV-3012	SERVICE WATER SUPPLY FOR MEDIA RETURN			Yes
	I36	SEPARATOR MEDIA RETURN CYCLE			Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 5A - SOUTH DAF

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
5A-01	LT-501	DAF PRESSURE TANK T-501 LEVEL	34-48"		No
	LI-501	DAF PRESSURE TANK T-501 LEVEL	34-48"		Yes
	LAH-501	HI DAF PRESSURE TANK T-501 LEVEL	34-48"	46	Yes
	LAL-501	LO DAF PRESSURE TANK T-501 LEVEL	34-48"	36	Yes
	LC-501	LEVEL CONTROL DAF PRESSURE TANK T-501			No
	I51	DAF PRESSURE TANK T-501 VENT ON LO LEVEL			Yes
	LV-501	LEVEL VALVE DAF PRESSURE TANK T-501			Yes
5A-02	FT-502	DAF RECYCLE FLOW	0-290 gpm		Yes
	FAL-502	LO DAF RECYCLE FLOW	0-290 gpm	100 gpm	Yes
	I53	STOP DAF PRESSURE PUMP P-501			Yes
	P-501	DAF PRESSURE PUMP P-501	Hand		Yes
	P-501	DAF PRESSURE PUMP P-501	Auto		Yes
5A-03	LSH-502	DAF FLOAT COMPARTMENT HI LEVEL	Fixed Switch Point		Yes
	I52	DAF FLOAT PUMP P-502 SHUTDOWN			Yes
	P-502	DAF FLOAT PUMP	Hand		Yes
	P-502	DAF FLOAT PUMP	Auto		Yes
5A-04	KC-504	SKIMMER AND SCREW DRIVE TIMER			Yes
	M-503	SKIMMER DRIVE	Hand		Yes
	M-503	SKIMMER DRIVE	Auto		Yes
	M-504	SCREW CONVEYOR DRIVE	Hand		Yes
	M-504	SCREW CONVEYOR DRIVE	Auto		Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 5B - NORTH DAF

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
5B-01	LT-551	DAF PRESSURE TANK T-551 LEVEL	34-48"		No
	LI-551	DAF PRESSURE TANK T-551 LEVEL	34-48"		Yes
	LAH-551	HI DAF PRESSURE TANK T-551 LEVEL	34-48"	46	Yes
	LAL-551	LO DAF PRESSURE TANK T-551 LEVEL	34-48"	36	Yes
	LC-551	LEVEL CONTROL DAF PRESSURE TANK T-551			No
	I51	DAF PRESSURE TANK T-551 VENT ON LO LEVEL			Yes
	LV-505	LEVEL VALVE DAF PRESSURE TANK T-551			Yes
5B-02	FT-506	DAF RECYCLE FLOW	0-290 gpm		Yes
	FAL-506	LO DAF RECYCLE FLOW	0-290 gpm	100 gpm	Yes
	I53	STOP DAF PRESSURE PUMP P-551			Yes
	P-551	DAF PRESSURE PUMP P-551	Hand		Yes
	P-551	DAF PRESSURE PUMP P-551	Auto		Yes
5B-03	LSH-505	DAF FLOAT COMPARTMENT HI LEVEL	Fixed Switch Point		Yes
	I52	DAF FLOAT PUMP P-552 SHUTDOWN			Yes
	P-552	DAF FLOAT PUMP	Hand		Yes
	P-552	DAF FLOAT PUMP	Auto		Yes
5B-04	KC-554	SKIMMER AND SCREW DRIVE TIMER			Yes
	M-553	SKIMMER DRIVE	Hand		Yes
	M-553	SKIMMER DRIVE	Auto		Yes
	M-554	SCREW CONVEYOR DRIVE	Hand		Yes
	M-554	SCREW CONVEYOR DRIVE	Auto		Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 6 - UV SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
6-01	AI-621	UV INTENSITY SIGNAL	0-100%		Yes
6-02	TAH-621	HI TEMPERATURE ALARM SIGNAL	Fixed Switch Point		Yes
	LAH-621	LO UV INTENSITY ALARM	Fixed Switch Point		Yes
	AA-621	LAMP OUT ALARM SIGNAL	Fixed Switch Point		Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 7 - EFFLUENT TRANSFER SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
7-01	LIT-601	EFFLUENT TANK T-601 LEVEL	0-120 inches		Yes
	LC-601	EFFLUENT TANK T-601 LEVEL CONTROL			No
	LCV-601	EFFLUENT TANK LEVEL CONTROL VALVE	0-100 %		Yes
	LI-601	EFFLUENT TANK T-601 LEVEL	0-120 inches		Yes
	LAH-601	HI LEVEL EFFLUENT TANK T-601	0-120 inches	108	Yes
	I62	SYSTEM FEED SHUTDOWN		108	Yes
	LAL-601	LO LEVEL EFFLUENT TANK T-601	0-120 inches	54	Yes
	I61	EFFLUENT PUMP SHUTDOWN DUE TO LO LEVEL		54	Yes
7-02	AIT-601	EFFLUENT TURBIDIMETER	0-100 ntu		Yes
	AI-601	EFFLUENT TURBIDIMETER	0-100 ntu		Yes
	AAH-601	HI EFFLUENT TURBIDITY	10 ntu		Yes
7-03	FIT-602	EFFLUENT FLOW RATE	0-1400 gpm		Yes
	FI-602	EFFLUENT FLOW RATE	0-1400 gpm		Yes
7-04	P-601	EFFLUENT PUMP	Hand		Yes
	P-601	EFFLUENT PUMP	Auto		Yes
	P-602	EFFLUENT PUMP	Hand		Yes
	P-602	EFFLUENT PUMP	Auto		Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 8 - SLUDGE THICKENER AND CONDITIONING TANK

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
8-01	M-611	THICKENER RAKE	Hand		Yes
	M-611	THICKENER RAKE	Auto		Yes
8-02	M-612	THICKENER FLOC MIXER	Hand		Yes
	M-612	THICKENER FLOC MIXER	Auto		Yes
8-03	M-613	THICKENER FLOC MIXER	Hand		Yes
	M-613	THICKENER FLOC MIXER	Auto		Yes
8-04	P-603	THICKENER UNDERFLOW PUMP	Hand		Yes
	P-603	THICKENER UNDERFLOW PUMP	Auto		Yes
	KC-603	THICKENER UNDERFLOW PUMP TIMER			Yes
8-05	XSH-611	THICKENER HIGH TORQUE SWITCH			Yes
	XAH-611	THICKENER HIGH TORQUE ALARM			Yes
	XSHH-611	THICKENER HIGH-HIGH TORQUE SWITCH			Yes
	XAHH-611	THICKENER HIGH-HIGH TORQUE ALARM			Yes
	I63	THICKENER RAKE SHUTDOWN ON HIGH-HIGH TORQUE			Yes
8-06	M-901	CONDITIONING TANK MIXER MOTOR	Hand		Yes
	M-901	CONDITIONING TANK MIXER MOTOR	Auto		Yes
8-07	LSH-901	CONDITIONING TANK HIGH LEVEL SWITCH	Fixed switch point		Yes
	LAH-901	CONDITIONING TANK HIGH LEVEL ALARM	Fixed switch point		Yes
	LSL-901	CONDITIONING TANK LOW LEVEL SWITCH	Fixed switch point		Yes
	LAL-901	CONDITIONING TANK LOW LEVEL ALARM	Fixed switch point		Yes
	LSLL-901	CONDITIONING TANK LOW-LOW LEVEL SWITCH	Fixed switch point		Yes
	LALL-901	CONDITIONING TANK LOW-LOW LEVEL ALARM	Fixed switch point		Yes
	I91	MIXER DISABLE ON LOW TANK LEVEL			Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 9A - EAST FILTER PRESS

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
9A-01	P-903	PRESS FILTRATE PUMP	Hand		Yes
	P-903	PRESS FILTRATE PUMP	Auto		Yes
9A-02	LSHH-902	FILTRATE TANK HIGH-HIGH LEVEL SWITCH	Fixed switch point		Yes
	LAHH-902	FILTRATE TANK HIGH-HIGH LEVEL ALARM	Fixed switch point		Yes
	LSH-902	FILTRATE TANK HIGH LEVEL SWITCH	Fixed switch point		Yes
	LAH-902	FILTRATE TANK HIGH LEVEL ALARM	Fixed switch point		Yes
	LSL-902	FILTRATE TANK LOW LEVEL SWITCH	Fixed switch point		Yes
	LSLL-902	FILTRATE TANK LOW LEVEL ALARM	Fixed switch point		Yes
9A-03	I92	FILTRATE PUMP DISABLE ON LOW TANK LEVEL			Yes
9A-04	I93	PRESS FEED PUMP DISABLE ON HIGH TANK LEVEL			Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 9B - WEST FILTER PRESS

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
9B-01	I93	PRESS FEED PUMP DISABLE ON HIGH TANK LEVEL			Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 10 - LIME SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
10-01	UA-752	LIME SYSTEM COMMON TROUBLE ALARM	Fixed Switch Point		Yes
10-02	KC-751	LIME SYSTEM FEED INITIATE			Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 11 - FERRIC SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
11-01	LS-751	FERRIC CHLORIDE LEAK DETECT LEVEL SWITCH	Fixed Switch Point		Yes
	LAH-751	FERRIC CHLORIDE LEAK ALARM	Fixed Switch Point		Yes
11-02	P-751	FERRIC CHLORIDE PUMP HAND/AUTO	Hand		Yes
	P-751	FERRIC CHLORIDE PUMP HAND/AUTO	Auto		Yes
11-03	LIT-751	FERRIC CHLORIDE TANK LEVEL TRANSMITTER	0-90.3"		Yes
	LAL-751	LOW LEVEL FERRIC CHLORIDE TANK	20"		Yes
11-04	KC-751	SEQUENCE TIMER			Yes
	FV-751E	FERRIC CHLORIDE VALVE TO CONDITIONING TANK			Yes
	I72	FEED VALVE DURATION TIME INTERLOCK			Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 12 - POLYMER FEED SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
12-01	LSL-704	POLYMER FEED TANK LOW LEVEL SWITCH	Fixed Switch Point		Yes
	LAL-704	LO LEVEL POLYMER FEED TANK	Fixed Switch Point		Yes
12-02	P-741	FBR 1 NUTRIENT PUMP HAND/AUTO	Hand		Yes
	P-741	FBR 1 NUTRIENT PUMP HAND/AUTO	Auto		Yes
	FC-741	FLOW CONTROL NUTRIENT PUMP P-721	0-100%	proportional	Yes
12-03	LSL-705	POLYMER FEED TANK LOW LEVEL SWITCH	Fixed Switch Point		Yes
	LAL-705	LO LEVEL POLYMER FEED TANK	Fixed Switch Point		Yes
12-04	P-742	FBR 2 NUTRIENT PUMP HAND/AUTO	Hand		Yes
	P-742	FBR 2 NUTRIENT PUMP HAND/AUTO	Auto		Yes
	FC-742	FLOW CONTROL NUTRIENT PUMP P-722	0-100%	proportional	Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 13 - NUTRIENT FEED SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
13-01	LSL-717	NUTRIENT TANK LOW LEVEL SWITCH	Fixed Switch Point		Yes
	LAL-717	LO LEVEL NUTRIENT TANK	Fixed Switch Point		Yes
13-02	P-721	FBR 1 NUTRIENT PUMP HAND/AUTO	Hand		Yes
	P-721	FBR 1 NUTRIENT PUMP HAND/AUTO	Auto		Yes
	FC-721	FLOW CONTROL NUTRIENT PUMP P-721	0-100%	proportional	Yes
	FI-1010	FEED FLOW FBR 1	0-500 gpm		Yes
13-03	FS-721	FLOW SWITCH NUTRIENT PUMP P-721	Fixed Switch Point		No
	FAL-721	LO NUTRIENT FLOW FBR 1	Fixed Switch Point		Yes
	I71	FBR 1 FEED SHUTDOWN			Yes
13-04	P-722	FBR 2 NUTRIENT PUMP HAND/AUTO	Hand		Yes
	P-722	FBR 2 NUTRIENT PUMP HAND/AUTO	Auto		Yes
	FC-722	FLOW CONTROL NUTRIENT PUMP P-722	0-100%	proportional	Yes
	FI-1020	FEED FLOW FBR 2	0-500 gpm		
13-05	FS-722	FLOW SWITCH NUTRIENT PUMP P-722	Fixed Switch Point		No
	FAL-722	LO NUTRIENT FLOW FBR 2	Fixed Switch Point		Yes
	I71	FBR 2 FEED SHUTDOWN			Yes
13-06	P-723	FBR 3 NUTRIENT PUMP HAND/AUTO	Hand		Yes
	P-723	FBR 3 NUTRIENT PUMP HAND/AUTO	Auto		Yes
	FC-723	FLOW CONTROL NUTRIENT PUMP P-723	0-100%	proportional	Yes
	FI-1110	FEED FLOW FBR 3	0-500 gpm		
13-07	FS-723	FLOW SWITCH NUTRIENT PUMP P-723	Fixed Switch Point		No
	FAL-723	LO NUTRIENT FLOW FBR 3	Fixed Switch Point		Yes
	I71	FBR 3 FEED SHUTDOWN			Yes
13-08	P-724	FBR 4 NUTRIENT PUMP HAND/AUTO	Hand		Yes
	P-724	FBR 4 NUTRIENT PUMP HAND/AUTO	Auto		Yes
	FC-724	FLOW CONTROL NUTRIENT PUMP P-724	0-100%	proportional	Yes
	FI-1120	FEED FLOW FBR 4	0-500 gpm		
13-09	FS-724	FLOW SWITCH NUTRIENT PUMP P-724	Fixed Switch Point		No
	FAL-724	LO NUTRIENT FLOW FBR 4	Fixed Switch Point		Yes
	I71	FBR 4 FEED SHUTDOWN			Yes
13-10	P-725	FBR 5 NUTRIENT PUMP HAND/AUTO	Hand		Yes
	P-725	FBR 5 NUTRIENT PUMP HAND/AUTO	Auto		Yes
	FC-725	FLOW CONTROL NUTRIENT PUMP P-725	0-100%	proportional	Yes
	FI-3010	FEED FLOW FBR 5	0-500 gpm		Yes
13-11	FS-725	FLOW SWITCH NUTRIENT PUMP P-725	Fixed Switch Point		No
	FAL-725	LO NUTRIENT FLOW FBR 5	Fixed Switch Point		Yes
	I71	FBR 5 FEED SHUTDOWN			Yes
13-12	P-726	FBR 6 NUTRIENT PUMP HAND/AUTO	Hand		Yes
	P-726	FBR 6 NUTRIENT PUMP HAND/AUTO	Auto		Yes
	FC-726	FLOW CONTROL NUTRIENT PUMP P-726	0-100%	proportional	Yes
	FI-3020	FEED FLOW FBR 6	0-500 gpm		Yes
13-13	FS-726	FLOW SWITCH NUTRIENT PUMP P-726	Fixed Switch Point		No
	FAL-726	LO NUTRIENT FLOW FBR 6	Fixed Switch Point		Yes
	I71	FBR 6 FEED SHUTDOWN			Yes
13-14	P-727	FBR 7 NUTRIENT PUMP HAND/AUTO	Hand		Yes
	P-727	FBR 7 NUTRIENT PUMP HAND/AUTO	Auto		Yes
	FC-727	FLOW CONTROL NUTRIENT PUMP P-727	0-100%	proportional	Yes
	FI-3030	FEED FLOW FBR 7	0-500 gpm		Yes
13-15	FS-727	FLOW SWITCH NUTRIENT PUMP P-727	Fixed Switch Point		No
	FAL-727	LO NUTRIENT FLOW FBR 7	Fixed Switch Point		Yes
	I71	FBR 7 FEED SHUTDOWN			Yes
13-16	P-728	FBR 8 NUTRIENT PUMP HAND/AUTO	Hand		Yes
	P-728	FBR 8 NUTRIENT PUMP HAND/AUTO	Auto		Yes
	FC-728	FLOW CONTROL NUTRIENT PUMP P-728	0-100%	proportional	Yes
	FI-3040	FEED FLOW FBR 8	0-500 gpm		Yes
13-17	FS-728	FLOW SWITCH NUTRIENT PUMP P-728	Fixed Switch Point		No
	FAL-728	LO NUTRIENT FLOW FBR 8	Fixed Switch Point		Yes
	I71	FBR 8 FEED SHUTDOWN			Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 14 - CAUSTIC FEED SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
14-01	LSL-701	PH TANK LOW LEVEL SWITCH	Fixed Switch Point		Yes
	LAL-701	LO LEVEL PH TANK	Fixed Switch Point		Yes
14-02	P-711	FBR 1 PH PUMP HAND/AUTO	Hand		Yes
	P-711	FBR 1 PH PUMP HAND/AUTO	Auto		Yes
	AC-1011	FLOW CONTROL PH PUMP P-711	0-100%	proportional	Yes
	AAL-1011	LO PH FBR 1	0-14	6.5	Yes
	AAH-1011	HI PH FBR 1	0-14	8	Yes
	I13	FBR 1 FEED SHUTDOWN	Fixed Switch Point		Yes
	TAH-1011	HI TEMP FBR 1	0-100 C	40	Yes
14-03	P-712	FBR 2 PH PUMP HAND/AUTO	Hand		Yes
	P-712	FBR 2 PH PUMP HAND/AUTO	Auto		Yes
	AC-1012	FLOW CONTROL PH PUMP P-712	0-100%	proportional	Yes
	AAL-1012	LO PH FBR 2	0-14	6.5	Yes
	AAH-1012	HI PH FBR 2	0-14	8	Yes
	I13	FBR 2 FEED SHUTDOWN	Fixed Switch Point		Yes
	TAH-1012	HI TEMP FBR 2	0-100 C	40	Yes
14-04	P-713	FBR 3 PH PUMP HAND/AUTO	Hand		Yes
	P-713	FBR 3 PH PUMP HAND/AUTO	Auto		Yes
	AC-1013	FLOW CONTROL PH PUMP P-713	0-100%	proportional	Yes
	AAL-1013	LO PH FBR 3	0-14	6.5	Yes
	AAH-1013	HI PH FBR 3	0-14	8	Yes
	I13	FBR 3 FEED SHUTDOWN	Fixed Switch Point		Yes
	TAH-1013	HI TEMP FBR 3	0-100 C	40	Yes
14-05	P-714	FBR 4 PH PUMP HAND/AUTO	Hand		Yes
	P-714	FBR 4 PH PUMP HAND/AUTO	Auto		Yes
	AC-1014	FLOW CONTROL PH PUMP P-714	0-100%	proportional	Yes
	AAL-1014	LO PH FBR 4	0-14	6.5	Yes
	AAH-1014	HI PH FBR 4	0-14	8	Yes
	I13	FBR 4 FEED SHUTDOWN	Fixed Switch Point		Yes
	TAH-1014	HI TEMP FBR 4	0-100 C	40	Yes
14-06	P-715	FBR 5 PH PUMP HAND/AUTO	Hand		Yes
	P-715	FBR 5 PH PUMP HAND/AUTO	Auto		Yes
	AC-3015	FLOW CONTROL PH PUMP P-715	0-100%	proportional	Yes
	AAL-3015	LO PH FBR 5	0-14	6.5	Yes
	AAH-3015	HI PH FBR 5	0-14	8	Yes
	I34	FBR 5 FEED SHUTDOWN	Fixed Switch Point		Yes
	TAH-3015	HI TEMP FBR 5	0-100 C	40	Yes
14-07	P-716	FBR 6 PH PUMP HAND/AUTO	Hand		Yes
	P-716	FBR 6 PH PUMP HAND/AUTO	Auto		Yes
	AC-3016	FLOW CONTROL PH PUMP P-716	0-100%	proportional	Yes
	AAL-3016	LO PH FBR 6	0-14	6.5	Yes
	AAH-3016	HI PH FBR 6	0-14	8	Yes
	I34	FBR 6 FEED SHUTDOWN	Fixed Switch Point		Yes
	TAH-3016	HI TEMP FBR 6	0-100 C	40	Yes
14-08	P-717	FBR 7 PH PUMP HAND/AUTO	Hand		Yes
	P-717	FBR 7 PH PUMP HAND/AUTO	Auto		Yes
	AC-3017	FLOW CONTROL PH PUMP P-717	0-100%	proportional	Yes
	AAL-3017	LO PH FBR 7	0-14	6.5	Yes
	AAH-3017	HI PH FBR 7	0-14	8	Yes
	I34	FBR 7 FEED SHUTDOWN	Fixed Switch Point		Yes
	TAH-3017	HI TEMP FBR 7	0-100 C	40	Yes
14-09	P-718	FBR 8 PH PUMP HAND/AUTO	Hand		Yes
	P-718	FBR 8 PH PUMP HAND/AUTO	Auto		Yes
	AC-3018	FLOW CONTROL PH PUMP P-718	0-100%	proportional	Yes
	AAL-3018	LO PH FBR 8	0-14	6.5	Yes
	AAH-3018	HI PH FBR 8	0-14	8	Yes
	I34	FBR 8 FEED SHUTDOWN	Fixed Switch Point		Yes
	TAH-3018	HI TEMP FBR 8	0-100 C	40	Yes

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
15-01	FIT 739	ELECTRON DONOR PUMP FLOW	0-120 gph		Yes
15-02	LIT 703	ETHANOL TANK LEVEL	0-120"		Yes
	LAH-703	HI LEVEL ELECTRON DONOR TANK			No - Truck Fill Station Alarm from Omtec
	LAHH-703	HI HI LEVEL ELECTRON DONOR TANK			No - Truck Fill Station Alarm from Omtec
	LAL-703	LO LEVEL ELECTRON DONOR TANK ALARM	0-120"	20"	Yes
15-03	AAL-1021	LO ORP FBR 1 ALARM	(-1000) - 0 mV	(-400) mV	Yes
	AAH-1021	HI ORP FBR 1 ALARM	(-1000) - 500 mV	(-50) mV	Yes
	AALL-1021	LO LO ORP FBR 1 ALARM	(-1000) - 0 mV	(-450) mV	Yes
	AAHH-1021	HI HI ORP FBR 1 ALARM	(-1000) - 500 mV	0 mV	Yes
	AC-1021	CONTROL OF ELECTRON DONOR PUMP P-731	0-100%		Yes
	I15	FBR 1 FEED SHUTDOWN		0 mV	Yes
	P-731	ELECTRON DONOR PUMP HAND/AUTO	Hand		Yes
	P-731	ELECTRON DONOR PUMP HAND/AUTO	Auto		Yes
15-04	AAL-1022	LO ORP FBR 2 ALARM	(-1000) - 0 mV	(-400) mV	Yes
	AAH-1022	HI ORP FBR 2 ALARM	(-1000) - 500 mV	(-50) mV	Yes
	AALL-1022	LO LO ORP FBR 2 ALARM	(-1000) - 0 mV	(-450) mV	Yes
	AAHH-1022	HI HI ORP FBR 2 ALARM	(-1000) - 500 mV	0 mV	Yes
	AC-1022	CONTROL OF ELECTRON DONOR PUMP P-732	0-100%		Yes
	I15	FBR 2 FEED SHUTDOWN		0 mV	Yes
	P-732	ELECTRON DONOR PUMP HAND/AUTO	Hand		Yes
	P-732	ELECTRON DONOR PUMP HAND/AUTO	Auto		Yes
15-05	AAL-1023	LO ORP FBR 3 ALARM	(-1000) - 0 mV	(-400) mV	Yes
	AAH-1023	HI ORP FBR 3 ALARM	(-1000) - 500 mV	(-50) mV	Yes
	AALL-1023	LO LO ORP FBR 3 ALARM	(-1000) - 0 mV	(-450) mV	Yes
	AAHH-1023	HI HI ORP FBR 3 ALARM	(-1000) - 500 mV	0 mV	Yes
	AC-1023	CONTROL OF ELECTRON DONOR PUMP P-733	0-100%		Yes
	I15	FBR 3 FEED SHUTDOWN		0 mV	Yes
	P-733	ELECTRON DONOR PUMP HAND/AUTO	Hand		Yes
	P-733	ELECTRON DONOR PUMP HAND/AUTO	Auto		Yes
15-06	AAL-1024	LO ORP FBR 4 ALARM	(-1000) - 0 mV	(-400) mV	Yes
	AAH-1024	HI ORP FBR 4 ALARM	(-1000) - 500 mV	(-50) mV	Yes
	AALL-1024	LO LO ORP FBR 4 ALARM	(-1000) - 0 mV	(-450) mV	Yes
	AAHH-1024	HI HI ORP FBR 4 ALARM	(-1000) - 500 mV	0 mV	Yes
	AC-1024	CONTROL OF ELECTRON DONOR PUMP P-734	0-100%		Yes
	I15	FBR 4 FEED SHUTDOWN		0 mV	Yes
	P-734	ELECTRON DONOR PUMP HAND/AUTO	Hand		Yes
	P-734	ELECTRON DONOR PUMP HAND/AUTO	Auto		Yes
15-06	AAL-3025	LO ORP FBR 5 ALARM	(-1000) - 0 mV	(-400) mV	Yes
	AAH-3025	HI ORP FBR 5 ALARM	(-1000) - 500 mV	(-50) mV	Yes
	AALL-3025	LO LO ORP FBR 5 ALARM	(-1000) - 0 mV	(-450) mV	Yes
	AAHH-3025	HI HI ORP FBR 5 ALARM	(-1000) - 500 mV	0 mV	Yes
	AC-3025	CONTROL OF ELECTRON DONOR PUMP P-735	0-100%		Yes
	I15	FBR 5 FEED SHUTDOWN		0 mV	Yes
	P-735	ELECTRON DONOR PUMP HAND/AUTO	Hand		Yes
	P-735	ELECTRON DONOR PUMP HAND/AUTO	Auto		Yes
15-07	AAL-3026	LO ORP FBR 6 ALARM	(-1000) - 0 mV	(-400) mV	Yes
	AAH-3026	HI ORP FBR 6 ALARM	(-1000) - 500 mV	(-50) mV	Yes
	AALL-3026	LO LO ORP FBR 6 ALARM	(-1000) - 0 mV	(-450) mV	Yes
	AAHH-3026	HI HI ORP FBR 6 ALARM	(-1000) - 500 mV	0 mV	Yes
	AC-3026	CONTROL OF ELECTRON DONOR PUMP P-736	0-100%		Yes
	I15	FBR 6 FEED SHUTDOWN		0 mV	Yes
	P-736	ELECTRON DONOR PUMP HAND/AUTO	Hand		Yes
	P-736	ELECTRON DONOR PUMP HAND/AUTO	Auto		Yes
15-08	AAL-3027	LO ORP FBR 7 ALARM	(-1000) - 0 mV	(-400) mV	Yes
	AAH-3027	HI ORP FBR 7 ALARM	(-1000) - 500 mV	(-50) mV	Yes
	AALL-3027	LO LO ORP FBR 7 ALARM	(-1000) - 0 mV	(-450) mV	Yes
	AAHH-3027	HI HI ORP FBR 7 ALARM	(-1000) - 500 mV	0 mV	Yes
	AC-3027	CONTROL OF ELECTRON DONOR PUMP P-737	0-100%		Yes
	I15	FBR 7 FEED SHUTDOWN		0 mV	Yes
	P-737	ELECTRON DONOR PUMP HAND/AUTO	Hand		Yes
	P-737	ELECTRON DONOR PUMP HAND/AUTO	Auto		Yes
15-09	AAL-3028	LO ORP FBR 8 ALARM	(-1000) - 0 mV	(-400) mV	Yes
	AAH-3028	HI ORP FBR 8 ALARM	(-1000) - 500 mV	(-50) mV	Yes
	AALL-3028	LO LO ORP FBR 8 ALARM	(-1000) - 0 mV	(-450) mV	Yes
	AAHH-3028	HI HI ORP FBR 8 ALARM	(-1000) - 500 mV	0 mV	Yes
	AC-3028	CONTROL OF ELECTRON DONOR PUMP P-738	0-100%		Yes
	I15	FBR 8 FEED SHUTDOWN		0 mV	Yes
	P-738	ELECTRON DONOR PUMP HAND/AUTO	Hand		Yes
	P-738	ELECTRON DONOR PUMP HAND/AUTO	Auto		Yes
15-10	I74	ETHANOL PUMP SOLENOID			Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 17 - COMPRESSED AIR SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
17-01	P-801	AIR COMPRESSOR	Start		
	P-801	AIR COMPRESSOR	Stop		
17-02	P-802	AIR COMPRESSOR	Start		
	P-802	AIR COMPRESSOR	Stop		
17-03	T-802	AIR DRYER	Start		
	T-802	AIR DRYER	Stop		
17-04	PSL-802	INSTRUMENT AIR PRESSURE			
	PAL-802	LO PRESSURE INSTRUMENT AIR		80 psig	Yes
	I81	SYSTEM SHUTDOWN		80 psig	Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 18 - AERATION SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
18-01	PSL-401	LO PRESSURE SWITCH AERATION BLOWER		10 psig	Yes
	PAL-401	LO PRESSURE AERATION BLOWER		10 psig	Yes
	I42	SYSTEM FEED SHUTDOWN			Yes
	AT-401	HYDROGEN SULFIDE TRANSMITTER	0-20 ppm		No
	AAH-401	HI HYDROGEN SULFIDE		5 ppm	Yes
	AAH-401	HI HYDROGEN SULFIDE		5 ppm	No
18-02	LSH-401	HI LEVEL SWITCH AERATION TANK	Fixed Switch Point		Yes
	LAH-401	HI LEVEL AERATION TANK	Fixed Switch Point		Yes
	I41	SYSTEM FEED SHUTDOWN			Yes
18-03	B-401	AERATION BLOWER	Hand		Yes
	B-401	AERATION BLOWER	Auto		Yes
18-04	FT-503	AERATION TANK EFFLUENT FLOW	0-1200 gpm		No
	FI-503	AERATION TANK EFFLUENT FLOW	0-1200 gpm		Yes
18-05	FT-507	AERATION TANK EFFLUENT FLOW	0-1200 gpm		No
	FI-507	AERATION TANK EFFLUENT FLOW	0-1200 gpm		Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 19 - SUMP PUMPS

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
19-01	P-1101	PAD SUMP PUMP	Hand		Yes
	P-1101	PAD SUMP PUMP	Auto		Yes
		LS-1101			No
		LAH-1101			Yes
19-02	P-1102	PAD SUMP PUMP	Hand		Yes
	P-1102	PAD SUMP PUMP	Auto		Yes
		LS-1102			No
		LAH-1102			Yes
19-03	P-1202	EXISTING D-1 SUMP PUMP			No
	LS	EXISTING D-1 SUMP PUMP LEVEL SWITCH			No

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 20 - FEED SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
20-01	PE-1015	SYSTEM FEED PRESSURE	0-100 psi		Yes
	PIT-1015	SYSTEM FEED PRESSURE	0-100 psi		Yes
	PCV-1015	SYSTEM FEED PRESSURE CONTROL VALVE	0-100%		Yes
20-02	AE-1020	SYSTEM FEED CONDUCTIVITY	0-15000 uS/cm		Yes
	AIT-1020	SYSTEM FEED CONDUCTIVITY	0-15000 uS/cm		Yes
	AAH-1020	HIGH ALARM SYSTEM FEED CONDUCTIVITY		15000 uS/cm	Yes
	I17	P-103 SHUTDOWN ON HIGH CONDUCTIVITY		15000 uS/cm	Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 25 - EYEWASH AND SAFETY SHOWER SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
25-01	FS-1201	FLOW SWITCH FOR SS-1201	Off		No
	FS-1201	FLOW SWITCH FOR SS-1201	On		No
	YA-1201	LOCAL ALARM AT SS-1201			No
	YA-1201	STATUS ALARM SS-1201 SAFETY SHOWER			No
25-02	FS-1202	FLOW SWITCH FOR SS-1202	Off		No
	FS-1202	FLOW SWITCH FOR SS-1202	On		No
	YA-1202	LOCAL ALARM AT SS-1202			No
	YA-1202	STATUS ALARM SS-1202 SAFETY SHOWER			Yes
25-03	FS-1203	FLOW SWITCH FOR SS-1203	Off		No
	FS-1203	FLOW SWITCH FOR SS-1203	On		No
	YA-1203	LOCAL ALARM AT SS-1203			No
	YA-1203	STATUS ALARM SS-1203 SAFETY SHOWER			Yes
25-04	FS-1204	FLOW SWITCH FOR SS-1204	Off		No
	FS-1204	FLOW SWITCH FOR SS-1204	On		No
	YA-1204	LOCAL ALARM AT SS-1204			No
	YA-1204	STATUS ALARM SS-1204 SAFETY SHOWER			Yes
25-05	FS-1205	FLOW SWITCH FOR SS-1205	Off		No
	FS-1205	FLOW SWITCH FOR SS-1205	On		No
	YA-1205	LOCAL ALARM AT SS-1205			No
	YA-1205	STATUS ALARM SS-1205 SAFETY SHOWER			Yes
25-06	FS-1206	FLOW SWITCH FOR SS-1206	Off		No
	FS-1206	FLOW SWITCH FOR SS-1206	On		No
	YA-1206	LOCAL ALARM AT SS-1206			No
	YA-1206	STATUS ALARM SS-1206 SAFETY SHOWER			Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 28 - BIOFILTER SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
28-01	B-402	BIOFILTER BLOWER	Local Hand Switch		Yes
28-02	P-402	BIOFILTER SUMP	Local Hand Switch		No
	LSH-402	BIOFILTER SUMP HIGH LEVEL SWITCH	Fixed position switch		No

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT 29 - MICRONUTRIENT FEED SYSTEM

Loop Check No.	PID Tag	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
29-01	LSL-753	LOW LEVEL MICRO NUTRIENT TANK	Fixed Switch Point		Yes
	LAL-753	LOW LEVEL MICRO NUTRIENT TANK	Fixed Switch Point		Yes
29-02	P-753A	MICRO NUTRIENT PUMP	Hand		No
	P-753A	MICRO NUTRIENT PUMP	Auto		Yes
29-03	FS-753A	LOW FLOW MICRO NUTRIENT PUMP	Fixed Switch Point		Yes
	FAL-753A	LOW FLOW ALARM MICRO NUTRIENT PUMP	Fixed Switch Point		Yes
29-04	P-753B	MICRO NUTRIENT PUMP	Hand		No
	P-753B	MICRO NUTRIENT PUMP	Auto		Yes
29-05	FS-753B	LOW FLOW MICRO NUTRIENT PUMP	Fixed Switch Point		Yes
	FAL-753B	LOW FLOW ALARM MICRO NUTRIENT PUMP	Fixed Switch Point		Yes
29-06	FC-753	MICRO NUTRIENT PUMP FLOW CONTROLLER	0-100%		Yes

PERCHLORATE REMOVAL SYSTEM - HENDERSON
SUBUNIT - 30 EQUALIZATION AREA

Loop Check No.	PID Tag.	DESCRIPTION	RANGE FOR 4-20ma	DEFAULT VALUE	HMI Indication Yes/No
30-01	E10-LIT-11	EQ TANK LEVEL	0-100%		Yes
	E10-LAL-11	EQ TANK LOW LEVEL ALARM			Yes
	E10-LAH-11	EQ TANK HIGH LEVEL ALARM			Yes
	E10-LAHH-11	EQ TANK HIGH-HIGH LEVEL ALARM			Yes
	I101	LOW LEVEL STOPS PUMPS P102A,B			Yes
	I102	HIGH LEVEL ENABLES START OF PUMPS P102A,B			Yes
	I103	HIGH-HIGH LEVEL SOUNDS ALARM AND DIALS OUT			Yes
	I104	LOW LEVEL CAUSES FBR FEED SHUTDOWN			Yes
30-02	E10-PT-14	EQ FEED PUMP PRESSURE	0-120 PSI		Yes
	E10-PAL-14	EQ FEED PUMP LOW PRESSURE ALARM			Yes
	E10-PAH-14	EQ FEED PUMP HIGH PRESSURE ALARM			Yes
30-03	E13-PT-12	EQ FEED PUMP PRESSURE AFTER GAC	0-120 PSI		Yes
	E13-PAL-12	EQ FEED PRESSURE LOW ALARM			Yes
	E13-PAH-12	EQ FEED PRESSURE HIGH ALARM			Yes
30-04	E10-PIC-13	ION EXCHANGE FEED PRESSURE CONTROLLER	0-100%		Yes
	FV-13	ION EXCHANGE FEED PRESSURE CONTROL VALVE	0-100%		Yes
30-05	E10-HV-10	FLOW VALVE LS2 TO EQ TANK			Yes
	E10-HZSC-10	CLOSED LIMIT SWITCH FOR E10-HV-10			Yes
	E10-HZSO-10	OPEN LIMIT SWITCH FOR E10-HV-10			Yes
30-06	E10-HV-11	FLOW VALVE GWTP TO EQ TANK			Yes
	E10-HZSC-11	CLOSED LIMIT SWITCH FOR E10-HV-11			Yes
	E10-HZSO-11	OPEN LIMIT SWITCH FOR E10-HV-11			Yes
30-07	E10-HV-17	FLOW VALVE LS2 TO POND			Yes
	E10-HZSC-17	CLOSED LIMIT SWITCH FOR E10-HV-17			Yes
	E10-HZSO-17	OPEN LIMIT SWITCH FOR E10-HV-17			Yes
30-08	E10-P-101A	EQ TANK FEED PUMP HAND/AUTO	Hand		Yes
	E10-P-101A	EQ TANK FEED PUMP HAND/AUTO	Auto		Yes
30-09	E10-P-101B	EQ TANK FEED PUMP HAND/AUTO	Hand		Yes
	E10-P-101B	EQ TANK FEED PUMP HAND/AUTO	Auto		Yes
30-10	E10-P-103	EQ TANK FEED PUMP HAND/AUTO	Hand		Yes
	E10-P-103	EQ TANK FEED PUMP HAND/AUTO	Auto		Yes
30-11	E10-P-102A	EQ SYSTEM FEED PUMP HAND/AUTO	Hand		Yes
	E10-P-102A	EQ SYSTEM FEED PUMP HAND/AUTO	Auto		Yes
30-12	E10-P-102B	EQ SYSTEM FEED PUMP HAND/AUTO	Hand		Yes
	E10-P-102B	EQ SYSTEM FEED PUMP HAND/AUTO	Auto		Yes
30-13	E10-FIT-13	IX FEED FLOW			Yes
30-14	E13-FIT-10	STABILIZED LAKE WATER FEED FLOW			Yes
	E13-FQI-10	STABILIZED LAKE WATER FEED FLOW TOTAL			Yes
30-15	E17-HV-10	FLOW VALVE EFFLUENT TO SEEP			Yes
	E17-HZSC-10	CLOSED LIMIT SWITCH FOR E17-HV-10			Yes
	E17-HZSO-10	OPEN LIMIT SWITCH FOR E17-HV-10			Yes
30-16	E17-HV-11	FLOW VALVE EFFLUENT TO POND			Yes
	E17-HZSC-11	CLOSED LIMIT SWITCH FOR E17-HV-11			Yes
	E17-HZSO-11	OPEN LIMIT SWITCH FOR E17-HV-11			Yes
30-17	E17-AIT-10B	EFFLUENT PH	0-14		Yes
	E17-AAL-10B	EFFLUENT LOW PH ALARM			Yes
	E17-AAH-10B	EFFLUENT HIGH PH ALARM			Yes
30-18	E17-AIT-12B	EFFLUENT PH	0-14		Yes
	E17-AAL-12B	EFFLUENT LOW PH ALARM			Yes
	E17-AAH-12B	EFFLUENT HIGH PH ALARM			Yes
30-19	E17-AIT-11	EFFLUENT PERCHLORATE	0-10,000 PPM		Yes
	E17-AAH-11	EFFLUENT HIGH PERCHLORATE ALARM			Yes
30-20	E17-AIT-13	EFFLUENT PERCHLORATE	0-10,000 PPM		Yes
	E17-AAH-13	EFFLUENT HIGH PERCHLORATE ALARM			Yes
30-21	I106	HIGH PH CAUSES DIAL-OUT TO OPERATOR			Yes
	I107	LOW PH CAUSES DIAL-OUT TO OPERATOR			Yes
	I108	HIGH PERCHLORATE DAILS-OUT TO OPERATOR			Yes
30-22	E19-LAH-11	EQ AREA SUMP HIGH LEVEL ALARM			Yes
	E19-LAHH-10	EQ AREA SUMP HIGH LEVEL ALARM			Yes
	I105	HIGH EQ AREA SUMP LEVEL CAUSE DIALS OUT TO OPERATOR			Yes

CHAPTER 15
STARTUP AND SHUTDOWN SEQUENCE

STARTUP SEQUENCE DESCRIPTION

The following startup sequence provides an overview of the required steps to start up the Perchlorate Treatment System. The sequence describes startup of the main process from raw water inlet at pressure control valve PCV-1015, to system discharge through the Effluent Booster Pumps P-1302A/B. The operator is referred to individual chapters contained within this manual and other vendor-supplied O&M manuals for detailed operating procedures. The sequence does not cover the solids handling system startup. As a general rule, installed spare pumps should have the manual inlet and outlet valves closed and the local motor disconnect switch in the “off“ position.

1. System Utilities must be operational prior to starting up the FBR system. Utilities include the electrical system, air compressor system, equipment pad sump pumps, service water and/or stabilized lake water, and safety shower equipment. More information may be found in Chapter 11 of this manual and the vendor-supplied equipment O&M manuals.

2. At the operator interface, make sure pressure control valve PCV-1015 on the system feed line in the “Hand” and set at 0% open.

3. Walk down the Perchlorate Treatment System and check manual valves to ensure that the system is set up to accept raw water and to allow treated water to move between unit operations to effluent discharge. The system has been designed to include flow bypass. Flow bypass includes the following locations: Second Stage FBR Bypass, North and South DAF Bypasses, UV Disinfection Bypass, and Recirculation Bypass of the system influent to the First Stage FBR’s. The operator is referred to the system’s P&ID’s for a more detailed description of system bypass piping.

4. Automatic feed valves for each FBR System should be placed into “Hand” and set at 25% open at the operator interface. Each FBR system will initially be operated in RECYCLE mode. Verify all manual valve positions in accordance with the Valve Position Chart. At the operator interface, start

each individual FBR System by turning on its fluidization pump in “AUTO”. Adjust the fluidization flow rate to the desired rate. Also, see Chapter 3 for a description of the FBR Operation.

5. After starting up each of the eight FBR Systems in RECYCLE mode, post treatment unit operations will be initiated. The following order of post treatment unit operations should be followed: Post Aeration System, Biofilter, and DAF Unit. The operator will select either the south or north DAF unit to bring on line. At each DAF, manual inlet and outlet valves should be positioned based on which unit is to be brought on line. For the non-operating DAF, the manual inlet and outlet valves should be closed. See Chapter 5 for a description for each operation.

6. Prior to processing treated water from the system, the UV Disinfection Unit should be turned on at the operator interface. In general, the UV Disinfection Unit requires five minutes of operation prior to treatment of system effluent to allow the lamps to reach operating temperature. The unit should only be turned on when water is present inside the unit. Please refer to Chapter 7 for a more complete description of the UV Disinfection Unit.

7. At the effluent pump skid, select the desired effluent pump to be operated. Manual Inlet and Outlet valves should be fully opened for the pump to be operated. Manual Inlet and Outlet valves on the spare pump should be closed. At the operator interface, set the level control valve LCV-601 into “HAND”. Adjust the valve to 26% open and start the selected effluent pump in “AUTO”. After the effluent pump has been started, set the level control valve LCV-601 into “AUTO” operation. The Effluent Booster Pumps will automatically start once the level in the Effluent Tank begins to increase. These pumps will speed up or slow down to maintain that operating level. See Chapter 5 for a description of the effluent system operation.

8. For each FBR System, place the level control valve on the discharge of each separator into “AUTO” operation at the operator interface

9. At the operator interface, slowly open pressure control valve PCV-1015 on the feed lines to the system. The pressure control valve should be opened in 1% increments until the desired influent feed flow rate has been established.

10. At the operator interface, turn on the chemical feed systems including Nutrient, pH, and Ethanol Pumps into “AUTO” for each individual FBR System. See Chapter 9 for a description of each Chemical Feed System.

11. At the operator interface, select the micronutrient pumps to be operated and place the pump into “AUTO” operation. Micronutrients will be added at a rate proportional to the total feed rate. See Chapter 9 for a description of the micronutrient feed system operation.

12. For each FBR System, place the automatic feed valve into “AUTO” operation at the operator interface. With feed flow established to a FBR System, the system is now operating in FBR RUNNING mode.

13. At the operator interface, place pressure control valve PCV-1015 into “AUTO” operation. The pressure control valve will control the feed pressure based on the operator adjustable set points value.

14. At the completion of the above sequence, the system will be running in automatic with all of the designed interlocks functional.

SHUTDOWN SEQUENCE DESCRIPTION

The system shutdown sequence is completed by reversing the steps noted in the system startup sequence.

1. At the operator interface, place pressure control valve PCV-1015 into “HAND” operation. Slowly close the pressure control valve by manually adjusting the % open valve until the feed flow has been reduced to 0 gpm. At this point, all chemical feed rates will be shut off due to the FEED SHUTDOWN, which will occur in each FBR system due to low feed flow.

2. For each FBR System, place the automatic feed vale into “HAND” operation at the operator interface. Adjust each feed valve to 0% open.

3. For each FBR System, place the chemical feeds including nutrient, pH, and ethanol pumps into “HAND” operation at the operator interface. Adjust the each chemical feed pump to 0% open.

At this point, the system is idling without forward feed. The operator may elect to continue shutting down the system by reversing steps in the startup sequence or allow the system to idle with each FBR System operating in RECYCLE mode. The UV Disinfection System should be shut down at the operator interface once the effluent pump is shut down.

CHAPTER 16
SAFETY

GENERAL

The safety hazards associated with the Perchlorate Treatment System are many and varied. They range from the dangers of sodium hydroxide handling to the potential for contracting waterborne diseases. It is important for both management and operating personnel to become thoroughly familiar with these potential hazards and to develop a safety consciousness governing all activities at the plant.

The maintenance of a good safety record at the plant has many benefits: lower operating costs, more efficient operation, good employee morale, and good public relations are just a few. More direct evidence of the benefits of a good safety program is found in study results, which have shown that the actual cost of an injury is at least five times the direct cost. Thus, for example, if the workmen's compensation and medical cost of an injury is $500, the injury will actually cost $2,500 when indirect costs such as accident investigation time and replacement training costs are considered.

Staying alert and always being aware of potentially dangerous situations are the greatest accident prevention practices an operator can follow. Sophisticated safety guards and provisions are completely ineffective against accidents to persons who are not alert and aware of the possibility that an accident can occur. In fact, safety guards often instill a feeling of false security that may lead to the disregard of the common sense safety practices, which are necessary to prevent accidents. An operator should always be aware that accidents could occur regardless of the provisions that are taken to prevent them.

The well-known saying, "familiarity breeds contempt is particularly applicable to the causes for accidents. The longer a person works under dangerous conditions, the less respect he has for the danger and the more likely he will disregard safety measures. Therefore, safety instruction classes and reviews should be conducted for the operating personnel at regular intervals. A portion of each session should be devoted to reviewing the dangers inherent in exposure to sewage, working in confined spaces, working with electricity, the explosion and fire potential of methane gas, working near rotating equipment, the dangers of acids and bases, etc. The aim of that portion of each safety session should be to renew the operator's respect for the hazards to which he is exposed.

SAFETY HAZARDS

The remaining part of this chapter is intended to familiarize the management and operating personnel at the wastewater system with the general types of hazards present at the plant and to discuss routine safety precautions that should be exercised. If desired, more in-depth discussions may be found in any of the references listed at the end of the chapter.

The general types of safety hazards at the treatment plant and some typical examples are:

1. mechanical equipment (motors, gearboxes, belts, shafts, hydraulics),
2. electrical (open panels, loose wiring, water),
3. chemical handling (corrosive and reactive liquids and gases),
4. noxious gas or oxygen deficiency (Hydrogen Sulfide, confined spaces, drowning)
5. explosion (welding gases, ethanol vapors and gasoline) and
6. fire (electrical, chemical, construction debris.)
7. Bacterial Infection

POTENTIAL HAZARDS

The first part of this section discusses general types of potential hazards present at the plant. Each section discusses routine safety precautions that must be exercised.

Mechanical Equipment Hazards

The high-speed rotation and movement of mechanical parts presents an obvious safety problem. Particular attention to safety precautions must be exercised when working with or near pumps and drive motor arrangements and other moving equipment. Particular hazards arise from drive belts or drive chains and from rotating shafts and impellers. Guards over couplings and shafts must be provided and kept in place at all times when the equipment is operating. The wearing of loose clothing rings and other jewelry around machinery is not permitted.

When starting rotating equipment after a prolonged shutdown, the operator should stay a good distance away from the edge of the rotating shafts. Dust, oil, and loose metal particles may be thrown from shafts and couplings, or fracture of the shaft may occur. Similar precautions are to be taken when working with the slower moving mechanical devices at the plant.

Electrical Hazards

An electrical shock hazard exists wherever electrically driven equipment is used with the system or pump station. All motors and control centers used to drive pumps, and agitators and all transmission lines are components of the facility's electrical system. General safety rules to be followed when working with any electrical equipment are presented below:

1. Follow site specific Lock out / Tag out procedures as referenced in the Safety Procedures section.
2. Only qualified and authorized persons are permitted to work on electrical equipment.
3. Keep all electrical controls in safe working order, accessible, and well marked.
4. Do not use metal ladders or metal tape measures around electrical equipment.
5. Always work from a firm base. Loss of balance may cause contact with live loads.
6. Use only double-insulated portable electric tools. Extreme care should be taken when using portable electric tools near water and they must not be used where an explosive hazard exists.
7. Keep wires from becoming a tripping hazard.
8. One man never works alone on energized equipment that operates at or above 440 volts. When two or more men work together, someone is always available to watch the other, de-energize circuits, apply first aid, or summon help if needed.

9. When work is to be done on equipment controlled by a switch located some distance away, the switch must be locked out and tagged with a red card to prevent others from closing the circuit while the equipment is being repaired.
10. Make certain there is no possibility of back feed occurring on a dead circuit.
11. Keep fire extinguishers suitable for use on electrical fires readily available.
12. Rubber mats should be used at all control centers and electrical panels.
13. All electric motors, switches, and control boxes are kept clean at all times.

Chemical Hazards

If a chemical is identified as potentially hazardous, failure to comply with precautionary measures may turn it into an “actual" hazard. This is important because any chemical can be safely stored, handled, and used once its potential hazard is understood and proper precautions and safeguards are adopted.

Chemical hazards may be present in many forms - liquids, particles, gases, dusts, vapors, and mists. The severity of a chemical health hazard depends on concentration and amount of exposure time. The safe concentration and amount of time will vary by chemical, as will individual susceptibility. Thus, assessing the degree of harmfulness of a hazard involves a basic knowledge of the nature and use of chemicals. In addition, the hazard may exist at any stage from the time the chemical is received until it is used. Thus any hazard assessment must cover receiving, storage, and transportation areas, dispensing stations, work processes (including laboratory and testing facilities), and waste disposal procedures.

Once the actual hazard is identified, control measures can be put into place to reduce employee chemical exposure. Such control measures usually include a combination of engineering controls (for example, closed transfer systems), administrative controls, correct work practices, and use of personal protective equipment. Each situation must be individually evaluated, the nature of the hazards considered (airborne or direct contact), and route of entry into the body determined, before the correct control strategy can be adopted.

To prevent injury, property loss and damage, the use of chemicals should be restricted and carefully supervised from the time of purchase to disposal. All hazardous chemicals must be identified, health and safety data obtained prior to use, and handling procedures and precautions made known and adopted. A program of chemical control should incorporate purchasing procedures, handling, storing, dispensing, labeling, use, disposal, first aid, and emergency procedures. It should also provide for audit checks to ensure that safe procedures are followed.

The Site Safety Program requires Respirators be carried in case of gas leak while on site.

Material Safety Data Sheets (MSDS)

MSDS will be on site for each chemical prior to use. In general, suppliers will provide MSDS that contain a detailed assessment of chemical characteristics, hazards, and other information relative to health, safety and-the environment. MSDS specifically provide the following information:

1. Identification of composition, CAS number, formula, molecular weight, and synonyms;
2. Physical data on boiling, freezing, melting points, specific gravity, solubility, and vapor pressure;
3. Reactivity such as incompatibility, decomposition products, polymerization potential;
4. Health hazard data on effects of exposure (acute and chronic), permissible exposure limits, and warning signals (II);
5. Environmental impact such as toxic effects upon the environment, shipping, and other pertinent federal regulations;
6. Exposure control methods such as personal protective measures and engineering and administrative controls;
7. Work practices such as handling and storage procedures, normal cleanup, and waste disposal methods;
8. Emergency procedures for handling spills, fires, and explosions; and
9. First aid procedures.

MSDS form the basis of an employee-training program, although they should not be considered a substitute for training. MSDS will be accessible to all employees and contractors as a reference source.

Noxious Gases and Oxygen Deficiency

A noxious gas or vapor may directly or indirectly threaten the health or life of human beings by causing burns, explosions, asphyxiation, or poisoning. The locations at the treatment system and pump stations that are most likely to be dangerous from a noxious gas or vapor situation or oxygen deficiency are confined areas such as:

1. Tightly covered pits and valve chambers,
2. Deep tanks and wet wells.
3. Closed chemical vessels
4. Aeration Tank
5. Fluidized Bed Reactors

One of the more hazardous conditions encountered is that of oxygen deficiency. Normal air contains about 21 percent (by volume) oxygen and 79 percent nitrogen. Any atmosphere containing less than 19.5% oxygen is called an oxygen-deficient atmosphere. Any level below 12 percent will not adequately support life.

Hydrogen sulfide may be present at the site in low concentrations but is not expected to be an issue during normal system operations. That said, engineering controls, such as the Biofilters and hydrogen sulfide monitors have been installed at the facility. The hydrogen sulfide monitors will provide alarm indication of hydrogen sulfide gas in an area. The Biofilter sub-unit has been installed to remove this and other odors from the treatment system area.

Hydrogen sulfide (H2S) is a colorless, flammable gas that can be identified in relatively low concentrations, by a characteristic rotten egg odor. It is therefore encountered in places such as sewers, treatment systems (H2S is often called sewer gas). Industrial sources of hydrogen sulfide include petroleum and natural gas extraction and refining, pulp and paper manufacturing, rayon textile production, leather tanning, chemical manufacturing and waste disposal.

While the distinctive odor of H2S is easily detected, its olfactory fatigue effects mean that one cannot rely on the nose as a warning device. The only reliable way to determine exposure levels is to measure the amount in the air. With a vapor density of 1.19, hydrogen sulfide is approximately 20 percent heavier than air, so this invisible gas will collect in depressions in the ground and in confined spaces.

Explosion Hazards

Ethanol (Ethyl Alcohol) is a colorless liquid or gas with an alcohol odor. The gas and liquid are flammable and the liquid has a specific gravity of 0.79 at 20 degrees C. The lower limit of its explosive range is 3.3 percent of air volume and its upper limit is 19.0 percent. Ethanol is used as a food source in the treatment of the groundwater. Therefore, wherever gas may be present, there should be no smoking, sparks or any open flame. Gas detectors must always be used before entering any confined space. A special fire protection system is provided on the Ethanol System at Kerr-McGee. Please refer to the vendor supplied equipment manual for additional information on this subject.

Fire Hazards

The possibility that a fire of any significance will disrupt the operation of the system is unlikely. This is due to the fact that very little combustible material is used in the construction of the buildings and structures. Regardless, the potential for fire exists when fuel, oxygen and heat are present.

One type of fire that could occur would be an electrical fire. This type of fire would typically be confined to burn out motors or motor control centers. If such a fire would occur, the electrical power to the affected units must be disconnected and chemical fire extinguishers used. Disruption of the normal system operation should be limited because of the duplication of equipment and isolation of the control centers. As soon as the fire is extinguished, the damage should be assessed.

Good housekeeping is a MUST to reduce the potential for a fire. Debris/trash accumulation is a source of fuel for fires. If sparks from welding, sanding or grinding, operations contact this source of fuel, now all the components are available to start a fire. Therefore, the operators must maintain good housekeeping practices throughout the project by disposing of trash in proper containers. Additionally, before welding, grinding etc., the contractor must remove combustible materials from the area so that the fuel source for a fire is not present.

Another fire potential is the ethanol used as a food source for the FBR process. The gas and liquid are flammable. Ethanol vapor can travel a considerable distance to an ignition source and "flash back." Ethanol vapor forms explosive mixtures with air at concentrations of 4.3 to 19% (by volume).

Ethanol fires are "invisible" to the naked eye. There is no smoke and the flame cannot be seen, making this type of fire extremely dangerous. Fire fighters responding to ethanol fires typically give the suspected area "the broom test" by carefully probing the suspect area with a corn straw broom to determine presence and location of the fire. Therefore, extreme caution needs to be exercised when approaching the Ethanol storage area and unauthorized personnel must be kept out of the area.

Hazardous gases produced in ethanol fires include carbon monoxide and carbon dioxide. Carbon dioxide or dry chemical extinguishers should be used for ethanol fires. Special care will be given to monitor and inspect the ethanol usage rates, storage tank and delivery lines. Special procedures will be prepared for use when performing maintenance work on the ethanol system.

BACTERIAL INFECTION

Biological organisms (Bacteria) are used in the treatment of the wastewater. Although these organisms used in the treatment of the wastewater are not disease causing organisms as such, they are present in the system. These organisms do not necessarily remain within the liquid or sludge. Aerosol sprays that may be produced during Wastewater aeration are capable of transporting the organisms through the air throughout the entire plant site, and have been documented to transport organisms as far as 4,000 feet from their source.

The best defense against bacterial or viral infection is to always practice good personal hygiene. The chances of operating personnel contracting a waterborne infection can be minimized by following these precautions:

a. When working at tasks, which bring you in contact with the Wastewater or sludge, always keep your hands below your collar, since a majority of infections reach the body by way of the mouth, nose, eyes, or ears.

b. Rubber gloves should be worn whenever an employee comes into contact with wastewater, sludges, grit, screenings, or other residual wastes. Gloves should also be worn when an employee's hands are chapped or burned, or when the skin is broken by any open wound.

c. Consider even the smallest scratch as having potential for infection and immediately treat it with an antiseptic.

d. Wear boots or rubber overshoes when working in damp places.

e. Wash work clothes at frequent intervals and only wear work clothes while at work. Work clothes should not be worn home. Fresh clothes should note be stored in a locker with work clothes.

f. Avoid eating or smoking until your hands are thoroughly washed.

g. Shower and wash up thoroughly after each work day.

CHAPTER 17
SPILL PREVENTION & RESPONSE

GENERAL

The GWETS plant and its supporting facilities contain miles of pipelines, numerous instruments and control valves, and many large tanks that contain chemicals, influent or treated water. Given the volume of pipe runs, joints, valves, flanges, and other connections, there is the possibility of a leak that will require immediate attention. As such, plant personnel must be observant of current conditions within the treatment plant at all times..

First, one should become familiar with the previous chapter on safety. In addition, review of the location and contents of the chemical MSDS sheets for the facility in case of a chemical spill are required.

One should be familiar with areas of the plant which utilize spill containment and areas that are not contained. The containment areas are key to determining spill response and clean up actions.

SPILL CONTROL PLANNING

This section is intended to familiarize the wastewater system management and operating personnel with the spill control planning and response measures in place to mitigate spills.

Spill Containment Infrastructure

1. FBR Pad

   The system equipment is primarily situated on curbed concrete pads designed to contain spills emanating from the system. The main FBR system and majority of the chemical tanks are contained on a pad, designed to contain the volume of the largest vessel on the pad as a minimum. This pad is drained by 2 sump pumps to GW-11 as annotated on PID-11.

2. D-1 Building Sump

The D-1 building contains a sump and a floor trench system to contain spills within the D-1 building. Some doors contain sills or bumps in order to add height such that spilled liquids will not exit the doorway. The doorways for the filter press operation require a removable spill boom to allow for access of the sludge dumpsters while maintaining spill containment while in operation.

3. Raw Water Sump, East Side of D-1

This sump and pad are on the east side of the D-1 building. At this location, the influent and effluent piping exits the ground from below grade pipe runs from the equalization area. This area also houses some pre-filters which are no longer used and other controls equipment to measure and stabilize flow.

4. D-1 PDM Sump

This sump is on the west side of the D-1 building. The FBR pad sumps, along with the Raw Water sump, pump liquid into this sump. The pump in this sump moves the contents into a line discharging to GW-11. The D-1 building PDM sump is tapped into the same discharge line to GW-11. For sizes and more explanation, see PID-11.

5. GWTP Chrome Plant Pad and Sump

The pad at the GWTP Chrome plant acts as spill containment and the pad sump collects material from the pad. The sump pump moves any spilled material collected to the GWTP influent equalization tank, thus returning material back into the chrome treatment process.

6. Equalization Area Pad and Sump

The equalization area equipment is situated on a curbed concrete pad, designed to contain spills from the GWETS equalization system. The design will contain the largest vessel volume on the pad as a minimum. This pad is drained by a sump pump which discharges to GW-11 as annotated on PID-10C

Equipment Inspections

As described in the previous 16 chapters of this manual, the GWETS overall plant is complex and comprised of a large number of items of equipment and miles of piping. A failure in any of these elements might result in a spill. In order to minimize the risk of a spill due to equipment failure, constant inspection and proper preventative maintenance is needed.

Attached in Appendix P is the GWETS Equipment Tracking form. This form will be used weekly by the site operating staff to perform, document, and annotate an overall plant inspection. The status of each item listed will be noted and for those items out of service due to maintenance, a criticality code will be chosen and annotated based on the nature of the repair and how it will affect the plant.

After the Tracking form is completed, the operator will forward a copy to the Trust or their representative for review and eventual incorporation into the GWETS monthly report.

Process Control Systems

There are two process control systems at the plant and each has an auto dialer system. The first system serves the GWTP Chrome Plant and the other serves the overall GWETS controls which include the FBR system and equalization area. The auto dialer will call a preset telephone number to notify operators of an alarm condition and if it is not immediately responded to by an operator. The auto dialers are active 24 hours per day and call the operator onsite or offsite to warn of a potential spill condition.

It should be noted that there are other alarms which will initiate the auto dialer, but these pertain to process related or low level conditions and as such are not discussed in this chapter.

The following alarms are related to potential spill conditions and will initiate a call out alarm for the overall GWETS system;

- T-621 – Effluent Tank – Inside building D-1 – High Level Alarm – PID-10C
    - Initiates plant wide feed shutdown
    - Initiates auto dialer call
- L1101H & L1102H – FBR Pad Sumps – High Level Alarm – PID- 11
    - After 5 minutes where the alarm condition has not subsided, initiates auto dialer
- L1202HH & L1203HH – D1, and PDM Sumps – High Level Alarm – PID- 11
    - After 5 minutes where the alarm condition has not subsided, initiates auto dialer
- L1201HH – Equalization Sump – High Level Alarm – PID- 10C
    - After 10 minutes where the alarm condition has not subsided, initiates auto dialer
- T1701 – Sand Filter Reject Tank – High Level Alarm – PID-17
    - Initiates auto dialer call
    - After 10 minutes where the alarm condition has not subsided, initiates plant wide feed shutdown
- L706 – Ethanol Tank Leak – Leak Detection – PID-7B
    - Shuts down electron donor booster pumps P739A & B
    - Initiates plant wide feed shutdown
    - Initiates auto dialer call

The following alarm is related to potential spill conditions and will initiate a call out alarm on the a overall GWTP Chrome Plant system;

- GWTP Holding Tank – High Alarm
    - Initiates the Klaxon alarm onsite
    - Initiates auto dialer call

Process Control Systems Testing

The following is the testing procedure for the alarms listed above;

- T-621 Effluent Tank High Level - Weekly
    - *On the Siemens SCADA computer main screen, click the "Go to Set Points" box at the bottom of the screen.*
    - *Click the "Go to Set Points-3" box.*
    - *Find T-621 Level Set point at the top left of the page.*
    - *Click the setting box and decrease the set point number to a reading that is below the level reading currently on the main screen.*
    - *Go to the main screen and wait for the auto-dialer active box to appear in the top right corner.*
    - *Shortly, there should be a call on the operator phone, Shutdown P_601 and turn all FBRs to recycle mode. Acknowledge the call by pressing "9" when you hear a steady tone.*
    - *Reset the set point to its original setting and turn back FBRs to the feeding mode.*
- L1101H, L1102H, L1202HH, L1203HH, & L1201HH – Sump High or High High Level Alarms - Weekly
    - *On the particular sump pump, select the HOA selector switch to Hand mode.*
    - *After five or ten minutes (see particular sump above), there should be a call on the operator phone. Acknowledge the call by pressing "9" when you hear a steady tone.*
    - *Return HOA selector switch to auto mode.*
- T1701 – Sand Filter Reject Tank – High Level Alarm - Weekly
    - *On the Siemens SCADA computer main screen, click the "Go to Set Points" box at the bottom of the screen.*
    - *Click the "Go to Set Points-3" box.*
    - *Find High Filter Reject Tank LVL at the top right of the page.*
    - *Click the setting box and decrease the set point number to a reading that is below the current tank level reading on the main screen.*

- *Go to the main screen and wait for the auto-dialer and horn active box to appear in the top right corner.*
- *Shortly, there should be a call on the operator phone. Acknowledge the call by pressing "9" when you hear a steady tone.*
- *After ten minutes the control system should shut down all FBRs.*
- *Reset the set point to its original setting and turn back FBRs to the feeding mode.*

- L706 – Ethanol Tank Leak - Quarterly
  - *On the FBR pad area, next to the Ethanol Tank, prepare a bucket of water.*
  - *Locate the leak sensor near the ethanol metering pump area and place the sensor in the water bucket.*
  - *Shortly, there should be a call on the operator phone, shutdown FBRs and ethanol pumps. Acknowledge the call by pressing "9" when you hear a steady tone.*
  - *Dry the sensor, and turn FBRs to feeding mode and re-start the ethanol pumps.*

- GWTP Holding Tank – High Alarm - Weekly
  - *On the GWTP SCADA (Dell) computer) in the D-1 control room, click on the "Flow/Level" block.*
  - *Go to holding tank set points and double click on the set point number for high level.*
  - *When the keypad appears, type in a number that is lower than the current level, then click on the download button.*
  - *Wait for a steady tone Klaxon at GWTP proceeded by a call on the operator phone. Acknowledge the call by pressing "9" while the recording is talking.*
  - *Go to GWTP panel south side and press the silence push button to silence the Klaxon. Press the reset button on the same panel to reset the alarm.*

The above testing will be conducted on a weekly (one item quarterly) basis to assure the functionality of the alarms. The plant operator will then log the results of these tests on a log sheet as found in Appendix Q

If during testing an alarm fails the test, it will immediately become a Criticality 2 repair. As such, if the repair cannot be made the same day the problem is discovered, it will trigger the enhanced coverage discussed in the next section of this chapter.

SPILL RESPONSE

This section is intended to familiarize the wastewater system management and operating personnel with spill control response measures and reporting.

Plant Operator Response

During periods when the facility is not manned 24 hours/day, 7 days/week, each day, one operator will be designated as the response operator for the hours when the plant is not manned. This operator will receive alarms via telephone and respond to the site.

When the response operator arrives on the site and if there is a spill, the response operator will secure the plant equipment to stop the spill, then inform the Plant Manager who will invoke the plant Emergency Response Plan, Appendix R.

If the site is manned when the spill occurs, the duty operator or anyone who discovers a spill will secure the plant equipment to stop the spill, then inform the Plant Manager who will invoke the plant Emergency Response Plan, Appendix R.

In both cases if the spill has reached any un-contained area, the operator(s) will employ all means necessary to capture, retain and recover any spilled material outside the contained area.

Plant Coverage

Upon discovery of a spill and depending upon the magnitude and nature of the spill, outside contractors from the Emergency Response Plan may be mobilized in to assist in equipment repairs and or spill cleanup.

During the entire period, whether the plant is operational or shut down, the plant will be manned 24 hours/day until ALL of the following conditions are satisfied.

- The spill is completely cleaned up and;
- The investigation into the source of the spill is completed and:
- Any repairs required to mitigate the spill risk are completed and:
- All equipment is restarted and the plant is operating at full flow and load and;
- At least one 24 hour period following the completion of the restart has passed

If the plant is not routinely being manned 24/7 when the spill occurs, the Plant Manager will establish a work schedule and ensure the proper personnel are available to satisfy the conditions outlined above.

Spill Reporting

Based on the permit requirements, the Trust will notify the Administrator within twenty-four (24) hours of any diversion, bypass, spill, upset, overflow or release of treated or untreated discharge other than that which is authorized by the permit. A written report will be submitted to the Administrator within five (5) days of diversion, bypass, spill, overflow, upset or discharge, detailing the entire incident.

A sample report is included in Appendix S. This report includes the following:

- Time and date of discharge;
- Exact location and estimated amount of discharge;
- Flow path and any bodies of water which the discharge reached;
- The specific cause of the discharge; and
- The preventive and/or corrective actions taken

SPILL PREVENTION TRAINING

At a minimum, the operating staff will conduct spill prevention and response training annually. The training, at a minimum, will cover the following;

- This chapter of the O&M manual
- Spill Prevention
- Equipment Inspection
- Spill Response
- GWETS Site Emergency Plan in Appendix R
- Good Housekeeping
- Materials Management Practices for Chemical used onsite
- Annual Site Inspection (see below)

This training will be documented via a sign in sheet and multiple sessions as required will be conducted in order to ensure the entire staff receives this training.

All new employees will receive this training within 30 days of beginning work at the site, and the training will be documented via a sign in sheet to the personnel file.

As part of the annual spill prevention training, the onsite operations staff will conduct an inspection of the GWETS. The GWETS will be inspected for evidence of leakage, evaluate Best Management Practices (BMPs) that have been implemented, and inspect all equipment. The site inspection report must include date of inspection, name of personnel conducting the inspection, observations, assessment of BMP's, corrective actions taken, and a signed certification.

APPENDIX A
GLOSSARY

ABSORPTION

The taking up of one substance into the body of another.

ACID

(1) A substance that tends to lose a proton. (2) A substance that dissolves in water with the formation of hydrogen ions. (3) A substance containing hydrogen which may be replaced by metals to form salts.

ACIDITY

Acidity is a method for expressing the capacity of a solution to donate hydrogen ions and gives an indication of the solutions' corrosiveness. It is caused by weak organic acids such as carbonic and acetic acids or strong mineral acids such as sulfuric and hydrochloric acids. Acidity is expressed in mg/L of $CaCO_3$ that would neutralize an equal amount of standard base.

ACTIVATED SLUDGE

Sludge particles produced in raw or settled wastewater (primary effluent) by the growth of organisms (including zoogleal bacteria) in aeration tanks in the presence of dissolved oxygen. The term "activated" comes from the fact that the particles are teeming with bacteria, fungi, and protozoa. Activated sludge is different from primary sludge in that the sludge particles contain many living organisms which can feed on the incoming wastewater.

ACTIVATED SLUDGE PROCESS

A biological wastewater treatment process which speeds up the decomposition of wastes in the wastewater being treated. Activated sludge is added to wastewater and the mixture (mixed liquor) is aerated and agitated. After some time in the aeration tank, the activated sludge is allowed to settle out by sedimentation and is disposed of (wasted) or reused (returned to the aeration tank) as needed. The remaining wastewater then undergoes more treatment.

ADSORPTION

The adherence of a gas, liquid or dissolved material on to the surface of a solid.

AERATION TANK

The tank where raw or settled wastewater is mixed with return sludge and aerated.

AEROBES

Bacteria that must have molecular (dissolved) oxygen (DO) to survive. Aerobes are aerobic bacteria.

AEROBIC DIGESTION

The breakdown of wastes by microorganisms in the presence of dissolved oxygen.

ALKALINITY

The capacity of a solution to neutralize acids. Total Alkalinity represents the content of carbonate, bicarbonate and hydroxide alkalinity. Sometimes borates, silicates and phosphates are present in sufficient quantities to influence alkalinity values. Alkalinity is expressed in mg/L of $CaCO_3$ that would neutralize an equal amount of a standard acid.

ANAEROBES

Bacteria that do not need molecular (dissolved) oxygen (DO) to survive.

ANION

A negatively charged ion in an electrolyte solution, attracted to the anode under the influence of a difference in electrical potential. Chloride ion (Cl-) is an anion.

ANODE

The positive or electrode of an electrolytic system, such as a battery. The anode attracts negatively charged particles or ions (anions).

AQUEOUS

Something made up of, similar to, or containing water; watery.

BACTERIAL CULTURE

In the case of activated sludge, the bacterial culture refers to the group of bacteria classified as AEROBES, and facultative organisms, which covers a wide range of organisms. Most treatment processes in the United States grow facultative organisms which utilize the carbonaceous (carbon compounds) BOD. Facultative organisms can live when oxygen resources are low. When "nitrification" is required, the nitrifying organisms are OBLIGATE AEROBES (require oxygen) and must have at least 0.5 mg/L of dissolved oxygen throughout the whole system to function properly.

BASE

(1) A substance which takes up or accepts protons. (2) A substance which dissociates (separates) in aqueous solution to yield hydroxyl ions (OH-). (3) A substance containing hydroxyl ions which reacts with an acid to form a salt or which may react with metals to form precipitates.

BATCH PROCESS

A treatment process in which a tank or reactor is filled, the water is treated, and the tank is emptied. The tank may then be filled and the process repeated.

BENCH SCALE ANALYSIS

A method of studying different ways of treating wastewater and solids on a small scale in a laboratory.

BIOMASS

A mass of clump of living organisms feeding of the wastes in wastewater, dead organisms and other debris. This mass may be formed for, or function as, the protection against predators and storage of food supplies.

BULKING

Clouds of billowing sludge that occur throughout secondary clarifiers and sludge thickeners when the sludge becomes too light and will not settle properly. In the activated sludge process, bulking is usually caused by filamentous bacteria or bound water.

CAS NUMBER

The unique identification number assigned by the Chemical Abstracts Service (American Chemical Society) to specific chemical substances. (Definition from California Labor Code, Division 5, Chapter 2.5).

CATION

A positively charged ion in an electrolyte solution, attracted to the cathode under the influent of a difference in electrical potential. Sodium ion (Na^+) is a cation.

CAVITATION

The formation and collapse of a gas pocket or bubble on the blade of an impeller or the gate of a valve. The collapse of this gas pocket or bubble drives water into the impeller or gate with a terrific force that can cause pitting on the impeller or gate surface. Cavitation is accompanied by loud noises that sound like someone is pounding on the impeller or gate with a hammer.

CATHODE

The negative pole or electrode of an electrolytic cell or system. The cathode attracts positively charged particles or ions (cations).

CHROMIUM

A hard, brittle metallic element often used in metal alloys and a corrosion resistant surface coating for metal parts. Chromium is an especially toxic metal, with hexavalent chromium being appreciably more toxic than trivalent chromium. Inadequate or improper handling and disposal of chromium may create serious environmental hazards. Also see HEXAVALENT CHROMIUM and TRIVALENT CHROMIUM.

COMMON METALS

Aluminum, cadmium, chromium, copper, iron, lead, nickel, tin, zinc or any combination of these elements are considered common metals.

COMPLEXED METALS

Metals with a tendency to remain in solution rather than form precipitates and settle out. These metals have reacted with or are tied up with chemical complexing agents such as ammonia or citrates, tartrates, quadrol and EDTA.

COMPOSITE SAMPLES

A composite sample is a collection of individual samples obtained at regular intervals, usually every one or two hours during a 24-hour time span. Each individual sample is combined with the others in proportion to the rate of flow when the sample was collected. The resulting mixture (composite sample) forms a representative sample and is analyzed to determine the average conditions during the sampling period.

CONTINUOUS PROCESS

A treatment process in which water is treated continuously in a tank or reactor. The water being treated continuously flows into the tank at one end, is treated as it flows through the tank, and flows out the opposite end as treated water.

CYANIDE

The cyanide ion (CN-) consists of carbon (C) and nitrogen (N). Cyanide is commonly found in metal plating wastewaters because most metal cyanides are soluble and plating occurs readily from cyanide solutions. The cyanide ion is extremely toxic and must be removed from metal wastes before discharge to the environment. Treatment of wastes containing cyanide under acidic conditions may produce extremely toxic gases which must never come in contact with people or animals.

DIFFUSER

A device (porous plate, tube, or bag) used to break the air stream from the blower system into fine bubbles in an aeration tank or reactor.

DISSOLVED OXYGEN

Molecular (atmospheric) oxygen dissolved in water or wastewater, usually abbreviated DO.

ELECTROLYTE

A substance which dissociates (separates) into two or more ions when it is dissolved in water.

ELEMENT

A substance which cannot be separated into its constituent parts and still retain its chemical identity. For example, sodium (Na) is an element.

FACULTATIVE

Facultative bacteria can use either molecular (dissolved) oxygen or oxygen obtained from food materials such as sulfate or nitrate ions. In other words, facultative bacteria can live under aerobic or anaerobic conditions.

FILAMENTOUS BACTERIA

Organisms that grow in a thread or filamentous form. Common types are thiothrix and actinomycetes. A common cause of sludge bulking in the activated sludge process.

FLOC

Groups or clumps of bacteria and particles or coagulants and impurities that have come together and formed a cluster. Found in aerations tanks, secondary clarifiers, and chemical precipitation processes.

FLOCCULATION

The gathering together of fine particles after coagulation to form larger particles by a process of gentle mixing.

GRAB SAMPLE

A single sample collected at a particular time and place which represents the composition of the waste stream only at that time and place.

HAZARDOUS WASTE (Abbreviated EPA definition)

A waste that possesses any one of the following four characteristics:

1. Ignitability, which identifies wastes that pose a fire hazard during routine management. Fires not only present immediate dangers of heat and smoke,

but also can spread harmful particles over wide areas. A liquid that has a flash point of less than 140°F (60°C).

2. Corrosivity, which identifies wastes requiring special containers because of their ability to corrode standard materials, or requiring segregation from other wastes because of their ability to dissolve toxic contaminants. An aqueous solution with a pH less than or equal to 2 or a pH greater than or equal to 12.5.

3. Reactivity (or explosiveness), which identifies wastes that, during routine management, tend to react spontaneously, to react vigorously with air or water, to be unstable to shock or heat, to sulfide bearing waste which, when exposed to a pH of between 2 and 12.5, can generate toxic gases, vapors or fumes in a quantity sufficient to present a danger to public health, safety, or welfare, or to the environment.

4. Toxicity, which identifies wastes that, when improperly managed, may release toxicants in sufficient quantities to pose a substantial present or potential hazard to human health or the environment.

HAZARDOUS WASTE (RCRA Definition)

A waste, or combination of wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may:

1. Cause, or significantly contribute to, an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or

2. Pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of or otherwise managed.

HEXAVALENT CHROMIUM

Hexavalent chromium (CR6+) bearing wastewaters are produced in chromium electroplating, chromium conversion coatings, etching with chromic acid, and in metal finishing operations carried out on chromium as a basis metal. Hexavalent chromium must be reduced to trivalent chromium (Cr3+) before chromium can be removed from metal waste streams by hydroxide precipitation. Hexavalent chromium is highly toxic in comparison with trivalent chromium. Also see CHROMIUM and TRIVALENT CHROMIUM.

HYDROXIDE PRECIPITATION

A method of removing common metals from waste streams by the precipitation process. The pH of the metal waste is increased to an optimum level for hydroxide metal precipitates to form for the wastes being treated. The metal precipitates are settled out of the waste stream in clarifiers and are removed from the bottom of the clarifiers as metal sludges.

HYGROSCOPIC

Absorbing or attracting moisture from the air.

IMPURITY

A hazardous substance which is unintentionally present with another substance or mixture.

INHIBITION

The introduction of pollutants into publicly owned treatment works (POTW) which could INTERFERE with the operation of the wastewater treatment processes. Also see INTERFERENCE.

INTERFERENCE

The introduction of pollutants into publicly owned treatment works (POTW) which could INTERFERE with the operation of the wastewater treatment processes. Also see INHIBITION.

MATERIAL SAFETY DATA SHEET (MSDS)

A document which provides pertinent information and a profile of a particular hazardous substance or mixture. An MSDS is normally developed by the manufacturer or formulator of the hazardous substance or mixture. The MSDS is required to be made available to employers and operators whenever there is the likelihood of the hazardous substance or mixture being introduced into a workplace.

MCRT (Mean Cell Residence Time)

Mean Cell Residence Time, days. An expression of the average time that a microorganism will spend in the activated sludge process

MCRT, days = $\frac{\text{Solids in Activated Sludge Process, lbs}}{\text{Solids Removed from Process, lbs/day}}$

METAL

An element yielding positively charged ions in aqueous solutions of its salts.

MICROORGANISMS

Very small organisms that can be seen only through a microscope. Some microorganisms use the wastes in wastewater for food and thus remove or alter much of the undesirable matter.

MIXED LIQUOR

When the activated sludge in an aeration tank is mixed with primary effluent or the raw wastewater and return sludge, this mixture is then referred to as mixed liquor as long as it is in the aeration tank. Mixed liquor also may refer to the contents of mixed aerobic or anaerobic digester.

MIXED LIQUOR SUSPENDED SOLIDS (MLSS)

Suspended solids in the mixed liquor of an aeration tank.

MIXTURE

Any solution or intimate admixture of two or more substances, at least one of which is present as a hazardous substance, which do not react chemically with each other.

MSDS

A document which supplies information about a particular hazardous substance or mixture. See MATERIAL SAFETY DATA SHEET.

NITRIFICATION

An aerobic process in which bacteria change the ammonia and organic nitrogen in wastewater into oxidized nitrogen (usually nitrate). The second-stage BOD is sometimes referred to as the "nitrification stage" (first-stage BOD is called the "carbonaceous stage").

OXIDATION

Oxidation is the addition of oxygen, removal of hydrogen, or the removal of electrons from an element or compound. In the environment, organic matter is oxidized to more stable substances. The opposite of REDUCTION.

OXIDATION-REDUCTION POTENTIAL (ORP)

The electrical potential required to transfer electrons from one compound or element (the oxidant) to another compound or element (the reductant); used as a qualitative measure of the state of oxidation in wastewater treatment systems.

OXIDIZING AGENT

Any substance, such as oxygen (O2) or chlorine (Cl2) that will readily add (take on) electrons. The opposite is a REDUCING AGENT.

pH (Pronounced as separate letters)

pH is an expression of the intensity of the basic or acid condition of a liquid. Mathematically, pH is the logarithm (base 10) of the reciprocal of the hydrogen ion activity.

$$pH = \frac{\text{Log } 1}{(H+)}$$

The pH may range from 0 to 14 where 0 is most acid, 14 most basic, and 7 neutral.

PILOT SCALE STUDY

A method of studying different ways of treating wastewater and solids or to obtain design criteria on a small scale in the field.

POLYELECTROLYTE

A high molecular weight polymer substance having points of positive or negative electrical charges formed by either natural or man-made processes. Natural polyelectrolytes may be of biological origin or derived from starch products and cellulose derivatives. Man-made polyelectrolytes consist of simple substances that have been made into complex, high molecular weight polymer. Used with other chemical coagulants to aid in binding small suspended particles to larger chemical flocs for their removal from water. Often called a POLYMER.

POLYMER

A chemical formed by the union of many monomers (a molecule of low molecular weight). Polymers are used with other chemical coagulants to aid in binding small suspended particles to larger chemical flocs for their removal from water. All polyelectrolytes are polymers, but not all polymers are polyelectrolytes.

POTTING COMPOUNDS

Sealing and holding compounds used in electrode probes.

PRECIOUS METALS

Metals that are very valuable, such as gold or silver.

PRECIPITATE

(1) An insoluble, finely divided substance which is a product of a chemical reaction within a liquid. (2) The separation from solution of an insoluble substance.

RAS (Return Activated Sludge)

Return Activated Sludge, mg/L. Settled activated sludge that is collected in the secondary clarifier and returned to the aeration basin to mix with incoming raw or primary settled wastewater.

RCRA

Public Law (PL) 94-580. The Resource Conservation and Recovery Act (10/21/78).

REDUCING AGENT

Any substance, such as base metal (iron) or the sulfide ion (S^{2-}) that will readily donate (give up) electrons. The opposite is an OXIDIZING AGENT.

REDUCTION

Reduction is the addition of hydrogen, removal of oxygen, or the addition of electrons to an element or compound. Under anaerobic conditions (no dissolved oxygen present), sulfur compounds are reduced to odor-producing hydrogen sulfide (H_2S) and other compounds. In the treatment of metal finishing wastewaters, hexavalent chromium (Cr^{6+}) is reduced to the trivalent form (Cr^{3+}). The opposite of OXIDATION.

REPRESENTATIVE SAMPLE

A portion of material or waste stream that is as nearly identical in content and consistency as possible to that in the larger body of material or waste stream being sampled.

RISING SLUDGE

Rising sludge occurs in the secondary clarifiers or activated systems when the sludge settles to the bottom of the clarifier, is compacted, and then starts to rise to the surface, usually as a result of denitrification.

SALT

A compound which upon dissociation yields cations (positively-charged) of a metal, and anions (negatively charged) of an acid radical.

SEGREGATE

To keep separate or prevent mixing (of two or more waste streams.) Wastes from various in-system sources are easier to treat before they become mixed together.

SEPTIC

A condition produced by anaerobic bacteria. If severe, the wastewater produces hydrogen sulfide, turns black, gives off foul odors, contains little or no dissolved oxygen and creates a high oxygen demand.

SLUDGE AGE

A measure of the length of time a particle of suspended solids has been retained in the activated sludge process

.

$$\text{Sludge Age, days} = \frac{\text{Suspended Solids Under Aeration, lbs or kg}}{\text{Suspended Solids Added, lbs/day or kg/day}}$$

SLUDGE DENSITY INDEX (SDI)

This calculation is used in a way similar to the Sludge Volume Index (SVI) to indicate the settle ability of a sludge in a secondary clarifier or effluent. The weight in grams of one milliliter of sludge after settling for 30 minutes. SDI = 100/SVI. Also see SLUDGE VOLUME INDEX.

SLUDGE VOLUME INDEX (SVI)

This is a calculation used to indicate the settling ability of activated sludge (aerated solids) in the secondary clarifier. The calculation is a measure of the volume of sludge compared with its weight. Allow the sludge sample from the aeration tank to settle for 30 minutes. Then calculate SVI by dividing the volume (mL) of wet settled sludge by the weight (mg) of that sludge after it has been dried. Sludge with an SVI of hundred or greater will not settle as readily as desirable because it is as light or lighter than water.

$$SVI = \frac{\text{Wet Settled Sludge, mL x 1,000}}{\text{Dried Sludge Solids, mg}}$$

SPECIFIC GRAVITY

Weight of a particle, substance or chemical solution in relation to the weight of water. Water has a specific gravity of 1.000 at 40°C (39°F).

TOXIC

A substance which is poisonous to an organism. Toxic substances may be classified in terms of their physiological action, such as irritants, asphyxiants, systemic poisons, and anesthetics and narcotics. Irritants are corrosive substances which attack the mucous membrane surfaces of the body. Asphyxiants interfere with the oxidation processes in the body. Systemic poisons are hazardous substances which injure or destroy internal organs of the body. The anesthetics and narcotics are hazardous substances which depress the central nervous system and lead to unconsciousness.

TOXIC ORGANICS

Organic compounds which can be classified according to the following categories:

CATEGORY	EXAMPLES
1. Base/Neutral Extractables	Benzilene, Hexachlorethane, Napthalene, Fluorine, Pyrene
2. Acid Extractable	P-Chloro-M-Cresol, 2-Chlorophenol, 4-Nitrophenol, Pentachlorophenol

3. Volatile Organics	Benzene, Carbon Tetrachloride, Chloroform, Toluene, Vinyl Chloride
4. Pesticides	Aldrin, Chlordane, Dieldrin,

TOXIC SUBSTANCES

Any chemical substance, biological agent (bacteria, virus or fungus), or physical stress (noise, heat, cold, vibration, repetitive motion, ionizing and non-ionizing radiation, hypo- or hyperbaric pressure) which:

(A) Is regulated by any state or Federal law or rule due to a hazard to health;

(B) Is listed in the latest printed edition of the National Institute for Occupation Safety and Health (NIOSH) Registry of Toxic Effects of Chemical Substances (RTECS);

(C) Has yielded positive evidence of an acute or chronic health hazard in human, animal, or other biological testing conducted by, or known to, the employer; or

(D) Is described by a material safety data sheet available to the employer which indicates that the material may pose a hazard to human health.

TOXICITY

The relative degree of being poisonous or toxic. A condition which may exist in wastes and will inhibit or destroy the growth or function of certain organisms.

TRIVALENT CHROMIUM

Trivalent chromium (Cr^{3+}) is the reduced state of hexavalent chromium (Cr^{6+}). Trivalent chromium is significantly less toxic than hexavalent chromium and can be removed from metal waste streams by hydroxide precipitation.

WATER HAMMER

The sound like someone hammering on a pipe that occurs when a valve is opened or closed very rapidly. When a valve position is changed quickly, the water pressure in a pipe will increase and decrease back and forth very quickly. This rise and fall in pressures can do serious damage to the system.

OXIDATION-REDUCTION POTENTIAL (ORP)

DEFINITION: The electrical potential required to transfer electrons from one compound or element (the oxidant) to another compound or element (the reductant). ORP is used as a qualitative measure of the state of oxidation in metal waste treatment systems. Important examples include the oxidation of cyanide and the reduction of hexavalent chromium to the trivalent state.

ORP is measured by electrodes in a manner similar to the measurement of pH. The reference electrodes can be identical, but a noble-metal (gold or platinum) electrode replaces the glass pH electrode. ORP readings usually are not adjusted for temperature. The signal from the ORP electrodes is fed into an amplifier for readout on an ORP meter.

The inert metal electrode (usually gold or platinum) in a well-mixed oxidation reduction system serves mainly to acquire the electromechanical potential of electrons, depending on the prevailing REDOX (reduction-oxidation potential) equilibrium in the solution. The actual ORP measured is the difference between that of the noble-metal electrode and the reference electrode. The reference electrode is usually a silver-silver chloride or calomel electrode.

In most metal waste treatment reactions, the oxidation-reduction potential is controlled at a point or ORP millivolt reading level that insures excess of one reactant. The operator or the automatic controls adjust the chemical feed to be sure the ORP reading indicates an excess. This excess provides sufficient chemical to make the chemical reaction go to completion.

pH is an important measurement in treatment processes being controlled by ORP levels, especially if the hydrogen ion is involved in the reactions. ORP levels are influenced considerably by pH values, so pH is often regulated or controlled as well as the chemical dosage which is adjusted on the basis of ORP readings.

When treating metal waste streams the target or desired ORP level often must be determined experimentally (rather than theoretically) due to the "mix" of wastes that the treatment chemical (sulfur dioxide, for example) oxidizes and reduces simultaneously. ORP responds to the concentrations and activities of all chemical reactions occurring in the metal waste stream being treated.

The noble-metal ORP electrode in a waste stream being chemically treated will rapidly acquire the electromechanical potential determined by the redox equilibrium. The rate of electron transfer across the metal's surface, however, depends on the condition of the surface. Electrode poisoning can cause a significant reduction in the exchange of current. Platinum electrodes can be poisoned by cyanide and sulfide ions. Poisoned electrodes can be restored by following proper cleaning procedures. To determine if an electrode is operating properly and has not been poisoned, solutions of known ORP can be developed by saturating buffer solutions with quihydrone. If poisoned platinum electrodes are a problem, gold electrodes can be used.

ORP is an important control guideline which must be understood by operators treating metal waste streams.

WAS (Waste Activated Sludge)

Waste Activated Sludge, mg/L. The excess growth of microorganisms which must be removed from the process to keep the biological system in balance.

APPENDIX B
ARITHMETIC OF WASTE TREATMENT

The English system of measurements is normally used for computations at waste treatment systems, except in the case of a few determinations. The metric system will be mentioned where the metric units are the conventional units of expression.

Basic Units

Linear

1 inch (in.)	= 2.540 centimeters (cm)
1 foot (ft)	= 12 inches (in.)
1 yard (yd)	= 3 feet (ft)
1 meter	= 39.37 in. = 3.281 ft = 1.094 yd = 100 centimeters 1 mile = 5,280 ft

Area

1 square foot (sq ft)	= 144 square inches (sq in)
1 square yd (sq yd)	= 9 sq ft
1 acre	= 43,560 sq ft
1 square mile	= 640 acres

Volume

1 cubic foot	= 1728 cubic inches (cu in)
1 cubic yard	= 27 cu ft
1 cubic foot	= 7.48 gallons
1 gallon (gal)	= 231 cubic inches (cu in)
1 gallon	= 4 quarts (qt)
1 gallon	= 3.785 liters (L) 1 liter = 1000 milliliters (mL)

Weight

1 pound (lb)	= 16 ounces = 7000 grains = 453.6 grams 1 ounce = 28.35 grams (g)
1 kilogram	= 1000 grams = 2.2 lbs. 1 gram = 1000 milligrams (mg)
1 cu ft water	= 62.4 pounds
1 gallon water	= 8.33 pounds
1 liter water	= 1 kilogram
1 milliliter water	= 1 gram

Density

1 gallon	= 8.34 pounds
1 cubic foot	= 62.4 pounds

Pressure

1 PSI	= 2.31 feet water
1 foot water	= 0.433 PSI
1 inch mercury	= 1.133 feet water

Dosage

1 PPM	= 1 mg/L
1 PPM	= 8.33 lbs./million gallons
1 grain/gallon	= 17.1 mg/L
1 mg	= 64.7 grains

Flow rate

1 MGD	= 694 gal/min = 1.55 cfs
1 cfs	= 447.7 gal/min

Power

1 Horsepower (hp)	= 0.746 kilowatt (kW)
1 Btu/sec	= 1.0551 kilowatt

Temperature

°F	= 9/5°C + 32
°C	= 5/9 (°F - 32)

Basic Formula

(1) Circumference of a circle = $3.14 * \mathrm{D} = 3.14\,(2 * \mathrm{R})$

(2) Area of a circle = $3.14 * \mathrm{R}^2 = 3.14 * \frac{\mathrm{D}^2}{4}$

(3) Area of triangle = 1/2 base x altitude

(4) Area of rectangle = base x altitude

(5) Cylindrical area = circumference of base x length

(6) Volume of cylinder = area of base x length

(7) Volume of cone = 1/3 x area of base x height

(8) Velocity = distance divided by time. Inches, feet, or miles divided by hours, minutes, or seconds.

(9) Discharge rate = volume of flow divided by time (Gallons or cubic feet divided by days, hours, minutes, or seconds).

Frequently Used Process Formula

Polymer Preparation:

(1) Polymer Req'd, lbs = (Vol.gal)(8.34 lbs/gal)(Polymer, %) / 100%

(2) Dose, mg/min = (Flow,gal/min)(Dose,mg/L)(3.785 L/gal)

(3) Polymer Solution = (Polymer,%)(10,000 mg/L/%) / 1000 mL/L
mg/mL

(4) Polymer Feed = Dose, mg/min / Polymer Solution, mg/mL
Rate, mL/min

(5) Chemical Feeder Setting, mL/min

$$= \frac{(\text{Flow,MGD})(\text{Polymer Dose mg/L})(3.785\ \text{L/gal})\ (1{,}000{,}000/\text{M})}{(\text{Polymer, mg/mL})(24\ \text{hr/day})(60\ \text{min/hr})}$$

(6) Chemical Feeder Setting, GPD

$$= \frac{(\text{Flow,MGD})(\text{Polymer Dose, mg/L})(8.34\ \text{lbs/gal})}{\text{Polymer Con, lbs/gal}}$$

(7) Polymer Feed, lbs/day

$$= \frac{(\text{Poly Conc,mg/L})(\text{Vol Pumped,mL})(60\ \text{min/hr})(24\ \text{hr/day})}{(\text{Time Pumped, min})(1000\ \text{mL/L})(1000\ \text{mg/gm})(454\ \text{gm/lb})}$$

Chemical Feed Pumps:

(8) Pump Feed, mL/min $= \frac{(\text{Pump Feed,gal/day})(3.785\ \text{L/gal})(1000\ \text{mL/L})}{(24\ \text{hr/day})(60\ \text{min/hr})}$

(9) Pump Feed, GPM $= \frac{(\text{Volume, mL})(24\ \text{hr/day})(50\ \text{min/hr})}{(\text{Time, min})(3.785\ \text{L/gal})(1000\ \text{mL/L})}$

Hexavalent Chromium Reduction with Ferrous Sulfate:

(10) Cr6+ Treated, lbs = (Waste,MG)(Cr^{6+}, mg/L)(8.34 lbs/gal)

(11) Dosage, lbs $FeSO_4$ = (Cr^{6+} Treated, lbs)(Treatment,9.0lbs $FeSO_4$/lbCr^{6+})

(12) FeSO4 Feed, lbs/min $= \frac{(\text{Flow,GPM})(\text{Waste,mg/L})(8.34\ \text{lbs/gal})(\text{Treat, 9.0lb/lb})}{(1{,}000{,}000)}$

(13) FeSO4 = (Flow,GPM)(Waste,mg/L)(8.34 lbs/gal)(Treat, 9.0lb/lb)

Feed, gal/min (1,000,000) (%$FeSO_4$) (spgr)x 8.34

Sludge Treatment:

(14) Polymer Dosage lb/ton

$$\text{Polymer Dosage, lb/ton} = \frac{(\text{Poly Sol. \%})(\text{Poly Added, mL})(2)}{(\text{Sludge Vol, L})(\text{Sludge Solids, \%})}$$

Example Problems

(Adapted from: Operations of Wastewater Treatment Plant, Vol. IV, California State Univ., Sacramento)

Example 1:

A flow recorder indicates that the average inflow to an industrial wastewater treatment system was 1.6 MGD during a certain time period. How many million gallons of wastewater entered the system during ten hours of this period?

Average Flow, MGD = 1.6 MGD
Time, hr = 10 hr
Volume, MG = ?

Calculate the volume of flow in million gallons during the eight hours.

$$\text{Volume, MG} = \frac{(\text{Flow, MGD})(\text{Time, hr})}{24 \text{ hrs/day}}$$

$$= \frac{(1.6 \text{ MGD})(10 \text{ hr})}{24 \text{ hrs/day}}$$

$$= 0.667 \text{ MG}$$

Example 2:

A flow equalization tank contains 25,000 gallons of wastewater to be treated. If the wastewater is to be released at a constant flow rate during an eight-hour period, what should be the discharge rate in gallons per minute?

Volume, gal = 25,000 gal
Time, hr = 8 hr
Discharge, GPM = ?

Calculate the discharge flow rate in gallons per minute.

$$\text{Discharge, GPM} = \frac{\text{Volume, gal}}{(\text{Time, hr})(60 \text{ min/hr})}$$

$$= \frac{25{,}000 \text{ gal}}{(8 \text{ hr})(60 \text{ min/hr})}$$

$$= 52.1 \text{ GPM}$$

Example 3:

Estimate the flow capacity of a wastewater pump in GPM if the pump lowers the wastewater in a 10 foot by 8 foot rectangular sump 40 inches in 15 minutes.

Length, ft	= 10 ft
Width, ft	= 8 ft
Depth, in.	= 40 in.
Time, min	= 15 min.
Capacity, GPM	= ?

Estimate the flow capacity of the pump in GPM.

$$\text{Capacity, GPM} = \frac{(\text{Length,ft})(\text{Width,ft})(\text{Depth,ft})(7.48\text{ gal/cu ft})}{\text{Time, min}}$$

$$= \frac{(10\text{ ft})(8\text{ ft})(40\text{ in.})(7.48\text{ gal/cu ft})}{(15\text{ min})(12\text{ in./ft})}$$

$$= 133\text{ GPM}$$

Example 4:

A chemical feed pump delivers 360 mL in five minutes. What is the feed rate in gallons per day?

Volume, mL	= 360 mL
Time, min	= 5 min
Pump Feed, GPD	= ?

Calculate the pump feed rate in gallons per day.

$$\text{Pump Feed, GPD} = \frac{(\text{Volume, mL})(24\text{ hr/day})(60\text{ min/hr})}{(\text{Time, min})(3.785\text{ L/gal})(1000\text{ mL/L})}$$

$$= \frac{(360\text{ mL})(24\text{ hr/day})(60\text{ min/hr})}{(5\text{ min})(3.785\text{ L/gal})(1000\text{ mL/L})}$$

$$= 27.4\text{ GPD}$$

Example 5:

Estimate the chemical feed rate in GPD when a chemical feed pump lowers a chemical solution 52 inches in a 36-inch diameter chemical container in 6 hours and 30 minutes.

Diameter, in. = 36 in.
Drop, in. = 52 in.
Time, hr = 6 hr + 30 min/60 min/hr
= 6.5 hr

Feed Rate, GPD = ?

Calculate the chemical feed rate in gallons per day.

$$\text{Feed Rate, GPD} = \frac{(0.785)(\text{Dia. in.})2(\text{Drop,in.})(24\ \text{hr/day})}{(231\ \text{cu in./gal})(\text{Time, hr})}$$

$$= \frac{(0.785)(36\ \text{in.})2(52\ \text{in.})(24\ \text{hr/day})}{(231\ \text{cu in./gal})(6.5\ \text{hr})}$$

= 845.6 GPD

Example 6:

How many pounds of polymer are required to make up 750 gallons of 0.25 percent polymer solution?

Volume, gal = 750 gallons
Polymer Sol, % = 0.25%
Polymer, lbs = ?

Calculate the pounds of polymer required.

$$\text{Polymer Req'd, lbs} = \frac{(\text{Vol. gal})(8.34\text{lbs/gal})(\text{Polymer,\%})}{100\%}$$

$$= \frac{(750\ \text{gal})(8.34\ \text{lbs/gal})(0.25\%)}{100\%}$$

= 15.6 lbs

Example 7:

A liquid polymer feeder is treating a wastewater flow of 300 GPM. The specific gravity of the 0.25 percent liquid polymer solution is 1.0. What should be the polymer feed rate in milliliters per minute when the polymer dose is 0.45 mg/L?

Flow, GPM	= 300 GPM
Dose, mg/L	= .45 mg/L
Polymer, %	= 0.25%
Polymer Feed, mL/min	= ?

(1) Determine the polymer dose required in milligrams of polymer per minute.

Dose, mg/min = (Flow, gal/min)(Dose, mg/L)(3.785 L/gal)

= (300 gal/min)(0.45 mg/L)(3.785 L/gal)

= 511 mg polymer/min

(2) Convert the polymer solution from percent to milligrams per milliliter. 1% - 10,000 mg/L

Polymer Solution mg/mL $= \frac{(\text{Polymer, \%})(10{,}000\ \text{mg/L/\%})}{1000\ \text{mL/L}}$

$= \frac{(0.25\%)(10{,}000\ \text{mg/L/\%})}{1000\ \text{mL/L}}$

= 2.5 mg/mL

(3) Calculate the polymer feed rate in milliliters per minute.

Polymer Feed Rate, mL/min $= \frac{\text{Dose, mg/min}}{\text{Polymer Solution, mg/mL}}$

$= \frac{511\ \text{mg polymer/min}}{2.5\ \text{mg polymer/mL}}$

= 204.4 mL/min

Example 8:

How much sodium bisulfite is required to treat 1300 gallons of chromic acid containing 400 mg/L of hexavalent chromium? Assume that one pound of hexavalent chromium is reduced to the trivalent state by the addition of 1.56 pounds of sodium bisulfite.

Waste, gal	= 1300 gal
Conc, mg/L	= 400 mg Cr6+/L
Treat, lbs/lb	= 1.56 lbs NaHSO3/lb Cr6+
Dosage, lbs NaHSO3	= ?

(1) Calculate the pounds of Cr6+ to be treated.

Cr^{6+} Treated, lbs = (Waste, MG)(Cr6+, mg/L)(8.34 lbs/gal)

= (0.0013 MG)(400 mg/L)(8.34 lbs/gal)

= (4.34 lbs Cr^{6+})

(2) Calculate the dosage of sodium bisulfite.

Dosage, lbs $NaHSO_3$ = (Cr^{6+} Treated, lbs)(Treatment, 1.56 lbs $NaHSO_3$/lb Cr^{6+})

= (4.34 lbs Cr^{6+})(1.56 lbs $NaHSO_3$/lb Cr^{6+})

= (6.77 lbs $NaHSO_3$)

Example 9:

A chrome waste flowing at a rate of 125 GPM from a manufacturing process contains 140 mg/L of hexavalent chromium. Determine the sodium bisulfite feed rate in pounds of sodium bisulfite per minute if one pound of hexavalent chromium is reduced to the trivalent state by the addition of 1.56 pounds of sodium bisulfite.

Flow, GPM	= 125 GPM
Waste, mg/L	= 140 mg Cr6+/L
Treat, lb/lb	= 1.56 lbs NaHSO3/lb Cr6+
Bisulfite Feed, lbs/min	= ?

Calculate the sulfonator feed rate in pounds of sodium bisulfite per minute.

$$\text{Bisulfite Feed, lbs/min} = \frac{\text{(Flow, GPM)(Waste, mg/L)(8.34 lbs/gal)(Treat,1.56 lb/lb)}}{\text{1,000,000/M}}$$

$$= \frac{(125\text{ GPM})(140\text{ mg }Cr^{6+}/L)(8.34\text{ lbs/gal})(1.56\text{ lbs }NaHSO_3)}{(1{,}000{,}000/M)\ (1\text{ lb }Cr^{6+})}$$

= 0.23 lbs $NaHSO_3$/min

Example 10:

Calculate the polymer dosage in pounds of polymer per ton of sludge if the optimum polymer dosage in a Buchner funnel test is 3.5 milliliters of a 1.5% polymer solution. The sludge sample tested was a 100 milliliter sample with a 3.2% solids content

Poly Added, mL = 3.5 mL
Poly Sol, % = 1.5%
Sludge Vol, L = 0.1 L = 100 mL
Sl Solids % = 3.2%
Polymer Dosage, lbs/ton = ?

Calculate the dosage in pounds of polymer per ton of sludge.

$$\text{Dosage, lbs/ton} = \frac{(\text{Poly Sol. \%})(\text{Poly Added, mL})(2)}{(\text{Sl Vol, L})(\text{Sl Solids, \%})}$$

$$= \frac{(1.5\%)(3.5\ \text{mL})(2)}{(0.1\ \text{L})(3.2\%)}$$

= 32.8 lbs polymer/ton sludge

Example 11:

Calculate the lime slurry feed rate (GPM) to the Reaction Tank based on the following parameters
.
Fluoride Conc. = 265 mg/L
Carbonate Conc. = 2000 mg/L
Treatment System Flow = 6 GPM
Lime Slurry = 2.5% by weight
1 lb Fluoride Requires 3.9 lbs $Ca(OH)_2$
1 lb Carbonate Requires 1.35 lbs $Ca(OH)_2$
Lime is 94% $Ca(OH)_2$

LBS F-/day = 0.00864 mgd x 8.34 lbs/gal x 265 mg/L

= 19.095 lbs F-/Day

LBS CO_3^{-2}/day = 0.00864 mgd x 8.34 lbs/gal x 2000 mg/L

= 144.1152 lbs CO_3^{-2}/Day

Example 11 (Cont.):

LBS Ca(OH)2 required for fluoride removal per day.

$$= \frac{(19.095 \text{ lbs } F^-)}{(\text{Day})} \; \frac{(3.9 \text{ lbs } Ca(OH)_2)}{(\text{LB F-})}$$

= 74.47 lbs Ca(OH)2/day

LBS $Ca(OH)_2$ required for carbonate removal per day

$$= \frac{(144.1152 \text{ lbs } CO_3^{-2})}{(\text{Day})} \; \frac{(1.35 \text{ lbs } Ca(OH)_2)}{(\text{LB F-})}$$

= 194.55 lbs Ca(OH)2/day

$$\frac{\text{Total lbs } Ca(OH)_2}{\text{Day}} = \frac{74.47 \text{ lbs Ca(OH)2}}{(\text{Day})} + \frac{194.55 \text{ lbs Ca(OH)2}}{(\text{Day})}$$

= 269.03 lbs $Ca(OH)_2$/Day

$$\frac{\text{Total lbs lime}}{\text{Day}} = \frac{(269.03 \text{ lbs } Ca(OH)_2)}{(\text{Day})} \; \frac{(100\% \text{ Lime})}{(94\% \; Ca(OH)_2)}$$

= 286.2 lbs lime/Day

$$\text{Feed Rate (GPM)} = \frac{(286.2 \text{ lbs lime})}{(\text{Day})} \; \frac{(\text{gal slurry})}{(8.34\text{lbs} \times 0.025)} \; \frac{(\text{day})}{(1440 \text{ min})}$$

= 0.95 GPM

Example 12:

Determine lime valve opening percentage based on the following parameters.

Fluoride/Carbonate Treatment requires 0.95 GPM of lime.
Maximum feed rate through lime control valve is 7.7 GPM

$$\text{Valve Open \%} = \frac{0.95 \text{ GPM required}}{7.7 \text{ GPM Max. Feed rate}}$$

= 12.3%

Example 13:

Determine the sludge age for an activated sludge system with an influent flow of 7.5 MGD (28,390 cu m/day). The primary effluent suspended solids concentration is 100 mg/L . Two aeration tanks have a volume of 0.6 MG (2,270 cu m) each and a mixed liquor suspended solids (MLSS) concentration of 2.200 mg/L.

Known		Unknown
Inf. Flow, MGD	= 7.5 MGD	Sludge Age, days
Prim. Eff. SS, mg/L	= 100 mg/L	
Tank Vol. MG	= 0.6 MG/tank	
MLVSS, mg/L	= 2,200 mg/L	
No. of tanks	= 2 tanks	

Sludge age, days = Solids Under Aeration, lbs / Solids Added, lbs /day

1. Calculate the solids under aeration, lbs.

   Solids under aeration, lbs = No. of tanks X Tank Vol. MG/tank X MLVSS, mg/L X 8.34 lbs. /gal.
   = 2 tanks x 0.3 MG/tank x 2,200 mg/L x 8.34 lbs/gal
   = 22,000 lbs.

2. Calculate the solids added, lbs/day

Solids added, lbs day = Inf. Flow, MGD X Prim Eff. SS, mg/L X 8.34 lbs/gal
= 7.5 MGD X 100 mg/L X 8.34 lbs/gal
= 6,255 lbs/day

3. Determine sludge age, days.

   Sludge Age, days = Solids Under Aeration, lbs / Solids Added, lbs/day

   = 22,000 lbs / 6,255 lbs/day

   = 3.5 days

Example 14:

Determine the waste activated sludge (WAS) flow rate in MGD and GPM for an activated sludge system that adds 6,255 lbs of solids per day. The solids under aeration are 33,075 pounds, the return activated sludge (RAS) suspended solids concentration is 6,300 mg/L and the desired sludge age is 5 days. Current sludge waste rate is 4,455 lbs per day.

Known		**Unknown**
Solids Added, lbs/day	= 6,255 lbs/day	WAS Flow, MGD and GPM
Solids Under Aeration	= 33,075 lbs	
RAS Susp. Sol, mg/L	= 6,300 mg/L	
Desired Sludge Age, days	= 5 days	
Current WAS Rate	=4,455 lbs/day	

1. Calculate the desired pounds of solids under aeration (MLVSS) for the desired sludge age of 5 days.

Desired Solids Under Aeration, lbs = Solids Added, lbs/day X Sludge Age, days

= 6,255 lbs/day X 5 days

= 31,275 lbs

2. Calculate the additional WAS flow, MGD and GPM, to maintain the desired sludge age.

$$\text{Additional WAS Flow, MGD and GPM} = \frac{\text{Solids Aerated, lbs} - \text{Desired Solids, lbs}}{\text{RAS Susp. Sol., mg/L X 8.34 lbs/gal}}$$

$$= \frac{\text{33,075 lbs} - \text{31,275 lbs}}{\text{6,300 mg/L X 8.34 lbs/gal}}$$

= 0.034 MGD X 694 GPM/MGD

= 24 GPM

3. Add the current WAS flow to the additional WAS flow, MGD.

Total WAS Flow MGD and GPM = Current, WAS Flow, MGD + Additional WAS Flow, MGD

$$= \frac{\text{Solids Wasted, lbs/day}}{\text{RAS Susp. Sol, mg/L X 8.34 lbs/gal}} + \text{Flow, MGD}$$

$$= \frac{\text{4,455 lbs/day}}{\text{6.300 mg/L X 8.34 lbs/gal}} + \text{0.034 MGD}$$

= 0.085 MGD + 0.034 MGD

= 0.119 MGD X 694 GPM/MGD

= 83 GPM

Example 15:

How many gallons per minute of water is required to makedown a 2.5% lime slurry if the hydrated lime feeder has a maximum feed rate of 700 lbs/hour. Speed setting of the lime feeder is 40 %.

Hydrate lime feed (lbs/min) $= \frac{\text{(700 lbs) (40\%) (hr)}}{\text{(hr) (100\%) (60 min)}}$

= 4.67 lbs/min

Water flow (GPM) $= \frac{\text{(4.67 lbs) (gal)}}{\text{(min) (8.34lbs x 0.025)}}$

= 22.1 GPM

Example 16:

Determine the polymer pump speed in strokes per minute based on the following parameters.

Treatment system flow	= 150 GPM
Polymer dosage	= 8 mg/L
Stroke length	= 20%
Max. poly. feed rate at 100% stroke and speed	= 2.0 GPH
Max. speed of polymer feed pump	= 100 strokes/min
Polymer conc.	= 0.5%
Polymer weight	= 9.5 lbs/gal

Max. poly. feed at 20% stroke (ml/stroke)

$$= \frac{\text{(2.0 gal) (hr) (20\%) (3785 ml) (min)}}{\text{(hr) (60 min) (100\%) (gal) (100 strokes)}}$$

= 0.25 ml/stroke

LBS polymer/day = 0.216 mgd x 8.34 lbs/gal x 8 mg/L

= 14.41 lbs polymer/Day

$$\text{Feed } \frac{\text{(ml)}}{\text{min}} = \frac{\text{(14.41 lbs) (day) (gal) (3785 ml)}}{\text{(day) (1440 min) (9.5 lbs) (gal)}}$$

= 3.99 ml poly/min

$$\text{Strokes/min} = \frac{\text{(3.99 ml poly) (stroke)}}{\text{(min) (0.25 ml)}}$$

=16 strokes/min

Example 17:

Determine dilution water flowrate required to makedown 0.5% polymer solution if the polymer pump feeds 14.41 lbs polymer per day.

$$\text{Polymer feed (lbs/min)} = \frac{\text{(14.41 lbs) (day)}}{\text{(day) (1440 min)}}$$

= 0.01 lbs/min

$$\text{Water flow (GPM)} = \frac{\text{(0.01lbs) (gal)}}{\text{(min) (8.34 lbs x 0.005)}}$$

= 0.24 GPM

Example 18:

Determine the food to microorganism ratio for an activated sludge system with a COD of 100 mg/L applied to the aeration tank, an influent flow of 7.5 MGD and 33,075 lbs of solids under aeration. Seventy percent of the MLSS are volatile matter. All knowns are seven day moving averages.

Known		Unknown
Inf. Flow, MGD	= 7.5 MGD	F/M, COD/day/day MLVSS
COD, mg/L	= 100 mg/L	
Solids Under Aeration lbs	= 33,075 lbs	
MLSS VM %	= 70%	

1. Calculate the food to microorganism ratio.

F/M, 1 lb COD/day / lb MLVSS = Flow, MGD X COD, mg/L X 8.34 lbs/gal / Solids Solids Under Aeration, lbs X VM Portion

= 7.5 MGD X 100 mg/L 8.34 mg/L / 33,075 mg/L X 0.70

= 6.255 lbs COD/day / 22,150 lbs MLVSS

= 0.27 lbs COD/day/lb MLVSS

Example 19:

Determine if the influent nutrient requirements are satisfied, first you must determine the following through laboratory analysis.

b. Wastewater influent COD in mg/L

c. Wastewater influent NH3-N in mg/L

d. Wastewater influent P in mg/L

Lets assume that the following conditions exist for the examples we will use to determine nutrient requirements.

a. Wastewater influent COD = **2,650 mg/L**

b. Wastewater influent NH3-N = **4 mg/L**

c. Wastewater influent P = **0.0 mg/L**

The following equation is used to determine the nutrient requirements.

Nutrient required in mg/L = <u>PACT influent COD in mg/L</u>
Influent COD to Nutrient Ratio

As stated earlier, the ratio of nitrogen to PACT influent COD is 2.5 parts nitrogen for every 100 parts of COD, or 100 ÷ 2.5 = 40. The following example will determine the nitrogen requirements for the given conditions.

Example: Nitrogen required in mg/L <u>= 2,650</u>
40

The result of the equation indicates that a nitrogen concentration of 66.25 mg/L is required. Since the influent waste contains a nitrogen concentration of 4 mg/L, that means that 62.24 mg/L of additional nitrogen must be added to the influent flow stream via the nutrient addition system.

The ratio of phosphorous to PACT influent COD is 0.5 parts phosphorus for every 100 parts of COD, or 100 ÷ 0.5 = 200. The following example will determine the phosphorous requirements for the given conditions.

Example: Phosphorous required in mg/L = <u>2,650</u>
200

The result of the equation indicates that a phosphorous concentration of 13.25 mg/L is required. Since the influent waste contains no phosphorous, that means that the entire quantity needed must be added to the influent flow stream via the nutrient addition system.

The following equation is used to convert nutrient requirements in mg/L to lbs. required per day.

Nutrient required in lbs. per day = nutrient required in mg/L x Influent flow in MGD x weight of one gallon of H2O in lbs.

For the following example assume an average daily flow of 130,000 gallons (0.13 MGD) and use the figures that we arrived at previously (additional nutrient required in mg/L) to determine the quantity of nutrient required in lbs. per day.

Example: Nitrogen required in lbs. per day = 62.25 mg/L x 0.13 MGD x 8.34

The result of the example indicates that 67.5 lbs. nitrogen must be added to the influent flow stream per day.

Example: Phosphorous required in lbs. per day = 13.25 mg/L x 0.13 MGD x 8.34

The result of the example indicates that 14.4 lbs. phosphorous must be added to the influent flow stream per day.

The following equation is used to determine the quantity of chemical required to obtain the desired nutrient weight.

Chemical required in lbs. per day = Nutrient to add in lbs. day x Atomic weight ratio x 100% / Concentration of chosen chemical in percent

For the following example, we will assume that a 50% solution of urea is used to satisfy nitrogen requirements and a 75% solution of phosphoric acid is used to satisfy phosphorous requirements. The figures from previous calculations for the lbs. of nutrients required per day.

Example: lbs. of (NH2)2CO required per day 100% = 67.5 lbs of nitrogen required per day x 2.1 x 100%

The result of the example indicates that 141.75 lbs of 50% urea are required per day to satisfy the nitrogen requirements.

Example: lbs. of H3PO4 required per day 100% = 14.4 lbs of nitrogen required per day x 3.2 x 100%

The result of the example indicates that 46.1 lbs of 75% phosphoric acid are required per day to satisfy the phosphorous requirements.

When a liquid is the chosen chemical for nutrient addition, the operator may want to convert the weight of the selected chemical to gallons.

The following equation is used to convert lbs. per day to gallons per day.

Selected chemical in gallons per day = Selected chemical in lbs. per day / Chemical density x Weight of one gallon of H2O in lbs.

APPENDIX C
ABBREVIATIONS

Several abbreviations appear regularly within the text of this Operations Manual.

The following is a list of some commonly used abbreviations and what they indicate:

ABBREVIATIONS

°C	Degrees Celsius
Cfm	Cubic Feet per Minute
cm	Centimeters
COP	Copper Pipe
CPVC	Chlorinated Polyvinyl Chloride
CSE	Confined Space Entry
cu ft	Cubic Feet
cu in	Cubic Inch
DAF	Dissolved Air Floatation
DAP	Di-Ammonium Phosphate
EOL	End of Lamp Life
EPA	Environmental Protection Agency
°F	Degrees Fahrenheit
FBR	Fluid Bed Reactor
FRP	Fiberglass Reinforced Plastic
Ft	Feet or Foot
ft-lb	Foot-Pound
ft-lb/min	Foot-Pounds per Minute

ABBREVIATIONS

GAC	Granular Activated Carbon
gal	Gallon
GPD	Gallon per Day
GPH	Gallon per Hour
GPM	Gallon per Minute
gpm/sq ft	Gallon per Minute per Square Foot
HMI	Human Machine Interface
HOA	Hand/Off/Automatic
HP	Horse Power
Hr	Hour
ICFM	Cable Feet Per Minute in Inches
I/O	Input/Output
IX	Ion Exchange
KLS	Kevlar Lined Steel
kPa	Kilopascal
kW	Kilowatt
lb	Pound
lb/min	Pounds per Minute
M	Meters
M3	Cubic Meters
M3/hr	Cubic Meters per Hour
MA	Manual Automatic
MCC	Motor Control Center

ABBREVIATIONS

MGD	Million Gallons per Day
mg/L	Milligrams per Liter
NaOH	Sodium Hydroxide or Caustic
N.C.	Normally Closed
NM	Nanometer
N.O.	Normally Open
NPDES	National Discharge Elimination System
OAD	Overall Depth
OIS	Operator Interface Station
PC	Personal Computer
PEP	Polyethylene Pipe
PLC	Programmable Logic Controller
PLS	Polypropylene Lined Steel
ppb	Parts per Billion
PPE	Personal Protective Equipment
Ppm	Parts per Million
PRV	Pressure Reducing Valve
psf	Pounds per Square Foot
psi	Pounds per Square Inch
psig	Pounds per Square Inch Gage
PVC	Polyvinyl Chloride Pipe
SCADA	Supervisory Control and Data Acquisition
scfm	Standard Cubic Feet per Minute

ABBREVIATIONS

SCFH	Standard Cubic Feet Per Hour
sq ft	Square Feet
sq in	Square Inch
SS	Straight Side
STL	Steel Pipe
SWD	Side Water Depth
SU	Standard Units (pH)
TOC	Total Organic Carbon
TDH	Total Dynamic Head (Ft or Fluid)
TSS	Total Suspended Solids
TYB	Tygon Tubing-Braided
UV	Ultraviolet
Ug/l	Micrograms/Liter
W	Watt
WTF	Wastewater Treatment Facilities
( )	Design Flow
[ ]	Maximum Flow

APPENDIX D
JAR TEST PROCEDURES

Jar Testing For DAF Chemical Dosages

1. Obtain the 5-gallon sample bucket from underneath the Jar Testing Table in the D-1 Building.
2. Verify that the air supply to P-403 is isolated, the AODD Pump that pumps Thickener overflow from the Thickener to the Aeration Tank. P-403 is available, but no longer in use. Verify that V-422, V-423, and V-424 are closed. Open V-415.
3. Open the drain valve V-421 on the Aeration Tank and blow off for 10 – 15 seconds until the water turns from black to a clear gray color.
4. Fill the 5-gallon sample bucket with this clear gray wastewater from the Aeration Tank.
5. Close Drain Valve V-421 and Aeration Tank isolation Valve V-415.
6. REMEMBER TO TURN ON THE AODD PUMP FOR THE THICKENER OVERFLOW.
7. Record the effluent flow at the time the sample was taken.
8. Fill each of the (6) square jars for the Jar Tester with 1-Liter of wastewater from the sample bucket. (Note: mix the sample bucket between each jar to make sure that contents remain thoroughly mixed.)
9. Place the (6) jars in place on the Jar Stirrer underneath of the mixing paddles.
10. Turn on the power to the Jar Stirrer.
11. Select #1 (Continuous Run) on the Key Pad.
12. When prompted to enter a speed, enter 300, hit the “ENTER” button, and then press the “START/STOP” button. This should start the Jar Stirrer at 300 RPM’s. Selecting the “START/STOP” button now at any time will start and stop the mixing paddles as necessary.
13. Turn on the light switch to the Jar Stirrer.

14. Place 5 mL of Cationic Polymer solution in Jar #1.
15. Place 10 mL of Cationic Polymer solution in Jar #2.
16. Place 15 mL of Cationic Polymer solution in Jar #3.
17. Place 20 mL of Cationic Polymer solution in Jar #4.
18. Place 25 mL of Cationic Polymer solution in Jar #5.
19. Place 30 mL of Cationic Polymer solution in Jar #6.
20. Allow the jars to mix for approximately 1 minute.
21. Reduce the RPM of the Mixing Paddles by using the “ARROW” Keys on the key pad to 100 RPM.
22. We are trying to build flocculated particles that approximately 1/16 to 1/8 inch in size in the jars. Identify the two jars where the floc is smaller in one and larger than the target floc size.
23. Add 1 mL dosages of the Cationic Polymer Solution to the jar which had the floc size smaller than the target size and mix for an additional minute. .)
24. Continue to add 1 mL dosages to the jar until the correct floc size is observed.
25. Record Cationic Polymer Dosage used in PPM.
26. Press the “START/STOP” Button and stop the mixing paddles.
27. Through visual observation, select the jar that displays the correct floc size and the clearest water. (Note: more than one of the jars may look good, but select the jar that has the lowest dosage, correct floc size, and the water that is not orange from an overdose of Ferric.)
28. Once the Jar is selected, record the Ferric Dosage used in PPM.
29. CLEAN THE (6) JARS IN THE SINK IN THE D-1 BUILDING AND CLEAN UP ANY ADDITIONAL MESS THAT MAY HAVE BEEN MADE DURING JAR TESTING!

30. Enter the Effluent Flow, Ferric Dosage in PPM, and Polymer Dosage in PPM into the Excel Spreadsheet. The spreadsheet will generate a Ferric Pump output in ml/minute and a Polymer Pump output in gal/hour.

31. Set the chemical pumps up to match the desired pump outputs.

32. Note that it will take approximately 1.5 hours from the time the pumps are changed until any impact is visible at the turbidity meter for the plant effluent.

Make up of Ferric Chloride Solution for Jar Testing

1. Thoroughly clean out a 1-Liter bottle with a lid.
2. Using a graduated cylinder, put 200 mL of distilled water into the 1-Liter bottle.
3. Using a syringe, put 2 mL of 40% Ferric Chloride into the 1-Liter bottle.
4. Again using a graduated cylinder, add an additional 558 mL of distilled water to the same 1-Liter bottle.
5. Cap the bottle and thoroughly mix.

(Note: 1 mL of this solution when added to a 1-Liter sample of wastewater from the Aeration Tank will be equivalent to a 1 PPM dosage.)

Make up of Cationic Polymer Solution for Jar Testing

1. Thoroughly clean out a 1-Liter bottle with a lid.
2. Using a graduated cylinder, put 200 mL of distilled water into the 1-Liter bottle.
3. Using a syringe, put 2 mL of neat 40% Cationic Polymer into the 1-Liter bottle.
4. Again using a graduated cylinder, add an additional 558 mL of distilled water to the same 1-Liter bottle.
5. Cap the bottle and thoroughly mix.

(Note: 1 mL of this solution when added to a 1-Liter sample of wastewater from the Aeration Tank will be equivalent to a 1 PPM dosage.)

APPENDIX E
PH AND ORP PROBE CLEANING AND CALIBRATION

Periodically calibrated instrumentation is essential for the effective treatment of wastewater. The pH and ORP probes must be cleaned and calibrated frequently to insure their reliability. The following are the procedures to clean and calibrate the pH and ORP probes.

pH PROBES

The basic procedures when cleaning the pH probes are outlined as follows:

a. At the pH probe control panel, place the probe operation in the HOLD status while cleaning the probe. The instrument manufacturer's manual thoroughly explains this procedure.

b. THE OPERATOR MUST USE CAUTION WHEN HANDLING AND CLEANING pH PROBES; THE INSTRUMENT ELECTRODE TIPS ARE FRAGILE.

c. Place the pH probe in a container so that the lower third of the probe is immersed in a 10% solution (i.e. 1:10) of muriatic acid. Again, be careful that the electrode tips are not damaged.

d. When the probe is sufficiently clean, usually after 1 to 3 minutes of immersion in muriatic acid, remove the pH probe from the solution and rinse thoroughly with clean water.

e. If scale or buildup remains on the probe, a cotton ball or swab or a soft-bristled brush can be used to gently work the buildup from the surface of the electrodes. Soak or spray the electrodes intermittently with muriatic acid solution during this process if necessary. The surrounding areas of the pH probe can be cleaned in this manner as well. Again, rinse the pH probe thoroughly with clean water when cleaning is complete.

f. After the pH probe has been thoroughly rinsed, return the probe to the wastewater stream and switch the transmitter to the operational mode by enacting the CANCEL HOLD command. If the probe is to be placed in storage, be sure to moisten the rubber electrode caps and place them on the pH probe electrodes. If the pH probe is to be stored for an extended period of time, place the probe in a container of water covering the lower third of the probe.

ORP PROBES

With the meter in the "OFF" or "STANDBY" position, the cleaning and calibration procedures for the ORP probes are as follows:

a. The metal measuring electrode and the glass reference electrodes should be carefully removed from the waste stream. The metal measuring electrode and the glass reference electrode should be inspected for signs of interfering coatings on the surfaces.

b. If scaling is evident, place the probes in a container with a 10% solution (i.e. 1:10) of muriatic acid in water. Immerse approximately 1 1/2 inch of the electrode.

c. After 2 to 3 minutes of soaking, remove the electrodes and rinse with clear water. Inspect the probes.

d. If scale remains on the electrodes, gently use a cotton swab or a soft bristle brush to work the buildup from the surface of the electrode. Continue to soak in muriatic acid solution and rinse as needed

e. After thorough cleaning, return the probe to the wastewater stream and activate the meter.

f. Calibration of the ORP probe, unlike the pH probes, requires only a one point calibration. The probe can be calibrated using a standardization solution made by adding 10 grams of quinhydrone to 1 liter of pH 4 buffer making a saturated solution. The solution should be made on the day of use, but may be used for more than one calibration.

g. Depending on the temperature of the solution the millivolt reading will change accordingly. The accompanying chart shows the relative millivolt reading for a temperature range of 40 to 100°F.

APPENDIX F
LIST OF VENDOR EQUIPMENT MANUALS

Vendor	Manual Title	Equipment ID
Envirex	O&M Manual for Fluidization and Effluent Pumps, Valves, Aeration Blower and Pressure Regulators	P-601, P-602, P-1011, P-1012, P-101A, P-1013, P-1014, P-102A P-3015, P-3016, P-301A, P-3017 P-3018, P-302A, B-401
Envirex	Service Manual Water & Wastewater Treatment Equipment (DAFs and Aeration Tank Diffusers)	D-501, D-551, P-501, P-551, T-501, T-550, M-503, M-553, M-502, M-552, X-401
Wedeco	UV System O&M Manual	X-621
USFilter Davco	Field Erected Clarifier O&M Manual	T-602, M-611, M-612, M-613
USFilter Stranco	Chemical Feed Skids O&M Manual	P-711, thru P-718, P-721 thru P-728
Shaw	Electron Donor Feed System (Ethanol) O&M Manual	T-703, P-739 NB, P-731 thru P-738, All ethanol system instrumentation
USFilter Stranco	Polymer Feed Equipment O &M Manual	P-741, P-742
USFilter Zimpro	WHM Model T-1 Lime Storage and Feed O&M Manual	T-752, M-756, M-753, M-754, M-755, M-757
USFilter Stranco	Micronutrient Pump Skid O&M Manual	P-753A, P-753B
Total Equipment	Air Compressor System O&M Manual	T-801, 1-802, P-801, P-802, F-802, F-803, F-804
USFilter Westates	Operation & Maintenance Manual for HP-1020 Granular Activated Carbon Adsorption System	GC-201C
Cutler Hammer	Coordinated Outdoor Houses & Motor Control Centers-O&M Manual	-

Vendor	Manual Title	Equipment ID
Shaw	Fluidized Bed O&M Manual - Equipment	FI-3015, 3016, 3025, 3026, In-Bed Cleaning Eductor for FBRs 5-8 PCV 3045, 3046,3055, 3056 Lateral Assembly FBRs 1-8 FBR Dip Tubes FBRs 1-4 Biomass Separators FBRs 5-8 Biomass Control Assembly FBRs 5-8
Envirex	Instrumentation O&M Manual	Refer to Instrument List
Titan	Barnes Installation & Operations Manual	P-1101 and P-1102
Lightnin	Mixer Installation, Operation and Maintenance Manual (Tote Agitator)	M-753A
Lightnin	Mixer Installation, Operation & Maintenance Manual (Sludge Conditioning Tank Agitator)	M-901
Shaw	Dual H-120 Biofilter System with Blower O&M Manual	T-401A/B, T-403, T-404, P401, P-402, B-402
USFilter Dewatering Systems	J-Press Filter Press Owner's Manual	X-901, X-902
Penn Valley	Double Disc Pumps O&M Manual	P-501, P-551, P-603, P-1021, P-1022, P-1023, P-1024, P-2011, P-2012, P-3011, P-3012
Fybroc	Fybroc Series 1500 Horizontal Pumps Installation Manual	P-903, P-751
Sandpiper	Sandpiper II Service & Operating Manual	P-901, P-902
Envirex	SCADA System	-

LIST OF VENDOR EQUIPMENT MANUALS
ADDED 2006

MANUFACTURER	MODEL #	ITEM
Asahi	Tru-union 1609	CPVC Ball valves
Asco	8321	3-way solenoid valve, FV-1401
Asco	8210	2-way solenoid valves, FV-4411, FV-4421, FV-1602, FV-4870, FV-4940
Ashcroft	Pressure Switch B450B	PS-1401
Ashcroft	Pressure Gauge 1009	PI-1450, PI-1401, PI-1402, PI-1403, PI-1426, PI-1603, PI-1701
Automax	Supernova Series B	FV-1401, FCV-1440, LCV-1702
Automax	5000	Located on FCV-1440, LCV-1702
Discflo	403-122HHD	Sludge Pump P-1601
Durco	BTL	Butterfly valves V-4290, V-4312, V-4320, V-4332, V-4319, FV-1401
Durco	T-41	Plug valves V-4380, V-4921V-4790, V-4800, V-4821, V-4810, V-4770, V-4774, V-4775, V-4780
Dwyer Instruments	VFB-53-BV	Flowmeters, FI-1420, FI-1430
Dwyer Instruments	VFA-1-BV	Flowmeter FI-1701
Dwyer Instruments	RMC	Flowmeters, FI-4413, FI-4423, FI-1602, FI-4027, FI-1703, FI-1704

MANUFACTURER	**MODEL #**	**ITEM**
Emerson – Rosemount	3051	FI/FT-1440, FI/FT-1401, LIT-1701
Fybroc	Series 1500, 10X8X15 2X3X8	P-1401A, P-1401B P-1701A, P-1701B
Glentech	850	S-1401A/B
Hayward (Webster)	S16 DELETED	Vertical Pump,P-1420
Hach	1720E	Turbidity:AE-1702, AIT-1702
Mazzei	M3090	Eductor:E-1603
Mazzei	N35-DT	O2 Mass Transfer
Onsite	0-75	PX-1601
Parkson	Dynasand Filter	T-1702
Penberthy	Jet Pump, 1-1/2”	In-bed Cleaning Eductor– FBR-A
Penberthy	1 ½” TME	T-1603 Mixing Eductor
Penn Valley Pump	2” Double Disc	P-1410
Rosemount Analytical	385	ORP sensor, AE-1440
Rosemount Analytical	389	pH sensor, AE-1401
Rosemount Analytical	54E	Transmitter, AIT-1401, AIT-1440
Siemens	XPS 10	LE-901
Siemens	Miniranger	LIT-901
SNF Floquip		Dry Polymer System
Spears		CPVC Butterfly valves
Spears	Large weir 2723	CPVC Diaphragm valves
Technocheck	5001 CPVC	Check valve, V-4333, V-4313

MANUFACTURER	**MODEL #**	**ITEM**
Wilkerson	R16-02-G00 w/GPA-95-011	Pressure Regulator, PCV-4430, PCV-1420, PCV-1440, PCV-1702