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DESIGN CRITERIA

BAUXITE-SULFURIC ACID FEED FACILITIES
100-K AREA

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DESIGN CRITERIA

BAUXITE-SULFURIC ACID FEED FACILITIES
100-K AREA

by

E.L. Etheridge

Plant Design Unit
Design Engineering Subsection
FACILITIES ENGINEERING SECTION

September 6, 1963

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APPROVAL SHEET

DESIGN CRITERIA, REVISION I

BAUXITE-SULFURIC ACID FEED FACILITIES
100-K AREA

PREPARED BY: E. L. Etheridge DATE: 4-29-64
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APPROVAL SHEETDESIGN CRITERIA, REVISION 2

BAUXITE-SULFURIC ACID FEED FACILITIES
100-K AREA

PREPARED BY:

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DESIGN CRITERIA

BAUXITE-SULFURIC ACID FEED FACILITIES
100-K AREA

1.0 INTRODUCTION

The following criteria delineate the objective, bases, and functional requirements that shall govern the preparation of the design of the bauxite-sulfuric acid feed facilities to be installed in the 183-KE and KW Buildings. These facilities will produce the chemical coagulant used in the treatment of Columbia River water in the K Area water plants and thus replace the existing liquid alum feed systems used for this purpose.

2.0 OBJECTIVE

The objective of this document is to define the operational and technical requirements of the new process and to outline the functional requirements of the proposed facilities. The criteria below define the requirements for a single K Area water plant. Unless otherwise stated they shall apply for both K Area water plants.

3.0 BASIC WATER TREATMENT REQUIREMENTS AND CONSIDERATIONS

3.1 General

Chemical treatment of Columbia River water is necessary prior to using it as reactor coolant to control (1) corrosion of reactor aluminum components; (2) film Buildup on heat transfer surfaces in the reactor which might otherwise restrict coolant flow or heat transfer; and (3) radioisotope types and concentrations discharged to the river by the reactor coolant effluent. Any interruption or deviation of the prescribed chemical treatment of the water may adversely affect these conditions, and thus the efficient operation of the reactors.

3.2 Water Plant Flow

3.2.1 Normal

The maximum raw water flow at the 183 Building headhouse during normal operation is 232,000 gpm. This flow is equally supplied between two 60-inch influent raw water headers entering the 183 Building headhouse. Each influent header supplies one-half of the K water treatment plant.

3.2.2 Shutdown

The minimum raw water flow at the 183 Building headhouse during reactor outages is 15,000 gpm. This flow is supplied through either influent header.

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3.3 Chemical Coagulant

Hydrated aluminum sulfate is the standard water treatment coagulant of the K Reactors' water plants. It is continuously introduced, at varying feed rates of a few parts per million by weight of the raw water flow, into the two 60-inch influent raw water headers at the 183 Building headhouse. The hydrated aluminum sulfate is uniformly mixed with the raw water by the turbulent flow in the headers before the raw water is discharged into the influent distribution flumes of the sedimentation basins. The current feed rate is 18 ppm and is constant throughout the year. This feed rate (18 ppm) shall be called the design feed rate for the new facilities. However, feeding from 3 to 25 ppm shall be possible for all possible water plant flows. The chemical formula of the hydrated aluminum sulfate shall be: $Al_2 (SO_4)_3 \cdot 15H_2O$.

3.4 pH Control

The pH of reactor process water may vary between the range of 6.6 and 7.0. The pH is currently controlled at 6.6 ± 0.2 referred to 10 degrees Centigrade. Acidity is added to the basic raw water by the hydrated aluminum sulfate feed and is supplemented by feeding commercial grade, 93 w/o sulfuric acid. Supplemental acid feed is introduced at the flash mixers of the influent distribution flumes of the sedimentation basins.

4.0 BAUXITE-SULFURIC ACID FEED PROCESS REQUIREMENTS AND CONSIDERATIONS

4.1 General

The production of hydrated aluminum sulfate on a continuous flow basis for usage in water treatment differs from commercial hydrated aluminum sulfate production practices. Crude bauxite ore and sulfuric acid are continuously fed to a reaction vessel while the reaction product, aluminum sulfate, unreacted solids, excess acid, and water, is continuously removed from the vessel, diluted with cold water, and introduced into the raw water header as the coagulant. Since sulfuric acid is utilized to regulate the pH of the treated water, an excess of acid is permissible in the bauxite reaction without incurring an economic loss. By providing excess acid in the reaction vessel and violently agitating the reaction, the reaction time and reaction vessel size can be reduced considerably from that normally employed in commercial aluminum sulfate plants. In addition, by optimizing the reactant feed ratios and reaction temperatures, high conversion yields are realized.

4.2 Process Technology

The chemical reaction of bauxite (impure aluminum oxide) and sulfuric acid is:

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For the reaction to be initiated, relatively high temperatures, 240-270 F, must be attained. One method of providing heat to the reaction is to feed water with the chemicals and utilize the heat of dilution from the mixing of water with concentrated sulfuric acid. The reaction, bauxite, sulfuric acid, and water, is exothermic, giving off approximately 37,500 BTU's per pound mole of H_2SO_4 feed. At steady state, the boiling point of the solution in the reaction vessel is reached and the temperature of the reaction becomes stabilized. Steam and acid fumes are evolved from the reaction thus creating an off-gas problem.

The stoichiometric feed ratio of the chemical reactants is 7.8 pounds of bauxite (63 w/o Al_2O_3) per gallon of 93 w/o H_2SO_4 . However, stoichiometric conversion is not realized. Approximately 8 to 10 per cent of the available Al_2O_3 is insoluble in 60 w/o H_2SO_4 and does not enter into the reaction. A 90 per cent conversion of the remaining Al_2O_3 is considered a good reaction. In determining the payoff of the bauxite sulfuric acid system for the project proposal a feed ratio of the chemical reactants of 8.9 pounds of bauxite per gallon of 93 w/o H_2SO_4 was used. This feed rate yielded a calculated production of 3 pounds of alum per pound of bauxite and 1.7 pounds of 93 w/o sulfuric acid.

The addition of water to the reaction in the ratio of one gallon per gallon of 93 w/o H_2SO_4 has been determined to be the optimum water feed in plant operation and pilot plant work. Higher water feed rates result in longer reaction holdup times for comparable conversion yields while lesser water feeds produce poor conversion due to freeze out of aluminum sulfate in the more concentrated acid solution in the reaction vessel.

In the bauxite feed range possible for the system, the reaction is not strongly affected by the holdup time in the range of 2 to 10 minutes. In the preliminary design of the system for determining system payout, 4 minutes was arbitrarily assumed.

Agitation of the reaction strongly affects the conversion yield of Al_2O_3 to $Al_2(SO_4)_3$. Violent agitation is necessary to obtain conversion yields above 90 per cent.

The reaction product must be diluted with cold water immediately after removal from the reaction vessel to prevent freeze out of the aluminum sulfate as the temperature of the product solution begins to drop. Minimum dilution required is about 6 gallons per gallon of reaction product.

4.3 Chemical Reactants

Bauxite - Chemical and screen analyses of the bauxite ore supplied IPD for water treatment use are listed in the Appendix.

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Sulfuric Acid - Commercial grade, 93 w/o concentrated sulfuric acid is supplied for IPD water treatment use. Consideration shall be taken in the design for feeding 99 w/o concentration sulfuric acid during summer months.

Water - Plant filtered water shall be used for the various water streams in the system.

5.0 FUNCTIONAL REQUIREMENTS

5.1 General

This section defines the operational and functional requirements of equipment for the bauxite-sulfuric acid feed process, and modifications to be made to the 183 Building and existing water treatment systems therein to install the facility.

5.2 Bauxite Storage

5.2.1 Storage Silos

Outdoor storage silos shall be provided at the 183 Building for the maintenance of an adequate bauxite supply inventory. The silos shall provide a minimum bauxite storage capacity of 480,000 pounds. The silos shall be installed at either of the following locations:

- 1) Space between the chlorine car building and headhouse facing the north side of the rail siding which services the 183 Building.
- 2) Space between the liquid alum storage tanks and the sulfuric acid storage tanks on the south side of the rail siding which services the headhouse.

The first location is preferred from an operational standpoint.

Consideration shall be given to the possible relocation and use of excess dry chemical storage silos located at the 183-C Building in the 100-B Area.

5.2.2 Conveyor System

A conveyor system shall be provided for unloading the bauxite ore from covered hopper railcars on the rail siding to the storage silos and moving the bauxite ore from the storage silos to a feed bin inside the 183 Building. The conveyor system shall have a minimum unloading capacity of 10 tons per hour to allow unloading a hopper car during a single work shift. The feed rate of conveyor system from the storage silos to the feed bin shall be a minimum of 5 tons per hour.

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Controls shall be provided for the conveyor system to permit operation of system from the rail siding location and inside the 183 Building.

5.2.3 Feed Bin

A bauxite feed bin shall be provided for the process and shall be located inside the 183 Building. The bin shall provide a minimum bauxite storage capacity of 34,000 pounds (two days' supply at normal water plant flow and 18 ppm alum feed). To provide space in the 183 Building to install the feed bin and other equipment of the bauxite-sulfuric acid feed system, the existing liquid solution storage tanks T-5 and T-6 may be removed from the building. The existing discharge piping and pumps of the remaining solution tanks may be relocated as required for necessary additional space. Permanent flooring shall be installed in the openings in the first floor of the building following removal of the tanks. The flooring shall support a live load limit of 100 pounds per square foot.

5.3 Bauxite Feed

Flow of bauxite material from the feed bin to the reaction vessels shall be continuous. Variation in the feed rates from 300 to 750 pounds per hour shall be less than ± 5 percent and below 300 pounds per hour ± 10 percent. Bauxite may be fed to the reaction vessels in the dry form or in a water slurry mixture.

5.4 Sulfuric Acid Feed

Sulfuric acid for the process shall be supplied from the existing constant head feed tank of the concentrated sulfuric system of the 183 Building.

5.5 Filtered Water Supply

An 8-inch filtered (service) water header supplies the 183 Building. Normal header pressure at the headhouse is 100 ± 5 psig; larger pressure fluctuations are experienced occasionally because of intermittent water usages from the filtered water system within the plant.

5.6 Reaction Vessels

The production of hydrated aluminum sulfate in this process shall be performed in two parallel reaction systems. Each system shall supply one-half of the water plant during normal operation. Provisions shall be made, however, to allow the removal of either reaction system from service and to produce and supply hydrated aluminum sulfate for all of the water plant from the other reaction system in service.

Special attention shall be given to the selection of reactor vessel materials as severe corrosion conditions are attendant with the high

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temperature bauxite-sulfuric acid reaction. The corrosion conditions are comparable with those encountered in 60 w/o boiling sulfuric acid. A reaction vessel service life of at least three years is desired.

Agitation of reaction in the vessels shall be performed mechanically or by steam sparging. The agitation shall be of sufficient intensity so that the bauxite feed material and unreacted solids do not settle at the bottom of the vessels. Plant operating experience with the two agitation methods indicate that steam sparging provides better agitation.

To facilitate operation of the bauxite-sulfuric acid system, a hot water and/or steam spray rinse shall be provided for the periodic washdown of the vessel walls of crud and insoluble materials that deposit on the vessel walls above the liquid surface in the vessels. An excessive build-up of this material on the vessel walls interferes with bauxite conversion efficiency in the reaction vessels.

A drain system shall be provided for the reaction vessels. Disposal of the drain effluent shall be to the existing neutralizing pit in the 183 Building.

5.7 Off-Gas System

An off-gas system shall be provided for removing and disposing of steam and sulfuric acid fumes generated in the reactor vessels. The system shall maintain a slightly negative pressure above the liquid surface of the reaction vessels. Failure of the off-gas system shall not pressurize the reaction vessels but shall provide an atmospheric vent for the off-gases to the outside of the 183 Building.

5.8 Raw Water Coagulant Feed Point

The coagulant produced by the bauxite-sulfuric acid system shall be fed to the influent raw water headers via the existing chlorine solution injection piping. Normal pressure in the chlorine solution injection piping is approximately 25-30 psig.

5.9 Controls and Instrumentation

Manual controls shall be provided for the bauxite-sulfuric acid feed system. Control and adjustment of the feed and discharge streams of the reaction vessels shall be located near the vessels. The bauxite feed stream to the reaction vessels shall also be provided with a totalizer for determining the amount of bauxite used over an operating period. The accuracy of the totalizer shall be ± 5 weight per cent. The reaction temperatures of the vessels shall be indicated at the reaction vessels and recorded in the 183 Building control room. Alarms for indicating system stoppages shall also be provided in the 183 Building control room. Sample taps shall be provided in the discharge streams from the reaction vessels for obtaining samples for chemical analyses.

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Calibration curves shall be provided for adjusting the feed and discharge streams in the system for all coagulant feed rates and water plant flows. These curves shall be verified during the acceptance tests of the facility (Section 5.12).

5.10 System Reliability

Significant chemical cost savings can be realized by supplying the water plant coagulant with the bauxite-sulfuric acid feed system rather than with the standby liquid alum feed system. To ensure reasonable operational continuity for the bauxite system, operational spare equipment shall be incorporated in the system for those components where failure cannot be repaired without interrupting the process.

5.11 Functional Testing

Upon completion of the installation of the feed facilities, the system shall be tested to demonstrate the operability for maximum, minimum, and design operating conditions. Acceptance test procedures shall be prepared for conducting these tests.

5.12 Liquid Alum Feed System

The existing liquid alum feed system will be placed on standby service for additional coagulant supply inventory and possible prolonged outages of the bauxite-sulfuric acid feed system. The intertie between the two systems shall be such that either system may be quickly placed in service without grossly affecting water treatment in the water plant.

6.0 CODES AND STANDARDS

Unless otherwise stated, the design, the material used, and the work to be performed shall adhere to the requirements set forth in the latest edition of Hanford Works Standards and applicable codes approved by these standards.

7.0 BIBLIOGRAPHY

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2. HW-76001, "Bauxite-Sulfuric Acid Coagulant Feed Systems, 100-K", Preliminary Engineering Report, E.L. Etheridge, January 14, 1963.
3. HW-76926, "Project Proposal, Modification for Use of Bauxite, KE and KW Water Plants," Project CGI-105, J.V. Loftus and T.H. Lyons, June 7, 1963.
4. HW-77803, "Design Bases, Bauxite-Sulfuric Acid Feed Facilities," E.L. Etheridge, June 10, 1963.

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APPENDIX

1.0 Crude Bauxite Ore

1.1 Supplier: Stauffer Chemical Company

1.2 Purchase Specifications

Chemical Analysis: 61 to 68 per cent aluminum oxide

Sieve Analysis: 75 $\pm$ 5 per cent through 100 mesh screen.

1.3 Latest Complete Sieve Analysis:

<u>Screen Mesh</u>	<u>Per Cent Retained</u>
80	0.9
100	2.3
200	10.6
325	15.3
thru 325	70.9

1.4 Density

60-66 pounds per cubic foot.

1.5 Gross Chemical Analysis in 60 w/o Boiling H₂SO₄.

<u>Components</u>	<u>Soluble</u>	<u>Insoluble</u>	<u>Total</u>
Al ₂ O ₃ (includes Fe ₂ O ₃)	55.3*	6.9	62.2
SiO ₂	-	5.8	6.0
H ₂ O	27.2*	3.1**	30.3**
Total	82.5	15.8	98.5

* By difference. Analyses are those reported by the analytical laboratory. These are not corrected to add to 100 percent..

** Weight loss on calcination at 800 C.

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2.0 Alternate Bauxite Ores (Revision I)

To provide facilities capable of utilizing alternate bauxite ores, the bauxite feed equipment shall be sized to permit feeding ores which may vary from 50 to 80 per cent in aluminum oxide content. Anticipated sieve analyses of these ores will be 75 $\pm$ 5 per cent through 100 mesh screen.

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REVISION 25.4 Sulfuric Acid Feed Addendum

This sulfuric acid system for the process shall be capable of concurrent feeding of acid for pH adjustment to the bauxite-sulfuric acid reaction vessels and feeding of acid for pH adjustment directly to the diluted product downstream of the reaction vessels.

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