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HW--34095

DE93 003400

RICHLAND, WASHINGTON

HANFORD ATOMIC PRODUCTS OPERATION

December 30, 1951

1-26-55

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WATER TREATMENT MODIFICATIONS TO PRESENT AREAS

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This document has been reviewed and approved by the appropriate members of the Process Engineering Sub-Section as an engineering basis to be used in the preparation of a project proposal for requesting funds for sulfuric acid addition facilities at 100-B, C, D, DR, F and H Areas and for Phase II of existing alum-activated silica water treatment facilities.

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WATER TREATMENT MODIFICATIONS TO PRESENT AREAS

INTRODUCTION

In a previous document (1) an engineering basis was outlined for the conversion of the existing filter plants to the alum-activated silica process and modifications necessary to present installations to meet the maximum prospective water flows under Project CG-558.

Because of the immediate need for some of the facilities before final approval of Project CG-558, the project was authorized in two phases with funds authorized for Phase I only (2). Phase I consisted of those facilities required for truck transportation of activated silica solution from 100-C or 100-K to 100-B and 100-H, and for the storage and feeding of activated silica solution to the raw water in those areas. Minor improvements to the existing test installations at 100-D, DR and F to continue operation for an interim two year period were included also. Phase II was to consist of the additional facilities required to permit the continued water treatment with activated silica at the maximum prospective water flows under Project CG-558 (up to 72,000 gpm to each reactor at B, D, DR, F, and H).

The installation of Phase I has been completed and one season of operating experience is available.

The advantages to be gained by lowering the pH of process water have been reviewed in HW-33143 (3). The most significant contribution will be the large savings in the cost of process tube replacement resulting from decreased corrosion rates. The magnitude of these savings have been developed in HW-31504 (4), and can be realized as monetary savings with operation at the same outlet temperature or as increased production with operation at the same corrosion rates at higher temperatures (3). A secondary benefit will result by lowering the pH with sulfuric acid at the filter plant to improve alum coagulation. This latter benefit increases with increasing flow rates through the filters of any given area.

PURPOSE

It is the purpose of this document to review and up-date the previously presented scope basis for the activated silica installations in light of the existence of the Phase I portion and the present expected water flow requirements of Project CG-558. It is the further purpose to outline the recommended scope bases for the sulfuric acid addition system for pH correction at all areas.

RECOMMENDATIONS

It is recommended that:

1. The scope bases developed for the sulfuric acid addition facilities for pH correction be accepted for all areas.
2. The specific changes outlined for the activated silica systems at each area be accepted as part of the broad scope design for the present area expansion program. The major changes include:
 - a. Pipe line from 183-C to present activated silica storage outside 183-B.

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- b. Move activated silica manufacturing facility in 100-D Area from present locations to 183-D Building.
- c. Rebuild temporary manufacturing facility in 183-F Building to permanent facility.
- d. Continue to haul activated silica from 183-C or 183-K to 183-H Building.

I. GENERAL

All areas are now utilizing alum and activated silica for water treatment. The alum acts as a coagulant to form a floc with the finely divided and colloidal impurities in the raw water so that these impurities can be removed effectively by settling and filtering. Activated silica acts as a coagulant aid for the alum during part of the year. The activated silica is obtained from sodium silicate by neutralization of 85 percent of the sodium oxide content with sulfuric acid. This neutralization is carried out at a 1.5 percent concentration as SiO_2 . The neutralized sol is aged at this concentration for at least one hour then diluted to a 1 percent concentration for addition to the water.

Sufficient data including one-half pile results are available for a firm recommendation to change the specifications for the pH of process water from 7.65 to 7.3. There is every indication that larger benefits can be attained by lowering the pH of the process water to 7.0 without any deleterious effects (3). The scope bases developed in this document will be based on a system for pH correction of process water to 7.0.

II. SULFURIC ACID ADDITION FACILITIES

A review of several important design considerations was included as a portion of a proposed scope of the 100-K sulfuric acid addition facilities in HW-33178 (5) and will not be repeated herein. Included in these considerations were the use of alum versus acid for pH adjustment, the effect of temperature on pH, and the addition of a base after an acid.

A. Acid Requirements

The alum used in the water treatment as a flocculating agent will lower the pH of the water. About 1.9 ppm of alum are equivalent to 1 ppm of 93 percent sulfuric acid. The acid requirements to decrease the water to a given pH will be decreased inversely with the amount of alum used for water treatment. For design purposes, a minimum alum requirement of 3 1/2 ppm will be considered essential at all times to minimize film buildup (6). At the time of minimum alum usage, it has been calculated (7) that about 10 ppm of 93 percent sulfuric acid will be required to lower the pH of the water to 7.0.

B. Storage Requirements

Sulfuric acid is obtained in the Northwest from the Tacoma, Washington, or Portland, Oregon, area and is presently not in short supply. It cannot be considered essential to the system under all circumstances since the reactors

have been operated several years without acid addition. Therefore, the standard 90-day supply requirement is not considered essential for this facility.

Some sulfuric acid storage facilities presently are available in connection with activated silica manufacturing facilities. The activated silica requirements normally increase with increasing alum usage. No activated silica is used during the summer and fall months when alum usage is at its minimum and consequently sulfuric acid usage for pH adjustment would be at its maximum. The sulfuric acid storage for activated silica manufacture therefore will be considered available for pH adjustment purposes.

Two 19,000 gallon horizontal tanks are in place for sulfuric acid storage for activated silica at the 183-C Building; two similar tanks are being utilized for the same purpose at the 185-D Building; two such tanks have been surplused at the 185-F Building and one 17,500 gallon tank has been surplused at the 108-F Building. All of these tanks will be utilized for the sulfuric acid storage and all new tanks required will be of the same size and shape to render uniformity in design and construction (four such tanks were included in the scope bases of sulfuric acid storage facilities for 100-K (2)).

The number of 19,000 gallon tanks required at each area was determined on the basis of minimum requirements per area, over-all requirements for all 100 Areas and the difficulty of trucking sulfuric acid from area to area. A plot of the number of days storage in one and two 19,000 gallon tanks is shown in Figure 1 for various flows. The useful reserve in one tank is considered 11,000 gallons since an 8,000 gallon void must be available before a normal sized tank car can be unloaded. The splitting of a tank carload is considered inadvisable as an operating practice. The second tank would result in 19,000 gallons additional storage per area. Based on Project CG-558 flows through the filter plant (present flows for 100-H and F Areas), two 19,000 gallon tanks appear justified at each area. The resulting storage capacities in days for each area are summarized in Table I.

Table I

Number of Days Sulfuric Acid Storage
at 10 ppm Feed

Area	Filter Plant Flow gpm	Days Storage	
		1 - 19,000 gal. tank*	2 - 19,000 gal. tank*
B	82,000	17	47
C	101,000	14	38
D	94,500	15	40
DR	67,000	21	57
F	50,500	28	76
H	64,000	22	60
Total**	459,000	25	56

* 11,000 usable gallons for one tank

** In calculating total for 100 Areas (excluding 100-K) one tank in each area was considered averaging 4000 gallons short (15,000 gallons).

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C. Type of Acid Addition System

Because of operating experience, interested Reactor Section personnel have indicated preference for a gravity, manually operated sulfuric acid addition system rather than an automatic feed system with the use of proportioning pumps (8). The acid will be pumped batchwise from outside storage to a small indoor head tank on the third floor of each headhouse. The concentrated acid will flow by gravity through rotameters into two small dilution tanks where a constant amount of dilution water will be added. The diluted acid will flow by gravity to the point of addition to the process water.

D. Summary of Scope Bases

1. The dosages of sulfuric acid based on process water demand will be sufficient to decrease the pH of the process water to the reactor to 7.0 at the temperature of measurement. A minimum of 3.5 ppm alum and a maximum of 10.0 ppm sulfuric acid will be considered essential.
2. Sulfuric acid will be purchased and stored as a 93 percent solution (66° Baume).
3. Two 19,000 gallon horizontal steel tanks per area will be required.
4. The sulfuric acid will be diluted to at least 10 percent before introduction to the raw water supply. All introduction will be by means of some type of diffuser as a sparger to assure minimum interference with other chemical additions. The preferred point of addition of the acid relative to the other chemicals is currently under test. It may be added with the alum if the point of alum and activated silica addition are separate.
5. Provisions for straining or settling the sludge material in the sulfuric acid will be provided.
6. The feeding rate of the sulfuric acid will be monitored by the present pH indicator in the control room and controlled manually by means of rotameters.
7. The head tanks will be sized to contain a minimum of a 24-hour supply.
8. Storage should be in steel tanks; pipe and fittings for the 93 percent sulfuric acid should be schedule 80 steel. Valves, gaskets and pumps should be of approved corrosion resistant materials. The pipe and equipment in contact with the dilute sulfuric acid should be lead lined materials or approved corrosion resistant plastics.

E. Cost Summary

The total cost of conversion and modification of all areas to automatic proportioning sulfuric acid addition facilities was estimated to be approximately \$400,000 (9). The estimates were based on details contained in a design criteria and accompanying scope drawings issued individually for each area.

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This project cost is broken down by area in Table II with each area corrected percentage wise for additives.

Table II

Cost of Automatic Proportioning Sulfuric Acid
Addition Facilities

100 Area	Cost
B	\$81,000
C	19,000
D	77,000
DR	81,000
F	69,000
H	73,000

- The sulfuric acid addition facilities presently are being rescope on the bases of manually operated gravity feed systems. The design scope has not been completed sufficiently to permit a complete estimate at this time. The B-Area design criteria and scope drawings have been utilized for a portion of the estimate and the corrected cost has been estimated at \$100,000. A portion of the added cost for the manual-gravity system compared to the automatic-proportioning pump system can be attributed to refinement such as using acid proof lined pipe trenches instead of buried pipe, installing a catwalk on the acid storage tanks to simplify rodding the tanks, etc. It is assumed the other areas will vary in cost with the B installation in the same ratio as in Table II.

III. ACTIVATED SILICA FACILITIES

A. General

As part of a previous study resulting from the engineering basis discussed above, a permanent activated silica manufacturing facility was scoped for each area (B and DR to be fed by pipeline from C & D, respectively). Though Project Representative approval of the scopes had been received, the program was divided into a Phase I and Phase II. As such, the Phase II portion must modify the previously scoped facilities to include that portion of the facilities constructed in Phase I and to consider the existence of a sulfuric acid addition at each area. The following design bases will be used for the modification of the scope for each area as part of Phase II.

B. All Areas

With the addition of acid facilities and increased flow rates, the work load for the head house operators may increase to the point of requiring increased manpower. To cut down the work load, the control stations for the activated silica feeding facilities will be moved from their present locations in B, D, F, and H Areas to a location in the head house control room. No change will be made in the location at C and DR Areas.

C. B and C Areas

Very little change will be required to the original proposal for pumping

activated silica from the 183-C Building to a large storage tank outside of the 183-B Building. A 35,000 gallon storage tank and all necessary feed equipment for storing and feeding activated silica to the 100-B water supply were installed as part of Phase I. The estimated cost of this import system will be about \$32,000.

The 183-C activated silica manufacturing facility has been de-bottlenecked to insure sufficient activated silica capacity for 5 ppm SiO_2 feed to both 100-C and 100-B at flows indicated in Table I.

D. D and DR Areas

The present activated silica facility for 100-D and DR Areas was installed as a test facility in early 1953. Sodium silicate is unloaded from a tank car to a storage tank outside the 108-D Building. It is pumped from this storage to a small storage tank upstairs in the 185-D Building. The sulfuric acid is hauled by truck to a 19,000 gallon sulfuric acid storage tank outside the 185-D Building. From this tank the acid is pumped to a small storage tank upstairs in the 185-D Building. The activated silica is manufactured alternately in two mix-age tanks in the 185-D Building then pumped to a large storage tank outside the 183-D Building. The 183-D and 183-DR activated silica feeding systems are fed from this storage tank.

Some alterations to this system will be necessary to permit sufficient activated silica production for treating the 160,000 gpm total flow (see Table I) through the D and DR filter plants. Essentially the batch system will be made automatic to enable the operators to maintain a tight production schedule. The cost of such alterations is estimated to be about \$5,000.

An operator is required on an around-the-clock basis in the 185-D Building to operate the activated silica installation during the six months of the year that activated silica feed is necessary.

A proposal to change the activated silica installation from the 185-D Building to the 183-D Building has been studied. The system at 183-D would be made sufficiently automatic to allow the head house operator to supervise the make-up in addition to his other duties. It has been estimated that a labor savings of about \$19,000 per year could be realized by such a change. The cost of a complete installation at 183-D was estimated to be \$69,000. The facilities required for the sulfuric acid unloading and storage have been proposed as a separate project as described in Section II of this report. Therefore this portion of the cost can be deducted from the over-all activated silica installation. The savings might be of the order of \$15,000.

The proposed sulfuric acid installation at 183-D includes two 19,000 gallon horizontal tanks to be moved from outside the 185-D Building. One of these tanks is presently in use for the activated silica installation and could not be utilized unless the activated silica installation were moved from the 185-D to 183-D Building. If the installation were not moved, an additional cost of about \$7,000 would be required for the sulfuric acid facility for the installation of a new tank.

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Although the estimates given in this discussion are not firm, it is apparent that the relocated system would not only give a more consolidated system but would show a payoff period of two to two and one-half years.

The change of the activated silica installation from the 185-D to the 183-D Building is submitted as a recommendation of merit.

E. F Area

Very little change will be required to the original proposal for rebuilding the F Area activated silica test facility to a manufacturing facility. The facilities required for the sulfuric acid unloading and storage have been proposed as a separate project as described in Section II of this report. Therefore this portion of the installation design and cost can be deducted from the over-all activated silica installation. The justification for rebuilding the activated silica installation at F Area at present is contained in reference (10) (see Section IV).

F. H Area

The proposed activated silica manufacturing facility for the 183-H Building would require some modification because of the 35,000 gallon storage tank and all necessary feed equipment that was installed as part of Phase I and because of the proposed installation of sulfuric acid addition facilities. The economical justification for an activated silica manufacturing facility at H Area is still questionable (see Section IV).

IV. EVALUATION OF THE HAULING OF ACTIVATED SILICA

A. General

An economic evaluation of the operating costs of hauling activated silica compared to the increased capital investment necessary to manufacture activated silica at various areas was made in document HW-29521 (11). Based on several assumptions detailed therein, the hauling of 1.5 percent activated silica compared to building permanent manufacturing facilities for planned 1954 flow rates was found to be economically attractive for B and H Areas but not attractive for D-DR and F Areas. The amortization periods were 3.9 years for H Area, 6.9 years for B Area and less than 2.5 years for D-DR and F Areas.

The permanent type facility appeared justified at the originally proposed Project CG-558 flows for all areas based on amortization periods of less than 2.5 years for B, D-DR and F, and 3.2 years for H Area.

B. Need for Re-Evaluation

1. Since the time of this evaluation, facilities for hauling to B and H Areas have been installed, a 5000-gallon trailer and a tractor have been purchased and one season's hauling with these facilities has been experienced.

2. Project CG-558 has been approved to date without consideration of increased flows at F and H Areas (though these areas may be included later).
3. The activated silica manufacturing facilities at the K Areas are now available.
4. Some laboratory tests have indicated a loss in efficiency with storage time for activated silica as a coagulant aid. About 20 percent more SiO_2 content is required after the 1.5 percent solution has had a 24-hour residence time; about 50 percent more after a one-week residence in storage (6). No more than a 10 percent loss in efficiency can be attributed to the extra residence time caused by hauling since comparable storage facilities are located in the hauling and manufacturing areas.
5. Some assumptions given in HW-29521 (11) need revising under present conditions:
 - a. Proposed maximum flows under Project CG-558 have been varied somewhat. A more correct filter plant flow is found in Table I. A water plant flow of 82,000 gpm will be considered for F and H Areas if funds for their modifications are approved.
 - b. Tank trucks of 5000 gallon capacity will at all times be available for the hauling of the silica solution. One such unit is already on hand, and a capital cost of \$23,000 will be considered necessary for each additional tank trailer and tractor required. The rental on such units will be

Truck tractor	\$185/month
Trailer	22/month

while in use with no charge while in storage.
 - c. Operating experience during the winter and spring of 1954 have indicated that a round trip haul of 5000 gallons from C to H Area was accomplished in 1 1/2 to 1 3/4 hours (12). This haul now can be made from K instead of C Area to H Area which would decrease the time of a round trip still further. The time for loading, delivering and unloading a 5000 gallon batch and returning to the source of supply will be considered equivalent to 3 1/2 loads per shift for design purposes (4 loads some shifts, 3 loads other shifts).
 - d. The charge for the truck operator's time has been increased to \$6/hour (\$13.70 per 5000 gallon batch).

C. Capital Costs

An estimate of the cost of permanent activated silica manufacturing facilities at D, F, and H Areas and piping activated silica from the C installation to B Area was included as part of the previous hauling study (HW-29521 (11)).

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All of these costs must be altered because sulfuric acid addition facilities are to be installed as part of another project (see Section above) and a portion of some facilities now have been installed at B and H Areas to permit the hauling of activated silica during the past year. New estimates of the present cost of converting to permanent manufacturing facilities are presently under preparation. The costs listed in Table III are very preliminary and are utilized only for evaluation order of magnitude amortization costs. A capital cost for hauling would be involved only for consideration of hauling to F Area.

Table III

Estimated Costs of Manufacturing and Hauling Installation

Area	Manufacturing	Hauling
B	32,000	-
D	60,000	-
F	50,000	26,000
H	65,000	-

D. Operating Costs

Table IV shows how the hauling charges would accumulate at H Area based on a flow of 64,000 gpm through the water plant and the assumptions set forth earlier. The table includes also the costs of operation should the flow be increased to 82,000 gpm.

The cost of hauling to other areas was developed in a similar manner. It was assumed in the calculation that hauling to H Area would be the most attractive economically, and hauling to any other area would be in addition to hauling to H Area.

Table V gives a summary of the hauling costs at all areas concerned based on flows listed in Table I.

Table IV

Cost for Hauling 1.5% Activated Silica from K to H Area
(10% correction for deterioration)

Month	Expected Average Feed Rate ppm	Present Flow			Future Flow		
		No. 5000 gal. batches	Labor Cost \$	Total Accumulated Cost * \$	No. 5000 gal. batches	Labor Cost \$	Total Accumulated Cost * \$
January	1	38	520	727	48	658	865
February	3	114	1562	2496	145	1987	3059
March	3	114	1562	4265	145	1987	5253
April	4	151	2069	6541	194	2658	8118
May	4	151	2069	8817	194	2658	10983
June	3	114	1562	10586	145	1987	13177
July	0.5	19	260	11053	24	329	13713
Aug.-Nov.	0	0	0	11053	0	0	13713
Dec.	0.5	19	260	11520	24	329	14249

* \$207/month added for truck and trailer rental during the months of operation.

Table V

Annual Operating Costs for Hauling 1.5% Activated Silica

Area	1956 Flows	Increased Flows at F & H
H	\$11,500	\$14,000
F (with hauling to H)	8,000	14,000
B (with hauling to H)	14,000	-
D and DR	26,500	-

F. Pay-off Periods

From Table III and Table V the number of years that the capital investment and operating costs of the hauling system would take to equal the capital investment in the manufacturing facility can be developed. Rather than treat each area individually, the over-all hauling picture must be considered as a unit. Because of the large initial capital investment for a manufacturing facility, H Area appears the most attractive economically for consideration of a hauling facility. In developing amortization times, hauling to other Areas is considered only in addition to H Area. A cost of \$23,000 has been added into the capital costs shown in Table III for the hauling alternate for each tank trailer and tractor combination required in addition to the combination now owned. The resulting periods of amortization for various combinations as shown are summarized in Table VI.

Table VI

Time of Amortization of Permanent Facility Compared to Hauling Facility

Area	Years	
	1956 Flows	Increased Flows at F & H
H	5.7	4.6
F only (After H is hauling)	3.0	0.5*
B only (after H is hauling)	0.6	0.6*
D & DR only (After H is hauling)	1.4*	1.4*
D & DR only (After H & F are hauling)	0.5**	0.5**

* One additional truck and 5000 gallon trailer combination required

** Two additional truck and 5000 gallon trailer combinations required.

There appears to be no justification for building a permanent activated silica manufacturing facility for H Area at the present planned flows. If the present temporary manufacturing facility at F Area is not adequate for long time operation, it appears that installation of the necessary equipment for a hauling facility is marginal compared to a permanent manufacturing facility as scoped for the cost estimate based on a 3 year pay-off period. If increased flows are authorized for H and F Areas, hauling may still be feasible to H Area but not to both H and F because of the necessity of purchasing an additional truck and trailer combination. Because of the pos-

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sibility of increased flows at F Area and the marginal gain by operation of a hauling installation, a permanent manufacturing facility is recommended.

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