AIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202

Centimeter

Inches

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

1 of 1

Hanford Site Treated Effluent Disposal Facility Process Flow Sheet

R. B. Bendixsen

Date Published
April 1993

To Be Presented at
American Nuclear Society
1993 Annual Meeting
San Diego, California
July 20-24, 1993

Prepared for the U.S. Department of Energy
Assistant Secretary for Nuclear Energy

**Westinghouse
Hanford Company**

P.O. Box 1970
Richland, Washington 99352

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

Copyright License By acceptance of this article, the publisher and/or recipient acknowledges the U.S. Government's right to retain a nonexclusive, royalty-free license in and to any copyright covering this paper.

MASTER

Approved for Public Release

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

YB

TREATED EFFLUENT DISPOSAL FACILITY FLOW SHEET

INTRODUCTION

This report presents a novel method of using precipitation, destruction and recycle factors to prepare a process flow sheet. The 300 Area Treated Effluent Disposal Facility (TEDF) will treat process sewer waste water from the 300 Area of the Hanford Site, located near Richland, Washington, and discharge a permittable effluent flow into the Columbia River. When completed and operating, the TEDF effluent water flow will meet or exceed water quality standards for the 300 Area process sewer effluents. A preliminary safety analysis document (PSAD), a preconstruction requirement, needed a process flow sheet detailing the concentrations of radionuclides, inorganics and organics throughout the process, including the effluents.

A PSAD usually includes a flow sheet, a requirement of Regulatory Guide 3.26 (NRC 1975), showing "the process, materials and heat balances and instrumentation." The flow sheet should provide estimates of stream flow quantities, activities, compositions, and properties (i.e. temperature, pressure, specific gravity, pH and heat transfer rates). Preparing a flow sheet with all of the information for the components was necessary to complete the safety document.

Previous flow sheets did not provide detailed information for each flow stream of the concentrations of radionuclide, inorganic and organic components. For radionuclide, inorganic and organic components, precipitation factors, destruction factors, and two recycle factors were needed to estimate stream flow quantities for the TEDF. The factors could then be entered on a computer spread sheet and equations would estimate the steady state concentrations of all of the components in the facility. The factors would also provide a convenient method for improving the accuracy of the flow sheet as the facility begins to operate and the factors reflect operating data.

As the facility begins to operate, data from process samples can be used to provide better estimates of the factors, the factors can be entered into the flow sheet and the flow sheet will estimate more accurate steady state concentrations for the components. This report shows how the factors were developed and how they were used in developing a flow sheet to estimate component concentrations for the process flows. The report will conclude with how TEDF sample data can improve the ability of the flow sheet to accurately predict concentrations of components in the process.

METHODOLOGY

The TEDF, to be operated by Westinghouse Hanford Company near Richland, Washington, will use best available technology to treat the process sewer waste water flow. Figure 1 shows a simplified schematic of the TEDF process flow streams. The process will use iron-coprecipitation, filtration, ion exchange, ultraviolet-hydrogen peroxide (UV/H₂O₂) destruction and sludge separation technology to further reduce low concentrations of heavy metals, suspended solids, organic compounds, and cyanide. Figure 1 shows a simplified schematic of the TEDF process. The TEDF building contains the main process components of the treatment system: tanks, pumps, ion exchange columns, a filter press, filter units, UV/H₂O₂ units, the control room, men and women change rooms, a lunchroom and the electrical distribution equipment. The clarifier tanks, chemical supply storage tanks, diversion tanks and equalization feed tank are located outside of and adjacent to the TEDF building.

Preparation of the TEDF flow sheet included using a computer spread sheet. During steady state operation, the TEDF flow sheet has four recycle flows (sludge, filter backwash, ion exchange backwash, and filter press filtrate) within the process. The recycle flows presented a challenge for the computer spread sheet because the circular reference of formulas "circ" status indicator will be lighted during spread sheet preparation if the calculations for 2 or more spread sheet cells are dependant on each other. The requirement for noncircular dependent equations was the driving force for developing "factors" to estimate concentrations of components in the recycle flows. The development of factors for the precipitation, filter, ion exchange and UV/H₂O₂ processing operations provided the "novel approach" for developing noncircular equations.

The precipitation factor means the fraction of the influent component that precipitates and exits with the effluent sludge flow. The UV/H₂O₂ factor means the fraction of the influent component destructed by the UV/H₂O₂ units. The filter and ion exchange factors estimate the fraction of the influent component captured by the respective filter units and ion exchange units and recycled during backwash operations of the filter and ion exchange units.

During steady state operations, the TEDF process continuously receives feed from the drain collection sump through the equalization feed tank, heavy metal components precipitate in the clarifiers, the filter units remove residual solids carry over from the clarifiers, the ion exchange columns remove mercury by adsorption on ion specific resins and the UV/H₂O₂ units destruct organic and cyanide compounds. Steady state operation depicts a relationship (set of equations) between the influent, effluents and recycle liquid flows that is both predictable and measurable. Therefore, the factors provide the means to avoid circular equations and, using other process assumption factors, estimate steady state liquid concentrations and flow quantities for the 28 flows in the process.

Laboratory experiments using synthetic and actual process sewer liquids and data from similar operating facilities provided the means to estimate the initial "factors" for the radionuclide, inorganic, and organic components. Where sample data is lacking, conservative factors using engineering judgement were used. In the laboratory, ferric chloride, sodium hydroxide, and a high-molecular-weight anionic polymer added to solutions simulating TEDF feed flows provided data of the concentrations in the supernate and sludge after settling of the solids. Dividing the sludge concentration by the initial solution concentration gives the precipitation factor for each component. Similar applications using the ferric chloride precipitation process suggest that a recycle rate of 20 kg of sludge solids per kg of new solids formed in the feed

Figure 1. Simplified Schematic of the 300 Area Treated Effluent Disposal Facility.

39211107.1

flow enhances metals removal and sludge settleability. Similarly, laboratory data from ion exchange column mercury removal simulation, simulated filtration and organic destruction using ultraviolet light with hydrogen peroxide additions provided estimates of the factors for these unit processes.

Equations in the spread sheet, placed in the spread sheet to estimate concentrations for the flows in the TEDF process, use the factors, data from similar applications and process assumptions to calculate the steady state concentrations. Figure 2 shows an example calculation for estimating ^{90}Sr flow quantity in liquid flow from the clarifiers to the filters (Flow #5). The example demonstrates the use of factors and process flow assumptions. The quantity in Flow #5 includes unprecipitated ^{90}Sr , a filter backwash quantity, an ion exchange backwash quantity, a backwash solution quantity, and minus a quantity contained in the solution mixed with the sludge effluent. Values for the quantities are also shown in Figure 2. This example uses three factors to estimate the flow quantity in the clarifier overflow: the precipitation factor, the filter backwash factor, and the IX backwash factor.

Figure 3 shows a sample calculation for estimating the destruction and effluent flow quantity ($4,300 \mu\text{g}/\text{min}$) of acetone within the UV/ H_2O_2 Oxidation units. The flow sheet contains equations for calculating the quantity of hydrogen peroxide added to the flow entering the UV/ H_2O_2 . The reaction equation (Figure 3) shows that 8 moles of hydrogen peroxide are needed for every mole of acetone and the reaction yields 3 moles of carbon dioxide and 11 moles of water. The flow sheet contains reaction equation information for all of the organics including the inorganics (CN^- , NO_2^- , and S^-), which are oxidized in the UV/ H_2O_2 Oxidation units. The byproducts of acetone oxidation are carbon dioxide and water. Carbon dioxide leaves the solution as a gas while the water from the reaction remains in the solution. The oxidation of some organics produces other ions (NO_3^- , Cl^- , F^- and SO_4), which remain in solution and flow with the effluent flow to the river.

RESULTS

The fully developed flow sheet for the TEDF contains factors for 15 radionuclides, 42 inorganics and 22 organic compounds. The spread sheet containing the flow sheet includes all of the flow values, the equations and the factors for 28 flows. Tables 1 and 2 display a sampling of the factors and concentrations for the primary radionuclide, inorganic and organic compounds. For example, a feed concentration for ^{137}Cs of 46 pCi/L results in a waste water effluent flow concentration of 45.5 pCi/L and a sludge concentration of 897 pCi/L.

Using a spread sheet for the process flow sheet benefits many groups other than the process engineering group. Other organizations can use the spread sheet by replacing the feed stream values with different values. The spread sheet responds by estimating new concentration values based on the new feed values. Changing the spread sheet values for the factors also changes the concentration values. The safety analysis group can use the flow sheet to estimate concentrations when accident or bounding source term values replace the feed values. Advanced engineering groups can use the spread sheet to predict the effects of changing the factors or for parametric studies involving a variety of feed stream concentration changes. Health Physics groups can use the spread sheet to estimate effluent stream concentrations

Figure 2. Sample Calculations for the
Clarifier Effluent Flow (Flow #5)

	⁹⁰ Sr pCi/min
Flow #5 = Unprecipitated 1,230 pCi/min * (1-.25 ^a)	+923
- Product Sludge Loss 923 pCi/min * (.482/1363)	- .3
+ Filter Recycle 1230 pCi/min * .02 ^b	24.6
+ IX Recycle 1230 pCi/min * .0001 ^c	.1
+ Solution Recycle	<u>42.6</u>
Flow #5 ⁹⁰ Sr	990 pCi/min

^aPrecipitation factor

^bFilter backflush factor

^cIX backflush factor

Figure 3. Sample Calculation
Acetone Destruction in the UV/H₂O₂ Oxidation Unit

Quantity in Flow #8, Flow into the UV/H₂O₂ Oxidation Unit

Unprecipitated - Sludge Loss - IX Adsorbed Loss	Flow #8
86,100 41.7 0	= 86,060 µg/min

UV/H ₂ O ₂ Destruction	Quantity in Effluent
86,060 µg/min * (1 - .95 ^a) =	4,300 µg/min

Acetone Destruction Reaction

a	Acetone destruction factor
UV	Ultraviolet
H ₂ O ₂	Hydrogen peroxide

Table 1. Typical Factors for Radionuclides
Inorganic and Organic Compounds

Description	Precipitation Factor	Filter Backwash Factor	Ion Exchange Backwash Factor	UV/H ₂ O ₂ Destruction Factor
Radionuclides				
⁹⁰ Sr	.25	.02	.0001	0
¹³⁷ Cs	.01	.02	.01	0
¹⁴⁷ Pm	.01	.02	.01	0
²⁴¹ Am	.95	.02	.01	0
Inorganics				
Al	.95	.02	.01	0
CN ⁻	.95	.02	.01	.49
Hg	.05	.02	.01	.949
Zn	.95	.02	.01	0
Organics				
Bis(ethyl- hexyl)phthalate	0	.05	.05	.963
Chlorodifluoro methane	0	.05	.05	.95
Methylene Chloride	0	.05	.05	.95

Table 2. Partial List of Flow Sheet Values				
Description	Units	Feed to the TEDF	TEDF Effluent to the River	TEDF Sludge Effluent
Form		Liquid	Liquid	Semi-Liquid
Flow	L/min	1230	1230	.653
Temperature	°C	10	13.2	23
Specific Gravity	g/cc	1.0	1.0	1.03
Radionuclides				
⁹⁰ Sr	pCi/L	1.0	.749	47.1
¹³⁷ Cs	pCi/L	46	45.5	897
¹⁴⁷ Pm	pCi/L	9	8.9	175
²⁴¹ Am	pCi/L	.6	.03	1,070
Inorganics				
Al	μg/L	418	20.9	74,800
CN ⁻	μg/L	50	2.37	89,400
Hg	μg/L	3	.003	284
Zn	μg/L	211	10.5	378,000
Organics				
Bis(ethyl hexyl)phthalate	μg/L	80	2.96	53.4
Chlorodifluoro methane	μg/L	20	.999	13.3
Methylene Chloride	μg/L	5.1	.255	3.4

TEDF-300 Area Treated Effluent Disposal Facility.

when plant conditions change. In addition, process engineering can study the effect of changing parameters for both current and future equipment configurations on the product and effluent values.

The spread sheet allows process engineering to predict process performance and to improve estimates as better sampling data becomes available. When estimated values are different than sample results, changing the factors will make the spread sheet a more accurate estimating tool for the process. Also, laboratory analysis of new specie allows process engineering to update the spread sheet by inserting the new compounds along with estimates of the factors, molecular weight, and destruction products if the new compound reacts in the UV/H₂O₂ Oxidation unit. Thus, the spread sheet becomes a better tool as more data becomes available on the process.

In conclusion, a computer spread sheet for the TEDF uses factors based on feed concentrations to estimate stream concentrations for radionuclide, inorganic and organic compounds. The factors are an improved method for estimating flow concentrations in the TEDF process. The process flow sheet satisfies the requirements for the safety analysis document. The computer spread sheet contains the flow values, equations and factors. This spread sheet can be used by many groups to study the effluent treatment process. The spread sheet can be updated as better sample analysis of the flow concentrations become available.

REFERENCES

- NRC, 1975, *Standard Format and Content of Safety Analysis Reports for Fuel Processing Plants*, Regulatory Guide 3.26, U.S. Nuclear Regulatory Commission, Washington, D.C.

**DATE
FILMED**

9/21/93

END