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Process Modeling for the Integrated Nonthermal Treatment System (INTS) Study

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ABSTRACT

This report describes the process modeling done in support of the Integrated Nonthermal Treatment System (INTS) study. This study was performed to supplement the Integrated Thermal Treatment System (ITTS) study and comprises five conceptual treatment systems that treat DOE contract-handled mixed low-level wastes (MLLW) at temperatures of less than 350°F. ASPEN PLUS, a chemical process simulator, was used to model the systems. Nonthermal treatment systems were developed as part of the INTS study and include sufficient processing steps to treat the entire inventory of MLLW. The final result of the modeling is a process flowsheet with a detailed mass and energy balance. In contrast to the ITTS study, which modeled only the main treatment system, the INTS study modeled each of the various processing steps with ASPEN PLUS, release 9.3-1. Trace constituents, such as radionuclides and minor pollutant species, were not included in the calculations.

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Process Modeling for the Integrated Nonthermal Treatment System (INTS) Study

1. INTRODUCTION

This report summarizes mass and energy balance calculations made for conceptual treatment systems analyzed by the Integrated Nonthermal Treatment System (INTS) study. The INTS study was a follow-on to the Integrated Thermal Treatment System (ITTS) study, wherein 19 different conceptual thermal treatment systems were analyzed for applicability to contact-handled mixed low-level radioactive waste (MLLW). The ITTS study Technical Support Group (TSG) reviewed the conclusions of the ITTS study and recommended that, to investigate all methods of treating the MLLW, some systems incorporating nonthermal treatment methods should also be analyzed. This report documents the process modeling only; neither process selection nor technological risks are discussed. More detailed descriptions of these issues are contained in the final report for the INTS study (Biagi et al., 1997).

2. TECHNICAL APPROACH

Nonthermal methods for waste treatment are perceived by many to offer advantages over thermal methods in many areas, including safety, environmental emissions, and cost. The INTS study used the same analysis techniques as used in the ITTS study. For the sake of brevity, these techniques are not repeated here, but may be obtained in the respective references.

The ITTS study analyzed a total of 19 different systems; however, because nonthermal methods are not as mature as thermal methods for waste destruction, it was difficult to identify this many nonthermal systems for analysis. Consequently, only five nonthermal systems were analyzed. These are summarized in Table 2-1 and will be described in Section 4. Detailed descriptions are found in the INTS final report.

Table 2-1. Systems included in the integrated nonthermal treatment system study.

System Designation	System Description
1	Grout Debris Case - mediated electrochemical oxidation of organic liquids and sludges; vacuum thermal desorption of process residue, inorganic sludges, and soil; grout stabilization of untreated debris and residual solids; polymer stabilization of salts and residual sludges
2	Desorption Case - catalytic wet oxidation of organic liquids and sludges; vacuum thermal desorption of process residue, inorganic sludges, debris, and soil; grout stabilization of residual solids; polymer stabilization of salts and residual sludges
3	Wash Case - mediated electrochemical oxidation of organic liquids and sludges; aqueous wash of process residue, inorganic sludges and soil; pressure wash of debris; grout stabilization of residual solids; polymer stabilization of residual sludges and salts
4	Acid Digestion Case - phosphoric/nitric acid digestion of organic liquids and sludges and soft debris; vacuum thermal desorption of process residue and inorganic sludges; aqueous wash of soil; high pressure wash of open debris; grout stabilization of complex debris; phosphate bonded ceramic stabilization of residual solids and salts
5	Catalytic Wet Oxidation Case - catalytic wet oxidation of organic liquids and sludges and soft debris; vacuum thermal desorption of process residue and inorganic sludges; aqueous wash of soil; high pressure wash of open debris; grout stabilization of complex debris and residual solids; polymer stabilization of salts and residual sludges

3. INPUT WASTE CHARACTERISTICS

As with the ITTS study, the INTS study used a waste stream that was characteristic of all MLLW in the DOE system. The waste stream considered was identical to that considered in the ITTS study and the input feed rate of waste to the system¹ was therefore the same as in the ITTS study. In the ITTS study, two thirds of the waste was treated by a single thermal process, such as incineration. For the INTS wastes, a variety of processes was required to treat the same waste. Thus in the INTS the wastes were categorized differently than in the ITTS study. This change in waste categories was one recommendation of the TSG. The waste categories used in the INTS study are shown in Table 3-1.

Table 3-1. Input waste categories for the integrated nonthermal treatment system study.

Waste Category	Designation	Feed Rate (lb/h)	Waste Description
Aqueous waste	1000	60.8	Water, heavy metals
Organic liquids, sludges	2000/3000	185.4	Organic sludge, oil, organic liquids, aqueous organics
Process residue, inorganic sludges	3000	1007.2	Inorganic sludge, cemented organic and inorganic sludge, absorbed liquids, concrete
Salt waste	3000	6.6	Halide, nitrate, and sulfate salts
Bulk Soil	4000	328.5	Soil/dirt
Soft debris	5000	434.8	Paper, plastic, FRP boxes, cloth, cardboard
Complex debris	5000	177.4	Metal drums, bulk metals
Open debris	5000	80.4	Misc. glass
Bulk metal	5000	462.1	Bulk nontoxic metals, metal drums
Special waste	6000	154.9	U and Be compounds, labpacks, batteries, etc.
Mercury Waste	7000	2.5	Bulk mercury
Lead waste	7000	26	Lead shielding, leaded rubber
Total		2927	

¹ The Basis for the ITTS study was a nominal 2000 lb/h waste throughput in the main thermal treatment subsystem. The amount of waste that necessarily accompanies this waste is as follows: metallic waste - 149 lb/h; metal to decontamination - 468 lb/h; lead waste - 26 lb/h; mercury waste - 50 lb/h; aqueous waste - 80 lb/h; special wastes - 153 lb/h; and halide salts - 1 lb/h, for a total of 2927 lb/h treated by the system.

More detailed information concerning each of these waste streams can be found in INTS final report. In order to perform mass balance calculations it was necessary to compile detailed waste input tables for each of the waste categories.

4. SYSTEM DESCRIPTIONS

This section provides brief descriptions of the five processing systems. More detailed descriptions of these systems and process flow diagrams (PFDs) are available in the INTS final report. It should be noted that the waste treatment technologies investigated in the INTS study are less technologically mature than the technologies investigated in the ITTS study. Consequently, the systems in the INTS study may undergo some refinement as further developments are made in nonthermal treatment technologies. The system descriptions provided herein can be only as descriptive of the state-of-the-art as it is understood at the time of the INTS study.

Certain subsystems are common to all of the processing systems considered in the INTS study. These subsystems are described below.

Receiving and Preparation. All INTS systems would necessarily incorporate a subsystem to receive waste and this subsystem would be the same for all of the systems in the INTS study. Because the treatment technologies in the INTS study can usually treat only specific wastes, receiving and preparation would be especially important for nonthermal systems. The MLLW would need to be sorted into numerous waste categories for treatment by the different nonthermal treatment technologies contained within the various INTS systems. Receiving and preparation includes unloading of the waste from storage containers, radioactive assay of the incoming waste, remote sorting, and, where appropriate, size reduction and shredding.

Aqueous Waste Treatment Subsystem. This subsystem would be identical for any of the systems in the INTS study. Aqueous waste treatment includes acid neutralization, removal of immiscible organics, precipitation of metals and concentration (evaporation) of scrubber bottoms. Photolytic UV oxidation is used for destruction of organics. Hydrogen peroxide (H_2O_2) and ozone (O_3) are converted to hydroxyl radicals ($OH\cdot$) that combine with the organics to form CO_2 and H_2O .

Metal Decontamination Subsystem. Bulk surface contaminated metals are decontaminated by abrasive blasting. Water and contaminants removed from the metal are sent for aqueous treatment; decontaminated metal is sent for certification and possible recycle within the DOE complex.

Special Waste Treatment Subsystem. As with the ITTS study, a certain portion of the waste is expected to be so diverse as to require treatment by methods that have yet to be identified. The treatment method or methods to be used in the special waste treatment subsystem will be defined as processes become available to treat these waste streams.

Mercury Amalgamation Subsystem. The bulk (elemental) mercury in the MLLW and mercury that can be separated from the rest of the MLLW is treated by amalgamation, wherein a stable copper-mercury amalgam is formed.

Lead Recovery Subsystem. The lead recovery subsystem separates different lead waste types. Lead brick or sheet is decontaminated by abrasive blasting. Lead with entrained contamination, such as leaded rubber gloves and similar leaded materials, is stabilized in grout.

Air Pollution Control Subsystem. Offgas from all subsystems is treated by the air pollution control subsystem. The gas is filtered to remove solids and fines and then is treated by a gas phase corona reactor which uses high voltage to destroy dilute gas-phase organics. The offgas is scrubbed with a caustic

solution and the scrubber solution sent to aqueous waste treatment. Mist is eliminated from the offgas which is filtered and released.

4.1 System 1—Grout Debris Case

Organic destruction subsystem. In System 1, mediated electrochemical oxidation (MEO) is used for organic destruction. The MEO process combines a dilute stream of organic liquid waste in an electrolyte (the anolyte) containing Ag^{2+} ions and nitric acid (HNO_3). The Ag^{2+} ions destroy the organic compounds by oxidation and in the process the silver is reduced to Ag^+ . As the electrolyte passes through an electrolytic cell, the Ag^{2+} ions are regenerated at the anode to continue the destruction of organic compounds. Carbon dioxide is produced from organics in the anolyte, while water is produced from oxidation of hydrogen ions (H^+) at the cathode. Silver is recycled from the salt (AgCl) that results from the process and nitric acid is recycled from the nitrous acid (HNO_2) byproduct. The sodium chloride (NaCl) solution from silver recovery is sent to the aqueous waste treatment subsystem. Offgas that results from organic destruction and nitric acid recovery is treated by the air pollution control subsystem.

Process residue and inorganic sludge treatment subsystem. In System 1, process residue and inorganic sludge is treated by a vacuum desorption process which subjects the waste to a high vacuum (1 psia) and temperatures of approximately 550°F. The volatile material driven off is condensed; the water fraction is sent to aqueous waste treatment and the organic phase is sent to organic destruction. Noncondensable gases are treated by the offgas treatment subsystem. The solid residue is treated by a mercury leaching process and then treated by the polymer stabilization subsystem.

Bulk soil treatment subsystem. System 1 treats bulk soils by vacuum desorption described above.

Polymer stabilization subsystem. In System 1, polymer stabilization is used to treat the solid residue from vacuum desorption of process residue and inorganic sludge, salt waste in the MLLW, and salt sludge that results from the aqueous waste treatment subsystem. The incoming waste is dried to 5% moisture content, and then combined with a 1:1 ratio of polyethylene in a stabilization process. Recovered water is sent to aqueous waste treatment.

Grout stabilization subsystem. Grout stabilization, the combination of cement and waste in a 2:1 ratio, is used in System 1 as direct treatment for soft, open, and complex debris. Bulk soils, after treatment by vacuum desorption, and lead with entrained contamination are also treated by grout stabilization.

4.2 System 2—Desorption Case

System 2 is very similar to System 1, except for the treatment of organic liquids and sludges and soft, open, and complex debris.

Organic destruction subsystem. In System 2, catalytic wet oxidation is used for oxidation of the organic liquid and sludges. Catalytic wet oxidation uses Fe^{3+} in a catalyzed acid solution (60% FeCl_3 and 3.6% HCl in a water solution with 0.001 M of catalysts) for oxidation and destruction of organics. Oxygen is used to regenerate Fe^{3+} from the Fe^{2+} produced in the organic oxidation reaction. The slurry from the reactor is filtered; the acid solution is recycled to the reactor and the solids are neutralized by the addition of caustic. Catalytic wet oxidation of organics results in offgas, salt solution, and solid residue, which are sent for treatment by the air pollution control, aqueous waste treatment, and polymer stabilization subsystems, respectively. The reactor operates at 301°F and 20 psig.

Soft, open, and complex debris treatment subsystem. System 2 treats soft, open, and complex debris by vacuum desorption which is described above. Soft debris is treated slightly differently; vacuum desorption of soft debris is performed at 250°F to allow desorption of the organics and to avoid melting of the plastic waste matrix itself.

4.3 System 3—Wash Case

Organic destruction subsystem. System 3 treats organic liquids and sludges with MEO which is described above for System 1.

Process residue and inorganic sludge treatment subsystem. In System 3, process residue and inorganic sludge are treated by an aqueous wash process, which washes organics from the waste with a solution of water and surfactant. Caustic (NaOH) is added to the wash water to neutralize acids, such as chlorides. The precipitate is filtered and then sent for treatment by polymer stabilization. Organics washed from the waste are separated from the wash water and sent to the organic destruction subsystem and the solid matrix is treated by polymer stabilization.

Bulk soil treatment subsystem. System 3 treats bulk soils by aqueous wash described above. Washed soil is dried and then sent to the grout stabilization subsystem. Moisture removed from the soil is treated by the aqueous waste treatment subsystem.

Soft debris treatment subsystem. Soft debris in System 3 is treated by low-pressure wash. Modeling of low-pressure wash is similar to modeling of aqueous wash. Washed debris is sent to the grout stabilization subsystem. The wash water with the washed organics is treated by the organic destruction subsystem.

Open debris treatment subsystem. Open debris is also treated by high pressure wash discussed above.

Complex debris treatment subsystem. Complex debris is also treated by low-pressure wash discussed above.

Polymer stabilization subsystem. Polymer stabilization is used to treat the solid residue from aqueous wash of process residue and inorganic sludge, salt waste in the MLLW, and salt sludge that results from the aqueous waste treatment subsystem.

Grout stabilization subsystem. Grout stabilization, the combination of cement and waste in a 2:1 ratio, is used in System 3 to treat the solid residue from washing of bulk soils, lead with entrained contamination, and soft, open, and complex debris.

4.4 System 4—Acid Digestion Case

Organic destruction subsystem. System 4 treats organic liquids and sludges with an acid digestion process, which uses a combination of phosphoric and nitric acid at 392°F and 14.7 psia to oxidize organics. The phosphoric acid serves mainly to keep the nitric acid from evaporating; the oxidation of the organics is due to the action of the nitric acid. Because phosphoric acid is not consumed by the reaction, it was not necessary to include it in the mass balance modeling. Oxygen is added to convert the nitrous acid byproduct (HNO_2) back to nitric acid which is recycled to the process. The offgas is neutralized with

caustic (NaOH) and the treated offgas, liquid, and solid residue are sent for treatment by the air pollution control, aqueous waste treatment, and phosphate-bonded ceramic stabilization subsystems, respectively.

Process residue and inorganic sludge treatment subsystem. In System 4, process residue and inorganic sludge is treated by vacuum desorption process, the same process used in Systems 1 and 2 and described above. Solid residue is treated by the phosphate-bonded ceramic stabilization subsystem.

Bulk soil treatment subsystem. System 4 treats bulk soils by aqueous wash, the same treatment used in System 3 and described above. The dried soil is treated by the phosphate-bonded ceramic stabilization subsystem.

Soft debris treatment subsystem. Soft debris in System 4 is treated by acid digestion described above.

Open debris treatment subsystem. Open debris is treated by high pressure wash, the same treatment used in System 3 and discussed above.

Complex debris treatment subsystem. Complex debris in System 4 is sent directly to grout stabilization, the same treatment used in System 1 and described above.

Phosphate-bonded ceramic stabilization subsystem. In System 4, solid residue from acid digestion of organic liquids and sludges and soft debris, vacuum desorption of process residue and inorganic sludge, aqueous wash of bulk soil, and salt sludge that results from the aqueous waste treatment subsystem is treated by phosphate-bonded ceramic stabilization. This process gives a high strength, low porosity solid that is an alternative to polymer stabilization.

Polymer stabilization subsystem. Polymer stabilization is used to treat the soluble salt waste in the MLLW.

Grout stabilization subsystem. Grout stabilization is used to treat the solid residue from washing of open debris, lead with entrained contamination, and complex debris.

4.5 System 5—Catalytic Wet Oxidation Case

Organic destruction subsystem. System 5 treats organic liquids and sludges by catalytic wet oxidation, the same process as is used in System 2. Catalytic wet oxidation uses Fe^{3+} in a catalyzed acid solution (60% FeCl_3 and 3.6% HCl in a water solution with 0.001 M of catalysts) for destruction of organics. Oxygen is added to regenerate Fe^{3+} from the Fe^{2+} byproduct. Caustic is added to neutralize acids; the precipitate is filtered from the liquid. The resulting offgas, salt solution, and solid residue are sent for treatment by the air pollution control, aqueous waste treatment, and polymer stabilization subsystems, respectively.

Process residue and inorganic sludge treatment subsystem. In System 5, process residue and inorganic sludge is treated by vacuum desorption process, the same process used in Systems 1, 2, and 4 and described above. Solid residue is treated by the polymer stabilization subsystem.

Bulk soil treatment subsystem. System 5 treats bulk soils by aqueous wash, the same treatment used in Systems 3 and 4 and described above. The dried soil is treated by the grout stabilization subsystem.

Soft debris treatment subsystem. Soft debris in System 5 is treated by catalytic wet oxidation described above. Solid residue from this subsystem is sent to grout stabilization.

Open debris treatment subsystem. Open debris is treated by high pressure wash, the same as is Systems 3 and 4 discussed above.

Complex debris treatment subsystem. Complex debris in System 5 is sent directly to grout stabilization, the same treatment used in Systems 1 and 4 and described above.

Polymer stabilization subsystem. In System 5, polymer stabilization is used for treatment of solid residue from catalytic wet oxidation of organic liquids and sludges, vacuum desorption of process residue and inorganic sludge, salt waste, and salt sludge that results from the aqueous waste treatment subsystem.

Grout stabilization subsystem. Grout stabilization is used to treat the solid residue from catalytic wet oxidation of soft debris, washing of soil and open debris, lead with entrained contamination, and complex debris.

5. MODELING DESCRIPTIONS AND RESULTS

5.1 Background

This work is an extension of the modeling that was performed for the 19 systems of the ITTS study. For mass and energy balance calculations, the database of MLLW used herein was the same as that used in the ITTS study. However, these wastes were categorized slightly differently for this study as mentioned in Section 3.

ASPEN PLUS was used to model the INTS systems. ASPEN PLUS is a chemical process simulator that allows mass and energy balances to be obtained from user-defined process flow diagrams. The code can model most unit operations in chemical engineering, such as chemical reactors, flow splitters, separators, mixers, distillation columns, etc. In addition, ASPEN PLUS allows for detailed feedback loops and design specifications that enable the user to specify certain design conditions and have the appropriate reaction conditions or feed requirements calculated by the code. Appendix B includes the ASCII input files for the ASPEN PLUS models for the INTS study. More details concerning ASPEN PLUS are found in the ITTS modeling report (Liebelt et al., 1995).

5.2 Technical Approach

As with the ITTS study, the objective of the ASPEN PLUS modeling was to achieve a mass balance for each system and to determine the energy requirements for treating the waste. These results would be used to make estimates on the life-cycle costs of MLLW treatment and the effluent from each system.

Because only five different systems were considered in the INTS study, compared to 19 systems in the ITTS study, it was decided to model each subsystem in the INTS study. ASPEN PLUS calculations for the ITTS study did not consider all of the subsystems because of the large number of systems being considered. In addition, modeling of the individual subsystems was necessary in the INTS study because they were more diverse than the subsystems of the ITTS study and the results from the mass balances would have more of an impact on the total system mass balance.

The special waste treatment subsystem was included in the systems modeled for the INTS study. However, consistent with the ITTS study, no calculations were performed on the special waste because its treatment has not been specified.

Flow diagrams generated by ASPEN PLUS for each of the five INTS models are included in Appendix A. These diagrams correspond to the respective PFDs for the INTS study (Biagi et al., 1996). The code had some restrictions that prevented the model from corresponding exactly to the PFDs. For example, ASPEN PLUS allows only one product stream from a reactor, which means that a chemical reactor with several output streams in the PFD must be modeled by two ASPEN PLUS blocks: a chemical reactor and a separator. The complexity of the systems being modeled also necessitated the use of simplifying assumptions to keep the calculation scheme manageable. Recycling of streams within a subsystem was often not included, particularly of aqueous waste. The overall balance remains correct, but more waste is sent to aqueous treatment than is shown in the PFDs. Modeling of the MEO subsystem also combines several operations that are separate in the PFDs, such as combining the anolyte and catholyte offgas streams. In some cases, it was possible to combine several unit operations within a single block, such as the leaching of solid waste with water.

The mass balance summary table (Table 6-1; found in Section 6) summarizes the calculations for the five INTS models. As with the ITTS study, it was not deemed necessary to provide comprehensive tables of all streams considered in the ASPEN PLUS models. The detailed stream data were used to compile the summary tables. An abbreviated form of the comprehensive stream data (including major waste constituents such as organics, water, solids and gases, as well as data for each chemical species considered) will be provided in a separate document as a supplement to the PFDs.

6. OVERALL MASS AND ENERGY BALANCES

Detailed results from the ASPEN PLUS modeling were output to a spreadsheet file (Lotus 1-2-3 format). Because this table was much more comprehensive than was necessary for evaluating the mass balance, total mass flow rates from this file were linked to another spreadsheet file (Excel format). The Excel file performed all of the necessary mass balance calculations. Results of the calculations are shown in Table 6-1.

Because the entire mass balance is performed by ASPEN PLUS, the closure on the mass balance is the same as that specified in the model input. This tolerance is usually 0.0001 or tighter. The INTS models included flow rates of approximately 10,000 lb/hr, which results in the mass balance closing to within 1 lb.

Also included in Table 6-1 are calculations to determine the amount of mass reduction and volume reduction that the wastes might undergo if processed by these systems. The mass reduction for the INTS systems (mass waste input/mass solids output) ranges from approximately 0.61 to 0.78. Thus, the mass of solid material that leaves the processing systems exceeds the mass of waste treated. The volume reduction ratio (volume waste input/volume solids output), which ranges from 1.05 to 1.24, indicates that processing of the waste results in a smaller volume of solids to be disposed. This apparent dichotomy (a larger processed mass, but a smaller processed volume) is acceptable when it is understood that the density of the solidified waste is much greater than that of the unprocessed waste.

Calculated energy requirements of the systems INTS study are seen in Table 6-2. Electrical and thermal energy requirements are converted to energy costs using an assumption of \$0.05/kWh and \$2.00/MMBtu. Energy costs range from about \$2 per hour to over \$21 per hour, which is less than 1% of the total treatment costs.

Table 6.1

INTS Mass Balance Summary

	A	C	D	E	F	G
1						
2	System	System 1	System 2	System 3	System 4	System 5
3		Grout Debris	Desorption	Wash	Acid Digestion	CWO
4	WASTE INPUT					
5	Aqueous Waste (1000)	60.8	60.8	60.8	60.8	60.8
6	Organic Liquids, Sludges (2000/3000)	185.4	185.4	185.4	185.4	185.4
7	Residue, Inorg. Sludge (3000)	1007.2	1007.2	1007.2	1007.2	1007.2
8	Salt Waste (3000)	6.6	6.6	6.6	6.6	6.6
9	Bulk Soils (4000)	328.5	328.5	328.5	328.5	328.5
10	Debris - Soft (5000)	434.8	434.8	434.8	434.8	434.8
11	Debris - Complex (5000)	177.4	177.4	177.4	177.4	177.4
12	Debris - Open (5000)	80.4	80.4	80.4	80.4	80.4
13	Bulk Metal (5000)	462.1	462.1	462.1	462.1	462.1
14	Special (6000)	154.9	154.9	154.9	154.9	154.9
15	Mercury waste (7000)	2.5	2.5	2.5	2.5	2.5
16	Lead Waste (7000)	26.0	26.0	26.0	26.0	26.0
17	Total Input Waste	2926.6	2926.6	2926.6	2926.6	2926.6
18						
19	PROCESS INPUTS					
20						
21	Hg Amalgamation Subsystem					
22	Waste Input					
23	Mercury waste (7000)	2.5	2.5	2.5	2.5	2.5
24	Process Inputs					
25	additives (copper)	1.9	3.6	1.8	1.8	1.9
26	Input from other subsystems					
27	process residue/inorganic sludge	0.1	0.1		0.1	0.1
28	debris treatment		2.5			
29	Total Subsystem Input	4.5	8.8	4.3	4.5	4.5
30						
31						
32	Air Pollution Control Subsystem					
33	Waste Input					
34	Process Inputs					
35	Air: O2	0.0	0.0	0.0	10.6	0.0
36	N2	0.0	0.0	0.0	34.8	0.0
37	NaOH	0.3	1.1	2.5	0.0	2.9
38	H2O	0.3	1.1	2.5	0.0	2.9
39	Input from other subsystems					
40	aqueous waste treatment	8.8	9.1	27.1	9.0	9.5
41	organic destruction - offgases	580.5	652.6	799.8	542.4	561.6
42	process residue/inorganic sludge	79.9	79.9		79.9	79.9
43	debris treatment		55.2		764.8	781.8
44	bulk soil treatment	26.1	26.1		0.0	0.0
45						
46	Total Subsystem Input	695.8	825.0	831.9	1441.5	1438.5
47						

Table 6.1

INTS Mass Balance Summary

	A	C	D	E	F	G
2	System	System 1	System 2	System 3	System 4	System 5
3		Grout Debris	Desorption	Wash	Acid Digestion	CWO
48	Aqueous Waste Treatment Subsystem					
49	Waste Input					
50	Aqueous Waste (1000)	60.8	60.8	60.8	60.8	60.8
51	Process Inputs					
52	Air (for ozone generation)	3.5	3.8	8.6	3.8	3.9
53	H2O2	0.6	0.6	1.4	0.6	0.6
54	H2O	24.1	45.8	0.5	7.6	9.0
55	NaOH	24.1	45.8	0.5	7.6	9.0
56	Input from other subsystems					
57	APC - moisture	0.0	0.0	0.0	0.0	0.0
58	APC - concentrate	0.3	2.0	5.0	0.1	5.2
59	process residue/inorganic sludge	349.6	349.6	0.0	349.6	349.6
60	debris treatment		32.4	129.3	432.6	406.9
61	bulk soil treatment	40.7	40.7	355.4	355.4	355.4
62	polymer stabilization	267.5	265.7	456.7	238.3	265.5
63	metal decontamination	126.2	126.2	126.2	126.2	126.2
64	organic destruction - liquids	238.9	380.3	320.3	420.3	386.1
65	organic destruction - salts	108.6		178.7		
66	Total Subsystem Input	1244.8	1353.8	1643.3	2002.9	1978.1
67						
68	Process Residue and Inorganic Sludge Treatment Subsystem					
69	Waste Input					
70	Residue, Inorg. Sludge (3000)	1007.2	1007.2	1007.2	1007.2	1007.2
71	Process Inputs					
72	oxygen					
73	N2 sweep gas	80	80		80	80
74	H2O	306	306	151.05	306	306
75	NH3					
76	NaOH					
77	Input from other subsystems					
78	Pb recovery	13.0	13.0	13.0	13.0	13.0
79	organic destruction					
80	Total Subsystem Input	1406.1	1406.1	1171.3	1406.1	1406.1
81						
82	Debris Treatment Subsystem					
83	Waste Input					
84	Debris - Soft (5000)		434.76	434.76	434.76	434.76
85	Debris - Complex (5000)		177.411	177.411		
86	Debris - Open (5000)		80.4	80.4	80.4	80.4
87	Process Inputs					
88	Acid-in (FeCl3, H2O, HCl)					15.2
89	HNO3				42.8	
90	oxygen				791.7	766.7
91	N2 sweep gas		54.9			
92	H2O		207.9	103.8	49.7	42.9
93	NH3				3.9	
94	NaOH				37.7	30.9
95	Input from other subsystems					
96	Pb recovery					
97	organic destruction					
98	Total Subsystem Input	0.0	955.4	796.4	1441.0	1370.9

Table 6.1

INTS Mass Balance Summary

	A	C	D	E	F	G
2	System	System 1	System 2	System 3	System 4	System 5
3		Grout Debris	Desorption	Wash	Acid Digestion	CWO
99						
100	Grout Stabilization Subsystem					
101	Waste Input					
102	Debris - Soft (5000)	434.8				
103	Debris - Complex (5000)	177.4			177.4	177.4
104	Debris - Open (5000)	80.4				
105	Process Inputs					
106	dry grout material (cement & sand)	1359.6	1290.0	1274.4	365.4	904.3
107	water required for grout	471.5	246.4	498.9	152.4	383.4
108	Input from other subsystems					
109	bulk soil treatment	384.8	384.8	285.5		285.5
110	Pb recovery	5.0	5.0	5.0	5.0	5.0
111	process residue/inorganic sludge					
112	debris treatment		838.2	667.1	82.8	182.2
113	Total Subsystem Input	2913.3	2764.3	2731.0	783.1	1937.8
114						
115	Metal Decontamination Subsystem					
116	Waste Input					
117	Bulk Metal (5000)	462.1	462.1	462.1	462.1	462.1
118	Process Inputs					
119	H2O	94.3	94.3	94.3	94.3	94.3
120	Input from other subsystems					
121	Total Subsystem Input	556.4	556.4	556.4	556.4	556.4
122						
123	Organic Destruction Subsystem					
124	Waste Input					
125	Organic Liquids, Sludges(2000/3000)	185.4	185.4	185.4	185.4	185.4
126	Process Inputs					
127	O2	566.7	701.0	775.6	575.7	604.6
128	HNO3	21.4		28.8	30.9	
129	H2O	33.7	37.8	55.5	58.6	50.7
130	NaOH - gas scrubbing	0.0	37.8	0.0	58.6	50.7
131	Ag recovery	33.7		55.5		
132	H2O2	28.7		47.2		
133	AgNO3	2.9		4.7		
134	Acid-in (FeCl3, H2O, HCl)		9.7			9.3
135	HCl - Ag precipitation	0.0		0.0		
136	NH3	4.0		5.5	2.8	
137	Input from other subsystems					
138	aqueous waste treatment - decanted orgs	32.9	31.5	79.1	31.9	31.9
139	process residue/inorganic sludge	17.0	22.6	45.4	22.6	22.6
140	debris treatment		27.1	0.0		
141	bulk soil treatment	1.6	1.6	16.1	16.1	16.1
142	Total Subsystem Input	928.1	1054.5	1298.7	982.7	971.3
143						
144	Lead Recovery Subsystem					
145	Waste Input					
146	Lead Waste (7000)	26.0	26.0	26.0	26.0	26.0
147	Process Inputs					
148	H2O	13	13	13	13	13
149	Input from other subsystems					
150	Total Subsystem Input	39.0	39.0	39.0	39.0	39.0
151						

Table 6.1

INTS Mass Balance Summary

	A	C	D	E	F	G
2	System	System 1	System 2	System 3	System 4	System 5
3		Grout Debris	Desorption	Wash	Acid Digestion	CWO
152	Polymer Stabilization Subsystem					
153	Waste Input					
154	Salt Waste (3000)	6.6	6.6	6.6	6.6	6.6
155	Process Inputs					
156	polyethylene or phosphate additive	801.1	843.8	788.9	6.6	861.0
157	Input from other subsystems					
158	process residue/inorganic sludge	959.5	953.9	1125.9		953.9
159	aqueous waste treatment - sludge	102.2	125.9	108.1		137.7
160	aqueous waste treatment - concentrate	0.3	2.0	5.0		5.2
161	organic destruction		21.2			23.0
162	bulk soil treatment					
163	debris treatment					
164	APC	0.0	0.0	0.0		0.0
165	Total Subsystem Input	1869.7	1953.3	2034.5	13.2	1987.5
166						
167	Phosphate Bonded Ceramic Stabilization Subsystem					
168	Waste Input					
169	Process Inputs					
170	phosphate additive				1354.0	
171	Input from other subsystems					
172	process residue/inorganic sludge				953.9	
173	aqueous waste treatment - sludge				172.5	
174	aqueous waste treatment - concentrate				0.1	
175	organic destruction				19.4	
176	bulk soil treatment				285.5	
177	debris treatment				160.9	
178	APC				0.0	
179	Total Subsystem Input				2946.3	
180						
181	Bulk Soil Treatment Subsystem					
182	Waste Input					
183	Bulk Soils (4000)	328.5	328.5	328.5	328.5	328.5
184	Process Inputs					
185	H2O	98.55	98.55	328.5	328.5	328.5
186	N2 sweep gas	26	26			
187	Input from other subsystems					
188	Total Subsystem Input	453.1	453.1	657.0	657.0	657.0
189						
190	Special Waste Treatment Subsystem					
191	Waste Input					
192	Special (6000)	154.9	154.9	154.9	154.9	154.9
193	Process Inputs					
194	Input from other subsystems					
195	Total Subsystem Input	154.9	154.9	154.9	154.9	154.9
196						

Table 6.1

INTS Mass-Balance Summary

	A	C	D	E	F	G
2	System	System 1	System 2	System 3	System 4	System 5
3		Grout Debris	Desorption	Wash	Acid Digestion	CWO
197	PROCESS OUTPUTS					
199	Hg Amalgamation Subsystem					
200	Process Outputs	4.5	8.8	4.3	4.5	4.5
201	Output to other subsystems					
202	Total Subsystem Output	4.5	8.8	4.3	4.5	4.5
203						
204	Air Pollution Control Subsystem					
205	Process Outputs					
206	Offgas					
207	O ₂	29.1	35.6	55.1	10.4	30.9
208	N ₂	117.9	165.1	18.9	132.1	84.2
209	NO	0.8	0.7	0.8	0.2	0.7
210	H ₂ O	9.8	1.8	15.2	10.5	3.8
211	CO ₂	537.9	619.8	737.0	1288.0	1313.6
212	HNO ₂	0.0		0.0		
213	total offgas	695.5	823.0	827.1	1441.4	1433.3
214	Output to other subsystems					
215	aqueous waste treatment - salts	0.3	2.0	5.0	0.1	5.2
216	aqueous waste treatment - moisture	0.0	0.0	0.0	0.0	0.0
217	polymer stabilization - metals	0.0	0.0	0.0	0.0	0.0
218	Total Subsystem Output	695.8	825.0	832.1	1441.5	1438.5
219						
220	Aqueous Waste Treatment Subsystem					
221	Process Outputs					
222	aqueous recycle	1100.8	1186.1	1423.9	1789.9	1794.5
223	Output to other subsystems					
224	organic destruction - decanted orgs	32.9	31.5	79.1	31.9	31.9
225	polymer stabilization	102.2	125.9	108.1	172.5	137.7
226	polymer stabilization - concentrate	0.3	2.0	5.0	0.0	5.2
227	APC	8.8	9.1	27.1	9.0	9.5
228	Total Subsystem Output	1245.1	1354.5	1643.2	2003.4	1978.9
229						
230	Process Residue and Inorganic Sludge Treatment Subsystem					
231	Process Outputs					
232	Output to other subsystems					
233	polymer stabilization	959.5	953.9	1125.9	953.9	953.9
234	organic destruction	17.0	22.6	45.4	22.6	22.6
235	aqueous waste treatment	349.6	349.6	0.0	349.6	349.6
236	APC	79.9	79.9	0.0	79.9	79.9
237	grout stabilization	0.0	0.0	0.0	0.0	0.0
238	Hg amalgamation	0.1	0.1	0.0	0.1	0.1
239	Total Subsystem Output	1406.1	1406.1	1171.3	1406.1	1406.1
240						
241	Debris Treatment Subsystem					
242	Process Outputs					
243	Output to other subsystems					
244	polymer stabilization	0.0			160.9	0.0
245	organic destruction	0.0	27.1	0.0	0.0	0.0
246	aqueous waste treatment	0.0	32.4	129.3	432.6	406.9
247	APC	0.0	55.2	0.0	764.8	781.8
248	grout stabilization	0.0	838.2	667.1	82.8	182.2
249	Hg amalgamation		2.5			
250	Total Subsystem Output	0.0	955.4	796.4	1441.0	1370.9

Table 6.1

INTS Mass Balance Summary

	A	C	D	E	F	G
2	System	System 1	System 2	System 3	System 4	System 5
3		Grout Debris	Desorption	Wash	Acid Digestion	CWO
252	Grout Stabilization Subsystem					
253	Process Outputs					
254	grouted product	2913.3	2764.3	2731.0	783.1	1937.8
255	Output to other subsystems					
256	Total Subsystem Output	2913.3	2764.3	2731.0	783.1	1937.8
258	Metal Decontamination Subsystem					
259	Process Outputs					
260	decontaminated metal	430.3	430.3	430.3	430.3	430.3
261	Output to other subsystems					
262	aqueous waste treatment	126.2	126.2	126.2	126.2	126.2
263	Total Subsystem Output	556.4	556.4	556.4	556.4	556.4
264						
265	Organic Destruction Subsystem					
266	Process Outputs					
267	Output to other subsystems					
268	process residue/inorganic sludge	0.0	0.0	0.0	0.0	0.0
269	aqueous waste treatment - water	238.9	380.3	320.3	420.3	386.1
270	aqueous waste treatment - salts	108.6	0.0	178.7	0.0	0.0
271	APC - gases	580.5	652.6	799.8	542.4	561.6
272	polymer stabilization	0.0	21.2	0.0	19.4	23.0
273	Total Subsystem Output	928.1	1054.1	1298.8	982.1	970.8
274						
275	Lead Recovery Subsystem					
276	Process Outputs					
277	lead out	21	21	21	21	21
278	Output to other subsystems					
279	process residue/inorganic sludge	13.0	13.0	13.0	13.0	13.0
280	grout - gloves	5.0	5.0	5.0	5.0	5.0
281	Total Subsystem Output	39.0	39.0	39.0	39.0	39.0
282						
283	Polymer Stabilization Subsystem					
284	Process Outputs					
285	polymer stabilized waste	1602.2	1687.6	1577.8	13.2	1722.0
286	Output to other subsystems					
287	aqueous waste treatment	267.5	265.7	456.7		265.5
288	Total Subsystem Output	1869.7	1953.3	2034.5	13.2	1987.5
289						
290	Phosphate Bonded Ceramic Stabilization Subsystem					
291	Process Outputs					
292	phosphate bonded ceramic stabilized waste				2707.9	
293	Output to other subsystems					
294	aqueous waste treatment				238.3	
295	Total Subsystem Output				2946.3	
296						
297	Bulk Soil Treatment Subsystem					
298	Process Outputs					
299	Output to other subsystems					
300	APC	26.1	26.1	0.0	0.0	0.0
301	aqueous waste treatment	40.7	40.7	355.4	355.4	355.4
302	grout	384.8	384.8	285.5	0.0	285.5
303	organic destruction	1.6	1.6	16.1	16.1	16.1
304	polymer stabilization	0.0	0.0	0.0	285.5	0.0
305	Total Subsystem Output	453.1	453.1	657.0	657.0	657.0

Table 6.1

INTS Mass Balance Summary

	A	C	D	E	F	G
2	System	System 1	System 2	System 3	System 4	System 5
3		Grout Debris	Desorption	Wash	Acid Digestion	CWO
306						
307	Special Waste Treatment Subsystem					
308	Process Outputs.	154.9	154.9	154.9	154.9	154.9
309	Output to other subsystems					
310	Total Subsystem Output	154.9	154.9	154.9	154.9	154.9
311						
321	Reagents Input to Process (density, lb/ft ³)					
322	Cu for Hg amalgamation (557)	1.9	3.6	1.8	1.8	1.9
323	NaOH (133)	58.0	84.7	58.5	104.0	93.4
324	acid solution (FeCl ₃ , H ₂ O, HCl) (~62)	0.0	9.7	0.0	0.0	24.5
325	NH ₃ (45)	4.0	0.0	5.5	6.8	0.0
326	HNO ₃ (94)	21.4	0.0	28.8	73.7	0.0
327	AgNO ₃ (271)	2.9	0.0	4.7	0.0	0.0
328	H ₂ O ₂ (91)	29.2	0.6	48.6	0.6	0.6
329	grout material (126)	1359.6	1290.0	1274.4	365.4	904.3
330	water required for grout (62)	471.5	246.4	498.9	152.4	383.4
331	polyethylene/phosphate ceramic (~80)	801.1	843.8	788.9	1360.6	861.0
332						

Table 6.1

INTS Mass Balance Summary

	A	C	D	E	F	G
2	System	System 1	System 2	System 3	System 4	System 5
3		Grout Debris	Desorption	Wash	Acid Digestion	CWO
333	MASS AND VOLUME REDUCTION CALCULATION					
334	Densities (lb/ft ³)					
335	Input Waste	64	64	64	64	64
336	Soil	67	67	67	67	67
337	Metal (Input)	480	480	480	480	480
338	Metal (Output)	480	480	480	480	480
339	Aqueous Liquid	62	62	62	62	62
340	Slag	187	187	187	187	187
341	Polymerized Salt	80	80	80	80	80
342	Polymerized Ash/Metal/Salt	94	94	94	94	94
343	Polymerized Lime	96.5	96.5	96.5	96.5	96.5
344	Grouted Debris	126.6	126.6	126.6	126.6	126.6
345	Stabilized Hg Amalgam	733.0	733.0	733.0	733.0	733.0
346						
347	Mass Flow Rate Calculation					
348	Mass Solids In (lb/hr, no aqueous)	2865.8	2865.8	2865.8	2865.8	2865.8
349	Mass Grouted Waste Out (lb/hr)	2913.3	2764.3	2731.0	783.1	1937.8
350	Mass Special Waste (not stabilized)	154.9	154.9	154.9	154.9	154.9
351	Mass Metal/Pb Out (lb/hr) clean	451.3	451.3	451.3	451.3	451.3
352	Mass Polymerized Waste Out (lb/hr)	1602.2	1687.6	1577.8	13.2	1722.0
353	Mass Phosphate Bonded Waste Out (lb/hr)				2707.9	
354	Mass Stabilized Hg Amalgam Out	4.5	8.8	4.3	4.5	4.5
355	Total Mass Processed Wastes Out (lb/hr, no metals)	4675	4616	4468	3664	3819
356	Waste Mass Reduction Ratio (In/Out)	0.61	0.62	0.64	0.78	0.75
357						
358	Volumetric Flow Rate Calculation					
359	Volume Solids In (ft ³ /hr)	45	45	45	45	45
360	Volume Grouted Waste Out (ft ³ /hr)	23.0	21.8	21.6	6.2	15.3
361	Volume Special Wastes (not stabilized) (ft ³ /hr)	2.4	2.4	2.4	2.4	2.4
362	Volume Metal/Pb Out (ft ³ /hr)	0.9	0.9	0.9	0.9	0.9
363	Volume Polymerized Waste Out (ft ³ /hr)	17.0	18.0	16.8	0.1	18.3
364	Volume Phosphate Waste Out (ft ³ /hr)				28.8	
365	Vol Stabilized Hg Amalgam Out	0.0	0.0	0.0	0.0	0.0
366	Total Volume Solids Out to Disposal (ft ³ /hr, no metals)	42.5	42.2	40.8	37.6	36.1
367	Volume Metal to Recycle (ft ³ /hr)	0.9	0.9	0.9	0.9	0.9
368	Waste Volume Reduction Ratio (In/Out)	1.05	1.06	1.10	1.19	1.24
369						
370	Total Water Requirements					
371	Aqueous Waste Treatment	24	46	1	8	9
372	Inorganic Sludge Washing / Hg Leaching	306	306	151	306	306
373	Lead Recovery	13	13	13	13	13
374	Debris Treatment / Hg Leaching	0	208	104	50	43
375	Metal Decontamination	94	94	94	94	94
376	Organic Destruction	34	38	55	59	51
377	Soil Washing / Hg Leaching	99	99	329	329	329
378	Air Pollution Control - scrubber water	0	1	3	0	3
379	Water for grout (30 weight %)	471	246	499	152	383
380	Total	1041	1051	1248	1010	1231
381	Total Water Available for Recycle	1101	1186	1424	1790	1795
382	Net Water Generation Rate (recycle - required)	59	135	176	780	564

Table 6.2

Integrated Nonthermal Treatment System Study
Energy Requirements

Energy Requirements of Waste Treatment for Five INTS Systems (Btu/h)						
(basis: 2927 lb/h waste feed)						
		System 1	System 2	System 3	System 4	System 5
	Energy Type	Baseline	Desorption	Wash	Acid Digestion	Combination
NOx removal	cooling water	-78.8E+3		-107.7E+3		
Gas Phase Corona Reactor (GPCR)	electricity	20.6E+3	24.4E+3	22.9E+3	40.3E+3	39.1E+3
Neutral3 - acid gas neutralization	cooling water	-12.1E+3	-52.2E+3	-11.2E+3	-105.1E+3	-98.6E+3
HEPA preheaters	gas	31.6E+3	37.1E+3	37.1E+3	64.4E+3	63.4E+3
Ozone Generation for photo-UV	electricity	1.1E+3	1.2E+3	2.6E+3	1.2E+3	1.2E+3
OH-generator (from O3 and H2O2)	cooling water	-82.2E+3	11.7E+3	-160.1E+3	2.7E+3	1.1E+3
Photo-UV reactor	cooling water	-17.7E+3	-18.2E+3	-42.6E+3	-24.4E+3	-22.8E+3
Ozone decomposition	cooling water	-46.4E+3	-91.6E+3	-2.1E+3	-17.0E+3	-22.2E+3
Salt concentrator (evaporator)	electricity	10.0E+0	43.0E+0	111.0E+0	2.0E+0	112.0E+0
Vacuum thermal desorption of inorganic sludge	gas	540.2E+3	515.6E+3		515.6E+3	515.6E+3
HNO2 recovery	cooling water	-736.0E+3		-1.0E+6	-1.1E+6	
MEO reactor - anode **	electricity	4.6E+6		6.4E+6		
MEO reactor - cathode	cooling water					
MEO reactor - Ag ppt	cooling water					
Ag recovery from MEO process	cooling water	140.4E+3		761.4E+3		
Dryer (before polymer stabilization)	gas if + / 0 if -	-19.5E+3	79.3E+3	91.4E+3	104.0E+3	14.6E+3
Vacuum thermal desorption of soil	gas	54.9E+3	54.9E+3			
Vacuum thermal desorption of debris	gas		518.6E+3			
Catalytic wet oxidation of organic liquids	cooling water		-3.7E+6			-3.3E+6
gas equilibration after organic destruction	cooling water		-7.3E+3			-11.9E+3
gas equilibration after debris treatment	cooling water					506.0E+0
acid gas neutralization after organic destruction	cooling water	-265.0E+0	-364.0E+3	-406.0E+0	-419.8E+3	-351.8E+3
Catalytic wet oxidation of debris	cooling water					-4.6E+6
Acid digestion of debris	cooling water				-29.3E+6	
HNO2 recovery after debris treatment	cooling water				-1.5E+6	
acid gas neutralization after debris treatment	cooling water				-470.4E+3	-388.0E+3
Acid digestion of organic liquids	cooling water				-2.2E+6	
Soil dryer after washing	gas			54.6E+3	54.6E+3	54.6E+3
totals (Btu)	electricity	4.6E+6	25.6E+3	6.4E+6	41.5E+3	40.5E+3
	gas	626.8E+3	1.2E+6	183.1E+3	738.6E+3	648.2E+3
	cooling water	-833.2E+3	-4.2E+6	-568.7E+3	-35.1E+6	-8.8E+6
Costs (\$)	e (\$0.05/kWh)	\$67.98	\$3.38	\$93.52	\$6.1	\$5.9
	g (\$2.00/MMBtu)	\$1.25	\$2.41	\$3.37	\$1.48	\$1.3
	cw (\$0)	\$	\$	\$	\$	\$
total		\$69.23	\$2.79	\$93.89	\$2.08	\$1.89
** - energy requirements for MEO process are \$0.63/kg waste @ \$0.05/kWh						

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Appendix A

Model Assumptions and ASPEN PLUS Process Flow Diagrams

System 1 - Grout Debris Case

ASSUMPTIONS and ENERGY BALANCES for GROUT DEBRIS CASE, System 1															
GENERAL COMMENTS:															
Unit Operation / ASPEN PLUS Block Name	Outlet Temp. (°F)	Heat Duty (MMBtu/hr)	Description and Assumptions												
APC filter / FILTER (SEP)	65	-	Filter to separate heavy metals and other solids from the gas stream. Gas streams entering the APC system usually have all particulates removed beforehand.												
Gas phase corona reactor / GPCR (RSTOIC)	180	20649	<p>Combines C, CO, H₂, and CH₄ with O₂ at 1 atm pressure to form H₂O and CO₂. Cl₂ is combined with H₂ to form HCl. Power input is determined by design spec GPCRPOWR, which calculates 56.49 W per SCFM of gases entering the process. The need for excess O₂ (100%) is determined by design spec AIR4.</p> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>2 H₂ + O₂ → 2 H₂O</td><td>0.95</td></tr><tr><td>C + O₂ → CO₂</td><td>0.95</td></tr><tr><td>2 CO + O₂ → 2 CO₂</td><td>0.95</td></tr><tr><td>CH₄ + 2 O₂ → CO₂ + 2 H₂O</td><td>0.95</td></tr><tr><td>H₂ + Cl₂ → 2 HCl</td><td>0.95</td></tr></table>	Reaction	Conversion	2 H ₂ + O ₂ → 2 H ₂ O	0.95	C + O ₂ → CO ₂	0.95	2 CO + O ₂ → 2 CO ₂	0.95	CH ₄ + 2 O ₂ → CO ₂ + 2 H ₂ O	0.95	H ₂ + Cl ₂ → 2 HCl	0.95
Reaction	Conversion														
2 H ₂ + O ₂ → 2 H ₂ O	0.95														
C + O ₂ → CO ₂	0.95														
2 CO + O ₂ → 2 CO ₂	0.95														
CH ₄ + 2 O ₂ → CO ₂ + 2 H ₂ O	0.95														
H ₂ + Cl ₂ → 2 HCl	0.95														
Acid gas scrubber / NEUTRAL3 (RSTOIC)	100	-12149	<p>Neutralizes SO₂ with NaOH at 1 atm pressure and 100°F to form Na₂SO₄ at a conversion level of 99%. Excess NaOH (1%) is determined by design spec NAOH-3.</p> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>2SO₂ + 4NaOH + O₂ → 2Na₂SO₄ + 2H₂O</td><td>0.99</td></tr></table>	Reaction	Conversion	2SO ₂ + 4NaOH + O ₂ → 2Na ₂ SO ₄ + 2H ₂ O	0.99								
Reaction	Conversion														
2SO ₂ + 4NaOH + O ₂ → 2Na ₂ SO ₄ + 2H ₂ O	0.99														
Scrubber liquor sump / BLOWDOWN (SEP)	100	-	Separates salts formed in the scrubber. Na ₂ SO ₄ and NaOH are sent with some water to the aqueous waste treatment subsystem. Water flow rate calculated for 20% salt solution by design spec SALTSOLN.												

Mist eliminator / FLASH (FLASH2)	100	0	Two-phase flash to separate out additional moisture. Flash determines vapor-liquid equilibrium at 100°F and 1 atm. Moisture sent to the aqueous waste treatment subsystem.
Filter / HETRHEPA (HEATER)	300	31630	Heater to raise temperature of the gas stream to 300°F to avoid condensate in the HEPA filter.
Ozone generator / OZ-GEN (RSTOIC)	100	1053	O ₃ generated from O ₂ at 100°F and 1 atm. <div> <div>Reaction</div> <div>3 O₂ → 2 O₃</div> </div> <div> <div>Conversion</div> <div>0.99</div> </div>
Aqueous liquids sorting / PHOTOMIX (MIXER)	94	-	Combines all streams entering the aqueous waste treatment subsystem.
Gross organics removal / OILSEP (SEP)	94	-	Oil-water separator to remove C and H ₂ from the liquid stream at an assumed efficiency of 99%.
OH generator / OH-GEN (RSTOIC)	100	-82246	Generates OH radicals from H ₂ O ₂ and O ₃ . <div> <div>Reaction</div> <div>H₂O₂ → 2OH •</div> </div> <div> <div>Conversion</div> <div>0.99</div> </div> <div> <div>Reaction</div> <div>O₃ + 3 H₂O → 6 OH •</div> </div> <div> <div>Conversion</div> <div>0.99</div> </div>
UV reactor / PHOTO-UV (RSTOIC)	100	-17740	Combines C and H ₂ with OH radicals. <div> <div>Reaction</div> <div>C + 4 OH • → CO₂ + 2 H₂O</div> </div> <div> <div>Conversion</div> <div>0.96</div> </div> <div> <div>Reaction</div> <div>H₂ + 2 OH • → 2 H₂O</div> </div> <div> <div>Conversion</div> <div>0.96</div> </div> <div> <div>Reaction</div> <div>H₂ + Cl₂ → 2 HCl</div> </div> <div> <div>Conversion</div> <div>0.96</div> </div>

Ozone decomposition / OZ-DECOM (RSTOIC)	100	-46396	<p>Decomposes unreacted ozone and neutralizes acids at 100°F and 1 atm. Excess NaOH (1%) is determined by design spec XX-NAOH.</p> <table><thead><tr><th>Reaction</th><th>Conversion</th></tr></thead><tbody><tr><td>$2 \text{ O}_3 \rightarrow 3 \text{ O}_2$</td><td>0.999</td></tr><tr><td>$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$</td><td>0.99</td></tr><tr><td>$4 \text{ NaOH} + 2 \text{ SO}_2 + \text{O}_2 \rightarrow 2 \text{ Na}_2\text{SO}_4 + 2 \text{ H}_2\text{O}$</td><td>0.99</td></tr><tr><td>$4 \text{ NaOH} + 2 \text{ Cl}_2 \rightarrow 4 \text{ NaCl} + 2 \text{ H}_2\text{O} + \text{O}_2$</td><td>0.99</td></tr><tr><td>$2 \text{ NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2 \text{ H}_2\text{O}$</td><td>0.99</td></tr></tbody></table>	Reaction	Conversion	$2 \text{ O}_3 \rightarrow 3 \text{ O}_2$	0.999	$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$	0.99	$4 \text{ NaOH} + 2 \text{ SO}_2 + \text{O}_2 \rightarrow 2 \text{ Na}_2\text{SO}_4 + 2 \text{ H}_2\text{O}$	0.99	$4 \text{ NaOH} + 2 \text{ Cl}_2 \rightarrow 4 \text{ NaCl} + 2 \text{ H}_2\text{O} + \text{O}_2$	0.99	$2 \text{ NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2 \text{ H}_2\text{O}$	0.99
Reaction	Conversion														
$2 \text{ O}_3 \rightarrow 3 \text{ O}_2$	0.999														
$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$	0.99														
$4 \text{ NaOH} + 2 \text{ SO}_2 + \text{O}_2 \rightarrow 2 \text{ Na}_2\text{SO}_4 + 2 \text{ H}_2\text{O}$	0.99														
$4 \text{ NaOH} + 2 \text{ Cl}_2 \rightarrow 4 \text{ NaCl} + 2 \text{ H}_2\text{O} + \text{O}_2$	0.99														
$2 \text{ NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2 \text{ H}_2\text{O}$	0.99														
Gas, water, sludge separator / AQ-SPLIT (SEP)	100	-	<p>Separates gas, liquid, and sludge from aqueous waste treatment. Gases (O_2, H_2, N_2, NO, CO_2, O_3) are sent to the APC subsystem. Liquids (H_2O, SO_2, FeCl_3, H_2SO_4, HNO_3, H^+, e^-, H_2O_2, OH radicals, 1% of C, 1% of SiO_2, 1% of Al_2O_3) are available for recycle in the system. Solids (Fe, As, Ba, Cd, Cr, Pb, Se, Ag, NaCl, AgCl, NaNO_3, Na_2SO_4, 99% of C, 99% of SiO_2, 99% of Al_2O_3) are routed to polymer stabilization subsystem.</p>												
Evaporator / CONCENT8 (FLASH2)	150	10	<p>Models evaporation of scrubber liquor from APC subsystem. Two-phase flash determines vapor-liquid equilibrium at 150°F and 1 atm. Vapor sent to PHOTOMIX, liquid/solid phase sent to polymer stabilization subsystem.</p>												
Soil dryer / VACTRAX3 (RGIBBS)	550	54911	<p>Models the vacuum desorber for bulk soils. Operates at 550°F and 1 psig. Equilibrium is assumed for species entered in the RGIBBS block: HCl and CH_4 are assumed to form from feed components. O_2 is excluded from reaction. A nitrogen sweep gas is used at a rate of 1.09 ft³ per lb waste (0.0793 lb N_2/lb waste) as determined by FORTRAN block N2SWEEP.</p>												

Mercury leaching / VACSEP-3 (SEP)	91	-	<p>Mercury leaching of soils by addition of leach water (30% of mass of incoming waste). Also includes separation of gases, liquids, organics, Hg-contaminated liquids, and solids.</p> <p>Gases (N_2) are sent to APC subsystem. Solids (H_2O in leach water, 50% of H_2, 50% of C, SiO_2, Al_2O_3) are routed to grout stabilization subsystem. Liquids (balance of H_2O, HCl) are sent to aqueous waste treatment. Organics (50% of H_2, CH_4, 50% of C) are routed to the organic destruction subsystem.</p>
Grout stabilization feed preparation / GROUTMIX (MIXER)	74	-	Combines all waste feed to grout stabilization, including soft, open, and complex debris.
Micro-solidification / GROUTER (MIXER)	68	-	Combines cement and water with incoming waste feed. Amount of dry cement is determined by design spec GROUT. Total grout:waste ratio is 2:1 and dry grout:water ratio is 0.7:0.3. Amount of water is determined by design spec GROUTH2O according to the above ratio.
Mercury amalgamation / HG-AMALG (MIXER)	68	-	Amalgamation of mercury wastes. Addition of copper in ratio of 0.7:1 (Cu:waste) as determined by FORTRAN block ADDITIVE.
Metal decontamination / MET-DCON (SEP)	64	-	Decontamination of metal with abrasive blasting. Assumes water input in a ratio of 112 lb per 468 lb waste. Assumes all grit recycled (no make-up grit added to process). Liquid stream (H_2O , H_2 , C, Al_2O_3 , and SiO_2) is sent to aqueous waste treatment. Clean metal (Fe) exits the process.
Organic destruction feed preparation / MEO-MIXR (MIXER)	183	-	Mixes all feed material to MEO process, including waste input, reagents, and recycle streams (water and nitric acid). Make-up silver nitrate is determined by FORTRAN block AGNO3-IN. Make-up nitric acid is determined by FORTRAN block HNO3-IN2.

MEO process - anode / MEO-ANOD (RSTOIC)	176	47505764	Reacts at 80°C and 35 psig. <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>$C + 2H_2O \rightarrow CO_2 + 4H^+ + 4e^-$</td><td>0.99</td></tr><tr><td>$H_2 \rightarrow 2 H^+ + 2 e^-$</td><td>1.00</td></tr><tr><td>$Cl_2 + 2 H^+ + 2 e^- \rightarrow 2 HCl$</td><td>1.00</td></tr><tr><td>$2 S + 2 H_2O + 3 O_2 \rightarrow 2 H_2SO_4$</td><td>1.00</td></tr><tr><td>$2 N_2 + 2 H_2O + 5 O_2 \rightarrow 4 HNO_3$</td><td>1.00</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	$C + 2H_2O \rightarrow CO_2 + 4H^+ + 4e^-$	0.99	$H_2 \rightarrow 2 H^+ + 2 e^-$	1.00	$Cl_2 + 2 H^+ + 2 e^- \rightarrow 2 HCl$	1.00	$2 S + 2 H_2O + 3 O_2 \rightarrow 2 H_2SO_4$	1.00	$2 N_2 + 2 H_2O + 5 O_2 \rightarrow 4 HNO_3$	1.00
<u>Reaction</u>	<u>Conversion</u>														
$C + 2H_2O \rightarrow CO_2 + 4H^+ + 4e^-$	0.99														
$H_2 \rightarrow 2 H^+ + 2 e^-$	1.00														
$Cl_2 + 2 H^+ + 2 e^- \rightarrow 2 HCl$	1.00														
$2 S + 2 H_2O + 3 O_2 \rightarrow 2 H_2SO_4$	1.00														
$2 N_2 + 2 H_2O + 5 O_2 \rightarrow 4 HNO_3$	1.00														
MEO process - cathode / MEO-CATH (RSTOIC)	176	-50040844	Reacts at 80°C and 35 psig at 100% conversion. <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>$HNO_3 + 2H^+ + 2 e^- \rightarrow H_2O + HNO_2$</td><td>1.00</td></tr><tr><td>$AgNO_3 + HCl \rightarrow AgCl + HNO_3$</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	$HNO_3 + 2H^+ + 2 e^- \rightarrow H_2O + HNO_2$	1.00	$AgNO_3 + HCl \rightarrow AgCl + HNO_3$	0.99						
<u>Reaction</u>	<u>Conversion</u>														
$HNO_3 + 2H^+ + 2 e^- \rightarrow H_2O + HNO_2$	1.00														
$AgNO_3 + HCl \rightarrow AgCl + HNO_3$	0.99														
Silver precipitation / AG-PPT (RSTOIC)	176	0	Precipitation of remaining AgNO ₃ with addition of HCl. Reacts and 80°C and 35 psig at 100% conversion.												
MEO process / MEO3 (RSTOIC)	176	-300	Converts remaining nitrate to HNO ₂ at 80°C and 35 psig. <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>$4 H^+ + 2 NO_3^- + 2 e^- \rightarrow$ $HNO_3 + HNO_2 + H_2O$</td><td>0.99</td></tr><tr><td>$H^+ + Cl^- \rightarrow HCl$</td><td>1.00</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	$4 H^+ + 2 NO_3^- + 2 e^- \rightarrow$ $HNO_3 + HNO_2 + H_2O$	0.99	$H^+ + Cl^- \rightarrow HCl$	1.00						
<u>Reaction</u>	<u>Conversion</u>														
$4 H^+ + 2 NO_3^- + 2 e^- \rightarrow$ $HNO_3 + HNO_2 + H_2O$	0.99														
$H^+ + Cl^- \rightarrow HCl$	1.00														
Centrifuge- Evaporator / MEO-SPLT (SEP)	176	-	Separates gases, solids, and recycle streams. Some H ₂ O and all HCl is recycled to the MEO process and is controlled by design spec H ₂ O-IN. The remaining H ₂ O, H ₂ , Cl ₂ , H ₂ SO ₄ , and HCl is routed aqueous waste treatment. Gases (O ₂ , CO ₂ , CH ₄ , and HNO ₂) are routed to nitrous acid conversion and NO _x removal. AgCl, AgNO ₃ , HNO ₃ , NO ₃ ⁻ , Ag ⁺ , Cl ⁻ , and e ⁻ are routed to silver conversion. S, F ₂ , Ba, Fe, Cd, Cr, C, SiO ₂ , Al ₂ O ₃ , and 10 ppm of HNO ₃ are routed to neutralization.												

Nitrous acid conversion / HNO2RECV (RSTOIC)	302	-735561	Converts HNO ₂ to HNO ₃ and to NO at 423 K and 35 psig. O ₂ input (1% excess) is determined by design spec O2-HNO2. <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>2 HNO₂ + O₂ → 2 HNO₃</td><td>0.99</td></tr><tr><td>4 HNO₂ → 2 H₂O + 4 NO + O₂</td><td>0.01</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	2 HNO ₂ + O ₂ → 2 HNO ₃	0.99	4 HNO ₂ → 2 H ₂ O + 4 NO + O ₂	0.01				
<u>Reaction</u>	<u>Conversion</u>												
2 HNO ₂ + O ₂ → 2 HNO ₃	0.99												
4 HNO ₂ → 2 H ₂ O + 4 NO + O ₂	0.01												
Nitrous acid conversion / NOX-SPLT (SEP)	302	-	Separates HNO ₃ for recycle back to MEO reactor.										
NOx removal / NOX-CONV (RSTOIC)	68	-78750	Reacts NO at 68°F and 1 atm and 99% conversion. Reaction is. Stoichiometric NH ₃ input is determined by FORTRAN block X-NH3. Gases are then routed to APC. <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>6 NO + 4 NH₃ → 5 N₂ + 6 H₂O</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	6 NO + 4 NH ₃ → 5 N ₂ + 6 H ₂ O	0.99						
<u>Reaction</u>	<u>Conversion</u>												
6 NO + 4 NH ₃ → 5 N ₂ + 6 H ₂ O	0.99												
Silver conversion-silver dissolving / AGRECOVR (RSTOIC)	100	140361	Converts AgCl to AgNO ₃ at 100°F and 1 atm; H ₂ O ₂ and NaOH fed to the block are determined by the FORTRAN block AGRECOVR. <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>4 AgCl + 4 NaOH + 4 H₂O₂ → 4 Ag + 4 NaCl + 6 H₂O + 3 O₂</td><td>0.99</td></tr><tr><td>Ag + HNO₃ → AgNO₃ + H⁺ + e⁻</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	4 AgCl + 4 NaOH + 4 H ₂ O ₂ → 4 Ag + 4 NaCl + 6 H ₂ O + 3 O ₂	0.99	Ag + HNO ₃ → AgNO ₃ + H ⁺ + e ⁻	0.99				
<u>Reaction</u>	<u>Conversion</u>												
4 AgCl + 4 NaOH + 4 H ₂ O ₂ → 4 Ag + 4 NaCl + 6 H ₂ O + 3 O ₂	0.99												
Ag + HNO ₃ → AgNO ₃ + H ⁺ + e ⁻	0.99												
Centrifuge / AG-SPLT (SEP)	100	-	Separates AgNO ₃ and HNO ₃ for recycle to MEO reactor. Gases (O ₂) are routed to APC system. Liquids (H ₂ O, Ag, NaOH, NaCl, H ⁺ , e ⁻ , H ₂ O ₂ , AgCl) are routed to aqueous waste treatment.										
Neutralization / NEUTRAL (RSTOIC)	68	- 265	Neutralizes acids at 68°F and 1 atm. Neutralized liquid is routed to aqueous waste treatment. <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>HCl + NaOH → NaCl + H₂O</td><td>0.99</td></tr><tr><td>HNO₃ + NaOH → NaNO₃ + H₂O</td><td>0.99</td></tr><tr><td>Cl⁻ + H⁺ + NaOH → NaCl + H₂O</td><td>1.00</td></tr><tr><td>NO₃⁻ + H⁺ → NaNO₃ + H₂O</td><td>1.00</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	HCl + NaOH → NaCl + H ₂ O	0.99	HNO ₃ + NaOH → NaNO ₃ + H ₂ O	0.99	Cl ⁻ + H ⁺ + NaOH → NaCl + H ₂ O	1.00	NO ₃ ⁻ + H ⁺ → NaNO ₃ + H ₂ O	1.00
<u>Reaction</u>	<u>Conversion</u>												
HCl + NaOH → NaCl + H ₂ O	0.99												
HNO ₃ + NaOH → NaNO ₃ + H ₂ O	0.99												
Cl ⁻ + H ⁺ + NaOH → NaCl + H ₂ O	1.00												
NO ₃ ⁻ + H ⁺ → NaNO ₃ + H ₂ O	1.00												

Lead recovery-separation / PB-SPLIT (SEP)	68	-	Separates brick or sheet lead (assumed to be 81% of total) for decontamination. Remaining lead (leaded gloves, blankets, shot) is routed to grout stabilization.
Lead decontamination / PB-DECON (SEP)	68	-	Decontaminates lead with water wash, separates clean lead, which exits the system. Liquid and sludge are routed to process residue treatment subsystem.
Polymer feed preparation / POLY-MIX (MIXER)	101	-	Mixes incoming waste for polymer stabilization.
Dryer / DRYER (HEATER)	200	-19532	Removes excess water prior to polymer stabilization.
Dryer / WATERSEP (SEP)	200	-	Separates water, input to polymer stabilization is dried to 5% moisture content, as determined by design spec DRYER. Excess H ₂ O, NO, and SO ₂ are sent to aqueous waste treatment subsystem.
Mixing / POLYSTAB (MIXER)			Adds polyethylene to encapsulate the waste. Polymer:waste ratio is 1:1.
Process residue dryer / VACTRAX1 (RGIBBS)	550	540225	Models the vacuum desorber for process residue and inorganic sludges. Operates at 550°F and 1 psig. Equilibrium is assumed for species entered in the RGIBBS block: H ₂ SO ₄ and CH ₄ are assumed to form from feed components. O ₂ is excluded from reaction. A nitrogen sweep gas is used at a rate of 1.09 ft ³ per lb waste (0.0793 lb N ₂ /lb waste) as determined by FORTRAN block N2SWEEP.

Mercury leaching / VACSEP-1 (SEP)	97	-	<p>Mercury leaching of process residue and inorganic sludges by addition of leach water (30% of mass of incoming waste). Also includes separation of gases, liquids, organics, Hg-contaminated liquids, and solids.</p> <p>Gases (N₂) are sent to APC subsystem. Solids (H₂O in leach water, 50% of H₂, O₂, S, 50% of C, SiO₂, Al₂O₃, Ba, As, Pb, Fe, Cd, Cr, Se, Ag) are routed to grout stabilization subsystem. Liquids (balance of H₂O, H₂SO₄) are sent to aqueous waste treatment. Organics (50% of H₂, 50% of C, 50% of Cl₂) are routed to the organic destruction subsystem. Mercury separated is routed to mercury amalgamation.</p>
Special waste	68	-	As with the ITTS study, no model was constructed for special waste.

System 2 - Desorption Case

ASSUMPTIONS and ENERGY BALANCES for DESORPTION CASE, System 2															
GENERAL COMMENTS:															
Unit Operation / ASPEN PLUS Block Name	Outlet Temp (°F)	Heat Duty (MMBtu/hr)	Description and Assumptions												
APC filter / FILTER (SEP)	251	-	Filter to separate heavy metals and other solids from gas stream. Gas streams entering the APC system usually have all particulates removed beforehand.												
Gas phase corona reactor / GPCR (RSTOIC)	378	24416	<p>Combines C, CO, H₂, and CH₄ with O₂ at 1 atm pressure to form H₂O and CO₂. Cl₂ is combined with H₂ to form HCl. Power input is determined by design spec GPCRPOWER, which calculates 56.49 W per SCFM of gases entering the process. The need for excess O₂ (100%) is determined by design spec AIR4.</p> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>2 H₂ + O₂ → 2 H₂O</td><td>0.95</td></tr><tr><td>C + O₂ → CO₂</td><td>0.95</td></tr><tr><td>2 CO + O₂ → 2 CO₂</td><td>0.95</td></tr><tr><td>CH₄ + 2 O₂ → CO₂ + 2 H₂O</td><td>0.95</td></tr><tr><td>H₂ + Cl₂ → 2 HCl</td><td>0.95</td></tr></table>	Reaction	Conversion	2 H ₂ + O ₂ → 2 H ₂ O	0.95	C + O ₂ → CO ₂	0.95	2 CO + O ₂ → 2 CO ₂	0.95	CH ₄ + 2 O ₂ → CO ₂ + 2 H ₂ O	0.95	H ₂ + Cl ₂ → 2 HCl	0.95
Reaction	Conversion														
2 H ₂ + O ₂ → 2 H ₂ O	0.95														
C + O ₂ → CO ₂	0.95														
2 CO + O ₂ → 2 CO ₂	0.95														
CH ₄ + 2 O ₂ → CO ₂ + 2 H ₂ O	0.95														
H ₂ + Cl ₂ → 2 HCl	0.95														
Acid gas scrubber / NEUTRAL3 (RSTOIC)	100	-52239	<p>Neutralizes HCl, Cl₂, and SO₂ with NaOH at 1 atm pressure and 100°F to form NaCl and Na₂SO₄. Excess NaOH (1%) is determined by design spec NAOH-3.</p> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>HCl + NaOH → NaCl + H₂O</td><td>0.99</td></tr><tr><td>2 Cl₂ + 4 NaOH → 4 NaCl + 2 H₂O + O₂</td><td>0.99</td></tr><tr><td>2 SO₂ + 4NaOH + O₂ → 2Na₂SO₄ + 2H₂O</td><td>0.99</td></tr></table>	Reaction	Conversion	HCl + NaOH → NaCl + H ₂ O	0.99	2 Cl ₂ + 4 NaOH → 4 NaCl + 2 H ₂ O + O ₂	0.99	2 SO ₂ + 4NaOH + O ₂ → 2Na ₂ SO ₄ + 2H ₂ O	0.99				
Reaction	Conversion														
HCl + NaOH → NaCl + H ₂ O	0.99														
2 Cl ₂ + 4 NaOH → 4 NaCl + 2 H ₂ O + O ₂	0.99														
2 SO ₂ + 4NaOH + O ₂ → 2Na ₂ SO ₄ + 2H ₂ O	0.99														

Scrubber liquor sump / BLOWDOWN (SEP)	100	-	Separates salts formed in scrubber. NaCl, NaOH, and Na ₂ SO ₄ are sent with some water to aqueous waste treatment subsystem. Water flow rate calculated for 20% salt solution by design spec SALT SOLN.
Mist eliminator / FLASH (FLASH2)	100	0	Two-phase flash to separate out additional moisture. Flash determines vapor-liquid equilibrium at 100°F and 1 atm. Moisture sent to aqueous waste treatment subsystem.
Filter / HETRHEPA (HEATER)	300	37124	Heater to raise temperature of gas stream to 300°F to avoid condensate in the HEPA filter.
Ozone generator / OZ-GEN (RSTOIC)	100	1162	O ₃ generated from O ₂ at 100°F and 1 atm. <div> <div>Reaction</div> <div>3 O₂ → 2 O₃</div> <div>Conversion</div> <div>0.99</div> </div>
Aqueous liquids sorting / PHOTOMIX (MIXER)	77	-	Combines all streams entering aqueous waste treatment subsystem.
Gross organics removal / OILSEP (SEP)	77	-	Oil-water separator to remove C and H ₂ from liquid stream at an assumed efficiency of 99%.
OH generator / OH-GEN (RSTOIC)	100	11659	Generates OH radicals from H ₂ O ₂ and O ₃ . <div> <div>Reaction</div> <div>H₂O₂ → 2 OH •</div> <div>O₃ + 3 H₂O → 6 OH •</div> <div>Conversion</div> <div>0.99</div> <div>0.99</div> </div>
UV reactor / PHOTO-UV (RSTOIC)	100	-18198	Combines C, H ₂ with OH radicals. <div> <div>Reaction</div> <div>C + 4 OH • → CO₂ + 2 H₂O</div> <div>H₂ + 4 OH • → 2 H₂O</div> <div>H₂ + Cl₂ → 2 HCl</div> <div>Conversion</div> <div>0.96</div> <div>0.96</div> <div>0.96</div> </div>

Ozone decomposition / OZ-DECOM (RSTOIC)	100	-91558	<p>Decomposes unreacted ozone and neutralizes acids at 100°F and 1 atm. Excess NaOH (1%) is determined by design spec XX-NAOH.</p> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>$2\text{O}_3 \rightarrow 3\text{O}_2$</td><td>0.999</td></tr><tr><td>$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$</td><td>0.99</td></tr><tr><td>$4\text{NaOH} + 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$</td><td>0.99</td></tr><tr><td>$4\text{NaOH} + 2\text{Cl}_2 \rightarrow 4\text{NaCl} + 2\text{H}_2\text{O} + \text{O}_2$</td><td>0.99</td></tr><tr><td>$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$</td><td>0.99</td></tr></table>	Reaction	Conversion	$2\text{O}_3 \rightarrow 3\text{O}_2$	0.999	$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$	0.99	$4\text{NaOH} + 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	0.99	$4\text{NaOH} + 2\text{Cl}_2 \rightarrow 4\text{NaCl} + 2\text{H}_2\text{O} + \text{O}_2$	0.99	$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	0.99
Reaction	Conversion														
$2\text{O}_3 \rightarrow 3\text{O}_2$	0.999														
$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$	0.99														
$4\text{NaOH} + 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	0.99														
$4\text{NaOH} + 2\text{Cl}_2 \rightarrow 4\text{NaCl} + 2\text{H}_2\text{O} + \text{O}_2$	0.99														
$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	0.99														
Gas, water, sludge separator / AQ-SPLIT (SEP)	100	-	<p>Separates gas, liquid, and sludge from aqueous waste treatment. Gases (O_2, H_2, N_2, NO, CO_2, O_3) are sent to APC subsystem. Liquids (H_2O, SO_2, H_2SO_4, HCl, H_2O_2, OH radicals, 1% of C, 1% of SiO_2, 1% of Al_2O_3) are available for recycle in the system. Solids (As, Ba, Cd, Cr, Pb, Se, Ag, NaCl, FeCl_3, AgCl, NaOH, Na_2SO_4, 99% of C, 99% of SiO_2, 99% of Al_2O_3) are routed to polymer stabilization subsystem.</p>												
Evaporator / CONCENT8 (FLASH2)	150	43	<p>Models evaporation of scrubber liquor from APC subsystem. Two-phase flash determines vapor-liquid equilibrium at 150°F and 1 atm. Vapor sent to PHOTOMIX, liquid/solid phase sent to polymer stabilization subsystem.</p>												
Soil dryer / VACTRAX3 (RGIBBS)	550	54911	<p>Models the vacuum desorber for bulk soils. Operates at 550°F and 1 psig. Equilibrium is assumed for species entered in the RGIBBS block: HCl and CH_4 are assumed to form from feed components. O_2 is excluded from reaction. A nitrogen sweep gas is used at a rate of 1.09 ft³ per lb waste (0.0793 lb N_2/lb waste) as determined by FORTRAN block N2SWEEP.</p>												

Mercury leaching / VACSEP-3 (SEP)	91	-	<p>Mercury leaching of soils by addition of leach water (30% of mass of incoming waste). Also includes separation of gases, liquids, organics, Hg-contaminated liquids, and solids.</p> <p>Gases (N_2) are sent to APC subsystem. Solids (H_2O in leach water, 50% of H_2, 50% of C, SiO_2, Al_2O_3) are routed to grout stabilization subsystem. Liquids (balance of H_2O, HCl) are sent to aqueous waste treatment. Organics (50% of H_2, CH_4, 50% of C) are routed to the organic destruction subsystem.</p>
Grout stabilization feed preparation / GROUTMIX (MIXER)	71	-	Combines all waste feed to grout stabilization.
Microsolidification / GROUTER (MIXER)	69	-	Combines cement and water with incoming waste feed. Amount of cement is determined by design spec GROUT. Total grout:waste ratio is 2:1 and dry grout:water ratio is 0.7:0.3. Amount of water is determined by design spec GROUTH2O according to the above ratio.
Mercury amalgamation / HG-AMALG (MIXER)	68	-	Amalgamation of mercury wastes. Addition of copper in ratio of 0.7:1 (Cu:waste) as determined by FORTRAN block ADDITIVE.
Metal decontamination / MET-DCON (SEP)	64	-	Decontamination of metal with abrasive blasting. Assumes water input in a ratio of 112 lb per 468 lb waste. Assumes all grit recycled (no make-up grit added to process). Liquid stream (H_2O , H_2 , C, Al_2O_3 , and SiO_2) is sent to aqueous waste treatment. Clean metal (Fe) exits the process.

Organic destruction / CWO-1 (RSTOIC)	302	-3724699	<p>Catalytic wet oxidation at 423 K and 35 psig . Oxygen input (5% excess) is determined by design spec O2-CWO. Acid solution (36% H₂O, 60% FeCl₃, 4% HCl) is set to be 7 lb solution/200 lb waste input by design spec ACID-IN.</p> <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>C + O₂ → CO₂</td><td>0.99</td></tr><tr><td>2 H₂ + O₂ → 2 H₂O</td><td>0.99</td></tr><tr><td>H₂ + Cl₂ → 2 HCl</td><td>0.99</td></tr><tr><td>S + H₂ + 2 O₂ → H₂SO₄</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	C + O ₂ → CO ₂	0.99	2 H ₂ + O ₂ → 2 H ₂ O	0.99	H ₂ + Cl ₂ → 2 HCl	0.99	S + H ₂ + 2 O ₂ → H ₂ SO ₄	0.99
<u>Reaction</u>	<u>Conversion</u>												
C + O ₂ → CO ₂	0.99												
2 H ₂ + O ₂ → 2 H ₂ O	0.99												
H ₂ + Cl ₂ → 2 HCl	0.99												
S + H ₂ + 2 O ₂ → H ₂ SO ₄	0.99												
Organic destruction filter / CWOSPLT (SEP)	299	-	Separation of products from CWO reactor. Solids (S, Fe, Ba, Cd, Cr, 50% of Fe(OH) ₃ , C, SiO ₂ , Al ₂ O ₃) are sent to polymer stabilization. Liquids (H ₂ O, HCl, NaCl, FeCl ₃ , H ₂ SO ₄ , and 50% of Fe(OH) ₃) are sent for neutralization. Gases (O ₂ , Cl ₂ , F ₂ , CO ₂ , CH ₄) are subject to equilibration and then sent to the APC subsystem.										
Gas equilibration / EQUIL-1 (RGIBBS)	302	-7324	This block equilibrates the gas leaving the CWO system to account for the non-equilibrium of the CWO reactor. It reacts the small amount of CH ₄ remaining with O ₂ to form H ₂ O and CO ₂ . Cl ₂ is combined with H ₂ to form HCl.										
Neutralization / NEUTRAL1 (RSTOIC)	100	-364010	<p>Neutralizes acids at 100°F and 1 atm. Neutralized liquid is filtered and then routed to aqueous waste treatment.</p> <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>HCl + NaOH → NaCl + H₂O</td><td>0.99</td></tr><tr><td>H₂SO₄ + 2 NaOH → Na₂SO₄ + 2 H₂O</td><td>0.99</td></tr><tr><td>2 Cl₂ + 4 NaOH → 4 NaCl + 2 H₂O+O₂</td><td>0.99</td></tr><tr><td>FeCl₃ + 3 NaOH → Fe(OH)₃ + 3 NaCl</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	HCl + NaOH → NaCl + H ₂ O	0.99	H ₂ SO ₄ + 2 NaOH → Na ₂ SO ₄ + 2 H ₂ O	0.99	2 Cl ₂ + 4 NaOH → 4 NaCl + 2 H ₂ O+O ₂	0.99	FeCl ₃ + 3 NaOH → Fe(OH) ₃ + 3 NaCl	0.99
<u>Reaction</u>	<u>Conversion</u>												
HCl + NaOH → NaCl + H ₂ O	0.99												
H ₂ SO ₄ + 2 NaOH → Na ₂ SO ₄ + 2 H ₂ O	0.99												
2 Cl ₂ + 4 NaOH → 4 NaCl + 2 H ₂ O+O ₂	0.99												
FeCl ₃ + 3 NaOH → Fe(OH) ₃ + 3 NaCl	0.99												
Precipitation filter / SALTFLTR	100	-	Removes Fe(OH) ₃ from aqueous stream. Solid is routed to polymer stabilization.										
Lead recovery-separation / PB-SPLIT (SEP)	68	-	Separates brick or sheet lead (assumed to be 81% of total) for decontamination. Remaining lead (leaded gloves, blankets, shot) is routed to grout stabilization.										

Lead decontamination / PB-DECON (SEP)	63	-	Decontaminates lead with water wash, separates clean lead, which exits the system. Liquid and sludge are routed to process residue treatment subsystem.
Polymer feed preparation / POLY-MIX (MIXER)	73	-	Mixes incoming waste for polymer stabilization.
Dryer / DRYER (HEATER)	200	79322	Removes excess water prior to polymer stabilization.
Dryer / WATERSEP (SEP)	200	-	Separates water, input to polymer stabilization is dried to 5% moisture content, as determined by design spec DRYER. Excess H ₂ O, NO, and SO ₂ are sent to aqueous waste treatment subsystem.
Mixing / POLYSTAB (MIXER)	102	-	Adds polyethylene to encapsulate the waste. Polymer:waste ratio is 1:1.
Process residue dryer / VACTRAX1 (RGIBBS)	550	515629	Models the vacuum desorber for process residue and inorganic sludges. Operates at 550°F and 1 psig. Equilibrium is assumed for species entered in the RGIBBS block: H ₂ SO ₄ , HCl, and CH ₄ are assumed to form from feed components. O ₂ is excluded from reaction. A nitrogen sweep gas is used at a rate of 1.09 ft ³ per lb waste (0.0793 lb N ₂ /lb waste) as determined by FORTRAN block N2SWEEP.

Mercury leaching / VACSEP-1 (SEP)	68	-	<p>Mercury leaching of process residue and inorganic sludges by addition of leach water (30% of mass of incoming waste). Also includes separation of gases, liquids, organics, Hg-contaminated liquids, and solids.</p> <p>Gases (N₂) are sent to APC subsystem. Solids (H₂O in leach water, S, 50% of H₂, O₂, 50% of C, SiO₂, Al₂O₃, Ba, As, Pb, Fe, Cd, Cr, Se, Ag) are routed to polymer stabilization subsystem. Liquids (balance of H₂O, HCl, H₂SO₄) are sent to aqueous waste treatment. Organics (50% of H₂, 50% of C, CH₄) are routed to the organic destruction subsystem. Mercury separated is routed to mercury amalgamation.</p>
Soft, open, complex debris dryer / VACTRAX2 (RGIBBS)	250	518600	<p>Models the vacuum desorber for soft, open, and complex debris. Operates at 250°F and 1 psig. Equilibrium is assumed for species entered in the RGIBBS block: HCl is assumed to form from feed components. O₂ and H₂O are excluded from reaction. A nitrogen sweep gas is used at a rate of 1.09 ft³ per lb waste (0.0793 lb N₂/lb waste) as determined by FORTRAN block N2SWEEP.</p>
Mercury leaching / VACSEP-2 (SEP)	68	-	<p>Mercury leaching of soft, open, and complex debris. Addition of leach water (30% of mass of incoming waste). Also includes separation of gases, liquids, organics, Hg-contaminated liquids, and solids.</p> <p>Gases (N₂) are sent to APC subsystem. Solids (H₂O in leach water, S, 90% of H₂, O₂, 90% of C, 90% of F₂, 90% of Cl₂, SiO₂, Al₂O₃, Fe) are routed to grout stabilization subsystem. Liquids (balance of H₂O, HCl) are sent to aqueous waste treatment. Organics (10% of H₂, 10% of C, 10% of F₂, 10% of Cl₂, and SiO₂,) are routed to the organic destruction subsystem. Mercury separated is routed to mercury amalgamation.</p>
Special waste	68	-	<p>As with the ITTS study, no model was constructed for special waste.</p>

System 3 - Wash Case

ASSUMPTIONS and ENERGY BALANCES for WASH CASE, System 3															
GENERAL COMMENTS:															
Unit Operation / ASPEN PLUS Block Name	Outlet Temp. (°F)	Heat Duty (MMBtu/hr)	Description and Assumptions												
APC filter / FILTER (SEP)	67	-	Filter to separate heavy metals and other solids from gas stream. Gas streams entering the APC system usually have all particulates removed beforehand.												
Gas phase corona reactor / GPCR (RSTOIC)	165	22933	<p>Combines C, CO, H₂, and CH₄ with O₂ at 1 atm pressure to form H₂O and CO₂. Cl₂ is combined with H₂ to form HCl. Power input is determined by design spec GPCRPOWER, which calculates 56.49 W per SCFM of gases entering the process. The need for excess O₂ (100%) is determined by design spec AIR4.</p> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>2 H₂ + O₂ → 2 H₂O</td><td>0.95</td></tr><tr><td>C + O₂ → CO₂</td><td>0.95</td></tr><tr><td>2 CO + O₂ → 2 CO₂</td><td>0.95</td></tr><tr><td>CH₄ + 2 O₂ → CO₂ + 2 H₂O</td><td>0.95</td></tr><tr><td>H₂ + Cl₂ → 2 HCl</td><td>0.95</td></tr></table>	Reaction	Conversion	2 H ₂ + O ₂ → 2 H ₂ O	0.95	C + O ₂ → CO ₂	0.95	2 CO + O ₂ → 2 CO ₂	0.95	CH ₄ + 2 O ₂ → CO ₂ + 2 H ₂ O	0.95	H ₂ + Cl ₂ → 2 HCl	0.95
Reaction	Conversion														
2 H ₂ + O ₂ → 2 H ₂ O	0.95														
C + O ₂ → CO ₂	0.95														
2 CO + O ₂ → 2 CO ₂	0.95														
CH ₄ + 2 O ₂ → CO ₂ + 2 H ₂ O	0.95														
H ₂ + Cl ₂ → 2 HCl	0.95														
Acid gas scrubber / NEUTRAL3 (RSTOIC)	100	-15633	<p>Neutralizes SO₂ with NaOH at 1 atm pressure and 100°F to form Na₂SO₄ at a conversion level of 99%. Excess NaOH (1%) is determined by design spec NAOH-3.</p> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>2SO₂ + 4NaOH + O₂ → 2Na₂SO₄ + 2H₂O</td><td>0.99</td></tr></table>	Reaction	Conversion	2SO ₂ + 4NaOH + O ₂ → 2Na ₂ SO ₄ + 2H ₂ O	0.99								
Reaction	Conversion														
2SO ₂ + 4NaOH + O ₂ → 2Na ₂ SO ₄ + 2H ₂ O	0.99														
Scrubber liquor sump / BLOWDOWN (SEP)	100	-	Separates salts formed in scrubber. Na ₂ SO ₄ and NaOH are sent with some water to aqueous waste treatment subsystem. Water flow rate calculated for 20% salt solution by design spec SALTSOLN.												

Mist eliminator / FLASH (FLASH2)	100	0	Two-phase flash to separate out additional moisture. Flash determines vapor-liquid equilibrium at 100°F and 1 atm. Moisture sent to aqueous waste treatment subsystem.
Filter / HETRHEPA (HEATER)	300	37070	Heater to raise temperature of gas stream to 300°F to avoid condensate in HEPA filter.
Ozone generator / OZ-GEN (RSTOIC)	100	2621	O ₃ generated from O ₂ at 100°F and 1 atm. <div> <div>Reaction</div> <div>3 O₂ → 2 O₃</div> <div>Conversion</div> <div>0.99</div> </div>
Aqueous liquids sorting / PHOTOMIX (MIXER)	188	-	Combines all streams entering aqueous waste treatment subsystem.
Gross organics removal / OILSEP (SEP)	188	-	Oil-water separator to remove C and H ₂ from liquid stream at an assumed efficiency of 99%.
OH generator / OH-GEN (RSTOIC)	100	-160080	Generates OH radicals from H ₂ O ₂ and O ₃ . <div> <div>Reaction</div> <div>H₂O₂ → 2OH •</div> <div>O₃ + 3H₂O → 6OH •</div> <div>Conversion</div> <div>0.99</div> <div>0.99</div> </div>
UV reactor / PHOTO-UV (RSTOIC)	100	-42590	Combines C and H ₂ with OH radicals. <div> <div>Reaction</div> <div>C + 4 OH • → CO₂ + 2 H₂O</div> <div>H₂ + 4 OH • → 2 H₂O</div> <div>H₂ + Cl₂ → 2 HCl</div> <div>Conversion</div> <div>0.96</div> <div>0.96</div> <div>0.96</div> </div>

Ozone decomposition / OZ-DECOM (RSTOIC)	100	-2100	<p>Decomposes unreacted ozone neutralizes acids at 100°F and 1 atm. Excess NaOH (1%) is determined by design spec XX-NAOH.</p> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>$2\text{O}_3 \rightarrow 3\text{O}_2$</td><td>0.999</td></tr><tr><td>$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$</td><td>0.99</td></tr><tr><td>$4\text{NaOH} + 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$</td><td>0.99</td></tr><tr><td>$4\text{NaOH} + 2\text{Cl}_2 \rightarrow 4\text{NaCl} + 2\text{H}_2\text{O} + \text{O}_2$</td><td>0.99</td></tr><tr><td>$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$</td><td>0.99</td></tr></table>	Reaction	Conversion	$2\text{O}_3 \rightarrow 3\text{O}_2$	0.999	$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$	0.99	$4\text{NaOH} + 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	0.99	$4\text{NaOH} + 2\text{Cl}_2 \rightarrow 4\text{NaCl} + 2\text{H}_2\text{O} + \text{O}_2$	0.99	$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	0.99
Reaction	Conversion														
$2\text{O}_3 \rightarrow 3\text{O}_2$	0.999														
$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$	0.99														
$4\text{NaOH} + 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	0.99														
$4\text{NaOH} + 2\text{Cl}_2 \rightarrow 4\text{NaCl} + 2\text{H}_2\text{O} + \text{O}_2$	0.99														
$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	0.99														
Gas, water, sludge separator / AQ-SPLIT (SEP)	100	-	<p>Separates gas, liquid, and sludge from aqueous waste treatment. Gases (O_2, H_2, N_2, F_2, NO, CO_2, O_3) are sent to APC subsystem. Liquids (H_2O, SO_2, H_2SO_4, HCl, HNO_3, H_2O_2, OH radicals, 1% of C, 1% of SiO_2, 1% of Al_2O_3) are available for recycle in the system. Solids (Fe, As, Ba, Cd, Cr, Pb, Hg, Se, Ag, NaCl, FeCl_3, AgCl, NaOH, Na_2SO_4, NaNO_3, 99% of C, 99% of SiO_2, 99% of Al_2O_3) are routed to polymer stabilization subsystem.</p>												
Evaporator / CONCENT8 (FLASH2)	150	111	<p>Models evaporation of scrubber liquor from APC subsystem. Two-phase flash determines vapor-liquid equilibrium at 150°F and 1 atm. Vapor sent to PHOTOMIX, liquid/solid phase sent to polymer stabilization subsystem.</p>												
Soil wash / AQ-WASH1 (SEP)	65	-	<p>Models the aqueous wash for bulk soils. Operates at 65°F and 1 atm. Water is added in a 1:1 ratio with the incoming soil. 95% of the H_2, 95% of the Cl_2, and 95% of the C are removed by washing and are routed to the organic destruction subsystem.</p>												
Soil dryer / SOLDRYER (HEATER)	200	54566	<p>Dryer removes water entrained in soil during washing.</p>												
Soil dryer / H2OSEP (SEP)	200	-	<p>Separates water dried from soil. Water is sent to the aqueous waste treatment subsystem. Dried soil is routed to the grout stabilization subsystem.</p>												

Grout stabilization feed preparation / GROUTMIX (MIXER)	88	-	Combines all waste feed to grout stabilization.												
Micro-solidification / GROUTER (MIXER)	72	-	Combines cement and water with incoming waste feed. Amount of cement is determined by design spec GROUT. Total grout:waste ratio is 2:1 and dry grout:water ratio is 0.7:0.3. Amount of water is determined by design spec GROUTH2O according to the above ratio.												
Mercury amalgamation / HG-AMALG (MIXER)	68	-	Amalgamation of mercury wastes. Addition of copper in ratio of 0.7:1 (Cu:waste) as determined by FORTRAN block ADDITIVE.												
Metal decontamination / MET-DCON (SEP)	64	-	Decontamination of metal with abrasive blasting. Assumes water input in a ratio of 112 lb per 468 lb waste. Assumes all grit recycled (no make-up grit added to process). Liquid stream (H ₂ O, H ₂ , C, Al ₂ O ₃ , and SiO ₂) is sent to aqueous waste treatment. Clean metal (Fe) exits the process.												
Organic destruction feed preparation / MEO-MIXR (MIXER)	184	-	Mixes all feed material to MEO process, including waste input, reagents, and recycle streams (water and nitric acid). Make-up silver nitrate is determined by FORTRAN block AGNO3-IN. Make-up nitric acid is determined by FORTRAN block HNO3-IN2.												
MEO process - anode / MEO-ANOD (RSTOIC)	176	64958648	<div>Reacts at 80°C and 35 psig.</div> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>$C + 2H_2O \rightarrow CO_2 + 4H^+ + 4e^-$</td><td>0.99</td></tr><tr><td>$H_2 \rightarrow 2H^+$</td><td>1.00</td></tr><tr><td>$Cl_2 + 2H^+ + 2e^- \rightarrow 2HCl$</td><td>1.00</td></tr><tr><td>$2S + 2H_2O + 3O_2 \rightarrow H_2SO_4$</td><td>1.00</td></tr><tr><td>$2N_2 + 2H_2O + 5O_2 \rightarrow 4HNO_3$</td><td>1.00</td></tr></table>	Reaction	Conversion	$C + 2H_2O \rightarrow CO_2 + 4H^+ + 4e^-$	0.99	$H_2 \rightarrow 2H^+$	1.00	$Cl_2 + 2H^+ + 2e^- \rightarrow 2HCl$	1.00	$2S + 2H_2O + 3O_2 \rightarrow H_2SO_4$	1.00	$2N_2 + 2H_2O + 5O_2 \rightarrow 4HNO_3$	1.00
Reaction	Conversion														
$C + 2H_2O \rightarrow CO_2 + 4H^+ + 4e^-$	0.99														
$H_2 \rightarrow 2H^+$	1.00														
$Cl_2 + 2H^+ + 2e^- \rightarrow 2HCl$	1.00														
$2S + 2H_2O + 3O_2 \rightarrow H_2SO_4$	1.00														
$2N_2 + 2H_2O + 5O_2 \rightarrow 4HNO_3$	1.00														

MEO process - cathode / MEO- CATH (RSTOIC)	176	-68479920	Reacts at 80°C and 35 psig.. <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>$\text{HNO}_3 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O} + \text{HNO}_2$</td><td>1.00</td></tr><tr><td>$\text{AgNO}_3 + \text{HCl} \rightarrow \text{AgCl} + \text{HNO}_3$</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	$\text{HNO}_3 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O} + \text{HNO}_2$	1.00	$\text{AgNO}_3 + \text{HCl} \rightarrow \text{AgCl} + \text{HNO}_3$	0.99
<u>Reaction</u>	<u>Conversion</u>								
$\text{HNO}_3 + 2\text{H}^+ + 2\text{e}^- \rightarrow \text{H}_2\text{O} + \text{HNO}_2$	1.00								
$\text{AgNO}_3 + \text{HCl} \rightarrow \text{AgCl} + \text{HNO}_3$	0.99								
Silver precipitation / AG-PPT (RSTOIC)	176	-496	Precipitation of remaining AgNO_3 with addition of HCl. Reacts and 80°C and 35 psig at 100% conversion.						
MEO process / MEO3 (RSTOIC)	176	0	Converts remaining nitrate to HNO_2 at 80°C and 35 psig. <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>$4\text{H}^+ + 2\text{NO}_3^- + 2\text{e}^- \rightarrow$ $\text{HNO}_3 + \text{HNO}_2 + \text{H}_2\text{O}$</td><td>0.99</td></tr><tr><td>$\text{H}^+ + \text{Cl}^- \rightarrow \text{HCl}$</td><td>1.00</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	$4\text{H}^+ + 2\text{NO}_3^- + 2\text{e}^- \rightarrow$ $\text{HNO}_3 + \text{HNO}_2 + \text{H}_2\text{O}$	0.99	$\text{H}^+ + \text{Cl}^- \rightarrow \text{HCl}$	1.00
<u>Reaction</u>	<u>Conversion</u>								
$4\text{H}^+ + 2\text{NO}_3^- + 2\text{e}^- \rightarrow$ $\text{HNO}_3 + \text{HNO}_2 + \text{H}_2\text{O}$	0.99								
$\text{H}^+ + \text{Cl}^- \rightarrow \text{HCl}$	1.00								
Centrifuge- Evaporator / MEO-SPLT (SEP)	176	-	Separates gases, solids, and recycle streams. Some H_2O and all HCl is recycled to MEO process and is controlled by design spec $\text{H}_2\text{O-IN}$. Remaining H_2O is routed aqueous waste treatment. Gases are routed to nitrous acid conversion and NO_x removal. AgCl and HNO_3 are routed to silver conversion. F_2 , Ba, Fe, Cd, Cr, C, SiO_2 , Al_2O_3 , and 10 ppm of HNO_3 are routed to neutralization.						
Nitrous acid conversion / HNO_2RECV (RSTOIC)	302	-1006403	Converts HNO_2 to HNO_3 and to NO at 423 K and 35 psig. O_2 input (1% excess) is determined by design spec $\text{O}_2\text{-HNO}_2$. <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>$2\text{HNO}_2 + \text{O}_2 \rightarrow 2\text{HNO}_3$</td><td>0.99</td></tr><tr><td>$4\text{HNO}_2 \rightarrow 2\text{H}_2\text{O} + 4\text{NO} + \text{O}_2$</td><td>0.01</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	$2\text{HNO}_2 + \text{O}_2 \rightarrow 2\text{HNO}_3$	0.99	$4\text{HNO}_2 \rightarrow 2\text{H}_2\text{O} + 4\text{NO} + \text{O}_2$	0.01
<u>Reaction</u>	<u>Conversion</u>								
$2\text{HNO}_2 + \text{O}_2 \rightarrow 2\text{HNO}_3$	0.99								
$4\text{HNO}_2 \rightarrow 2\text{H}_2\text{O} + 4\text{NO} + \text{O}_2$	0.01								
Nitrous acid conversion / NOX-SPLT (SEP)	302	-	Separates HNO_3 for recycle back to MEO reactor.						

NOx removal / NOX-CONV (RSTOIC)	68	-107747	<p>Reacts NO at 68°F and 1 atm and 99% conversion. Reaction is. Stoichiometric NH₃ input is determined by FORTRAN block X-NH3. Gases are then routed to APC.</p> <p><u>Reaction</u> <u>Conversion</u> $6 \text{ NO} + 4 \text{ NH}_3 \rightarrow 5 \text{ N}_2 + 6 \text{ H}_2\text{O}$ 0.99</p>
Silver conversion- silver dissolving / AGRECOVR (RSTOIC)	100	761415	<p>Converts AgCl to AgNO₃ at 100°F and 1 atm; H₂O₂ and NaOH fed to the block are determined by the FORTRAN block AGRECOVR.</p> <p><u>Reaction</u> <u>Conversion</u> $4 \text{ AgCl} + 4 \text{ NaOH} + 4 \text{ H}_2\text{O}_2 \rightarrow$ 0.99 $4 \text{ Ag} + 4 \text{ NaCl} + 6 \text{ H}_2\text{O} + 3 \text{ O}_2$ $\text{Ag} + \text{HNO}_3 \rightarrow \text{AgNO}_3 + \text{H}^+ + \text{e}^-$ 0.99</p>
Centrifuge / AG-SPLT (SEP)	100	-	<p>Separates AgNO₃ and HNO₃ for recycle to MEO reactor. Gases (O₂) are routed to APC system. Liquids (H₂O, Ag, NaOH, NaCl, H⁺, e⁻, H₂O₂, AgCl) are routed to aqueous waste treatment.</p>
Neutralization / NEUTRAL (RSTOIC)	68	-406	<p>Neutralizes acids at 68°F and 1 atm. Neutralized liquid is routed to aqueous waste treatment.</p> <p><u>Reaction</u> <u>Conversion</u> $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$ 0.99 $\text{HNO}_3 + \text{NaOH} \rightarrow \text{NaNO}_3 + \text{H}_2\text{O}$ 0.99 $\text{Cl}^- + \text{H}^+ + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$ 1.00 $\text{NO}_3^- + \text{H}^+ \rightarrow \text{NaNO}_3 + \text{H}_2\text{O}$ 1.00</p>
Lead recovery- separation / PB-SPLIT (SEP)	68	-	<p>Separates brick or sheet lead (assumed to be 81% of total) for decontamination. Remaining lead (leaded gloves, blankets, shot) is routed to grout stabilization.</p>
Lead decontamination / PB-DECON (SEP)	63	-	<p>Decontaminates lead with water wash, separates clean lead, which exits the system. Liquid and sludge are routed to process residue treatment subsystem.</p>
Polymer feed preparation / POLY-MIX (MIXER)	70	-	<p>Mixes incoming waste for polymer stabilization.</p>

Dryer / DRYER (HEATER)	200	91425	Removes excess water prior to polymer stabilization.
Dryer / WATERSEP (SEP)	200	-	Separates water, input to polymer stabilization is dried to 5% moisture content, as determined by design spec DRYER. Excess H ₂ O, NO, and SO ₂ are sent to aqueous waste treatment subsystem.
Mixing / POLYSTAB (MIXER)	96	-	Adds polyethylene to encapsulate the waste. Polymer:waste ratio is 1:1.
Process residue wash / AQ-WASH2 (SEP)	67	-	Models the aqueous wash for process residue and inorganic sludges. Make-up water of 15% of mass of incoming waste is used. The washing process produces an organic stream (95% of O ₂ , 95% of H ₂ , 95% of Cl ₂ , 95% of C, 1% of SiO ₂ , and 1% of Al ₂ O ₃) that is sent to organic destruction. The remaining solids (H ₂ O, 5% of O ₂ , 5% of H ₂ , N ₂ , S, 5% of Cl ₂ , Fe, As, Ba, Cd, Cr, Pb, Hg, Se, Ag, 5% of C, 99% of SiO ₂ , and 99% of Al ₂ O ₃) are routed to the polymer stabilization subsystem.
Soft debris wash / AQ-WASH3 (SEP)	64	-	Models the aqueous wash for soft debris. Make-up water of 15% of mass of incoming waste is used. Two-thirds of the make-up water will be routed to aqueous waste treatment; one-third of the water is assumed to be entrained with the waste after washing. The washing process produces an aqueous stream (10% of O ₂ , 10% of H ₂ , 10% of Cl ₂ , 10% of F ₂ , 10% of Hg, 10% of C, 1% of SiO ₂ , and 1% of Al ₂ O ₃ , and two-thirds of the wash H ₂ O) that is sent to aqueous waste treatment. The remaining solids (remainder of H ₂ O, 90% of O ₂ , 90% of H ₂ , N ₂ , S, 90% of Cl ₂ , 90% of F ₂ , Fe, Pb, 90 % of Hg, Se, Ag, 90% of C, 99% of SiO ₂ , and 99% of Al ₂ O ₃) are routed to the grout stabilization subsystem.

Open debris wash / AQ-WASH4 (SEP)	66	-	Models the aqueous wash for open debris. Make-up water of 15% of mass of incoming waste is used. Two-thirds of the make-up water will be routed to aqueous waste treatment; one-third of the water is assumed to be entrained with the waste after washing. The washing process produces an aqueous stream (98% of O ₂ , 98% of H ₂ , 98% of C, two-thirds of the wash H ₂ O, 1% of SiO ₂ , and 1% of Al ₂ O ₃) that is sent to aqueous waste treatment. The remaining solids (remainder of H ₂ O, 2% of O ₂ , 2% of H ₂ , N ₂ , S, 2% of Cl ₂ , Fe, As, Ba, Cd, Cr, Pb, Hg, Se, Ag, 2% of C, 99% of SiO ₂ , and 99% of Al ₂ O ₃) are routed to the polymer stabilization subsystem.
Complex debris wash / AQ-WASH5 (SEP)	63	-	Models the aqueous wash for complex debris. Make-up water of 15% of mass of incoming waste is used. Two-thirds of the make-up water will be routed to aqueous waste treatment; one-third of the water is assumed to be entrained with the waste after washing. The washing process produces an aqueous stream (98% of H ₂ , 98% of C, two-thirds of the wash H ₂ O, 1% of SiO ₂ , and 1% of Al ₂ O ₃ .) that is sent to aqueous waste treatment. The remaining solids (remainder of H ₂ O, 2% of H ₂ , Fe, Hg, 2% of C, 99% of SiO ₂ , and 99% of Al ₂ O ₃) are routed to the polymer stabilization subsystem.
Special waste	68	-	As with the ITTS study, no model was constructed for special waste.

System 4 - Acid Digestion Case

ASSUMPTIONS and ENERGY BALANCES for ACID DIGESTION CASE, System 4															
GENERAL COMMENTS:															
Unit Operation / ASPEN PLUS Block Name	Outlet Temp. (°F)	Heat Duty (MMBtu/hr)	Description and Assumptions												
APC filter / FILTER (SEP)	100	-	Filter to separate heavy metals and other solids from gas stream. Gas streams entering the APC system usually have all particulates removed beforehand.												
Gas phase corona reactor / GPCR (RSTOIC)	419	40292	<p>Combines C, CO, H₂, and CH₄ with O₂ at 1 atm pressure to form H₂O and CO₂. Cl₂ is combined with H₂ to form HCl. Power input is determined by design spec GPCRPOWER, which calculates 56.49 W per SCFM of gases entering the process. The need for excess O₂ (100%) is determined by design spec AIR4.</p> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>2 H₂ + O₂ → 2 H₂O</td><td>0.95</td></tr><tr><td>C + O₂ → CO₂</td><td>0.95</td></tr><tr><td>2 CO + O₂ → 2 CO₂</td><td>0.95</td></tr><tr><td>CH₄ + 2 O₂ → CO₂ + 2 H₂O</td><td>0.95</td></tr><tr><td>H₂ + Cl₂ → 2 HCl</td><td>0.95</td></tr></table>	Reaction	Conversion	2 H ₂ + O ₂ → 2 H ₂ O	0.95	C + O ₂ → CO ₂	0.95	2 CO + O ₂ → 2 CO ₂	0.95	CH ₄ + 2 O ₂ → CO ₂ + 2 H ₂ O	0.95	H ₂ + Cl ₂ → 2 HCl	0.95
Reaction	Conversion														
2 H ₂ + O ₂ → 2 H ₂ O	0.95														
C + O ₂ → CO ₂	0.95														
2 CO + O ₂ → 2 CO ₂	0.95														
CH ₄ + 2 O ₂ → CO ₂ + 2 H ₂ O	0.95														
H ₂ + Cl ₂ → 2 HCl	0.95														
Acid gas scrubber / NEUTRAL3 (RSTOIC)	100	-105058	<p>Neutralizes SO₂ with NaOH at 1 atm pressure and 100°F to form Na₂SO₄ at a conversion level of 99%. Excess NaOH (1%) is determined by design spec NAOH-3.</p> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>2SO₂+4NaOH+O₂ → 2Na₂SO₄+2H₂O</td><td>0.99</td></tr></table>	Reaction	Conversion	2SO ₂ +4NaOH+O ₂ → 2Na ₂ SO ₄ +2H ₂ O	0.99								
Reaction	Conversion														
2SO ₂ +4NaOH+O ₂ → 2Na ₂ SO ₄ +2H ₂ O	0.99														
Scrubber liquor sump / BLOWDOWN (SEP)	100	-	Separates salts formed in scrubber. NaOH and NaCl are sent with some water to aqueous waste treatment subsystem. Water flow rate calculated for 20% salt solution by design spec SALTSOLN.												

Mist eliminator / FLASH (FLASH2)	100	0	Two-phase flash to separate out additional moisture. Flash determines vapor-liquid equilibrium at 100°F and 1 atm. Moisture sent to aqueous waste treatment subsystem.
Filter / HETRHEPA (HEATER)	300	64397	Heater to raise temperature of gas stream to 300°F to avoid condensate in HEPA filter.
Ozone generator / OZ-GEN (RSTOIC)	100	1165	O ₃ generated from O ₂ at 100°F and 1 atm. <div> <div>Reaction</div> <div>3 O₂ → 2 O₃</div> <div>Conversion</div> <div>0.99</div> </div>
Aqueous liquids sorting / PHOTOMIX (MIXER)	89	-	Combines all streams entering aqueous waste treatment subsystem.
Gross organics removal / OILSEP (SEP)	89	-	Oil-water separator to remove C and H ₂ from liquid stream at an assumed efficiency of 99%.
OH generator / OH-GEN (RSTOIC)	100	2671	Generates OH radicals from H ₂ O ₂ and O ₃ . <div> <div>Reaction</div> <div>H₂O₂ → 2OH •</div> <div>Conversion</div> <div>0.99</div> <div>O₃ + 3H₂O → 6OH •</div> <div>0.99</div> </div>
UV reactor / PHOTO-UV (RSTOIC)	100	-24360	Combines C and H ₂ with OH radicals. <div> <div>Reaction</div> <div>C + 4 OH • → CO₂ + 2 H₂O</div> <div>Conversion</div> <div>0.96</div> <div>H₂ + 4 OH • → 2 H₂O</div> <div>0.96</div> <div>H₂ + Cl₂ → 2 HCl</div> <div>0.96</div> </div>
Ozone decomposition / OZ-DECOM (RSTOIC)	100	-17033	Decomposes unreacted ozone neutralizes acids at 100°F and 1 atm. Excess NaOH (1%) is determined by design spec XX-NAOH. <div> <div>Reaction</div> <div>2 O₃ → 3 O₂</div> <div>Conversion</div> <div>0.999</div> <div>NaOH + HCl → NaCl + H₂O</div> <div>0.99</div> <div>NaOH + HNO₃ → NaNO₃ + H₂O</div> <div>0.99</div> <div>2NaOH + H₂SO₄ → Na₂SO₄ + 2H₂O</div> <div>0.99</div> </div>

Gas, water, sludge separator / AQ-SPLIT (SEP)	100	-	Separates gas, liquid, and sludge from aqueous waste treatment. Gases (O_2 , H_2 , N_2 , CO_2 , O_3) are sent to APC subsystem. Liquids (H_2O , SO_2 , H_2SO_4 , HCl , HNO_3 , H_2O_2 , NH_3 , OH radicals, 1% of C, 1% of SiO_2 , 1% of Al_2O_3) are available for recycle in the system. Solids (As, Ba, Cd, Cr, Pb, Hg, Se, Ag, NaCl, AgCl, NaOH, Na_2SO_4 , $NaNO_3$, 99% of C, 99% of SiO_2 , 99% of Al_2O_3) are routed to polymer stabilization subsystem.
Evaporator / CONCENT8 (FLASH2)	150	2	Models evaporation of scrubber liquor from APC subsystem. Two-phase flash determines vapor-liquid equilibrium at 150°F and 1 atm. Vapor sent to PHOTOMIX, liquid/solid phase sent to polymer stabilization subsystem.
Soil wash / AQ-WASH1 (SEP)	65	-	Models the aqueous wash for bulk soils. Operates at 65°F and 1 atm. Water is added in a 1:1 ratio with the incoming soil. 95% of the H_2 , 95% of the Cl_2 , and 95% of the C are removed by washing and are routed to the organic destruction subsystem.
Soil dryer / SOLDRYER (HEATER)	200	54566	Dryer removes water entrained in soil during washing.
Soil dryer / H2OSEP (SEP)	200	-	Separates water dried from soil. Water is sent to the aqueous waste treatment subsystem. Dried soil is routed to the grout stabilization subsystem.
Grout stabilization feed preparation / GROUTMIX (MIXER)	68	-	Combines all waste feed to grout stabilization, including complex debris.
Micro-solidification / GROUTER (MIXER)	56	-	Combines cement and water with incoming waste feed. Amount of cement is determined by design spec GROUT. Total grout:waste ratio is 2:1 and dry grout:water ratio is 0.7:0.3. Amount of water is determined by design spec GROUTH2O according to the above ratio.

Mercury amalgamation / HG-AMALG (MIXER)	68	-	Amalgamation of mercury wastes. Addition of copper in ratio of 0.7:1 (Cu:waste) as determined by FORTRAN block ADDITIVE.												
Metal decontamination / MET-DCON (SEP)	64	-	Decontamination of metal with abrasive blasting. Assumes water input in a ratio of 112 lb per 468 lb waste. Assumes all grit recycled (no make-up grit added to process). Liquid stream (H ₂ O, H ₂ , C, Al ₂ O ₃ , and SiO ₂) is sent to aqueous waste treatment. Clean metal (Fe) exits the process.												
Digestion reactor / ACID-DG1 (RSTOIC)	392	-2118832	<p>Organic destruction of organics with nitric acid. Phosphoric acid, although present in the reactor, does not participate in the reaction. Reacts at 200°C and 1 atm. 5% excess HNO₃ is used, as determined by design spec HNO3-IN1.</p> <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>3C + 4HNO₃ → 3CO₂ + 4NO + 2H₂O</td><td>0.95</td></tr><tr><td>3H₂ + 2HNO₃ → 2NO + 4H₂O</td><td>0.95</td></tr><tr><td>Cl₂ + H₂ → 2HCl</td><td>0.95</td></tr><tr><td>S + H₂ + 2O₂ → H₂SO₄</td><td>0.95</td></tr><tr><td>3CH₄ + 8HNO₃ → 3CO₂ + 8NO + 10H₂O</td><td>0.95</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	3C + 4HNO ₃ → 3CO ₂ + 4NO + 2H ₂ O	0.95	3H ₂ + 2HNO ₃ → 2NO + 4H ₂ O	0.95	Cl ₂ + H ₂ → 2HCl	0.95	S + H ₂ + 2O ₂ → H ₂ SO ₄	0.95	3CH ₄ + 8HNO ₃ → 3CO ₂ + 8NO + 10H ₂ O	0.95
<u>Reaction</u>	<u>Conversion</u>														
3C + 4HNO ₃ → 3CO ₂ + 4NO + 2H ₂ O	0.95														
3H ₂ + 2HNO ₃ → 2NO + 4H ₂ O	0.95														
Cl ₂ + H ₂ → 2HCl	0.95														
S + H ₂ + 2O ₂ → H ₂ SO ₄	0.95														
3CH ₄ + 8HNO ₃ → 3CO ₂ + 8NO + 10H ₂ O	0.95														
Acid recovery / HNO2RECV (RSTOIC)	302	-1093339	<p>Recovers nitric acid from NO produced in digestion reactor. Reaction proceeds at 423 K and 35 psig. Amount of O₂ (1% excess) determined by design spec OXYGEN1.</p> <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>4NO + 3O₂ + 2H₂O → 4HNO₃</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	4NO + 3O ₂ + 2H ₂ O → 4HNO ₃	0.99								
<u>Reaction</u>	<u>Conversion</u>														
4NO + 3O ₂ + 2H ₂ O → 4HNO ₃	0.99														
Acid recovery / HNO3-SEP (SEP)	302	-	Separates HNO ₃ for recycle to digestion reactor. Assumes a 99% separation of HNO ₃ .												

Acid gas scrubber / NEUTRAL1 (RSTOIC)	100	-419798	Neutralizes acids and removes NO _x at 100°F and 1 atm. Amount of NaOH (1% excess) determined by design spec NAOH-1. Amount of NH ₃ (5% excess) determined by design spec NH3-IN-1. <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>HCl + NaOH → NaCl + H₂O</td><td>0.99</td></tr><tr><td>2 Cl₂ + 4 NaOH → 4 NaCl + 2 H₂O + O₂</td><td>0.99</td></tr><tr><td>H₂SO₄ + 2 NaOH → Na₂SO₄ + 2 H₂O</td><td>0.99</td></tr><tr><td>HNO₃ + NaOH → NaNO₃ + H₂O</td><td>0.99</td></tr><tr><td>6 NO + 4 NH₃ → 5 N₂ + 6 H₂O</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	HCl + NaOH → NaCl + H ₂ O	0.99	2 Cl ₂ + 4 NaOH → 4 NaCl + 2 H ₂ O + O ₂	0.99	H ₂ SO ₄ + 2 NaOH → Na ₂ SO ₄ + 2 H ₂ O	0.99	HNO ₃ + NaOH → NaNO ₃ + H ₂ O	0.99	6 NO + 4 NH ₃ → 5 N ₂ + 6 H ₂ O	0.99
<u>Reaction</u>	<u>Conversion</u>														
HCl + NaOH → NaCl + H ₂ O	0.99														
2 Cl ₂ + 4 NaOH → 4 NaCl + 2 H ₂ O + O ₂	0.99														
H ₂ SO ₄ + 2 NaOH → Na ₂ SO ₄ + 2 H ₂ O	0.99														
HNO ₃ + NaOH → NaNO ₃ + H ₂ O	0.99														
6 NO + 4 NH ₃ → 5 N ₂ + 6 H ₂ O	0.99														
Acid gas scrubber / DG-SPLT1 (SEP)	100	-	Separates products of reaction from acid digestion process. Gases (N ₂ , O ₂ , Cl ₂ , NO, CO ₂ , and CH ₄) are routed to the APC subsystem. Liquids (H ₂ O, NaOH, NaCl, HCl, H ₂ SO ₄ , Na ₂ SO ₄ , HNO ₃ , NaNO ₃ , NH ₃) are sent to the aqueous waste treatment subsystem. Solids (S, Fe, Ba, Cd, Cr, C, SiO ₂ , Al ₂ O ₃) are sent to phosphate bonded ceramic stabilization.												
Lead recovery-separation / PB-SPLIT (SEP)	68	-	Separates brick or sheet lead (assumed to be 81% of total) for decontamination. Remaining lead (leaded gloves, blankets, shot) is routed to grout stabilization.												
Lead decontamination / PB-DECON (SEP)	63	-	Decontaminates lead with water wash, separates clean lead, which exits the system. Liquid and sludge are routed to process residue treatment subsystem.												
Phosphate bonded ceramic feed preparation / PHOS-MIX (MIXER)	160	-	Mixes incoming waste for polymer stabilization.												
Dryer / DRYER (HEATER)	200	104038	Removes excess water prior to polymer stabilization.												
Dryer / WATERSEP (SEP)	200	-	Separates water, input to polymer stabilization is dried to 5% moisture content, as determined by design spec DRYER. Excess H ₂ O, NO, and SO ₂ are sent to aqueous waste treatment subsystem.												

Mixing / POLYSTAB (MIXER)	154	-	Adds polyethylene to encapsulate the waste. Polymer:waste ratio is 1:1.										
Process residue dryer / VACTRAX1 (RGIBBS)	550	515629	Models the vacuum desorber for process residue and inorganic sludges. Operates at 550°F and 1 psig. Equilibrium is assumed for species entered in the RGIBBS block: H ₂ SO ₄ , HCl, and CH ₄ are assumed to form from feed components. O ₂ is excluded from reaction. A nitrogen sweep gas is used at a rate of 1.09 ft ³ per lb waste (0.0793 lb N ₂ /lb waste) as determined by FORTRAN block N2SWEEP.										
Mercury leaching / VACSEP-1 (SEP)	97	-	<p>Mercury leaching of process residue and inorganic sludges by addition of leach water (30% of mass of incoming waste). Also includes separation of gases, liquids, organics, Hg-contaminated liquids, and solids.</p> <p>Gases (N₂) are sent to APC subsystem. Solids (H₂O in leach water, 50% of H₂, O₂, S, 50% of C, SiO₂, Al₂O₃, Ba, As, Pb, Fe, Cd, Cr, 5% of Hg, Se, Ag) are routed to grout stabilization subsystem. Liquids (balance of H₂O, H₂SO₄) are sent to aqueous waste treatment. Organics (50% of H₂, 50% of C) are routed to the organic destruction subsystem. Mercury separated (95%) is routed to mercury amalgamation.</p>										
Soft debris digestion reactor / ACID-DG2 (RSTOIC)	392	-29288296	<p>Organic destruction of soft debris with nitric acid. Phosphoric acid, although present in the reactor, does not participate in the reaction. Reacts and 200°C and 1 atm.</p> <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>3C + 4HNO₃ → 3CO₂ + 4NO + 2H₂O</td><td>0.95</td></tr><tr><td>3H₂ + 2HNO₃ → 2NO + 4H₂O</td><td>0.95</td></tr><tr><td>Cl₂ + H₂ → 2 HCl</td><td>0.95</td></tr><tr><td>S + H₂ + 2O₂ → H₂SO₄</td><td>0.95</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	3C + 4HNO ₃ → 3CO ₂ + 4NO + 2H ₂ O	0.95	3H ₂ + 2HNO ₃ → 2NO + 4H ₂ O	0.95	Cl ₂ + H ₂ → 2 HCl	0.95	S + H ₂ + 2O ₂ → H ₂ SO ₄	0.95
<u>Reaction</u>	<u>Conversion</u>												
3C + 4HNO ₃ → 3CO ₂ + 4NO + 2H ₂ O	0.95												
3H ₂ + 2HNO ₃ → 2NO + 4H ₂ O	0.95												
Cl ₂ + H ₂ → 2 HCl	0.95												
S + H ₂ + 2O ₂ → H ₂ SO ₄	0.95												

Acid recovery / HNO2REC2 (RSTOIC)	302	-1518081	<p>Recovers nitric acid from NO produced in digestion reactor. Reaction proceeds at 423 K and 35 psig. Amount of O₂ (0% excess) is determined by design spec OXYGEN2. Oxygen in soft debris not available for conversion to HNO₃.</p> <p><u>Reaction</u> <u>Conversion</u> $4 \text{ NO} + 3 \text{ O}_2 + 2 \text{ H}_2\text{O} \rightarrow 4 \text{ HNO}_3$ 0.99</p>
Acid recovery / HNO3SEP2 (SEP)	302	-	<p>Separates HNO₃ for recycle to digestion reactor. Assumes a 99% separation of HNO₃.</p>
Acid gas scrubber / NEUTRAL2 (RSTOIC)	100	-470362	<p>Neutralizes acids and removes NO_x at 100°F and 1 atm. Amount of NaOH (1% excess) determined by design spec NAOH-2. Amount of NH₃ (5% excess) determined by design spec NH3-IN-2.</p> <p><u>Reaction</u> <u>Conversion</u> $\text{HCl} + \text{NaOH} \rightarrow \text{NaCl} + \text{H}_2\text{O}$ 0.99 $2 \text{ Cl}_2 + 4 \text{ NaOH} \rightarrow 4 \text{ NaCl} + 2 \text{ H}_2\text{O} + \text{O}_2$ 0.99 $\text{H}_2\text{SO}_4 + 2 \text{ NaOH} \rightarrow \text{Na}_2\text{SO}_4 + 2 \text{ H}_2\text{O}$ 0.99 $\text{HNO}_3 + \text{NaOH} \rightarrow \text{NaNO}_3 + \text{H}_2\text{O}$ 0.99 $6 \text{ NO} + 4 \text{ NH}_3 \rightarrow 5 \text{ N}_2 + 6 \text{ H}_2\text{O}$ 0.99</p>
Acid gas scrubber / DG-SPLT2 (SEP)	100	-	<p>Separates products of reaction from acid digestion process. Gases (H₂, N₂, Cl₂, F₂, NO, CO₂) are routed to the APC subsystem. Liquids (H₂O, 5% of Hg, NaOH, NaCl, HCl, H₂SO₄, Na₂SO₄, HNO₃, NaNO₃, NH₃) are sent to the aqueous waste treatment subsystem. Solids (O₂, S, Fe, 95% of Hg, C, SiO₂, Al₂O₃) are sent to phosphate bonded ceramic stabilization.</p>

Open debris wash / HP-WASH (SEP)	66	-	Models the aqueous wash for open debris. Make-up water of 15% of mass of incoming waste is used. Two-thirds of the make-up water will be routed to aqueous waste treatment; one-third of the water is assumed to be entrained with the waste after washing. The washing process produces an aqueous stream (98% of O ₂ , 98% of H ₂ , 98% of C, two-thirds of the wash water, 1% of SiO ₂ , and 1% of Al ₂ O ₃) that is sent to aqueous waste treatment. The remaining solids (remainder of H ₂ O, 2% of O ₂ , 2% of H ₂ , N ₂ , S, 2% of Cl ₂ , Fe, As, Ba, Cd, Cr, Pb, Hg, Se, Ag, 2% of C, 99% of SiO ₂ , and 99% of Al ₂ O ₃) are routed to the grout stabilization subsystem.
Special waste	68	-	As with the ITTS study, no model was constructed for special waste.

System 5 - Catalytic Wet Oxidation Case

ASSUMPTIONS and ENERGY BALANCES for CATALYTIC WET OXIDATION CASE, System 5															
GENERAL COMMENTS:															
Unit Operation / ASPEN PLUS Block Name	Outlet Temp. (°F)	Heat Duty (MMBtu/hr)	Description and Assumptions												
APC filter / FILTER (SEP)	288	-	Filter to separate heavy metals and other solids from gas stream. Gas streams entering the APC system usually have all particulates removed beforehand.												
Gas phase corona reactor / GPCR (RSTOIC)	405	39148	<p>Combines C, CO, H₂, and CH₄ with O₂ at 1 atm pressure to form H₂O and CO₂. Cl₂ is combined with H₂ to form HCl. Power input is determined by design spec GPCRPOWER, which calculates 56.49 W per SCFM of gases entering the process. The need for excess O₂ (100%) is determined by design spec AIR4.</p> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>2 H₂ + O₂ → 2 H₂O</td><td>0.95</td></tr><tr><td>C + O₂ → CO₂</td><td>0.95</td></tr><tr><td>2 CO + O₂ → 2 CO₂</td><td>0.95</td></tr><tr><td>CH₄ + 2 O₂ → CO₂ + 2 H₂O</td><td>0.95</td></tr><tr><td>H₂ + Cl₂ → 2 HCl</td><td>0.95</td></tr></table>	Reaction	Conversion	2 H ₂ + O ₂ → 2 H ₂ O	0.95	C + O ₂ → CO ₂	0.95	2 CO + O ₂ → 2 CO ₂	0.95	CH ₄ + 2 O ₂ → CO ₂ + 2 H ₂ O	0.95	H ₂ + Cl ₂ → 2 HCl	0.95
Reaction	Conversion														
2 H ₂ + O ₂ → 2 H ₂ O	0.95														
C + O ₂ → CO ₂	0.95														
2 CO + O ₂ → 2 CO ₂	0.95														
CH ₄ + 2 O ₂ → CO ₂ + 2 H ₂ O	0.95														
H ₂ + Cl ₂ → 2 HCl	0.95														
Acid gas scrubber / NEUTRAL3 (RSTOIC)	100	-98578	<p>Neutralizes HCl, Cl₂, and SO₂ with NaOH at 1 atm pressure and 100°F to form NaCl and Na₂SO₄. Excess NaOH (1%) is determined by design spec NAOH-3.</p> <table><tr><th>Reaction</th><th>Conversion</th></tr><tr><td>HCl + NaOH → NaCl + H₂O</td><td>0.99</td></tr><tr><td>2 Cl₂ + 4 NaOH → 4 NaCl + 2 H₂O + O₂</td><td>0.99</td></tr><tr><td>2SO₂ + 4NaOH + O₂ → 2Na₂SO₄ + 2H₂O</td><td>0.99</td></tr></table>	Reaction	Conversion	HCl + NaOH → NaCl + H ₂ O	0.99	2 Cl ₂ + 4 NaOH → 4 NaCl + 2 H ₂ O + O ₂	0.99	2SO ₂ + 4NaOH + O ₂ → 2Na ₂ SO ₄ + 2H ₂ O	0.99				
Reaction	Conversion														
HCl + NaOH → NaCl + H ₂ O	0.99														
2 Cl ₂ + 4 NaOH → 4 NaCl + 2 H ₂ O + O ₂	0.99														
2SO ₂ + 4NaOH + O ₂ → 2Na ₂ SO ₄ + 2H ₂ O	0.99														

Scrubber liquor sump / BLOWDOWN (SEP)	100	-	Separates salts formed in scrubber. NaCl, NaOH, and Na ₂ SO ₄ are sent with some water to aqueous waste treatment subsystem. Water flow rate calculated for 20% salt solution by design spec SALTSOLN.
Mist eliminator / FLASH (FLASH2)	100	0	Two-phase flash to separate out additional moisture. Flash determines vapor-liquid equilibrium at 100°F and 1 atm. Moisture sent to aqueous waste treatment subsystem.
Filter / HETRHEPA (HEATER)	300	63421	Heater to raise temperature of gas stream to 300°F to avoid condensate in HEPA filter.
Ozone generator / OZ-GEN (RSTOIC)	100	1196	O ₃ generated from O ₂ at 100°F and 1 atm. <div> <div>Reaction</div> <div>3 O₂ → 2 O₃</div> <div>Conversion</div> <div>0.99</div> </div>
Aqueous liquids sorting / PHOTOMIX (MIXER)	89	-	Combines all streams entering aqueous waste treatment subsystem.
Gross organics removal / OILSEP (SEP)	89	-	Oil-water separator to remove C and H ₂ from liquid stream at an assumed efficiency of 99%.
OH generator / OH-GEN (RSTOIC)	100	1097	Generates OH radicals from H ₂ O ₂ and O ₃ . <div> <div>Reaction</div> <div>H₂O₂ → 2 OH •</div> <div>O₃ + 3 H₂O → 6OH •</div> <div>Conversion</div> <div>0.99</div> <div>0.99</div> </div>
UV reactor / PHOTO-UV (RSTOIC)	100	-22756	Combines C and H ₂ with OH radicals. <div> <div>Reaction</div> <div>C + 4 OH • → CO₂ + 2 H₂O</div> <div>H₂ + 4 OH • → 2 H₂O</div> <div>H₂ + Cl₂ → 2 HCl</div> <div>Conversion</div> <div>0.96</div> <div>0.96</div> <div>0.96</div> </div>

Ozone decomposition / OZ-DECOM (RSTOIC)	100	-22116	<p>Decomposes unreacted ozone neutralizes acids at 100°F and 1 atm. Excess NaOH (1%) is determined by design spec XX-NAOH.</p> <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>$2\text{O}_3 \rightarrow 3\text{O}_2$</td><td>0.999</td></tr><tr><td>$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$</td><td>0.99</td></tr><tr><td>$4\text{NaOH} + 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$</td><td>0.99</td></tr><tr><td>$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	$2\text{O}_3 \rightarrow 3\text{O}_2$	0.999	$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$	0.99	$4\text{NaOH} + 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	0.99	$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	0.99
<u>Reaction</u>	<u>Conversion</u>												
$2\text{O}_3 \rightarrow 3\text{O}_2$	0.999												
$\text{NaOH} + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O}$	0.99												
$4\text{NaOH} + 2\text{SO}_2 + \text{O}_2 \rightarrow 2\text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	0.99												
$2\text{NaOH} + \text{H}_2\text{SO}_4 \rightarrow \text{Na}_2\text{SO}_4 + 2\text{H}_2\text{O}$	0.99												
Gas, water, sludge separator / AQ-SPLIT (SEP)	100	-	<p>Separates gas, liquid, and sludge from aqueous waste treatment. Gases (O_2, H_2, N_2, NO, CO_2, O_3) are sent to APC subsystem. Liquids (H_2O, SO_2, H_2SO_4, HCl, H_2O_2, OH radicals, 1% of C, 1% of SiO_2, 1% of Al_2O_3) are available for recycle in the system. Solids (As, Ba, Cd, Cr, Pb, Se, Ag, NaCl, FeCl_3, AgCl, NaOH, Na_2SO_4, 99% of C, 99% of SiO_2, 99% of Al_2O_3) are routed to polymer stabilization subsystem.</p>										
Evaporator / CONCENT8 (FLASH2)	150	112	<p>Models evaporation of scrubber liquor from APC subsystem. Two-phase flash determines vapor-liquid equilibrium at 150°F and 1 atm. Vapor sent to PHOTOMIX, liquid/solid phase sent to polymer stabilization subsystem.</p>										
Soil wash / AQ-WASH1 (SEP)	65	-	<p>Models the aqueous wash for bulk soils. Operates at 65°F and 1 atm. Water is added in a 1:1 ratio with the incoming soil. 95% of the H_2, 95% of the Cl_2, and 95% of the C are removed by washing and are routed to the organic destruction subsystem.</p>										
Soil dryer / SOLDRYER (HEATER)	200	54566	<p>Dryer removes water entrained in soil during washing.</p>										
Soil dryer / H2OSEP (SEP)	200	-	<p>Separates water dried from soil. Water is sent to the aqueous waste treatment subsystem. Dried soil is routed to the grout stabilization subsystem.</p>										

Grout stabilization feed preparation / GROUTMIX (MIXER)	152	-	Combines all waste feed to grout stabilization, including complex debris.												
Micro-solidification / GROUTER (MIXER)	83	-	Combines cement and water with incoming waste feed. Amount of cement is determined by design spec GROUT. Total grout:waste ratio is 2:1 and dry grout:water ratio is 0.7:0.3. Amount of water is determined by design spec GROUTH2O according to the above ratio.												
Mercury amalgamation / HG-AMALG (MIXER)	68	-	Amalgamation of mercury wastes. Addition of copper in ratio of 0.7:1 (Cu:waste) as determined by FORTRAN block ADDITIVE.												
Metal decontamination / MET-DCON (SEP)	64	-	Decontamination of metal with abrasive blasting. Assumes water input in a ratio of 112 lb per 468 lb waste. Assumes all grit recycled (no make-up grit added to process). Liquid stream (H ₂ O, H ₂ , C, Al ₂ O ₃ , and SiO ₂) is sent to aqueous waste treatment. Clean metal (Fe) exits the process.												
Organic destruction / CWO-1 (RSTOIC)	302	-3252045	<p>Catalytic wet oxidation at 423 K and 35 psig. Oxygen input (5% excess) is determined by design spec O2-CWO. Acid solution (36% H₂O, 60% FeCl₃, 4% HCl) is set to be 7 lb solution/200 lb waste input by design spec ACID-IN.</p> <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>C + O₂ → CO₂</td><td>0.99</td></tr><tr><td>2 H₂ + O₂ → 2 H₂O</td><td>0.99</td></tr><tr><td>CH₄ + 2 O₂ → CO₂ + 2 H₂O</td><td>0.99</td></tr><tr><td>S + H₂ + 2 O₂ → H₂SO₄</td><td>0.99</td></tr><tr><td>H₂ + Cl₂ → 2 HCl</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	C + O ₂ → CO ₂	0.99	2 H ₂ + O ₂ → 2 H ₂ O	0.99	CH ₄ + 2 O ₂ → CO ₂ + 2 H ₂ O	0.99	S + H ₂ + 2 O ₂ → H ₂ SO ₄	0.99	H ₂ + Cl ₂ → 2 HCl	0.99
<u>Reaction</u>	<u>Conversion</u>														
C + O ₂ → CO ₂	0.99														
2 H ₂ + O ₂ → 2 H ₂ O	0.99														
CH ₄ + 2 O ₂ → CO ₂ + 2 H ₂ O	0.99														
S + H ₂ + 2 O ₂ → H ₂ SO ₄	0.99														
H ₂ + Cl ₂ → 2 HCl	0.99														
Organic destruction filter / CWOSPLT (SEP)	299	-	Separation of products from CWO reactor. Solids (S, Fe, Ba, Cd, Cr, Fe(OH) ₃ , C, SiO ₂ , Al ₂ O ₃) are sent to polymer stabilization. Liquids (H ₂ O, HCl, FeCl ₃ , H ₂ SO ₄) are sent for neutralization. Gases (O ₂ , Cl ₂ , F ₂ , CO ₂ , CH ₄) are subject to equilibration and then sent to the APC subsystem.												

Gas equilibration / EQUIL-1 (RGIBBS)	302	-11916	This block equilibrates the gas leaving the CWO system to account for the non-equilibrium of the CWO reactor. It reacts the small amount of CH ₄ remaining with O ₂ to form H ₂ O and CO ₂ . Cl ₂ is combined with H ₂ to form HCl.										
Neutralization / NEUTRAL1 (RSTOIC)	100	-351812	Neutralizes acids at 100°F and 1 atm. Neutralized liquid is filtered and then routed to aqueous waste treatment. <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>HCl + NaOH → NaCl + H₂O</td><td>0.99</td></tr><tr><td>H₂SO₄ + 2NaOH → Na₂SO₄ + 2H₂O</td><td>0.99</td></tr><tr><td>2Cl₂ + 4NaOH → 4NaCl + 2H₂O + O₂</td><td>0.99</td></tr><tr><td>FeCl₃ + 3NaOH → Fe(OH)₃ + 3NaCl</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	HCl + NaOH → NaCl + H ₂ O	0.99	H ₂ SO ₄ + 2NaOH → Na ₂ SO ₄ + 2H ₂ O	0.99	2Cl ₂ + 4NaOH → 4NaCl + 2H ₂ O + O ₂	0.99	FeCl ₃ + 3NaOH → Fe(OH) ₃ + 3NaCl	0.99
<u>Reaction</u>	<u>Conversion</u>												
HCl + NaOH → NaCl + H ₂ O	0.99												
H ₂ SO ₄ + 2NaOH → Na ₂ SO ₄ + 2H ₂ O	0.99												
2Cl ₂ + 4NaOH → 4NaCl + 2H ₂ O + O ₂	0.99												
FeCl ₃ + 3NaOH → Fe(OH) ₃ + 3NaCl	0.99												
Precipitation filter / SALTFLTR	100	-	Filters insoluble precipitate Fe(OH) ₃ from aqueous stream. Solid is routed to polymer stabilization.										
Lead recovery-separation / PB-SPLIT (SEP)	68	-	Separates brick or sheet lead (assumed to be 81% of total) for decontamination. Remaining lead (leaded gloves, blankets, shot) is routed to grout stabilization.										
Lead decontamination / PB-DECON (SEP)	63	-	Decontaminates lead with water wash, separates clean lead, which exits the system. Liquid and sludge are routed to process residue treatment subsystem.										
Polymer feed preparation / POLY-MIX (MIXER)	188	-	Mixes incoming waste for polymer stabilization.										
Dryer / DRYER (HEATER)	200	14613	Removes excess water prior to polymer stabilization.										
Dryer / WATERSEP (SEP)	200	-	Separates water, input to polymer stabilization is dried to 5% moisture content, as determined by design spec DRYER. Excess H ₂ O, NO, SO ₂) are sent to aqueous waste treatment subsystem.										
Mixing / POLYSTAB (MIXER)	103	-	Adds polyethylene to encapsulate the waste. Polymer:waste ratio is 1:1.										

Process residue dryer / VACTRAX1 (RGIBBS)	550	515629	Models the vacuum desorber for process residue and inorganic sludges. Operates at 550°F and 1 psig. Equilibrium is assumed for species entered in the RGIBBS block: H ₂ SO ₄ , HCl, and CH ₄ are assumed to form from feed components. O ₂ is excluded from reaction. A nitrogen sweep gas is used at a rate of 1.09 ft ³ per lb waste (0.0793 lb N ₂ /lb waste) as determined by FORTRAN block N2SWEEP.
Mercury leaching / VACSEP-1 (SEP)	97	-	<p>Mercury leaching of process residue and inorganic sludges by addition of leach water (30% of mass of incoming waste). Also includes separation of gases, liquids, organics, Hg-contaminated liquids, and solids.</p> <p>Gases (N₂) are sent to APC subsystem. Solids (H₂O in leach water, S, 50% of H₂, O₂, 50% of C, SiO₂, Al₂O₃, Ba, As, Pb, Fe, Cd, Cr, Se, Ag) are routed to polymer stabilization subsystem. Liquids (balance of H₂O, HCl, H₂SO₄) are sent to aqueous waste treatment. Organics (50% of H₂, 50% of C, CH₄) are routed to the organic destruction subsystem. Mercury separated is routed to mercury amalgamation.</p>
Open debris wash / HP-WASH (SEP)	66	-	Models the aqueous wash for open debris. Make-up water of 15% of mass of incoming waste is used. Two-thirds of the make-up water will be routed to aqueous waste treatment; one-third of the water is assumed to be entrained with the waste after washing. The washing process produces an aqueous stream (98% of O ₂ , 98% of H ₂ , 98% of C, two-thirds of the wash water, 1% of SiO ₂ , and 1% of Al ₂ O ₃) that is sent to aqueous waste treatment. The remaining solids (remainder of H ₂ O, 2% of O ₂ , 2% of H ₂ , N ₂ , S, 2% of Cl ₂ , Fe, As, Ba, Cd, Cr, Pb, Hg, Se, Ag, 2% of C, 99% of SiO ₂ , and 99% of Al ₂ O ₃) are routed to the grout stabilization subsystem.

Soft debris destruction / CWO-2 (RSTOIC)	302	-4625466	<p>Catalytic wet oxidation at 423 K and 35 psig. Oxygen input (5% excess) is determined by design spec O2-CWO. Acid solution (36% H₂O, 60% FeCl₃, 4% HCl) is set to be 7 lb solution/200 lb waste input by design spec ACID-IN.</p> <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>C + O₂ → CO₂</td><td>0.99</td></tr><tr><td>2 H₂ + O₂ → 2 H₂O</td><td>0.99</td></tr><tr><td>S + H₂ + 2 O₂ → H₂SO₄</td><td>0.99</td></tr><tr><td>H₂ + Cl₂ → 2 HCl</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	C + O ₂ → CO ₂	0.99	2 H ₂ + O ₂ → 2 H ₂ O	0.99	S + H ₂ + 2 O ₂ → H ₂ SO ₄	0.99	H ₂ + Cl ₂ → 2 HCl	0.99
<u>Reaction</u>	<u>Conversion</u>												
C + O ₂ → CO ₂	0.99												
2 H ₂ + O ₂ → 2 H ₂ O	0.99												
S + H ₂ + 2 O ₂ → H ₂ SO ₄	0.99												
H ₂ + Cl ₂ → 2 HCl	0.99												
Organic destruction filter / CWOSPL2 (SEP)	299	-	<p>Separation of products from CWO reactor. Solids (O₂, S, Fe, 95% of Hg, Fe(OH)₃, C, SiO₂, Al₂O₃) are sent to grout stabilization. Liquids (H₂O, 5% of Hg, HCl, FeCl₃, H₂SO₄, Na₂SO₄, NaOH, and NaCl) are sent for neutralization. Gases (N₂, Cl₂, F₂, CO₂) are subject to equilibration and then sent to the APC subsystem.</p>										
Gas equilibration / EQUIL-2 (RGIBBS)	302	506	<p>This block equilibrates the gas leaving the CWO system to account for possible non-equilibrium of the CWO reactor. In this case, it only serves as a heater to raise the temperature to 302°F.</p>										
Neutralization / NEUTRAL2 (RSTOIC)	100	-388029	<p>Neutralizes acids at 100°F and 1 atm. Neutralized liquid is filtered and then routed to aqueous waste treatment.</p> <table><tr><td><u>Reaction</u></td><td><u>Conversion</u></td></tr><tr><td>HCl + NaOH → NaCl + H₂O</td><td>0.99</td></tr><tr><td>H₂SO₄ + 2NaOH → Na₂SO₄ + 2H₂O</td><td>0.99</td></tr><tr><td>2Cl₂ + 4NaOH → 4NaCl + 2H₂O + O₂</td><td>0.99</td></tr><tr><td>FeCl₃ + 3NaOH → Fe(OH)₃ + 3NaCl</td><td>0.99</td></tr></table>	<u>Reaction</u>	<u>Conversion</u>	HCl + NaOH → NaCl + H ₂ O	0.99	H ₂ SO ₄ + 2NaOH → Na ₂ SO ₄ + 2H ₂ O	0.99	2Cl ₂ + 4NaOH → 4NaCl + 2H ₂ O + O ₂	0.99	FeCl ₃ + 3NaOH → Fe(OH) ₃ + 3NaCl	0.99
<u>Reaction</u>	<u>Conversion</u>												
HCl + NaOH → NaCl + H ₂ O	0.99												
H ₂ SO ₄ + 2NaOH → Na ₂ SO ₄ + 2H ₂ O	0.99												
2Cl ₂ + 4NaOH → 4NaCl + 2H ₂ O + O ₂	0.99												
FeCl ₃ + 3NaOH → Fe(OH) ₃ + 3NaCl	0.99												
Precipitation filter / SALTFLTR	100	-	<p>Removes Fe(OH)₃ from aqueous stream. Solid is routed to polymer stabilization.</p>										
Special waste	68	-	<p>As with the ITTS study, no model was constructed for special waste.</p>

INTS System 1

INTS System 2

INTS System 3

Appendix B

ASPEN PLUS Input Files

ASPEN PLUS Input Files

The following input files are can be entered as .INP (input) files to ASPEN PLUS to reproduce the results obtained herein. Convergence may be difficult, if not impossible, with the code as listed below; it may be necessary to remove and then successively reintroduce the design specifications from the model (using the HIDE and REVEAL features of Model Manager, or by commenting out the coded lines) in order to obtain converged runs.

System 1

;Input Summary created by ASPEN PLUS Rel. 9.2-1 at 10:48:19 Thu Dec 19, 1996
;Directory C:\ASPENRUN Filename C:\ASPENRUN\newsys1z.inp
;

TITLE 'This is System 1 for INTS'

IN-UNITS ENG PRESSURE=ATM

DEF-STREAMS MIXCISLD ALL

RUN-CONTROL MAX-TIME=300

DATABANKS COMBUST / INORGANIC / PURECOMP / SOLIDS / &
AQUEOUS / PURE856 / ASPENPCD

PROP-SOURCES COMBUST / INORGANIC / PURECOMP / SOLIDS / &
AQUEOUS / PURE856 / ASPENPCD

;Cement approximated by $\text{CaAl}_2\text{SiO}_6$ ($\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{SiO}_2$), Shreve & Brink p. 162

COMPONENTS

C C C /
C-S C C-S /
H2 H2 H2 /
O2 O2 O2 /
N2 N2 N2 /
S S S /
CL2 CL2 CL2 /
F2 F2 F2 /
NO NO NO /
SO2 SO SO2 /
NO2 NO2 NO2 /
H2O H2O H2O /
SIO2 SIO2 SIO2 /
SIO2-S SIO2 SIO2-S /
AL2O3 AL2O3 AL2O3 /
AL2O3-S AL2O3 AL2O3-S /
FE FE FE /
AS AS AS /
BA BA BA /
BE BE BE /
CD CD CD /
CR CR CR /
PB PB PB /
HG HG HG /
SE SE SE /
AG AG AG /
TA TA TA /
U U U /
NAOH NAOH NAOH /
NACL NACL NACL /
CO2 CO2 CO2 /
CO CO CO /
O3 O3 O3 /

HCL HCL HCL /
 FECL3 FECL3 FECL3 /
 H2SO4 H2SO4 H2SO4 /
 NA2SO4 NA2SO4 NA2SO4 /
 CH4 CH4 CH4 /
 POLYMER C2H4 POLYMER /
 CEMENT CAAL2SIO6 CEMENT /
 CASO4 CASO4 CASO4 /
 AGNO3 AGNO3 AGNO3 /
 HNO3 HNO3 HNO3 /
 HNO2 HNO2 HNO2 /
 NO3- NO3- NO3- /
 H+ H+ H+ /
 E- E- E- /
 AG+ AG+ AG+ /
 AG++ AG+2 AG++ /
 H2O2 H2O2 H2O2 /
 AGCL AGCL AGCL /
 CL- CL- CL- /
 CU CU CU /
 OH-RAD OH OH-RAD /
 NH3 H3N NH3 /
 NANO3 NANO3 NANO3

FLWSHEET APC-SYS

BLOCK GPCR IN=FILTERED AIR4 OUT=GPCR-OUT
 BLOCK FILTER IN=AQ-OFGAS VACGAS-1 VACGAS-3 AG-GAS NOX &
 OUT=FILTERED METALS
 BLOCK NEUTRAL3 IN=NAOH-3 GPCR-OUT OUT=SPLITIN
 BLOCK BLOWDOWN IN=SPLITIN OUT=FLASH-IN SALTSOLN
 BLOCK FLASH IN=FLASH-IN OUT=HEATERIN MOISTURE
 BLOCK HETRHEPA IN=HEATERIN OUT=OFFGAS

FLWSHEET AQUEOUS

BLOCK AQ-SPLIT IN=AQ-OUT OUT=AQ-SLUDG AQ-OFGAS AQ-RECYC
 BLOCK PHOTO-UV IN=OH-RAD OUT=PRODUCTS
 BLOCK OZ-GEN IN=AIR1 OUT=OZONE
 BLOCK OZ-DECOM IN=PRODUCTS OUT=AQ-OUT
 BLOCK CONCENT8 IN=SALTSOLN OUT=AQ-RECY2 CONCENT8
 BLOCK PHOTOMIX IN=VACLIQ-1 METLRECY 1000 VACLIQ-3 H2ORECYC &
 OZONE MEO-LIQ AG-SALTS MOISTURE H2O2-IN2 ACIDSLUD &
 XX-NAOH AQ-RECY2 OUT=X-PHOTIN
 BLOCK OH-GEN IN=PHOTO-IN OUT=OH-RAD
 BLOCK OILSEP IN=X-PHOTIN OUT=PHOTO-IN X-ORGS

FLWSHEET BULKSOIL

BLOCK VACSEP-3 IN=VACOUT-3 XYLEACH3 OUT=VACLIQ-3 VACGAS-3 &
 VACSOL-3 VACORG-3 VAC-HG-3
 BLOCK VACTRAX3 IN=4000 N2SWEEP3 OUT=VACOUT-3

FLWSHEET GROUT

BLOCK GROUTMIX IN=PBGLOVES VACSOL-3 5000 OUT=GROUTRIN
 BLOCK GROUTER IN=GROUTDRY GROUTRIN GROUTH2O OUT=GROUTOUT
 BLOCK DEBR-MIX IN=5000COMP 5000SOFT 5000OPEN OUT=5000

FLWSHEET HG-AMAL

BLOCK HG-AMALG IN=VAC-HG-3 VAC-HG-1 ADDITIVE 7000-HG OUT= &
 HG-OUT

FLWSHEET METLDCON

BLOCK MET-DCON IN=5000METL METLWASH OUT=METALOUT METLRECY

FLWSHEET ORGDEST

BLOCK MEO-SPLT IN=SHIFTOUT OUT=MEO-LIQ HNO2 NITRIC-2 &
ACID-OUT H2O-IN

BLOCK MEO-ANOD IN=MEO-IN OUT=MEO1-OUT

BLOCK AGRECOVER IN=NAOH-1 H2O2-IN HNO3-IN1 NITRIC-2 OUT= &
AGRECOVER

BLOCK AG-SPLT IN=AGRECOVER OUT=AGRECYC AG-SALTS AG-GAS

BLOCK NOX-SPLT IN=HNO2-NO3 OUT=NITRIC-1 X-NOX

BLOCK MEO-MIXR IN=AGNO3-IN 20003000 VACORG-1 VACORG-3 &
AGRECYC NITRIC-1 X-ORGS HNO3-IN2 H2O-IN OUT=MEO-IN

BLOCK HNO2RECV IN=HNO2 OXYGEN1 OUT=HNO2-NO3

BLOCK MEO-3 IN=PPT-OUT OUT=SHIFTOUT

BLOCK AG-PPT IN=MEO-OUT HCL-IN OUT=PPT-OUT

BLOCK NEUTRAL IN=ACID-OUT NAOH-4 OUT=ACIDSLUD

BLOCK MEO-CATH IN=MEO1-OUT OUT=MEO-OUT

BLOCK NOX-CONV IN=X-NH3 X-NOX OUT=NOX

FLWSHEET PB-RECVR

BLOCK PB-DECON IN=PBBRICKS PB-WATER OUT=LEAD-OUT PBSLUDGE

BLOCK PB-SPLIT IN=7000-PB OUT=PBBRICKS PBGLOVES

FLWSHEET POLYMER

BLOCK POLYSTAB IN=PLYSTBIN POLYETHL OUT=POLY-OUT

BLOCK POLY-MIX IN=3000POLY AQ-SLUDG CONCENT8 METALS &
VACSOL-1 OUT=MIXED-IN

BLOCK DRYER IN=MIXED-IN OUT=HOT-MIX

BLOCK WATERSEP IN=HOT-MIX OUT=PLYSTBIN H2ORECYC

FLWSHEET RES-SLUD

BLOCK VACSEP-1 IN=VACOUT-1 XYLEACH1 OUT=VACLIQ-1 VACGAS-1 &
VACSOL-1 VACORG-1 VAC-HG-1

BLOCK VACTRAX1 IN=3000 PBSLUDGE N2SWEEP1 OUT=VACOUT-1

FLWSHEET SPECIAL

BLOCK SPESHULL IN=6000 OUT=SPEC-OUT

PROPERTIES SOLIDS

PROPERTIES IDEAL

USER-PROPS DRUSR2 1 2 3

PROP-DATA U-2

IN-UNITS ENG PRESSURE=ATM

PROP-LIST TC

PVAL HNO2 100

PROP-DATA U-1

IN-UNITS ENG PRESSURE=ATM

PROP-LIST PLXANT

PVAL HNO2 7.511 -1406 221

PROP-DATA U-1

IN-UNITS ENG PRESSURE=ATM

PROP-LIST DHVLWT

PVAL HNO2 1 1

;Tables dated 04/24/96 from Daryoush Bahar, MK, (415) 442-7688
;Glass inerts assumed to be 50% SiO2 and 50% Al2O3 for all waste streams.

STREAM 1000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=60.8
MASS-FLOW H2 3613 <KG/HR> / O2 172053 <KG/HR> / N2 &
50211 <KG/HR> / H2O 2456410 <KG/HR> / AS 5647 <KG/HR> &
/ BA 2823 <KG/HR> / CD 42352 <KG/HR> / CR &
56469 <KG/HR> / PB 14117 <KG/HR> / HG 14117 <KG/HR> / &
SE 2823 <KG/HR> / AG 2823 <KG/HR>

;Tables dated 04/24/96 from MK

STREAM 3000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=352.12
MASS-FLOW H2 268596 <KG/HR> / O2 10180 <KG/HR> / N2 &
122 <KG/HR> / S 6233 <KG/HR> / CL2 383185 <KG/HR> / &
H2O 18588527 <KG/HR> / FE 107084 <KG/HR> / AS &
3383 <KG/HR> / BA 12700 <KG/HR> / CD 158485 <KG/HR> / &
CR 299848 <KG/HR> / PB 9640 <KG/HR> / HG 8445 <KG/HR> &
/ SE 1689 <KG/HR> / AG 1693 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=655.08
MASS-FLOW C-S 1658863 <KG/HR> / SIO2-S 17644467 <KG/HR> / &
AL2O3-S 17644467 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 3000POLY

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=3.28
MASS-FLOW CL2 98888 <KG/HR> / NO 37279 <KG/HR> / SO2 &
47075 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=3.32
MASS-FLOW SIO2-S 92796 / AL2O3-S 92796

;tables dated 04/24/96 from MK

STREAM 4000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=40.74
MASS-FLOW H2 21653 <KG/HR> / CL2 761580 <KG/HR> / H2O &
1514279 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=287.76
MASS-FLOW C-S 175090 <KG/HR> / SIO2-S 8027287.5 <KG/HR> / &
AL2O3-S 8027287.5 <KG/HR>

;Data table dated 04/24/96. Supplied by Daryoush Bahar, MK (415) 442-7688

STREAM 5000COMP

SUBSTREAM MIXED TEMP=68 PRES=1
MASS-FLOW H2 3.026 / H2O 0.197 / FE 148.890 / HG 1.3
SUBSTREAM CISOLID TEMP=68 PRES=1
MASS-FLOW C-S 17.992 / SIO2-S 3.003 / AL2O3-S 3.003

;tables dated 04/24/96 from MK

STREAM 5000METL

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=434.82
MASS-FLOW H2 141789 / FE 13383118

SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=27.29
MASS-FLOW C-S 844686 / SIO2-S 1981 / AL2O3-S 1981

;tables dated 04/24/96 from MK

STREAM 5000OPEN

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.40
MASS-FLOW H2 4587 <KG/HR> / O2 18201 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=80
MASS-FLOW C-S 22543 <KG/HR> / SIO2-S 2243854 <KG/HR> / &
AL2O3-S 2243854 <KG/HR>

;tables dated 04/30/96, used mass flow lb/hr rather than kg in waste inventory

STREAM 5000SOFT

SUBSTREAM MIXED TEMP=68 PRES=1
MASS-FLOW H2 33.213 / O2 103.327 / N2 0.252 / S 0.903 &
/ CL2 19.233 / F2 0.126 / H2O 12.458 / FE 3.204 / &
HG 1.2
SUBSTREAM CISOLID TEMP=68 PRES=1
MASS-FLOW C-S 217.042 / SIO2-S 21.901 / AL2O3-S 21.901

;tables dated 04/24/96 from MK

STREAM 6000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=125.46
MASS-FLOW H2 13980 <KG/HR> / O2 1775708 <KG/HR> / N2 &
546 <KG/HR> / S 1469 <KG/HR> / H2O 195474 <KG/HR> / &
FE 913 <KG/HR> / AS 64 <KG/HR> / BA 50656 <KG/HR> / &
BE 763726 <KG/HR> / CD 11416 <KG/HR> / CR 652 <KG/HR> &
/ PB 104216 <KG/HR> / HG 160 <KG/HR> / SE 32 <KG/HR> &
/ AG 32 <KG/HR> / TA 23100 <KG/HR> / U &
2415249 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=29.44
MASS-FLOW C-S 131953 <KG/HR> / SIO2-S 561390.5 <KG/HR> / &
AL2O3-S 561390.5 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 7000-HG

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=2.5
MASS-FLOW HG 1167608 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 7000-PB

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=25.986
MASS-FLOW H2 228 <KG/HR> / S 41 <KG/HR> / PB &
10645151 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=.00393 <KG/HR>
MASS-FLOW C-S 1811 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 20003000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=78.28
MASS-FLOW H2 922853 <KG/HR> / O2 59994 <KG/HR> / S &
10234 <KG/HR> / CL2 1654619 <KG/HR> / H2O &

1229766 <KG/HR> / FE 325702 <KG/HR> / BA 32570 <KG/HR> &
 / CD 32570 <KG/HR> / CR 65140 <KG/HR>
 SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=107.12 &
 FLASH-OPTION=NOFLASH
 MASS-FLOW C-S 5723044 <KG/HR> / SIO2-S 103248 <KG/HR> / &
 AL2O3-S 103248 <KG/HR>

STREAM ADDITIVE
 SUBSTREAM MIXED TEMP=68 PRES=1
 MASS-FLOW CU 1.8548

STREAM AGNO3-IN
 SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=2.5
 MASS-FRAC AGNO3 1

STREAM AGRECYC
 SUBSTREAM MIXED TEMP=100 PRES=1 MASS-FLOW=43861
 MASS-FRAC HNO3 1

STREAM AIR1
 SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=5200
 MOLE-FRAC O2 0.21 / N2 0.79

STREAM AIR4
 SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.001
 MOLE-FRAC O2 0.21 / N2 0.79

STREAM GROUTDRY
 SUBSTREAM MIXED TEMP=68 PRES=1
 SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=1
 MASS-FRAC CEMENT 1

STREAM GROUTH2O
 SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=.00001
 MASS-FRAC H2O 1

STREAM H2O-IN
 SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.000001
 MASS-FRAC H2O 1

STREAM H2O2-IN
 SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
 MASS-FRAC H2O2 1

STREAM H2O2-IN2
 SUBSTREAM MIXED TEMP=68 PRES=1 MOLE-FLOW=1
 MASS-FRAC H2O2 1

STREAM HCL-IN
 SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.00000001
 MASS-FRAC HCL 1

STREAM HG-OUT
 SUBSTREAM MIXED TEMP=68 PRES=1
 MASS-FLOW HG 2.64 / CU 1.8548

STREAM HNO3-IN1
 SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1000

MASS-FRAC HNO3 1.0

STREAM HNO3-IN2

SUBSTREAM MIXED TEMP=68 PRES=1 MOLE-FLOW=31.17204

MASS-FRAC HNO3 1

;Water set to 112/468 times the bulk metal flow rate, from Figure 3-22

; (page 3-46) in ITTS Phase 2 Final Report

STREAM METL WASH

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=94.327

MASS-FRAC H2O 1

;Daryoush Bahar uses 1200 ft3/h for 1100 lb/hr of process residue,

;uses a density of 0.06 lb/ft3

STREAM N2SWEEP1

SUBSTREAM MIXED TEMP=68 PRES=1 VOLUME-FLOW=1200

MOLE-FRAC N2 1

STREAM N2SWEEP3

SUBSTREAM MIXED TEMP=68 PRES=1 VOLUME-FLOW=392

MOLE-FRAC N2 1

;According to Delphi flowsheet D-1002A, 50% NaOH solution

STREAM NAOH-1

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=76

MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM NAOH-3

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1

MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM NAOH-4

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=31

MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM NITRIC-2

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=100

MASS-FRAC HNO3 1

STREAM OXYGEN1

SUBSTREAM MIXED TEMP=68 PRES=1 MOLE-FLOW=435

MOLE-FLOW O2 1

STREAM PB-WATER

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=13

MASS-FRAC H2O 1

;Polymer assumed to be polyethylene; C2H4 used as the monomer.

STREAM POLYETHL

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=812

MASS-FRAC POLYMER 1

STREAM PRODUCTS

SUBSTREAM MIXED TEMP=100 PRES=1

MASS-FLOW H2 .688 / O2 4.908 / N2 108.8 / NO 2.738 / &
H2O 851.703 / AS 0.16 / BA 0.08 / CD 1.2 / CR &
1.6 / PB 0.4 / HG 0.43 / SE 0.08 / AG 0.08 / &
NAOH 0.187 / NACL 20.7 / O3 32.576 / HCL 0.13 / &
FECL3 0.6

STREAM X-NH3
SUBSTREAM MIXED TEMP=68 PRES=1 MOLE-FLOW=1
MASS-FRAC NH3 1

STREAM XX-NAOH
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM XYLEACH1
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=306
MASS-FRAC H2O 1

STREAM XYLEACH3
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=98.55
MASS-FRAC H2O 1

BLOCK DEBR-MIX MIXER

BLOCK GROUTER MIXER
PARAM PRES=1 NPHASE=2 MAXIT=99 TOL=0.01

BLOCK GROUTMIX MIXER
PARAM PRES=1

BLOCK HG-AMALG MIXER

BLOCK MEO-MIXR MIXER
PARAM PRES=1 MAXIT=99 TOL=0.0001

BLOCK PHOTOMIX MIXER

BLOCK POLY-MIX MIXER
PARAM MAXIT=100

BLOCK POLYSTAB MIXER
BLOCK-OPTION ENERGY-BAL=NO

BLOCK SPESHULL MIXER

BLOCK AG-SPLT SEP
PARAM PRES=1
FRAC STREAM=AGRECYC SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- CU NH3 &
NANO3 FRACS=000000000000000000 &
000000000000000000000000 &
11000000000000
FRAC STREAM=AGRECYC SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0000
FRAC STREAM=AG-GAS SUBSTREAM=MIXED COMPS=C C-S H2 O2 N2 &

S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA &
 CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL FECL3 &
 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 HNO3 HNO2 &
 NO3- H+ E- AG+ AG++ H2O2 AGCL FRACS=001110 &
 1100000000000000000011 &
 10000100000000000000
 FRAC STREAM=AG-GAS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0000
 FLASH-SPECS AGRECYC TEMP=100 PRES=1
 FLASH-SPECS AG-SALTS TEMP=100 PRES=1 NPHASE=1
 FLASH-SPECS AG-GAS TEMP=100 PRES=1

BLOCK AQ-SPLIT SEP

DESCRIPTION "this separates water, gases, and solids"
 FRAC STREAM=AQ-SLUDG SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
 FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
 HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- CU &
 FRACS=110001000000.99.99.99 &
 0.9911111111111100001010 &
 111100000000101
 FRAC STREAM=AQ-SLUDG SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0.99.99.99.99
 FRAC STREAM=AQ-OF GAS SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SO2 NO2 H2O SIO2 SIO2-S AL2O3 &
 AL2O3-S FE AS BA CD CR PB HG SE AG NAOH NACL CO2 &
 CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT &
 CASO4 FRACS=0011101110100000 &
 000000000001110000100 &
 0
 FRAC STREAM=AQ-OF GAS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0000

BLOCK BLOWDOWN SEP

FRAC STREAM=SALT SOLN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SO2 NO2 H2O SIO2 SIO2-S AL2O3 &
 AL2O3-S FE AS BA BE CD CR PB HG SE AG TA U NAOH &
 NACL CO2 CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &
 CEMENT CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ &
 H2O2 AGCL CL- CU OH-RAD NH3 NANO3 FRACS=00000 &
 0000000200000000000000 &
 000110000001000000000 &
 0000000001
 FRAC STREAM=SALT SOLN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=1111

BLOCK FILTER SEP

PARAM PRES=1
 FRAC STREAM=METALS SUBSTREAM=MIXED COMPS=C C-S H2 O2 N2 &
 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S FE &
 AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
 FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
 HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- CU &
 OH-RAD NH3 NANO3 FRACS=00000000001 &
 111111111111000000101 &
 0111000000000101001
 FRAC STREAM=METALS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &

AL2O3-S CEMENT FRACS=1 1 1 1

BLOCK MEO-SPLT SEP

DESCRIPTION "for the moment, assumes complete separation"

FRAC STREAM=MEO-LIQ SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL FRACS=0 0 &
1000100010000000000000 &
000000001000000000100 &
000

FRAC STREAM=MEO-LIQ SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

FRAC STREAM=HNO2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 N2 &
S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA &
CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL FECL3 &
H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 HNO3 HNO2 &
NO3- H+ E- AG+ AG++ H2O2 AGCL FRACS=0 0 0 1 0 0 &
0000000000000000000010 &
00000100000100000000

FRAC STREAM=HNO2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

FRAC STREAM=NITRIC-2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- FRACS= &
0000000000000000000000 &
000000000000000010.99999 0 0 &
0111010

FRAC STREAM=NITRIC-2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

FRAC STREAM=ACID-OUT SUBSTREAM=MIXED COMPS=S H2O FE BA &
CD CR HNO3 FRACS=1 0 1 1 1 0.00001

FRAC STREAM=ACID-OUT SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1 1 1 1

BLOCK MET-DCON SEP

DESCRIPTION "Separates water from metal"

FRAC STREAM=METLRECY SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO HCL FECL3 &
H2SO4 NA2SO4 CH4 POLYMER CEMENT FRACS=0 0 1 0 0 0 &
0001000000000000000000 &
0000000

FRAC STREAM=METLRECY SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1 1 1 0

BLOCK NOX-SPLT SEP

FRAC STREAM=NITRIC-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- CU NH3 &
NANO3 FRACS=0000000000000000 &
0000000000000000000000 &
0100000000000000

FRAC STREAM=NITRIC-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

BLOCK OILSEP SEP

DESCRIPTION "assumes 99% separation of organics (C,H,CHx)"

FRAC STREAM=PHOTO-IN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 NO2 H2O SIO2 SIO2-S AL2O3 &
AL2O3-S FE AS BA BE CD CR PB HG SE AG TA U NAOH &
NACL CO2 CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &
CEMENT CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ &
H2O2 AGCL CL- CU OH-RAD NH3 NANO3 FRACS=0.01 0.01 &
0.01 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 &
1 1 1 1 1 1 1 1 1 1 1 1 1 1 0.01 0.01 1 1 &
1 1 1 1 1 1 1 1 1 1 1 1 1 1

FRAC STREAM=PHOTO-IN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.01 1 1 1

BLOCK PB-DECON SEP

FRAC STREAM=LEAD-OUT SUBSTREAM=MIXED COMPS=PB FRACS=1
FRAC STREAM=LEAD-OUT SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

BLOCK PB-SPLIT SEP

FRAC STREAM=PBBRICKS SUBSTREAM=MIXED COMPS=H2 S FRACS= &
0.81 0.81
MASS-FLOW STREAM=PBBRICKS SUBSTREAM=MIXED COMPS=PB FLOWS= &
21
FRAC STREAM=PBBRICKS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S FRACS=0.81 0.81 0.81

;For now, assumes 50% desorption to gas phase of C, H2, Cl2, F2

BLOCK VACSEP-1 SEP

DESCRIPTION "For now, a simple separation (w/o condensers,etc)"

FRAC STREAM=VACGAS-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- CU &
FRACS=0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 0 0 0 &
0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0 &
0 0 0 0 0 0 0 0 0 0

FRAC STREAM=VACGAS-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

FRAC STREAM=VACSOL-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA BE CD CR PB HG SE AG TA U NAOH NACL CO2 CO &
O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 &
AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- &
CU NANO3 FRACS=0 0 0.5 1 0 1 0.5 0.5 0 0 1 1 1 &
1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 0 0 0 0 1 0 &
1 0 0 1 1 1 0 0 0 0 0 0 0 0 1 0 1 1

MASS-FLOW STREAM=VACSOL-1 SUBSTREAM=MIXED COMPS=H2O FLOWS= &
306

FRAC STREAM=VACSOL-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.5 1 1 1

FRAC STREAM=VACORG-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &

```

FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- CU &
FRACS=000.50000.505000000000 &
00000000000000000001100 &
00000000000000
FRAC STREAM=VACORG-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.5000
FRAC STREAM=VAC-HG-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 NO2 H2O SIO2 SIO2-S AL2O3 &
AL2O3-S FE AS BA BE CD CR PB HG SE AG TA U NAOH &
NACL CO2 CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &
CEMENT CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ &
H2O2 AGCL CL- CU OH-RAD NH3 NANO3 FRACS=00000 &
0000000000000000000100 &
0000000000000000000000 &
0000000000
FRAC STREAM=VAC-HG-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0000

```

For now, assumes 50% desorption to gas phase of C, H2, Cl2, F2

BLOCK VACSEP-3 SEP

```

DESCRIPTION "For now, a simple separation (w/o condensers,etc)"
FRAC STREAM=VACGAS-3 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 NO2 H2O SIO2 SIO2-S AL2O3 &
AL2O3-S FE AS BA CD CR PB HG SE AG NAOH NACL CO2 &
CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT &
CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL &
CL- CU OH-RAD NH3 NANO3 FRACS=000010001 &
0000000000000000000111 &
0000000000000000000000 &
00
FRAC STREAM=VACGAS-3 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0000
FRAC STREAM=VACSOL-3 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 NO2 SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- CU &
OH-RAD NH3 NANO3 FRACS=000.51000.50500 &
0111111111101111100001 &
110111100000000000000000
MASS-FLOW STREAM=VACSOL-3 SUBSTREAM=MIXED COMPS=H2O FLOWS= &
98.55
FRAC STREAM=VACSOL-3 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.5110
FRAC STREAM=VACORG-3 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 NO2 H2O SIO2 SIO2-S AL2O3 &
AL2O3-S FE AS BA CD CR PB HG SE AG NAOH NACL CO2 &
CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT &
CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL &
CL- CU OH-RAD NH3 NANO3 FRACS=110.50000.5 &
0.5000000000000000000000 &
0000000100000000000000 &
00000
FRAC STREAM=VACORG-3 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.5000

```


FRAC STREAM=VAC-HG-3 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SO2 NO2 H2O SIO2 SIO2-S AL2O3 &
 AL2O3-S FE AS BA BE CD CR PB HG SE AG TA U NAOH &
 NACL CO2 CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &
 CEMENT CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ &
 H2O2 AGCL CL- CU OH-RAD NH3 NANO3 FRACS=0 0 0 0 0 &
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 &
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
 0 0 0 0 0 0 0 0 0
 FRAC STREAM=VAC-HG-3 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0 0 0 0

;Perry's Handbook p. 20-33 shows moisture contents of below 1% from dryers.

BLOCK WATERSEP SEP

DESCRIPTION "This separates water in polymer stab. subsystem"
 FRAC STREAM=PLYSTBIN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
 BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
 FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT AGCL NANO3 &
 FRACS=1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 &
 1 1 1 1 1 1 0 0 0 1 1 1 1 0 1 1 1 1
 FRAC STREAM=PLYSTBIN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=1 1 1 1

BLOCK DRYER HEATER

DESCRIPTION "This models the dryer for the polymer stab. sys."
 PARAM TEMP=200 PRES=1

BLOCK HETRHEPA HEATER

DESCRIPTION "heater to raise temperature for HEPA filters"
 PARAM TEMP=300 PRES=1

BLOCK CONCENT8 FLASH2

PARAM TEMP=150 PRES=1

BLOCK FLASH FLASH2

PARAM TEMP=100 PRES=1

BLOCK AG-PPT RSTOIC

PARAM TEMP=80 <C> PRES=35 <PSI>
 STOIC 1 MIXED AGNO3 -1 / HCL -1 / AGCL 1 / HNO3 1
 CONV 1 MIXED HCL 1

BLOCK AGRECOVR RSTOIC

DESCRIPTION "SWAG on T, P"
 PARAM TEMP=100 PRES=1 SERIES=YES MAXIT=500 TOL=0.0001
 STOIC 1 MIXED AGCL -4 / NAOH -4 / H2O2 -4 / AG 4 / &
 NACL 4 / H2O 6 / O2 3
 STOIC 2 MIXED AG -1 / HNO3 -1 / AGNO3 1 / H+ 1 / &
 E- 1
 CONV 1 MIXED AGCL 0.99
 CONV 2 MIXED AG 0.99

;Data obtained from "Description of Recommended Non-Thermal.."pp. 6-43 to 6-45
 ;Although room temperature operation is listed on p. 6-43, 1000 C is listed
 ;on page 6-45, and the higher temperature is more believable
 ;DRE of 0.999 listed for TCE and 0.90-0.95 for PCE -> use 0.95 for all waste

assume 1 atm pressure

BLOCK GPCR RSTOIC

DESCRIPTION "Gas Phase Corona Reactor, see comments"

PARAM PRES=1 DUTY=100 <KW> SERIES=YES

STOIC 1 MIXED H2 -2 / O2 -1 / H2O 2

STOIC 2 CISOLID C-S -1 / MIXED O2 -1 / CO2 1

STOIC 3 MIXED H2 -1 / CL2 -1 / HCL 2

STOIC 4 MIXED CO -1 / O2 -0.5 / CO2 1

STOIC 5 MIXED CH4 -1 / O2 -2 / CO2 1 / H2O 2

CONV 1 MIXED H2 0.95

CONV 2 CISOLID C-S 0.95

CONV 3 MIXED CL2 0.95

CONV 4 MIXED CO 0.95

CONV 5 MIXED CH4 0.95

BLOCK HNO2RECV RSTOIC

PARAM TEMP=423 <K> PRES=35 <PSI>

STOIC 1 MIXED HNO2 -1 / O2 -0.5 / HNO3 1

STOIC 2 MIXED HNO2 -2 / H2O 1 / NO 2 / O2 0.5

CONV 1 MIXED HNO2 0.99

CONV 2 MIXED HNO2 0.01

BLOCK MEO-3 RSTOIC

DESCRIPTION "2nd reactor to convert H + NO3 -> HNO2 + H2O"

PARAM TEMP=80 <C> PRES=35 <PSI> SERIES=NO

STOIC 1 MIXED H+ -4 / NO3- -2 / E- -2 / HNO3 1 / &
HNO2 1 / H2O 1

STOIC 2 MIXED CL- -1 / H+ -1 / HCL 1

CONV 1 MIXED NO3- 0.99

CONV 2 MIXED CL- 1

BLOCK MEO-ANOD RSTOIC

DESCRIPTION "MEO reactor"

PARAM TEMP=80 <C> PRES=35 <PSI> SERIES=YES TOL=0.000001

STOIC 1 CISOLID C-S -1 / MIXED H2O -2 / CO2 1 / H+ &
4 / E- 4

STOIC 2 MIXED H2 -1 / H+ 2 / E- 2

STOIC 3 MIXED CL2 -1 / H+ -2 / E- -2 / HCL 2

STOIC 4 MIXED S -1 / H2O -1 / O2 -1.5 / H2SO4 1

STOIC 5 MIXED N2 -1 / H2O -1 / O2 -2.5 / HNO3 2

CONV 1 CISOLID C-S 0.99

CONV 2 MIXED H2 1

CONV 3 MIXED CL2 1

CONV 4 MIXED S 1

CONV 5 MIXED N2 1

BLOCK MEO-CATH RSTOIC

DESCRIPTION "MEO reactor"

PARAM TEMP=80 <C> PRES=35 <PSI> SERIES=YES TOL=0.000001

STOIC 1 MIXED HNO3 -1 / H+ -2 / E- -2 / H2O 1 / &
HNO2 1

STOIC 2 MIXED AGNO3 -1 / HCL -1 / AGCL 1 / HNO3 1

CONV 1 MIXED HNO3 1

CONV 2 MIXED HCL 0.99

BLOCK NEUTRAL RSTOIC

PARAM TEMP=68 PRES=1

STOIC 1 MIXED NaOH -1 / HCl -1 / NaCl 1 / H2O 1
 STOIC 2 MIXED NaOH -1 / HNO3 -1 / NaNO3 1 / H2O 1
 STOIC 3 MIXED Cl- -1 / NaOH -1 / H+ -1 / NaCl 1 / &
 H2O 1
 STOIC 4 MIXED NO3- -1 / H+ -1 / NaOH -1 / NaNO3 1 / &
 H2O 1
 CONV 1 MIXED HCl 0.99
 CONV 2 MIXED HNO3 0.99
 CONV 3 MIXED Cl- 1
 CONV 4 MIXED NO3- 1

;scrubbing efficiency of 0.99 assumed for now

BLOCK NEUTRAL3 RSTOIC

DESCRIPTION "neutralizes HCl in offgas stream"

PARAM TEMP=100 PRES=1

STOIC 1 MIXED HCl -1 / NaOH -1 / NaCl 1 / H2O 1

STOIC 2 MIXED Cl2 -1 / NaOH -2 / NaCl 2 / H2O 1 / &
 O2 0.5

STOIC 3 MIXED H2SO4 -1 / NaOH -2 / Na2SO4 1 / H2O 2

STOIC 4 MIXED SO2 -1 / NaOH -2 / O2 -0.5 / Na2SO4 1 &
 / H2O 1

STOIC 5 MIXED HNO2 -1 / NaOH -1 / O2 -0.5 / H2O 1 / &
 NaNO3 1

CONV 1 MIXED HCl 0.99

CONV 2 MIXED Cl2 0.99

CONV 3 MIXED H2SO4 0.99

CONV 4 MIXED SO2 0.99

CONV 5 MIXED HNO2 1

BLOCK NOX-CONV RSTOIC

PARAM TEMP=68 PRES=1

STOIC 1 MIXED NO -6 / NH3 -4 / N2 5 / H2O 6

CONV 1 MIXED NO 0.99

BLOCK OH-GEN RSTOIC

PARAM TEMP=100 PRES=1

STOIC 1 MIXED H2O2 -1 / OH-RAD 2

STOIC 2 MIXED O3 -1 / H2O -3 / OH-RAD 6

CONV 1 MIXED H2O2 0.99

CONV 2 MIXED O3 0.99

BLOCK OZ-DECOM RSTOIC

DESCRIPTION "ozone decomposer"

PARAM TEMP=100 PRES=1

STOIC 1 MIXED O3 -2 / O2 3

STOIC 2 MIXED HCl -1 / NaOH -1 / NaCl 1 / H2O 1

STOIC 3 MIXED SO2 -1 / NaOH -2 / O2 -0.5 / Na2SO4 1 &
 / H2O 1

STOIC 4 MIXED H2SO4 -1 / NaOH -2 / Na2SO4 1 / H2O 2

CONV 1 MIXED O3 0.999

CONV 2 MIXED HCl 0.99

CONV 3 MIXED SO2 0.99

CONV 4 MIXED H2SO4 0.99

;assumed temperature and pressure

BLOCK OZ-GEN RSTOIC

DESCRIPTION "generates ozone from air"
PARAM TEMP=100 PRES=1
STOIC 1 MIXED O2 -3 / O3 2
CONV 1 MIXED O2 0.999

;Destruction efficiency of 96% assumed (p. 2-78 of "Description of Recommended
;Non-Thermal Mixed Waste Treatment Technologies Version 1.0," Emile A. Bernard
;temperature and pressure assumed by BWBrown

BLOCK PHOTO-UV RSTOIC

DESCRIPTION "Photolytic oxidation of waste, see comments"
PARAM TEMP=100 PRES=1 SERIES=YES
STOIC 1 CISOLID C-S -1 / MIXED OH-RAD -4 / CO2 1 / &
H2O 2
STOIC 2 MIXED H2 -1 / OH-RAD -2 / H2O 2
STOIC 3 MIXED H2 -1 / CL2 -1 / HCL 2
CONV 1 CISOLID C-S 0.96
CONV 2 MIXED H2 0.96
CONV 3 MIXED CL2 0.96

BLOCK VACTRAX1 RGIBBS

PARAM TEMP=550 PRES=1 <PSI> MAXIT=500
PROD H2O / H2 / O2 / N2 / S / CL2 / FE / AS / &
BA M / CD M / CR M / PB M / HG / SE M / AG &
M / H2SO4 / C-S S / SIO2-S S / AL2O3-S S / NaCL &
/ NAOH / NANO3 / E- / HCL
PROD-FRAC O2 1

BLOCK VACTRAX3 RGIBBS

PARAM TEMP=550 PRES=1 <PSI> MAXIT=500
PROD N2 / H2 / O2 / CL2 / SIO2-S S / AL2O3-S S / &
HCL / CH4 / C-S S / H2O
PROD-FRAC O2 1

;10% excess O3

DESIGN-SPEC AIR1

DEFINE OHROUT MOLE-FLOW STREAM=PRODUCTS SUBSTREAM=MIXED &
COMPONENT=OH-RAD
DEFINE OHRIN MOLE-FLOW STREAM=OH-RAD SUBSTREAM=MIXED &
COMPONENT=OH-RAD
SPEC "OHROUT*(1+100/10)" TO "OHRIN"
TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=AIR1 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "1" "4.5"

;Perry's Handbook p. 20-33 has moisture contents about 0.5% from dryers
;review meeting of 2/8/96 : moisture content to 5%

DESIGN-SPEC DRYER

DEFINE H2OMAS MASS-FLOW STREAM=PLYSTBIN SUBSTREAM=MIXED &
COMPONENT=H2O
DEFINE MIXMAS STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
DEFINE SOLMAS STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW
SPEC "H2OMAS" TO "(MIXMAS+SOLMAS)*0.05"

TOL-SPEC "0.001"
 VARY BLOCK-VAR BLOCK=WATERSEP SENTENCE=FRAC VARIABLE=FRACS &
 ID1=MIXED ID2=PLYSTBIN ELEMENT=10
 LIMITS "0" "1"

;power input is calculated to be 56.49 W / SCFM according to information
 ; supplied by Ben Tehranian, MK Environmental Services
 ;
 ;lbmol/hr converted to SCFM by multiplying by 359/60
 ;
 ;1 W = 3.413 Btu/hr

DESIGN-SPEC GPCRPOWER

DEFINE MOLOUT STREAM-VAR STREAM=GPCR-OUT SUBSTREAM=MIXED &
 VARIABLE=MOLE-FLOW
 DEFINE POWER BLOCK-VAR BLOCK=GPCR VARIABLE=DUTY &
 SENTENCE=PARAM
 SPEC "POWER" TO "MOLOUT*359/60*56.49*3.413"
 TOL-SPEC "0.01"
 VARY BLOCK-VAR BLOCK=GPCR VARIABLE=DUTY SENTENCE=PARAM
 LIMITS "0" "10000000"

;conversation with Daryoush Bahar 3/6/96 - dry basis used for grout calculation
 ;because with System 3, too much water exists, which results in too much grout
 ;being calculated
 ;
 ;
 ;4/15/96 - ratio of grout to water is 0.7:0.3 (?)

DESIGN-SPEC GROUT

DEFINE R1 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 DEFINE R2 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=CISOLID &
 VARIABLE=MASS-FLOW
 DEFINE R3 MASS-FLOW STREAM=GROUTRIN SUBSTREAM=MIXED &
 COMPONENT=H2O
 DEFINE GROUT STREAM-VAR STREAM=GROUTDRY SUBSTREAM=CISOLID &
 VARIABLE=MASS-FLOW
 F EXCES =R3-0.6*(R1+R2-R3)
 F IF(EXCES.LT.0.) EXCES = 0.
 SPEC "GROUT" TO "1.4*(R1+R2-R3)+2.333*EXCES"
 TOL-SPEC "0.1"
 VARY STREAM-VAR STREAM=GROUTDRY SUBSTREAM=CISOLID &
 VARIABLE=MASS-FLOW
 LIMITS "0.1" "6000"

DESIGN-SPEC GROUTH2O

DEFINE R1 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 DEFINE R2 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=CISOLID &
 VARIABLE=MASS-FLOW
 DEFINE R3 MASS-FLOW STREAM=GROUTRIN SUBSTREAM=MIXED &
 COMPONENT=H2O
 DEFINE H2OFLO STREAM-VAR STREAM=GROUTH2O SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 F EXCES = R3 - 0.6 * (R1+R2-R3)
 F IF(EXCES.GT.0.) EXCES = 0.0
 C SETS EXCESS WATER TO 0 IF WATER IS ACTUALLY EXCESS

C WATER REQUIRED, IF ANY, IS RETURNED AS A NEGATIVE NUMBER
 SPEC "H2OFLO" TO "-EXCES"
 TOL-SPEC "0.01"
 VARY STREAM-VAR STREAM=GROUTH2O SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 LIMITS "0" "2000"

DESIGN-SPEC H2O-IN
 DEFINE H2OIN MASS-FLOW STREAM=MEO-IN SUBSTREAM=MIXED &
 COMPONENT=H2O
 DEFINE H2OOUT MASS-FLOW STREAM=MEO1-OUT SUBSTREAM=MIXED &
 COMPONENT=H2O
 SPEC "H2OIN" TO "H2OOUT*(1+100/10)"
 TOL-SPEC "1.0"
 VARY BLOCK-VAR BLOCK=MEO-SPLT SENTENCE=FRAC VARIABLE=FRACS &
 ID1=MIXED ID2=MEO-LIQ ELEMENT=11
 LIMITS "0.330" "0.345"

DESIGN-SPEC HCL-IN
 DEFINE HCLOUT MOLE-FLOW STREAM=PPT-OUT SUBSTREAM=MIXED &
 COMPONENT=HCL
 DEFINE HCLIN MOLE-FLOW STREAM=HCL-IN SUBSTREAM=MIXED &
 COMPONENT=HCL
 DEFINE CLOUT MOLE-FLOW STREAM=PPT-OUT SUBSTREAM=MIXED &
 COMPONENT=CL-
 SPEC "HCLIN " TO "HCLOUT*(1+100/1)"
 TOL-SPEC "0.01"
 VARY STREAM-VAR STREAM=HCL-IN SUBSTREAM=MIXED &
 VARIABLE=MOLE-FLOW
 LIMITS "0.00001" "60"

; This design spec is merely to provide enough
 ; HNO3 to allow the reaction to proceed (1% excess).

DESIGN-SPEC HNO3-IN1
 DEFINE HNO3OT MASS-FLOW STREAM=AGRECOVR SUBSTREAM=MIXED &
 COMPONENT=HNO3
 DEFINE NO3IN1 MASS-FLOW STREAM=NITRIC-2 SUBSTREAM=MIXED &
 COMPONENT=HNO3
 DEFINE NO3IN2 MASS-FLOW STREAM=HNO3-IN1 SUBSTREAM=MIXED &
 COMPONENT=HNO3
 SPEC "NO3IN1+NO3IN2 " TO &
 "HNO3OT*(1+100/1) "
 TOL-SPEC "0.0001"
 VARY STREAM-VAR STREAM=HNO3-IN1 SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 LIMITS "0.0001" "90000"

DESIGN-SPEC NAOH-1
 DEFINE NAOHIN MASS-FLOW STREAM=NAOH-1 SUBSTREAM=MIXED &
 COMPONENT=NAOH
 DEFINE NAOHOT MASS-FLOW STREAM=AGRECOVR SUBSTREAM=MIXED &
 COMPONENT=NAOH
 DEFINE AGCLIN MASS-FLOW STREAM=NITRIC-2 SUBSTREAM=MIXED &
 COMPONENT=AGCL
 DEFINE AGCLOT MASS-FLOW STREAM=AGRECOVR SUBSTREAM=MIXED &
 COMPONENT=AGCL
 SPEC "NAOHIN" TO "NAOHOT*(1+100/1) "

TOL-SPEC "1 "
VARY STREAM-VAR STREAM=NAOH-1 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.1 " "800 "

DESIGN-SPEC NAOH-3
DEFINE NAOHIN MOLE-FLOW STREAM=NAOH-3 SUBSTREAM=MIXED &
COMPONENT=NAOH
DEFINE NAOHOT MOLE-FLOW STREAM=SPLITIN SUBSTREAM=MIXED &
COMPONENT=NAOH
SPEC "NAOHIN" TO "NAOHOT*(1+100/1)" "
TOL-SPEC "0.01 "
VARY STREAM-VAR STREAM=NAOH-3 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.50" "10 "

DESIGN-SPEC NAOH-4
DEFINE NAOHIN MASS-FLOW STREAM=NAOH-4 SUBSTREAM=MIXED &
COMPONENT=NAOH
DEFINE NAOHOT MASS-FLOW STREAM=ACIDSLUD SUBSTREAM=MIXED &
COMPONENT=NAOH
SPEC "NAOHIN" TO "NAOHOT*(1+100/1)"
TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=NAOH-4 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.0010" "0.01"

DESIGN-SPEC O2-HNO2
DEFINE O2IN1 MASS-FLOW STREAM=OXYGEN1 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE O2IN2 MASS-FLOW STREAM=HNO2 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE O2OUT MASS-FLOW STREAM=HNO2-NO3 SUBSTREAM=MIXED &
COMPONENT=O2
SPEC "O2IN1+O2IN2" TO "O2OUT*(1+100/1)"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=OXYGEN1 SUBSTREAM=MIXED &
VARIABLE=MOLE-FLOW
LIMITS "17.0" "30 "

DESIGN-SPEC POLYMER
DEFINE WASTIN STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
DEFINE SOLDIN STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW
DEFINE POLYIN STREAM-VAR STREAM=POLYETHL SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
SPEC "POLYIN" TO "(WASTIN+SOLDIN)"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=POLYETHL SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.1" "5000"

;20% moisture content set at review meeting 2/8/96

DESIGN-SPEC SALTSOLN
DEFINE SALTFL MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
COMPONENT=NaCl

```

DEFINE H2OFLO MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
  COMPONENT=H2O
DEFINE NAOHFL MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
  COMPONENT=NAOH
DEFINE NA2SO4 MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
  COMPONENT=NA2SO4
SPEC "H2OFLO*4 " TO "SALTFL+NAOHFL+NA2SO4"
TOL-SPEC "0.01"
VARY BLOCK-VAR BLOCK=BLOWDOWN SENTENCE=FRAC VARIABLE=FRACS &
  ID1=MIXED ID2=SALTSOLN ELEMENT=12
LIMITS "0.00001" "1"

DESIGN-SPEC XX-NAOH
  DEFINE NAOHIN MASS-FLOW STREAM=PRODUCTS SUBSTREAM=MIXED &
    COMPONENT=NAOH
  DEFINE NAOHOT MASS-FLOW STREAM=AQ-OUT SUBSTREAM=MIXED &
    COMPONENT=NAOH
  SPEC "NAOHIN" TO "NAOHOT*(1+100/1)"
  TOL-SPEC "25"
  VARY STREAM-VAR STREAM=XX-NAOH SUBSTREAM=MIXED &
    VARIABLE=MASS-FLOW
  LIMITS "48 " "49"

FORTRAN ADDITIVE
  DEFINE HGOUT MASS-FLOW STREAM=HG-OUT SUBSTREAM=MIXED &
    COMPONENT=HG
  DEFINE COPPIN MASS-FLOW STREAM=ADDITIVE SUBSTREAM=MIXED &
    COMPONENT=CU
F   COPPIN = 0.7 * HGOUT
  READ-VARS HGOUT
  WRITE-VARS COPPIN

FORTRAN AGNO3-IN
  DEFINE AGNO3 MOLE-FLOW STREAM=AGNO3-IN SUBSTREAM=MIXED &
    COMPONENT=AGNO3
  DEFINE CL2IN1 MOLE-FLOW STREAM=20003000 SUBSTREAM=MIXED &
    COMPONENT=CL2
  DEFINE CL2IN2 MOLE-FLOW STREAM=VACORG-1 SUBSTREAM=MIXED &
    COMPONENT=CL2
  DEFINE AGNREC MOLE-FLOW STREAM=AGRECYC SUBSTREAM=MIXED &
    COMPONENT=AGNO3
  DEFINE HCLREC MOLE-FLOW STREAM=H2O-IN SUBSTREAM=MIXED &
    COMPONENT=HCL
F   AGNO3 = (CL2IN1 + CL2IN2)*2 + HCLREC - AGNREC
F   IF (AGNO3.LT.0.) AGNO3 = 0.
  READ-VARS CL2IN1 CL2IN2 AGNREC HCLREC
  WRITE-VARS AGNO3

FORTRAN AGRECOVR
  DEFINE AGCLIN MOLE-FLOW STREAM=NITRIC-2 SUBSTREAM=MIXED &
    COMPONENT=AGCL
  DEFINE NAOHIN MOLE-FLOW STREAM=NAOH-1 SUBSTREAM=MIXED &
    COMPONENT=NAOH
  DEFINE H2O2IN MOLE-FLOW STREAM=H2O2-IN SUBSTREAM=MIXED &
    COMPONENT=H2O2
  DEFINE MASSNA MASS-FLOW STREAM=NAOH-1 SUBSTREAM=MIXED &
    COMPONENT=NAOH
  DEFINE MASSH2 MASS-FLOW STREAM=NAOH-1 SUBSTREAM=MIXED &

```

```

      COMPONENT=H2O
F   NAOHIN = AGCLIN
F   H2O2IN = AGCLIN
F   MASSH2 = MASSNA
      READ-VARS AGCLIN MASSNA
      WRITE-VARS NAOHIN H2O2IN MASSH2

```

```

FORTRAN H2O2-IN2
      DEFINE O3IN MOLE-FLOW STREAM=PHOTO-IN SUBSTREAM=MIXED &
      COMPONENT=O3
      DEFINE H2O2IN STREAM-VAR STREAM=H2O2-IN2 SUBSTREAM=MIXED &
      VARIABLE=MOLE-FLOW
F   H2O2IN = O3IN
      READ-VARS O3IN
      WRITE-VARS H2O2IN

```

```

FORTRAN HNO3-IN2
      DEFINE HPIN MOLE-FLOW STREAM=MEO1-OUT SUBSTREAM=MIXED &
      COMPONENT=H+
      DEFINE HNO3IN STREAM-VAR STREAM=HNO3-IN2 SUBSTREAM=MIXED &
      VARIABLE=MOLE-FLOW
      DEFINE HNO3R1 MOLE-FLOW STREAM=NITRIC-1 SUBSTREAM=MIXED &
      COMPONENT=HNO3
      DEFINE HNO3R2 MOLE-FLOW STREAM=AGRECYC SUBSTREAM=MIXED &
      COMPONENT=HNO3
F   HNO3IN = HPIN / 2 - HNO3R1 - HNO3R2
      READ-VARS HPIN HNO3R1 HNO3R2
      WRITE-VARS HNO3IN

```

;constant is obtained by taking 1200 ft³/1200 lb and mult. by 0.0727 lb/ft³

```

FORTRAN N2SWEEP
      DEFINE N2SWP1 STREAM-VAR STREAM=N2SWEEP1 SUBSTREAM=MIXED &
      VARIABLE=MASS-FLOW
      DEFINE N2SWP2 STREAM-VAR STREAM=N2SWEEP3 SUBSTREAM=MIXED &
      VARIABLE=MASS-FLOW
      DEFINE MS3000 STREAM-VAR STREAM=3000 SUBSTREAM=CISOLID &
      VARIABLE=MASS-FLOW
      DEFINE MM3000 STREAM-VAR STREAM=3000 SUBSTREAM=MIXED &
      VARIABLE=MASS-FLOW
      DEFINE MS4000 STREAM-VAR STREAM=4000 SUBSTREAM=CISOLID &
      VARIABLE=MASS-FLOW
      DEFINE MM4000 STREAM-VAR STREAM=4000 SUBSTREAM=MIXED &
      VARIABLE=MASS-FLOW
F   N2SWP1 = 0.0793 * (MS3000+MM3000)
F   N2SWP2 = 0.0793 * (MS4000+MM4000)
      READ-VARS MS3000 MM3000 MS4000 MM4000
      WRITE-VARS N2SWP1 N2SWP2

```

```

FORTRAN X-NH3
      DEFINE NOXIN MOLE-FLOW STREAM=X-NOX SUBSTREAM=MIXED &
      COMPONENT=NO
      DEFINE XNH3IN STREAM-VAR STREAM=X-NH3 SUBSTREAM=MIXED &
      VARIABLE=MOLE-FLOW
F   XNH3IN = NOXIN * 2/3
      READ-VARS NOXIN
      WRITE-VARS XNH3IN

```


CONV-OPTIONS

PARAM TEAR-METHOD=BROYDEN TOL=0.0011

WEGSTEIN MAXIT=9999 ACCELERATE=0 NACCELERATE=1

STREAM-REPOR MOLEFLOW MASSFLOW

;
;
;
;
;
;
;

System 2

;Input Summary created by ASPEN PLUS Rel. 9.2-1 at 10:48:45 Thu Dec 19, 1996
;Directory C:\ASPENRUN Filename C:\ASPENRUN\newsys2p.inp
;

TITLE 'This is System 2 for INTS'

IN-UNITS ENG PRESSURE=ATM

DEF-STREAMS MIXCISLD ALL

DATABANKS COMBUST / INORGANIC / PURECOMP / SOLIDS / &
NOASPENPCD

PROP-SOURCES COMBUST / INORGANIC / PURECOMP / SOLIDS

;Cement approximated by $\text{CaAl}_2\text{SiO}_6$ ($\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{SiO}_2$), Shreve & Brink p. 162

COMPONENTS

C C C /
C-S C C-S /
H2 H2 H2 /
O2 O2 O2 /
N2 N2 N2 /
S S S /
CL2 CL2 CL2 /
F2 F2 F2 /
NO NO NO /
SO2 SO SO2 /
H2O H2O H2O /
SIO2 SIO2 SIO2 /
SIO2-S SIO2 SIO2-S /
AL2O3 AL2O3 AL2O3 /
AL2O3-S AL2O3 AL2O3-S /
FE FE FE /
AS AS AS /
BA BA BA /
BE BE BE /
CD CD CD /
CR CR CR /
PB PB PB /
HG HG HG /
SE SE SE /
AG AG AG /
TA TA TA /
U U U /
NAOH NAOH NAOH /
NACL NACL NACL /
CO2 CO2 CO2 /
CO CO CO /

O3 O3 O3 /
H2O2 H2O2 H2O2 /
HCL HCL HCL /
FECL3 FECL3 FECL3 /
H2SO4 H2SO4 H2SO4 /
NA2SO4 NA2SO4 NA2SO4 /
CH4 CH4 CH4 /
POLYMER C2H4 POLYMER /
CEMENT CAAL2SIO6 CEMENT /
CASO4 CASO4 CASO4 /
CU CU CU /
"FE(OH)3" "FE(OH)3" "FE(OH)3" /
OH-RAD OH OH-RAD

FLWSHEET APC-SYS

BLOCK GPCR IN=FILTERED AIR4 OUT=GPCR-OUT
BLOCK FILTER IN=AQ-OFGAS EQUIL1 VACGAS-1 VACGAS-2 VACGAS-3 &
OUT=FILTERED METALS
BLOCK NEUTRAL3 IN=NAOH-3 GPCR-OUT OUT=SPLITIN
BLOCK BLOWDOWN IN=SPLITIN OUT=FLASH-IN SALTSOLN
BLOCK FLASH IN=FLASH-IN OUT=HEATERIN MOISTURE
BLOCK HETRHEPA IN=HEATERIN OUT=OFFGAS

FLWSHEET AQUEOUS

BLOCK AQ-SPLIT IN=AQ-OUT OUT=AQ-SLUDG AQ-OFGAS AQ-RECYC
BLOCK OZ-GEN IN=AIR1 OUT=OZONE
BLOCK CONCENT8 IN=SALTSOLN OUT=AQ-RECY2 CONCENT8
BLOCK PHOTOMIX IN=VACLIQ-2 VACLIQ-1 METLRECY 1000 VACLIQ-3 &
SPLT-H2O H2ORECYC OZONE MOISTURE H2O2-IN2 XX-NAOH &
AQ-RECY2 OUT=X-PHOTIN
BLOCK OH-GEN IN=PHOTO-IN OUT=OH-RAD
BLOCK PHOTO-UV IN=OH-RAD OUT=PRODUCTS
BLOCK OZ-DECOM IN=PRODUCTS OUT=AQ-OUT
BLOCK OILSEP IN=X-PHOTIN OUT=PHOTO-IN X-ORGS

FLWSHEET BULKSOIL

BLOCK VACSEP-3 IN=VACOUT-3 XYLEACH3 OUT=VACLIQ-3 VACGAS-3 &
VACSOL-3 VACORG-3 VAC-HG-3
BLOCK VACTRAX3 IN=4000 N2SWEEP3 OUT=VACOUT-3

FLWSHEET GROUT

BLOCK GROUTMIX IN=PBGLOVES VACSOL-3 VACSOL-2 OUT=GROUTIN
BLOCK GROUTER IN=GROUTDRY GROUTIN GROUTH2O OUT=GROUTOUT

FLWSHEET HG-AMAL

BLOCK HG-AMALG IN=VAC-HG-2 VAC-HG-3 ADDITIVE 7000-HG &
VAC-HG-1 OUT=HG-OUT

FLWSHEET METLDCON

BLOCK MET-DCON IN=METLWASH 5000METL OUT=METALOUT METLRECY

FLWSHEET ORGDEST

BLOCK CWOSPLT IN=CWO-OUT SCRBSALT OUT=CWO-LIQ CWO-SLD &

CWO-GAS
 BLOCK CWO-1 IN=ACID-IN 20003000 OXYGEN1 VACORG-2 VACORG-1 &
 VACORG-3 X-ORGS OUT=CWO-OUT
 BLOCK NEUTRAL1 IN=NAOH-1 CWO-LIQ OUT=SCRBOUT1
 BLOCK EQUIL-1 IN=CWO-GAS OUT=EQUIL1
 BLOCK SALTFLTR IN=SCRBOUT1 OUT=SPLT-H2O SCRBSALT

 FLOWSHEET PB-RECVR
 BLOCK PB-SPLIT IN=7000-PB OUT=PBBRICKS PBGLOVES
 BLOCK PB-DECON IN=PBBRICKS PB-WATER OUT=LEAD-OUT PBSLUDGE

 FLOWSHEET POLYMER
 BLOCK POLYSTAB IN=PLYSTBIN POLYETHL OUT=POLY-OUT
 BLOCK POLY-MIX IN=3000POLY CWO-SLD AQ-SLUDG CONCENT8 &
 METALS VACSOL-1 OUT=MIXED-IN
 BLOCK DRYER IN=MIXED-IN OUT=HOT-MIX
 BLOCK WATERSEP IN=HOT-MIX OUT=PLYSTBIN H2ORECYC

 FLOWSHEET RES-SLUD
 BLOCK DEBR-MIX IN=5000COMP 5000SOFT 5000OPEN OUT=5000
 BLOCK VACSEP-2 IN=VACOUT-2 XYLEACH2 OUT=VACLIQ-2 VACGAS-2 &
 VACSOL-2 VACORG-2 VAC-HG-2
 BLOCK VACTRAX2 IN=5000 N2SWEEP2 OUT=VACOUT-2
 BLOCK VACTRAX1 IN=3000 PBSLUDGE N2SWEEP1 OUT=VACOUT-1
 BLOCK VACSEP-1 IN=VACOUT-1 XYLEACH1 OUT=VAC-HG-1 VACSOL-1 &
 VACLIQ-1 VACGAS-1 VACORG-1

 FLOWSHEET SPECIAL
 BLOCK SPESHULL IN=6000 OUT=SPEC-OUT

 PROPERTIES SOLIDS
 PROPERTIES IDEAL

 USER-PROPS DRUSR2 1 2 3

 PROP-DATA U-2
 IN-UNITS ENG PRESSURE=ATM
 PROP-LIST TC
 PVAL "FE(OH)3" 100

 PROP-DATA U-1
 IN-UNITS ENG PRESSURE=ATM
 PROP-LIST PLXANT
 PVAL "FE(OH)3" 7.511 -1406 221 0 0 0 0 1000

 PROP-DATA U-1
 IN-UNITS ENG PRESSURE=ATM
 PROP-LIST DHVLWT
 PVAL "FE(OH)3" 1 1 0.38 0 0

;Tables dated 04/24/96 from Daryoush Bahar, MK, (415) 442-7688
 ;Glass inerts assumed to be 50% SiO2 and 50% Al2O3 for all waste streams.

STREAM 1000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=60.8
MASS-FLOW H2 3613 <KG/HR> / O2 172053 <KG/HR> / N2 &
50211 <KG/HR> / H2O 2456410 <KG/HR> / AS 5647 <KG/HR> &
/ BA 2823 <KG/HR> / CD 42352 <KG/HR> / CR &
56469 <KG/HR> / PB 14117 <KG/HR> / HG 14117 <KG/HR> / &
SE 2823 <KG/HR> / AG 2823 <KG/HR>

;Tables dated 04/24/96 from MK

STREAM 3000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=352.12
MASS-FLOW H2 268596 <KG/HR> / O2 10180 <KG/HR> / N2 &
122 <KG/HR> / S 6233 <KG/HR> / CL2 383185 <KG/HR> / &
H2O 18588527 <KG/HR> / FE 107084 <KG/HR> / AS &
3383 <KG/HR> / BA 12700 <KG/HR> / CD 158485 <KG/HR> / &
CR 299848 <KG/HR> / PB 9640 <KG/HR> / HG 8445 <KG/HR> &
/ SE 1689 <KG/HR> / AG 1693 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=655.08
MASS-FLOW C-S 1658863 <KG/HR> / SIO2-S 17644467 <KG/HR> / &
AL2O3-S 17644467 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 3000POLY

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=3.28
MASS-FLOW CL2 98888 <KG/HR> / NO 37279 <KG/HR> / SO2 &
47075 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=3.32
MASS-FLOW SIO2-S 92796 / AL2O3-S 92796

;tables dated 04/24/96 from MK

STREAM 4000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=40.74
MASS-FLOW H2 21653 <KG/HR> / CL2 761580 <KG/HR> / H2O &
1514279 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=287.76
MASS-FLOW C-S 175090 <KG/HR> / SIO2-S 8027287.5 <KG/HR> / &
AL2O3-S 8027287.5 <KG/HR>

;Data table dated 04/24/96. Supplied by Daryoush Bahar, MK (415) 442-7688

STREAM 5000COMP

SUBSTREAM MIXED TEMP=68 PRES=1
MASS-FLOW H2 3.026 / H2O 0.197 / FE 148.890 / HG 1.3
SUBSTREAM CISOLID TEMP=68 PRES=1
MASS-FLOW C-S 17.992 / SIO2-S 3.003 / AL2O3-S 3.003

;tables dated 04/24/96 from MK

STREAM 5000METL

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=434.82

MASS-FLOW H2 141789 / FE 13383118
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=27.29
MASS-FLOW C-S 844686 / SIO2-S 1981 / AL2O3-S 1981

;tables dated 04/24/96 from MK

STREAM 5000OPEN

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.40
MASS-FLOW H2 4587 <KG/HR> / O2 18201 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=80
MASS-FLOW C-S 22543 <KG/HR> / SIO2-S 2243854 <KG/HR> / &
AL2O3-S 2243854 <KG/HR>

;tables dated 04/30/96, used mass flow lb/hr rather than kg in waste inventory

STREAM 5000SOFT

SUBSTREAM MIXED TEMP=68 PRES=1
MASS-FLOW H2 33.213 / O2 103.327 / N2 0.252 / S 0.903 &
/ CL2 19.233 / F2 0.126 / H2O 12.458 / FE 3.204 / &
HG 1.2
SUBSTREAM CISOLID TEMP=68 PRES=1
MASS-FLOW C-S 217.042 / SIO2-S 21.901 / AL2O3-S 21.901

;tables dated 04/24/96 from MK

STREAM 6000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=125.46
MASS-FLOW H2 13980 <KG/HR> / O2 1775708 <KG/HR> / N2 &
546 <KG/HR> / S 1469 <KG/HR> / H2O 195474 <KG/HR> / &
FE 913 <KG/HR> / AS 64 <KG/HR> / BA 50656 <KG/HR> / &
BE 763726 <KG/HR> / CD 11416 <KG/HR> / CR 652 <KG/HR> &
/ PB 104216 <KG/HR> / HG 160 <KG/HR> / SE 32 <KG/HR> &
/ AG 32 <KG/HR> / TA 23100 <KG/HR> / U &
2415249 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=29.44
MASS-FLOW C-S 131953 <KG/HR> / SIO2-S 561390.5 <KG/HR> / &
AL2O3-S 561390.5 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 7000-HG

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=2.5
MASS-FLOW HG 1167608 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 7000-PB

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=25.986
MASS-FLOW H2 228 <KG/HR> / S 41 <KG/HR> / PB &
10645151 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=.00393 <KG/HR>
MASS-FLOW C-S 1811 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 20003000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=78.28
MASS-FLOW H2 922853 <KG/HR> / O2 59994 <KG/HR> / S &
10234 <KG/HR> / CL2 1654619 <KG/HR> / H2O &
1229766 <KG/HR> / FE 325702 <KG/HR> / BA 32570 <KG/HR> &
/ CD 32570 <KG/HR> / CR 65140 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=107.12 &
FLASH-OPTION=NOFLASH
MASS-FLOW C-S 5723044 <KG/HR> / SIO2-S 103248 <KG/HR> / &
AL2O3-S 103248 <KG/HR>

;According to Daryoush Bahar of MK (415) 442-7688, 7 lb makeup solution/200 lb
; waste input

STREAM ACID-IN

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=7
MASS-FRAC H2O 36 / HCL 4 / FECL3 60

STREAM ADDITIVE

SUBSTREAM MIXED TEMP=68 PRES=1
MOLE-FLOW CU 0.0567276

STREAM AIR1

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=90.19
MOLE-FRAC O2 0.21 / N2 0.79

STREAM AIR4

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MOLE-FRAC O2 0.21 / N2 0.79

STREAM GROUTDRY

SUBSTREAM MIXED TEMP=68 PRES=1
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC CEMENT 1

STREAM GROUTH2O

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.0001
MASS-FRAC H2O 1

STREAM H2O2-IN2

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC H2O2 1

STREAM HG-OUT

SUBSTREAM MIXED TEMP=68 PRES=1
MOLE-FLOW CU 0.0567276

;Water set to 112/468 times the bulk metal flow rate, from Figure 3-22
; (page 3-46) in ITTS Phase 2 Final Report

STREAM METLWASH

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=94.327
MASS-FRAC H2O 1

STREAM N2SWEEP1
SUBSTREAM MIXED TEMP=68 PRES=1 VOLUME-FLOW=1200
MOLE-FRAC N2 1

STREAM N2SWEEP2
SUBSTREAM MIXED TEMP=68 PRES=1 VOLUME-FLOW=785
MOLE-FRAC N2 1

STREAM N2SWEEP3
SUBSTREAM MIXED TEMP=68 PRES=1 VOLUME-FLOW=392
MOLE-FRAC N2 1

;According to Delphi flowsheet D-1002A, 50% NaOH solution

STREAM NAOH-1
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM NAOH-3
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM OXYGEN1
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MOLE-FLOW O2 1

STREAM PB-WATER
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=13
MASS-FRAC H2O 1

;Polymer assumed to be polyethylene; C2H4 used as the monomer.

STREAM POLYETHL
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC POLYMER 1

STREAM PRODUCTS
SUBSTREAM MIXED TEMP=100 PRES=1
MASS-FLOW H2 .688 / O2 4.908 / N2 108.8 / NO 2.738 / &
H2O 851.703 / AS 0.16 / BA 0.08 / CD 1.2 / CR &
1.6 / PB 0.4 / HG 0.43 / SE 0.08 / AG 0.08 / &
NAOH 0.187 / NaCl 20.7 / O3 32.576 / HCL 0.13 / &
FECL3 0.6

STREAM XX-NAOH
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM XYLEACHI
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=306

MASS-FRAC H2O 1

STREAM XYLEACH2
 SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=207.9
 MASS-FRAC H2O 1

STREAM XYLEACH3
 SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=98.55
 MASS-FRAC H2O 1

BLOCK DEBR-MIX MIXER

BLOCK GROUTER MIXER
 PARAM PRES=1

BLOCK GROUTMIX MIXER
 PARAM PRES=1 MAXIT=200 TOL=0.001

BLOCK HG-AMALG MIXER

BLOCK PHOTOMIX MIXER

BLOCK POLY-MIX MIXER
 PARAM MAXIT=100

BLOCK POLYSTAB MIXER
 BLOCK-OPTION ENERGY-BAL=YES

BLOCK SPESHULL MIXER

BLOCK AQ-SPLIT SEP
 DESCRIPTION "this separates water, gases, and solids"
 FRAC STREAM=AQ-SLUDG SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
 FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 CU &
 "FE(OH)3" FRACS=1 1 0 0 0 1 0 0 0 0 0 0 0.99 0.99 &
 0.99 0.99 0.99 1 1 1 1 1 1 1 1 1 0 0 0 0 1 &
 0 1 0 0.99 0.99 1 1 1

FRAC STREAM=AQ-SLUDG SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0.99 0.99 0.99 0.99

FRAC STREAM=AQ-OFGAS SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
 FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 &
 FRACS=0 0 1 1 1 0 1 1 1 0 0 0 0 0 0 0 0 0 &
 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 1 0 0 0

FRAC STREAM=AQ-OFGAS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0 0 0 0

BLOCK BLOWDOWN SEP
 FRAC STREAM=FLASH-IN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &

FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 &
FRACS=11111111110.91111111 &
1111110011111101001
FRAC STREAM=FLASH-IN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

BLOCK CWOSPLT SEP

DESCRIPTION "for the moment, assumes complete separation"
FRAC STREAM=CWO-LIQ SUBSTREAM=MIXED COMPS=C-S H2 O2 N2 &
S CL2 F2 NO H2O SIO2-S AL2O3-S FE AS BA CD CR PB &
HG SE AG NAOH NACL CO2 HCL FECL3 H2SO4 FRACS=0 0 &
000000100000000000100 &
111
FRAC STREAM=CWO-LIQ SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0
FRAC STREAM=CWO-SLD SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 HCL FECL3 &
CEMENT CASO4 CU "FE(OH)3" FRACS=11000100 &
00111111111111010001 &
111
FRAC STREAM=CWO-SLD SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S FRACS=111

BLOCK FILTER SEP

PARAM PRES=1
FRAC STREAM=METALS SUBSTREAM=MIXED COMPS=C C-S H2 O2 N2 &
S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S FE &
AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 FRACS=0 &
00000000001111111111 &
111100001010111
FRAC STREAM=METALS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1111

BLOCK MET-DCON SEP

DESCRIPTION "Separates water from metal"
FRAC STREAM=METLRECY SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO HCL FECL3 &
H2SO4 NA2SO4 CH4 POLYMER CEMENT FRACS=001000 &
00010000000000000000 &
0000000
FRAC STREAM=METLRECY SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1110

BLOCK OILSEP SEP

DESCRIPTION "assumes 99% separation of organics (C,H,CHx)"
FRAC STREAM=PHOTO-IN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA BE CD CR PB HG SE AG TA U NAOH NACL &
CO2 CO O3 H2O2 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &

FRAC STREAM=PHOTO-IN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.01 1 1 1

BLOCK PB-DECON SEP

```

FRAC STREAM=LEAD-OUT SUBSTREAM=MIXED COMPS=H2O PB FRACS= &
  0 1
FRAC STREAM=LEAD-OUT SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
  AL2O3-S CEMENT FRACS=0 0 0 0

```

BLOCK PB-SPLIT SEP

```

FRAC STREAM=PBBRICKS SUBSTREAM=MIXED COMPS=H2 S FRACS= &
  0.81 0.81
MASS-FLOW STREAM=PBBRICKS SUBSTREAM=MIXED COMPS=PB FLOWS= &
  21
FRAC STREAM=PBBRICKS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
  AL2O3-S FRACS=0.81 0.81 0.81

```

BLOCK SALTFLTR SEP

```

FRAC STREAM=SPLT-H2O SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
H2O2 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 &
CU "FE(OH)3" OH-RAD FRACS=1 1 1 1 1 1 1 1 1 1 1 &
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 &
1 1 1 1 1 1 1 0 1
FRAC STREAM=SPLT-H2O SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1 1 1 1

```

For now, assumes 50% desorption of C, H₂, Cl₂, F₂

BLOCK VACSEP-1 SEP

```

FRAC STREAM=VAC-HG-1 SUBSTREAM=MIXED COMPS=C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 CU FRACS=&
0000000000000000000001 &
000000000000000000
FRAC STREAM=VAC-HG-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0000
FRAC STREAM=VACSOL-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA &
CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL FECL3 &
H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 CU FRACS=11 &
0.51010.50.50111111111101 &
111000010100111
MASS-FLOW STREAM=VACSOL-1 SUBSTREAM=MIXED COMPS=H2O FLOWS=&
306.
FRAC STREAM=VACSOL-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.5111

```

FRAC STREAM=VACLIQ-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA &
 CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL FECL3 &
 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 CU FRACS=0 0 &
 0000000000000000000000 &
 0000101000000
 MASS-FLOW STREAM=VACLIQ-1 SUBSTREAM=MIXED COMPS=H2O FLOWS= &
 342.5798
 FRAC STREAM=VACLIQ-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0 0 0 0
 FRAC STREAM=VACGAS-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
 BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
 FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 CU FRACS= &
 0000100010000000000000 &
 00001010000000000
 FRAC STREAM=VACGAS-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0 0 0 0
 FLASH-SPECS VACLIQ-1 TEMP=68 PRES=1
 FLASH-SPECS VACGAS-1 TEMP=68 PRES=1
 FLASH-SPECS VAC-HG-1 TEMP=68 PRES=1
 FLASH-SPECS VACSOL-1 TEMP=68 PRES=1
 FLASH-SPECS VACORG-1 TEMP=68 PRES=1

;Based on review comments, only 10% of hydrocarbons will be desorbed from soft
 ; debris.

BLOCK VACSEP-2 SEP

DESCRIPTION "For now, a simple separation (w/o condensers,etc)"
 FRAC STREAM=VACLIQ-2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA &
 CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL FECL3 &
 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 FRACS=0 0 0 0 &
 0000000000000000000000 &
 0010000000
 MASS-FLOW STREAM=VACLIQ-2 SUBSTREAM=MIXED COMPS=H2O FLOWS= &
 12.655
 FRAC STREAM=VACLIQ-2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0 0 0 0
 FRAC STREAM=VACGAS-2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
 BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
 FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 FRACS=0 &
 0001000100000000000000 &
 00011100000000
 FRAC STREAM=VACGAS-2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0 0 0 0
 FRAC STREAM=VACSOL-2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA &
 CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL FECL3 &
 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 FRACS=0 0 0.9 &
 1010.90.901111111111011 &
 1100001110011

MASS-FLOW STREAM=VACSOL-2 SUBSTREAM=MIXED COMPS=H2O FLOWS= &
 207.9
 FRAC STREAM=VACSOL-2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0.9 1 1 1
 FRAC STREAM=VACORG-2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
 BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
 FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 FRACS=0 &
 00.10000.10.100000000000000 &
 0000000000001100
 FRAC STREAM=VACORG-2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S FRACS=0.100
 FLASH-SPECS VACSOL-2 TEMP=68 PRES=1
 FLASH-SPECS VACLIQ-2 TEMP=68 PRES=1
 FLASH-SPECS VACGAS-2 TEMP=68 PRES=1
 FLASH-SPECS VACORG-2 TEMP=68 PRES=1
 FLASH-SPECS VAC-HG-2 TEMP=68 PRES=1
 PROPERTIES SOLIDS
 BLOCK-OPTION ENERGY-BAL=YES

;For now, assumes 50% desorption to gas phase of C, H2, Cl2, F2

BLOCK VACSEP-3 SEP

DESCRIPTION "For now, a simple separation (w/o condensers,etc)"

FRAC STREAM=VACLIQ-3 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA &
 CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL FECL3 &
 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 FRACS=0 0 0 0 &
 000000000000000000000000 &
 0010000000

MASS-FLOW STREAM=VACLIQ-3 SUBSTREAM=MIXED COMPS=H2O FLOWS= &
 26.85154

FRAC STREAM=VACLIQ-3 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0 0 0 0
 FRAC STREAM=VACGAS-3 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
 BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
 FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT FRACS=0 0 0 0 &
 100010000000000000000000 &
 1110000000

FRAC STREAM=VACGAS-3 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0 0 0 0

FRAC STREAM=VACSOL-3 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA &
 CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL FECL3 &
 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 FRACS=0 0 0.5 &
 1000.50.501111111111011 &
 1100001110111

MASS-FLOW STREAM=VACSOL-3 SUBSTREAM=MIXED COMPS=H2O FLOWS= &
 98.55

FRAC STREAM=VACSOL-3 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S FRACS=0.5 1 1
 FRAC STREAM=VACORG-3 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &

N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
 BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
 FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 FRACS=1 &
 10.50000.50.500000000000000 &
 00000000000001000
 FRAC STREAM=VACORG-3 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0.5000

;Perry's Handbook p. 20-33 shows moisture contents of below 1% from dryers.

BLOCK WATERSEP SEP

DESCRIPTION "This separates water in polymer stab. subsystem"
 FRAC STREAM=PLYSTBIN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
 BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
 FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT "FE(OH)3" FRACS= &
 11110111011111111111 &
 111100011110111
 FRAC STREAM=PLYSTBIN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=1111

BLOCK DRYER HEATER

DESCRIPTION "This models the dryer for the polymer stab. sys."
 PARAM TEMP=200 PRES=1

BLOCK HETRHEPA HEATER

DESCRIPTION "heater to raise temperature for HEPA filters"
 PARAM TEMP=300 PRES=1

BLOCK CONCENT8 FLASH2

PARAM TEMP=150 PRES=1

BLOCK FLASH FLASH2

PARAM TEMP=100 PRES=1

;Data obtained from "Development Studies for a Novel Wet Oxidation Process,
 ;Topical Report," Patrick M. Dhooge and Lena B. Hakim, Delphi Research, Inc.
 ;January 1994, DE-AC21-92MC27109

;Operating conditions: page 63
 ;Detox solution composition: page 2
 ;Metal solubility: page xvii, 18
 ;Reaction stoichiometry: page xiv
 ;Excess oxygen: page 58
 ;Extent of reaction: page xvi

;Temperature and pressure also reported in "Description of Recommended
 ;Non-Thermal Mixed Waste Treatment Technologies," p. 2-12
 ;MK flowsheet shows 423 K and 20 psi (+15=35 psia)

BLOCK CWO-1 RSTOIC

DESCRIPTION "Detox reactor"
 PARAM TEMP=423 <K> PRES=35 <PSI> SERIES=NO
 STOIC 2 CISOLID C-S -1 / MIXED O2 -1 / CO2 1

STOIC 3 MIXED H2 -1 / O2 -0.5 / H2O 1
 STOIC 4 MIXED CL2 -1 / H2 -1 / HCL 2
 STOIC 5 MIXED S -1 / H2 -1 / O2 -2 / H2SO4 1
 STOIC 6 MIXED CH4 -1 / O2 -2 / CO2 1 / H2O 2
 STOIC 1 MIXED POLYMER -1 / CISOLID C-S 1 / MIXED CH4 &
 1
 CONV 2 CISOLID C-S 0.99
 CONV 3 MIXED H2 0.99
 CONV 4 MIXED CL2 0.99
 CONV 5 MIXED S 0.99
 CONV 6 MIXED CH4 0.99
 CONV 1 MIXED POLYMER 1

;Data obtained from "Description of Recommended Non-Thermal.."pp. 6-43 to 6-45
 ;Although room temperature operation is listed on p. 6-43, 1000 C is listed
 ;on page 6-45, and the higher temperature is more believable
 ;DRE of 0.999 listed for TCE and 0.90-0.95 for PCE --> use 0.95 for all waste
 ;assume 1 atm pressure

BLOCK GPCR RSTOIC

DESCRIPTION "Gas Phase Corona Reactor, see comments"
 PARAM PRES=1 DUTY=20000 SERIES=YES
 STOIC 1 MIXED H2 -2 / O2 -1 / H2O 2
 STOIC 2 CISOLID C-S -1 / MIXED O2 -1 / CO2 1
 STOIC 3 MIXED H2 -1 / CL2 -1 / HCL 2
 STOIC 4 MIXED CO -1 / O2 -0.5 / CO2 1
 STOIC 5 MIXED CH4 -1 / O2 -2 / CO2 1 / H2O 2
 CONV 1 MIXED H2 0.95
 CONV 2 CISOLID C-S 0.95
 CONV 3 MIXED CL2 0.95
 CONV 4 MIXED CO 0.95
 CONV 5 MIXED CH4 0.95

BLOCK NEUTRAL1 RSTOIC

DESCRIPTION "neutralizes excess HCl"
 PARAM TEMP=100 PRES=1
 STOIC 1 MIXED NAOH -1 / HCL -1 / NACL 1 / H2O 1
 STOIC 2 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 2
 STOIC 3 MIXED CL2 -2 / NAOH -4 / NACL 4 / H2O 2 / &
 O2 1
 STOIC 4 MIXED FECL3 -1 / NAOH -3 / "FE(OH)3" 1 / NACL &
 3
 CONV 1 MIXED HCL 0.99
 CONV 2 MIXED H2SO4 0.99
 CONV 3 MIXED CL2 0.99
 CONV 4 MIXED FECL3 0.99

;scrubbing efficiency of 0.99 assumed for now

BLOCK NEUTRAL3 RSTOIC

DESCRIPTION "neutralizes HCl in offgas stream"
 PARAM TEMP=100 PRES=1
 STOIC 1 MIXED HCL -1 / NAOH -1 / NACL 1 / H2O 1

STOIC 2 MIXED CL2 -1 / NAOH -2 / NACL 2 / H2O 1 / &
 O2 0.5
 STOIC 3 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 2
 STOIC 4 MIXED SO2 -1 / NAOH -2 / O2 -0.5 / NA2SO4 1 &
 / H2O 1
 CONV 1 MIXED HCL 0.99
 CONV 2 MIXED CL2 0.99
 CONV 3 MIXED H2SO4 0.99
 CONV 4 MIXED SO2 0.99

BLOCK OH-GEN RSTOIC

PARAM TEMP=100 PRES=1
 STOIC 1 MIXED H2O2 -1 / OH-RAD 2
 STOIC 2 MIXED O3 -1 / H2O -3 / OH-RAD 6
 CONV 1 MIXED H2O2 0.99
 CONV 2 MIXED O3 0.99

BLOCK OZ-DECOM RSTOIC

DESCRIPTION "ozone decomposer"
 PARAM TEMP=100 PRES=1
 STOIC 1 MIXED O3 -2 / O2 3
 STOIC 2 MIXED HCL -1 / NAOH -1 / NACL 1 / H2O 1
 STOIC 3 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 1
 STOIC 4 MIXED CL2 -2 / NAOH -4 / NACL 4 / H2O 2 / &
 O2 1
 STOIC 5 MIXED SO2 -2 / NAOH -4 / O2 -1 / NA2SO4 2 / &
 H2O 2
 CONV 1 MIXED O3 0.999
 CONV 2 MIXED HCL 0.99
 CONV 3 MIXED H2SO4 0.99
 CONV 4 MIXED CL2 0.99
 CONV 5 MIXED SO2 0.99

;temperature and pressure assumed arbitrarily

BLOCK OZ-GEN RSTOIC

DESCRIPTION "generates ozone from air"
 PARAM TEMP=100 PRES=1
 STOIC 1 MIXED O2 -3 / O3 2
 CONV 1 MIXED O2 0.999

;Destruction efficiency of 96% assumed (p. 2-78 of "Description of Recommended
 ;Non-Thermal Mixed Waste Treatment Technologies Version 1.0," Emile A. Bernard
 ;temperature and pressure assumed by BWBrown

BLOCK PHOTO-UV RSTOIC

DESCRIPTION "Photolytic oxidation of waste, see comments"
 PARAM TEMP=100 PRES=1 SERIES=NO MAXIT=500 TOL=0.0011
 STOIC 1 CISOLID C-S -1 / MIXED OH-RAD -4 / CO2 1 / &
 H2O 2
 STOIC 2 MIXED H2 -1 / OH-RAD -2 / H2O 2
 STOIC 3 MIXED H2 -1 / CL2 -1 / HCL 2
 CONV 1 CISOLID C-S 0.96

CONV 2 MIXED H2 0.96
CONV 3 MIXED CL2 0.96

BLOCK EQUIL-1 RGIBBS
PARAM TEMP=423 <K> PRES=35 <PSI> MAXIT=500

;Chuch Biaggi said 250 F and no CO to form 1/3/96

BLOCK VACTRAX1 RGIBBS
PARAM TEMP=550 PRES=1 <PSI>
PROD H2O / H2 / O2 / N2 / S / CL2 / SIO2-S S / &
AL2O3-S S / AS / HG / AG / HCL / H2SO4 / CH4 / &
C-S S / BA M / CD M / CR M / PB M / SE M / &
FE
PROD-FRAC O2 1

BLOCK VACTRAX2 RGIBBS
PARAM TEMP=250 PRES=1 <PSI>
PROD H2O / H2 / O2 / N2 / S / F2 / SIO2-S S / &
AL2O3-S S / FE / HG / HCL / C-S S
PROD-FRAC O2 1 / H2O 1

BLOCK VACTRAX3 RGIBBS
PARAM TEMP=550 PRES=1 <PSI>
PROD H2 / O2 / N2 / CL2 / SIO2-S S / AL2O3-S S / &
HCL / CH4 / C-S S / FE / H2O
PROD-FRAC O2 1

DESIGN-SPEC ACID-IN
DEFINE MACID STREAM-VAR STREAM=ACID-IN SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
DEFINE MASOTM STREAM-VAR STREAM=CWO-OUT SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
DEFINE MASOTS STREAM-VAR STREAM=CWO-OUT SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW
DEFINE MASO2 STREAM-VAR STREAM=OXYGEN1 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
SPEC "MACID*200 " TO "(MASOTM+MASOTS-MASO2)*7"
TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=ACID-IN SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.01" "20"

;10% excess O3

DESIGN-SPEC AIR1
DEFINE OHROUT MOLE-FLOW STREAM=PRODUCTS SUBSTREAM=MIXED &
COMPONENT=OH-RAD
DEFINE OHRIN MOLE-FLOW STREAM=OH-RAD SUBSTREAM=MIXED &
COMPONENT=OH-RAD
SPEC "OHROUT*(1+100/10)" TO "OHRIN "
TOL-SPEC "0.05"
VARY STREAM-VAR STREAM=AIR1 SUBSTREAM=MIXED &

VARIABLE=MASS-FLOW
LIMITS "2" "4"

DESIGN-SPEC AIR4

DEFINE OXOUT MASS-FLOW STREAM=GPCR-OUT SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE OX1 MASS-FLOW STREAM=AIR4 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE OX2 MASS-FLOW STREAM=FILTERED SUBSTREAM=MIXED &
COMPONENT=O2
SPEC "OX1+OX2" TO "OXOUT*(1+100/100)"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=AIR4 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.01" "50"

;Perry's Handbook p. 20-33 has moisture contents about 0.5% from dryers
;review meeting of 2/8/96 : moisture content to 5%

DESIGN-SPEC DRYER

DEFINE H2OMAS MASS-FLOW STREAM=PLYSTBIN SUBSTREAM=MIXED &
COMPONENT=H2O
DEFINE MIXMAS STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
DEFINE SOLMAS STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW
SPEC "H2OMAS" TO "(MIXMAS+SOLMAS)*0.05"
TOL-SPEC "0.001"
VARY BLOCK-VAR BLOCK=WATERSEP SENTENCE=FRAC VARIABLE=FRACS &
ID1=MIXED ID2=PLYSTBIN ELEMENT=10
LIMITS "0" "1"

;power input is calculated to be 56.49 W / SCFM according to information
; supplied by Ben Tehranian, MK Environmental Services
;
;lbmol/hr converted to SCFM by multiplying by 359/60
;;
;1 W = 3.413 Btu/hr

DESIGN-SPEC GPCRPOWER

DEFINE MOLOUT STREAM-VAR STREAM=GPCR-OUT SUBSTREAM=MIXED &
VARIABLE=MOLE-FLOW
DEFINE POWER BLOCK-VAR BLOCK=GPCR VARIABLE=DUTY &
SENTENCE=PARAM
SPEC "POWER" TO "MOLOUT*359/60*56.49*3.413"
TOL-SPEC "0.01"
VARY BLOCK-VAR BLOCK=GPCR VARIABLE=DUTY SENTENCE=PARAM
LIMITS "0" "10000000"

;conversation with Daryoush Bahar 3/6/96 - dry basis used for grout calculation
;because with System 3, too much water exists, which results in too much grout
;being calculated

DESIGN-SPEC GROUT

```

DEFINE R1 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
DEFINE R2 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
DEFINE R3 MASS-FLOW STREAM=GROUTRIN SUBSTREAM=MIXED &
  COMPONENT=H2O
DEFINE GROUT STREAM-VAR STREAM=GROUTDRY SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
F EXCES =R3-0.6*(R1+R2-R3)
F IF(EXCES.LT.0.) EXCES = 0.
SPEC "GROUT" TO "1.4*(R1+R2-R3)+2.333*EXCES"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=GROUTDRY SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
LIMITS "0.1" "6000"

```

DESIGN-SPEC GROUTH2O

```

DEFINE R1 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
DEFINE R2 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
DEFINE R3 MASS-FLOW STREAM=GROUTRIN SUBSTREAM=MIXED &
  COMPONENT=H2O
DEFINE H2OFLO STREAM-VAR STREAM=GROUTH2O SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
F EXCES = R3 - 0.6 * (R1+R2-R3)
F IF(EXCES.GT.0.) EXCES = 0.0
C SETS EXCESS WATER TO 0 IF WATER IS ACTUALLY EXCESS
C WATER REQUIRED, IF ANY, IS RETURNED AS A NEGATIVE NUMBER
SPEC "H2OFLO" TO "-EXCES"
TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=GROUTH2O SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
LIMITS "0" "2000"

```

DESIGN-SPEC NAOH-1

```

DEFINE NAOHIN MOLE-FLOW STREAM=NAOH-1 SUBSTREAM=MIXED &
  COMPONENT=NAOH
DEFINE NAOHOT MOLE-FLOW STREAM=SCRBOU1 SUBSTREAM=MIXED &
  COMPONENT=NAOH
SPEC "NAOHIN" TO "NAOHOT*(1+100/1)"
TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=NAOH-1 SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
LIMITS "74" "100"

```

DESIGN-SPEC NAOH-3

```

DEFINE NAOHIN MOLE-FLOW STREAM=NAOH-3 SUBSTREAM=MIXED &
  COMPONENT=NAOH
DEFINE NAOHOT MOLE-FLOW STREAM=SPLITIN SUBSTREAM=MIXED &
  COMPONENT=NAOH
SPEC "NAOHIN" TO "NAOHOT*(1+100/1) "

```

TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=NAOH-3 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "2" "5"

;Excess oxygen from Delphi flowsheet D-1002A (5% excess)

;4947 g O2 out for 59082 g O2 in

;

;This was changed to make $C + H_2 = 0$ in the outlet stream

DESIGN-SPEC O2-CWO

DEFINE O2OUT MASS-FLOW STREAM=CWO-OUT SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE OX1 MASS-FLOW STREAM=OXYGEN1 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE OX2 MASS-FLOW STREAM=ACID-IN SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE OX3 MASS-FLOW STREAM=20003000 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE OX4 MASS-FLOW STREAM=VACORG-1 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE OX5 MASS-FLOW STREAM=VACORG-2 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE OX6 MASS-FLOW STREAM=VACORG-3 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE O7 MASS-FLOW STREAM=X-ORGS SUBSTREAM=MIXED &
COMPONENT=O2
SPEC "O2OUT*(1+100/5)" TO "OX1+OX2+OX3+OX4+OX5+OX6+O7"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=OXYGEN1 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "640" "1000"

DESIGN-SPEC POLYMER

DEFINE WASTIN STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
DEFINE SOLDIN STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW
DEFINE POLYIN STREAM-VAR STREAM=POLYETHL SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
SPEC "POLYIN" TO "(WASTIN+SOLDIN)"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=POLYETHL SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.1" "5000"

;20% moisture content set at review meeting 2/8/96

DESIGN-SPEC SALTSOLN

DEFINE SALTFL MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
COMPONENT=NaCl
DEFINE H2OFLO MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
COMPONENT=H2O

```

DEFINE NAOHFL MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
  COMPONENT=NAOH
SPEC "H2OFLO*4" TO "SALTFL+NAOHFL"
TOL-SPEC "0.01"
VARY BLOCK-VAR BLOCK=BLOWDOWN SENTENCE=FRAC VARIABLE=FRACS &
  ID1=MIXED ID2=FLASH-IN ELEMENT=11
LIMITS "0.001" "1"

```

```

DESIGN-SPEC XX-NAOH
DEFINE NAOHIN MASS-FLOW STREAM=PRODUCTS SUBSTREAM=MIXED &
  COMPONENT=NAOH
DEFINE NAOHOT MASS-FLOW STREAM=AQ-OUT SUBSTREAM=MIXED &
  COMPONENT=NAOH
SPEC "NAOHIN" TO "NAOHOT*(1+100/1)"
TOL-SPEC "25"
VARY STREAM-VAR STREAM=XX-NAOH SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
LIMITS "91.5" "93"

```

```

FORTRAN ADDITIVE
  DEFINE HGOUT MASS-FLOW STREAM=HG-OUT SUBSTREAM=MIXED &
    COMPONENT=HG
  DEFINE COPPIN MASS-FLOW STREAM=ADDITIVE SUBSTREAM=MIXED &
    COMPONENT=CU
F    COPPIN = 0.7 * HGOUT
  READ-VARS HGOUT
  WRITE-VARS COPPIN

```

```

FORTRAN H2O2-IN2
  DEFINE O3IN MOLE-FLOW STREAM=PHOTO-IN SUBSTREAM=MIXED &
    COMPONENT=O3
  DEFINE H2O2IN STREAM-VAR STREAM=H2O2-IN2 SUBSTREAM=MIXED &
    VARIABLE=MOLE-FLOW
F    H2O2IN = O3IN
  READ-VARS O3IN
  WRITE-VARS H2O2IN

```

;constant is obtained by taking 1200 ft³/1200 lb and mult. by 0.0727 lb/ft³

```

FORTRAN N2SWEEP
  DEFINE N2SWP1 STREAM-VAR STREAM=N2SWEEP1 SUBSTREAM=MIXED &
    VARIABLE=MASS-FLOW
  DEFINE N2SWP3 STREAM-VAR STREAM=N2SWEEP3 SUBSTREAM=MIXED &
    VARIABLE=MASS-FLOW
  DEFINE N2SWP2 STREAM-VAR STREAM=N2SWEEP2 SUBSTREAM=MIXED &
    VARIABLE=MASS-FLOW
  DEFINE MS3000 STREAM-VAR STREAM=3000 SUBSTREAM=CISOLID &
    VARIABLE=MASS-FLOW
  DEFINE MM3000 STREAM-VAR STREAM=3000 SUBSTREAM=MIXED &
    VARIABLE=MASS-FLOW
  DEFINE MS4000 STREAM-VAR STREAM=4000 SUBSTREAM=CISOLID &
    VARIABLE=MASS-FLOW
  DEFINE MM4000 STREAM-VAR STREAM=4000 SUBSTREAM=MIXED &

```

```

VARIABLE=MASS-FLOW
DEFINE MS5000 STREAM-VAR STREAM=5000 SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW
DEFINE MM5000 STREAM-VAR STREAM=5000 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
F  N2SWP1 = 0.0793 * (MS3000+MM3000)
F  N2SWP2 = 0.0793 * (MS5000+MM5000)
F  N2SWP3 = 0.0793 * (MS4000+MM4000)
READ-VARS MS3000 MM3000 MS4000 MM4000 MS5000 MM5000
WRITE-VARS N2SWP1 N2SWP2 N2SWP3

```

```

CONV-OPTIONS
PARAM TEAR-METHOD=WEGSTEIN TOL=0.0021

```

```

STREAM-REPOR MOLEFLOW MASSFLOW

```

```

;
;
;
;
;
;
;

```

System 3

;Input Summary created by ASPEN PLUS Rel. 9.2-1 at 10:49:08 Thu Dec 19, 1996
;Directory C:\ASPENRUN Filename C:\ASPENRUN\nnewsys3f.inp
;

TITLE This is System 3 for INTS

IN-UNITS ENG PRESSURE=ATM

DEF-STREAMS MIXCISLD ALL

DATABANKS COMBUST / INORGANIC / PURECOMP / SOLIDS / &
AQUEOUS / PURE856 / ASPENPCD

PROP-SOURCES COMBUST / INORGANIC / PURECOMP / SOLIDS / &
AQUEOUS / PURE856 / ASPENPCD

;Cement approximated by $\text{CaAl}_2\text{SiO}_6$ ($\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{SiO}_2$), Shreve & Brink p. 162

COMPONENTS

C C C /
C-S C C-S /
H2 H2 H2 /
O2 O2 O2 /
N2 N2 N2 /
S S S /
CL2 CL2 CL2 /
F2 F2 F2 /
NO NO NO /
NO2 NO2 NO2 /
SO2 SO SO2 /
H2O H2O H2O /
SIO2 SIO2 SIO2 /
SIO2-S SIO2 SIO2-S /
AL2O3 AL2O3 AL2O3 /
AL2O3-S AL2O3 AL2O3-S /
FE FE FE /
AS AS AS /
BA BA BA /
BE BE BE /
CD CD CD /
CR CR CR /
PB PB PB /
HG HG HG /
SE SE SE /
AG AG AG /
TA TA TA /
U U U /
NAOH NAOH NAOH /
NACL NACL NACL /
CO2 CO2 CO2 /
CO CO CO /
O3 O3 O3 /
HCL HCL HCL /
FECL3 FECL3 FECL3 /
H2SO4 H2SO4 H2SO4 /
NA2SO4 NA2SO4 NA2SO4 /
CH4 CH4 CH4 /
POLYMER C2H4 POLYMER /

CEMENT CAAL2SIO6 CEMENT /
CASO4 CASO4 CASO4 /
AGNO3 AGNO3 AGNO3 /
HNO3 HNO3 HNO3 /
HNO2 HNO2 HNO2 /
NO3- NO3- NO3- /
H+ H+ H+ /
E- E- E- /
AG+ AG+ AG+ /
AG++ AG+2 AG++ /
H2O2 H2O2 H2O2 /
AGCL AGCL AGCL /
CL- CL- CL- /
NANO3 NANO3 NANO3 /
NH3 H3N NH3 /
CU CU CU /
OH-RAD OH OH-RAD

FLWSHEET APC-SYS

BLOCK GPCR IN=AIR4 FILTERED OUT=GPCR-OUT
BLOCK NEUTRAL3 IN=NAOH-3 GPCR-OUT OUT=SPLITIN
BLOCK BLOWDOWN IN=SPLITIN OUT=FLASH-IN SALTSOLN
BLOCK FLASH IN=FLASH-IN OUT=HEATERIN MOISTURE
BLOCK FILTER IN=AQ-OFGAS NOX AG-GAS OUT=FILTERED METALS
BLOCK HETRHEPA IN=HEATERIN OUT=OFFGAS

FLWSHEET AQUEOUS

BLOCK AQ-SPLIT IN=AQ-OUT OUT=AQ-SLUDG AQ-OFGAS AQ-RECYC
BLOCK OZ-GEN IN=AIR1 OUT=OZONE
BLOCK CONCENT8 IN=SALTSOLN OUT=AQ-RECY2 CONCENT8
BLOCK PHOTOMIX IN=METLRECY 1000 H2ORECYC OZONE MEO-LIQ &
AG-SALTS AQWASTE MOISTURE H2O2-IN2 EXCESH2O ACIDSLUD &
XX-NAOH AQ-RECY2 OUT=X-PHOTIN
BLOCK OH-GEN IN=PHOTO-IN OUT=OH-RAD
BLOCK PHOTO-UV IN=OH-RAD OUT=PRODUCTS
BLOCK OZ-DECOM IN=PRODUCTS OUT=AQ-OUT
BLOCK OILSEP IN=X-PHOTIN OUT=PHOTO-IN X-ORGS

FLWSHEET BULKSOIL

BLOCK AQ-WASH1 IN=4000 H2OWASH1 OUT=IMM-ORG1 TRETSOL1
BLOCK SOLDRYER IN=TRETSOL1 OUT=WARMSOL1
BLOCK H2OSEP IN=WARMSOL1 OUT=EXCESH2O DRYSL1

FLWSHEET GROUT

BLOCK GROUTMIX IN=PBGLOVES WASHSLUD DRYSL1 OUT=GROUTRIN
BLOCK GROUTER IN=GROUTDRY GROUTRIN GROUTH2O OUT=GROUTOUT

FLWSHEET HG-AMAL

BLOCK HG-AMALG IN=ADDITIVE 7000-HG OUT=HG-OUT

FLWSHEET METLDCON

BLOCK MET-DCON IN=5000METL METLWASH OUT=METLRECY METALOUT

FLWSHEET ORGDEST

BLOCK MEO-SPLT IN=SHIFTOUT OUT=MEO-LIQ HNO2 NITRIC-2 &
ACID-OUT H2O-IN
BLOCK AGRECOVR IN=NAOH-1 H2O2-IN HNO3-IN1 NITRIC-2 OUT= &
AGRECOVR
BLOCK AG-SPLT IN=AGRECOVR OUT=AGRECYC AG-SALTS AG-GAS
BLOCK NOX-SPLT IN=HNO2-NO3 OUT=NITRIC-1 X-NOX
BLOCK MEO-MIXR IN=AGNO3-IN 20003000 H2O-IN HNO3-IN2 &
AGRECYC NITRIC-1 IMM-ORG IMM-ORG1 X-ORGS OUT=MEO-IN
BLOCK HNO2RECV IN=HNO2 OXYGEN1 OUT=HNO2-NO3

BLOCK NEUTRAL IN=ACID-OUT NAOH-4 OUT=ACIDSLUD
BLOCK AG-PPT IN=MEO-OUT HCL-IN OUT=PPT-OUT
BLOCK MEO-3 IN=PPT-OUT OUT=SHIFTOUT
BLOCK MEO-CATH IN=MEO1-OUT OUT=MEO-OUT
BLOCK MEO-ANOD IN=MEO-IN OUT=MEO1-OUT
BLOCK NOX-CONV IN=X-NH3 X-NOX OUT=NOX

FLWSHEET PB-RECVR

BLOCK PB-DECON IN=PBBRICKS PB-WATER OUT=LEAD-OUT PBSLUDGE
BLOCK PB-SPLIT IN=7000-PB OUT=PBBRICKS PBGLOVES

FLWSHEET POLYMER

BLOCK POLYSTAB IN=PLYSTBIN POLYETHL OUT=POLY-OUT
BLOCK POLY-MIX IN=3000POLY AQ-SLUDG CONCENT8 TRET SOL2 &
METALS OUT=MIXED-IN
BLOCK DRYER IN=MIXED-IN OUT=HOT-MIX
BLOCK WATERSEP IN=HOT-MIX OUT=PLYSTBIN H2ORECYC

FLWSHEET RES-SLUD

BLOCK AQ-WASH4 IN=H2OWASH4 5000OPEN OUT=IMM-ORG4 TRET SOL4 &
AQWASTE4
BLOCK AQ-WASH2 IN=H2OWASH2 3000 PBSLUDGE OUT=IMM-ORG2 &
TRET SOL2 AQWASTE2
BLOCK ORG-MIXR IN=IMM-ORG4 IMM-ORG3 IMM-ORG2 IMM-ORG5 OUT= &
IMM-ORG
BLOCK AQU-MIXR IN=AQWASTE3 AQWASTE4 AQWASTE2 AQWASTE5 OUT= &
AQWASTE
BLOCK SOL-MIXR IN=TRET SOL3 TRET SOL4 TRET SOL5 OUT=WASHSLUD
BLOCK AQ-WASH5 IN=H2OWASH5 5000COMP OUT=IMM-ORG5 TRET SOL5 &
AQWASTE5
BLOCK AQ-WASH3 IN=H2OWASH3 5000SOFT OUT=IMM-ORG3 TRET SOL3 &
AQWASTE3

FLWSHEET SPECIAL

BLOCK SPESHULL IN=6000 OUT=SPEC-OUT

PROPERTIES SOLIDS

PROPERTIES IDEAL

USER-PROPS DRUSR2 1 2 3

PROP-DATA U-2

IN-UNITS ENG PRESSURE=ATM
PROP-LIST TC
PVAL HNO2 100

PROP-DATA U-1

IN-UNITS ENG PRESSURE=ATM
PROP-LIST PLXANT
PVAL HNO2 7.511 -1406 221

PROP-DATA U-1

IN-UNITS ENG PRESSURE=ATM
PROP-LIST DHVLWT
PVAL HNO2 1 1

;Tables dated 04/24/96 from Daryoush Bahar, MK, (415) 442-7688

;Glass inerts assumed to be 50% SiO2 and 50% Al2O3 for all waste streams.

STREAM 1000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=60.8
MASS-FLOW H2 3613 <KG/HR> / O2 172053 <KG/HR> / N2 &
50211 <KG/HR> / H2O 2456410 <KG/HR> / AS 5647 <KG/HR> &

/ BA 2823 <KG/HR> / CD 42352 <KG/HR> / CR &
56469 <KG/HR> / PB 14117 <KG/HR> / HG 14117 <KG/HR> / &
SE 2823 <KG/HR> / AG 2823 <KG/HR>

;Tables dated 04/24/96 from MK

STREAM 3000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=352.12
MASS-FLOW H2 268596 <KG/HR> / O2 10180 <KG/HR> / N2 &
122 <KG/HR> / S 6233 <KG/HR> / CL2 383185 <KG/HR> / &
H2O 18588527 <KG/HR> / FE 107084 <KG/HR> / AS &
3383 <KG/HR> / BA 12700 <KG/HR> / CD 158485 <KG/HR> / &
CR 299848 <KG/HR> / PB 9640 <KG/HR> / HG 8445 <KG/HR> &
/ SE 1689 <KG/HR> / AG 1693 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=655.08
MASS-FLOW C-S 1658863 <KG/HR> / SIO2-S 17644467 <KG/HR> / &
AL2O3-S 17644467 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 3000POLY

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=3.28
MASS-FLOW CL2 98888 <KG/HR> / NO 37279 <KG/HR> / SO2 &
47075 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=3.32
MASS-FLOW SIO2-S 92796 / AL2O3-S 92796

;tables dated 04/24/96 from MK

STREAM 4000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=40.74
MASS-FLOW H2 21653 <KG/HR> / CL2 761580 <KG/HR> / H2O &
1514279 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=287.76
MASS-FLOW C-S 175090 <KG/HR> / SIO2-S 8027287.5 <KG/HR> / &
AL2O3-S 8027287.5 <KG/HR>

;Data table dated 04/24/96. Supplied by Daryoush Bahar, MK (415) 442-7688

STREAM 5000COMP

SUBSTREAM MIXED TEMP=68 PRES=1
MASS-FLOW H2 3.026 / H2O 0.197 / FE 148.890 / HG 1.3
SUBSTREAM CISOLID TEMP=68 PRES=1
MASS-FLOW C-S 17.992 / SIO2-S 3.003 / AL2O3-S 3.003

;tables dated 04/24/96 from MK

STREAM 5000METL

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=434.82
MASS-FLOW H2 141789 / FE 13383118
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=27.29
MASS-FLOW C-S 844686 / SIO2-S 1981 / AL2O3-S 1981

;tables dated 04/24/96 from MK

STREAM 5000OPEN

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.40
MASS-FLOW H2 4587 <KG/HR> / O2 18201 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=80
MASS-FLOW C-S 22543 <KG/HR> / SIO2-S 2243854 <KG/HR> / &
AL2O3-S 2243854 <KG/HR>

;tables dated 04/30/96, used mass flow lb/hr rather than kg in waste inventory

STREAM 5000SOFT

SUBSTREAM MIXED TEMP=68 PRES=1

MASS-FLOW H2 33.213 / O2 103.327 / N2 0.252 / S 0.903 &

/ CL2 19.233 / F2 0.126 / H2O 12.458 / FE 3.204 / &

HG 1.2

SUBSTREAM CISOLID TEMP=68 PRES=1

MASS-FLOW C-S 217.042 / SIO2-S 21.901 / AL2O3-S 21.901

;tables dated 04/24/96 from MK

STREAM 6000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=125.46

MASS-FLOW H2 13980 <KG/HR> / O2 1775708 <KG/HR> / N2 &

546 <KG/HR> / S 1469 <KG/HR> / H2O 195474 <KG/HR> / &

FE 913 <KG/HR> / AS 64 <KG/HR> / BA 50656 <KG/HR> / &

BE 763726 <KG/HR> / CD 11416 <KG/HR> / CR 652 <KG/HR> &

/ PB 104216 <KG/HR> / HG 160 <KG/HR> / SE 32 <KG/HR> &

/ AG 32 <KG/HR> / TA 23100 <KG/HR> / U &

2415249 <KG/HR>

SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=29.44

MASS-FLOW C-S 131953 <KG/HR> / SIO2-S 561390.5 <KG/HR> / &

AL2O3-S 561390.5 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 7000-HG

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=2.5

MASS-FLOW HG 1167608 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 7000-PB

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=25.986

MASS-FLOW H2 228 <KG/HR> / S 41 <KG/HR> / PB &

10645151 <KG/HR>

SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=.00393 <KG/HR>

MASS-FLOW C-S 1811 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 20003000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=78.28

MASS-FLOW H2 922853 <KG/HR> / O2 59994 <KG/HR> / S &

10234 <KG/HR> / CL2 1654619 <KG/HR> / H2O &

1229766 <KG/HR> / FE 325702 <KG/HR> / BA 32570 <KG/HR> &

/ CD 32570 <KG/HR> / CR 65140 <KG/HR>

SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=107.12 &

FLASH-OPTION=NOFLASH

MASS-FLOW C-S 5723044 <KG/HR> / SIO2-S 103248 <KG/HR> / &

AL2O3-S 103248 <KG/HR>

STREAM ADDITIVE

SUBSTREAM MIXED TEMP=68 PRES=1

MOLE-FLOW CU 0.0275391

STREAM AGNO3-IN

SUBSTREAM MIXED TEMP=68 PRES=1 MOLE-FLOW=1.121407

MASS-FRAC AGNO3 1

STREAM AGRECYC

SUBSTREAM MIXED TEMP=100 PRES=1 MASS-FLOW=43861

MASS-FRAC HNO3 1

STREAM AIR1
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=5200
MOLE-FRAC O2 0.21 / N2 0.79

STREAM AIR4
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.001
MOLE-FRAC O2 0.21 / N2 0.79

STREAM GROUTDRY
SUBSTREAM MIXED TEMP=68 PRES=1
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=4127.367
MASS-FRAC CEMENT 1

STREAM GROUTH2O
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.000001
MASS-FRAC H2O 1

STREAM H2O-IN
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.000001
MASS-FRAC H2O 1

STREAM H2O2-IN
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC H2O2 1

STREAM H2O2-IN2
SUBSTREAM MIXED TEMP=68 PRES=1 MOLE-FLOW=1
MASS-FRAC H2O2 1

STREAM H2OWASH1
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=328.5
MASS-FRAC H2O 1

;water flow rate reduced to 15% of waste input

STREAM H2OWASH2
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=151.05
MASS-FRAC H2O 1

;water flow rate reduced to 15% of waste input, 10% to recycle, 5% with waste

STREAM H2OWASH3
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=65.25
MASS-FRAC H2O 1

;amount of water set to be 15% of waste input, 10% to recycle, 5% with waste

STREAM H2OWASH4
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=12
MASS-FRAC H2O 1

;water flow rate reduced to 15% of waste input, 10% to recycle, 5% with waste

STREAM H2OWASH5
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=26.55
MASS-FRAC H2O 1

STREAM HCL-IN
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC HCL 1

STREAM HG-OUT
SUBSTREAM MIXED TEMP=68 PRES=1

MOLE-FLOW HG 0.0124632 / CU 0.0275391

STREAM HNO3-IN1

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1000
MASS-FRAC HNO3 1.0

STREAM HNO3-IN2

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=30.5
MASS-FRAC HNO3 1

Water set to 112/468 times the bulk metal flow rate. from Figure 3-22
; (page 3-46) in ITTS Phase 2 Final Report

STREAM METLWASH

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=94.327
MASS-FRAC H2O 1

According to Delphi flowsheet D-1002A, 50% NaOH solution

STREAM NAOH-1

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=116
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM NAOH-3

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM NAOH-4

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.00000001
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM NITRIC-2

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=100
MASS-FRAC HNO3 1

STREAM OXYGEN1

SUBSTREAM MIXED TEMP=68 PRES=1 MOLE-FLOW=435
MOLE-FLOW O2 1

STREAM PB-WATER

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=13
MASS-FRAC H2O 1

Polymer assumed to be polyethylene; C2H4 used as the monomer.

STREAM POLYETHL

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=32.307
MASS-FRAC POLYMER 1

STREAM PRODUCTS

SUBSTREAM MIXED TEMP=100 PRES=1
MASS-FLOW H2 .688 / O2 4.908 / N2 108.8 / NO 2.738 / &
H2O 851.703 / AS 0.16 / BA 0.08 / CD 1.2 / CR &
1.6 / PB 0.4 / HG 0.43 / SE 0.08 / AG 0.08 / &
NAOH 0.187 / NACL 20.7 / O3 32.576 / HCL 0.13 / &
FECL3 0.6

STREAM X-NH3

SUBSTREAM MIXED TEMP=68 PRES=1 MOLE-FLOW=1
MASS-FRAC NH3 1

STREAM XX-NAOH

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1

MASS-FRAC H2O 0.5 / NAOH 0.5

BLOCK AQU-MIXR MIXER
PARAM PRES=1

BLOCK GROUTER MIXER
PARAM PRES=1 NPHASE=2 MAXIT=500 TOL=0.01

BLOCK GROUTMIX MIXER
PARAM PRES=1

BLOCK HG-AMALG MIXER

BLOCK MEO-MIXR MIXER
PARAM PRES=1 MAXIT=99

BLOCK ORG-MIXR MIXER
PARAM PRES=1

BLOCK PHOTOMIX MIXER

BLOCK POLY-MIX MIXER
PARAM MAXIT=100

BLOCK POLYSTAB MIXER
BLOCK-OPTION ENERGY-BAL=YES

BLOCK SOL-MIXR MIXER
PARAM PRES=1 MAXIT=500

BLOCK AG-SPLT SEP
PARAM PRES=1
FRAC STREAM=AGRECYC SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- NANO3 &
NH3 CU FRACS=0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
0 &
0 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
FRAC STREAM=AGRECYC SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0
FRAC STREAM=AG-GAS SUBSTREAM=MIXED COMPS=C C-S H2 O2 N2 &
S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA &
CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL FECL3 &
H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 HNO3 HNO2 &
NO3- H+ E- AG+ AG++ H2O2 AGCL FRACS=0 0 1 1 1 0 &
1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 &
1 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
FRAC STREAM=AG-GAS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0
FLASH-SPECS AGRECYC TEMP=100 PRES=1
FLASH-SPECS AG-SALTS TEMP=100 PRES=1 NPHASE=1
FLASH-SPECS AG-GAS TEMP=100 PRES=1

BLOCK AQ-SPLIT SEP
DESCRIPTION "this separates water, gases, and solids"
FRAC STREAM=AQ-SLUDG SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- NANO3 &
FRACS=1 1 0 0 0 1 0 0 0 0 0 0 0.99 0.99 0.99 &

```

0.9911111111111100000010 &
111100000000101
FRAC STREAM=AQ-SLUDG SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.99 0.99 0.99 0.99
FRAC STREAM=AQ-OFGAS SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 SO2 H2O SIO2 SIO2-S AL2O3 &
AL2O3-S FE AS BA CD CR PB HG SE AG NAOH NA CL CO2 &
CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT &
CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL &
CL- NANO3 NH3 FRACS=0 0 1 1 1 0 1 1 1 0 1 0 0 &
00000000000000001110000 &
100000000000000000
FRAC STREAM=AQ-OFGAS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

```

BLOCK AQ-WASH1 SEP

```

FRAC STREAM=IMM-ORG1 SUBSTREAM=MIXED COMPS=H2 CL2 H2O &
FRACS=0.95 0.95 0
FRAC STREAM=IMM-ORG1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.95 0 0 0

```

;decontamination factor of 50 used (Emile Bernard, p.9-4)

;taken to be 98% of organics in organic stream, 1% remains with debris, 1%

; goes to wetsolids

;

; 10/18/96 according to Julia Vetromile at MK, there are only two streams

; from this washer: organics and sludges (sludges include the water)

; THE AQUEOUS STREAM WAS ZEROED OUT INSTEAD OF BEING DELETED - THE SUMMARY

; TABLES IN EXCEL ARE ALREADY SET UP EXPECTING THE STREAM NAMES TO BE THERE

BLOCK AQ-WASH2 SEP

DESCRIPTION "estimated separation"

```

FRAC STREAM=IMM-ORG2 SUBSTREAM=MIXED COMPS=H2 O2 CL2 F2 &
H2O FRACS=0.95 0.95 0.95 0.95 0

```

```

FRAC STREAM=IMM-ORG2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S FRACS=0.95 0.01 0.01

```

```

FRAC STREAM=AQWASTE2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 SO2 H2O SIO2 SIO2-S AL2O3 &

```

```

AL2O3-S FE AS BA BE CD CR PB HG SE AG TA U NAOH &
NA CL CO2 CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &
CEMENT CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ &
H2O2 AGCL CL- NANO3 NH3 CU OH-RAD FRACS=0 0 0 0 0 &

```

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000000000000000000000000 &

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000000000000000000000000 &

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```

FRAC STREAM=AQWASTE2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

```

;decontamination factor of 50 used (Emile Bernard, p.9-4)

;taken to be 98% of organics in organic stream, 1% remains with debris, 1%

; goes to wetsolids

;

;conversation with Bill Schwinkendorf 12/20/95 reveals that for SOFT debris

; (paper, cardboard, rags, etc.) the amount of hydrocarbons removed from the

; debris will be minimal. 10 % assumed.

;

;6/24/96 according to Figure B3-7 from MK, there are only two streams:

; washed debris and aqueous organics.

;;

;10/18 all organics put in with aqueous stream. ORGANICS STREAM ZEROED OUT

;INSTEAD OF BEING DELETED; POST-PROCESSING BY EXCEL EXPECTS THE STREAM NAME

;

;wash water routed to aqueous waste (2/3) and to solids (1/3)

DESCRIPTION "estimated separation"

```
FRAC STREAM=AQWASTE3 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &  
AL2O3-S CEMENT FRACS=0.10 0.01 0.01 0
```

```

;decontamination factor of 50 used (Emile Bernard, p.9-4)
;taken to be 98% of organics in organic stream, 1% remains with debris, 1%
; goes to wetsolids
;according to Julia Vetromile, solids contain 1:1 ratio of water (1% left over)
;; 3/8/96 Julia said that open and complex debris would have ~5% water entrain
;; 3/29/96 changed to be the same as HPWash for systems 4 & 5, immorg stream
; zeroed out
;; 8/19/96 agreed with Julia to have 15% of debris mass as make-up water, with
;; 2/3 of water going to aqueous waste, 1/3 going with solids
;
;10/18 all organics put with aqueous stream. ORGANIC STREAM NOT DELETED;
;POST-PROCESSING BY EXCEL EXPECTS STREAM NAME IN EXPORTED FILE.

```

DESCRIPTION "estimated separation"

```
FRAC STREAM=TRETSOL4 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &  
AL2O3-S CEMENT FRACS=0.02 0.99 0.99 0
```

- ;decontamination factor of 50 used (Emile Bernard, p.9-4)
- ;taken to be 98% of organics in organic stream, 1% remains with debris, 1%
- ; goes to wetsolids
- ;3/8/96 Julia Vetromile said that complex, open debris would have ~5% entrain.


```

;ment of H2O
;Figure B3-9 has only two product streams: washed debris and aqueous organics
;
;10/18 all organics put with aqueous stream. ORGANIC STREAM NOT DELETED;
;POST-PROCESSING BY EXCEL EXPECTS STREAM NAME IN EXPORTED OUTPUT FILE.
;
;aqueous stream contains 2/3 of the wash water, 1/3 of wash water with solids

```

BLOCK AQ-WASH5 SEP

```

DESCRIPTION "estimated separation"
PARAM NPHASE=3 TOL=0.01
FRAC STREAM=IMM-ORG5 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 SO2 H2O SIO2 SIO2-S AL2O3 &
AL2O3-S FE AS BA BE CD CR PB HG SE AG TA U NAOH &
NACL CO2 CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &
CEMENT CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ &
H2O2 AGCL CL- NANO3 NH3 CU OH-RAD FRACS=0 0 0 0 0 &
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
0 0 0 0 0 0 0 0 0
FRAC STREAM=IMM-ORG5 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0
FRAC STREAM=AQWASTE5 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 SO2 SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA BE CD CR PB HG SE AG TA U NAOH NACL &
CO2 CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT &
CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL &
CL- NANO3 NH3 CU OH-RAD FRACS=0 0 0.98 0.98 0 0 &
0.98 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
0 0 0 0 0 0 0 0 0
MASS-FLOW STREAM=AQWASTE5 SUBSTREAM=MIXED COMPS=H2O FLOWS= &
17.70
FRAC STREAM=AQWASTE5 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.98 0.01 0.01 0

```

BLOCK BLOWDOWN SEP

```

FRAC STREAM=FLASH-IN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 SO2 H2O SIO2 SIO2-S AL2O3 &
AL2O3-S FE AS BA CD CR PB HG SE AG NAOH NACL CO2 &
CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT &
CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL &
CL- NANO3 NH3 CU FRACS=1 1 1 1 1 1 1 1 1 1 1 &
0.9 1 1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 &
1 1 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0
FRAC STREAM=FLASH-IN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

```

BLOCK FILTER SEP

```

FRAC STREAM=FILTERED SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 SO2 H2O SIO2 SIO2-S AL2O3 &
AL2O3-S FE AS BA CD CR PB HG SE AG NAOH NACL CO2 &
CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT &
CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL &
CL- NANO3 NH3 CU FRACS=0 0 1 1 1 0 1 1 1 1 1 &
1 0 0 0 0 0 0 0 0 0 1 0 0 1 1 1 1 1 1 1 &
1 0 1 1 0 0 0 1 1 1 1 1 1 1 0 1 0 1 0
FRAC STREAM=FILTERED SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

```

```

;This is slightly different than the corresponding subsystems in #4 and #5,
;but all of the constituents are bound for the same downstream processing.
;

```

;according to note from Julia 6/26/96, no aqueous waste stream from soil wash,
;this makes sense with grout especially (why dry soil, only to add water later

BLOCK H2OSEP SEP

DESCRIPTION "separates remaining H2O from washed soil"

FRAC STREAM=EXCESH2O SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 SO2 H2O SIO2 SIO2-S AL2O3 &
AL2O3-S FE AS BA CD CR PB HG SE AG NAOH NACL CO2 &
CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT &
CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL &
CL- NANO3 NH3 CU OH-RAD FRACS=0 0 0 0 0 0 0 0 0 &
0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
0 &
0 0 0
FRAC STREAM=EXCESH2O SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

;Hg retention in solid set to 0.90 to allow some in gas phase

BLOCK MEO-SPLT SEP

DESCRIPTION "for the moment, assumes complete separation"

FRAC STREAM=MEO-LIQ SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL FRACS=0 0 &
1 0 0 0 1 0 0 0 0 3 1 9 0 0 0 0 0 0 0 0 0 0 0 &
0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 0 0 0 1 &
0 0 0 0 0
FRAC STREAM=MEO-LIQ SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0
FRAC STREAM=HNO2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 N2 &
S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA &
CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL FECL3 &
H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 HNO3 HNO2 &
NO3- H+ E- AG+ AG++ H2O2 AGCL FRACS=0 0 0 1 0 0 &
0 1 0 &
0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0
FRAC STREAM=HNO2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0
FRAC STREAM=NITRIC-2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- FRACS= &
0 &
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 9 9 9 9 9 0 0 &
0 1 1 1 0 1 0
FRAC STREAM=NITRIC-2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0
FRAC STREAM=ACID-OUT SUBSTREAM=MIXED COMPS=F2 FE BA CD &
CR HNO3 FRACS=1 1 1 1 1 0.00001
FRAC STREAM=ACID-OUT SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1 1 1 1

BLOCK MET-DCON SEP

DESCRIPTION "Separates water from metal"

FRAC STREAM=METLRECY SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO HCL FECL3 &
H2SO4 NA2SO4 CH4 POLYMER CEMENT FRACS=0 0 1 0 0 0 &
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
0 0 0 0 0 0 0 0

FRAC STREAM=METLRECY SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1 1 1 0

BLOCK NOX-SPLT SEP

FRAC STREAM=NITRIC-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- NANO3 &
NH3 CU FRACS=0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
0 &
0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
FRAC STREAM=NITRIC-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

BLOCK OILSEP SEP

DESCRIPTION "assumes 99% separation of organics (C,H,CHx)"
FRAC STREAM=PHOTO-IN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO NO2 SO2 H2O SIO2 SIO2-S AL2O3 &
AL2O3-S FE AS BA BE CD CR PB HG SE AG TA U NAOH &
NACL CO2 CO O3 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &
CEMENT CASO4 AGNO3 HNO3 HNO2 NO3- H+ E- AG+ AG++ &
H2O2 AGCL CL- NANO3 NH3 CU OH-RAD FRACS=0.01 0.01 &
0.01 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 &
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0.01 0.01 1 1 &
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
FRAC STREAM=PHOTO-IN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.01 1 1 1

BLOCK PB-DECON SEP

FRAC STREAM=LEAD-OUT SUBSTREAM=MIXED COMPS=H2O PB FRACS= &
0 1
FRAC STREAM=LEAD-OUT SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

BLOCK PB-SPLIT SEP

FRAC STREAM=PB BRICKS SUBSTREAM=MIXED COMPS=H2 S FRACS= &
0.81 0.81
MASS-FLOW STREAM=PB BRICKS SUBSTREAM=MIXED COMPS=PB FLOWS= &
21
FRAC STREAM=PB BRICKS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S FRACS=0.81 0.81 0.81

;Perry's Handbook p. 20-33 shows moisture contents of below 1% from dryers.

BLOCK WATERSEP SEP

DESCRIPTION "This separates water in polymer stab. subsystem"
FRAC STREAM=PLYSTBIN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 AGNO3 &
HNO3 HNO2 NO3- H+ E- AG+ AG++ H2O2 AGCL CL- NANO3 &
NH3 FRACS=1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 1 1 1 &
1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 0 1 1 1 1 0 &
1 0 0 0 0 0 0 1 0 1 0
FRAC STREAM=PLYSTBIN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1 1 1 1

BLOCK DRYER HEATER

DESCRIPTION "This models the dryer for the polymer stab. sys."
PARAM TEMP=200 PRES=1

BLOCK HETRHEPA HEATER

DESCRIPTION "heater to raise temperature for HEPA filters"
PARAM TEMP=300 PRES=1

BLOCK SOLDRYER HEATER
PARAM TEMP=200 PRES=1

BLOCK CONCENT8 FLASH2
PARAM TEMP=150 PRES=1

BLOCK FLASH FLASH2
PARAM TEMP=100 PRES=1

BLOCK AG-PPT RSTOIC
PARAM TEMP=80 <C> PRES=35 <PSI>
STOIC 1 MIXED AGNO3 -1 / HCL -1 / AGCL 1 / HNO3 1
CONV 1 MIXED AGNO3 1

BLOCK AGRECOVR RSTOIC
DESCRIPTION "SWAG on T, P"
PARAM TEMP=100 PRES=1 SERIES=YES
STOIC 1 MIXED AGCL -4 / NAOH -4 / H2O2 -4 / AG 4 / &
NACL 4 / H2O 6 / O2 3
STOIC 2 MIXED AG -1 / HNO3 -1 / AGNO3 1 / H+ 1 / &
E- 1
CONV 1 MIXED AGCL 0.99
CONV 2 MIXED AG 0.99

;Data obtained from "Description of Recommended Non-Thermal.."pp. 6-43 to 6-45
;Although room temperature operation is listed on p. 6-43, 1000 C is listed
;on page 6-45, and the higher temperature is more believable
;DRE of 0.999 listed for TCE and 0.90-0.95 for PCE -> use 0.95 for all waste
;assume 1 atm pressure

BLOCK GPCR RSTOIC
DESCRIPTION "Gas Phase Corona Reactor, see comments"
PARAM PRES=1 DUTY=20000
STOIC 1 MIXED H2 -2 / O2 -1 / H2O 2
STOIC 2 CISOLID C-S -1 / MIXED O2 -1 / CO2 1
STOIC 3 MIXED H2 -1 / CL2 -1 / HCL 2
STOIC 4 MIXED CO -1 / O2 -0.5 / CO2 1
STOIC 5 MIXED CH4 -1 / O2 -2 / CO2 1 / H2O 2
CONV 1 MIXED H2 0.95
CONV 2 CISOLID C-S 0.95
CONV 3 MIXED CL2 0.95
CONV 4 MIXED CO 0.95
CONV 5 MIXED CH4 0.95

BLOCK HNO2RECV RSTOIC
PARAM TEMP=423 <K> PRES=35 <PSI>
STOIC 1 MIXED HNO2 -1 / O2 -0.5 / HNO3 1
STOIC 2 MIXED HNO2 -2 / H2O 1 / NO 2 / O2 0.5
CONV 1 MIXED HNO2 0.99
CONV 2 MIXED HNO2 0.01

;reactor also precipitates Ag+

BLOCK MEO-3 RSTOIC
DESCRIPTION "2nd reactor to convert H + NO3 -> HNO2 + H2O"
PARAM TEMP=80 <C> PRES=35 <PSI> SERIES=YES MAXIT=500 &
TOL=0.00000001
STOIC 1 MIXED H+ -4 / NO3- -2 / E- -2 / HNO3 1 / &
HNO2 1 / H2O 1
STOIC 2 MIXED CL- -1 / H+ -1 / HCL 1

CONV 1 MIXED NO3- 0.99
CONV 2 MIXED CL- 1

BLOCK MEO-ANOD RSTOIC

DESCRIPTION "MEO reactor"
PARAM TEMP=80 <C> PRES=35 <PSI> SERIES=NO TOL=0.000001
STOIC 1 CISOLID C-S -1 / MIXED H2O -2 / CO2 1 / H+ &
4 / E- 4
STOIC 2 MIXED H2 -1 / H+ 2 / E- 2
STOIC 3 MIXED CL2 -1 / H+ -2 / E- -2 / HCL 2
STOIC 4 MIXED S -2 / H2O -2 / O2 -3 / H2SO4 2
STOIC 5 MIXED N2 -2 / H2O -2 / O2 -5 / HNO3 4
CONV 1 CISOLID C-S 0.99
CONV 2 MIXED H2 1
CONV 3 MIXED CL2 1
CONV 4 MIXED S 1
CONV 5 MIXED N2 1

BLOCK MEO-CATH RSTOIC

DESCRIPTION "MEO reactor"
PARAM TEMP=80 <C> PRES=35 <PSI> SERIES=YES TOL=0.000001
STOIC 1 MIXED HNO3 -1 / H+ -2 / E- -2 / H2O 1 / &
HNO2 1
STOIC 2 MIXED AGNO3 -1 / HCL -1 / AGCL 1 / HNO3 1
CONV 1 MIXED HNO3 1
CONV 2 MIXED HCL 0.99

BLOCK NEUTRAL RSTOIC

PARAM TEMP=68 PRES=1
STOIC 1 MIXED NAOH -1 / HCL -1 / NACL 1 / H2O 1
STOIC 2 MIXED NAOH -1 / HNO3 -1 / NANO3 1 / H2O 1
STOIC 3 MIXED CL- -1 / NAOH -1 / H+ -1 / NACL 1 / &
H2O 1
STOIC 4 MIXED NO3- -1 / H+ -1 / NAOH -1 / NANO3 1 / &
H2O 1
CONV 1 MIXED HCL 0.99
CONV 2 MIXED HNO3 0.99
CONV 3 MIXED CL- 0.99
CONV 4 MIXED NO3- 1

;scrubbing efficiency of 0.99 assumed for now

BLOCK NEUTRAL3 RSTOIC

DESCRIPTION "neutralizes HCl in offgas stream"
PARAM TEMP=100 PRES=1
STOIC 1 MIXED HCL -1 / NAOH -1 / NACL 1 / H2O 1
STOIC 2 MIXED CL2 -1 / NAOH -2 / NACL 2 / H2O 1 / &
O2 0.5
STOIC 3 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 2
STOIC 4 MIXED SO2 -1 / NAOH -2 / O2 -0.5 / NA2SO4 1 &
/ H2O 1
STOIC 5 MIXED HNO2 -1 / NAOH -1 / O2 -0.5 / H2O 1 / &
NANO3 1
CONV 1 MIXED HCL 0.99
CONV 2 MIXED CL2 0.99
CONV 3 MIXED H2SO4 0.99
CONV 4 MIXED SO2 0.99
CONV 5 MIXED HNO2 1

BLOCK NOX-CONV RSTOIC

PARAM TEMP=68 PRES=1
STOIC 1 MIXED NO -6 / NH3 -4 / N2 5 / H2O 6
CONV 1 MIXED NO 0.99

BLOCK OH-GEN RSTOIC

PARAM TEMP=100 PRES=1
STOIC 1 MIXED H2O2 -1 / OH-RAD 2
STOIC 2 MIXED O3 -1 / H2O -3 / OH-RAD 6
CONV 1 MIXED H2O2 0.99
CONV 2 MIXED O3 0.99

BLOCK OZ-DECOM RSTOIC

DESCRIPTION "ozone decomposer"
PARAM TEMP=100 PRES=1
STOIC 1 MIXED O3 -2 / O2 3
STOIC 2 MIXED HCL -1 / NAOH -1 / NACL 1 / H2O 1
STOIC 3 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 1
STOIC 4 MIXED CL2 -1 / NAOH -2 / NACL 2 / H2O 1 / &
O2 0.5
STOIC 5 MIXED SO2 -1 / NAOH -2 / O2 -0.5 / NA2SO4 1 &
/ H2O 1
CONV 1 MIXED O3 0.999
CONV 2 MIXED HCL 0.99
CONV 3 MIXED H2SO4 0.99
CONV 4 MIXED CL2 0.99
CONV 5 MIXED SO2 0.99

;temperature and pressure assumed arbitrarily

BLOCK OZ-GEN RSTOIC

DESCRIPTION "generates ozone from air"
PARAM TEMP=100 PRES=1
STOIC 1 MIXED O2 -3 / O3 2
CONV 1 MIXED O2 0.999

;Destruction efficiency of 96% assumed (p. 2-78 of "Description of Recommended
;Non-Thermal Mixed Waste Treatment Technologies Version 1.0," Emile A. Bernard
;temperature and pressure assumed by BWBrown

BLOCK PHOTO-UV RSTOIC

DESCRIPTION "Photolytic oxidation of waste, see comments"
PARAM TEMP=100 PRES=1 SERIES=YES MAXIT=500 TOL=0.0000001
STOIC 1 CISOLID C-S -1 / MIXED OH-RAD -4 / CO2 1 / &
H2O 2
STOIC 2 MIXED H2 -1 / OH-RAD -2 / H2O 2
STOIC 3 MIXED H2 -1 / CL2 -1 / HCL 2
CONV 1 CISOLID C-S 0.96
CONV 2 MIXED H2 0.96
CONV 3 MIXED CL2 0.96

BLOCK SPESHULL RGIBBS

DESCRIPTION "for the moment, this block does nothing"
PARAM TEMP=68 PRES=1 MAXIT=500 TOL=0.01

;10% excess OH radicals

DESIGN-SPEC AIR1

DEFINE OHROUT MOLE-FLOW STREAM=PRODUCTS SUBSTREAM=MIXED &
COMPONENT=OH-RAD
DEFINE OHRIN MOLE-FLOW STREAM=OH-RAD SUBSTREAM=MIXED &
COMPONENT=OH-RAD
SPEC "OHROUT*(1+100/10)" TO "OHRIN"
TOL-SPEC "0.05"
VARY STREAM-VAR STREAM=AIR1 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "8 " "20 "

DESIGN-SPEC AIR4

```

DEFINE OXOUT MASS-FLOW STREAM=SPLITIN SUBSTREAM=MIXED &
  COMPONENT=O2
DEFINE OX1 MASS-FLOW STREAM=AIR4 SUBSTREAM=MIXED &
  COMPONENT=O2
DEFINE OX2 MASS-FLOW STREAM=FILTERED SUBSTREAM=MIXED &
  COMPONENT=O2
SPEC "OX1+OX2" " TO "OXOUT*(1+100/100)"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=AIR4 SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
LIMITS "0" "8000"

```

;Perry's Handbook p. 20-33 has moisture contents about 0.5% from dryers
 ;review meeting of 2/8/96 : moisture content to 5%

DESIGN-SPEC DRYER

```

DEFINE H2OMAS MASS-FLOW STREAM=PLYSTBIN SUBSTREAM=MIXED &
  COMPONENT=H2O
DEFINE MIXMAS STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
DEFINE SOLMAS STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
SPEC "H2OMAS" TO "(MIXMAS+SOLMAS)*0.05"
TOL-SPEC "0.001"
VARY BLOCK-VAR BLOCK=WATERSEP SENTENCE=FRAC VARIABLE=FRACS &
  ID1=MIXED ID2=PLYSTBIN ELEMENT=10
LIMITS "0" "1"

```

;power input is calculated to be 56.49 W / SCFM according to information
 ; supplied by Ben Tehranian, MK Environmental Services
 ;
 ;lbmol/hr converted to SCFM by multiplying by 359/60
 ;
 ;1 W = 3.413 Btu/hr

DESIGN-SPEC GPCRPOWER

```

DEFINE MOLOUT STREAM-VAR STREAM=GPCR-OUT SUBSTREAM=MIXED &
  VARIABLE=MOLE-FLOW
DEFINE POWER BLOCK-VAR BLOCK=GPCR VARIABLE=DUTY &
  SENTENCE=PARAM
SPEC "POWER" TO "MOLOUT*359/60*56.49*3.413"
TOL-SPEC "0.10"
VARY BLOCK-VAR BLOCK=GPCR VARIABLE=DUTY SENTENCE=PARAM
LIMITS "0" "10000000"

```

;conversation with Daryoush Bahar 3/6/96 - dry basis used for grout calculation
 ;because with System 3, too much water exists, which results in too much grout
 ;being calculated

DESIGN-SPEC GROUT

```

DEFINE R1 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
DEFINE R2 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
DEFINE R3 MASS-FLOW STREAM=GROUTRIN SUBSTREAM=MIXED &
  COMPONENT=H2O
DEFINE GROUT STREAM-VAR STREAM=GROUTDRY SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
F EXCES =R3-0.6*(R1+R2-R3)
F IF(EXCES.LT.0.) EXCES = 0.
SPEC "GROUT" " TO "1.4*(R1+R2-R3)+2.333*EXCES"
TOL-SPEC "0.1"

```

VARY STREAM-VAR STREAM=GROUTDRY SUBSTREAM=CISOLID &
 VARIABLE=MASS-FLOW
 LIMITS "0.1" "6000"

DESIGN-SPEC GROUTH2O

DEFINE R1 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 DEFINE R2 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=CISOLID &
 VARIABLE=MASS-FLOW
 DEFINE R3 MASS-FLOW STREAM=GROUTRIN SUBSTREAM=MIXED &
 COMPONENT=H2O
 DEFINE H2OFLO STREAM-VAR STREAM=GROUTH2O SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 F EXCES = R3 - 0.6 * (R1+R2-R3)
 F IF(EXCES.GT.0.) EXCES = 0.0
 C SETS EXCESS WATER TO 0 IF WATER IS ACTUALLY EXCESS
 C WATER REQUIRED, IF ANY, IS RETURNED AS A NEGATIVE NUMBER
 SPEC "H2OFLO" TO "-EXCES"
 TOL-SPEC "0.01"
 VARY STREAM-VAR STREAM=GROUTH2O SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 LIMITS "0" "2000"

DESIGN-SPEC HCL-IN

DEFINE HCLOUT MOLE-FLOW STREAM=PPT-OUT SUBSTREAM=MIXED &
 COMPONENT=HCL
 DEFINE HCLIN MOLE-FLOW STREAM=HCL-IN SUBSTREAM=MIXED &
 COMPONENT=HCL
 DEFINE CLOUT MOLE-FLOW STREAM=PPT-OUT SUBSTREAM=MIXED &
 COMPONENT=CL-
 SPEC "HCLIN " TO "HCLOUT*(1+100/1)"
 TOL-SPEC "0.01"
 VARY STREAM-VAR STREAM=HCL-IN SUBSTREAM=MIXED &
 VARIABLE=MOLE-FLOW
 LIMITS "0.00001" "60"

;This design spec is merely to provide enough excess
 ; HNO3 to allow the reaction to proceed (1% excess).

DESIGN-SPEC HNO3-IN1

DEFINE HNO3OT MASS-FLOW STREAM=AGRECOVR SUBSTREAM=MIXED &
 COMPONENT=HNO3
 DEFINE NO3IN1 MASS-FLOW STREAM=NITRIC-2 SUBSTREAM=MIXED &
 COMPONENT=HNO3
 DEFINE NO3IN2 MASS-FLOW STREAM=HNO3-IN1 SUBSTREAM=MIXED &
 COMPONENT=HNO3
 SPEC "NO3IN1+NO3IN2 " TO "HNO3OT*(1+100/1)"
 TOL-SPEC "0.05"
 VARY STREAM-VAR STREAM=HNO3-IN1 SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 LIMITS "0.00001" "90"

DESIGN-SPEC NAOH-3

DEFINE NAOHIN MOLE-FLOW STREAM=NAOH-3 SUBSTREAM=MIXED &
 COMPONENT=NAOH
 DEFINE NAOHOT MOLE-FLOW STREAM=SPLITIN SUBSTREAM=MIXED &
 COMPONENT=NAOH
 SPEC "NAOHIN" TO "NAOHOT*(1+100/1) "
 TOL-SPEC "0.001"
 VARY STREAM-VAR STREAM=NAOH-3 SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 LIMITS "5.0" "10."

DESIGN-SPEC NAOH-4

DEFINE NAOHIN MASS-FLOW STREAM=NAOH-4 SUBSTREAM=MIXED &
COMPONENT=NAOH
DEFINE NAOHOT MASS-FLOW STREAM=ACIDSLUD SUBSTREAM=MIXED &
COMPONENT=NAOH
SPEC "NAOHIN" TO "NAOHOT*(1+100/1)"
TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=NAOH-4 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.001" "0.002"

DESIGN-SPEC O2-HNO2

DEFINE O2IN1 MASS-FLOW STREAM=OXYGEN1 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE O2IN2 MASS-FLOW STREAM=HNO2 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE O2OUT MASS-FLOW STREAM=HNO2-NO3 SUBSTREAM=MIXED &
COMPONENT=O2
SPEC "O2IN1+O2IN2" TO "O2OUT*(1+100/1)"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=OXYGEN1 SUBSTREAM=MIXED &
VARIABLE=MOLE-FLOW
LIMITS "23.7" "30.0"

DESIGN-SPEC POLYMER

DEFINE WASTIN STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
DEFINE SOLDIN STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW
DEFINE POLYIN STREAM-VAR STREAM=POLYETHL SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
SPEC "POLYIN" TO "(WASTIN+SOLDIN)"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=POLYETHL SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.1" "8000"

20% moisture content set at review meeting 2/8/96

DESIGN-SPEC SALTSOLN

DEFINE SALTFL MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
COMPONENT=NaCl
DEFINE H2OFLO MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
COMPONENT=H2O
DEFINE NAOHFL MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
COMPONENT=NAOH
DEFINE NA2SO4 MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
COMPONENT=Na2SO4
DEFINE NANO3 MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
COMPONENT=NANO3
SPEC "H2OFLO*4" TO "SALTFL+NAOHFL+NA2SO4+NANO3"
TOL-SPEC "0.01"
VARY BLOCK-VAR BLOCK=BLOWDOWN SENTENCE=FRAC VARIABLE=FRACS &
ID1=MIXED ID2=FLASH-IN ELEMENT=12
LIMITS "0.001" "1"

DESIGN-SPEC XX-NAOH

DEFINE NAOHIN MASS-FLOW STREAM=PRODUCTS SUBSTREAM=MIXED &
COMPONENT=NAOH
DEFINE NAOHOT MASS-FLOW STREAM=AQ-OUT SUBSTREAM=MIXED &
COMPONENT=NAOH
SPEC "NAOHIN" TO "NAOHOT*(1+100/1)"
TOL-SPEC "10 "

VARY STREAM-VAR STREAM=XX-NAOH SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 LIMITS "0.01" "200"

FORTTRAN ADDITIVE
 DEFINE HGOUT MASS-FLOW STREAM=HG-OUT SUBSTREAM=MIXED &
 COMPONENT=HG
 DEFINE COPPIN MASS-FLOW STREAM=ADDITIVE SUBSTREAM=MIXED &
 COMPONENT=CU
 F COPPIN = 0.7 * HGOUT
 READ-VARS HGOUT
 WRITE-VARS COPPIN

FORTTRAN AGNO3-IN
 DEFINE AGNO3 MOLE-FLOW STREAM=AGNO3-IN SUBSTREAM=MIXED &
 COMPONENT=AGNO3
 DEFINE CL2IN1 MOLE-FLOW STREAM=20003000 SUBSTREAM=MIXED &
 COMPONENT=CL2
 DEFINE CL2IN2 MOLE-FLOW STREAM=IMM-ORG SUBSTREAM=MIXED &
 COMPONENT=CL2
 DEFINE CL2IN3 MOLE-FLOW STREAM=IMM-ORG1 SUBSTREAM=MIXED &
 COMPONENT=CL2
 DEFINE AGNREC MOLE-FLOW STREAM=AGRECYC SUBSTREAM=MIXED &
 COMPONENT=AGNO3
 DEFINE HCLREC MOLE-FLOW STREAM=H2O-IN SUBSTREAM=MIXED &
 COMPONENT=HCL
 F AGNO3 = (CL2IN1 + CL2IN2 + CL2IN3)*2 + HCLREC - AGNREC
 F IF (AGNO3.LT.0.) AGNO3 = 0.
 READ-VARS CL2IN1 CL2IN2 AGNREC HCLREC
 WRITE-VARS AGNO3

FORTTRAN AGRECOVER
 DEFINE AGCLIN MOLE-FLOW STREAM=NITRIC-2 SUBSTREAM=MIXED &
 COMPONENT=AGCL
 DEFINE NAOHIN MOLE-FLOW STREAM=NAOH-1 SUBSTREAM=MIXED &
 COMPONENT=NAOH
 DEFINE H2O2IN MOLE-FLOW STREAM=H2O2-IN SUBSTREAM=MIXED &
 COMPONENT=H2O2
 DEFINE MASSNA MASS-FLOW STREAM=NAOH-1 SUBSTREAM=MIXED &
 COMPONENT=NAOH
 DEFINE MASSH2 MASS-FLOW STREAM=NAOH-1 SUBSTREAM=MIXED &
 COMPONENT=H2O
 F NAOHIN = AGCLIN
 F H2O2IN = AGCLIN
 F MASSH2 = MASSNA
 READ-VARS AGCLIN MASSNA
 WRITE-VARS NAOHIN H2O2IN MASSH2

FORTTRAN H2O2-IN2
 DEFINE O3IN MOLE-FLOW STREAM=PHOTO-IN SUBSTREAM=MIXED &
 COMPONENT=O3
 DEFINE H2O2IN STREAM-VAR STREAM=H2O2-IN2 SUBSTREAM=MIXED &
 VARIABLE=MOLE-FLOW
 F H2O2IN=O3IN
 READ-VARS O3IN
 WRITE-VARS H2O2IN

FORTTRAN HNO3-IN2
 DEFINE HPIN MOLE-FLOW STREAM=MEO1-OUT SUBSTREAM=MIXED &
 COMPONENT=H+
 DEFINE HNO3IN STREAM-VAR STREAM=HNO3-IN2 SUBSTREAM=MIXED &
 VARIABLE=MOLE-FLOW
 DEFINE HNO3R1 MOLE-FLOW STREAM=NITRIC-1 SUBSTREAM=MIXED &

```

      COMPONENT=HNO3
      DEFINE HNO3R2 MOLE-FLOW STREAM=AGRECYC SUBSTREAM=MIXED &
      COMPONENT=HNO3
F      HNO3IN = HPIN / 2 - HNO3R1 - HNO3R2
F      IF (HNO3IN.LT.0.0) HNO3IN = 0.
      READ-VARS HPIN HNO3R1 HNO3R2
      WRITE-VARS HNO3IN

```

```

FORTRAN X-NH3
      DEFINE NOXIN MOLE-FLOW STREAM=X-NOX SUBSTREAM=MIXED &
      COMPONENT=NO
      DEFINE XNH3IN STREAM-VAR STREAM=X-NH3 SUBSTREAM=MIXED &
      VARIABLE=MOLE-FLOW
F      XNH3IN = NOXIN * 2/3
      READ-VARS NOXIN
      WRITE-VARS XNH3IN

```

```

CONV-OPTIONS
      PARAM TEAR-METHOD=BROYDEN TOL=0.00111
      WEGSTEIN MAXIT=9999
      SECANT STEP-SIZE=0.01 MAX-STEP-SIZ=1 BRACKET=NO
      BROYDEN MAXIT=999

```

```

STREAM-REPOR MOLEFLOW MASSFLOW

```

```

;
;
;
;
;
;
;

```

System 4

;Input Summary created by ASPEN PLUS Rel. 9.2-1 at 10:49:32 Thu Dec 19, 1996
;Directory C:\ASPENRUN Filename C:\ASPENRUN\newsys4w.inp
;

TITLE This is System 4 for INTS'

IN-UNITS ENG PRESSURE=ATM

DEF-STREAMS MIXCISLD ALL

SIM-OPTIONS

IN-UNITS ENG

SIM-OPTIONS RESTART=NO

DATABANKS COMBUST / INORGANIC / PURECOMP / SOLIDS / &
NOASPENPCD

PROP-SOURCES COMBUST / INORGANIC / PURECOMP / SOLIDS

;Cement approximated by $\text{CaAl}_2\text{SiO}_6$ ($\text{CaO}.\text{Al}_2\text{O}_3.\text{SiO}_2$), Shreve & Brink p. 162

COMPONENTS

C C C /

C-S C C-S /

H2 H2 H2 /

O2 O2 O2 /

N2 N2 N2 /

S S S /

CL2 CL2 CL2 /

F2 F2 F2 /

NO NO NO /

SO2 SO SO2 /

H2O H2O H2O /

SIO2 SIO2 SIO2 /

SIO2-S SIO2 SIO2-S /

AL2O3 AL2O3 AL2O3 /

AL2O3-S AL2O3 AL2O3-S /

FE FE FE /

AS AS AS /

BA BA BA /

BE BE BE /

CD CD CD /

CR CR CR /

PB PB PB /

HG HG HG /

SE SE SE /

AG AG AG /

TA TA TA /

U U U /

NAOH NAOH NAOH /

NACL NACL NACL /

CO2 CO2 CO2 /

CO CO CO /

O3 O3 O3 /
 H2O2 H2O2 H2O2 /
 HCL HCL HCL /
 FECL3 FECL3 FECL3 /
 H2SO4 H2SO4 H2SO4 /
 NA2SO4 NA2SO4 NA2SO4 /
 CH4 CH4 CH4 /
 POLYMER C2H4 POLYMER /
 CEMENT CAAL2SIO6 CEMENT /
 CASO4 CASO4 CASO4 /
 HNO3 HNO3 HNO3 /
 NANO3 NANO3 NANO3 /
 NH3 H3N NH3 /
 CU CU CU /
 OH-RAD OH OH-RAD

FLWSHEET APC-SYS

BLOCK GPCR IN=FILTERED AIR4 OUT=GPCR-OUT
 BLOCK FILTER IN=AQ-OFGAS VACGAS-1 WSHOFGAS DG-GAS-1 &
 DG-GAS-2 OUT=FILTERED METALS
 BLOCK NEUTRAL3 IN=NAOH-3 GPCR-OUT OUT=SPLITIN
 BLOCK BLOWDOWN IN=SPLITIN OUT=FLASH-IN SALTSOLN
 BLOCK FLASH2 IN=FLASH-IN OUT=HEATERIN MOISTURE
 BLOCK HETRHEPA IN=HEATERIN OUT=OFFGAS

FLWSHEET AQUEOUS

BLOCK OZ-GEN IN=AIR1 OUT=OZONE
 BLOCK CONCENT8 IN=SALTSOLN OUT=AQ-RECY2 CONCENT8
 BLOCK PHOTOMIX IN=VACLIQ-1 METLRECY 1000 WASHLIQ OZONE &
 DG-LIQ-1 DG-LIQ-2 MOISTURE H2O2-IN2 HPWATOUT EXCESH2O &
 XX-NAOH XY-EXCES AQ-RECY2 OUT=X-PHOTIN
 BLOCK AQ-SPLIT IN=AQ-OUT OUT=AQ-OFGAS AQ-SLUDG AQ-RECYC
 BLOCK OH-GEN IN=PHOTO-IN OUT=OH-RAD
 BLOCK PHOTO-UV IN=OH-RAD OUT=PRODUCTS
 BLOCK OZ-DECOM IN=PRODUCTS OUT=AQ-OUT
 BLOCK OILSEP IN=X-PHOTIN OUT=PHOTO-IN X-ORGS

FLWSHEET BULKSOIL

BLOCK SOILWASH IN=4000 AQ-WASH OUT=WASHLIQ WSHOFGAS &
 TRET SOL WASHORG
 BLOCK H2OSEP IN=WARMSOL OUT=EXCESH2O DRY SOL
 BLOCK SOLDRYER IN=TRET SOL OUT=WARMSOL

FLWSHEET GROUT

BLOCK GROUTMIX IN=5000COMP WASHDEBR PBGLOVES OUT=GROUTRIN
 BLOCK GROUTER IN=GROUTDRY GROUTRIN GROUTH2O OUT=GROUTOUT

FLWSHEET HG-AMAL

BLOCK HG-AMALG IN=VAC-HG-1 7000-HG ADDITIVE OUT=HG-OUT

FLWSHEET METLDCON

BLOCK MET-DCON IN=METLWASH 5000METL OUT=METLRECY METALOUT

FLWSHEET ORGDEST

BLOCK DG-SPLT1 IN=DG-SCRB1 OUT=DG-LIQ-1 DG-SLD-1 DG-GAS-1
 BLOCK ACID-DG1 IN=HNO3-IN1 20003000 WASHORG VACORG-1 &
 HNO3RECY X-ORGS OUT=DG-OUT-1

BLOCK NEUTRAL1 IN=NAOH-1 NH3-IN-1 NOX OUT=DG-SCRB1
BLOCK HNO3-SEP IN=HNO2HNO3 OUT=HNO3RECY NOX
BLOCK HNO2RECV IN=DG-OUT-1 OXYGEN1 OUT=HNO2HNO3

FLowsheet PB-RECV

BLOCK PB-DECON IN=PBBRICKS PB-WATER OUT=LEAD-OUT PBSLUDGE
BLOCK PB-SPLIT IN=7000-PB OUT=PBBRICKS PBGLOVES

FLowsheet POLYMER

BLOCK PHOSCEM IN=PLYSTBIN POLYETHL OUT=POLY-OUT
BLOCK PHOS-MIX IN=DG-SLD-1 AQ-SLUDG CONCENT8 METALS &
DG-SLD-2 VACSOL-1 DRYSL OUT=XY-DRYIN
BLOCK DRYER IN=XY-DRYIN OUT=XY-DRYOT
BLOCK WATERSEP IN=XY-DRYOT OUT=PLYSTBIN XY-EXCES
BLOCK POLY-MER IN=XYX-PE 3000POLY OUT=XYX-POLY

FLowsheet RES-SLUD

BLOCK VACTRAX1 IN=3000 PBSLUDGE N2SWEEP1 OUT=VACOUT-1
BLOCK HP-WASH IN=H2OWASH 5000OPEN OUT=WASHDEBR HPWATOUT
BLOCK NEUTRAL2 IN=NAOH-2 NH3-IN-2 NOX-2 OUT=DG-SCRB2
BLOCK ACID-DG2 IN=HNO3-IN2 5000SOFT HNO3REC2 OUT=DG-OUT-2
BLOCK DG-SPLT2 IN=DG-SCRB2 OUT=DG-LIQ-2 DG-SLD-2 DG-GAS-2
BLOCK VACSEP-1 IN=VACOUT-1 XYLEACH1 OUT=VACLIQ-1 VACORG-1 &
VACGAS-1 VAC-HG-1 VACSOL-1
BLOCK HNO2REC2 IN=OXYGEN2 DG-OUT-2 OUT=HNO2HN32
BLOCK HNO3SEP2 IN=HNO2HN32 OUT=HNO3REC2 NOX-2

FLowsheet SPECIAL

BLOCK SPESHULL IN=6000 OUT=SPEC-OUT

PROPERTIES SOLIDS

PROPERTIES IDEAL

USER-PROPS DRUSR2 1 2 3

PROP-DATA U-2

IN-UNITS ENG PRESSURE=ATM
PROP-LIST TC
PVAL CEMENT 1000

PROP-DATA U-1

IN-UNITS ENG PRESSURE=ATM
PROP-LIST PLXANT
PVAL CEMENT 10 -1000 100

PROP-DATA U-1

IN-UNITS ENG PRESSURE=ATM
PROP-LIST DHVLWT
PVAL CEMENT 100000 500

;Tables dated 04/24/96 from Daryoush Bahar, MK, (415) 442-7688

;Glass inerts assumed to be 50% SiO2 and 50% Al2O3 for all waste streams.

STREAM 1000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=60.8
MASS-FLOW H2 3613 <KG/HR> / O2 172053 <KG/HR> / N2 &
50211 <KG/HR> / H2O 2456410 <KG/HR> / AS 5647 <KG/HR> &

/ BA 2823 <KG/HR> / CD 42352 <KG/HR> / CR &
56469 <KG/HR> / PB 14117 <KG/HR> / HG 14117 <KG/HR> / &
SE 2823 <KG/HR> / AG 2823 <KG/HR>

;Tables dated 04/24/96 from MK

STREAM 3000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=352.12
MASS-FLOW H2 268596 <KG/HR> / O2 10180 <KG/HR> / N2 &
122 <KG/HR> / S 6233 <KG/HR> / CL2 383185 <KG/HR> / &
H2O 18588527 <KG/HR> / FE 107084 <KG/HR> / AS &
3383 <KG/HR> / BA 12700 <KG/HR> / CD 158485 <KG/HR> / &
CR 299848 <KG/HR> / PB 9640 <KG/HR> / HG 8445 <KG/HR> &
/ SE 1689 <KG/HR> / AG 1693 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=655.08
MASS-FLOW C-S 1658863 <KG/HR> / SIO2-S 17644467 <KG/HR> / &
AL2O3-S 17644467 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 3000POLY

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=3.28
MASS-FLOW CL2 98888 <KG/HR> / NO 37279 <KG/HR> / SO2 &
47075 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=3.32
MASS-FLOW SIO2-S 92796 / AL2O3-S 92796

;tables dated 04/24/96 from MK

STREAM 4000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=40.74
MASS-FLOW H2 21653 <KG/HR> / CL2 761580 <KG/HR> / H2O &
1514279 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=287.76
MASS-FLOW C-S 175090 <KG/HR> / SIO2-S 8027287.5 <KG/HR> / &
AL2O3-S 8027287.5 <KG/HR>

;Data table dated 04/24/96. Supplied by Daryoush Bahar, MK (415) 442-7688

STREAM 5000COMP

SUBSTREAM MIXED TEMP=68 PRES=1
MASS-FLOW H2 3.026 / H2O 0.197 / FE 148.890 / HG 1.3
SUBSTREAM CISOLID TEMP=68 PRES=1
MASS-FLOW C-S 17.992 / SIO2-S 3.003 / AL2O3-S 3.003

;tables dated 04/24/96 from MK

STREAM 5000METL

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=434.82
MASS-FLOW H2 141789 / FE 13383118
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=27.29
MASS-FLOW C-S 844686 / SIO2-S 1981 / AL2O3-S 1981

;tables dated 04/24/96 from MK

STREAM 5000OPEN

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.40

MASS-FLOW H2 4587 <KG/HR> / O2 18201 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=80
MASS-FLOW C-S 22543 <KG/HR> / SIO2-S 2243854 <KG/HR> / &
AL2O3-S 2243854 <KG/HR>

;tables dated 04/30/96, used mass flow lb/hr rather than kg in waste inventory

STREAM 5000SOFT

SUBSTREAM MIXED TEMP=68 PRES=1
MASS-FLOW H2 33.213 / O2 103.327 / N2 0.252 / S 0.903 &
/ CL2 19.233 / F2 0.126 / H2O 12.458 / FE 3.204 / &
HG 1.2
SUBSTREAM CISOLID TEMP=68 PRES=1
MASS-FLOW C-S 217.042 / SIO2-S 21.901 / AL2O3-S 21.901

;tables dated 04/24/96 from MK

STREAM 6000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=125.46
MASS-FLOW H2 13980 <KG/HR> / O2 1775708 <KG/HR> / N2 &
546 <KG/HR> / S 1469 <KG/HR> / H2O 195474 <KG/HR> / &
FE 913 <KG/HR> / AS 64 <KG/HR> / BA 50656 <KG/HR> / &
BE 763726 <KG/HR> / CD 11416 <KG/HR> / CR 652 <KG/HR> &
/ PB 104216 <KG/HR> / HG 160 <KG/HR> / SE 32 <KG/HR> &
/ AG 32 <KG/HR> / TA 23100 <KG/HR> / U &
2415249 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=29.44
MASS-FLOW C-S 131953 <KG/HR> / SIO2-S 561390.5 <KG/HR> / &
AL2O3-S 561390.5 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 7000-HG

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=2.5
MASS-FLOW HG 1167608

;tables dated 04/24/96 from MK

STREAM 7000-PB

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=25.986
MASS-FLOW H2 228 <KG/HR> / S 41 <KG/HR> / PB &
10645151 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=.00393 <KG/HR>
MASS-FLOW C-S 1811 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 20003000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=78.28
MASS-FLOW H2 922853 <KG/HR> / O2 59994 <KG/HR> / S &
10234 <KG/HR> / CL2 1654619 <KG/HR> / H2O &
1229766 <KG/HR> / FE 325702 <KG/HR> / BA 32570 <KG/HR> &
/ CD 32570 <KG/HR> / CR 65140 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=107.12 &
FLASH-OPTION=NOFLASH
MASS-FLOW C-S 5723044 <KG/HR> / SIO2-S 103248 <KG/HR> / &
AL2O3-S 103248 <KG/HR>

STREAM ADDITIVE

SUBSTREAM MIXED TEMP=68 PRES=1

MOLE-FLOW CU 0.029106

STREAM AIR1

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=230

MOLE-FRAC O2 0.21 / N2 0.79

STREAM AIR4

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=370.2670

MOLE-FRAC O2 0.21 / N2 0.79

STREAM AQ-WASH

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=328.5

MASS-FRAC H2O 1

STREAM GROUTDRY

SUBSTREAM MIXED TEMP=68 PRES=1

SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=4501.452

MASS-FRAC CEMENT 1

STREAM GROUTH2O

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.000001

MASS-FRAC H2O 1

STREAM H2O2-IN2

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1

MASS-FRAC H2O2 1

;flow rate set to 15% of waste input, 10% to recycle, 5% with solids

STREAM H2OWASH

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=12

MASS-FRAC H2O 1

STREAM HG-OUT

SUBSTREAM MIXED TEMP=68 PRES=1

MOLE-FLOW HG 0.0131723 / CU 0.029106

STREAM HNO3-IN1

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1666

MASS-FRAC HNO3 1

STREAM HNO3-IN2

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=21.1

MASS-FRAC HNO3 1

;Water set to 112/468 times the bulk metal flow rate, from Figure 3-22
; (page 3-46) in ITTS Phase 2 Final Report

STREAM METLWASH

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=94.327

MASS-FRAC H2O 1

;3/26/96 Daryoush Bahar uses value of 1200SCFH of N2 for 1100 lb/h of debris

STREAM N2SWEEP1

SUBSTREAM MIXED TEMP=68 PRES=1 VOLUME-FLOW=1200
MOLE-FRAC N2 1

;According to Delphi flowsheet D-1002A, 50% NaOH solution

STREAM NAOH-1
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=128
MASS-FRAC H2O 0.5 / NAOH 0.5

;According to Delphi flowsheet D-1002A, 50% NaOH solution

STREAM NAOH-2
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=73.7
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM NAOH-3
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=34.21764
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM NH3-IN-1
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=290.7029
MASS-FRAC NH3 1

STREAM NH3-IN-2
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=420
MASS-FRAC NH3 1

STREAM OXYGEN1
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.0001
MOLE-FLOW O2 1

STREAM OXYGEN2
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.0001
MOLE-FLOW O2 1

STREAM PB-WATER
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=13
MASS-FRAC H2O 1

;Polymer assumed to be polyethylene; C2H4 used as the monomer.

STREAM POLYETHL
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=113.4696
MASS-FRAC CEMENT 1

STREAM PRODUCTS
SUBSTREAM MIXED TEMP=100 PRES=1
MASS-FLOW H2 .688 / O2 4.908 / N2 108.8 / NO 2.738 / &
H2O 851.703 / AS 0.16 / BA 0.08 / CD 1.2 / CR &
1.6 / PB 0.4 / HG 0.43 / SE 0.08 / AG 0.08 / &
NAOH 0.187 / NAOL 20.7 / O3 32.576 / HCL 0.13 / &
FECL3 0.6

STREAM XX-NAOH
SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM XYLEACH1

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=306

MASS-FRAC H2O 1

;Polymer assumed to be polyethylene; C2H4 used as the monomer.

STREAM YYX-PE

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=113.4696

MASS-FRAC POLYMER 1

BLOCK GROUTER MIXER

PARAM PRES=1 NPHASE=3 MAXIT=500 TOL=0.1

BLOCK GROUTMIX MIXER

PARAM PRES=1 NPHASE=2 MAXIT=500 TOL=0.0010

BLOCK-OPTION ENERGY-BAL=YES

BLOCK HG-AMALG MIXER

BLOCK PHOS-MIX MIXER

PARAM PRES=1 MAXIT=100

BLOCK PHOSCERM MIXER

BLOCK-OPTION ENERGY-BAL=YES

BLOCK PHOTOMIX MIXER

BLOCK POLY-MER MIXER

DESCRIPTION "for the moment, this is only a mixer"

BLOCK-OPTION ENERGY-BAL=YES

BLOCK SPESHULL MIXER

BLOCK AQ-SPLIT SEP

FRAC STREAM=AQ-OFGAS SUBSTREAM=MIXED COMPS=H2 O2 N2 CL2 &

F2 NO SO2 CO2 CO O3 CH4 NH3 FRACS=1 1 1 1 1 1 &

0 1 1 1 1 0

FRAC STREAM=AQ-OFGAS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &

AL2O3-S CEMENT FRACS=0 0 0 0

FRAC STREAM=AQ-SLUDG SUBSTREAM=MIXED COMPS=C C-S S SO2 &

SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA CD CR PB HG SE &

AG NAOH NACL FECL3 NA2SO4 POLYMER CEMENT CASO4 NANO3 &

NH3 CU FRACS=1 1 1 0 1 1 1 1 1 1 1 1 1 1 &

1 1 1 1 1 1 1 1 1 0 1

FRAC STREAM=AQ-SLUDG SUBSTREAM=CISOLID COMPS=C-S SIO2-S &

AL2O3-S CEMENT FRACS=0.99 0.99 0.99 1

BLOCK BLOWDOWN SEP

FRAC STREAM=FLASH-IN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &

N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &

FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &

HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 &

NANO3 NH3 CU FRACS=1 1 1 1 1 1 1 1 1 1 0.9 1 &

1 1 1 1 1 1 1 1 1 1 0 0 1 1 1 1 1 0 &

1 0 0 1 1 1 1 1

FRAC STREAM=FLASH-IN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &

AL2O3-S CEMENT FRACS=0 0 0 0

;Hg retention in solid set to 0.90 to allow some in gas phase

BLOCK DG-SPLT1 SEP

DESCRIPTION "for the moment, assumes complete separation"

FRAC STREAM=DG-LIQ-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 &
NANO3 NH3 CU FRACS=0000000001000 &
000000000011000101100 &
011110

FRAC STREAM=DG-LIQ-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0000

FRAC STREAM=DG-SLD-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 &
NANO3 NH3 CU FRACS=1100010000111 &
11111110.1110000000000 &
0100001

FRAC STREAM=DG-SLD-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1111

;Hg retention in solid set to 0.95 to allow 5% in liquid phase

BLOCK DG-SPLT2 SEP

DESCRIPTION "for the moment, assumes complete separation"

FRAC STREAM=DG-LIQ-2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 &
NANO3 NH3 CU FRACS=0000000001000 &
00000000.05001100010110 &
0011110

FRAC STREAM=DG-LIQ-2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0000

FRAC STREAM=DG-SLD-2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 &
NANO3 NH3 CU FRACS=1101010000111 &
11111110.95110000000000 &
0100001

FRAC STREAM=DG-SLD-2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1111

BLOCK FILTER SEP

PARAM PRES=1

FRAC STREAM=METALS SUBSTREAM=MIXED COMPS=C C-S H2 O2 N2 &
S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S FE &
AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 &
NANO3 NH3 CU FRACS=0000000000011 &
111111111111100001010 &
1110101

FRAC STREAM=METALS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &

AL2O3-S CEMENT FRACS=1 1 1 1

;This separates the water driven off by the soil dryer after soil washing

BLOCK H2OSEP SEP

DESCRIPTION "separates remaining H2O from washed soil"

FRAC STREAM=EXCESH2O SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
H2O2 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 &
HNO3 NANO3 NH3 CU OH-RAD FRACS=0 0 0 0 0 0 0 0 &
0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

FRAC STREAM=EXCESH2O SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

BLOCK HNO3-SEP SEP

FRAC STREAM=HNO3RECY SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 &
NANO3 NH3 CU FRACS=0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
0 &
0 0 0.99 0 0 0

FRAC STREAM=HNO3RECY SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

BLOCK HNO3SEP2 SEP

FRAC STREAM=HNO3REC2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 &
NANO3 NH3 CU FRACS=0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
0 &
0 0 0.99 0 0 0

FRAC STREAM=HNO3REC2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

;wash water flow rate set to 15% of waste input; 10% to recycle, 5% to solids

BLOCK HP-WASH SEP

DESCRIPTION "estimated separation"

FRAC STREAM=WASHDEBR SUBSTREAM=MIXED COMPS=H2 O2 CL2 FE &
FRACS=0.02 0.02 0.02 1

MASS-FLOW STREAM=WASHDEBR SUBSTREAM=MIXED COMPS=H2O FLOWS= &
4

FRAC STREAM=WASHDEBR SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S FRACS=0.02 0.99 0.99

BLOCK MET-DCON SEP

DESCRIPTION "Separates water from metal"

FRAC STREAM=METLRECY SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO HCL FECL3 &
H2SO4 NA2SO4 CH4 POLYMER CEMENT FRACS=0 0 1 0 0 0 &
0 0 0 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
0 0 0 0 0 0 0 0

FRAC STREAM=METLRECY SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1 1 1 0

BLOCK OILSEP SEP

DESCRIPTION "assumes 99% separation of organics (C,H,CHx)"

FRAC STREAM=PHOTO-IN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA BE CD CR PB HG SE AG TA U NAOH NACL &
CO2 CO O3 H2O2 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &
CEMENT CASO4 HNO3 NANO3 NH3 CU OH-RAD FRACS=0.01 &
0.01 0.01 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 &
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 0.01 0.01 &
1 1 1 1 1 1 1

FRAC STREAM=PHOTO-IN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.01 1 1 1

BLOCK PB-DECON SEP

FRAC STREAM=LEAD-OUT SUBSTREAM=MIXED COMPS=H2O PB FRACS= &
0 1

FRAC STREAM=LEAD-OUT SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

BLOCK PB-SPLIT SEP

FRAC STREAM=PBBRICKS SUBSTREAM=MIXED COMPS=H2 S FRACS= &
0.81 0.81

MASS-FLOW STREAM=PBBRICKS SUBSTREAM=MIXED COMPS=PB FLOWS= &
21

FRAC STREAM=PBBRICKS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S FRACS=0.81 0.81 0.81

For now, assumes 95% removal by washing of C, H2, CL2

BLOCK SOILWASH SEP

DESCRIPTION "For now, a simple separation (w/o condensers,etc)"

FRAC STREAM=WASHLIQ SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA BE CD CR PB HG SE AG TA U NAOH NACL &
CO2 CO O3 H2O2 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &
CEMENT CASO4 HNO3 NANO3 NH3 CU OH-RAD FRACS=0 0 0 &
0 &
0 &
0

FRAC STREAM=WASHLIQ SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

FRAC STREAM=WSHOF GAS SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA BE CD CR PB HG SE AG TA U NAOH NACL &
CO2 CO O3 H2O2 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &
CEMENT CASO4 HNO3 NANO3 NH3 CU OH-RAD FRACS=0 0 0 &
0 &
0 &
0

FRAC STREAM=WSHOF GAS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

FRAC STREAM=TRETSOL SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 FECL3 &

H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 NANO3 NH3 &
 CU FRACS=0.05 0.05 0.05 0.05 0 1 0.05 0 0 1 1 1 &
 1 1 1 1 1 1 1 0 1 1 1 1 0 0 0 1 1 1 1 1 &
 1 1 0 0 0 1
 FRAC STREAM=TRETSOL SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0.05 1 1 1

;assumes 50% desorption of C, H2 5% of Hg removed by aqueous washing

BLOCK VACSEP-1 SEP

FRAC STREAM=VACLIQ-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA &
 CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL FECL3 &
 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 NANO3 NH3 &
 CU FRACS=0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 0 0 &
 0
 MASS-FLOW STREAM=VACLIQ-1 SUBSTREAM=MIXED COMPS=H2O FLOWS= &
 342.5798
 FRAC STREAM=VACLIQ-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0 0 0 0
 FRAC STREAM=VACORG-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
 BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
 FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 &
 NANO3 NH3 CU FRACS=0 0 0 0.5 0 0 0 0.5 0.5 0 0 0 &
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 &
 1 1 0 0 0 0 0 0
 FRAC STREAM=VACORG-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0.5 0 0 0
 FRAC STREAM=VACGAS-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
 BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
 FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 &
 NANO3 NH3 CU FRACS=0 0 0 0 1 0 0 0 1 0 0 0 0 &
 0 0 0 0 0 0 0 0 0 0 0 0 1 0 1 0 0 0 0 0 0 &
 0 0 0 0 0 0
 FRAC STREAM=VACGAS-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0 0 0 0
 FRAC STREAM=VAC-HG-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
 BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
 FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 HNO3 &
 NANO3 NH3 CU FRACS=0 0 0 0 0 0 0 0 0 0 0 0 0 0 &
 0 0 0 0 0 0 0 0.95 0 0 0 0 0 0 0 0 0 0 0 0 &
 0 0 0 0 0 0 0
 FRAC STREAM=VAC-HG-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0 0 0 0

BLOCK WATERSEP SEP

FRAC STREAM=PLYSTBIN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
 FE AS BA BE CD CR PB HG SE AG TA U NAOH NACL &
 CO2 CO O3 H2O2 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &
 CEMENT CASO4 HNO3 NANO3 NH3 CU OH-RAD FRACS=1 1 1 &
 1 1 1 1 1 0 0 1 1 1 1 1 1 1 1 1 1 1 1 1 1 &
 1 &

1
FRAC STREAM=PLYSTBIN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1 1 1 1

;8/21/96 - dryer added to System 4 after discussing with Julia Vetromile

BLOCK DRYER HEATER

DESCRIPTION "This models the dryer for the polymer stab. sys."

PARAM TEMP=200 PRES=1

BLOCK HETRHEPA HEATER

DESCRIPTION "heater to raise temperature for HEPA filters"

PARAM TEMP=300 PRES=1

BLOCK SOLDRYER HEATER

PARAM TEMP=200 PRES=1

BLOCK CONCENT8 FLASH2

PARAM TEMP=150 PRES=1

BLOCK FLASH2 FLASH2

PARAM TEMP=100 PRES=1

;Acid digestion, uses HNO3 to oxidize C and H2

;H3PO4 does not participate in the reaction stoichiometry

BLOCK ACID-DG1 RSTOIC

DESCRIPTION "Acid digestion"

PARAM TEMP=200 <C> PRES=1

STOIC 1 CISOLID C-S -3 / MIXED HNO3 -4 / CO2 3 / NO &
4 / H2O 2

STOIC 2 MIXED H2 -3 / HNO3 -2 / H2O 4 / NO 2

STOIC 3 MIXED CL2 -0.5 / H2 -0.5 / HCL 1

STOIC 4 MIXED S -1 / H2 -1 / O2 -2 / H2SO4 1

STOIC 5 MIXED CH4 -3 / HNO3 -8 / NO 8 / CO2 3 / &
H2O 10

CONV 1 CISOLID C-S 0.95

CONV 2 MIXED H2 0.95

CONV 3 MIXED CL2 0.95

CONV 4 MIXED S 0.95

CONV 5 MIXED CH4 0.95

;Acid digestion, uses HNO3 to oxidize C and H2

;H3PO4 does not participate in the reaction stoichiometry

BLOCK ACID-DG2 RSTOIC

DESCRIPTION "Acid digestion"

PARAM TEMP=200 <C> PRES=1

STOIC 1 CISOLID C-S -3 / MIXED HNO3 -4 / CO2 3 / NO &
4 / H2O 2

STOIC 2 MIXED H2 -1.5 / HNO3 -1 / H2O 2 / NO 1

STOIC 3 MIXED CL2 -0.5 / H2 -0.5 / HCL 1

STOIC 4 MIXED S -1 / H2 -1 / O2 -2 / H2SO4 1

CONV 1 CISOLID C-S 0.95

CONV 2 MIXED H2 0.95

CONV 3 MIXED CL2 0.95

CONV 4 MIXED S 0.95

;Data obtained from "Description of Recommended Non-Thermal.."pp. 6-43 to 6-45
;Although room temperature operation is listed on p. 6-43, 1000 C is listed
;on page 6-45, and the higher temperature is more believable
;DRE of 0.999 listed for TCE and 0.90-0.95 for PCE -> use 0.95 for all waste
;assume 1 atm pressure

BLOCK GPCR RSTOIC

DESCRIPTION "Gas Phase Corona Reactor, see comments"

PARAM PRES=1 DUTY=20000

STOIC 1 MIXED H2 -2 / O2 -1 / H2O 2

STOIC 2 CISOLID C-S -1 / MIXED O2 -1 / CO2 1

STOIC 3 MIXED H2 -1 / CL2 -1 / HCL 2

STOIC 4 MIXED CO -1 / O2 -0.5 / CO2 1

STOIC 5 MIXED CH4 -1 / O2 -2 / CO2 1 / H2O 2

CONV 1 MIXED H2 0.95

CONV 2 CISOLID C-S 0.95

CONV 3 MIXED CL2 0.95

CONV 4 MIXED CO 0.95

CONV 5 MIXED CH4 0.95

BLOCK HNO2REC2 RSTOIC

PARAM TEMP=423 <K> PRES=35 <PSI>

STOIC 1 MIXED NO -4 / O2 -3 / H2O -2 / HNO3 4

CONV 1 MIXED NO 0.99

BLOCK HNO2RECV RSTOIC

PARAM TEMP=423 <K> PRES=35 <PSI>

STOIC 1 MIXED NO -4 / O2 -3 / H2O -2 / HNO3 4

CONV 1 MIXED NO 0.99

BLOCK NEUTRAL1 RSTOIC

DESCRIPTION "neutralizes excess HCl, NO"

PARAM TEMP=100 PRES=1 SERIES=YES

STOIC 1 MIXED NAOH -1 / HCL -1 / NACL 1 / H2O 1

STOIC 2 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 2

STOIC 3 MIXED CL2 -1 / NAOH -2 / NACL 2 / H2O 1 / &

O2 0.5

STOIC 4 MIXED NO -6 / NH3 -4 / N2 5 / H2O 6

STOIC 5 MIXED HNO3 -1 / NAOH -1 / NANO3 1 / H2O 1

CONV 1 MIXED HCL 0.99

CONV 2 MIXED H2SO4 0.99

CONV 3 MIXED CL2 0.99

CONV 4 MIXED NO 0.99

CONV 5 MIXED HNO3 0.99

BLOCK NEUTRAL2 RSTOIC

DESCRIPTION "neutralizes excess HCl"

PARAM TEMP=100 PRES=1 SERIES=YES

STOIC 1 MIXED NAOH -1 / HCL -1 / NACL 1 / H2O 1

STOIC 2 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 2

STOIC 3 MIXED CL2 -1 / NAOH -2 / NACL 2 / H2O 1 / &

O2 0.5

STOIC 4 MIXED NO -3 / NH3 -2 / N2 2.5 / H2O 3

STOIC 5 MIXED HNO3 -1 / NAOH -1 / NANO3 1 / H2O 1

CONV 1 MIXED HCL 0.99

CONV 2 MIXED H2SO4 0.99

CONV 3 MIXED CL2 0.99
CONV 4 MIXED NO 0.99
CONV 5 MIXED HNO3 0.99

;scrubbing efficiency of 0.99 assumed for now

BLOCK NEUTRAL3 RSTOIC

DESCRIPTION "neutralizes HCl in offgas stream"
PARAM TEMP=100 PRES=1
STOIC 1 MIXED HCL -1 / NAOH -1 / NACL 1 / H2O 1
STOIC 2 MIXED CL2 -1 / NAOH -2 / NACL 2 / H2O 1 / &
O2 0.5
STOIC 3 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 2
STOIC 4 MIXED SO2 -1 / NAOH -2 / O2 -0.5 / NA2SO4 1 &
/ H2O 1
CONV 1 MIXED HCL 0.99
CONV 2 MIXED CL2 0.99
CONV 3 MIXED H2SO4 0.99
CONV 4 MIXED SO2 0.99

BLOCK OH-GEN RSTOIC

PARAM TEMP=100 PRES=1
STOIC 1 MIXED H2O2 -1 / OH-RAD 2
STOIC 2 MIXED O3 -1 / H2O -3 / OH-RAD 6
CONV 1 MIXED H2O2 0.99
CONV 2 MIXED O3 0.99

BLOCK OZ-DECOM RSTOIC

DESCRIPTION "ozone decomposer"
PARAM TEMP=100 PRES=1
STOIC 1 MIXED O3 -2 / O2 3
STOIC 2 MIXED HCL -1 / NAOH -1 / NACL 1 / H2O 1
STOIC 3 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 2
STOIC 4 MIXED CL2 -1 / NAOH -2 / NACL 2 / H2O 1 / &
O2 0.5
STOIC 5 MIXED SO2 -1 / NAOH -2 / O2 -0.5 / NA2SO4 1 &
/ H2O 1
STOIC 6 MIXED HNO3 -1 / NAOH -1 / NANO3 1 / H2O 1
CONV 1 MIXED O3 0.999
CONV 2 MIXED HCL 0.99
CONV 3 MIXED H2SO4 0.99
CONV 4 MIXED CL2 0.99
CONV 5 MIXED SO2 0.99
CONV 6 MIXED HNO3 0.99

;assumed temperature and pressure

BLOCK OZ-GEN RSTOIC

DESCRIPTION "generates ozone from air"
PARAM TEMP=100 PRES=1
STOIC 1 MIXED O2 -3 / O3 2
CONV 1 MIXED O2 0.999

;Destruction efficiency of 96% assumed (p. 2-78 of "Description of Recommended
;Non-Thermal Mixed Waste Treatment Technologies Version 1.0," Emile A. Bernard
;temperature and pressure assumed by BWBrown

BLOCK PHOTO-UV RSTOIC

DESCRIPTION "Photolytic oxidation of waste, see comments"
PARAM TEMP=100 PRES=1 SERIES=YES
STOIC 1 CISOLID C-S -1 / MIXED OH-RAD -4 / CO2 1 / &
H2O 2
STOIC 2 MIXED H2 -1 / OH-RAD -2 / H2O 2
STOIC 3 MIXED H2 -1 / CL2 -1 / HCL 2
CONV 1 CISOLID C-S 0.96
CONV 2 MIXED H2 0.96
CONV 3 MIXED CL2 0.96

BLOCK VACTRAX1 RGIBBS

PARAM TEMP=550 PRES=1 <PSI>
PROD H2O / H2 / O2 / N2 / S / CL2 / NO / SiO2-S &
S / AL2O3-S S / AS / FE / HG / AG / HCL / &
H2SO4 / CH4 / NH3 / C-S S / BA M / CD M / CR &
M / PB M / SE M
PROD-FRAC O2 1

;10% excess OH radicals

DESIGN-SPEC AIR1

DEFINE OHROUT MOLE-FLOW STREAM=PRODUCTS SUBSTREAM=MIXED &
COMPONENT=OH-RAD
DEFINE OHRIN MOLE-FLOW STREAM=OH-RAD SUBSTREAM=MIXED &
COMPONENT=OH-RAD
SPEC "OHROUT*(1+100/10)" TO "OHRIN"
TOL-SPEC "0.101"
VARY STREAM-VAR STREAM=AIR1 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.01 " "5"

DESIGN-SPEC AIR4

DEFINE OXOUT MASS-FLOW STREAM=GPCR-OUT SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE OX1 MASS-FLOW STREAM=AIR4 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE OX2 MASS-FLOW STREAM=FILTERED SUBSTREAM=MIXED &
COMPONENT=O2
SPEC "OX1+OX2" TO "OXOUT*(1+100/100)"
TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=AIR4 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.00001" "100"

;Perry's Handbook p. 20-33 has moisture contents about 0.5% from dryers
;review meeting of 2/8/96 : moisture content to 5%

DESIGN-SPEC DRYER

DEFINE H2OMAS MASS-FLOW STREAM=PLYSTBIN SUBSTREAM=MIXED &
COMPONENT=H2O
DEFINE MIXMAS STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
DEFINE SOLMAS STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW
SPEC "H2OMAS" TO "(MIXMAS+SOLMAS)*0.05"
TOL-SPEC "0.001"

```
VARY BLOCK-VAR BLOCK=WATERSEP SENTENCE=FRAC VARIABLE=FRACS &
ID1=MIXED ID2=PLYSTBIN ELEMENT=12
LIMITS "0" "1"
```

```
;power input is calculated to be 56.49 W / SCFM according to information
; supplied by Ben Tehranian, MK Environmental Services
;
;lbmol/hr converted to SCFM by multiplying by 359/60
;
;1 W = 3.413 Btu/hr
```

DESIGN-SPEC GPCRPOWER

```
DEFINE MOLOUT STREAM-VAR STREAM=GPCR-OUT SUBSTREAM=MIXED &
VARIABLE=MOLE-FLOW
DEFINE POWER BLOCK-VAR BLOCK=GPCR VARIABLE=DUTY &
SENTENCE=PARAM
SPEC "POWER" TO "MOLOUT*359/60*56.49*3.413"
TOL-SPEC "0.01"
VARY BLOCK-VAR BLOCK=GPCR VARIABLE=DUTY SENTENCE=PARAM
LIMITS "0" "10000000"
```

```
;conversation with Daryoush Bahar 3/6/96 - dry basis used for grout calculation
;because with System 3, too much water exists, which results in too much grout
;being calculated
```

DESIGN-SPEC GROUT

```
DEFINE R1 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
DEFINE R2 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW
DEFINE R3 MASS-FLOW STREAM=GROUTRIN SUBSTREAM=MIXED &
COMPONENT=H2O
DEFINE GROUT STREAM-VAR STREAM=GROUTDRY SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW
F EXCES =R3-0.6*(R1+R2-R3)
F IF(EXCES.LT.0.) EXCES = 0.
SPEC "GROUT" TO "1.4*(R1+R2-R3)+2.333*EXCES"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=GROUTDRY SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW
LIMITS "0.1" "6000"
```

DESIGN-SPEC GROUTH2O

```
DEFINE R1 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
DEFINE R2 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW
DEFINE R3 MASS-FLOW STREAM=GROUTRIN SUBSTREAM=MIXED &
COMPONENT=H2O
DEFINE H2OFLO STREAM-VAR STREAM=GROUTH2O SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
F EXCES = R3 - 0.6 * (R1+R2-R3)
F IF(EXCES.GT.0.) EXCES = 0.0
C SETS EXCESS WATER TO 0 IF WATER IS ACTUALLY EXCESS
C WATER REQUIRED, IF ANY, IS RETURNED AS A NEGATIVE NUMBER
SPEC "H2OFLO" TO "-EXCES"
TOL-SPEC "0.01"
```

VARY STREAM-VAR STREAM=GROUTH2O SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0" "2000"

DESIGN-SPEC HNO3-IN1

DEFINE ACIDIN MASS-FLOW STREAM=HNO3-IN1 SUBSTREAM=MIXED &
COMPONENT=HNO3
DEFINE ACDOUT MASS-FLOW STREAM=DG-OUT-1 SUBSTREAM=MIXED &
COMPONENT=HNO3
DEFINE ACIDRE MASS-FLOW STREAM=HNO3RECY SUBSTREAM=MIXED &
COMPONENT=HNO3
SPEC "ACIDIN+ACIDRE" TO "ACDOUT*(1+100/5)"
TOL-SPEC "0.5"
VARY STREAM-VAR STREAM=HNO3-IN1 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "30 " "32"

DESIGN-SPEC HNO3-IN2

DEFINE ACIDIN MASS-FLOW STREAM=HNO3-IN2 SUBSTREAM=MIXED &
COMPONENT=HNO3
DEFINE ACDOUT MASS-FLOW STREAM=DG-OUT-2 SUBSTREAM=MIXED &
COMPONENT=HNO3
DEFINE ACIDRE MASS-FLOW STREAM=HNO3REC2 SUBSTREAM=MIXED &
COMPONENT=HNO3
SPEC "ACIDIN+ACIDRE" TO "ACDOUT*(1+100/5)"
TOL-SPEC "10"
VARY STREAM-VAR STREAM=HNO3-IN2 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "42.76" "42.904"

DESIGN-SPEC NAOH-1

DEFINE NAOHIN MOLE-FLOW STREAM=NAOH-1 SUBSTREAM=MIXED &
COMPONENT=NAOH
DEFINE NAHOUT MOLE-FLOW STREAM=DG-SCRB1 SUBSTREAM=MIXED &
COMPONENT=NAOH
SPEC "NAOHIN" TO "NAHOUT*(1+100/1)"
TOL-SPEC "0.001"
VARY STREAM-VAR STREAM=NAOH-1 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "115" "200"

DESIGN-SPEC NAOH-2

DEFINE NAOHIN MOLE-FLOW STREAM=NAOH-2 SUBSTREAM=MIXED &
COMPONENT=NAOH
DEFINE NAHOUT MOLE-FLOW STREAM=DG-SCRB2 SUBSTREAM=MIXED &
COMPONENT=NAOH
SPEC "NAOHIN" TO "NAHOUT*(1+100/1)"
TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=NAOH-2 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "75 " "85"

DESIGN-SPEC NAOH-3

DEFINE NAOHIN MOLE-FLOW STREAM=NAOH-3 SUBSTREAM=MIXED &
COMPONENT=NAOH
DEFINE NAOHOT MOLE-FLOW STREAM=SPLITIN SUBSTREAM=MIXED &
COMPONENT=NAOH

SPEC "NAOHIN" TO "NAOHOT*(1+100/1)"
TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=NAOH-3 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.01" "1000"

DESIGN-SPEC NH3-IN-1

DEFINE NH3IN MASS-FLOW STREAM=NH3-IN-1 SUBSTREAM=MIXED &
COMPONENT=NH3
DEFINE NH3OUT MASS-FLOW STREAM=DG-SCRB1 SUBSTREAM=MIXED &
COMPONENT=NH3
SPEC "NH3IN" TO "NH3OUT*(1+100/5)"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=NH3-IN-1 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "2.8" "3.5"

DESIGN-SPEC NH3-IN-2

DEFINE NH3IN MASS-FLOW STREAM=NH3-IN-2 SUBSTREAM=MIXED &
COMPONENT=NH3
DEFINE NH3OUT MASS-FLOW STREAM=DG-SCRB2 SUBSTREAM=MIXED &
COMPONENT=NH3
SPEC "NH3IN" TO "NH3OUT*(1+100/5)"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=NH3-IN-2 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "0.01" "400"

;1% excess O2 in the outlet stream

DESIGN-SPEC OXYGEN1

DEFINE O2OUT MASS-FLOW STREAM=HNO2HNO3 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE O2IN MASS-FLOW STREAM=OXYGEN1 SUBSTREAM=MIXED &
COMPONENT=O2
SPEC "O2OUT*(1+100/1)" TO "O2IN"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=OXYGEN1 SUBSTREAM=MIXED &
VARIABLE=MOLE-FLOW
LIMITS "17" "50"

;0% excess O2 in the outlet stream

; sets O2 out to be equal to O2 in the soft debris, because this O2 is not
; available for reaction back to HNO3, O2 then routed with the solids

DESIGN-SPEC OXYGEN2

DEFINE O2OUT MASS-FLOW STREAM=HNO2HN32 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE O2IN MASS-FLOW STREAM=OXYGEN2 SUBSTREAM=MIXED &
COMPONENT=O2
DEFINE O2SOFT MASS-FLOW STREAM=DG-OUT-2 SUBSTREAM=MIXED &
COMPONENT=O2
SPEC "O2OUT" TO "O2SOFT"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=OXYGEN2 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW
LIMITS "690" "810"

DESIGN-SPEC PHOSFATE

```

DEFINE WASTIN STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
DEFINE SOLDIN STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
DEFINE POLYIN STREAM-VAR STREAM=POLYETHL SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
SPEC "POLYIN" TO "WASTIN+SOLDIN"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=POLYETHL SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
LIMITS "0.1" "5000"

```

DESIGN-SPEC POLYMER

```

DEFINE WASTIN STREAM-VAR STREAM=3000POLY SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
DEFINE SOLDIN STREAM-VAR STREAM=3000POLY SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
DEFINE POLYIN STREAM-VAR STREAM=XYX-PE SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
SPEC "POLYIN" TO "(WASTIN+SOLDIN)"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=XYX-PE SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
LIMITS "0.1" "50"

```

DESIGN-SPEC SALTSOLN

```

DEFINE SALTFL MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
  COMPONENT=NACL
DEFINE H2OFLO MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
  COMPONENT=H2O
SPEC "H2OFLO/SALTFL" TO "0.3"
TOL-SPEC "0.1"
VARY BLOCK-VAR BLOCK=BLOWDOWN SENTENCE=FRAC VARIABLE=FRACS &
  ID1=MIXED ID2=FLASH-IN ELEMENT=12
LIMITS "0.001" "1"

```

DESIGN-SPEC XX-NAOH

```

DEFINE NAOHIN MASS-FLOW STREAM=PRODUCTS SUBSTREAM=MIXED &
  COMPONENT=NAOH
DEFINE NAOHOT MASS-FLOW STREAM=AQ-OUT SUBSTREAM=MIXED &
  COMPONENT=NAOH
SPEC "NAOHIN" TO "NAOHOT*(1+100/1)"
TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=XX-NAOH SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
LIMITS "15" "25"

```

FORTAN ADDITIVE

```

DEFINE HGOUT MASS-FLOW STREAM=HG-OUT SUBSTREAM=MIXED &
  COMPONENT=HG
DEFINE COPPIN MASS-FLOW STREAM=ADDITIVE SUBSTREAM=MIXED &
  COMPONENT=CU
F  COPPIN = 0.7 * HGOUT
READ-VARS HGOUT
WRITE-VARS COPPIN

```

FORTTRAN H2O2-IN2

DEFINE O3IN MOLE-FLOW STREAM=PHOTO-IN SUBSTREAM=MIXED &
COMPONENT=O3

DEFINE H2O2IN STREAM-VAR STREAM=H2O2-IN2 SUBSTREAM=MIXED &
VARIABLE=MOLE-FLOW

F H2O2IN = O3IN

READ-VARS O3IN

WRITE-VARS H2O2IN

;constant is obtained by taking 1200 ft³/1200 lb and mult. by 0.0727 lb/ft³

FORTTRAN N2SWEEP

DEFINE N2SWP1 STREAM-VAR STREAM=N2SWEEP1 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW

DEFINE MS3000 STREAM-VAR STREAM=3000 SUBSTREAM=CISOLID &
VARIABLE=MASS-FLOW

DEFINE MM3000 STREAM-VAR STREAM=3000 SUBSTREAM=MIXED &
VARIABLE=MASS-FLOW

F N2SWP1 = 0.0793 * (MS3000+MM3000)

READ-VARS MS3000 MM3000

WRITE-VARS N2SWP1

CONV-OPTIONS

PARAM TEAR-METHOD=BROYDEN TOL=0.00001 SPEC-METHOD=SECANT &
SPEC-LOOP=INSIDE

SECANT STEP-SIZE=0.10 MAX-STEP-SIZ=0.5

BROYDEN MAXIT=100

STREAM-REPOR MOLEFLOW MASSFLOW

;
;
;
;
;
;
;
;
;
;

System 5

;Input Summary created by ASPEN PLUS Rel. 9.2-1 at 10:49:56 Thu Dec 19, 1996
;Directory C:\ASPENRUN Filename C:\ASPENRUN\nnewsys5p.inp
;

TITLE This is System 5 for INTS

IN-UNITS ENG PRESSURE=ATM

DEF-STREAMS MIXCISLD ALL

DATABANKS COMBUST / INORGANIC / PURECOMP / SOLIDS / &
AQUEOUS / ASPENPCD / PURE856

PROP-SOURCES COMBUST / INORGANIC / PURECOMP / SOLIDS / &
AQUEOUS / ASPENPCD / PURE856

;Cement approximated by $\text{CaAl}_2\text{SiO}_6$ ($\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{SiO}_2$), Shreve & Brink p. 162

COMPONENTS

C C C /
C-S C C-S /
H2 H2 H2 /
O2 O2 O2 /
N2 N2 N2 /
S S S /
CL2 CL2 CL2 /
F2 F2 F2 /
NO NO NO /
SO2 SO SO2 /
H2O H2O H2O /
SiO2 SiO2 SiO2 /
SiO2-S SiO2 SiO2-S /
AL2O3 AL2O3 AL2O3 /
AL2O3-S AL2O3 AL2O3-S /
FE FE FE /
AS AS AS /
BA BA BA /
BE BE BE /
CD CD CD /
CR CR CR /
PB PB PB /
HG HG HG /
SE SE SE /
AG AG AG /
TA TA TA /
U U U /
NAOH NAOH NAOH /
NACL NACL NACL /
CO2 CO2 CO2 /
CO CO CO /
O3 O3 O3 /
H2O2 H2O2 H2O2 /

HCL HCL HCL /
FECL3 FECL3 FECL3 /
H2SO4 H2SO4 H2SO4 /
NA2SO4 NA2SO4 NA2SO4 /
CH4 CH4 CH4 /
POLYMER C2H4 POLYMER /
CEMENT CAAL2SIO6 CEMENT /
CASO4 CASO4 CASO4 /
CU CU CU /
"FE(OH)3" "FE(OH)3" "FE(OH)3" /
OH-RAD OH OH-RAD

FLWSHEET APC-SYS

BLOCK GPCR IN=FILTERED AIR4 OUT=GPCR-OUT
BLOCK FILTER IN=AQ-OF GAS EQUIL1 VACGAS-1 SOILVAPR EQUIL2 &
OUT=FILTERED METALS
BLOCK NEUTRAL3 IN=NAOH-3 GPCR-OUT OUT=SPLITIN
BLOCK BLOWDOWN IN=SPLITIN OUT=FLASH-IN SALT SOLN
BLOCK FLASH2 IN=FLASH-IN OUT=HEATERIN MOISTURE
BLOCK HETRHEPA IN=HEATERIN OUT=OFFGAS

FLWSHEET AQUEOUS

BLOCK AQ-SPLIT IN=AQ-OUT OUT=AQ-SLUDG AQ-OF GAS AQ-RECYC
BLOCK OZ-GEN IN=AIR1 OUT=OZONE
BLOCK CONCENT8 IN=SALT SOLN OUT=AQ-RECY2 CONCENT8
BLOCK PHOTOMIX IN=VACLIQ-1 METLRECY 1000 SPENTH2O H2ORECYC &
OZONE MOISTURE H2O2-IN2 SPLT-H2O SPLTH2O2 HPWATOUT &
EXCESH2O XX-NAOH AQ-RECY2 OUT=X-PHOTIN
BLOCK OH-GEN IN=PHOTO-IN OUT=OH-RAD
BLOCK PHOTO-UV IN=OH-RAD OUT=PRODUCTS
BLOCK OZ-DECOM IN=PRODUCTS OUT=AQ-OUT
BLOCK OILSEP IN=X-PHOTIN OUT=PHOTO-IN X-ORGS

FLWSHEET BULKSOIL

BLOCK SOILWASH IN=4000 WASH-IN OUT=SPENTH2O SOILVAPR &
SOIL-ORG TRET SOIL
BLOCK H2OSEP IN=WARM SOIL OUT=EXCESH2O DRY SOIL
BLOCK SOLDRYER IN=TRET SOIL OUT=WARM SOIL

FLWSHEET GROUT

BLOCK GROUTER IN=GROUT DRY GROUTRIN GROUTH2O OUT=GROUT OUT
BLOCK GROUTMIX IN=5000 COMP WASHDEBR PBGLOVES CWOSLD2 &
DRY SOIL OUT=GROUTRIN

FLWSHEET HG-AMAL

BLOCK HG-AMALG IN=7000-HG ADDITIVE VAC-HG-1 OUT=HG-OUT

FLWSHEET METLDCON

BLOCK MET-DCON IN=METLWASH 5000METL OUT=METALOUT METLRECY

FLWSHEET ORGDEST

BLOCK EQUIL-1 IN=CWO-GAS OUT=EQUIL1
BLOCK CWO-1 IN=ACID-IN 20003000 OXYGEN1 VACORG-1 SOIL-ORG &
X-ORGS OUT=CWO-OUT
BLOCK CWOSPLT IN=CWO-OUT SCRBSALT OUT=CWO-LIQ CWO-SLD &
CWO-GAS
BLOCK NEUTRAL1 IN=NAOH-1 CWO-LIQ OUT=SCRBOUT1
BLOCK SALTFLTR IN=SCRBOUT1 OUT=SPLT-H2O SCRBSALT

FLWSHEET PB-RECVR

BLOCK PB-DECON IN=PBBRICKS PB-WATER OUT=LEAD-OUT PBSLUDGE
BLOCK PB-SPLIT IN=7000-PB OUT=PBBRICKS PBGLOVES

FLWSHEET POLYMER

BLOCK POLYSTAB IN=PLYSTBIN POLYETHL OUT=POLY-OUT
BLOCK POLY-MIX IN=3000POLY CWO-SLD AQ-SLUDG CONCENT8 &
METALS VACSOL-1 OUT=MIXED-IN
BLOCK DRYER IN=MIXED-IN OUT=HOT-MIX
BLOCK WATERSEP IN=HOT-MIX OUT=H2ORECYC PLYSTBIN

FLWSHEET RES-SLUD

BLOCK VACTRAX1 IN=3000 PBSLUDGE N2SWEEP1 OUT=VACOUT-1
BLOCK EQUIL-2 IN=CWOGAS2 OUT=EQUIL2
BLOCK NEUTRAL2 IN=NAOH-2 CWOLIQ2 OUT=SCRBOUT2
BLOCK CWO-2 IN=ACID-IN2 OXYGEN2 5000SOFT OUT=CWO-OUT2
BLOCK CWOSPL2 IN=CWO-OUT2 SCRBSLT2 OUT=CWOLIQ2 CWOSLD2 &
CWOGAS2
BLOCK HP-WASH IN=H2OWASH 5000OPEN OUT=WASHDEBR HPWATOUT
BLOCK VACSEP-1 IN=VACOUT-1 XYLEACH1 OUT=VACGAS-1 VACORG-1 &
VACSOL-1 VAC-HG-1 VACLIQ-1
BLOCK SALTFILT2 IN=SCRBOUT2 OUT=SPLTH2O2 SCRBSLT2

FLWSHEET SPECIAL

BLOCK SPESHULL IN=6000 OUT=SPEC-OUT

PROPERTIES SOLIDS

PROPERTIES IDEAL

USER-PROPS DRUSR2 1 2 3

PROP-DATA U-1

IN-UNITS ENG PRESSURE=ATM
PROP-LIST TC
PVAL "FE(OH)3" 100

PROP-DATA U-2

IN-UNITS ENG PRESSURE=ATM
PROP-LIST PLXANT
PVAL "FE(OH)3" 7.511 -1406 221 0 0 0 0 1000

PROP-DATA U-2

IN-UNITS ENG PRESSURE=ATM
PROP-LIST DHVLWT
PVAL "FE(OH)3" 1 1 0.38 0 0

;Tables dated 04/24/96 from Daryoush Bahar, MK, (415) 442-7688

;Glass inerts assumed to be 50% SiO2 and 50% Al2O3 for all waste streams.

STREAM 1000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=60.8
MASS-FLOW H2 3613 <KG/HR> / O2 172053 <KG/HR> / N2 &
50211 <KG/HR> / H2O 2456410 <KG/HR> / AS 5647 <KG/HR> &
/ BA 2823 <KG/HR> / CD 42352 <KG/HR> / CR &
56469 <KG/HR> / PB 14117 <KG/HR> / HG 14117 <KG/HR> / &
SE 2823 <KG/HR> / AG 2823 <KG/HR>

;Tables dated 04/24/96 from MK

STREAM 3000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=352.12
MASS-FLOW H2 268596 <KG/HR> / O2 10180 <KG/HR> / N2 &
122 <KG/HR> / S 6233 <KG/HR> / CL2 383185 <KG/HR> / &
H2O 18588527 <KG/HR> / FE 107084 <KG/HR> / AS &
3383 <KG/HR> / BA 12700 <KG/HR> / CD 158485 <KG/HR> / &
CR 299848 <KG/HR> / PB 9640 <KG/HR> / HG 8445 <KG/HR> &
/ SE 1689 <KG/HR> / AG 1693 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=655.08
MASS-FLOW C-S 1658863 <KG/HR> / SIO2-S 17644467 <KG/HR> / &
AL2O3-S 17644467 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 3000POLY

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=3.28
MASS-FLOW CL2 98888 <KG/HR> / NO 37279 <KG/HR> / SO2 &
47075 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=3.32
MASS-FLOW SIO2-S 92796 / AL2O3-S 92796

;tables dated 04/24/96 from MK

STREAM 4000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=40.74
MASS-FLOW H2 21653 <KG/HR> / CL2 761580 <KG/HR> / H2O &
1514279 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=287.76
MASS-FLOW C-S 175090 <KG/HR> / SIO2-S 8027287.5 <KG/HR> / &
AL2O3-S 8027287.5 <KG/HR>

;Data table dated 04/24/96. Supplied by Daryoush Bahar, MK (415) 442-7688

STREAM 5000COMP

SUBSTREAM MIXED TEMP=68 PRES=1
MASS-FLOW H2 3.026 / H2O 0.197 / FE 148.890 / HG 1.3
SUBSTREAM CISOLID TEMP=68 PRES=1
MASS-FLOW C-S 17.992 / SIO2-S 3.003 / AL2O3-S 3.003

;tables dated 04/24/96 from MK

STREAM 5000METL

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=434.82
MASS-FLOW H2 141789 / FE 13383118
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=27.29
MASS-FLOW C-S 844686 / SIO2-S 1981 / AL2O3-S 1981

;tables dated 04/24/96 from MK

STREAM 5000OPEN

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.40
MASS-FLOW H2 4587 <KG/HR> / O2 18201 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=80
MASS-FLOW C-S 22543 <KG/HR> / SIO2-S 2243854 <KG/HR> / &
AL2O3-S 2243854 <KG/HR>

;tables dated 04/30/96, used mass flow lb/hr rather than kg in waste inventory

STREAM 5000SOFT

SUBSTREAM MIXED TEMP=68 PRES=1
MASS-FLOW H2 33.213 / O2 103.327 / N2 0.252 / S 0.903 &
/ CL2 19.233 / F2 0.126 / H2O 12.458 / FE 3.204 / &
HG 1.2
SUBSTREAM CISOLID TEMP=68 PRES=1
MASS-FLOW C-S 217.042 / SIO2-S 21.901 / AL2O3-S 21.901

;tables dated 04/24/96 from MK

STREAM 6000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=125.46
MASS-FLOW H2 13980 <KG/HR> / O2 1775708 <KG/HR> / N2 &
546 <KG/HR> / S 1469 <KG/HR> / H2O 195474 <KG/HR> / &
FE 913 <KG/HR> / AS 64 <KG/HR> / BA 50656 <KG/HR> / &
BE 763726 <KG/HR> / CD 11416 <KG/HR> / CR 652 <KG/HR> &
/ PB 104216 <KG/HR> / HG 160 <KG/HR> / SE 32 <KG/HR> &
/ AG 32 <KG/HR> / TA 23100 <KG/HR> / U &
2415249 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=29.44
MASS-FLOW C-S 131953 <KG/HR> / SIO2-S 561390.5 <KG/HR> / &
AL2O3-S 561390.5 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 7000-HG

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=2.5
MASS-FLOW HG 1167608 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 7000-PB

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=25.986
MASS-FLOW H2 228 <KG/HR> / S 41 <KG/HR> / PB &
10645151 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=.00393 <KG/HR>
MASS-FLOW C-S 1811 <KG/HR>

;tables dated 04/24/96 from MK

STREAM 20003000

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=78.28
MASS-FLOW H2 922853 <KG/HR> / O2 59994 <KG/HR> / S &
10234 <KG/HR> / CL2 1654619 <KG/HR> / H2O &
1229766 <KG/HR> / FE 325702 <KG/HR> / BA 32570 <KG/HR> &
/ CD 32570 <KG/HR> / CR 65140 <KG/HR>
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=107.12 &
FLASH-OPTION=NOFLASH
MASS-FLOW C-S 5723044 <KG/HR> / SIO2-S 103248 <KG/HR> / &
AL2O3-S 103248 <KG/HR>

;According to Daryoush Bahar, MK (415) 442-7688, 7 lb solution/200 lb waste

STREAM ACID-IN

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=7
MASS-FRAC H2O 36 / HCL 4 / FECL3 60

STREAM ACID-IN2

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=15.21
MASS-FRAC H2O 36 / HCL 4 / FECL3 60

STREAM ADDITIVE

SUBSTREAM MIXED TEMP=68 PRES=1
MOLE-FLOW CU 0.0291885

STREAM AIR1

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=90.19
MOLE-FRAC O2 0.21 / N2 0.79

STREAM AIR4

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.0001
MOLE-FRAC O2 0.21 / N2 0.79

STREAM GROUTDRY

SUBSTREAM MIXED TEMP=68 PRES=1
SUBSTREAM CISOLID TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC CEMENT 1

STREAM GROUTH2O

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=0.000001
MASS-FRAC H2O 1

STREAM H2O2-IN2

SUBSTREAM MIXED TEMP=68 PRES=1 MOLE-FLOW=1
MASS-FRAC H2O2 1

;flow rate set to 5% of open debris, all H2O goes to grout

STREAM H2OWASH

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=12
MASS-FRAC H2O 1

STREAM HG-OUT

SUBSTREAM MIXED TEMP=68 PRES=1
MOLE-FLOW CU 0.0291885

;Water set to 112/468 times the bulk metal flow rate, from Figure 3-22
; (page 3-46) in ITTS Phase 2 Final Report

STREAM METLWASH

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=94.327
MASS-FRAC H2O 1

;3/26/96 Daryoush Bahar uses 1200 SCFH N2 for 1100 lb/h debris

STREAM N2SWEEP1

SUBSTREAM MIXED TEMP=68 PRES=1 VOLUME-FLOW=1200
MOLE-FRAC N2 1

;According to Delphi flowsheet D-1002A, 50% NaOH solution

STREAM NAOH-1

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=109
MASS-FRAC H2O 0.5 / NAOH 0.5

;According to Delphi flowsheet D-1002A, 50% NaOH solution

STREAM NAOH-2

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM NAOH-3

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM OXYGEN1

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MOLE-FLOW O2 1

STREAM OXYGEN2

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MOLE-FLOW O2 1

STREAM PB-WATER

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=13
MASS-FRAC H2O 1

;Polymer assumed to be polyethylene; C2H4 used as the monomer.

STREAM POLYETHL

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC POLYMER 1

STREAM PRODUCTS

SUBSTREAM MIXED TEMP=100 PRES=1
MASS-FLOW H2 .688 / O2 4.908 / N2 108.8 / NO 2.738 / &
H2O 851.703 / AS 0.16 / BA 0.08 / CD 1.2 / CR &
1.6 / PB 0.4 / HG 0.43 / SE 0.08 / AG 0.08 / &
NAOH 0.187 / NACL 20.7 / O3 32.576 / HCL 0.13 / &
FECL3 0.6

STREAM WASH-IN

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=328.5
MASS-FRAC H2O 1

STREAM XX-NAOH

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=1
MASS-FRAC H2O 0.5 / NAOH 0.5

STREAM XYLEACH1

SUBSTREAM MIXED TEMP=68 PRES=1 MASS-FLOW=306
MASS-FRAC H2O 1

BLOCK GROUTER MIXER

PARAM PRES=1 MAXIT=500 TOL=0.0001

BLOCK GROUTMIX MIXER

PARAM NPHASE=2 MAXIT=99 TOL=0.0001

BLOCK HG-AMALG MIXER

BLOCK PHOTOMIX MIXER

BLOCK POLY-MIX MIXER

PARAM PRES=1 MAXIT=100

BLOCK POLYSTAB MIXER

DESCRIPTION "for the moment, this is only a mixer"

BLOCK-OPTION ENERGY-BAL=YES

BLOCK SPESHULL MIXER

BLOCK AQ-SPLIT SEP

DESCRIPTION "this separates water, gases, and solids"

FRAC STREAM=AQ-SLUDG SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 &
"FE(OH)3" FRACS=1 1 0 0 0 1 1 1 0 0 0 0 0.99 0.99 &
0.99 0.99 1 1 1 1 1 1 1 1 1 1 0 0 0 0 1 0 &
1 0 1 1 1 1

FRAC STREAM=AQ-SLUDG SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.99 0.99 0.99 1

FRAC STREAM=AQ-OFGAS SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 &
FRACS=0 0 1 1 1 0 0 0 1 0 0 0 0 0 0 0 0 0 &
0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 1 0 0 0

FRAC STREAM=AQ-OFGAS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

BLOCK BLOWDOWN SEP

FRAC STREAM=FLASH-IN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 &
FRACS=1 1 1 1 1 1 1 1 1 1 0.9 1 1 1 1 1 1 1 &
1 1 1 1 1 1 0 0 1 1 1 1 1 1 0 1 0 0 1

FRAC STREAM=FLASH-IN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

;Hg retention in solid set to 0.95 to allow 5% removal to aqueous phase

BLOCK CWOSPL2 SEP

DESCRIPTION "for the moment, assumes complete separation"

FRAC STREAM=CWOLIQ2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 CU FRACS= &
0 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 0 0 0 &
0.05 0 0 1 1 0 0 0 1 1 1 1 0 0 0 1 0

FRAC STREAM=CWOLIQ2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0 0 0 0

FRAC STREAM=CWOSLD2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 CU &
"FE(OH)3" FRACS=1 1 0 1 0 1 0 0 0 0 1 1 1 1 1 &
1 1 1 1 1 0.95 1 1 0 0 0 0 0 0 0 0 0 0 0 0 &
0 0 1

FRAC STREAM=CWOSLD2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1 1 1 1

BLOCK CWOSPLT SEP

DESCRIPTION "for the moment, assumes complete separation"

FRAC STREAM=CWO-LIQ SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2-S AL2O3-S FE AS BA CD CR &
PB HG SE AG NAOH NACL CO2 HCL FECL3 H2SO4 FRACS=0 &
0000000010000000000000 &
10111

FRAC STREAM=CWO-LIQ SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0000

FRAC STREAM=CWO-SLD SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 HCL FECL3 &
"FE(OH)3" FRACS=110001000011111 &
11111111000001

FRAC STREAM=CWO-SLD SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S FRACS=111

BLOCK FILTER SEP

PARAM PRES=1

FRAC STREAM=METALS SUBSTREAM=MIXED COMPS=C C-S H2 O2 N2 &
S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S FE &
AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 FRACS=0 &
00000000001111111111 &
111100001010111

FRAC STREAM=METALS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=1111

;this separates the moisture dried from the soil after soil washing

BLOCK H2OSEP SEP

DESCRIPTION "separates remaining H2O from washed soil"

FRAC STREAM=EXCESH2O SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
H2O2 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 &
CU OH-RAD FRACS=0000000001000 &
00000000000000000000 &
00000

FRAC STREAM=EXCESH2O SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0000

;wash water flow rate set to 15% of waste input, 10% to recycle, 5% to solids

BLOCK HP-WASH SEP

DESCRIPTION "estimated separation"

FRAC STREAM=WASHDEBR SUBSTREAM=MIXED COMPS=H2 O2 CL2 FE &
FRACS=0.02 0.02 0.02 1

MASS-FLOW STREAM=WASHDEBR SUBSTREAM=MIXED COMPS=H2O FLOWS= &
4

FRAC STREAM=WASHDEBR SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S FRACS=0.02 0.99 0.99

BLOCK MET-DCON SEP

DESCRIPTION "Separates water from metal"

FRAC STREAM=METLRECY SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO HCL FECL3 &

H2SO4 NA2SO4 CH4 POLYMER CEMENT FRACS=001000 &
 0001000000000000000000 &
 0000000
 FRAC STREAM=METLRECY SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=1110

BLOCK OILSEP SEP

DESCRIPTION "assumes 99% separation of organics (C,H,CHx)"
 FRAC STREAM=PHOTO-IN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
 FE AS BA BE CD CR PB HG SE AG TA U NAOH NACL &
 CO2 CO O3 H2O2 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER &
 CEMENT CASO4 CU "FE(OH)3" OH-RAD FRACS=0.01 0.01 0.01 &
 1111111111111111111111 &
 11111111111110.01 0.01 1111 &
 1
 FRAC STREAM=PHOTO-IN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0.01 111

BLOCK PB-DECON SEP

FRAC STREAM=LEAD-OUT SUBSTREAM=MIXED COMPS=PB FRACS=1
 FRAC STREAM=LEAD-OUT SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0000

BLOCK PB-SPLIT SEP

FRAC STREAM=PBBRICKS SUBSTREAM=MIXED COMPS=H2 S FRACS= &
 0.81 0.81
 MASS-FLOW STREAM=PBBRICKS SUBSTREAM=MIXED COMPS=PB FLOWS= &
 21
 FRAC STREAM=PBBRICKS SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S FRACS=0.81 0.81 0.81

BLOCK SALTFLT2 SEP

FRAC STREAM=SPLTH2O2 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
 FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
 H2O2 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 &
 CU "FE(OH)3" OH-RAD FRACS=111111111111 &
 1111111111111111111111 &
 111111101
 FRAC STREAM=SPLTH2O2 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=1111

BLOCK SALTFLTR SEP

FRAC STREAM=SPLT-H2O SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
 FE AS BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 &
 H2O2 HCL FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 &
 CU "FE(OH)3" OH-RAD FRACS=111111111111 &
 1111111111111111111111 &
 111111101
 FRAC STREAM=SPLT-H2O SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=1111

BLOCK SOILWASH SEP

FRAC STREAM=SPENTH2O SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO SO2 H2O SIO2 SIO2-S AL2O3 AL2O3-S &
 FE AS BA BE CD CR PB HG SE AG TA U NAOH NACL &

:assumes 50% desorption of C, H2

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FRAC STREAM=VACGAS-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 CU FRACS= &
000010001000000000000 &
00001010000000000
FRAC STREAM=VACGAS-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0000
FRAC STREAM=VACORG-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 CU FRACS= &
000.50000.50.500000000000 &
000000010000011000
FRAC STREAM=VACORG-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.5000
FRAC STREAM=VACSOL-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO SIO2 SIO2-S AL2O3 AL2O3-S FE AS BA &
CD CR PB SE AG NAOH NACL CO2 CO O3 HCL FECL3 &
H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 CU FRACS=0.0 &
0.51010001111111111111 &
1000010100111
MASS-FLOW STREAM=VACSOL-1 SUBSTREAM=MIXED COMPS=H2O FLOWS= &
306
FRAC STREAM=VACSOL-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
AL2O3-S CEMENT FRACS=0.5111
FRAC STREAM=VAC-HG-1 SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 CU FRACS= &
00000000.50.500000000000 &

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010000000000000000
 FRAC STREAM=VAC-HG-1 SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=0 0 0 0

;Perry's Handbook p. 20-33 shows moisture contents of below 1% from dryers.

BLOCK WATERSEP SEP

DESCRIPTION "This separates water in polymer stab. subsystem"
 FRAC STREAM=PLYSTBIN SUBSTREAM=MIXED COMPS=C C-S H2 O2 &
 N2 S CL2 F2 NO H2O SIO2 SIO2-S AL2O3 AL2O3-S FE AS &
 BA CD CR PB HG SE AG NAOH NACL CO2 CO O3 HCL &
 FECL3 H2SO4 NA2SO4 CH4 POLYMER CEMENT CASO4 CU &
 "FE(OH)3" FRACS=1 1 1 1 0 1 1 1 0 1 1 1 1 1 1 &
 1 1 1 1 1 1 1 1 1 0 0 0 1 1 1 1 0 1 1 1 &
 1 1
 FRAC STREAM=PLYSTBIN SUBSTREAM=CISOLID COMPS=C-S SIO2-S &
 AL2O3-S CEMENT FRACS=1 1 1 1

BLOCK DRYER HEATER

DESCRIPTION "This models the dryer for the polymer stab. sys."
 PARAM TEMP=200 PRES=1

BLOCK HETRHEPA HEATER

DESCRIPTION "heater to raise temperature for HEPA filters"
 PARAM TEMP=300 PRES=1

BLOCK SOLDRYER HEATER

PARAM TEMP=200 PRES=1

BLOCK CONCENT8 FLASH2

PARAM TEMP=150 PRES=1

BLOCK FLASH2 FLASH2

PARAM TEMP=100 PRES=1

;Data obtained from "Development Studies for a Novel Wet Oxidation Process,
 ;Topical Report," Patrick M. Dhooze and Lena B. Hakim, Delphi Research, Inc.
 ;January 1994, DE-AC21-92MC27109

;Operating conditions: page 63
 ;Detox solution composition: page 2
 ;Metal solubility: page xvii, 18
 ;Reaction stoichiometry: page xiv
 ;Excess oxygen: page 58
 ;Extent of reaction: page xvi

;Temperature and pressure also reported in "Descriptions of Recom ..", p. 2-12
 ;MK flowsheet shows 423 K and 20 psi (+15=35 psia)

BLOCK CWO-1 RSTOIC

DESCRIPTION "wet oxidation reactor"
 PARAM TEMP=423 <K> PRES=35 <PSI>
 STOIC 1 CISOLID C-S -1 / MIXED O2 -1 / CO2 1
 STOIC 2 MIXED H2 -2 / O2 -1 / H2O 2
 STOIC 3 MIXED CL2 -1 / H2 -1 / HCL 2
 STOIC 4 MIXED S -1 / H2 -1 / O2 -2 / H2SO4 1
 STOIC 5 MIXED CH4 -1 / O2 -2 / CO2 1 / H2O 2
 CONV 1 CISOLID C-S 0.99
 CONV 2 MIXED H2 0.99

CONV 3 MIXED CL2 0.99
CONV 4 MIXED S 0.99
CONV 5 MIXED CH4 0.99

;Data obtained from "Development Studies for a Novel Wet Oxidation Process,
;Topical Report," Patrick M. Dhooge and Lena B. Hakim, Delphi Research, Inc.
;January 1994, DE-AC21-92MC27109
;Operating conditions: page 63
;Detox solution composition: page 2
;Metal solubility: page xvii, 18
;Reaction stoichiometry: page xiv
;Excess oxygen: page 58
;Extent of reaction: page xvi
;
;Temperature and pressure also reported in "Description of Recom.." , p. 2-12
;MK flowsheet shows 423 K and 20 psi (+15=35 psia)

BLOCK CWO-2 RSTOIC

DESCRIPTION "Wet oxidation reactor"
PARAM TEMP=423. <K> PRES=35 <PSI>
STOIC 1 CISOLID C-S -1 / MIXED O2 -1 / CO2 1
STOIC 2 MIXED H2 -1 / O2 -0.5 / H2O 1
STOIC 3 MIXED CL2 -0.5 / H2 -0.5 / HCL 1
STOIC 4 MIXED S -1 / H2 -1 / O2 -2 / H2SO4 1
CONV 1 CISOLID C-S 0.99
CONV 2 MIXED H2 0.99
CONV 3 MIXED CL2 0.99
CONV 4 MIXED S 0.99

;Data obtained from "Description of Recommended Non-Thermal.." pp. 6-43 to 6-45
;Although room temperature operation is listed on p. 6-43, 1000 C is listed
;on page 6-45, and the higher temperature is more believable
;DRE of 0.999 listed for TCE and 0.90-0.95 for PCE --> use 0.95 for all waste
;assume 1 atm pressure

BLOCK GPCR RSTOIC

DESCRIPTION "Gas Phase Corona Reactor, see comments"
PARAM PRES=1 DUTY=20000 SERIES=YES
STOIC 1 MIXED H2 -2 / O2 -1 / H2O 2
STOIC 2 CISOLID C-S -1 / MIXED O2 -1 / CO2 1
STOIC 3 MIXED H2 -1 / CL2 -1 / HCL 2
STOIC 4 MIXED CO -1 / O2 -0.5 / CO2 1
STOIC 5 MIXED CH4 -1 / O2 -2 / CO2 1 / H2O 2
CONV 1 MIXED H2 0.95
CONV 2 CISOLID C-S 0.95
CONV 3 MIXED CL2 0.95
CONV 4 MIXED CO 0.95
CONV 5 MIXED CH4 0.95

BLOCK NEUTRAL1 RSTOIC

DESCRIPTION "neutralizes excess HCl"
PARAM TEMP=100 PRES=1
STOIC 1 MIXED NAOH -1 / HCL -1 / NACL 1 / H2O 1
STOIC 2 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 2
STOIC 3 MIXED CL2 -1 / NAOH -2 / NACL 2 / H2O 1 / &
O2 0.5
STOIC 4 MIXED FECL3 -1 / NAOH -3 / "FE(OH)3" 1 / NACL &
3

CONV 1 MIXED HCL 0.99
CONV 2 MIXED H2SO4 0.99
CONV 3 MIXED CL2 0.99
CONV 4 MIXED FECL3 0.99

BLOCK NEUTRAL2 RSTOIC

DESCRIPTION "neutralizes excess HCl"

PARAM TEMP=100 PRES=1

STOIC 1 MIXED NAOH -1 / HCL -1 / NACL 1 / H2O 1

STOIC 2 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 2

STOIC 3 MIXED CL2 -1 / NAOH -2 / NACL 2 / H2O 1 / &
O2 0.5

STOIC 4 MIXED FECL3 -1 / NAOH -3 / "FE(OH)3" 1 / NACL &
3

CONV 1 MIXED HCL 0.99

CONV 2 MIXED H2SO4 0.99

CONV 3 MIXED CL2 0.99

CONV 4 MIXED FECL3 0.99

;scrubbing efficiency of 0.99 assumed for now

BLOCK NEUTRAL3 RSTOIC

DESCRIPTION "neutralizes HCl in offgas stream"

PARAM TEMP=100 PRES=1

STOIC 1 MIXED HCL -1 / NAOH -1 / NACL 1 / H2O 1

STOIC 2 MIXED CL2 -1 / NAOH -2 / NACL 2 / H2O 1 / &
O2 0.5

STOIC 3 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 2

STOIC 4 MIXED SO2 -1 / NAOH -2 / O2 -0.5 / NA2SO4 1 &
/ H2O 1

CONV 1 MIXED HCL 0.99

CONV 2 MIXED CL2 0.99

CONV 3 MIXED H2SO4 0.99

CONV 4 MIXED SO2 0.99

BLOCK OH-GEN RSTOIC

PARAM TEMP=100 PRES=1

STOIC 1 MIXED H2O2 -1 / OH-RAD 2

STOIC 2 MIXED O3 -1 / H2O -3 / OH-RAD 6

CONV 1 MIXED H2O2 0.99

CONV 2 MIXED O3 0.99

BLOCK OZ-DECOM RSTOIC

DESCRIPTION "ozone decomposer"

PARAM TEMP=100 PRES=1

STOIC 1 MIXED O3 -2 / O2 3

STOIC 2 MIXED HCL -1 / NAOH -1 / NACL 1 / H2O 1

STOIC 3 MIXED H2SO4 -1 / NAOH -2 / NA2SO4 1 / H2O 2

STOIC 4 MIXED CL2 -1 / NAOH -2 / NACL 2 / H2O 1 / &
O2 0.5

STOIC 5 MIXED SO2 -1 / NAOH -2 / O2 -0.5 / NA2SO4 1 &
/ H2O 1

CONV 1 MIXED O3 0.999

CONV 2 MIXED HCL 0.99

CONV 3 MIXED H2SO4 0.99

CONV 4 MIXED CL2 0.99

CONV 5 MIXED SO2 0.99

;temperature and pressure assumed arbitrarily

BLOCK OZ-GEN RSTOIC

DESCRIPTION "generates ozone from air"

PARAM TEMP=100 PRES=1

STOIC 1 MIXED O2 -3 / O3 2

CONV 1 MIXED O2 0.999

;Destruction efficiency of 96% assumed (p. 2-78 of "Description of Recommended
;Non-Thermal Mixed Waste Treatment Technologies Version 1.0," Emile A. Bernard
;temperature and pressure assumed by BWBrown

BLOCK PHOTO-UV RSTOIC

DESCRIPTION "Photolytic oxidation of waste, see comments"

PARAM TEMP=100 PRES=1 SERIES=YES MAXIT=500 TOL=0.00001

STOIC 1 CISOLID C-S -1 / MIXED OH-RAD -4 / CO2 1 / &

H2O 2

STOIC 2 MIXED H2 -1 / OH-RAD -2 / H2O 2

STOIC 3 MIXED H2 -1 / CL2 -1 / HCL 2

CONV 1 CISOLID C-S 0.96

CONV 2 MIXED H2 0.96

CONV 3 MIXED CL2 0.96

BLOCK EQUIL-1 RGIBBS

PARAM TEMP=423 <K> PRES=35 <PSI> MAXIT=500

BLOCK EQUIL-2 RGIBBS

PARAM TEMP=423 <K> PRES=35 <PSI> MAXIT=500

;Chuck Biaggi said that temp should be less than 250 F, no CO 1/3/96

BLOCK VACTRAX1 RGIBBS

PARAM TEMP=550 PRES=1 <PSI>

PROD H2O / H2 / O2 / N2 / S / CL2 / NO / SiO2-S &

S / AL2O3-S S / FE / AS / HG / AG / HCL / &

H2SO4 / CH4 / C-S S / BA M / CD M / CR M / &

PB M / SE M

PROD-FRAC O2 1

DESIGN-SPEC ACID-IN

DEFINE MACID STREAM-VAR STREAM=ACID-IN SUBSTREAM=MIXED &

VARIABLE=MASS-FLOW

DEFINE MASOTM STREAM-VAR STREAM=CWO-OUT SUBSTREAM=MIXED &

VARIABLE=MASS-FLOW

DEFINE MASOTS STREAM-VAR STREAM=CWO-OUT SUBSTREAM=CISOLID &

VARIABLE=MASS-FLOW

DEFINE MASO2 STREAM-VAR STREAM=OXYGEN1 SUBSTREAM=MIXED &

VARIABLE=MASS-FLOW

SPEC "MACID*200 " TO &

"(MASOTM+MASOTS-MASO2)*7"

TOL-SPEC "0.01"

VARY STREAM-VAR STREAM=ACID-IN SUBSTREAM=MIXED &

VARIABLE=MASS-FLOW

LIMITS "0.01" "20"

;10% excess OH radicals

DESIGN-SPEC AIR1

```

DEFINE O3OUT MOLE-FLOW STREAM=PRODUCTS SUBSTREAM=MIXED &
  COMPONENT=O3
DEFINE O3IN MOLE-FLOW STREAM=OZONE SUBSTREAM=MIXED &
  COMPONENT=O3
DEFINE OHROUT MOLE-FLOW STREAM=PRODUCTS SUBSTREAM=MIXED &
  COMPONENT=OH-RAD
DEFINE OHRIN MOLE-FLOW STREAM=OH-RAD SUBSTREAM=MIXED &
  COMPONENT=OH-RAD
SPEC "OHROUT*(1+100/10)" TO "OHRIN"
TOL-SPEC "0.101"
VARY STREAM-VAR STREAM=AIR1 SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
LIMITS "3" "4"

```

;Perry's Handbook p. 20-33 has moisture contents about 0.5% from dryers
;review meeting of 2/8/96 : moisture content to 5%

DESIGN-SPEC DRYER

```

DEFINE H2OMAS MASS-FLOW STREAM=PLYSTBIN SUBSTREAM=MIXED &
  COMPONENT=H2O
DEFINE MIXMAS STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
DEFINE SOLMAS STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
SPEC "H2OMAS" TO "(MIXMAS+SOLMAS)*0.05"
TOL-SPEC "0.001"
VARY BLOCK-VAR BLOCK=WATERSEP SENTENCE=FRAC VARIABLE=FRACS &
  ID1=MIXED ID2=PLYSTBIN ELEMENT=10
LIMITS "0" "1"

```

;power input is calculated to be 56.49 W / SCFM according to information
; supplied by Ben Tehranian, MK Environmental Services
;
;lbmol/hr converted to SCFM by multiplying by 359/60
;;
;1 W = 3.413 Btu/hr

DESIGN-SPEC GPCRPOWER

```

DEFINE MOLOUT STREAM-VAR STREAM=GPCR-OUT SUBSTREAM=MIXED &
  VARIABLE=MOLE-FLOW
DEFINE POWER BLOCK-VAR BLOCK=GPCR VARIABLE=DUTY &
  SENTENCE=PARAM
SPEC "POWER" TO "MOLOUT*359/60*56.49*3.413"
TOL-SPEC "0.01"
VARY BLOCK-VAR BLOCK=GPCR VARIABLE=DUTY SENTENCE=PARAM
LIMITS "0" "10000000"

```

;conversation with Daryoush Bahar 3/6/96 - dry basis used for grout calculation
;because with System 3, too much water exists, which results in too much grout
;being calculated

DESIGN-SPEC GROUT

```

DEFINE R1 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
DEFINE R2 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
DEFINE R3 MASS-FLOW STREAM=GROUTRIN SUBSTREAM=MIXED &
  COMPONENT=H2O

```



```

DEFINE GROUT STREAM-VAR STREAM=GROUTDRY SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
F  EXCES =R3-0.6*(R1+R2-R3)
F  IF(EXCES.LT.0.) EXCES = 0.
SPEC "GROUT" " TO "1.4*(R1+R2-R3)+2.333*EXCES"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=GROUTDRY SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
LIMITS "0.1" "6000"

```

DESIGN-SPEC GROUTH2O

```

DEFINE R1 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
DEFINE R2 STREAM-VAR STREAM=GROUTRIN SUBSTREAM=CISOLID &
  VARIABLE=MASS-FLOW
DEFINE R3 MASS-FLOW STREAM=GROUTRIN SUBSTREAM=MIXED &
  COMPONENT=H2O
DEFINE H2OFLO STREAM-VAR STREAM=GROUTH2O SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
F  EXCES = R3 - 0.6 * (R1+R2-R3)
F  IF(EXCES.GT.0.) EXCES = 0.0
C SETS EXCESS WATER TO 0 IF WATER IS ACTUALLY EXCESS
C WATER REQUIRED, IF ANY, IS RETURNED AS A NEGATIVE NUMBER
SPEC "H2OFLO" TO "-EXCES"
TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=GROUTH2O SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
LIMITS "0" "2000"

```

DESIGN-SPEC NAOH-1

```

DEFINE NAOHIN MOLE-FLOW STREAM=NAOH-1 SUBSTREAM=MIXED &
  COMPONENT=NAOH
DEFINE NAOHOT MOLE-FLOW STREAM=SCRBOUT1 SUBSTREAM=MIXED &
  COMPONENT=NAOH
SPEC "NAOHIN" TO "NAOHOT*(1+100/1)"
TOL-SPEC "0.01"
VARY STREAM-VAR STREAM=NAOH-1 SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
LIMITS "100" "110"

```

DESIGN-SPEC NAOH-2

```

DEFINE NAOHIN MOLE-FLOW STREAM=NAOH-2 SUBSTREAM=MIXED &
  COMPONENT=NAOH
DEFINE HCLIN MOLE-FLOW STREAM=CWOLIQ2 SUBSTREAM=MIXED &
  COMPONENT=HCL
DEFINE H2SIN MOLE-FLOW STREAM=CWOLIQ2 SUBSTREAM=MIXED &
  COMPONENT=H2SO4
DEFINE CL2 MOLE-FLOW STREAM=CWOLIQ2 SUBSTREAM=MIXED &
  COMPONENT=CL2
DEFINE NAOHOT MOLE-FLOW STREAM=SCRBOUT2 SUBSTREAM=MIXED &
  COMPONENT=NAOH
SPEC "NAOHIN" TO "NAOHOT*(1+100/1)"
TOL-SPEC "0.1"
VARY STREAM-VAR STREAM=NAOH-2 SUBSTREAM=MIXED &
  VARIABLE=MASS-FLOW
LIMITS "50" "1000"

```

DESIGN-SPEC NAOH-3

DEFINE NAOHIN MOLE-FLOW STREAM=NAOH-3 SUBSTREAM=MIXED &
 COMPONENT=NAOH
 DEFINE NAOHOT MOLE-FLOW STREAM=SPLITIN SUBSTREAM=MIXED &
 COMPONENT=NAOH
 SPEC "NAOHIN" TO "NAOHOT*(1+100/1)"
 TOL-SPEC "0.05"
 VARY STREAM-VAR STREAM=NAOH-3 SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 LIMITS "5" "20"

;Excess oxygen from Delphi flowsheet D-1002A (5% excess)
 ;4947 g O2 out for 59082 g O2 in
 ;
 ;5% excess O2 in design spec

DESIGN-SPEC O2-CWO
 DEFINE O2OUT MASS-FLOW STREAM=CWO-OUT SUBSTREAM=MIXED &
 COMPONENT=O2
 DEFINE OX1 MASS-FLOW STREAM=OXYGEN1 SUBSTREAM=MIXED &
 COMPONENT=O2
 DEFINE OX2 MASS-FLOW STREAM=ACID-IN SUBSTREAM=MIXED &
 COMPONENT=O2
 DEFINE OX3 MASS-FLOW STREAM=X-ORGS SUBSTREAM=MIXED &
 COMPONENT=O2
 DEFINE OX4 MASS-FLOW STREAM=VACORG-1 SUBSTREAM=MIXED &
 COMPONENT=O2
 DEFINE OX5 MASS-FLOW STREAM=SOIL-ORG SUBSTREAM=MIXED &
 COMPONENT=O2
 DEFINE OX6 MASS-FLOW STREAM=20003000 SUBSTREAM=MIXED &
 COMPONENT=O2
 SPEC "O2OUT*(1+100/5)" TO "OX1+OX2+OX3+OX4+OX5+OX6"
 TOL-SPEC "0.1"
 VARY STREAM-VAR STREAM=OXYGEN1 SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 LIMITS "600" "1000"

;Excess oxygen from Delphi flowsheet D-1002A (5% excess)
 ;4947 g O2 out for 59082 g O2 in
 ;
 ;5% excess O2 in the outlet stream

DESIGN-SPEC O2-CWO2
 DEFINE O2OUT MASS-FLOW STREAM=CWO-OUT2 SUBSTREAM=MIXED &
 COMPONENT=O2
 DEFINE OX1 MASS-FLOW STREAM=OXYGEN2 SUBSTREAM=MIXED &
 COMPONENT=O2
 DEFINE OX2 MASS-FLOW STREAM=ACID-IN2 SUBSTREAM=MIXED &
 COMPONENT=O2
 DEFINE OX3 MASS-FLOW STREAM=5000SOFT SUBSTREAM=MIXED &
 COMPONENT=O2
 SPEC "O2OUT*(1+100/5)" TO "OX1+OX2+OX3"
 TOL-SPEC "0.1"
 VARY STREAM-VAR STREAM=OXYGEN2 SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 LIMITS "750" "900"

DESIGN-SPEC POLYMER
 DEFINE WASTIN STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=MIXED &

VARIABLE=MASS-FLOW
 DEFINE SOLDIN STREAM-VAR STREAM=PLYSTBIN SUBSTREAM=CISOLID &
 VARIABLE=MASS-FLOW
 DEFINE POLYIN STREAM-VAR STREAM=POLYETHL SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 SPEC "POLYIN" TO "(WASTIN+SOLDIN)"
 TOL-SPEC "0.1"
 VARY STREAM-VAR STREAM=POLYETHL SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 LIMITS "0.1" "5000"

;20% moisture content set at review meeting 2/8/96

DESIGN-SPEC SALTSOLN

DEFINE SALTFL MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
 COMPONENT=NACL
 DEFINE H2OFLO MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
 COMPONENT=H2O
 DEFINE NAOHFL MASS-FLOW STREAM=SALTSOLN SUBSTREAM=MIXED &
 COMPONENT=NAOH
 SPEC "H2OFLO*4" TO "SALTFL+NAOHFL"
 TOL-SPEC "0.01"
 VARY BLOCK-VAR BLOCK=BLOWDOWN SENTENCE=FRAC VARIABLE=FRACS &
 ID1=MIXED ID2=FLASH-IN ELEMENT=11
 LIMITS "0.001" "1"

DESIGN-SPEC XX-NAOH

DEFINE NAOHIN MASS-FLOW STREAM=PRODUCTS SUBSTREAM=MIXED &
 COMPONENT=NAOH
 DEFINE NAOHOT MASS-FLOW STREAM=AQ-OUT SUBSTREAM=MIXED &
 COMPONENT=NAOH
 SPEC "NAOHIN" TO "NAOHOT*(1+100/1)"
 TOL-SPEC "0.10"
 VARY STREAM-VAR STREAM=XX-NAOH SUBSTREAM=MIXED &
 VARIABLE=MASS-FLOW
 LIMITS "17" "18.5"

FORTTRAN ADDITIVE

DEFINE HGOUT MASS-FLOW STREAM=HG-OUT SUBSTREAM=MIXED &
 COMPONENT=HG
 DEFINE COPPIN MASS-FLOW STREAM=ADDITIVE SUBSTREAM=MIXED &
 COMPONENT=CU
 F COPPIN = 0.7 * HGOUT
 READ-VARS HGOUT
 WRITE-VARS COPPIN

FORTTRAN H2O2-IN2

DEFINE O3IN MOLE-FLOW STREAM=PHOTO-IN SUBSTREAM=MIXED &
 COMPONENT=O3
 DEFINE H2O2IN STREAM-VAR STREAM=H2O2-IN2 SUBSTREAM=MIXED &
 VARIABLE=MOLE-FLOW
 F H2O2IN=O3IN
 READ-VARS O3IN
 WRITE-VARS H2O2IN

;constant is obtained by taking 1200 ft3/1200 lb and mult. by 0.0727 lb/ft3

FORTTRAN N2SWEEP

```
DEFINE N2SWP1 STREAM-VAR STREAM=N2SWEEP1 SUBSTREAM=MIXED &  
  VARIABLE=MASS-FLOW  
DEFINE MS3000 STREAM-VAR STREAM=3000 SUBSTREAM=CISOLID &  
  VARIABLE=MASS-FLOW  
DEFINE MM3000 STREAM-VAR STREAM=3000 SUBSTREAM=MIXED &  
  VARIABLE=MASS-FLOW  
F  N2SWP1 = 0.0793 * (MS3000+MM3000)  
  READ-VARS MS3000 MM3000  
  WRITE-VARS N2SWP1
```

```
CONV-OPTIONS  
  PARAM TEAR-METHOD=BROYDEN TOL=0.00011  
  BROYDEN MAXIT=200
```

```
TEAR  
  TEAR PRODUCTS 0.1
```

```
STREAM-REPOR MOLEFLOW MASSFLOW
```

```
;  
;  
;  
;  
;  
;  
;
```