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Modelling of RTF Glove-Box and Stripper System

The glove box-stripper system for the Replacement Tritium Facility (RTF) has been modelled to determine its steady-state performance. Based on these calculations I would like to make the following recommendations, some of which impact on the scope of the RTF glove box-stripper system:

Recommendations

1. **Retain the purge system stripper in the RTF scope.** Depending on the actual dryness of the glove box atmosphere, the achievable zeolite bed efficiency without a purge system stripper may not be adequate to meet the activity specification in the glove boxes and the annual emission goal. The purge stripper will provide the logical place to assure final clean up since all routine activity to be discharged to the environment must pass through it. Its small size also makes it the logical place to inject moisture or deuterium swamping to improve zeolite bed efficiency.

2. **Retain the deuterium swamping capability for both primary and secondary strippers.** They may be needed to improve zeolite bed efficiency to meet the activity specification in the glove boxes.

3. Evaluate the benefit of eliminating the low-temperature oxidation line from the scope versus the additional heating cost needed.. The original basis for dual-temperature lines was a saving in heating cost. The lower stripper flow rates we have may have altered the economics. Furthermore, elimination of the low-temperature line would lead to lower total activity emission as well as simplify design and operation of the stripper system.

4. If after economic evaluation per Recommendation 3, the high-low temperature dual-lines are to be retained, change the stripper system configuration from recycle to single-pass.

5. Relax glove box in-leakage specs by an order of magnitude to allow greater air in-leakage. This should help to reduce glove box cost.

6. Investigate removal of the oxygen control (De-Oxo) system from the stripper scope and modify glove box oxygen spec as follows:

	Present Spec	New Spec
oxygen into stripper	< 2000 ppm	< 3000 ppm
oxygen out of stripper	< 1000 ppm	< 3000 ppm > 100 ppm

The oxygen spec at start-up and after maintenance shut-downs can be achieved by repeated nitrogen flushes.

Introduction

The glove box-stripper system for the Replacement Tritium Facility (RTF) has been modelled to calculate the steady-state levels of various gas species such as N_2, O_2, T_2, H_2O, T_2O, and CT_4 that might be expected to be present. These calculations are intended to determine the ultimate concentration levels we can expect. Two different equipment configurations have been modelled to reflect different strategies for splitting flows to the high and low temperature hydrogen oxidation reactors. The present design configuration recycles part of the main flow through the high temperature reactor back to the main flow through the low temperature reactor. In the second configuration, the flows split and rejoin after single-pass flow through the two reactors. Other cases were simulated to investigate the effect of the following parameters:

- the ratio of split flows to high and low temperature beds
- the oxidation efficiencies of hydrogen and methane (the model organic impurity)
- the swamping (flow) rates of nitrogen, air and deuterium
- the process leak composition.

This model does <u>not</u> give the time-dependent change of the various species to an impulse injection or release of tritium that might occur. The time needed to clean-up a release to a certain desired level can be easily calculated with a worst-case assumption of a well-mixed glove box. Results have been previously reported by Harding Owen, but are re-derived in Appendix B for your convenience.

The results presented here did not take into account the potential for gradual trapping of tritium in the system through isotopic exchange with lighter hydrogens in zeolite molecular sieves and other hydrogen traps. Exchange may help to reduce tritium emission, but tends to create a tritium accountability problem.

Summary

A steady-state model requires well-defined, time-invariant inputs. Analysis of expected leaks and other gas infusions to the glove boxes indicate that relatively constant inputs such as room air and instrument air in-leakages will constitute a very small fraction of the expected discharges to the glove boxes. In these simulations, making the non-continuous inputs continuous implies imposing a time-averaging effect which tends to produce optimum stripper performance results. We can expect the actual glove box-stripper system to produce less favorable results.

Given the expected glove box inleakage rates, simulations indicate that the glove box atmosphere will be very dry. For 90 % zeolite bed (Z bed) efficiency in trapping moisture, steady state water concentration may become as low as 1 ppm. If Z bed efficiency is as low as 10 %, the moisture level could rise to about 85 ppm.

For expected oxidation bed efficiencies of greater than 99 % conversion per pass, the current recycle configuration gives a lower overall system activity DF than the single-pass configuration.

Splitting flows, intended to reduce heating cost, will increase the final activity in the glove boxes. As expected, the lowest activity discharge is for 100 % flow to the high temperature oxidation bed. Activity discharge increases exponentially with increased flow to the low temperature oxidation bed.

Conclusions

1. The overall stripper system efficiency in removing tritiated species will pivot on zeolite efficiency. The operation of the present system will be very demanding on the zeolite beds because of the very dry conditions predicted. It may prove to be necessary to inject moisture (H_2O or D_2O) or D_2 to increase zeolite bed efficiency.

2. Deuterium swamping in the primary and secondary strippers may have to be used to assure that activity specs can be achieved in the glove boxes. Deuterium swamping will help not so much by increasing the oxidation efficiency of tritium as by raising

moisture (D2O) level to increase zeolite bed operating efficiency.

3. For the expected oxidation bed performances, the single-pass configuration is superior to the recycle configuration.
4. For splitting flows to the two oxidation beds, the most advantageous split may be 60:40 to the low:high temperature beds. Thus a correct decision was made to size the split streams equally, as shown in the current P & I blueprints.
5. The strict air in-leakage specs on the glove boxes will necessitate air swamping to provide adequate oxygen for hydrogen oxidation. Slight relaxation of the inleakage spec should be acceptable. Gross relaxation may be inadvisable as room air may contain potential stripper catalyst poisons.
6. The significant spec is that of activity concentration. In meeting that spec, the moisture will be considerably less than the Technical Data Summary (TDS) spec of 300 ppm max to stripper and 200 ppm max out of stripper.
7. Although not directly related to simulation results, relaxing the oxygen spec in the system may allow elimination of the oxygen removal (De-Oxo) system from the current scope. Excess oxygen is only expected to be present at start-up and after maintenance clean-ups. Repeated "flushes" with nitrogen should be able to lower oxygen to within the acceptable limit.

Methods

The use and structure of the simulation programs are explained in Appendix A-1, which includes a program listing. A sample simulation output is given in Appendix A-2.

The most important performance specification for the stripper system is the activity spec. The current specs are 0.1 µCi/cc in the glove box atmosphere and 0.01 µCi/cc in the return lines to the glove boxes, after stripper clean-up. Other stripper performance specs are for levels of oxygen and moisture. The simulation results will emphasize the effect of various parameters on these specs, particularly the activity spec. Also of interest is the cumulative yearly activity discharge to the environment. It is calculated simply from the concentration and flow rate of the purge or vent stream. <u>The yearly activity discharge numbers presented in these simulation results should only be considered in relative terms.</u> The actual yearly activity discharge will depend on the actual process leak composition and production rates. The goal activity discharge for the entire RTF is 1000 Ci/year, including both routine and abnormal losses.

Standard Case

To permit comparison, simulations of modified cases will be compared with a standard or base case. The conditions for the Standard Case are as follows:

<u>Process Leak Composition</u>

H2	.00000050	scfm	24.75 %
D2	.00000050	scfm	24.75 %
T2	.00000099	scfm	49.5 %
CT4	.00000002	scfm	1.0 %
Total	.00000200	scfm	100.0 %

<u>Adjustable Parameters:</u>

T2/H2 ox efficiency	99 %	(DF = 100)
CT4 ox efficiency	99 %	(DF = 100)
Z bed efficiency	90 %	(DF = 10)
N2 swamping rate	1	scfm
Air swamping rate	0.01	scfm
D2 swamping rate	0	scfm
Cu bed efficiency	0 %	
Flow split ratio	60 % to low temp oxidation 40 % to high temp oxidation	

<u>Other Assumptions:</u>

- Room air leak in at 20,000 ppm (2 %) moisture
- Air swamp at 1,000 ppm moisture (Dew point ~ 20 °C)
- Nitrogen swamp at 1,000 ppm moisture

The current RTF specs are for 50 % relative humidity in the room air (about 1 % moisture) and -40 °C dew point instrument air (about 162 ppm moisture). These are drier than numbers used in the calculations here; actual glove box atmospheres should be drier than calculated here.

SIMULATION RESULTS

1. Effect of Equipment Configuration

Two different equipment configurations have been modelled to reflect different strategies for splitting flows to the high and low temperature hydrogen oxidation reactors. The purpose for splitting flows is to reduce heating cost. The present design configuration (See Fig. 1) recycles part of the main flow through the high temperature reactor back to the main flow through the low temperature reactor. In the other configuration (See Fig. 2), the flows split and rejoin after single-pass flow through the two reactors. (Note: The present equipment configuration does not actually provide for heat economizers as shown in Fig. 1, but this has no affect on material balance calculations. Also, the location of the oxygen removal bed is upstream rather than downstream of the Z beds. However, since the oxygen removal bed is not needed for steady-state operation of the system, it has no effect on simulation results either.)

Data in Fig. 3 show that the single-pass configuration is more desirable than the recycle configuration. In Fig. 3 the overall system activity DF is shown as a function of the Z bed efficiency. The three pairs of data sets compare the effect of configuration for assumed oxidation efficiencies of 99 %, 90 % and 50 %. The upper two pairs of data show that Config. 1 (single-pass) results in greater overall system DF than Config. 2. Only in the 50 % oxidation efficiency case is the recycle configuration better. Since oxidation efficiencies of less than 50 % are highly unlikely and would be unacceptable anyway, the single-pass configuration is preferrable.

2. Effect of Split Flow Ratio

The current stripper design is based on splitting flows to separate high and low temperature oxidation reactors. The high temperature reactor (anticipated operating temperature: 400-550 °C) is primarily designed to oxidize tritiated methane and organics, but will oxidize hydrogen isotopes as well. The low temperature bed (operating temperature ~175 °C) is capable only of oxidizing hydrogen isotopes. The objective of splitting the flows is to reduce heating cost, as otherwise the entire stream must be processed through the high temperature bed at ≥ 400 °C. Flow splitting is based on economic rather than technical considerations. In light of the lower stripper flow rate than in earlier designs, I suggest that you reevaluate the economic justification for the dual oxidation lines.

The optimum stripper performance will be when flow is directed completely through the high temperature oxidation reactor. Splitting flows to high and low temperature reactors will raise the final glove box activity level and the total activity discharge through the system purge. Fig. 4 shows the overall system activity DF as a function of fractional flow to the low temperature reactor. The two lines represent results for the two different configurations. The upper curve shows results for the single-pass configuration. As expected, the highest system activity DF occurs at 100 % flow to the high temperature oxidation bed. System DF decreases exponentially as more flow is diverted to the low temperature bed. Numerical results for the single-pass configuration (Fig. 2) are shown in the table below.

Split Flow (to low T bed)	[O2]	[H2O]	[*]	Total *
0 %	2079 ppm	1.1 ppm	.0032 µCi/cc	48.19 Ci
20 %	2079 "	1.1 "	.0035 "	52.08 "
40 %	2079 "	1.1 "	.0039 "	58.52 "
60 %	2079 "	1.1 "	.0047 "	71.23 "
80 %	2079 "	1.1 "	.0072 "	108.14 "
90 %	2079 "	1.1 "	.0117 "	176.67 "

The moisture and oxygen concentrations at steady-state are not affected by flow splitting. The lowest glove box activity (given by [*]) and cumulative yearly activity discharge (given by Total *) occur at 0 % flow to the low temperature bed (or 100 % flow to the high temperature bed). The cumulative yearly activity discharge shown above is for one stripper system at 100 scfm. The RTF has two primary and one secondary stripper systems of the same capacity. As more flow is diverted to the low temperature bed, both the activity concentration and the total activity discharged through the purge will increase. If all flow is directed to the low temperature bed, activity in the system will increase indefinitely as CT4 will continue to accumulate until the amount of CT4 purged from the system is equal to the amount of entering CT4.

Fig. 4 shows that the optimum flow split may be at 60:40 low:high flow. Increasing the low temperature stream to 80 % of total flow would increase the steady state activity discharge by about 50 %. This is the reason that 60:40 flow split was selected for the Standard Case. Analysis of component flows shows that most of the activity lost in the purge is due to T2O. However, CT4 in the purge stream will increase in significance as more flow is diverted to the low temperature bed.

3. Effect of Oxidation Efficiency

Oxidation of hydrogen and methane to oxides is necessary before oxides can be trappped on Z beds. The effect of the oxidation efficiency of hydrogen and methane together and individually on steady-state oxygen, water, and purge stream activity concentrations as well as the total yearly activity discharge is shown in the next table. The "eff" column shows the H2/T2 oxidation efficiency followed by the CH4/CT4 oxidation efficiency.

Case	eff#	[O2]	[H2O]	[*]	Total *
1	.99/.99	2079 ppm	1.1 ppm	.00474 µCi/cc	71.23 Ci
2	.90/.90	2079 "	1.1 "	.00756 "	113.56 "
3	.50/.50	2079 "	1.1 "	.03209 "	481.9 "
4	.90/.99	2079 "	1.1 "	.0073 "	109.8 "
5	.99/.90	2079 "	1.1 "	.00499 "	75.0 "
6	.99/.50	2079 "	1.1 "	.00715 "	107.42 "
7	.99/.10	2079 "	1.1 "	.0219 "	329.5 "

Oxidation efficiencies of hydrogens/methanes

As expected, cases 1-3 show that both activity concentration and the total activity discharge will increase significantly as oxidation efficiencies decrease simultaneously, which is the most likely scenario. Both moisture and oxygen concentrations remain essentially unchanged.

Case 4 shows that if T2 oxidation efficiency is reduced from 99% to 90 %, with CT4 oxidation efficiency unchanged, the activity level and discharge would increase by about 40 %. Here the activity increase is due to higher [T2] level caused by reduced T2 oxidation efficiency.

Cases 5-7 show the results when only the CT4 oxidation efficiency decreases, a creditable scenario since CT4 is much more difficult to oxidize than hydrogen and also more susceptible to deactivation. In this case, the activity level is increased by higher steady-state [CT4] levels. The lower CT4 oxidation efficiency also results in lower levels of CO2, which is formed from oxidation of CT4.

4. Effect of Z bed Efficiency

Z beds trap tritiated oxides for subsequent recovery. Lowering of the Z bed efficiency will cause higher moisture levels in the glove boxes. More importantly, activity level in glove boxes will increase due to build up of T2O. Significant increases in the cumulative activity discharge can also be expected, as shown by the results below.

Case	Z bed eff	[H2O]	[O2]	[*]	Total *
1	90 %	1.1 ppm	2079 ppm	.00474 µCi/cc	71.2 Ci
2	50 %	9.9 ppm	2079 ppm	.028 "	420.9 Ci
3	10 %	82.4 ppm	2079 ppm	.21986 "	3302.0 Ci

Increasing the level of moisture in the feed is helpful as Z bed efficiency is concentration dependent. These offsetting factors make the actual situation somewhat more complex. The estimated concentration dependence of dynamic Z bed operation is shown in the table on the next page, for 4A molecular sieves:

Feed [H2O]	Equilibrium Z Bed Loading*		Dynamic Efficiency**
1000 ppm	20	lb H2O/lb Z	0.5
100 ppm	16	"	0.4
10 ppm	8	"	0.2
1 ppm	3.5	"	0.088

* from Linde zeolite data sheet

** sample calculation for 100 ppm [H2O] feed:

The Z bed is is asssumed to have 50 % oxide removal efficiency (based on dynamic Pd/Z experimental data) for 1000 ppm H2O feed. For 100 ppm water feed, the Z bed efficiency is 0.5 * 16/20 = 0.4

5. Effect of Process Leak Composition

The composition of the process leak stream to the glove boxes has an important effect on the steady-state activity level. Cases were simulated where [CT4] was increased from 1% to 2% to 3%. The concentrations of the remaining species were assumed to stay proportionally the same. Calculations show that this would result in slight decreases in [T2], as shown in the table below.

Case	[CT4]	[T2]	[H2O]	[O2]	[*]		Total *
1	1 %	24.75 %	1.1 ppm	2079 ppm	.00474	µCi/cc	71.2 Ci
2	2 %	24.5 %	1.1 ppm	2079 ppm	.00637	"	95.7 Ci
3	3 %	24.25 %	1.1 ppm	2079 ppm	.0080	"	120.1 Ci

Both activity concentration and the overall activity discharged through the purge stream appear to increase linearly with [CT4]. The activity increase was due mainly to the split flow. Both oxidation beds will oxidize T2, but only the high temperature bed can oxidize CT4, resulting in higher steady-state levels of activity.

6. Air and N2 Swamping

Air swamping is required to provide adequate oxygen for oxidation of hydrogen isotopes and organics. Nitrogen swamping is necessary to maintain a nitrogen-inerted atmosphere.

To obtain about 2,000 ppm [O2] in the glove boxes, with no D2 swamping, a N2 swamping about 10 times of the air swamping rate is needed.

If nitrogen swamping to the stripper system is negligible compared to the air in-leakges/swamping, then the system will slowly increase in oxygen content to 21 %.

The results of a five-fold increase in both air and nitrogen swamping is compared to the Standard Case in the next table. Nitrogen is increased five-fold to match the increase in air swamping in order to maintain a constant [O2] level. Data in the table show that although the activity concentration is reduced somewhat, the higher purge rate causes an overall increase in the cumulative activity discharge of almost five times. This result suggests that, in general, nitrogen purging should be minimized to reduce overall discharge, although there may be operational advantages to a constant nitrogen sweep through the glove boxes.

Air swamp	N2 swamp	[H2O]	[O2]	[*]	Total *
0.01 scfm	1	1.1 ppm	2079 ppm	.00474 µCi/cc	71.2 Ci
0.05 "	5	1.1 ppm	2079 ppm	.00446 "	335.0 Ci

7. Effect of Deuterium Swamping

Deuterium swamping has been reported to help the overall system activity DF. It probably does so by increasing the moisture level in the feed to the Z beds, thereby increasing Z bed adsorption efficiency. Deuterium swamping can also be used to exchange out unregenerated tritium trapped in the Z beds.

Utilization of deuterium swamping will increase the moisture (D2O) content in the glove boxes and D2O loading on Z beds. Furthermore, since D2 swamping will lead to a lower O2 concentration, one must also increase air swamping to maintain the desired level of oxygen.

The Standard Case is compared with a case where 0.01 scfm D2 is swamped. To maintain the oxygen level, air swamping is increased to 0.035 scfm (0.01 + 0.5 * 0.01 * 5):

D2 swamp	Air swamp	[H2O]	[O2]	[*]	Total *
0 scfm	0.01 scfm	1.1 ppm	2079 ppm	.00474 µCi/cc	71.23 Ci
0.01 scfm	0.035 scfm	1.15 ppm	2246 ppm	.00474 µCi/cc	72.62 Ci

The simulation shows that there are marginal differences between the two cases because oxidation efficiencies are assumed to stay the same. The higher total activity discharge is due to slightly higher purge flow rate. The expected increase in Z bed efficiency should actually lead to lower activity levels.

8. Effect of [CO2] and Other Impurities

Carbon dioxide is formed from oxidation of CH4 or CT4. Its steady-state concentration in the system depends on the rate of CH4 input or generation. If flows are split to the oxidation reactors, steady-state levels of CO2 also depend on the flow split ratio. The maximum [CO2] will result when all flow is directed to the high temperature oxidation bed. The calculations show that at expected CT4 and CH4 levels, the steady state [CO2] will be on the order of 1 ppb. This level should not present a problem.

Other impurities such as NH3, NT3 or Ar may also be present in the system. However, since we have insufficient data to characterize them at this time, they were not considered in the calculations.

9. Oxygen Removal (Getter) Beds

The existing scope for the stripper system includes provisions for oxygen removal or getter beds. These beds were not simulated because excess oxygen is only expected to be present at start-up and after maintenance clean-ups. Oxygen from other sources such as glove box air in-leakages is expected to be negligible.

These oxygen removal (or De-Oxo) beds may be eliminated from the scope if satisfactory alternatives can be developed for removing oxygen at start-up and following maintenance shutdowns. One possibility is to use nitrogen "flushes" to lower the oxygen level. The oxygen specs may also be relaxed somewhat to allow more flexibility for operation without oxygen removal beds.

FIG.1 Schematic of Proposed RTF Stripper System (Config. 2)

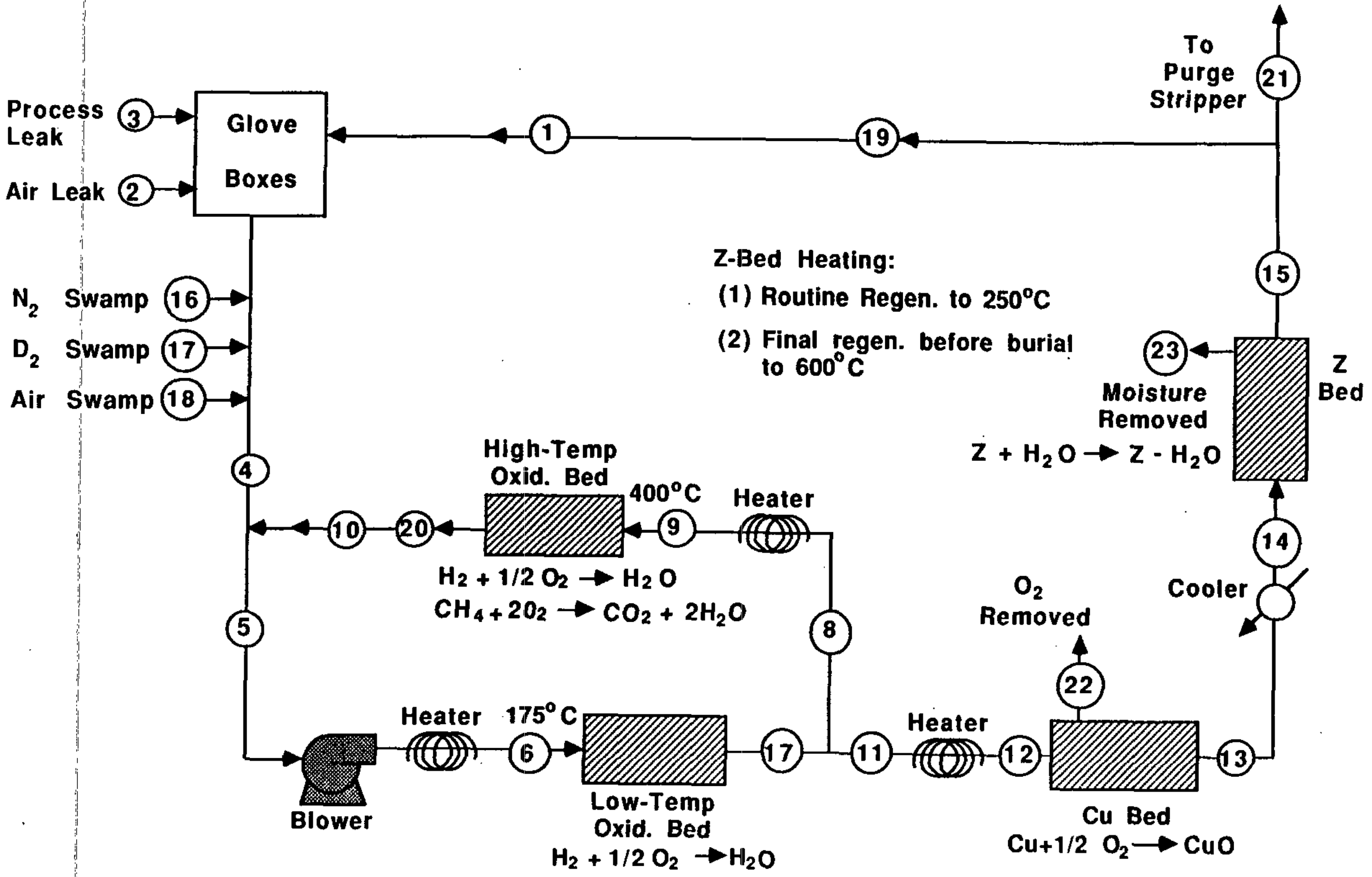
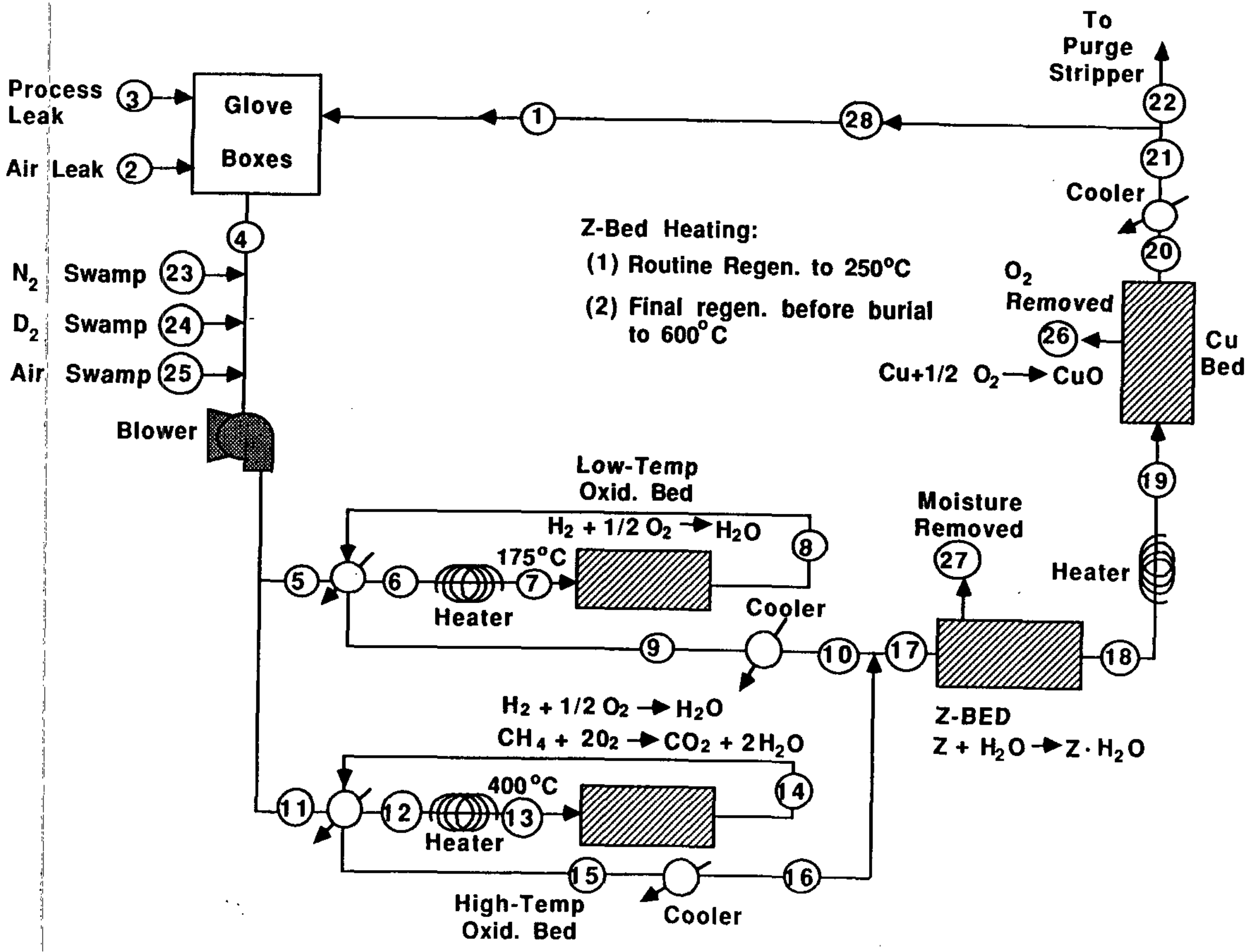


FIG.2 Schematic of Proposed RTF Stripper System (Config. 1)



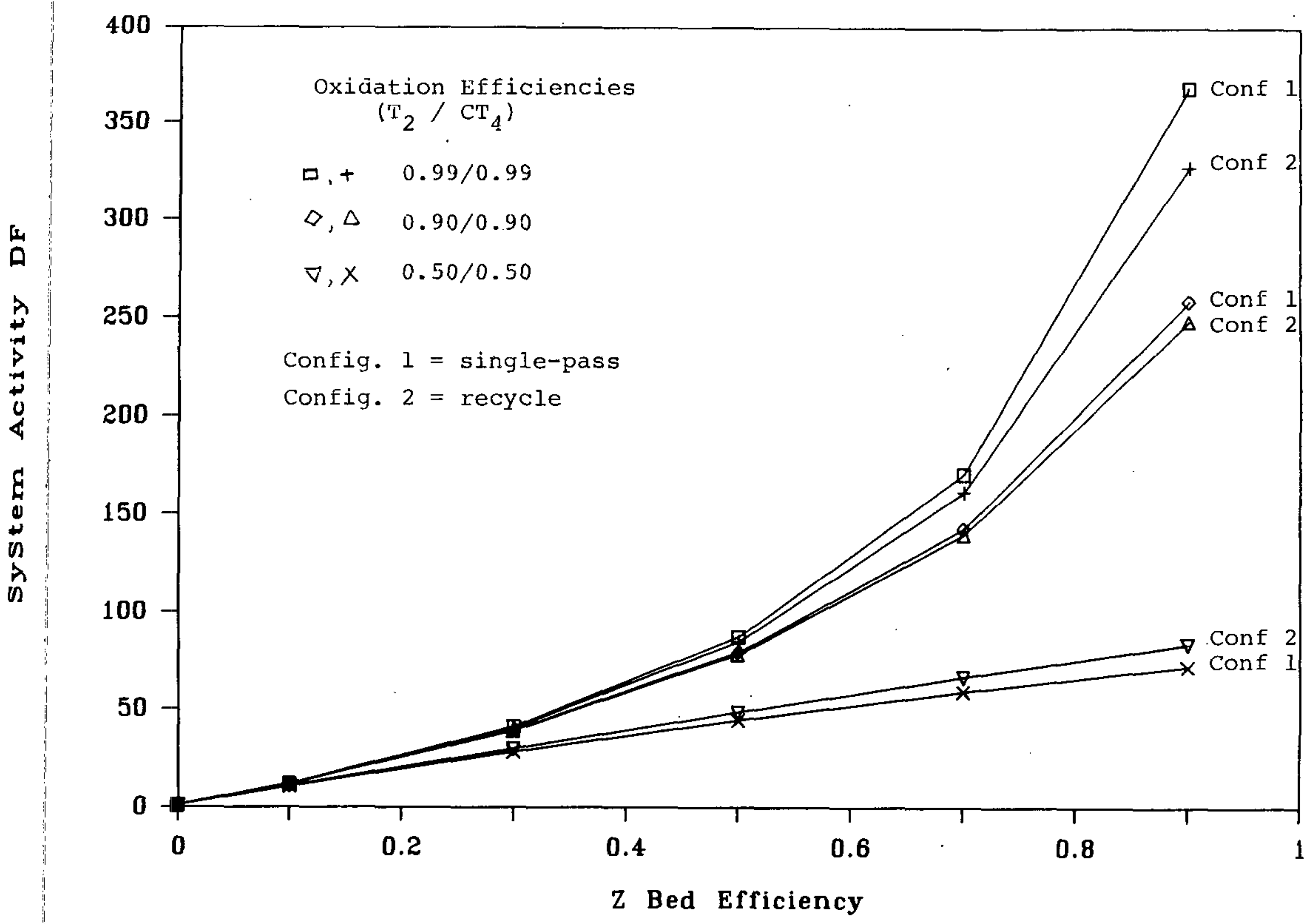


Fig. 3. Overall stripper system activity DF as a function of Z bed oxide trapping efficiency, system configuration, and T_2/CT_4 oxidation efficiencies.

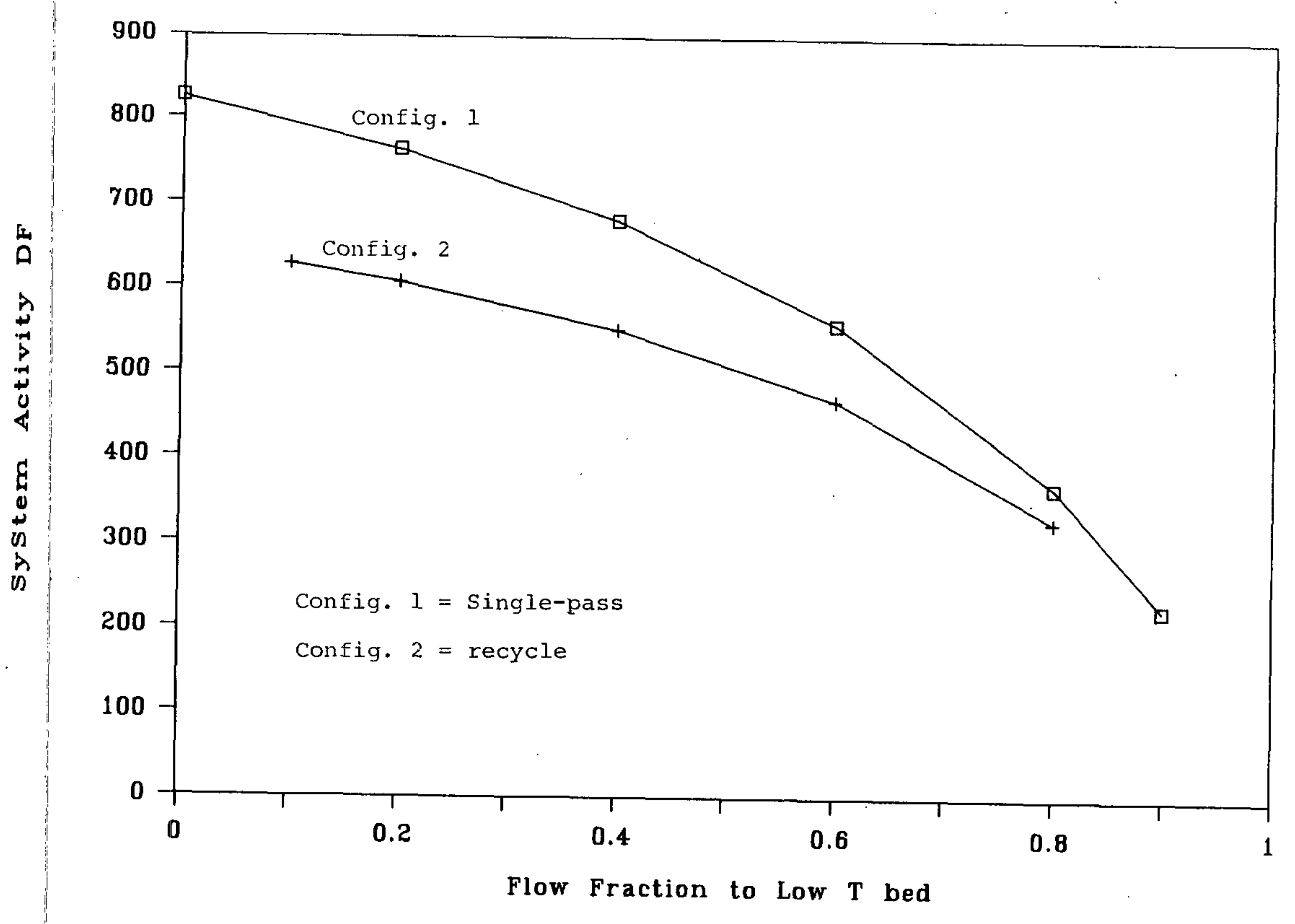


Fig. 4. Overall stripper system activity DF as a function of system configuration and flow fraction to the low temperature oxidation reactor.

Appendix A-1. Simulation Program

Features and Use Instructions

The RTF stripper-glove box systems in Figs. 1 and 2 are simulated to produce the steady state concentrations of various components. The simulation programs are written in Basic and can be run as is on any IBM-PC, PC-XT or PC-Compatibles. Program listings may be found at the end of this appendix.

These programs are interactive in nature. As each program executes, you will first be asked to see if you want to continue. This is the normal way for terminating program execution. As you continue, a menu containing adjustable parameters for the Standard Case will be presented. Changes may be made from the computer keyboard to these parameters to simulate other cases of interest. After completing changes, a menu of initial componenet flows in the test stream will be shown. The program calculates stream flow rates iteratively until the assumed component flow rates in the test stream agree with calculated flow rates. These initial guesses may also be adjusted from the keyboard. Program execution starts when all changes have been completed. Simulation results will appear on the computer monitor at the end of execution and will be stored to Floppy Unit A. (Note: the program will not execute unless a floppy disk is inserted in Floppy Drive A.)

To assist in the convergence of the oxygen flow rate, which is normally the slowest converging component, the initial flow rate of oxygen is automatically calculated using the formula below:

$$\text{Initial } [O2] = \frac{0.21 * \text{Air swamp} - \text{D2 swamp} * 5 * 0.5 * \text{H2 ox eff}}{\text{Air swamp} + \text{N2 swamp} + \text{D2 swamp}}$$

In these programs the total flow to the glove boxes is assumed to remain at a constant 100 scfm. The balance of the gases leaving the zeolite beds is purged out of the stripper system. Thus the purge flow rate will vary depending on the case simulated. For consistency, the nitrogen flow rate in the initial guesses is automatically calculated from the other component streams to give a total of 100 scfm.

```
10 '***************************************************************
20 'RTF-1.BAS             Single-Pass
30 'RTF Stripper-Nitrogen Box Simulation (Config. 1)
40 'Written by R. H. Hsu.       June 1986.
50 '***************************************************************
60 DIM CHEM$(15),Q(30,15),C(30,15),ACT(100),PQ(100,15)
70 DIM TAIL$(15),P(15),QSTART(15)
80 CHEM$(1) = "H2 "
90 CHEM$(2) = "D2 "
100 CHEM$(3) = "T2 "
110 CHEM$(4) = "CO "
120 CHEM$(5) = "CO2"
130 CHEM$(6) = "CH4"
140 CHEM$(7) = "CT4"
150 CHEM$(8) = "H2O"
160 CHEM$(9) = "D2O"
170 CHEM$(10) = "T2O"
180 CHEM$(11) = "O2 "
190 CHEM$(12) = "N2 "
200 CHEM$(13) = "TOTAL FLOW"
210 AIRLEAK = .000002
220 PROCLEAK = .000002
230 QSPLIT = .4                'fraction to hig temp bed
240 H2OX = .99
250 CH4OX = .99
260 CUEFF = 01
270 ZEFF = .9
280 AIRPURGE = .01
290 N2PURGE = 1
300 D2PURGE = 0
310 NITER = 50                 'number of iterations
320 OPEN "A:RTFDATA1.DAT" FOR OUTPUT AS #1
330 'CHECK TO GET OUT
340 BEEP
350 INPUT "Do you want to quit (Y/N) "; ANS$
360 IF ANS$ = "Y" OR ANS$ = "y" THEN END
370 'Initial parameters set up ---------------------------------------
380 P(1) = AIRLEAK
390 P(2) = PROCLEAK
400 P(3) = QSPLIT
410 P(4) = H2OX
420 P(5) = CH4OX
430 P(6) = CUEFF
440 P(7) = ZEFF
450 P(8) = AIRPURGE
460 P(9) = N2PURGE
470 P(10) = D2PURGE
480 P(11) = NITER
490 TAIL$(1) = "scfm AIRLEAK"
500 TAIL$(2) = "scfm PROCLEAK"
510 TAIL$(3) = "fraction to high temperature oxidation"
520 TAIL$(4) = "fraction H2 oxidized"
530 TAIL$(5) = "fraction CH4 oxidized"
540 TAIL$(6) = "fraction O2 oxidized"
550 TAIL$(7) = "fraction water removed"
560 TAIL$(8) = "scfm AIRPURGE"
570 TAIL$(9) = "scfm N2PURGE"
580 TAIL$(10) = "scfm D2PURGE"
590 TAIL$(11) = "iterations"
600 PRINT "Set up of Parameter values "
```

```
610 FOR I = 1 TO 11
620 PRINT "  (" I ")   " P(I) TAIL$(I)
630 NEXT I
640 INPUT "Do you want to make changes (Y/N) "; ANS$
650 IF ANS$ = "N" OR ANS$ = "n" THEN GOTO 700
660 INPUT "Select item number to be changed:", I
670 IF I >11 OR I < 1 THEN GOTO 4310
680 INPUT "Enter new value:",P(I)
690 GOTO 600
700 AIRLEAK = P(1)
710 PROCLEAK = P(2)
720 QSPLIT = P(3)
730 H2OX = P(4)
740 CH4OX = P(5)
750 CUEFF = P(6)
760 ZEFF = P(7)
770 AIRPURGE = P(8)
780 N2PURGE = P(9)
790 D2PURGE = P(10)
800 NITER = P(11)
810 'Initialize Flow Matrix -------------------------------------
820 FOR I = 1 TO 30
830 FOR J = 1 TO 15
840 Q(I,J) = 0
850 NEXT J
860 NEXT I
870 'Initialize Recirculating Stream ----------------- Stream # 1
880 Q(1,1) = .0000001
890 Q(1,2) = H2OX*D2PURGE
900 Q(1,3) = .0000001
910 Q(1,5) = .0000001
920 Q(1,7) = .0000001
930 Q(1,8) = .0001074
940 Q(1,9) = (1-ZEFF)*D2PURGE
950 Q(1,10) = .0000001
960 Q(1,11) = 100*(.21*AIRPURGE-.5*D2PURGE)/(AIRPURGE+N2PURGE)
970 Q(1,12) = 100 - Q(1,1) - Q(1,2) - Q(1,3) - Q(1,4) - Q(1,5)
980 Q(1,12) = Q(1,12) - Q(1,6) - Q(1,7) - Q(1,8) - Q(1,9)
990 Q(1,12) = Q(1,12) - Q(1,10) - Q(1,11)
1000 Q(1,13) = 100
1010 'Initial flow rates set up
1020 PRINT "Set-up of initial flow rates (scfm):"
1030 FOR I = 1 TO 12
1040 PRINT "  (" I ")   " CHEM$(I) Q(1,I)
1050 NEXT I
1060 INPUT "Do you want to make changes (Y/N) "; ANS$
1070 IF ANS$ = "N" OR ANS$ = "n" THEN GOTO 1170
1080 INPUT "Select item number to be changed:", I
1090 IF I >12 OR I < 1 THEN GOTO 4310
1100 INPUT "Enter new value:",Q(1,I)
1110 IF Q(1,I) < 0 THEN GOTO 4310
1120 IF I = 12 THEN GOTO 1010
1130 Q(1,12) = 100 - Q(1,1) - Q(1,2) - Q(1,3) - Q(1,4) - Q(1,5)
1140 Q(1,12) = Q(1,12) - Q(1,6) - Q(1,7) - Q(1,8) - Q(1,9)
1150 Q(1,12) = Q(1,12) - Q(1,10) - Q(1,11)
1160 GOTO 1010
1170 FOR I = 1 TO 13
```

```
1180 QSTART(I) = Q(1,I)
1190 NEXT I
1200 ACTSTART = (Q(1,3)*6+Q(1,7)*24*12/24+Q(1,10)*22*6/22)
1210 ACTSTART = ACTSTART/100/28316.85*1000000!*454*9700/359
1220 'Air Leak to Glove Boxes -------------------------- Stream # 2
1230 Q(2,8) = AIRLEAK*.02
1240 Q(2,11) = .21*.98*AIRLEAK
1250 Q(2,12) = .79*.98*AIRLEAK
1260 'Process Leak to Glove Boxes ---------------------- Stream # 3
1270 CT4IN = .01
1280 Q(3,1) = .25*PROCLEAK*(1-CT4IN)
1290 Q(3,2) = .25*PROCLEAK*(1-CT4IN)
1300 Q(3,3) = .5*PROCLEAK*(1-CT4IN)
1310 Q(3,7) = CT4IN*PROCLEAK
1320 ACTIN = Q(3,3)*6+Q(3,7)*24*12/24+Q(3,10)*22*6/22
1330 ACTIN = ACTIN * 60 * 24 * 365 * 454 * 9700 /359
1340 'N2 Purge Stream --------------------------------- Stream # 23
1350 Q(23,8) = .001*N2PURGE
1360 Q(23,12) = .999*N2PURGE
1370 'D2 Purge Stream --------------------------------- Stream # 24
1380 Q(24,2) = .999*D2PURGE
1390 Q(24,8) = .001*D2PURGE
1400 'Compressed Air Purge Stream --------------------- Stream # 25
1410 Q(25,8) = .001*AIRPURGE
1420 Q(25,11) = .21*.999*AIRPURGE
1430 Q(25,12) = .79*.999*AIRPURGE
1440 'LPRINT CHR$(12)
1450 'LPRINT "RTF Glove Box -- Stripper Simulation (Config. 1)"
1460 'LPRINT " Date =    " DATE$
1470 'LPRINT " Execution starts = " TIME$
1480 PRINT #1, CHR$(12)
1490 PRINT #1, "RTF Glove Box -- Stripper Simulation (Config. 1)"
1500 PRINT #1, " Date =    " DATE$
1510 PRINT #1, " Execution starts = " TIME$
1520 ITER = 0
1530 'Start of iterative calculations
1540 ITER = ITER + 1
1550 IF ITER > NITER THEN GOTO 3200
1560 'Combined Streams To Blower ----------------------- Stream # 4
1570 FOR I = 1 TO 12
1580 Q(4,I) = Q(1,I)+Q(2,I)+Q(3,I)+Q(23,I)+Q(24,I)+Q(25,I)
1590 NEXT I
1600 'Split to Low Temperature Oxidation --------------- Stream # 5
1610 FOR I = 1 TO 12
1620 Q(5,I) = (1-QSPLIT)*Q(4,I)
1630 NEXT I
1640 'After Heat Economizer ---------------------------- Stream # 6
1650 FOR I = 1 TO 12
1660 Q(6,I) = Q(5,I)
1670 NEXT I
1680 'After Heater ------------------------------------- Stream # 7
1690 FOR I = 1 TO 12
1700 Q(7,I) = Q(6,I)
1710 NEXT I
```

```
1720 'After Catalyst Bed --------------------------------- Stream # 8
1730 FOR I = 1 TO 12
1740 Q(8,I) = Q(7,I)
1750 NEXT I
1760 Q(8,1) = Q(7,1)*(1-H2OX)
1770 Q(8,2) = Q(7,2)*(1-H2OX)
1780 Q(8,3) = Q(7,3)*(1-H2OX)
1790 Q(8,8) = Q(7,8)+Q(7,1)*H2OX
1800 Q(8,9) = Q(7,9)+Q(7,2)*H2OX
1810 Q(8,10) = Q(7,10)+Q(7,3)*H2OX
1820 Q(8,11) = Q(7,11)-(Q(7,1)+Q(7,2)+Q(7,3))*H2OX*.5
1830 'After Heat Economizer ------------------------------ Stream # 9
1840 FOR I = 1 TO 12
1850 Q(9,I) = Q(8,I)
1860 NEXT I
1870 'After Cooler ------------------------------------- Stream # 10
1880 FOR I = 1 TO 12
1890 Q(10,I) = Q(9,I)
1900 NEXT I
1910 'Split to High Temperature Oxidation -------------- Stream # 11
1920 FOR I = 1 TO 12
1930 Q(11,I) = QSPLIT*Q(4,I)
1940 NEXT I
1950 'After Heat Economizer ---------------------------- Stream # 12
1960 FOR I = 1 TO 12
1970 Q(12,I) = Q(11,I)
1980 NEXT I
1990 'After Heater ------------------------------------- Stream # 13
2000 FOR I = 1 TO 12
2010 Q(13,I) = Q(12,I)
2020 NEXT I
2030 'After Catalyst Bed ------------------------------- Stream # 14
2040 Q(14,1) = Q(13,1)*(1-H2OX)
2050 Q(14,2) = Q(13,2)*(1-H2OX)
2060 Q(14,3) = Q(13,3)*(1-H2OX)
2070 Q(14,4) = Q(13,4)
2080 Q(14,5) = Q(13,5)+(Q(13,6)+Q(13,7))*CH4OX
2090 Q(14,6) = Q(13,6)*(1-CH4OX)
2100 Q(14,7) = Q(13,7)*(1-CH4OX)
2110 Q(14,8) = Q(13,8)+Q(13,1)*H2OX+2*Q(13,6)*CH4OX
2120 Q(14,9) = Q(13,9)+Q(13,2)*H2OX
2130 Q(14,10) = Q(13,10)+Q(13,3)*H2OX+2*Q(13,7)*CH4OX
2140 Q(14,11) = Q(13,11)-(Q(13,1)+Q(13,2)+Q(13,3))*H2OX*.5
2150 Q(14,11) = Q(14,11)-(Q(13,6)+Q(13,7))*CH4OX*2
2160 Q(14,12) = Q(13,12)
2170 'After Heat Economizer --------------------------- Stream # 15
2180 FOR I = 1 TO 12
2190 Q(15,I) = Q(14,I)
2200 NEXT I
2210 'After Cooler ------------------------------------ Stream # 16
2220 FOR I = 1 TO 12
2230 Q(16,I) = Q(15,I)
2240 NEXT I
2250 'Feed Z Bed -------------------------------------- Stream # 17
2260 FOR I = 1 TO 12
2270 Q(17,I) = Q(16,I)+Q(10,I)
2280 NEXT I
```

```
2290 'After Z Bed --------------------------------- Stream # 18
2300 FOR I = 1 TO 12
2310 Q(18,I) = Q(17,I)
2320 NEXT I
2330 Q(18,8) = Q(17,8)*(1-ZEFF)
2340 Q(18,9) = Q(17,9)*(1-ZEFF)
2350 Q(18,10) = Q(17,10)*(1-ZEFF)
2360 'Feed to Cu Bed ------------------------------ Stream # 19
2370 FOR I = 1 TO 12
2380 Q(19,I) = Q(18,I)
2390 NEXT I
2400 'DeOxed Stream ------------------------------- Stream # 20
2410 FOR I = 1 TO 12
2420 Q(20,I) = Q(19,I)
2430 NEXT I
2440 Q(20,11) = Q(19,11)*(1-CUEFF)
2450 'Cooled Stream ------------------------------- Stream # 21
2460 FOR I = 1 TO 12
2470 Q(21,I) = Q(20,I)
2480 NEXT I
2490 '
2500 'Calculate Total Stream Flow Rates (Streams 1 TO 21)
2510 FOR I = 1 TO 21
2520 Q(I,13) = 0
2530 FOR J = 1 TO 12
2540 Q(I,13) = Q(I,13) + Q(I,J)
2550 NEXT J
2560 NEXT I
2570 '
2580 'Calculate Concentrations (Streams 1 TO 21)
2590 FOR J =1 TO 21
2600 IF Q(J,13) = 0 THEN GOTO 2680
2610 C(J,13) = 0
2620 FOR I = 1 TO 12
2630 'PRINT J I Q(J,I)
2640 C(J,I) = Q(J,I)/Q(J,13)*1000000!
2650 C(J,13) = C(J,13) + C(J,I)
2660 NEXT I
2670 'PRINT J I Q(J,13)
2680 NEXT J
2690 'Stack Vent --------------------------------- Stream # 22
2700 FOR I = 1 TO 12
2710 Q(22,I) = C(21,I)*(Q(21,13)-100)/1000000!
2720 NEXT I
2730 'Oxygen Removed ----------------------------- Stream # 26
2740 FOR I = 1 TO 12
2750 Q(26,I) = 0
2760 NEXT I
2770 Q(26,11) = Q(19,11)*CUEFF
2780 'Water Removed ------------------------------ Stream # 27
2790 FOR I = 1 TO 12
2800 Q(27,I) = 0
2810 NEXT I
2820 Q(27,8) = Q(17,8)*ZEFF
2830 Q(27,9) = Q(17,9)*ZEFF
2840 Q(27,10) = Q(17,10)*ZEFF
2850 'Calculated Recirculation Stream ------------ Stream # 28
2860 FOR I = 1 TO 12
2870 Q(28,I) = Q(21,I) - Q(22,I)
2880 NEXT I
2890 '
```

```
2900 'Calculate Total Stream Flow Rates (Streams 22 TO 28)
2910 FOR I = 22 TO 28
2920 Q(I,13) = 0
2930 FOR J = 1 TO 12
2940 Q(I,13) = Q(I,13) + Q(I,J)
2950 'PRINT ITER, Q(I,13)        'Check total flow addition
2960 NEXT J
2970 NEXT I
2980 '
2990 'Calculate Concentrations (Streams 22 TO 28)
3000 FOR J = 22 TO 28
3010 IF Q(J,13) = 0 THEN GOTO 3090
3020 C(J,13) = 0
3030 FOR I = 1 TO 12
3040 'PRINT J I Q(J,I)
3050 C(J,I) = Q(J,I)/Q(J,13)*1000000!
3060 C(J,13) = C(J,13) + C(J,I)
3070 NEXT I
3080 'PRINT J I Q(J,13)
3090 NEXT J
3100 'Resetting Stream 1 Component Flows for next iteration
3110 FOR I = 1 TO 13
3120 Q(1,I) = Q(28,I)
3130 PQ(ITER,I) = Q(28,I)
3140 'PRINT "ITERATION =",ITER, Q(28,I)
3150 NEXT I
3160 ACT(ITER) = (Q(28,3)*6+Q(28,7)*24*12/24+Q(28,10)*22*6/22)
3170 ACT(ITER) = ACT(ITER)/100/28316.85*1000000!*454*9700/359
3180 PRINT "Finished iteration # = ", ITER
3190 GOTO 1530
3200 'Printout for Stream # 28 Checkout
3210 'PRINT " ","Flow Rate (scfm)","Concentration (ppm)"
3220 'FOR I = 1 TO 13
3230 'PRINT CHEM$(I),Q(28,I), C(28,I)
3240 'NEXT I
3250 'Print Iterations of Recirculation Stream Composition
3260 ACTOUT = Q(22,13)*ACT(NITER)*28316.85*60*24*365/1000000!
3270 DF = ACTIN/ACTOUT
3280 PRINT " "
3290 PRINT "AIRLEAK =     ", AIRLEAK , "scfm"
3300 PRINT "PROCESS LEAK =", PROCLEAK , "scfm"
3310 PRINT "HI-LOW SPLIT =", QSPLIT, "fraction to high temp bed"
3320 PRINT "H2 OXIDATION EFFICIENCY =", H2OX, "fraction oxidized"
3330 PRINT "CH4 OXIDATION EFFICIENCY =", CH4OX, "fraction oxidized"
3340 PRINT "COPPER BED EFFICIENCY =", CUEFF, "fraction O2 oxidized"
3350 PRINT "Z BED EFFICIENCY =", ZEFF, "fraction adsorbed/pass"
3360 PRINT "AIR PURGE RATE =", AIRPURGE, "scfm"
3370 PRINT "N2 PURGE RATE =", N2PURGE, "scfm"
3380 PRINT "D2 PURGE RATE =", D2PURGE, "scfm"
3390 PRINT "TOTAL ITERATIONS =", NITER
3400 PRINT "  "
3410 PRINT "O2 REMOVED BY CU BED =", Q(26,13), "scfm"
3420 PRINT "WATER REMOVED BY Z BED =    ";
3430 PRINT USING "##.######"; Q(27,13);
3440 PRINT "     scfm"
3450 PRINT "ANNUAL RELEASE/STRIPPER =",ACTOUT, "Ci"
3460 PRINT " PURGE STREAM FLOW RATE =",Q(22,13), "scfm"
3470 PRINT " PURGE STREAM ACTIVITY =",
```

```
3480 PRINT USING " #.######  "; ACT(NITER),
3490 PRINT "   uCi/cc"
3500 PRINT "ANNUAL ACTIVITY INPUT =", ACTIN, "Ci"
3510 PRINT "OVERALL STRIPPER DF =", DF
3520 PRINT "  "
3530 PRINT "ASSUMED PROCESS LEAK COMPOSITION:"
3540 FOR I = 1 TO 13
3550 IF Q(3,I) = 0 THEN GOTO 3610
3560 PRINT " ", CHEM$(I),
3570 PRINT USING "###.########  "; Q(3,I),
3580 PRINT "scfm",
3590 PRINT USING "###.####"; C(3,I)/10000,
3600 PRINT "  %"
3610 NEXT I
3620 PRINT "  "
3630 PRINT "RECIRCULATION STREAM COMPONENT FLOWS BY ITERATION:"
3640 PRINT "  "
3650 PRINT "              ----------------------- Iteration";
3660 PRINT " -----------------------"
3670 PRINT " ", "  1 in        " "1 out        " NITER-2;
3680 PRINT "         " NITER-1 "         " NITER
3690 FOR I = 1 TO 13
3700 PRINT USING "\           \"; CHEM$(I);
3710 PRINT USING "###.####### "; QSTART(I),PQ(1,I);
3720 PRINT USING "###.####### "; PQ(NITER-2,I),PQ(NITER-1,I),PQ(NITER,I)
3730 NEXT I
3740 PRINT "ACTIVITY    ";
3750 PRINT USING "###.####### ";ACTSTART,ACT(1),ACT(NITER-2);
3760 PRINT USING "###.####### ";ACT(NITER-1),ACT(NITER)
3770 PRINT "(uCi/cc)"
3780 PRINT #1, " Execution ends =    " TIME$
3790 PRINT #1, " "
3800 PRINT #1, "AIRLEAK =      ", AIRLEAK , "scfm"
3810 PRINT #1, "PROCESS LEAK =", PROCLEAK , "scfm"
3820 PRINT #1, "HI-LOW SPLIT =", QSPLIT, "fraction to high temp bed"
3830 PRINT #1, "H2 OXIDATION EFFICIENCY =", H2OX, "fraction oxidized"
3840 PRINT #1, "CH4 OXIDATION EFFICIENCY =", CH4OX, "fraction oxidized"
3850 PRINT #1, "COPPER BED EFFICIENCY =", CUEFF, "fraction O2 oxidized"
3860 PRINT #1, "Z BED EFFICIENCY =", ZEFF, "fraction adsorbed/pass"
3870 PRINT #1, "AIR PURGE RATE =", AIRPURGE, "scfm"
3880 PRINT #1, "N2 PURGE RATE =", N2PURGE, "scfm"
3890 PRINT #1, "D2 PURGE RATE =", D2PURGE, "scfm"
3900 PRINT #1, "TOTAL ITERATIONS =", NITER
3910 PRINT #1, "  "
3920 PRINT #1, "O2 REMOVED BY CU BED =", Q(26,13), "scfm"
3930 PRINT #1, "WATER REMOVED BY Z BED =    ";
3940 PRINT #1, USING "##.######"; Q(27,13);
3950 PRINT #1, "     scfm"
3960 PRINT #1, "ANNUAL RELEASE/STRIPPER =",ACTOUT, "Ci"
3970 PRINT #1, " PURGE STREAM FLOW RATE =",Q(22,13), "scfm"
3980 PRINT #1, " PURGE STREAM ACTIVITY =",
3990 PRINT #1, USING " #.######  "; ACT(NITER),
4000 PRINT #1, "   uCi/cc"
```

```
4010 PRINT "ANNUAL ACTIVITY INPUT", ACTIN, "Ci"
4020 PRINT "OVERALL STRIPPER DF =", DF
4030 PRINT #1, "  "
4040 PRINT #1, "ASSUMED PROCESS LEAK COMPOSITION:"
4050 FOR I = 1 TO 13
4060 IF Q(3,I) = 0 THEN GOTO 4120
4070 PRINT #1, " ", CHEM$(I),
4080 PRINT #1, USING "###.#########  "; Q(3,I),
4090 PRINT #1, "scfm",
4100 PRINT #1, USING "###.####"; C(3,I)/10000,
4110 PRINT #1, "  %"
4120 NEXT I
4130 PRINT #1, "  "
4140 PRINT #1, "RECIRCULATION STREAM COMPONENT FLOWS BY ITERATION:"
4150 PRINT #1, "  "
4160 PRINT #1, "              ----------------------- Iteration";
4170 PRINT #1, " -----------------------"
4180 PRINT #1, " ", "  1 in        " "1 out        " NITER-2;
4190 PRINT #1, "         " NITER-1 "         " NITER
4200 FOR I = 1 TO 13
4210 PRINT #1, USING "\           \"; CHEM$(I);
4220 PRINT #1, USING "###.####### "; QSTART(I),PQ(1,I);
4230 PRINT #1, USING "###.####### "; PQ(NITER-2,I),PQ(NITER-1,I),PQ(NITER,
4240 NEXT I
4250 PRINT#1, "ACTIVITY    ";
4260 PRINT #1, USING "###.####### ";ACTSTART,ACT(1),ACT(NITER-2);
4270 PRINT #1, USING "###.####### ";ACT(NITER-1),ACT(NITER)
4280 PRINT #1, "(uCi/cc)"
4290 GOTO 330
4300 END
4310 'Out of range indicator
4320 PRINT "Number out of range.  Please re-excute."
4330 END
```

Appendix A-2. Sample Simulation Output

```
RTF Glove Box -- Stripper Simulation (Config. 1)
 Date =   07-01-1986
 Execution starts = 07:50:04
 Execution ends =   08:03:45

AIRLEAK =                      .000002     scfm
PROCESS LEAK =                 .000002     scfm
HI-LOW SPLIT =                 .4          fraction to high temp bed
H2 OXIDATION EFFICIENCY =      .99         fraction oxidized
CH4 OXIDATION EFFICIENCY =     .99         fraction oxidized
COPPER BED EFFICIENCY =        0           fraction O2 oxidized
Z BED EFFICIENCY =             .9          fraction adsorbed/pass
AIR PURGE RATE =               .01         scfm
N2 PURGE RATE =                1           scfm
D2 PURGE RATE =                0           scfm
TOTAL ITERATIONS =             50

O2 REMOVED BY CU BED =         0           scfm
WATER REMOVED BY Z BED =       0.001011    scfm
ANNUAL RELEASE/STRIPPER =      71.2316     Ci
 PURGE STREAM FLOW RATE =      1.008995    scfm
 PURGE STREAM ACTIVITY =       0.004743    µCi/cc

ASSUMED PROCESS LEAK COMPOSITION:
              H2                0.00000050  scfm          24.7500  %
              D2                0.00000050  scfm          24.7500  %
              T2                0.00000099  scfm          49.5000  %
              CT4               0.00000002  scfm           1.0000  %
              TOTAL FLOW        0.00000200  scfm         100.0000  %

RECIRCULATION STREAM COMPONENT FLOWS BY ITERATION:

              ----------------------- Iteration -----------------------
                1 in        1 out          48           49           50
H2           0.0000001    0.0000000    0.0000000    0.0000000    0.0000000
D2           0.0000000    0.0000000    0.0000000    0.0000000    0.0000000
T2           0.0000001    0.0000000    0.0000000    0.0000000    0.0000000
CO           0.0000000    0.0000000    0.0000000    0.0000000    0.0000000
CO2          0.0000001    0.0000001    0.0000009    0.0000009    0.0000009
CH4          0.0000000    0.0000000    0.0000000    0.0000000    0.0000000
CT4          0.0000001    0.0000001    0.0000000    0.0000000    0.0000000
H2O          0.0001074    0.0001107    0.0001110    0.0001110    0.0001110
D2O          0.0000000    0.0000000    0.0000001    0.0000001    0.0000001
T2O          0.0000001    0.0000001    0.0000001    0.0000001    0.0000001
O2           0.2079208    0.2079201    0.2078979    0.2078975    0.2078971
N2          99.7919700   99.7919700   99.7919900   99.7919900   99.7919900
TOTAL FLOW 100.0000000  100.0000000  100.0000000  100.0000000  100.0000000
ACTIVITY     0.0103968    0.0072893    0.0047433    0.0047433    0.0047433
(µCi/cc)
```

Appendix B. Decontamination Time Calculation

The time needed to clean up or decontaminate an activity release from a glove box is approximated by the following formula:

$$T = \frac{-V}{Q\ (1 - 1/DF)}\ \ln\left(\frac{Cout}{Cin}\right)$$

where,

T = time to clean up, min
V = volume of enclosure or glove box, ft3
Q = purge flow rate, ft3/min
DF = decontamination efficiency of stripper per pass
Cout = desired concentration, ppm
Cin = initial concentration, ppm

The primary assumptions are

1. Perfect or complete mixing in the glove box
2. Released activity is instantaneously and completely dispersed in the entire glove box at time zero
3. The stripper has a constant decontamination efficiency each pass, independent of concentration

Based on the above equation, the approximate times for cleaning up a 10 gram tritium release in a V/Sta B glovebox is 58 minutes and in a V/Sta A glove box is 123 minutes. A gas temperature of 25 °C and a DF of 100 per pass are assumed. The flow rate is assumed to be 100 scfm, which is only valid in case of a large release and when the secondary stripper is operational.

	V/Sta B glove box	V/Sta A glove box
T2	10 gm	10 gm
Volume	423 ft3	955.5 ft3
Q	100 scfm	100 scfm
DF	100	100
Cin (0 °C gas)	3117 ppm	1380 ppm
(25 °C gas)	3402 ppm	1506 ppm
Cout (0°C gas)	3.8 ppb	3.8 ppb
(25 °C gas)	4.2 ppb	4.2 ppb

For the enclosure volumes and flow rates given in the above table, to clean from 0.1 µCi/cc to 0.01 µCi/cc would require about 10 minutes for the V/Sta B glove box and 22 minutes for the V/Sta A glove box. Flow rates from individual glove boxes to the primary strippers will be less than 100 scfm, resulting in longer clena-up times than those given here.