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Signature

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THIS DOCUMENT CONSISTS OF 5 PAGES NO. 7 OF 7 COPIES, SERIES A

K/TL-629, pt. 4 2818

FEB 24 9 24 AM '77

PLANT RECORDS RECEIPT NO. AL85980

STUDIES OF GASEOUS EFFLUENTS FROM NUCLEAR FACILITIES (U)

Principal Investigator - R. W. Levin (615) 483-8611, Ext. 3-3142

Project Scientist - J. H. Stewart, Jr. (615) 483-8611, Ext. 3-3377

February 15, 1977

K25RC

Authorization No. NC-40-253

Program No. 40-09

KTL 629 PT4 7 A

Contract Date: October 14, 1976 - March 31, 1977
ARPA Order No. 3255, Amendment 1

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Advanced Research Projects Agency, The Air Force Technical Applications Center, or the US Government.

Classification changed to: UNCLASSIFIED (level and category)

Thomas W. Sellby 2/19/96
ADC or ADD signature (first reviewer) Date

Jon Harston 2/20/96
ADD signature (final reviewer) Date

This document has been approved for release to the public by: J. Preston for A. S. Quist / SGT 3/13/96
Technical Information Officer Date
K-25 Site

— DECLASSIFIED —
by authority of: J. W. Sellby 2/19/96
Classification Specialist, LMES K-25 (date)
(authorized Declassifier's name and organization)
(official declass. notice, etc.) 3/13/96 (date)
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UNION CARBIDE

OAK RIDGE GASEOUS DIFFUSION PLANT
OAK RIDGE, TENNESSEE

prepared for the **U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION**
under **U.S. GOVERNMENT** *Contract W-7405 eng 26*

DOCUMENT INVENTORIED	
Date	
3-13-83	pte
9-8-84	pte
6-28-85	pte
7-1-86	pte
6-23-87	pte

This research was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by AFTAC/VT/6310/-/ERDA Patrick AFB FL 32925, under Contract No. 97 TO 400.1302.

[redacted]

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
P. O. BOX P, OAK RIDGE, TENNESSEE 37830

February 15, 1977

K/TL-629, Pt. 4

Lt. Col. Frederick B. Buoni
1035 TCHOG/TAS
Patrick Air Force Base, Florida 32925

Dear Col. Buoni:

The revised VT-6310 project funding estimate of $60,000, furnished in K/TL-629, Pt 3, may be considered a firm value. All Oak Ridge costs will be accumulated by March 31, 1977, and the project charge account will be closed. The actual charges will be made to your account during the first week of April, 1977.

Research Program and Plan

The flow diagrams for the laser and the aerodynamic (nozzle-type) enrichment plants submitted with our January report, K/TL-629, Pt 3, are as complete as can be generated for this state-of-the-art technology and should be considered our final data.

The March progress report will refine the data now being presented for UF_6 production plants and for facilities for reducing UF_6 to uranium metal.

We will collect gaseous effluents from typical gas centrifuge fabrication areas for quantitative analysis during late February. We also plan to complete sampling of the diffusion plant cascade gaseous effluents by the end of February.

Major Accomplishments During January 10 -February 10, 1977

The flow sheets on two versions of a laser UF_6 enrichment plant, and two versions of an aerodynamic UF_6 enrichment plant were completed.

We have now searched several thousand potentially useful literature references which may be of value to this program. A bibliography of pertinent references is being compiled.

The UF_6 production facility and the UF_6 reduction facility flow sheets have been compiled.

The actual barrier plant stack gas sampling has been accomplished. These specimens have been submitted for analytical studies.

Stack effluent sampling of the diffusion plant cascade was started, and the first collected specimens were submitted for analysis.

Additional infrared gas scanning information was furnished to Dr. Richard D. Hake (Standford Research Institute), in response to a new request.

Problems Encountered

The preparation of special sampling devices has required modification of existing techniques. These problems have been solved and the sampling program is underway. The extremely poor climatic sampling conditions from the severe winter in this area have also improved.

Final Status

It is our understanding that the scope of this program requires stack effluent sampling and analysis only for typical gaseous diffusion and gas centrifuge enrichment facilities. Therefore, our preliminary estimate of $60,000 to complete the project may now be considered a firm estimate.

We are collecting all costs for this project by March 31, and will close the account on that date. Our accounting system will then process the account, and the final billing will be made in April 1977.

Schedule

We will provide a March progress report, a separate data package described in K/TL-629, Pt. 3 (Future Plans), and a project completion report on March 31, 1977. A full compilation of the sampling and analysis data will be provided by June 30, 1977, as you requested.

Very truly yours,

R. W. Levin

R. W. Levin, Director
K-25 Technical Services Division

RWL:JHS:ae

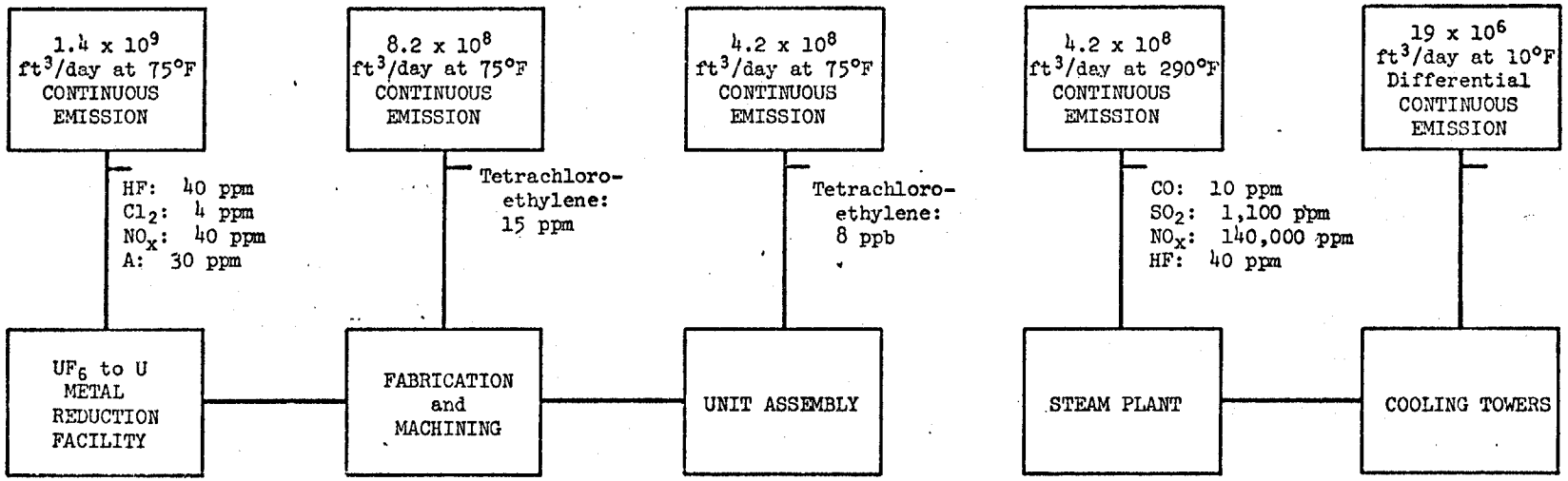
Attachments (2)

Copies: AFTAC/TAS (2)
ARDA/MIS (2)
W. J. Wilcox, Jr.
File - RC

B Series Distribution
Charles G. Halstead - du Pont
Aiken, S. C.

Attachment 1

GASES EMITTED FROM A TYPICAL URANIUM HEXAFLUORIDE REDUCTION AND METAL FABRICATION PLANT



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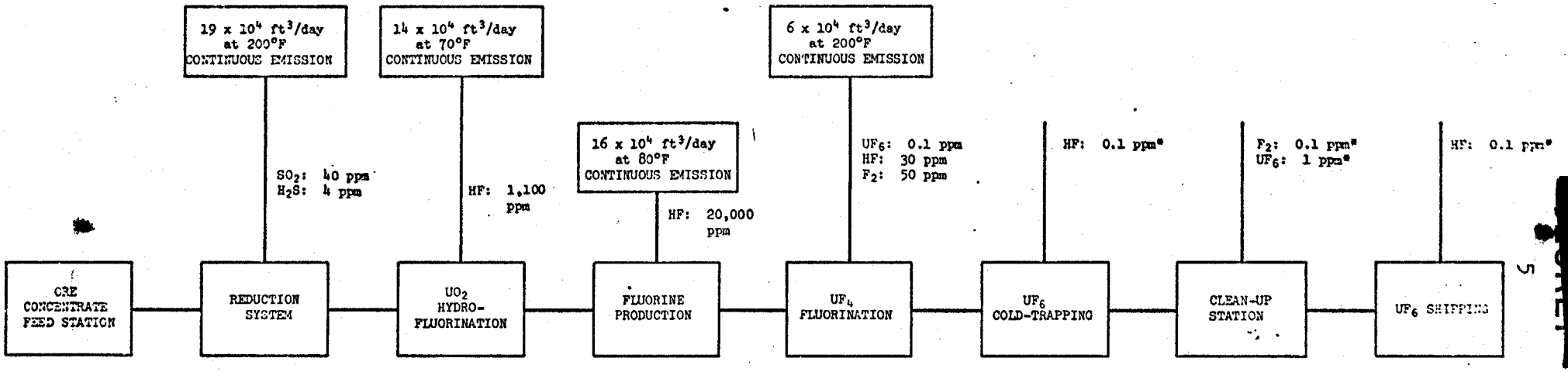
Attachment 2

GASES EMITTED FROM A TYPICAL URANIUM HEXAFLUORIDE PRODUCTION FACILITY



UNION CARBIDE FLUIDIZED BED PROCESS

*Estimated concentration.

ChemRisk/Shonka Research Associates, Inc., Document Request Form

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Signature

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K25RC

This document consists of 7 pages
No. 7 of 7 copies. Series A
K/TL-629, Pt. 3 2819

STUDIES OF GASEOUS EFFLUENTS FROM NUCLEAR FACILITIES (U)

Principal Investigator - R. W. Levin (615) 483-8611, Ext. 3-3142

Project Scientist - J. H. Stewart, Jr. (615) 483-8611, Ext. 3-3377

January 17, 1977

Authorization No. NC-40-253 Program No. 40-09

Contract Date: October 14, 1976 - March 31, 1977
ARPA Order No. 3255, Amendment 1

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Advanced Research Projects Agency, The Air Force Technical Applications Center, or the U. S. Government.

prepared for the **U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION** *under* **U.S. GOVERNMENT** *Contract W-7405 eng 26*

This research was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by AFTAC/VT/6310/-/ERDA Patrick AFB FL 32925, under Contract No. 97 TO 400.1302.

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
P. O. BOX P, OAK RIDGE, TENNESSEE 37830

January 17, 1977

K/TL-629, Pt. 3

Lt. Col. Frederick B. Buoni
1035 TCHOG/TAS
Patrick Air Force Base, Florida 32925

Dear Lt. Col. Buoni:

A revised VT-6310 project funding estimate has been made. This will now include field-sampling of ORGDP stack gas effluents and laboratory analysis for compounds of interest to this program.

Research Program and Plan

An evaluation of all available information has shown that the flow diagrams for both gaseous diffusion and gas centrifuge enrichment facilities submitted with our last report (K/TL-629, Pt 2) are as complete as can be generated at this time and are, therefore, our final data on these systems. This current progress report describes our best state-of-knowledge for the laser and for aerodynamic (nozzle-type) enrichment plants. The February report will consider UF_6 production and UF_6 reduction facilities. We plan to send documents, infrared scans of gases, etc. (as outlined in K/TL-629, Pt. 2 - Future Plans) in March.

Objectives

This study will identify the gaseous effluents which are emitted by American Uranium enrichment facilities, UF_6 production facilities, and facilities used to produce uranium metal from UF_6. Where possible, we will indicate gaseous effluents considered characteristic of these facilities, we will also provide on-site sampling and laboratory analysis to indicate the reliability of the computed gas concentrations previously reported.

Scope

The study will continue to be restricted to the gaseous diffusion, gas centrifuge, laser, and Becker "Nozzle-types" of enrichment facilities, to UF_6 production facilities, and to facilities for the reduction of UF_6 to uranium metal.

Major Accomplishments

The final report on gaseous diffusion enrichment and gas centrifuge enrichment was submitted on December 14, 1976. Please note, however, a necessary correction on the flow diagram for the gas centrifuge enrichment plant (K/TL-629, Pt. 2). The Freon/TA* is 89% trichlorotrifluoroethane and 11% acetone, not the R-113.

We have compiled flow sheets on two versions of a laser UF_6 enrichment plant, and two versions of an aerodynamic UF_6 enrichment plant.

You are aware that no laser, or aerodynamic, production-scale enrichment plant exists. Therefore, we have taken the best available literature, consultant, and ERDA information to provide these flow diagrams. With no operating experience we are not able to provide useful estimated concentrations of the IF_7, H_2, Ar, He, etc. We would expect to find these gases in higher-than background concentrations near these types of full-scale UF_6 enrichment plants.

We have now prepared a tentative bibliography of 23 published items (from several hundred searched) which may be of value to this program. We plan to computer-search at least two more major data banks and evaluate all of the "possible interest" documents, to ensure their value and relevance. We plan to submit this expanded listing in our March 10, 1977 progress report.

We have begun collecting data on the UF_6 production and UF_6 reduction facilities, which will be submitted in the February 10, 1977 report.

Our environmental sampling teams have been preparing special sorption tubes and evacuated specimen collection bulbs. The actual sampling of stacks is scheduled to begin during the week of January 17, 1977.

A set of approximately 24 infrared gas scans was sent to Dr. Richard D. Hake (Stanford Research Institute) on January 13, 1977, as you requested.

Problems Encountered

Expansion of the original project request, from a theoretical study to a sampling and analysis study, required reassignment of some personnel. This has now been essentially completed. We may, however, be unable to complete a total plant-wide sampling and analysis program prior to June 30, 1977. The weather is also a factor in this region, when considering a careful sampling study on rooftops and vent stacks during high winds on cold days. We have planned to initiate the sampling during the week of January 17, 1977.

Fiscal Status

We estimate that the ORGDP costs for this project will not exceed $60,000. This estimate will be further refined for the February 10 report, after the initial portion of the stack sampling is completed.

Future Plans

A separate data package will be prepared to include HF polymer data, infrared scans, the estimated uranium inventory of production-scale diffusion and centrifuge plants, and upper limits of gaseous compounds which may be expected in a catastrophic incident concerning HF or UF_6 cylinders. Unless other personnel need individual copies of ORO-651 R-3, (a 72 page document entitled *Uranium Hexafluoride: Handling Procedures and Container Criteria*), we plan to send only one copy to Col. Buoni.

The gas chromatographic - mass spectrometer and the special instrumentation laboratories have agreed to furnish analytical priority to support our schedules, but may be unable to complete all analyses prior to June 30, 1977.

Schedule

The reports schedule has not been changed except that a full compilation of sampling and analysis data may not be possible prior to June 30, 1977. In this case, we can issue a status report on March 31, 1977 and the full completion report by June 30. If you wish, we can still issue the completion report on March 31, and an "update" report by June 30, 1977, which will include the analytical data.

Please advise me of your wishes concerning the schedule for this project.

Very truly yours,

R. W. Levin, Director
K-25 Technical Services Division

RWL:JHS:ae

Attachments (3)

Copies: AFTAC/TAS (2)
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W. J. Wilcox, Jr.
File (RC)✓

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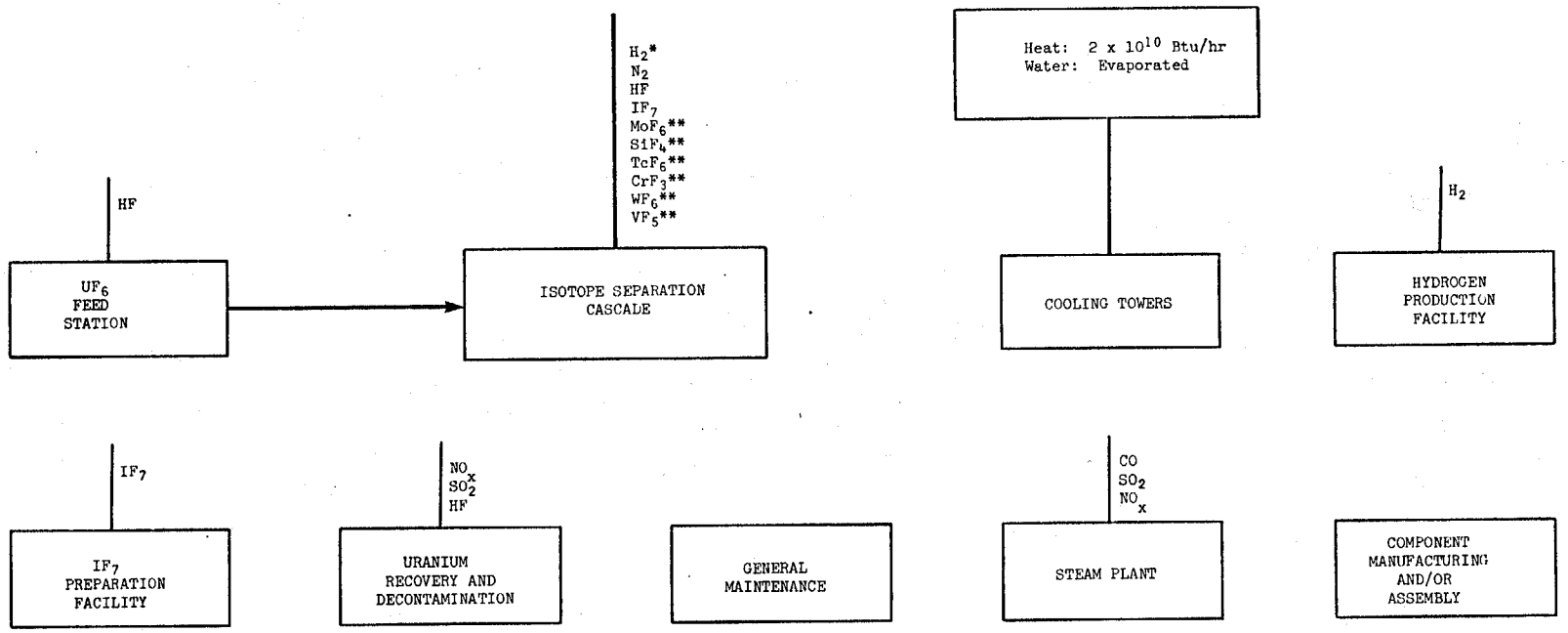
Charles G. Halstead - du Pont
Aiken, S. C.

Attachment 1

GASES EMITTED FROM A CONCEPTUAL 8.75 x 10^6 SWU/YR ISOTOPE ENRICHMENT PLANT USING THE AERODYNAMIC JET-NOZZLE* OR STATIONARY-WALL CENTRIFUGE* PROCESS (BASED ON THE 1976 U.S.A. STATE OF THE TECHNOLOGY)

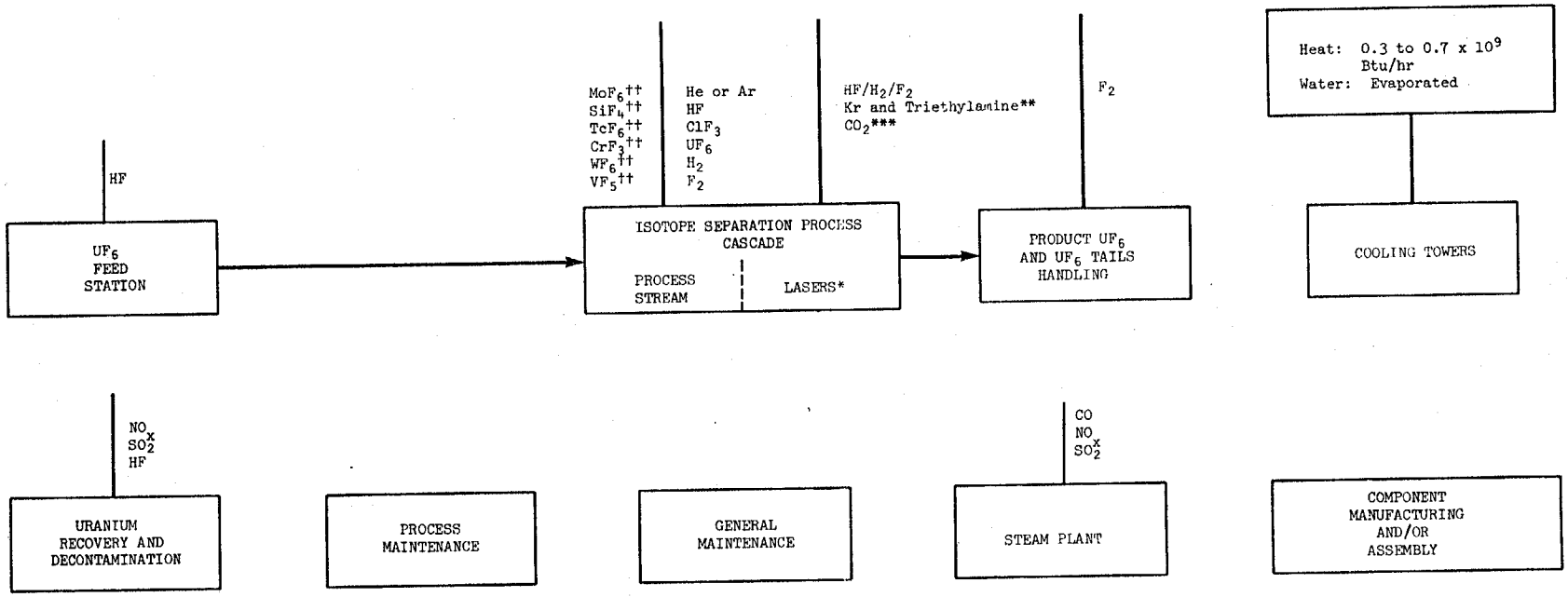


*Greater emission rates are likely from the stationary-wall centrifuge process than from the jet-nozzle process since the former operates at up to 6 atmospheres, while the operating pressure for the latter is subatmospheric.

**Chemically unstable compounds which may exist in gas releases if reprocessed reactor uranium is fed to the cascade.

Attachment 2

GASES EMITTED FROM A CONCEPTUAL† 8.75 x 10^6 SWU/YR ISOTOPE ENRICHMENT LASER PLANT, USING URANIUM HEXAFLUORIDE AS THE PROCESS MEDIUM (BASED ON THE 1976 U.S.A. STATE OF THE TECHNOLOGY)



*As technology advances in this and any country, other lasers may be chosen for a uranium isotope enrichment plant. Emissions from the plant laser stream will change correspondingly.

**One of several frequency-shifting vapor phase dyes that may prove suitable.

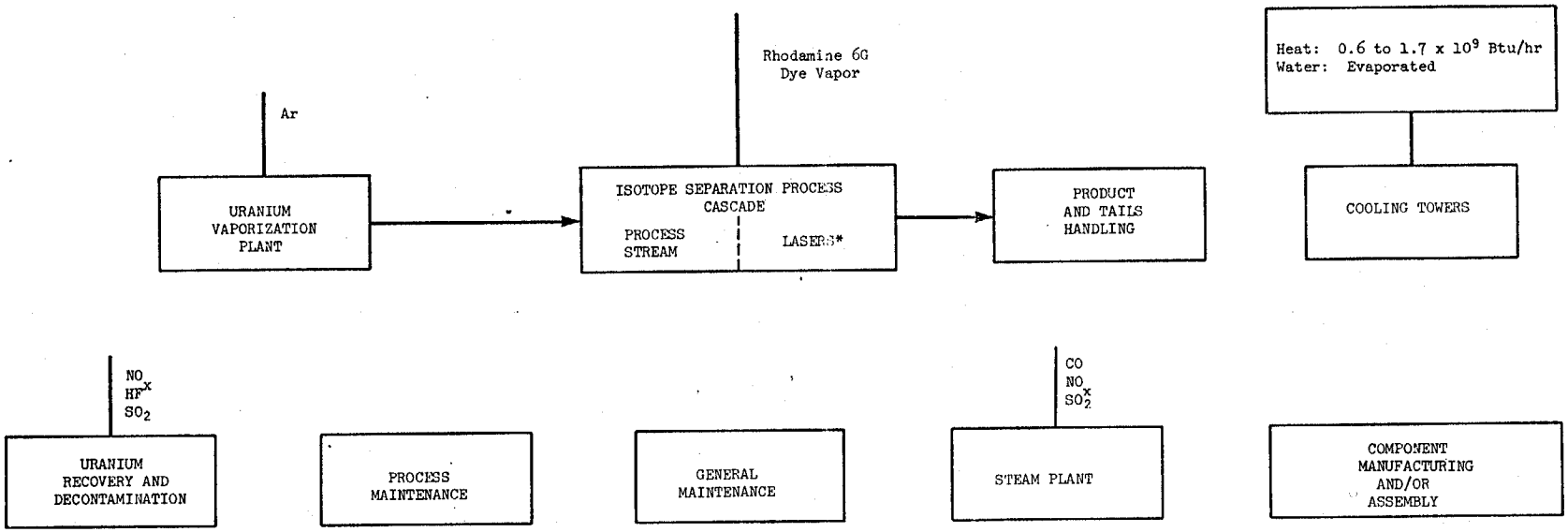
***Modification of the carbon, i.e., ^{12}C and ^{14}C, isotopic concentration may prove desirable.

†Currently in the world, technology has not reached the point where the design of a laser plant for the enrichment of uranium isotopes is possible. The information presented here is strictly conjectural.

††Chemically unstable compounds which may exist in gas releases if reprocessed reactor uranium is fed to the cascade.

Attachment 3

GASES EMITTED FROM A CONCEPTUAL** 8.75 x 10^6 SWU/YR ISOTOPE ENRICHMENT LASER PLANT, USING URANIUM VAPOR AS THE PROCESS MEDIUM (BASED ON THE 1976 U.S.A. STATE OF THE TECHNOLOGY)



*As technology advances in this and any country, other lasers may be chosen for a uranium isotope enrichment plant. Emissions from the plant laser stream will change correspondingly.

**Currently in the world, technology has not reached the point where the design of a laser plant for the enrichment of uranium isotopes is possible. The information presented here is strictly conjectural.

2818

ChemRisk/Shonka Research Associates, Inc., Document Request Form

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(This section to be completed by ChemRisk/Shonka Research Associates, I

Date document received

Signature

2818

K/EM-382

SANITIZED VERSION OF STUDIES OF GASEOUS EFFLUENTS FROM NUCLEAR FACILITIES (6/13/77)

(SANITIZED VERSION OF CRD DOCUMENT # K/TL-629/PT5)

Compiled by
S. G. Thornton
Environmental Management Division
OAK RIDGE K-25 SITE
for the Health Studies Agreement

March 13, 1996

Oak Ridge K-25 Site
Oak Ridge, Tennessee 37831-7314
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the U.S. DEPARTMENT OF ENERGY
under Contract DE-AC05-84OR21400

KTL-629 Part 5

STUDIES OF GASEOUS EFFLUENTS FROM NUCLEAR FACILITIES (U)

Principal Investigator
R. W. Levin (615) 483-8611, Ext. 3-3142

Project Scientist
J. H. Stewart, Jr. (615) 483-8611, Ext. 3-9316

June 13, 1977

Authorization No. NC-40-253 Program No. 40-09

Contract Date: October 14, 1976 - March 31, 1977
ARPA Order No. 3255, Amendment 1

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Advanced Research Projects Agency, The Air Force Technical Applications Center, or the US Government.

UNION CARBIDE
OAK RIDGE GASEOUS DIFFUSION PLANT
OAK RIDGE, TENNESSEE

prepared for the **U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION**
under **U.S. GOVERNMENT** *Contract W-7405 eng 26*

This research was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by AFTAC/VT/6310/-/ERDA Patrick AFB FL 32925, under Contract No. 97 TO 400.1302.

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
P. O. BOX P, OAK RIDGE, TENNESSEE 37830

June 13, 1977
K/[illegible]-629, Page 5
2

Lt. Col. Frederick B. Buoni
1035 TCHOG/TAS
Patrick Air Force Base, Florida 32925

Dear Col. Buoni:

The Oak Ridge Gaseous Diffusion Plant (ORGDP), Technical Services Division, has completed the requirements of the revised VT-6310 Project. We appreciate your permission to consolidate the March 1977 progress report and this completion report into a single document.

Summary

The purpose of Project VT-6310 was to provide a study of uranium production facilities and to identify gaseous effluents of potential value in detecting these facilities within the ARPA/AFTAC Remote Sensing Program.

The ORGDP studies have provided:

1. Flow diagrams of the gaseous diffusion, gas centrifuge, laser and aerodynamic (nozzle type) enrichment facilities.

2. Flow diagrams of UF_6 production facilities and a gaseous effluent listing.

3. A flow diagram for facilities which produce uranium metal from UF_6 and a gaseous effluent listing.

4. A document (ORO-651, Rev. 4) on procedures for handling uranium hexafluoride (Attachment 1).

5. A literature search of approximately 3.2 million references and an evaluation of some 200 potentially-valuable references which resulted in a bibliography of 25 pertinent references (Attachment 2).

6. A reference paper concerning polymeric hydrogen fluoride (Attachment 3).

7. A gaseous diffusion plant sampling-and-analysis program for stack gas effluents to determine the reliability of the computed effluent concentrations in the flow charts.

8. A list of chemical compounds which would be indicative of uranium enrichment facilities (Table 1).

9. A list of chemical compounds indicative of UF_6 production facilities (Table 2).

10. The uranium inventory of 8750 MTU centrifuge and diffusion enrichment facilities.

11. The hydrogen fluoride air concentration expected from an inadvertent rupture of a UF_6 shipping cylinder or from a hydrogen fluoride storage tank.

12. A set of infrared spectra of the compounds of interest in this study (Attachment 4).

13. Recommendations for future studies.

The VT-6310 Project was completed within the allocated $85,000 funding.

Introduction

The AFTAC Project VT-6310-ERDA studies performed under this contract have identified gaseous nonradioactive effluents from uranium enrichment, uranium production, and uranium reduction facilities. The gases considered characteristic of these uranium facilities may be of potential value in detecting such facilities within the ARPA/AFTAC Remote Sensing Program. These gaseous effluents are listed in Table 1 and Table 2. The flow charts for typical uranium facilities (Figures 1-8) show gaseous effluents and their expected concentrations at the emission sites in each facility.

Classified technology about uranium enrichment is revealed in this report and therefore is protected as Secret-Restricted Data. Some of the most sensitive information concerns materials used in centrifuge rotor manufacture and distribution of this information should be controlled.

Description of Work

The flow charts, computed concentration of gases, and conclusions were reached in this study by evaluating the best available Union Carbide, Energy Research and Development Administration, literature search, and consultant data.

The uranium inventory of an 8750 metric ton gas centrifuge enrichment plant is 13 metric tons of UF_6; the inventory of a similar gaseous diffusion plant is 550 metric tons of UF_6.

The hydrogen fluoride concentration expected in the general area of a ruptured hydrogen fluoride storage tank is 2.7×10^5 mg/M^3. The hydrogen fluoride concentration in the immediate area of a ruptured UF_6 shipping cylinder is 2×10^4 mg/M^3.

Stack gas effluents have been sampled in both the gaseous diffusion and the gas centrifuge Oak Ridge enrichment facilities. These specimens are now being analyzed by such methods as gas chromatography-mass spectrometry, infrared analysis, mass spectrometry, spark source-mass spectrometry, atomic absorption, and emission spectroscopy. The data will be compiled, evaluated, and reported in July 1977.

Recommendations for Future Work

The infrared detection of gaseous effluents characteristic of uranium enrichment facilities depends on availability of high quality spectra of the pure gases. The use of existing spectra of these unusual compounds is difficult, since they were derived for different purposes. The Oak Ridge Gaseous Diffusion Plant could produce and purify gases such as UF_6, ClF_3, ClO_2F, ClO_3F, and OF_2; these gases could then be scanned in corrosion-resistant sample cells in a high resolution infrared spectrometer to provide digital-quality spectra. The estimated cost for this study would be approximately $15,000. It may also be possible to prepare and study additional gases of interest.

Conclusions

There are gaseous effluents which are indicative of uranium enrichment and uranium production facilities. Several of these compounds have been identified for each type of facility. The VT-6310 Project was completed within the $85,000 budget.

Very truly yours,

R. W. Levin

R. W. Levin, Director
K-25 Technical Services Division

RWL:JHS:cr
Enclosures: 4

ORO-651, Rev. 4
Nonradioactive Gaseous Effluents from Selected Fuel Cycle Activities: A Bibliography
The Overlapping Hydrogen Fluoride Monomer-Dimer Spectra
Infrared Spectra of Gaseous Effluents (Data Sheets)

Distribution
1-2. AFTAC/TAS
3-4. ARDA/MIS
5-6. DDC
7. R. W. Levin (RC)
8. W. J. Wilcox, Jr.
9. C. G. Halstead - du Pont
Aiken, S. C.

Table 1

GASEOUS EFFLUENTS CHARACTERISTIC OF URANIUM ENRICHMENT FACILITIES

Gaseous Diffusion	Gas Centrifuge
1. ClF_3; chlorine trifluoride	1. MPDA; m-phenylenediamine
2. ClO_2F; chloryl fluoride	2. ECPE; 2,3 epoxycyclopentyl ether
3. ClO_3F; perchloryl fluoride	3. freon/TA; trichlorotrifluorethane and 11% acetone
Aerodynamic (nozzle) Process	**Laser Enrichment**
1. H_2; hydrogen gas	1. He; helium gas
2. IF_7; iodine heptoiodide	2. Ar; argon gas
3. HF; hydrogen fluoride	3. ClF_3; chlorine trifluoride
	4. HF; hydrogen fluoride

Chemically unstable compounds which may exist in purge stack gases include MoF_6, SiF_4, TcF_6, CrF_3, WF_6, and VF_5.

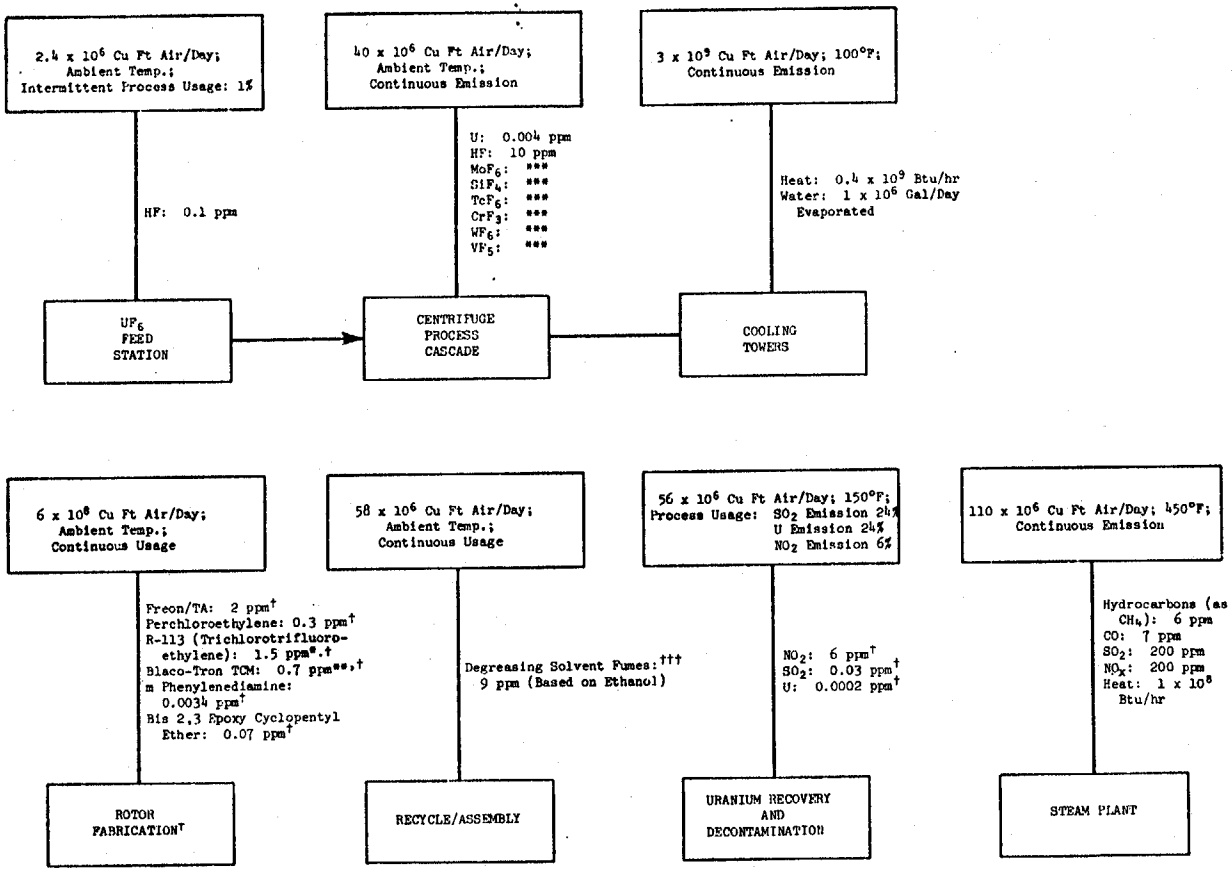
Table 2

GASEOUS EFFLUENTS CHARACTERISTIC OF URANIUM PRODUCTION AND UF_6 REDUCTION FACILITIES

UF_6 Production Facility	UF_6 Reduction-Metal Fabrication
1. HF; hydrogen fluoride	1. HF; hydrogen fluoride
2. F_2; fluorine	2. $Cl_2C:CCl_2$; tetrachloroethylene
	3. Cl_2; chlorine

Figure 1

GASES EMITTED FROM A TYPICAL 8.75 x 10^6 SWU/YR GAS CENTRIFUGE ENRICHMENT PLANT(a)



*R-113 is 89% trichlorotrifluoroethane and 11% acetone.

**Blaco-Tron TCM is an azeotropic mixture containing 39% trichlorotrifluoroethane, 52% methylene chloride, and 9% cyclopentane.

***Chemically unstable compounds which may exist in purge stack gas. Estimated max. concentration = 0.2 ppm for each.

†These values apply if all operations are in process simultaneously.

††If rotors are made of metal, the noted emissions will not apply. Instead only SO_2 or NO_2 fumes from standard non-chloride anodizing solutions will be present in the process off gases.

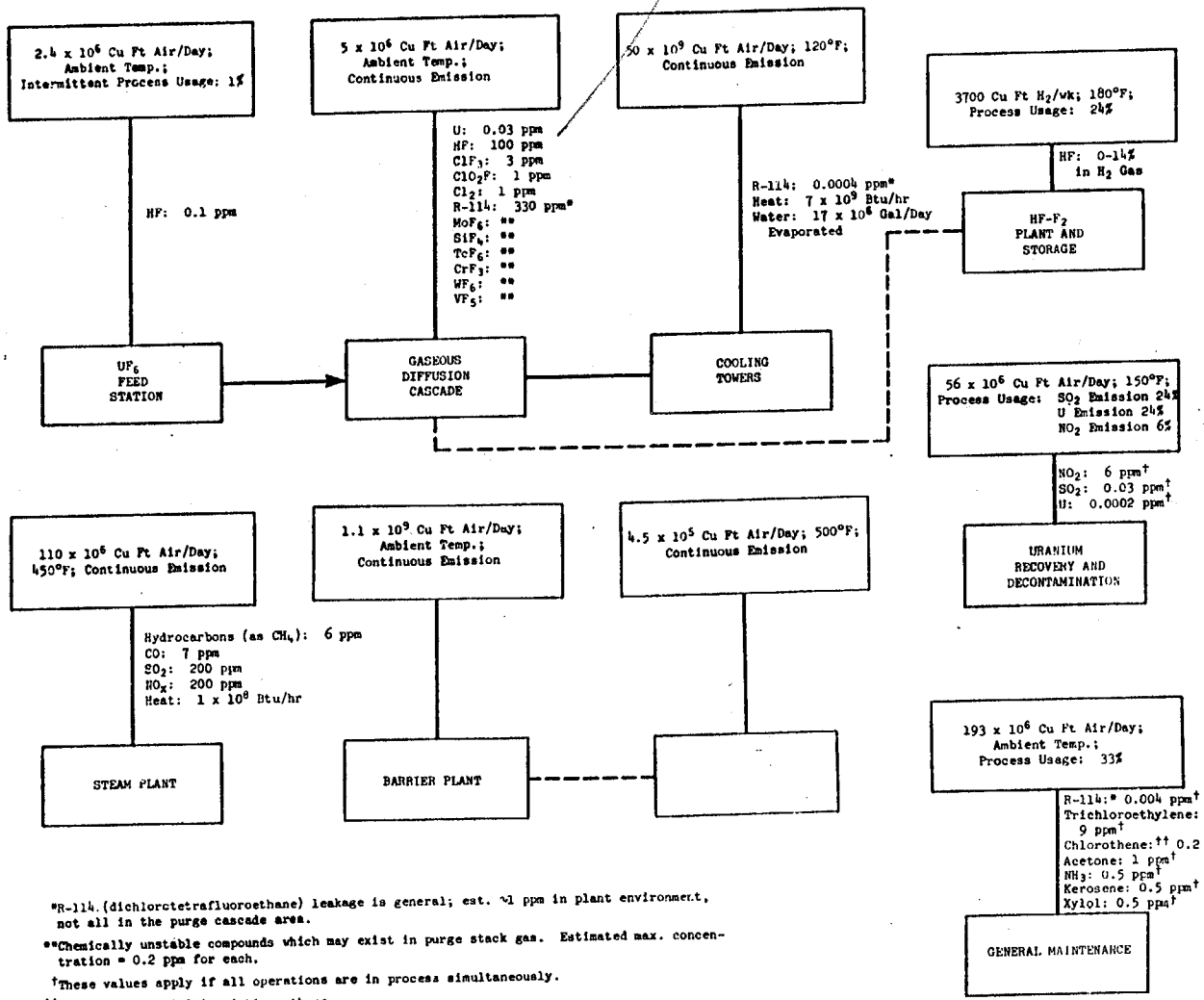
†††The degreasing solvent could also be of Freon (R-113), acetone, methylene chloride, or even soapy water.

The concentrations of the effluents are computed from the best available data, but should not be considered exact values.

(a) Classified technology about uranium enrichment is revealed in this report and therefore is protected as Secret-Restricted Data. Some of the most sensitive information concerns materials used in centrifuge rotor manufacture and distribution of this information should be controlled.

Figure 2

GASES EMITTED FROM A TYPICAL 8.75 x 10^6 SWU/YR GASEOUS DIFFUSION PLANT



*R-114 (dichlorctetrafluoroethane) leakage is general; est. .1 ppm in plant environment, not all in the purge cascade area.

**Chemically unstable compounds which may exist in purge stack gas. Estimated max. concentration = 0.2 ppm for each.

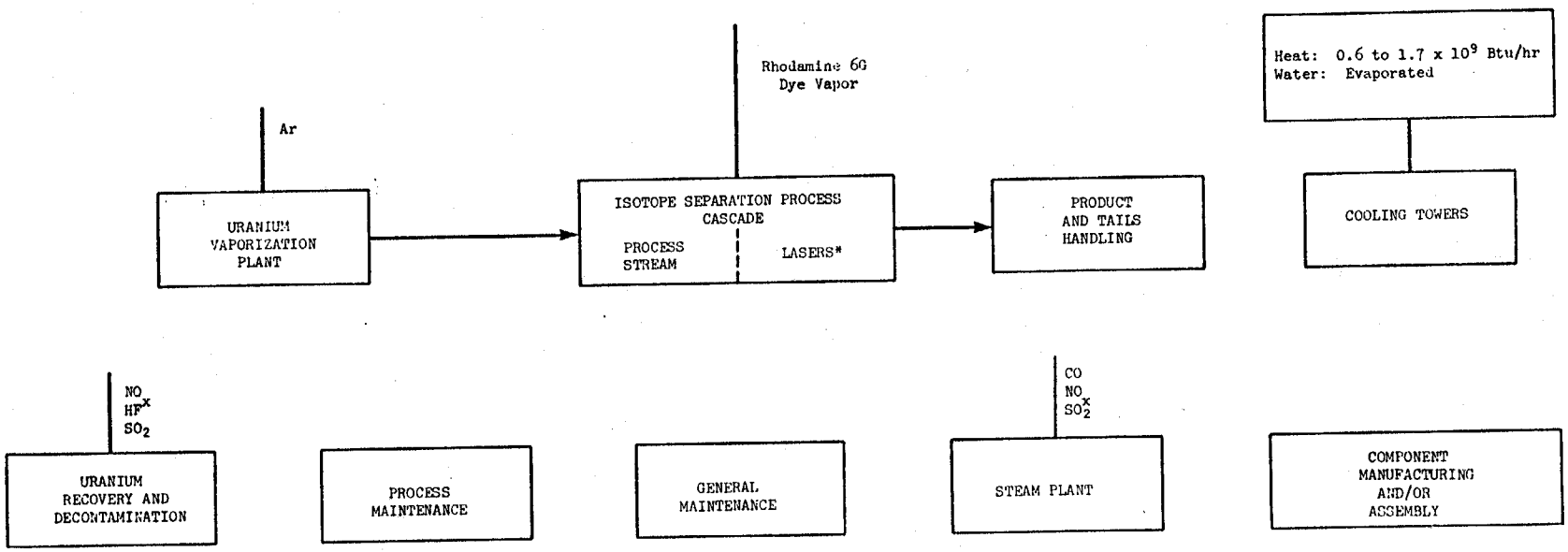
†These values apply if all operations are in process simultaneously.

††Chlorothene is 1,1,1 trichloroethane.

The concentrations of the effluents are computed from the best available data, but should not be considered exact values.

Figure 3

GASES EMITTED FROM A CONCEPTUAL** 8.75 x 10^6 SWU/YR ISOTOPE ENRICHMENT LASER PLANT,
USING URANIUM VAPOR AS THE PROCESS MEDIUM
(BASED ON THE 1976 U.S.A. STATE OF THE TECHNOLOGY)

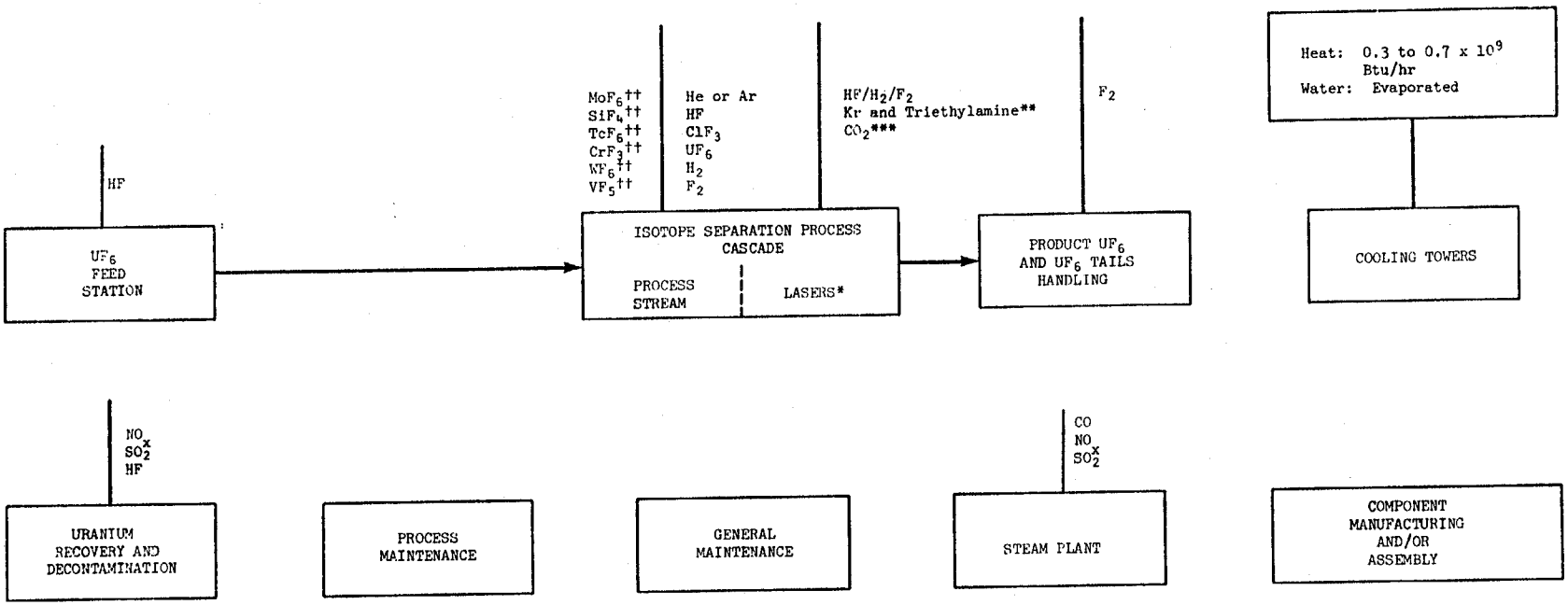


*As technology advances in this and any country, other lasers may be chosen for a uranium isotope enrichment plant. Emissions from the plant laser stream will change correspondingly.

**Currently in the world, technology has not reached the point where the design of a laser plant for the enrichment of uranium isotopes is possible. The information presented here is strictly conjectural.

Figure 4

GASES EMITTED FROM A CONCEPTUAL† 8.75 x 10^6 SWU/YR ISOTOPE ENRICHMENT LASER PLANT, USING URANIUM HEXAFLUORIDE AS THE PROCESS MEDIUM (BASED ON THE 1976 U.S.A. STATE OF THE TECHNOLOGY)



*As technology advances in this and any country, other lasers may be chosen for a uranium isotope enrichment plant. Emissions from the plant laser stream will change correspondingly.

**One of several frequency-shifting vapor phase dyes that may prove suitable.

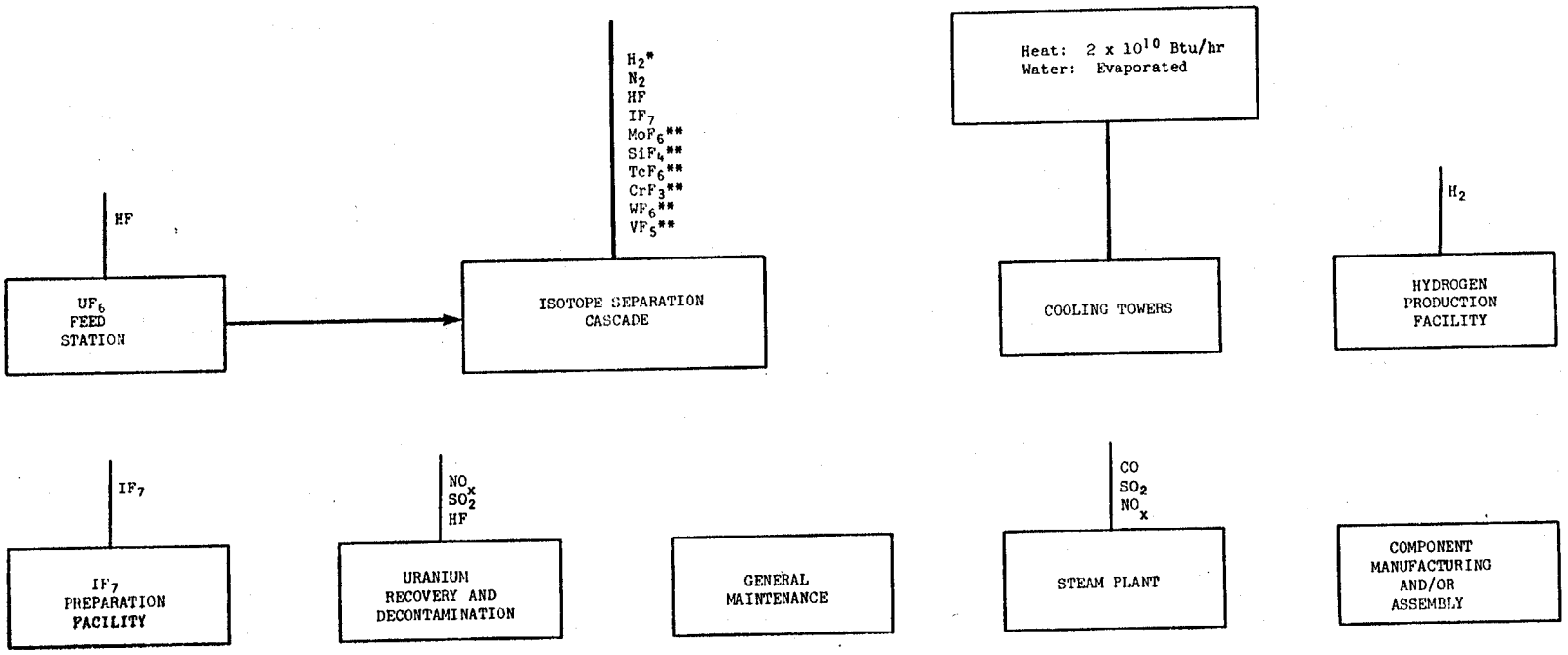
***Modification of the carbon, i.e., ^{12}C and ^{14}C, isotopic concentration may prove desirable.

†Currently in the world, technology has not reached the point where the design of a laser plant for the enrichment of uranium isotopes is possible. The information presented here is strictly conjectural.

††Chemically unstable compounds which may exist in gas releases if reprocessed reactor uranium is fed to the cascade.

Figure 5

GASES EMITTED FROM A CONCEPTUAL 8.75 x 10^6 SWU/YR ISOTOPE ENRICHMENT PLANT USING THE AERODYNAMIC JET-NOZZLE* OR STATIONARY-WALL CENTRIFUGE* PROCESS (BASED ON THE 1976 U.S.A. STATE OF THE TECHNOLOGY)



*Greater emission rates are likely from the stationary-wall centrifuge process than from the jet-nozzle process since the former operates at up to 6 atmospheres, while the operating pressure for the latter is subatmospheric.
**Chemically unstable compounds which may exist in gas releases if reprocessed reactor uranium is fed to the cascade.

Figure 6

GASES EMITTED FROM A TYPICAL URANIUM HEXAFLUORIDE REDUCTION AND METAL FABRICATION PLANT

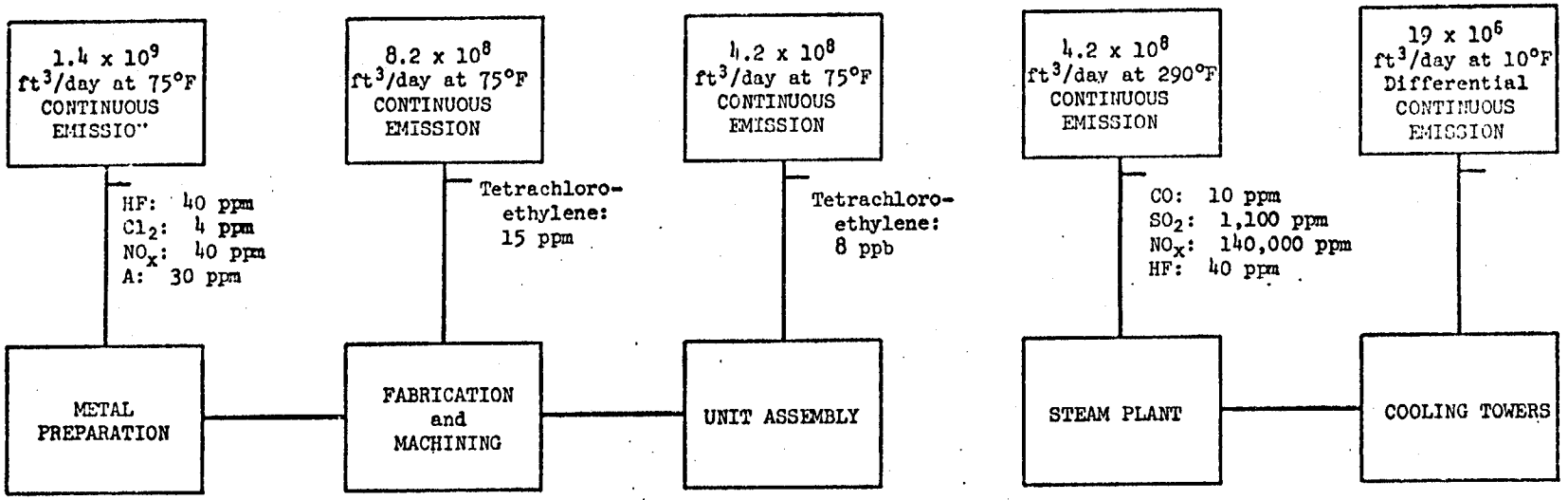
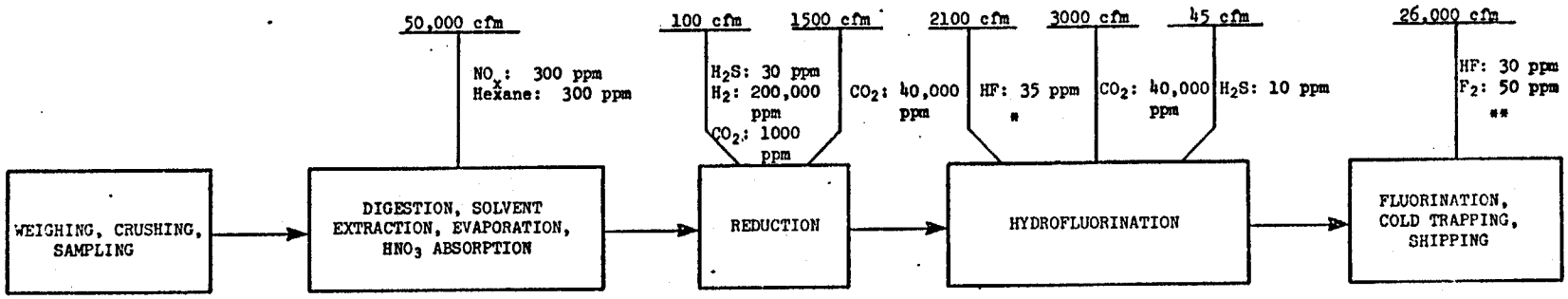
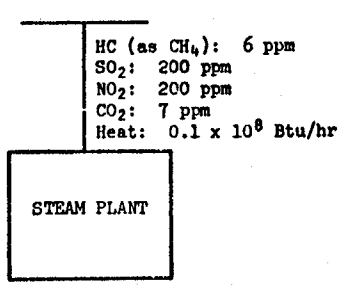
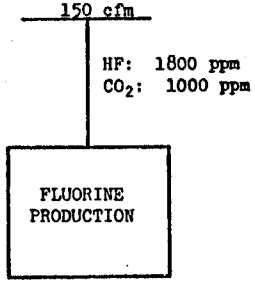


Figure 7

10,000 SHORT TONS U/YEAR UF_6 PRODUCTION FACILITY, *WET* PROCESS







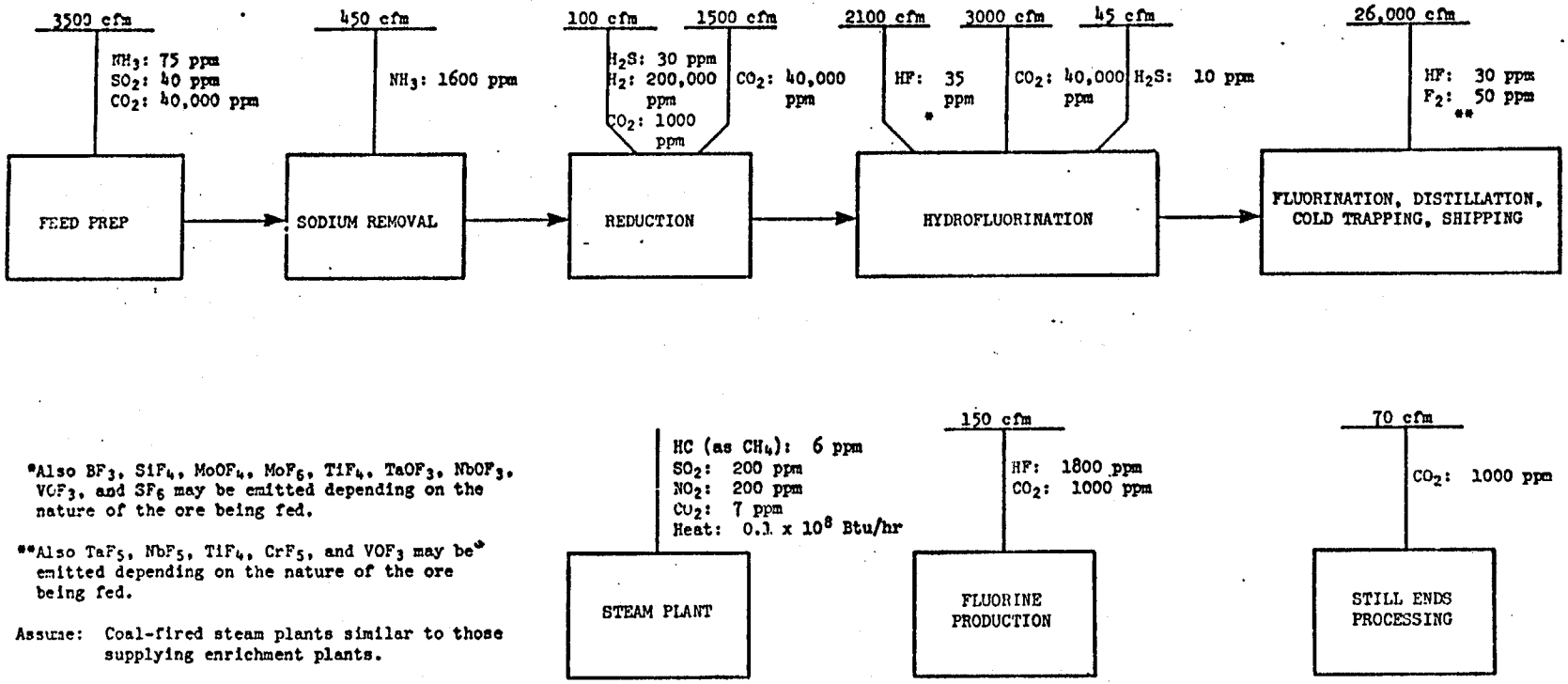
*Also BF_3, SiF_4, $MoOF_4$, MoF_6, TiF_4, $TaOF_3$, $NbOF_3$, VOF_3, and SF_6 may be emitted depending on the nature of the ore being fed.

**Also TaF_5, NbF_5, TiF_4, CrF_5, and VOF_3 may be emitted depending on the nature of the ore being fed.

Assume: Coal-fired steam plants similar to those supplying enrichment plants.

Figure 8

10,000 SHORT TONS U/YEAR UF_6 PRODUCTION FACILITY, *DRY* PROCESS



*Also BF_3, SiF_4, $MoOF_4$, MoF_6, TiF_4, $TaOF_3$, $NbOF_3$, VOF_3, and SF_6 may be emitted depending on the nature of the ore being fed.

**Also TaF_5, NbF_5, TiF_4, CrF_5, and VOF_3 may be emitted depending on the nature of the ore being fed.

Assume: Coal-fired steam plants similar to those supplying enrichment plants.

DISTRIBUTION

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J. Lamb / 1034A
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K/EM-381

SANITIZED VERSION OF STUDIES OF GASEOUS EFFLUENTS FROM NUCLEAR FACILITIES (12/14/76)

(SANITIZED VERSION OF CRD DOCUMENT # K/TL-629/PT2)

Compiled by
S. G. Thornton
Environmental Management Division
OAK RIDGE K-25 SITE
for the Health Studies Agreement

March 13, 1996

Oak Ridge K-25 Site
Oak Ridge, Tennessee 37831-7314
managed by
LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the U.S. DEPARTMENT OF ENERGY
under Contract DE-AC05-84OR21400

STUDIES OF GASEOUS EFFLUENTS FROM NUCLEAR FACILITIES (U)

Principal Investigator - R. W. Levin (615) 483-8611, Ext. 3-3143

Project Scientist - J. H. Stewart, Jr.(615) 483-8611, Ext. 3-3377

December 14, 1976

Authorization No. NC-40-253 Program No. 40-09

Contract Date: October 14, 1976 - March 31, 1977
ARPA Order No. 3255, Amendment 1

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Advanced Research Projects Agency, The Air Force Technical Applications Center, or the US Government.

UNION CARBIDE
OAK RIDGE GASEOUS DIFFUSION PLANT
OAK RIDGE, TENNESSEE

prepared for the **U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION**
under **U.S. GOVERNMENT** *Contract W-7405 eng 26*

This research was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by AFTAC/VT/6310/-/ERDA Patrick AFB FL 32925, under Contract No. 97 TO 400.1302.

UNION CARBIDE CORPORATION
NUCLEAR DIVISION
P. O. BOX P, OAK RIDGE, TENNESSEE 37830

December 14, 1976

[redacted]

Lt. Col. Frederick B. Buoni
1035 TCHOG/TAS
Patrick Air Force Base, Florida 32925

Dear Lt. Col. Buoni:

The Oak Ridge Gaseous Diffusion Plant (ORGDP) personnel assigned to the VT-6310 project have revised and expanded the preliminary draft of our document K/TL-629, to reflect your expanded request during our December 9, 1976 meeting. The concentrations of some compounds have now been determined more precisely, and the volumes and temperatures of stack gas effluents have been added to the two flow charts. Our first progress report follows:

RESEARCH PROGRAM AND PLAN

The Oak Ridge Gaseous Diffusion Plant (ORGDP) Technical Services Division personnel have initiated project VT-6310, as requested in W. B. Meharg's letter, dated September 13, 1976. We will furnish monthly progress reports on the 10th of each month, beginning with December 10, 1976. The formal project completion date will be March 31, 1977. As discussed with you during your November 1, 1976 visit to ORGDP, we are limiting the scope of the study at this time to exclude aerosols and particulates. We will omit from this study other nuclear fuel cycle steps that we also discussed, thus there will be no study of particulates, aerosols or radioactive gases, and there will be no study of weapons fabrication facilities. The scope of the original contract stated that we would not perform laboratory or experimental work, but available literature and unpublished data would be searched to determine the types, and general concentration ranges, of gaseous effluents emitted by ERDA facilities. Following our meeting on December 9, however, we are expanding our effort to include limited sampling and analysis of some stack effluents. This increased responsibility will require reevaluation of our effort for the next three months.

OBJECTIVES

This study will identify the gaseous effluents which are emitted by American Uranium enrichment facilities, UF_6 production facilities, and facilities used to produce uranium metal from UF_6. Where possible, we will indicate gaseous effluents considered characteristic of these facilities.

SCOPE

This study will be restricted to the gaseous diffusion, gas centrifuge, laser, and Becker "Nozzle-types" of enrichment facilities, to UF_6 production facilities, and to facilities for the reduction of UF_6 to uranium metal.

MAJOR ACCOMPLISHMENTS

Preliminary reports have been made for the nonradioactive gaseous effluents from a typical full-sized gaseous diffusion plant and a full-sized gas centrifuge plant. The estimated quantities and/or concentrations of these emissions, as well as the stack effluent volumes and temperatures, have been listed on the attached flow sheets. Effluents which are considered unique to the diffusion process are (1) ClF_3, (2) ClO_2F, and (3) ClO_3F. The centrifuge plant may also utilize these compounds. The centrifuge plant may also be characterized by the emission of (1) methylene dianiline, (2) m-phenylenediamine, (3) and bis 2, 3, epoxycyclopentyl ether from the rotor fabrication facility.

We have begun preparation of a bibliography of available published reports which are pertinent to the effluents from fuel cycle facilities which are within the scope of this study.

PROBLEMS ENCOUNTERED

Expansion of the project, from a literature search and theoretical computations, to a limited sampling and analysis program alters somewhat the personnel effort. We are currently evaluating the amount of support that can be completed by March 31, 1977, and will provide that estimate in a later report.

FISCAL STATUS

We will be able to provide a project cost estimate after the sampling and analysis costs are compiled. It will not exceed the allotted $85,000 in any case, and should be substantially lower.

FUTURE PLANS

We expect to provide a copy of document ORO 651 R-3, which details UF_6 shipping cylinders; to provide the estimated uranium inventory of a hypothetical MT 8750 SWU diffusion and centrifuge plants, and reference information on polymers of hydrogen fluoride. From existing data we will predict the upper limits of gaseous compounds which could be expected in a catostropic incident concerning the hydrogen fluoride tank storage area, or a uranium shipping cylinder. We will also prepare a set of infrared absorption spectra for compounds of interest in this study.

Col Buoni

SECRET

December 14, 1976

SCHEDULE

Type of Facility	Preliminary Draft	Final Report
Gaseous Diffusion enrichment	12-10-76	1-10-77
Gas Centrifuge enrichment	12-10-76	1-10-77
Laser enrichment	1-10-77	2-10-77
nozzle enrichment	1-10-77	2-10-77
UF_6 production facilities	2-10-77	3-10-77
UF_6 reduction facilities	2-10-77	3-10-77

The final project completion report will be issued by March 31, 1977.

Very truly yours,

R. W. Levin

R. W. Levin, Director
K-25 Technical Services Division

RWL:JHS:ae

Attachments (2)

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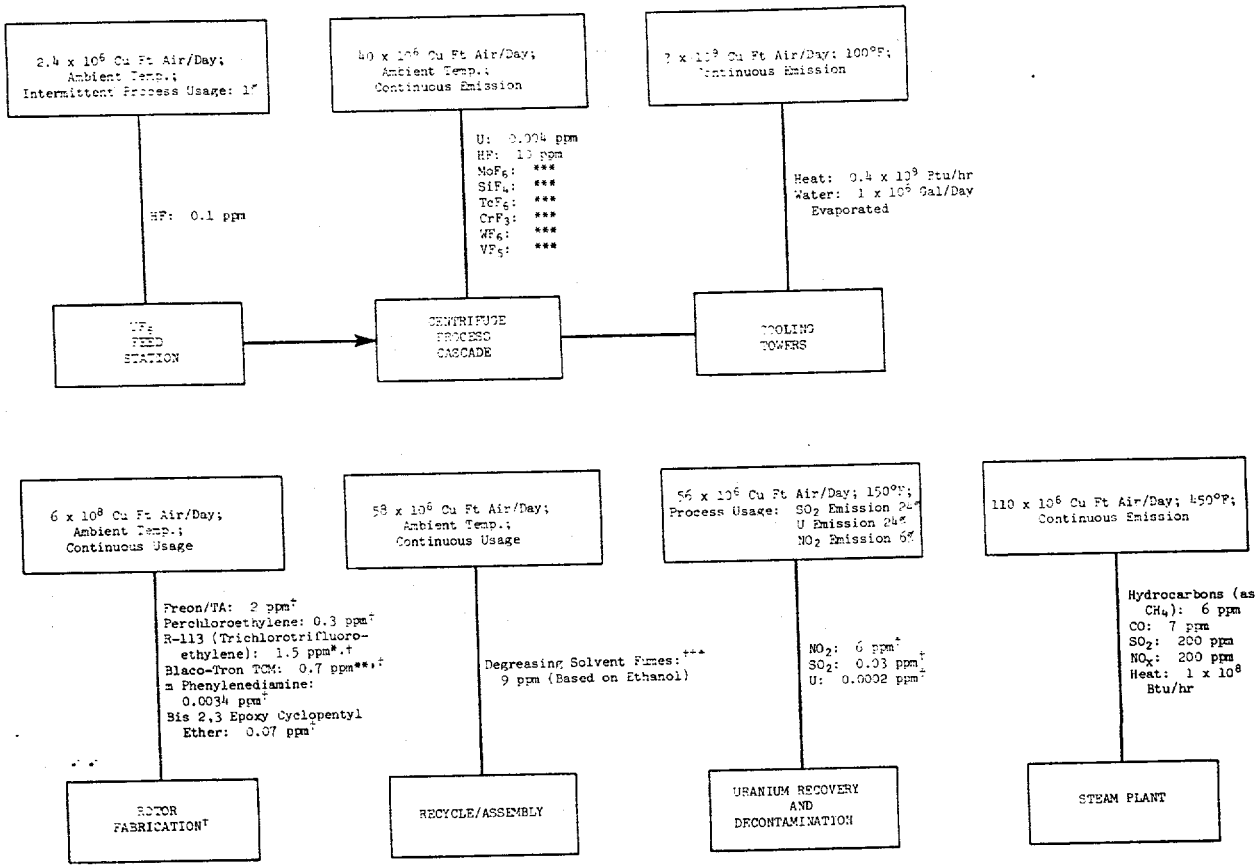


*R-113 is 89% trichlorotrifluoroethane and 11% acetone.

**Blaco-Tron TCM is an azeotropic mixture containing 39% trichlorotrifluoroethane, 52% methylene chloride, and 9% cyclopentane.

***Chemically unstable compounds which may exist in purge stack gas. Estimated max. concentration = 0.2 ppm for each.

†These values apply if all operations are in process simultaneously.

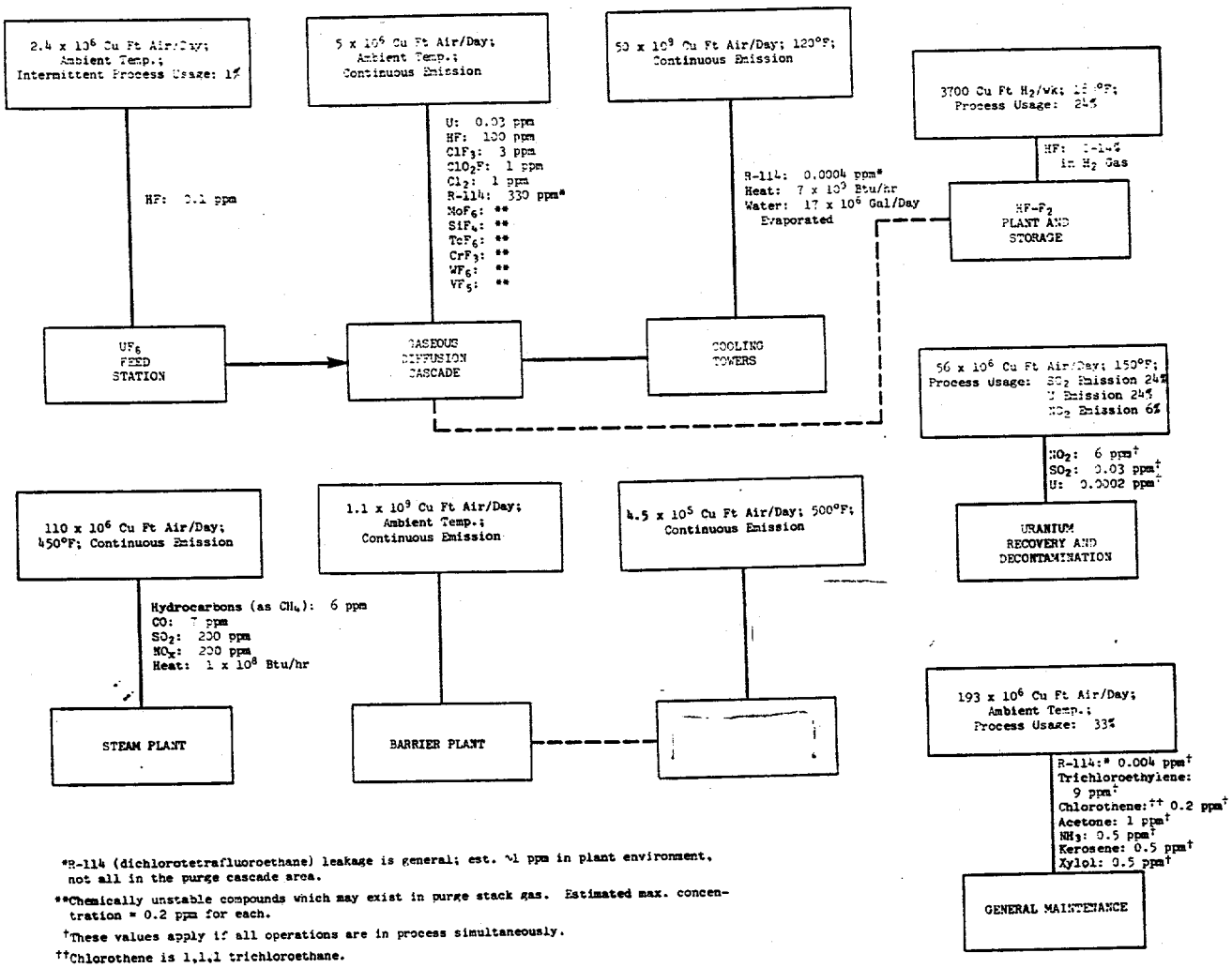
††If rotors are made of metal, the noted emissions will not apply. Instead only CO_2 or NO_2 fumes from standard non-chloride anodizing solutions will be present in the process off gases.

†††The degreasing solvent could also be of Freon (R-113), acetone, methylene chloride, or even soapy water.

The concentrations of the effluents are computed from the best available data, but should not be considered exact values.

GASES EMITTED FROM A TYPICAL 8.75 x 10^6 SWU/YR GAS CENTRIFUGE ENRICHMENT PLANT

DWG. NO. G-76-1457 (S)



*R-114 (dichlorotetrafluoroethane) leakage is general; est. ~1 ppm in plant environment, not all in the purge cascade area.

**Chemically unstable compounds which may exist in purge stack gas. Estimated max. concentration = 0.2 ppm for each.

†These values apply if all operations are in process simultaneously.

††Chlorothene is 1,1,1 trichloroethane.

The concentrations of the effluents are computed from the best available data, but should not be considered exact values.

GASES EMITTED FROM A TYPICAL 8.75 x 10^6 SWU/YR GASEOUS DIFFUSION PLANT

DISTRIBUTION

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K/EM-383

SANITIZED VERSION OF STUDIES OF GASEOUS EFFLUENTS FROM NUCLEAR FACILITIES (9/20/77)

(SANITIZED VERSION OF CRD DOCUMENT # K/TL-629/PT6)

Compiled by
S. G. Thornton
Environmental Management Division
OAK RIDGE K-25 SITE
for the Health Studies Agreement

March 13, 1996

Oak Ridge K-25 Site
Oak Ridge, Tennessee 37831-7314
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LOCKHEED MARTIN ENERGY SYSTEMS, INC.
for the U.S. DEPARTMENT OF ENERGY
under Contract DE-AC05-84OR21400

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STUDIES OF GASEOUS EFFLUENTS FROM NUCLEAR FACILITIES (U)

KTL 629 PT6 7 A

PLANT RECORDS RECEIPT NO. AL 85978

Principal Investigator
R. W. Levin (615) 483-8611, Ext. 3-3142

Project Scientist
J. H. Stewart, Jr. (615) 483-8611, Ext. 3-9316

September 20, 1977

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7-1-86	pte
6-23-87	pte

Authorization No. NC-40-253   Program No. 40-09

Contract Date: October 14, 1976 - March 31, 1977
ARPA Order No. 3255, Amendment 1

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the Advanced Research Projects Agency, The Air Force Technical Applications Center, or the US Government.

UNION CARBIDE

OAK RIDGE GASEOUS DIFFUSION PLANT
OAK RIDGE, TENNESSEE

prepared for the U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION
under U.S. GOVERNMENT *Contract W-7405 eng 26*

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UNION CARBIDE CORPORATION
NUCLEAR DIVISION
P. O. BOX P, OAK RIDGE, TENNESSEE 37830

September 20, 1977

Lt. Col. Frederick B. Buoni
1035 TCHOG/TAS
Patrick Air Force Base, Florida 32925

Dear Col. Buoni:

The Technical Services Division of the Oak Ridge Gaseous Diffusion Plant has obtained analytical measurement data on gaseous effluents taken from the Oak Ridge diffusion facility. As stated in the prior report (K/TL-629, Part 5), the effluents were studied by gas chromatography-mass spectrometry (GC-MS), spark source-mass spectrometry (SSMS), infrared spectrometry (IR), atomic absorption (AA), and emission spectroscopy.

Introduction

The purpose of Project VT-6310 was to provide a study of uranium production facilities and to identify nonradioactive gaseous effluents of potential value in detecting these facilities within the ARPA/AFTAC Remote Sensing Program. The five previous reports have provided flow diagrams of various enrichment plants, and our best estimates of nonradioactive effluent concentrations. As requested, we have also collected effluent gases for analysis. These actual concentrations have now been compared with the estimated concentrations of specific compounds.

Description of Work

Several methods, including caustic scrubbing, charcoal tubes, condensation sampling, vacuum bulbs and Tenax* absorption columns, were evaluated before obtaining samples from the various plant effluent sources. The Tenax absorption column was found to be preferable for effluent sampling since it does not absorb atmospheric water and it is also very efficient in collection of higher molecular-weight hydrocarbons. The concentrated effluent compounds were thermally removed in a flowing helium stream for GC-MS analysis. The caustic scrubber solution was dried and the residue utilized for SSMS, AA, and emission spectrographic analysis.

---

*Tenax-GC, porous polymer of 2,6 diphenyl paraphenylene oxide developed by the AKZO Research Laboratory.

Table 1 shows analytical results obtained from twenty consecutive days of effluent sampling in the diffusion cascade area. The purpose of the extended sampling was to determine the variability of effluent concentration during a normal month of diffusion plant operation. As expected, there were significant variations due to operational changes. The average results, however, are in good agreement with the computed average values (Table 2).

The barrier plant has six separate exhaust stacks and the concentrations of effluents were expected to be relatively constant. Each stack was sampled on the same day.

Recommendations for Future Work

1. The ORGDP Technical Services Division could produce and purify gases such as UF_6, ClF_3, ClO_2F, ClO_3F, and OF_2; these gases would then be scanned in infrared corrosion-resistant sample cells to obtain digital quality spectra.

2. The infrared technical expertise of ORGDP could be used to support the personnel designing instrumentation for AFTAC.

3. The stack gas effluents from the Oak Ridge gas centrifuge facility could be sampled and analyzed. The analysis of effluents from an easily-concealed centrifuge plant should be of interest to the AFTAC program.

4. The ORGDP could provide an ideal testing site for the AFTAC remote sensing instrumentation since both the centrifuge and the diffusion plant effluents could be studied at one time.

The Oak Ridge Gaseous Diffusion Plant management will develop a feasibility study and cost estimate of these recommendations, if desired.

Please notify us if we may be of further assistance with this program.

Very truly yours,

R. W. Levin

R. W. Levin, Director
K-25 Technical Services Division

RWL:JHS:emck

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Table 1

STACK GAS CONSTITUENTS FROM
CASCADE OPERATIONS AREA

ClF_3 (ppm)	UF_6 (ppm)	F_2 (ppm)	HF (ppm)	Cl_2 (ppm)	W (ppb)	Mo (ppb)	Cr (ppb)	Tc (ppb)
0.57	0.024	11.5	12.6	0.22	< 0.04	0.1	0.05	< 0.01
< 0.10	0.015	< 1	< 1.1	< 0.04	< 0.04	0.03	0.1	< 0.01
0.52	0.041	9.6	10.5	0.20	< 0.04	0.03	0.2	< 0.01
0.44	0.041	8.7	9.5	0.17	< 0.04	0.7	0.30	0.021
< 0.10	0.015	< 1	< 1.1	< 0.04	< 0.04	< 0.03	0.1	< 0.01
0.50	0.072	14.7	15.8	0.19	< 0.04	0.1	0.2	< 0.01
1.02	0.053	13.4	14.7	0.39	< 0.04	0.3	0.2	< 0.01
1.04	0.041	3.4	4.2	0.40	< 0.04	0.1	0.38	0.020
0.13	0.025	9.9	10.5	0.05	< 0.04	0.07	0.05	< 0.01
< 0.10	0.004	< 1	< 1.1	< 0.04	< 0.04	< 0.03	0.1	< 0.01
< 0.10	0.004	26	27.4	< 0.04	< 0.04	0.04	0.1	< 0.01
0.97	0.068	16.4	17.9	0.37	< 0.04	0.1	0.1	0.01
0.34	0.043	23.3	25.3	0.13	< 0.04	0.04	1	0.025
0.21	0.038	5.9	6.3	0.08	< 0.04	0.03	0.1	0.15
< 0.10	0.003	< 1	< 1.1	< 0.04	< 0.04	< 0.03	0.1	< 0.01
0.10	0.053	9.9	10.5	0.04	< 0.04	0.1	0.1	< 0.01
< 0.10	0.108	21	22.1	< 0.04	< 0.04	0.03	0.1	< 0.01
< 0.10	0.101	43	45.2	< 0.04	< 0.04	0.04	0.1	< 0.01
< 0.10	0.078	40	42.1	< 0.04	< 0.04	0.1	0.1	0.024
< 0.10	0.028	< 1	< 1.1	< 0.04	< 0.04	0.03	0.2	< 0.01
Avg.								
0.29	0.043	12.8	13.7	0.011	< 0.04	0.097	0.18	< 0.01

Table 2

ANALYZED AVERAGE EFFLUENT CONCENTRATION*
VERSUS COMPUTED VALUE

Constituent	Avg. Conc (Estimated)	Avg. Conc (Analyzed)	Range (Actual)
U	0.03 ppm	0.03 ppm	0.002-0.07 ppm
HF	100 ppm	14 ppm	< 1-45 ppm
ClF_3	3 ppm	0.3 ppm	< 0.10-1.0 ppm
Cl_2	1 ppm	0.01 ppm	< 0.04-0.40 ppm
R-114	330 ppm	60 ppm	30-80 ppm
Mo	0.2 ppb	0.10 ppb	< 0.03-0.7 ppb
Tc	0.2 ppb	< 0.01 ppb	< 0.01-0.15 ppb
Cr	0.2 ppb	0.18 ppb	0.05-1 ppb
W	0.2 ppb	< 0.04 ppb	< 0.04 ppb

*The computed impurity concentrations were based on an 8750 MTU diffusion plant. The analyzed impurity concentrations were from stack effluents from a 2700 MTU diffusion plant. We would expect slightly higher impurity concentrations in effluents from actual 8750 MTU operation.

DISTRIBUTION

1. K-25 Site Records (RC)
2. ChemRisk/Shonka Research Associates
3. S. G. Thornton (K-25 EMD)
4. DOE Public Reading Room