Environmental and Chemical Analysis Technician Curriculum Planning Guide

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Research Project 1266-6

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ABSTRACT

The Environmental and Chemical Analysis Technician (ECAT) Curriculum Planning Guide is one of three such guides developed as part of project RP 1266-6, Educational Research in Solid-Fuel Technology. The first phase of the project included a needs assessment survey to determine the number of entry-level employees required as Environmental and Chemical Analysis Technicians. The need for 2900 technicians over the next decade warrants the development of a specialized ECAT curriculum. A detailed task inventory of the skills and knowledge used by Environmental and Chemical Analysis Technicians in the safe and efficient performance of their jobs has been completed. The task inventory forms the basis for the model two-year (six quarter) curriculum presented in this document. Course and module outlines are included which have been formulated to provide students with entry-level skills and the background necessary for further advancement.

EPRI PERSPECTIVE

PROJECT DESCRIPTION

Utilities have always acknowledged the need for effective training of power plant employees. This perception has been sharpened over the past decade by the fact that power plants have grown increasingly complex. More sophisticated control circuitry has been introduced, a whole new generation of analytical instrumentation has been required, and unit operating conditions have become more rigorous. Thus the requirement for more highly skilled and trained personnel has become increasingly urgent.

To meet this need, EPRI in 1978 provided funding under RP1266-6 for the preparation of three curriculum guides to be used in power plant training programs. The guides were specifically related to three job categories now fairly-well represented in power plant organizations. The model curriculum for the job of Environmental and Chemical Analysis Technician is the substance of this report. Two other guides, one for the position of Control Room Operator and the other for Instrument and Control Technician, are being published concurrently.

PROJECT OBJECTIVE

A primary goal of this project is to provide the utility industry with educational material of suitable structure and content for use in training power plant personnel. Emphasis was placed on fashioning material which could serve the dual purposes of aiding in the preparation of in-house training programs or allowing post-secondary schools to develop suitable programs of their own. In so doing, it was thought that a wide range of companies could best be served; on one hand large utilities could use this material as an adjunct to their own efforts, while smaller companies could call upon community institutions for their training needs.

PROJECT RESULTS

This report represents the ideas and thoughts of utility and educational institutions personnel actively involved in personnel training programs. The names and affiliations of those who contributed to its form and substance are listed in the text. Besides contributing in this manner, a number of utilities have indicated great interest in field testing material now under development. Delivery of this material is planned for early September of 1980. It is expected that it will initially be used by Arkansas Power and Light Co., Utah Power and Light Co., Public Service Co. of New Mexico, Commonwealth Edison Co., Texas Utilities Generating Company, and Detroit Edison Co., among others. The modular format in which each course of study is cast will allow easy adaptation of the curricula to individual company and institutional needs. Confirmation of this should be demonstrated by results from the field tests.

To supplement this guide and the two others, a Resource Handbook has been prepared and will be published separately. The Handbook is an ordered compilation of training material now available through commercial channels and should be of considerable value to organizations now in the process of developing specific training programs.

It is hoped that the curriculum guides, the Resource Handbook, and supporting material developed by this project will be of value to the utility industry in meeting its goal of supplying reliable and economical electrical energy.

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ACKNOWLEDGMENTS

Throughout the initial phases of this project, management and engineering personnel of the electric power generating industry from across the nation provided valuable guidance and inputs to the project staff's workforce "needs-assessment" and "task-inventory" efforts. The significant contributions of these individuals are acknowledged with appreciation. The framework of an educational program requires attention equal to the program's technical content; for this reason, the contributions of educators - notably, administrators of two-year, postsecondary vocational-technical institutions - and power plant training directors during these initial phases must be given equal recognition with a similar level of appreciation. Further gratitude is extended for their willingness to continue to serve through subsequent phases.

Together, these managers, engineers, educators and training directors comprised a highly effective Project Advisory Committee. Their names and organization affiliations appear on the following page.

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SUMMARY

The Environmental and Chemical Analysis Technician (ECAT) Curriculum Planning Guide is one of three such guides developed as part of Project RP 1266-6, Educational Research in Solid-Fuel Technology. The project has included a needs assessment survey to determine the number of entry-level employees required as Environmental and Chemical Analysis Technicians. The need for 2900 technicians over the next decade warrants the development of a specialized ECAT Curriculum. A detailed inventory of the skills and knowledge used by an ECAT in the safe, efficient performance of his/her job has been compiled. This task inventory forms the basis for the model two-year (six quarter) curriculum. The curriculum is designed to provide students with entry-level skills and sufficient background that, with a reasonable amount of work experience, they may advance to positions with increasing responsibilities.

The Environmental and Chemical Analysis Technician Curriculum consists of the following courses:

- FIRST YEAR
  - --Introduction to Environmental and Chemical Analysis.
  - --Environmental Chemistry I and II.
  - --Technical Math I and II.
  - --Unified Technical Concepts I, II and III.
  - --Technical Communications I.
  - --Power Plant Fundamentals and Systems I.
  - --Gravimetric and Volumetric Analysis.
  - --Properties and Reactions of Organic Materials.
  - --Fundamentals of Electricity and Electronics.
- SECOND YEAR
  - --Power Plant Fundamentals and Systems II.
  - --Environmental Biology.
  - --Instrumental Analysis I and II.
  - --Technical Communications II.

--Blueprint and Schematic Reading.

--Power Plant Chemistry.

--Environmental Analysis.

--Plant and Laboratory Safety.

--Pollution Control for Coal-Fired Power Plants.

--Water Treatment.

--2 electives.

Descriptions and outlines are supplied for each course and its component modules. Preceding each instructional module is a list of learning objectives which are based on the skills and knowledge required for job performance.

It is not intended that the proposed curriculum be rigid but that it should provide the framework for adaptation to suit local needs. The curriculum reflects the consensus of ideas from representatives of various power plants and postsecondary, vocational-technical institutions. This type of cooperative effort should be incorporated also by local institutions and employers when the curriculum is implemented at schools to ensure that the program will produce qualified technicians with the skills and knowledge most needed by local industry.

Section 1

INTRODUCTION

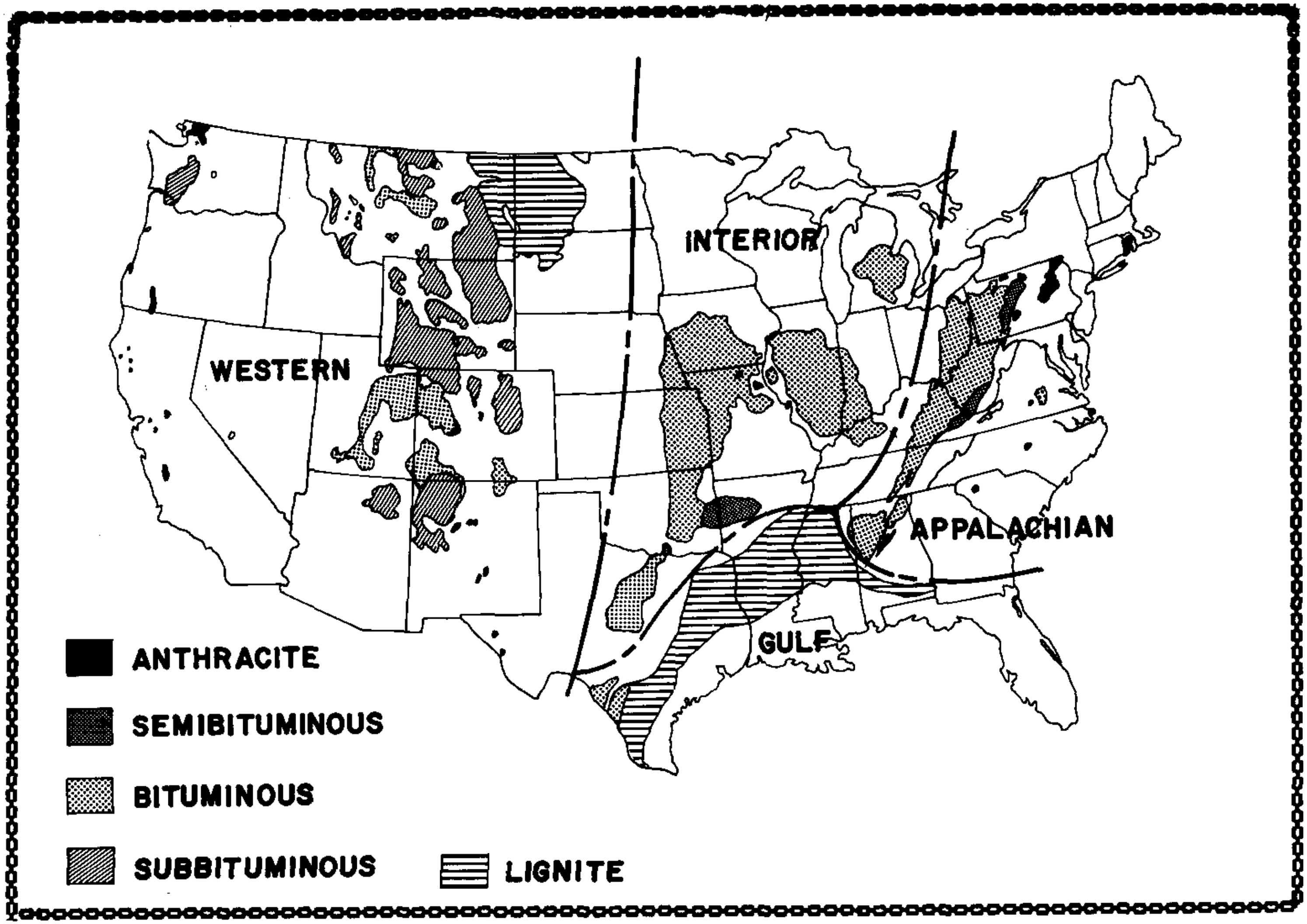


Figure 1. United States Coal Supply Regions.

Section 1

INTRODUCTION

Upon realizing that the supply of domestic oil and natural gas is limited and because of national goals to reduce dependence on imports, utility companies in the seventies have begun, by planning and constructing new and modified electric generating stations, to use currently available alternate fuel sources -- primarily coal and nuclear. This process has been slowly gaining momentum. In 1974, the Federal Energy Administration ordered twenty-five electric utilities to convert seventy-four plants from oil to coal; nevertheless, it was not until 1977, when the President outlined a sweeping conversion program in the National Energy Plan, that conversion became a major factor in the power generating industry planning. On November 9, 1978, the Power Plant and Industrial Fuel Act (P. L. 95-620) was signed into law. The current Administration has re-emphasized the need for conversion throughout 1979.

With the use of natural gas and petroleum products as boiler fuels being discouraged, the industry is faced with some important decisions regarding fuel choices for the future. The availability of coal and lignite (a low grade of coal) make these solid fuels viable choices.

There are vast quantities of coal in America (30.8% of the world's coal reserve is found in the U. S.), not all of the same Btu output or sulfur content. Lignite from the Gulf and upper Western Regions (Figure 1), though abundant and accessible for surface mining, has a low Btu value (4,500 to 8,000) and a high sulfur content. Soft coal from the Western Region averages about 10,000 Btu's and has low sulfur content. The bituminous coal mined in the midwest and Appalachian Regions has high Btu content (12,000 to above 14,000) but is burdened with a high sulfur content. Anthracite coal, mined almost exclusively in the Appalachian Region, has the highest Btu value, and very low sulfur content. Because of its high quality, anthracite is used mainly in industry and is hardly a factor in electric utility operations or planning.

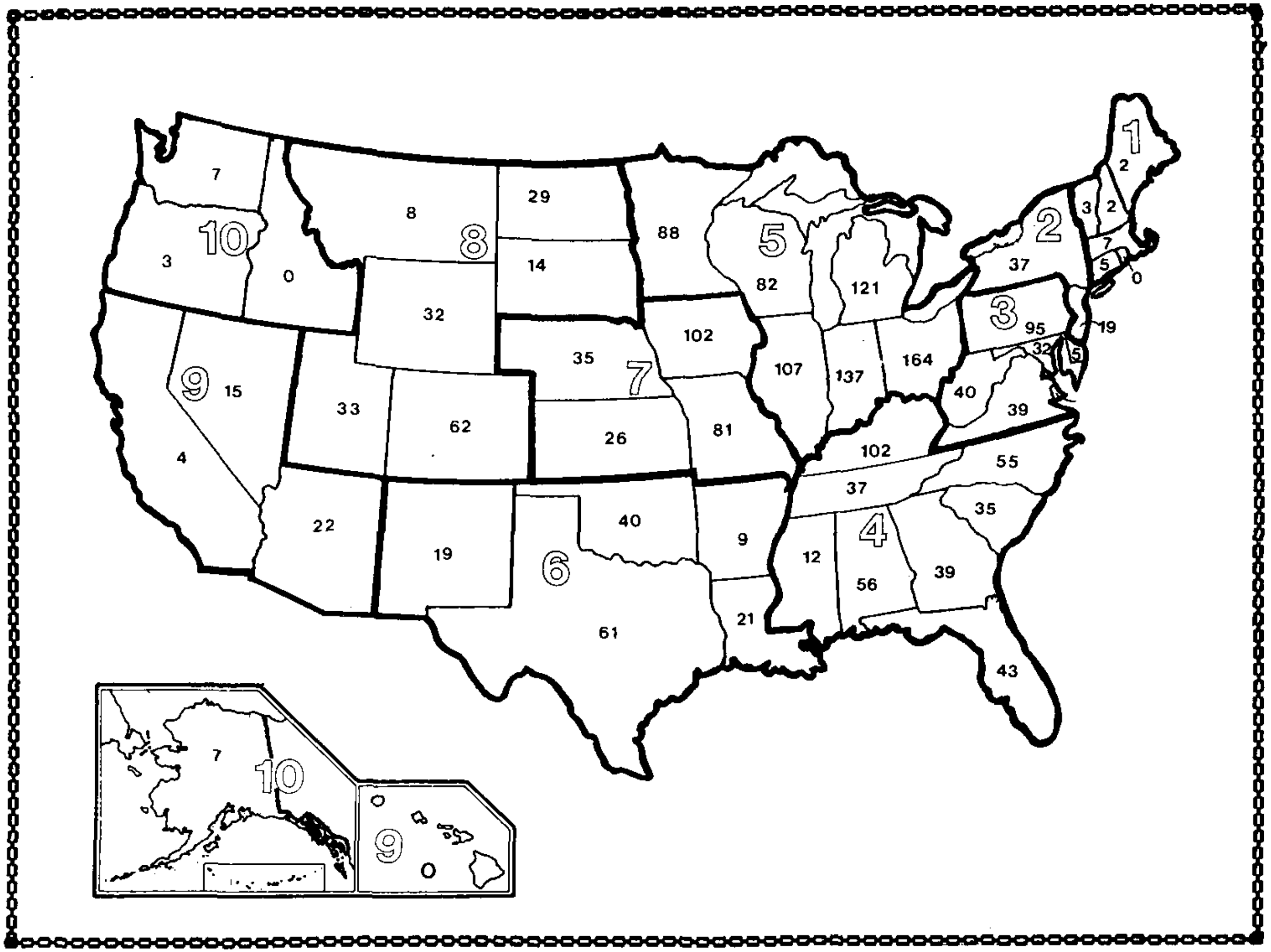


Figure 2. Coal-Fired Units Location by State and Department of Energy Regions.

Coal is being used, or will be used by 1990, in all but four states in this country, according to a recent Department of Energy publication entitled, Inventory of Power Plants in the United States. Figure 2 shows how many units in each state of the ten DOE Energy Regions currently are operating or are scheduled to come on line by 1990, which use coal as either the primary fuel or as backup. This information is summarized by region in Table 1.

Table 1-1

COAL-FIRED UNITS BY D.O.E. REGIONS

Department of Energy Region	Number of Coal-Fired Units	% of Total
1	19	1.0
2	56	2.8
3	211	10.6
4	379	19.0
5	699	35.1
6	150	7.5
7	244	12.2
8	178	8.9
9	41	2.1
10	17	0.8
Total	1994	100.0%

Modern plants are more complex than their predecessors in that 1) they are more automated, many using computer controls, 2) they are more efficient due to super-critical operating pressures, and 3) they have more equipment and attention paid to controlling combustion by-products and limiting their effects on the environment. For these reasons, plants require larger and more highly trained staffs of operators, technicians and maintenance personnel.

It was the purpose of an earlier study made by the Center for Occupational Research and Development (CORD) [formerly Technical Education Research Center - Southwest (TERC-SW)] for EPRI to determine what job categories composed this technical workforce, what tasks were performed by each group and how many technicians would be needed through 1990. Through the use of surveys of 409 power plants, and personal visits by CORD staff to additional power plants, seven job categories were identified as shown in Figure 3. These categories often are organized differently and the names may vary from plant to plant, but the tasks performed are generally the same throughout the industry. These same surveys also established the needs of utilities for each job category through the year 1990. Figure 4 gives the projected needs for new employees for each year in each of the seven job categories.

Task inventories were developed for three of the seven categories:

- Environmental and Chemical Analysis Technician.
- Instrumentation and Control Technician.
- Power Plant Operator.

These inventories were used as the basis of the curriculum designs developed in the current project. This document relates only to the category of Environmental and Chemical Analysis Technician and contains the completed curriculum plans for training this technician.

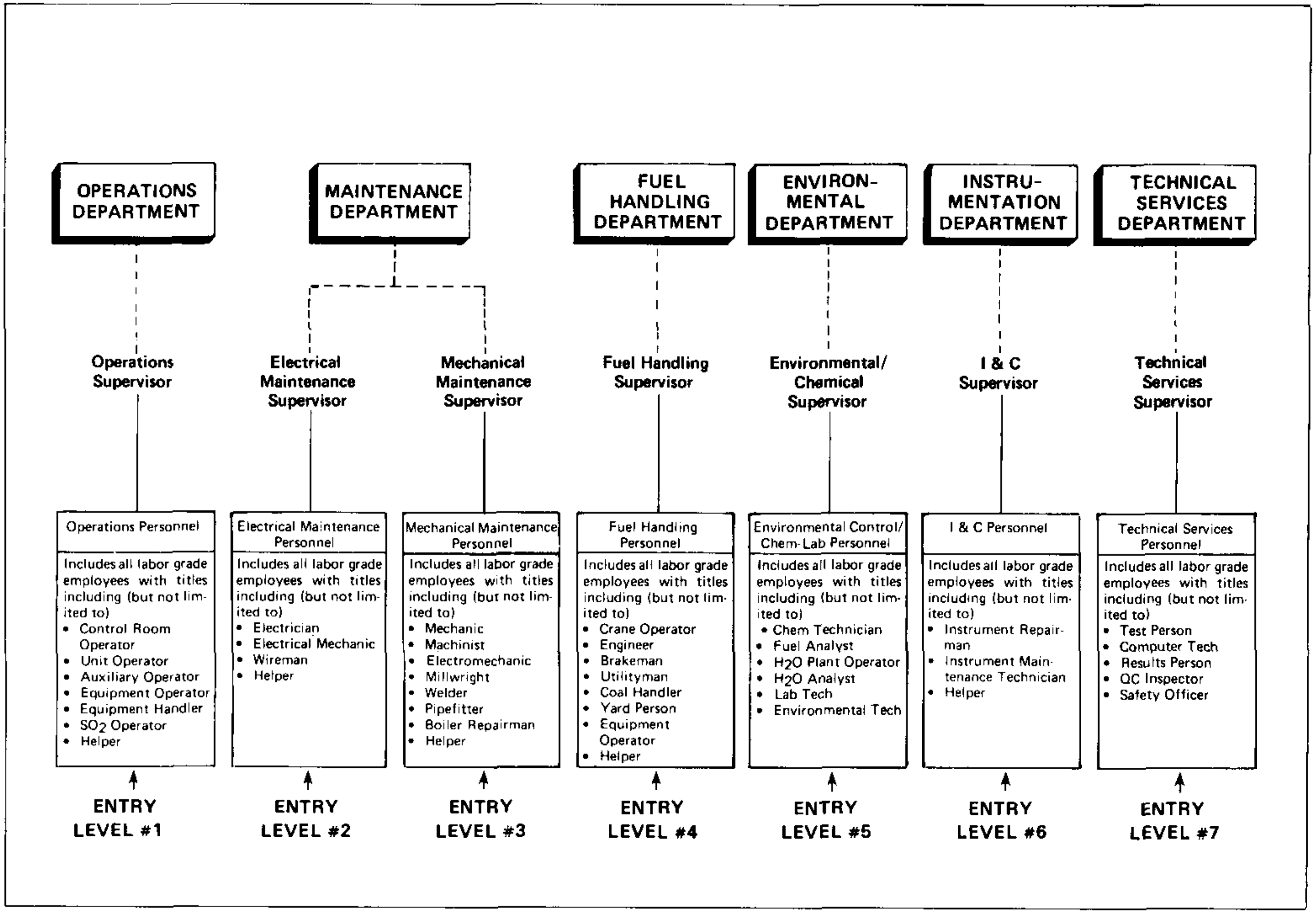


Figure 3. Functional Organizations and Job Categories within a Coal-Fired Power Plant.

JOB TITLE	Year												
	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	Total
Operator	2301	2346	2350	2384	2401	2426	2452	2478	2505	2532	2543	2586	31,611
Electrician	570	576	582	588	594	601	607	613	620	627	633	640	7,775
Mechanic	1935	1956	1976	1997	2019	2040	2062	2084	2106	2128	2151	2174	26,543
Fuel Handler	1016	1025	1038	1049	1060	1072	1083	1094	1107	1219	1131	1143	14,045
Environmental & Chemical Analysis Technician	209	211	213	215	218	220	222	225	227	230	232	235	2,863
Instrumentation & Control Technician	427	432	437	442	447	451	456	461	467	472	477	482	5,874
Technical Services Technician	541	547	555	560	567	573	580	587	594	601	608	615	7,463

Figure 4. Projected Yearly Needs for New Employees (to Accommodate Growth and Attrition) in Coal- and Lignite-Fired Electrical Power Plants.

Section 2

ENVIRONMENTAL AND CHEMICAL ANALYSIS TECHNICIAN

Section 2

ENVIRONMENTAL AND CHEMICAL ANALYSIS TECHNICIAN

Coal-Fired Power Plant

Job Description

The Environmental and Chemical Analysis Technician (ECAT) is responsible for monitoring the quality of air, water and fuel at all stages of power production. It is important that these tests and analysis be performed accurately and precisely. There is a minute tolerance range for impurities in the feedwater which if exceeded could cause corrosion or scale problems in plant equipment. Environmental monitoring is also important to ensure that the plants are operating within legal limits. As these analyses must be made continually while the plant is operating, the ECAT will be expected to work shifts as do production personnel.

The following list of tasks was compiled from the task inventories gathered from surveys of various power plants. All of the tasks listed will not be performed by all environmental and chemical analysis technicians at every plant.

SPECIFIC TASKS

1. Perform various water sampling procedures.

   --Specify appropriate techniques for sampling various water sources.

   --Specify appropriate procedures for preserving samples until analyses are performed.

   --Identify appropriate sampling sites for the following:

      --Raw water.
      --Filtering system.
      --NPDES treatment system.
      --Demineralizer.
      --Treated water.
      --Boiler water.
      --Condenser.
      --Softened water.

--Drinking water.

--Distilled water.

--Heating system.

--Other plant water.

2. Perform the following tests on water samples as appropriate, and record results using the proper units, graphs, charts, etc.:

   --Chlorine and/or chlorides content determination.

   --Hydrazide content determination.

   --Ammonia content determination.

   --Phosphate content determination.

   --pH determination.

   --Conductivity determination.

   --Alkalinity determination.

   --Hardness determination.

   --Dissolved oxygen content determination.

   --Silica content determination.

   --Turbidity determination.

   --Trace metals.

   --Oil and grease.

   --Total suspended solids.

   --B.O.D.

   --Report test results in proper format.

3. Perform the following miscellaneous tests and report results in proper format:

   --Ash fusion temperature determination.

   --Corrosive properties determination.

   --Corrosive effects determination.

   --Boiler deposits analysis.

   --Condenser deposits analysis.

   --Acid strength determination.

4. Perform the following solid-fuel tests and report results in proper format:

   --Caloric value determination.

   --Volatile matter content determination.

   --Fixed carbon content determination.

   --Ash content determination.

   --Sulfur content determination.

5. Collect air samples from stack and analyze emissions for each of the following:

   --Particulates.

   --Nitrogen compounds.

   --Sulfur compounds.

   --Chloride compounds.

   --Fluoride compounds.

   --Carbon compounds.

   --Oxidants.

   --Hydrocarbons.

6. Operate, calibrate, clean and maintain appropriate analyzers and meters, such as the following:

   --pH meters.

   --Specific ion meters.

   --Filter photometers.

   --Spectrophotometers.

   --Chlorimeters.

   --Calorimeters.

   --Temperature probes.

   --Flow meters.

   --Residual chlorine analyzers.

   --Strip and circular chart recorders.

7. Prepare and replenish the following:

--Solutions.

--Standardized reagents.

--Treatment chemicals.

--Cleaning solvents.

8. Perform the appropriate analyses of all test results to determine the following:

--Results are within acceptable limits.

--Probable cause, if results are not within acceptable limits.

9. Take (or recommend) corrective actions, as needed, to adjust the following:

--Blow-down valve settings.

--Chemical feed rates.

--Treatment chemical (formulas and dosages).

--Flow rates.

--Circulation time frames.

--Heaters and/or chillers.

--Coagulators.

--Sedimentation.

--Filtration.

--Softening (parameters and rates).

10. Operate the following plant systems:

--NPDES.

--Demineralizer.

--Polisher.

--Coagulator.

--Deflocculator.

11. Maintain an inventory of chemicals for use in the procedures and activities noted above.

12. Maintain appropriate records, charts and graphs.

13. Maintain daily log of activities, data obtained and adjustments made.

14. Monitor and interpret environmental regulations.

15. Perform or oversee operational and pre-operational chemical cleaning.

SPECIAL REQUIREMENTS

The ECAT must be able to work with others, and to communicate effectively, both orally and in writing.

EDUCATIONAL REQUIREMENTS

To enter this job category, an individual should have two years of specialized Environmental and Chemical Analysis training (as outlined in this guide) or a baccalaureate degree in chemistry.

Section 3

CURRICULUM

Section 3

CURRICULUM

The purpose of this curriculum planning guide is to provide a national model for training Environmental and Chemical Analysis Technicians (ECAT) to work in coal-fired power plants. It is not intended that the proposed curriculum be rigid but that it should provide the framework for adaption to suit local needs. This curriculum reflects the consensus of ideas from representatives of various power plants and postsecondary, vocational-technical institutions across the country. This type of cooperative effort should also be incorporated by local institutions and employers when the curriculum is implemented at schools.

This curriculum (see Table 2) was designed for use by two-year, postsecondary institutions to prepare Environmental and Chemical Analysis Technicians for entry-level jobs at electrical power plants. This course of study should also provide the graduates with sufficient background that, with a reasonable amount of work experience, they may advance to positions with increasing responsibilities. In order to accomplish this, the ECAT curriculum has to accomplish three objectives. They are:

- To teach students those techniques and skills that they will be required to perform on the job.
- To provide sufficient depth in technical principles related to the equipment and systems in power plant operation that they may quickly learn additional skills and knowledge to meet changing job requirements or to qualify them for promotion to a higher level position.
- To provide the students with a broad knowledge of the entire power plant system operation and with a sufficient understanding of human relations and communication skills that they can relate the details and functions of their job to other equipment and personnel throughout the plant.

The ECAT curriculum consists of technical and support courses. The technical subjects are specifically designed to achieve the above goals, whereas, the support courses are taught to provide students with the required background for the technical courses. This curriculum also includes two electives. The project advisory committee has recommended that these electives be chosen from courses in human relations, sociology or economics. The first two areas, sociology and human relations, would best prepare students for situations where they must work closely with other power plant employees in order to ensure efficient plant operation. An economics course would show these future technicians in "dollar and cents" terms, the benefits of an efficient plant. It would also make them more aware of how much careless and wasteful work habits cost the company and ultimately themselves in the form of higher electric bills. Another use for the electives would be to provide flexibility for schools to add additional courses needed by local industry or courses required to meet state or regional accreditation requirements.

This program is not intended to make individuals proficient in every task they will have to perform in the power plant. Each power plant will have to provide plant specific training. Also, proficiency in work comes only with practice and experience. It is impossible to forecast the exact requirements of any individual or to predict changing technology. The material in this curriculum planning guide is only that - a guide and should be used as such. Institutions adopting this curriculum should work closely with local utilities to ensure that the program will produce qualified technicians with the skills and knowledge most needed in the industry.

Table 2-1 shows the recommended sequence of courses for a two-year curriculum. The quarter system is used assuming 10 full weeks of class and laboratory activities. In situations where recommended sequence cannot be followed, the Course Flow Chart (page 3-4) provides ready reference to course prerequisites and co-requisites for use in rescheduling.

TABLE 3-1

MODEL CURRICULUM

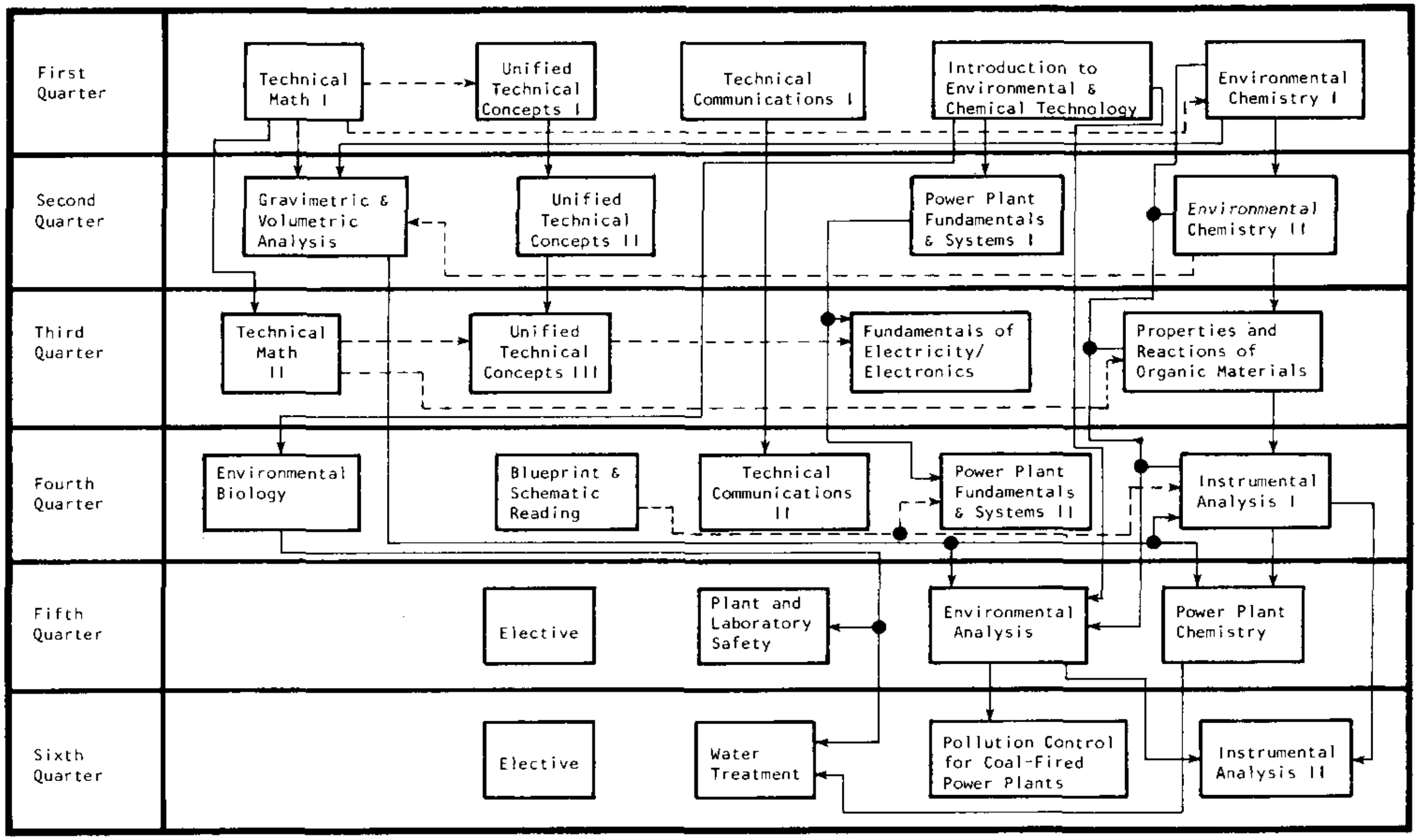
ENVIRONMENTAL AND CHEMICAL ANALYSIS TECHNOLOGY (ECAT)

Course	Class Hours	Lab Hours	Contact Hours
First Quarter			
Introduction to Environmental and Chemical Technology	2	0	2
Environmental Chemistry I	3	6	9
Technical Math I	3	3*	6
Unified Technical Concepts I	3	3	6
Technical Communications I	3	0	3
	14	12	26
Second Quarter			
Power Plant Fundamentals and Systems I	4	3	7
Environmental Chemistry II	3	5	8
Unified Technical Concepts II	3	2	5
Gravimetric and Volumetric Analysis	3	6	9
	13	16	29
Third Quarter			
Properties and Reactions of Organic Materials	3	6	9
Technical Math II	3	3*	6
Fundamentals of Electricity/Electronics	3	5	8
Unified Technical Concepts III	3	3	6
	12	17	29
Fourth Quarter			
Power Plant Fundamentals and Systems II	3	3	6
Environmental Biology	3	3	6
Instrumental Analysis I	3	6	9
Technical Communications II	3	0	3
Blueprint and Schematic Reading	1	3	4
	13	15	28
Fifth Quarter			
Power Plant Chemistry	5	6	11
Environmental Analysis	3	6	9
Plant and Laboratory Safety	3	3	6
Elective	3	0	3
	14	15	29
Sixth Quarter			
Pollution Control for Solid-Fueled Power Plants	3	2	5
Water Treatment	3	6	9
Instrumental Analysis II	3	6	9
Elective	3	0	3
	12	14	26

*Technical Calculations

COURSE FLOW CHART

Environmental and Chemical Analysis Technician - Coal-Fired Power Plants



Section 4

COURSE AND MODULE DESCRIPTIONS AND OUTLINES

Outlines for the recommended courses and modules may be found on the following pages. A resource handbook listing references and materials suitable for use in these courses will be available in the spring of 1980. It should be noted that the length of an outline or section of outline does not necessarily denote importance or depth.

Introduction to Environmental and Chemical Analysis
Unified Technical Concepts I, II and III
Environmental Chemistry I
Technical Math I
Technical Communications I
Power Plant Fundamentals and Systems I
Environmental Chemistry II
Gravimetric and Volumetric Analysis
Properties and Reactions of Organic Materials
Technical Math II
Fundamentals of Electricity and Electronics
Power Plant Fundamentals and Systems II
Environmental Biology
Instrumental Analysis I
Technical Communications II
Blueprint and Schematic Reading
Power Plant Chemistry
Environmental Analysis
Plant and Laboratory Safety
Pollution Control for Coal-Fired Power Plants
Water Treatment
Instrumental Analysis II

INTRODUCTION TO ENVIRONMENTAL AND CHEMICAL ANALYSIS

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 2 hours per week.
Laboratory - none.

PRESENTATION

This course is designed to be presented in the first quarter of the first year of instruction.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

This course introduces the student to Environmental and Chemical Analysis Technology. It gives an overview of the curriculum, as well as a synopsis of on-the-job activities.

MODULE TITLES

- Overview - Field and Curriculum (IE-01).
- Environmental and Chemical Analysis Technicians in the Power Plant (IE-02).
- Power Plant Water Analysis and Treatment (IE-03).
- Pollution and Abatement (IE-04).
- Environment and Production (IE-05).

OVERVIEW - FIELD AND CURRICULUM (IE-01)

Module Outline

COURSE: Introduction to Environmental and Chemical Analysis.
CONTACT HOURS: Lecture - 4 hours.

INTRODUCTION

This module discusses the general field of environmental and chemical analysis, describes the curriculum and tells how it prepares the student for a career. A guest speaker could be invited to talk about the field of environmental and chemical analysis.

PREREQUISITES

None.

OBJECTIVES

Upon completion of this module the student should be able to:

- Tell where environmental and chemical analysis is used.
- Outline the tasks performed by an Environmental and Chemical Analysis Technician.
- Describe the curriculum design and tell why it includes the courses it does.

SUBJECT MATTER

I. Environmental and Chemical Analysis Technology.
   A. Definitions.
   B. Concepts.
      1. Environmental.
      2. Biological.
      3. Chemical.

II. Curriculum Defined.

  A. Rationale.

  B. Integration.

III. Careers.

  A. Job description.

  B. Job potential.

  C. Further education.

ENVIRONMENTAL AND CHEMICAL ANALYSIS TECHNICIAN
IN THE POWER PLANT (IE-02)

Module Outline

COURSE: Introduction to Environmental and Chemical Analysis.

CONTACT HOURS: Lecture - 4 hours.

INTRODUCTION

This module elaborates on the role of an Environmental and Chemical Analysis Technician in a modern electric power generating plant.

PREREQUISITES

None.

OBJECTIVES

Upon completion of this module the student should be able to:

- Briefly outline the process of generating electricity.
- Discuss the major differences in various power plant types.
- Describe the job of an Environmental and Chemical Analysis Technician in a power plant.

SUBJECT MATTER

I. Generation of electricity.
   A. Coal.
   B. Oil.
   C. Gas.
   D. Nuclear.
   E. Hydro.

II. Chemical analysis and treatment in power plants.
   A. Water analysis.
   B. Water treatment.

C. Fuel analysis.

D. Environmental analysis.

III. Job Description - Power Plant Environmental and Chemical Analysis Technician.

POWER PLANT WATER ANALYSIS AND TREATMENT (IE-03)

Module Outline

COURSE: Introduction to Environmental and Chemical Analysis.

CONTACT HOURS: Lecture - 4 hours.

INTRODUCTION

Environmental and Chemical Analysis Technicians in a power plant will spend much of their time on water analysis and treatment. This module briefly discusses the importance of these tasks.

PREREQUISITES

None.

OBJECTIVES

Upon completion of this module the student should be able to:

- Discuss the uses of water in a power plant.
- Discuss the "purity" of water used in a power plant.
- Discuss the reasons why water analyses and treatment are so vital to a modern power plant.

SUBJECT MATTER

I. Water uses in a power plant.

II. Problems associated with impurities in plant water.

III. Prevention through water treatment.

POLLUTION AND ABATEMENT (IE-04)

Module Outline

COURSE: Introduction to Environmental and Chemical Analysis.

CONTACT HOURS: Lecture - 4 hours.

INTRODUCTION

This module discusses pollution from coal-fired power plants and methods of abatement.

PREREQUISITES

None.

OBJECTIVES

Upon completion of this module the student should be able to:

- Discuss the various types of pollutants from a coal-fired power plant.
- Outline control strategies commonly used by power plants to control various types of pollutants.
- Define the Environmental and Chemical Analysis Technician's role in the power plant pollution problem.

SUBJECT MATTER

I. Pollution in the power plant.
   A. Air.
      1. Particulate.
      2. Gaseous.
   B. Water.
      1. Thermal.
      2. Toxic substances.
      3. Oxygen demand in wastes.

        4. Suspended solids.
        5. Others (oil, PCB's, etc.).
    C. Solid wastes.
        1. Ash.
        2. Slag.
        3. Scrubber sludge.
        4. Dust.
        5. Water treatment wastes.
    D. Noise.

II. Pollution monitoring.
    A. Air.
    B. Water.
    C. Solid waste.

III. Pollution control devices and processes.
    A. Air.
    B. Water.
    C. Solid waste.

ENVIRONMENT AND PRODUCTION (IE-05)

Module Outline

COURSE: Introduction to Environmental and Chemical Analysis.

CONTACT HOURS: Lecture - 4 hours.

INTRODUCTION

This module discusses the conflicting interests of environment and production and areas where compromise must be made in order to provide an adequate supply of energy with the least amount of environmental degradation.

PREREQUISITES

None.

OBJECTIVES

Upon completion of this module the student should be able to:

- Describe the situation which would occur if power plants were allowed to produce as much power as was needed with no environmental restraints.
- Describe the situation if power plants were forced to remove 100% of all pollution created during the generation of electricity.
- List areas where compromise must take place.

SUBJECT MATTER

I. Alternatives.
   A. Environment.
   B. Production.

II. Basic conflicts of interest.

III. Compromise.

A. Efficiency.

B. Tolerance levels.

C. Economics.

D. Ethical considerations.

UNIFIED TECHNICAL CONCEPTS I, II AND III

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 3 hours per week.

PRESENTATION

These courses are designed to be taught in the first year.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

Unified Technical Concepts is designed to teach basic principles of physics as they apply to mechanical, fluid, electrical and thermal systems. Practical applications and hands-on laboratory work are stressed throughout the course. Concepts presented include:

- Force and Forcelike Quantites.
- Work and Energy.
- Rate.
- Momentum.
- Resistance.
- Power.
- Potential and Kinetic Energy.
- Force Transformers.
- Energy Converters.
- Transducers.
- Vibrations and Waves.
- Time Constants.
- Radiation.

UNIFIED TECHNICAL CONCEPTS

Course Design for
Environmental and Chemical Analysis Technicians

Quarter System

Unified Technical Concepts application modules recommended for the Environmental and Chemical Analysis Technician Curriculum are listed in the table below by concept module number and quarter. Concepts are listed in the order recommended to meet prerequisites for other courses in the ECAT curriculum.

Quarter	Concept Number	Essential Application Modules	Optional Application Modules	Total
First (UTC I)	1-0	8	10	18
	2-0	4	4	8
	3-0	5	6	11
	5-0	7	12	19
Quarter Totals		24	32	56
Second (UTC II)	6-0	5	4	9
	7-0	5	15	20
	8-0	2	6	8
	11-0	5*	12	17
Quarter Totals		17	37	54
Third (UTC III)	9-0	6	7	13
	10-0	7	7	14
	12-0	3	5	8
	13-0	5	17	22
Quarter Totals		21	36	57
Total		62	105	167

UNIFIED TECHNICAL CONCEPTS

Unified Technical Concepts is a flexible physics instructional system consisting of 191 modules designed to meet the needs of a number of technologies. The CORD staff has determined that the following modules are best suited for use in the Environmental and Chemical Analysis Technician curriculum. Those application modules preceded by an asterisk are considered essential. Other application modules listed are optional. TERC-SW recommends that UTC courses for an ECAT include the 25 "essential" application modules and a selection of additional "optional" modules chosen to meet the needs, schedules and budgets of individual schools.

*Essential modules.

CONCEPT, CONCEPT SUPPORT AND APPLICATION MODULES

*1-0 Force

- 1M1 Gravity
- 1M2 Addition of Mechanical Forces
- 1M3 Addition of Torques
- 1M4 Mechanical Equilibrium in Structures
- 1M5 Stress and Strain
- 1M6 Tension in Wires and Cables
- *1F1 Atmospheric Pressure
- *1F2 Density, Buoyancy and Specific Gravity
- 1F3 Hydraulic Jack
- *1F4 Manometers
- 1E1 Potential Difference and Charge Flow
- 1E2 Series and Parallel Voltage Sources
- *1E3 Electric Forces and Fields
- *1E4 Magnetic Forces and Fields
- 1E5 Lead-Acid Storage Battery
- *1T1 Thermometers
- *1T2 Temperature Difference and Heat Flow
- *1T3 Thermal Stress

*2-0 Work

- 2M1 Work Done on an Elevator
- 2M2 Work Done by a Winch
- *2F1 Work Done by a Water Pump
- 2F2 Work Done by a Hydraulic Lift

*2T1 Heat Energy Required for a Temperature Increase
2T2 Heat Energy Required for Melting
*2T3 Heat Energy Required for Boiling
*2T4 Fundamentals of Air Conditioning

*3-0 Rate

3M1 Graphic Approach to Linear Motion
*3M2 Velocity at Constant Acceleration
*3M3 Displacement at Constant Acceleration
3M4 Acceleration of a Mass by Constant Force
*3M5 Rotational Motion
3M6 Radial Acceleration and Centripetal Force
*3F1 Flow Rate Measurement with a Venturi Meter
*3E1 Electric Current
3E2 Frequency
3T1 Heating and Cooling Rate
3T2 Rate of Heat Conduction

4-0 Momentum

4M1 Angular Momentum of a Flywheel
4M2 Impulse and Momentum
4M3 Conservation of a Momentum in Collisions
4M4 Gyroscopes
4F1 Rocket Engines

*5-0 Resistance

5M1 Static and Sliding Friction
5M2 Effect of Lubricants
5M3 Rolling Friction
*5F1 Laminar and Turbulent Flow
*5F2 Viscosity
*5F3 Fluid Resistance in Pipes
*5F4 Valves and Regulators
5F5 Shock Absorbers
5F6 Drag-Resistance to Motion Through FLuids
*5E1 Ohm's Law
5E2 Series and Parallel Resistors
5E3 Internal Resistance of a Battery
5E4 Conductors, Semiconductors and Insulators
5E5 Resistance of Wires
5E6 Resistance of Semiconductor Junctions
5E7 Resistance of Gas Laser Tubes
*5E8 Volt-Ohm Milliammeter
*5T1 Thermal Conductivity
5T2 Heat Flow Through Insulation

*6-0 Power

*6M1 Horsepower
6M2 Prony Brake
*6F1 Hydraulic Power
*6E1 Electrical Power Measurement
6E2 Electric Heater
6E3 Efficiency of Electric Motors and Generators
6E4 Electrical Power Consumption
*6T1 Heat Exchangers

*7-0 Potential and Kinetic Energy

7M1 Piledriver
7M2 Potential Energy of a Spring
7M3 Rotational Kinetic Energy of a Flywheel
7M4 Conservation of Energy in Collisions
7M5 Kinetic Energy and Horsepower of an Automobile
7F1 Energy Stored in Large Tanks
*7F2 Venturi Meters
*7F3 Pitot Tubes
*7F4 Energy Conversion in Fluid Systems
*7F5 Gas Laws
7F6 Siphons
7E1 Energy Stored in a Battery
7E2 Energy Stored in a Capacitor
7E3 Energy Stored in an Inductor
7E4 Series and Parallel Capacitors
7T1 Heat Storage Systems
7T2 Electrical Equivalent of Heat
7T3 Mechanical Equivalent of Heat
7T4 Thermal Drying
*7T5 Mixing Liquids at Different Temperatures

*8-0 Force Transformers

8M1 Levers
8M2 Wedges and Inclined Planes
*8M3 Drive Systems
8M4 Gear Trains
8M5 Block and Tackle
8M6 Differential Hoist
8F1 Hydraulic Press
*8E1 Electrical Transformers

*9-0 Energy Converters

*9F1 Turbines
9F2 Fluid Pumps
9F3 Wind Power
9F4 Fans and Blowers
9F5 Vacuum Pumps
*9E1 Electric Generators
9E2 Alternators
*9E3 Electric Motors
*9E4 Solenoids and Relays
*9E6 Photovoltaic Materials
*9T1 Boilers
9T2 Thermoelectric Generators
9T3 Solar Collectors

*10-0 Transducers

10M1 Strain Gages
10M2 Accelerometers
*10F1 Bourdon Tubes
10F2 Aneroid Barometers
10F3 Differential Pressure Transducers
*10F4 Fluid-Flow Measuring Devices
10F5 Vacuum Gages

*10E1 Meter Movements
10T1 Automobile Thermostats
10T2 Bimetallic Strips
*10T3 Temperature Measuring Devices
*10T4 Thermocouples
*10T5 Thermistors
*10T6 Pyrometers

*11-0 Vibrations and Waves

11M1 Speed of Sound in Materials
11M2 Reflection and Absorption of Sound Energy
11M3 Vibration Isolation
*11M4 Resonance
11M5 Sound Speakers
11F1 Cavity Vibrations and Standing Waves
11F2 Speaker Enclosures
11F3 Reverberation Time
11F4 Doppler Effect
11F5 Pressure Measurement in Sound Waves
*11E1 Alternating Voltage and Current
*11E2 Phase Relationships in a.c. Circuits
*11E3 Oscilloscope
*11E4 Rectifiers
11E5 Electronic Filtering in d.c. Power Supplies
11E6 Electronic Filtering for Frequency Selection
11E7 Modulation of Electrical Waves

*12-0 Time Constants

12M1 Shock Isolation by Absorbers
12F1 Rate of Emptying Tanks
*12E1 RC Circuits
12E2 RL Circuits
12E3 RLC Circuits
*12T1 Response Time of Thermocouples
*12T2 Time Constants of Heating and Cooling

*13-0 Radiation

*13L1 Inverse Square Law - Spreading of Light
*13L2 The Optical Spectrum
*13L3 Light Sources
13L4 Lasers
13L5 Stroboscopes - Light Pulses
*13L6 Optical Filters - Absorption of Light
13L7 Specular and Diffuse Reflection of Light
13L8 Image Formation with Mirrors
13L9 Prisms - Refraction and Dispersion of Light
13L10 Lenses - Focusing and Spreading of Light
13L11 Interference - Testing Flat Surfaces
13L12 Diffraction Grating - Measuring the Wavelengths of Light
13L13 Polarization - Glare Reduction
13L14 Holography - Three Dimensional Photography
*13L15 Spectroscopy - Light Analysis
13L16 Infrared Radiation Thermometers
13L17 Illumination
13L18 Single Lens Reflex Camera

13N1 Geiger Counters
13N2 Penetrating Power of Alpha and Beta Radiation
13N3 Radioactivity
13N4 Absorption of Gamma Radiation

SUPPLEMENTARY MODULES

S1 Formula Interpretation
S2 International System of Units
S3 Logarithms and Exponents
*S4 Angles and Triangles
S5 Vectors and Scalars
S6 Dimensional Analysis
*S7 Reading and Drawing Graphs
*S8 Precision, Accuracy and Measurement

ENVIRONMENTAL CHEMISTRY I

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 6 hours per week.

PRESENTATION

This course is designed to be presented in the first year.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

Environmental Chemistry I is an introduction to basic chemistry concepts including a consideration of atomic structure and the "language" of chemistry. Fundamental laboratory techniques are included with an emphasis on safety.

MODULE TITLES

- Safety in Chemical Operations (CH-01).
- Atoms, Molecules, and Ions (CH-02).
- Atomic Structure and Chemical Equations (CH-03).
- Periodic Classification of Elements (CH-04).
- Chemical Bonding (CH-05).

SAFETY IN CHEMICAL OPERATIONS (CH-01)

Module Outline

COURSE: Environmental Chemistry I.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 12 hours.

INTRODUCTION

The importance of safety both to industry and to the individual will be discussed in this module.

PREREQUISITES

The student should have completed one year of high school algebra.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define in writing the following terms:
  --Combustion.
  --Flash point.
  --Ignition temperature.
  --Auto-ignition temperature.
  --Pyrophoric materials.
  --Acute.
  --Chronic.
- Identify the hazard associated with:
  --Strong acids.
  --Caustic or alkaline materials.
  --Toxic chemicals.
  --Volatile liquids.
  --Handling and assembling glassware.
  --Using various heating devices.

--Disposal of chemical wastes.

--Vacuum apparatus.

--Perchloric acid.

--Mercury.

--Carbon tetrachloride.

--Benzene.

--Electrical equipment.

--Excessive pressure.

--Cryogenics.

- Describe the proper procedure and hazards associated with the following aspects of handling compressed gases:

  --Transporting cylinders.

  --Selection of regulator.

  --Attaching and using the regulator.

- List three sources of ignition of chemicals.

- Identify the three most common ways in which toxic chemicals enter the body and precautions to be observed to prevent the toxic materials from entering the body.

- Describe when the following protective equipment should be used:

  --Safety glasses.

  --Face shield.

  --Safety shields.

  --Safety showers.

  --Fire extinguisher.

  --Fume hoods.

  --Gloves.

  --Lab coats and aprons.

  --Safety fountain.

SUBJECT MATTER

I. Chemical laboratory safety.

   A. General types of hazards.

   B. Some rules for safe handling of chemicals.

   C. Ventilation.

   D. Glassware.

   E. Heating devices.

   F. Reagent bottles.

   G. Solid and liquid disposal.

II. Personal protective equipment.

   A. Laboratory safety equipment.

      1. Shields.
      2. Showers and fountains.
      3. Fire extinguishers.
      4. Fume hoods.
      5. Exhaust fans.
      6. Breathing apparatus.

   B. Lab coats and aprons.

   C. Gloves.

   D. Hard hats and protective shoes.

   E. Safety glasses, goggles and face shields.

III. Fire safety and explosions.

   A. Flammable liquids and gases.

      1. Combustion requirements.
      2. Flash point.
      3. Ignition temperature.
      4. Auto-ignition temperature.

   B. Storage of flammable liquids.

   C. Fire prevention.

   D. Fire extinguishing.

   E. Pyrophoric materials.

IV. Toxicity of chemicals.

   A. Toxic chemicals.

   B. How toxic chemicals enter the body.

   C. Table of disabling work injuries caused by toxic materials.

      1. Physiological effects.
      2. Threshold limit value (TLV).
      3. Exposure by inhalation.
      4. Exposure by skin contact.
      5. Exposure by swallowing.
      6. Concentrated acids.
      7. Alkali-bases.
      8. Benzene.
      9. Mercury.
      10. Carbon tetrachloride.

V. Electrical hazards.
   A. Common electrical hazards.
   B. Current/voltage/resistance.
   C. Grounding of equipment.
   D. Precautions.

VI. Special hazards.
   A. Compressed gases.
      1. Transporting.
      2. Regulators.
      3. Storage.
   B. Sodium.
   C. Mercury.
   D. Cryogenics.
   E. Unattended operations.
   F. Refrigerators.
   G. Vacuum/pressure.

VII. First aid.
   A. Physical shock.
   B. Bleeding.
   C. Burns.
   D. Fractures.
   E. Poisons.
   F. Fainting.
   G. Heat stroke and exhaustion.
   H. Electrical shock.

MATERIALS FOR LABORATORY PROCEDURES

- Personal protective equipment for teacher demonstration.
- Safety glasses, face shield, explosion shield, fire extinguisher, eye-wash fountain, safety shower.
- Major laboratory equipment such as: vacuum pump, gas cylinders/ regulators, fume hood, for teacher demonstration.
- 16 mm safety film - "Safety in the Chemical Laboratory." Manufacturing Chemists Association.

LABORATORY PROCEDURES

- Assignment of locker/lab equipment.
  Discussion of notebook/reporting procedures.

- Student sketch lab, identifying major safety equipment such as: fume hood, eye-wash fountain, safety shower, fire extinguisher, emergency exits, solid and liquid waste disposal.

- Teacher demonstrates use of face and explosion shields, vacuum pump operation, handling gas cylinders/regulators, fume hood operation, etc., and discusses safety.

- View 16 mm safety film, "Safety in the Chemical Laboratory."

REFERENCES

1. Dangerous Properties of Industrial Materials. Reinhold.

2. "Health Factors in Safe Handling of Chemicals," Safety Guide SG-1. Washington, DC: Manufacturing Chemists Association, Inc., 1960.

3. Meyer, Eugene. Chemistry of Hazardous Materials. Englewood Cliffs, NJ: Prentice-Hall, 1977.

4. Safety in the Chemical Laboratory. Easton, PA: American Chemical Society, Division of Chemical Education, 1967.

5. The Handbook of Laboratory Safety. Cleveland, OH: Chemical Rubber Company.

ATOMS, MOLECULES AND IONS (CH-02)

Module Outline

COURSE: Environmental Chemistry I.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 12 hours.

INTRODUCTION

This module includes a brief introduction to the concept of atoms and molecules and a description of symbols and formulas used in chemistry.

PREREQUISITES

The student should have completed one year of high school algebra and the previous module of this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define in writing the following terms:
  --Element.
  --Atom.
  --Molecule.
  --Homogeneous.
  --Heterogeneous.
  --Mixture.
  --Compound.
  --Ion.
- Write the basic chemical formulas.
- Write the name of a compound given its formula, or write the formula given its name.
- Match the name of an element with its symbol.
- Identify changes as chemical or physical changes.

SUBJECT MATTER

I. States of matter.
   A. Solid, liquids, gases.
   B. Physical and chemical changes.

II. Classification of matter.
   A. Mixtures.
      1. Homogeneous (solutions).
      2. Heterogeneous.
   B. Elements.
   C. Compounds.

III. Separation of mixtures.
   A. Filtration.
   B. Distillation.
   C. Chromatography.

IV. Elements.
   A. Number.
   B. Abundance.
   C. Common elements and their symbols.

V. Compounds.
   A. Water as an example.
   B. Comparison of water, hydrogen and oxygen.
   C. Comparison of salt, sodium and chlorine.

VI. Atoms.
   A. Definition.
   B. Atomic theory.

VII. Molecules.
   A. Diatomic.
   B. Monoatomic.
   C. Some common molecules.
   D. Structural formulas - space relationships.

VIII. Ions.
   A. Formation of positive ions.
   B. Formation of negative ions.
   C. Radicals.
   D. Some common ions.

IX. Naming inorganic compounds.
   A. Importance of correctly naming compounds.
   B. Binary compounds.
   C. Acids and their salts.

MATERIALS FOR LABORATORY PROCEDURES

- Laboratory 1.
  --Sodium bicarbonate, $NaHCO_3$.
  --Magnesium sulfate, $MgSO_4 \cdot 7\ H_2O$ (Epsom salts).
  --4 small crucibles with lids.
  --2 Meker or Bunsen burners.
  --2 ring stands.
  --2 small iron rings.
  --2 clay triangles.
  --1 pair crucible tongs.
  --1 desiccator.
  --Analytical balance.
- Laboratory 2.
  --Silver metal (sheet).
  --6 M nitric acid.
  --6 M sulfuric acid.
  --50-ml beaker.
  --Ribbed watch glass.
  --Desiccator.
  --Dropper.
  --Burner.
  --Wire gauze.
  --Oven.
  --Balance.
- Laboratory 3.
  --Materials to be specified.

LABORATORY PROCEDURES

Laboratory 1 - Decomposition of Compounds.

Sodium bicarbonate and magnesium sulfate are separately heated and the weight losses are determined. The experiment illustrates weight relationships in chemical formulas.

Laboratory 2 - The Formula of a Metal Chloride.

The purpose of this experiment is to determine the formula for silver chloride by reacting silver with hydrochloric acid, thereby illustrating the quantitative features of chemical formulas.

Laboratory 3 - Laboratory to be specified.

REFERENCES

1. Devault, D.D. "Electronic Structure of the Atom," J. Chem. Educ., 2, 526 (1944).

2. Petrucci, Ralph. General Chemistry. New York: Macmillan Publishing Co., 1977. Chapter 2.

3. Swinehart, D.F. "The Build-up of Principle and Atomic and Ionic Structure," J. Chem. Educ., 27, 622 (1950).

4. van Spronsen, J.W. "The Prehistory of the Periodic System of the Elements," J. Chem. Educ., 36, 565 (1959).

ATOMIC STRUCTURE AND CHEMICAL EQUATIONS (CH-03)

Module Outline

COURSE: Environmental Chemistry I.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 12 hours.

INTRODUCTION

This module will discuss the structure of the atom, weight relationships and chemical equations.

PREREQUISITES

The student should have completed one year of high school algebra and the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Write the electrical charge and relative weight of electrons, protons, and neutrons.
- Draw a pictorial representation of simple atoms, giving the location of electrons, protons and neutrons.
- Given the formula of a compound, calculate the percentage composition.
- Write and balance chemical equations.
- Calculate the weight of product produced from a given quantity of reactants.
- Determine atomic and molecular weights of elements and compounds.
- Calculate the number of moles in a given quantity of an element or compound.
- Calculate the number of grams in a sample, given the number of moles in the sample.

SUBJECT MATTER

I. Model for the atom.
   A. Electrons.
   B. Protons.
   C. Neutrons.
   D. Nucleus.

II. Atomic weight.
   A. Atomic mass unit.
   B. Atomic number.

III. Molecular weight.
   A. Examples.
   B. Gram molecular weight - mole.
   C. Avogadro's number.

IV. Percentage composition from formulas.
   A. Percentage composition of water.
   B. Law of definite proportions.
   C. Percentage composition of magnesium sulfate.

V. Writing chemical equations.
   A. Information needed.
   B. Steps in balancing.
   C. Example - decomposition of potassium chlorate.

VI. Types of chemical reactions.
   A. Combination.
   B. Decomposition.
   C. Single replacement.
   D. Double replacement.

VII. Calculations based upon equations.
   A. Example - potassium chlorate.
   B. Example - combustion of ethane.

MATERIALS FOR LABORATORY PROCEDURES

- Laboratory 1.

  --Bunsen burner.
  --Crucible and cover.
  --Ring stand, ring, wire triangle.
  --Powdered sulfur.
  --0.1 M sodium oxalate.

--0.1 M $KMnO_4$.

--10 M NaOH.

--0.1 M $Pb(NO_3)_2$.

--0.1 M $BaCl_2$.

--1.0 M K_2CrO_4.

--0.1 M Na_2So_3.

--Thistle tube and long-stem funnel.

--6 M NH_4OH.

--2-in. length copper wire.

--6 M HCl.

--Copper oxide.

--Mossy zinc.

--0.01 M $CuSo_4$.

--Concentrated HNO_3.

--3 M $(NH_4)_2CO_3$.

--$KMnO_4$ (solid).

--Na_2CO_3 (solid).

--ZnS (solid).

- Laboratory 2.

--250-ml beakers (2).

--Sintered glass crucibles (2).

--Vacuum tubing.

--Vacuum filter flask.

--Crucible holder.

--25-ml graduated cylinder.

--Stirring rod.

--Rubber policeman.

--Bunsen burner.

--Wire gauze.

--Oven.

--Weighing paper.

--Wash bottle.

--50-ml beaker.

--Ring stand, iron ring.

--Distilled water.

--Chloride-free 6 M HNO_3.

--0.2 M $AgNO_3$.

--Unknown chloride sample.

- Laboratory 3.
  --Materials to be specified.

LABORATORY PROCEDURES

Laboratory 1 - Chemical Reactions.

Objectives: To observe some typical chemical reactions, identify some of the products and summarize the chemical changes in terms of balanced chemical equations.

Laboratory 2 - Gravimetric Determination of Chloride.

Objective: To introduce gravimetric analysis, an important technique of analytical chemistry, and weight relationships in chemical equations.

Laboratory 3 - Laboratory to be specified.

REFERENCES

1. Hecht, Selig. Explaining the Atom. New York: Viking Press, Inc., 1954.
2. Labbauf, A. "The Carbon-12 Scale of Atomic Masses," J. Chem. Educ., 32, 48 (1955).
3. Miller, Erwin W. "Atoms Visualized." Scientific American, 196, June, 1957.

PERIODIC CLASSIFICATION OF ELEMENTS (CH-04)

Module Outline

COURSE: Environmental Chemistry I.

CONTACT HOURS: Lecture - 6 hours
Laboratory - 12 hours.

INTRODUCTION

This module will discuss the importance of the periodic table as a predictive device.

PREREQUISITES

The student should have completed one year of high school algebra and the previous modules of this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- State the periodic law.
- Predict the properties of an element given its location in the periodic table.
- List some of the chemical and physical properties of families of elements.
- Explain the relative chemical reactivity of elements from an electronic viewpoint.
- Write the nuclear isotope symbols of an element given the mass numbers.

SUBJECT MATTER

I. Structure of the periodic table.

II. Families of elements.

   A. Vertical relationships.

B. Alkali metals.
C. Halogens.
D. Inert gases.
E. Differences in properties.
F. Electronic structure.

III. Periods.
A. Build-up principles.
B. Representative metals.
C. Transition metals.

IV. Trends in atomic properties.
A. Size.
B. Ionization energy.
C. Electronegativity.
D. Metallic character.
E. Nonmetals.
F. Metalloids.

V. Predictions based on the periodic table.
A. Physical properties of elements.
B. Relative properties.
C. Predicting formulas.
D. Historical predictions.

VI. Isotopes.
A. Definition.
B. Hydrogen.
C. Uranium.
D. Nuclear symbols.

MATERIALS FOR LABORATORY PROCEDURES

- Laboratory I

--Bunsen burner.
--7 test tubes.
--Test-tube rack.
--Aluminum metal.
--Copper metal.
--Lead metal.
--Magnesium.
--Tin.
--Zinc.

--Iron.

--6 M HCl.

--3 M H_2SO_4.

--3 M NaOH.

--3 M HNO_3.

- Laboratory 2

  --Test tubes.

  --Test-tube rack.

  --10-ml graduated cylinder.

  --Mercuric chloride, saturated solution.

  --1 M hydrochloric acid.

  --Zinc metal, granulated.

  --Vanadyl sulfate, 0.03 M solution in H_2SO_4.

- Laboratory 3

  --Materials to be specified.

LABORATORY PROCEDURES

Laboratory 1 - Reactivity of Metals.

This experiment shows the variable reactivity in a period of the periodic table.

Laboratory 2 - Reactions of Vanadium.

This experiment illustrates the effect of valence on chemical reactivity.

Laboratory 3 - Laboratory to be specified.

REFERENCES

1. "History of Development of the Periodic Chart and Its Use as a Teaching Aid," Science Education, 42, 142 (1958).

2. Sisler, Harry H. Electronic Structure, Properties, and the Periodic Law. Reinhold Publishing Corp., 1963.

3. "The Periodic System and Atomic Structure," J. Chem. Educ., 22, 314, (1954).

4. Weeks, M.E. "Periodic System of the Elements," Discovery of the Elements. Easton, PA: Journal of Chemical Education, 1956.

CHEMICAL BONDING (CH-05)

Module Outline

COURSE: Environmental Chemistry I.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 12 hours.

INTRODUCTION

This module will discuss the importance of electrons in chemical bonding, properties of compounds, ionic, covalent and metallic bonding.

PREREQUISITES

The student should have completed one year of high school algebra and the previous modules of this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define and illustrate the following:

  --Ionic bond.

  --Covalent bond.

  --Coordinate covalent bond.

  --Metallic bond.

  --Electronegativity.

  --Cation.

  --Anion.

- Draw the electronic formulas for elements and compounds.
- List observable characteristics that distinguish ionic substances from covalent substances.
- Identify polar molecules and nonpolar molecules given the molecular formula.

- Rank elements in order of increasing electronegativity.
- Given a listing of compounds, identify those that are conductors in solution.
- Discuss metallic bonding and the properties of metals.

SUBJECT MATTER

I. Electronic explanation of chemical activity.
   A. Inert atoms.
   B. Seven electrons.
   C. One electron.

II. Ionic bonding.
   A. Binding forces in ionic compounds.
   B. Valence.
   C. Ionic crystals.
   D. Electronic formulas for ionic compounds.

III. Covalent bonding.
   A. Electronic formulas for covalent compounds.
   B. Oxidation number in covalent compounds.
   C. Coordinate covalence.

IV. Electronegativity.

V. Polarity.

VI. Writing formulas.

VII. Valence relationships in the periodic table.

VIII. Metallic bonding.

MATERIALS FOR LABORATORY PROCEDURES

- Laboratory 1
  --Electrical conductance apparatus.
  --50-ml beakers (8).
  --Distilled water.
  --Methyl alcohol.
  --Kerosene or gasoline.
  --Acetone.
  --Carbon tetrachloride.
  --Potassium bromide.
  --Potassium chloride.
  --Barium chloride.

--Potassium nitrate.
--Sugar.
--Sodium chloride.
--Copper sulfate.
--Sodium phosphate.

- Laboratory 2
  --Pyrex test tube.
  --One-hole stopper.
  --Ring stand with clamp.
  --Bunsen burner.
  --6 wide-mouth gas bottles.
  --6 glass plates.
  --Water trough.
  --Tongs.
  --Potassium chlorate.
  --Manganese dioxide.
  --Splint.
  --Magnesium ribbon.
  --Steel wool.
  --Sulfur.
  --Charcoal.
  --Deflagrating spoon.
- Laboratory 3
  --Materials to be specified.

LABORATORY PROCEDURES

Laboratory 1 - Conductance of Electrolytes and Nonelectrolytes.

In this experiment a series of chemical compounds will be examined to determine if they are electrolytes or nonelectrolytes. The property of electrical conductance will be related to the type of chemical bonding of the compounds.

Laboratory 2 - Preparation and Properties of a Covalent Compound.

In this experiment, oxygen, a covalent compound, will be prepared. Some of the reactions of oxygen will be examined.

Laboratory 3 - Laboratory to be specified.

REFERENCES

1. "Chemistry of the Covalent Bond," J. Chem. Educ., 30, 530 (1953).

2. Greenwood, N.N. "Chemical Bonds," Educ. in Chemistry, 4, 164 (1967).

3. Pauling, L. Nature of the Chemical Bond. Ithaca, NY: Cornell University Press, 1960.

4. Sanderson, R.T. "Principles of Chemical Bonding," J. Chem. Educ., 31, 382 (1961).

TECHNICAL MATH I

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.

Laboratory - 3 hours per week.

PRESENTATION

This course is designed to be presented at the beginning of the first year.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

Technical Math I is intended to provide students with the math background necessary for performing various environmental and chemical analyses. This course will present information ranging from a cursory review of simple mathematics through technical algebra. The laboratory will stress solving technical problems encountered in introductory courses in chemistry and physics. Students should be reasonably competent in basic arithmetic before taking this class and if not should consider a remedial course.

COURSE OUTLINE

I. Arithmetic.
   A. Whole numbers.
      1. Addition.
      2. Subtraction.
      3. Multiplication.
      4. Division.

B. Fractions.
   1. Computation.
   2. Less than 1.
   3. Mixed numbers.
C. Decimals.
   1. Conversion to fractions.
   2. Addition and subtraction.
   3. Multiplication and division.
D. Percentages.
   1. Conversion to fractions and decimals.
   2. Rate and base.
E. Word problems.
F. Metric system.
   1. Temperature.
   2. Pressure.
   3. Volume.
   4. Length.
G. Square roots.
H. Number bases.

II. Algebra.
   A. Signed numbers.
      1. Negative and positive numbers.
      2. Absolute value.
      3. Computations.
   B. Algebraic expressions and operations.
      1. Monomials.
      2. Polynomials.
   C. Equations.
      1. Fractional.
      2. Systems of equations.
   D. Graphing.
      1. Coordinate system.
      2. Equations and graphs.
      3. Slope.
   E. Exponents, roots and powers.
      1. Fractions.
      2. Exponents.
      3. Scientific notation.

F. Radicals.

1. Irrational numbers.
2. Radicals.

TECHNICAL COMMUNICATIONS I

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - none.

PRESENTATION

This course is designed to be taught in the first quarter of the first year of instruction.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

Technical Communications I is intended to provide the student with language structure-and-use review, followed by working knowledge of and firsthand experience in the use of communication techniques, procedures, forms and formats employed in power plants and related industries. Also, proper use of written manuals, guides and vendor instructions is reviewed.

MODULE TITLES

- Reviewing Language Structure (TC-01).
- Reviewing Language Usage (TC-02).
- Technical Writing Style and Graphics (TC-03).
- Familiarization with the Handbook of Chemistry and Physics (TC-04).
- Using Manuals and Guides (TC-05).

REVIEWING LANGUAGE STRUCTURE (TC-01)

Module Outline

COURSE: Technical Communications I.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - none.

INTRODUCTION

This module reviews the fundamentals of grammatical structure. Emphasis is placed on those aspects of the language of most immediate concern to a technician whose job performance and recognition may hinge upon competence in work-related communications.

PREREQUISITES

None.

OBJECTIVES

Upon completion of this module the student should be able to:

- Identify the eight parts of speech.
- Identify and construct clauses and phrases.
- Identify and construct simple sentences, complex sentences and compound sentences.
- Properly use common forms of punctuation.

SUBJECT MATTER

I. *Review of grammatic construction.*
   A. Phrases.
   B. Clauses.
      1. Dependent.
      2. Independent.

C. Sentence structures.
   1. Simple.
   2. Complex.
   3. Compound.

D. Sentence types.
   1. Assertion.
   2. Question.
   3. Command.
   4. Wish.
   5. Exclamation.

E. Paragraphs.

II. Review of punctuation.

A. Period.

B. Comma.

C. Colon.

D. Capitalization.

E. Others.

REVIEWING LANGUAGE USAGE (TC-02)

Module Outline

COURSE: Technical Communications I.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - none.

INTRODUCTION

This module reviews the essentials of good usage. Emphasis is placed on those aspects of language most significant to the development of good technical communication as it relates to job performance and recognition.

PREREQUISITES

The student should have completed Module TC-01, "Reviewing Language Structure."

OBJECTIVES

Upon completion of this module the student should be able to:

- Properly use industry-accepted abbreviations and acronyms.
- Properly use industry-accepted symbols.
- Demonstrate familiarity with industry jargon.

SUBJECT MATTER

I. Review of common symbols.
   A. Chemical.
   B. Electrical.
   C. Mechanical.
   D. Others.

II. Review of short forms.
   A. Abbreviations.
      1. Common usage.
      2. Acceptable usage.

B. Acronyms.

III. Review of power plant jargon.

A. Acceptable applications.

B. Unacceptable applications.

TECHNICAL WRITING STYLE AND GRAPHICS (TC-03)

Module Outline

COURSE: Technical Communications I.

CONTACT HOURS: Lecture - 9 hours.
Laboratory - none.

INTRODUCTION

This module describes and provides examples of good literary style for technical writing. Also it explains the selection and use of appropriate graphics.

PREREQUISITES

Student should have completed Module TC-01, "Reviewing Language Structure," and TC-02, "Reviewing Language Usage."

OBJECTIVES

Upon completion of this module the student should be able to:

- State briefly, and in clearly written sentences, the five basic principles of good technical writing and presentations.
- Define "scientific attitude."
- Explain "reader adaptation."
- Define the "mechanics of style."
- Prepare an outline of this module.
- Write an abstract of this module.
- Explain purpose(s) of graphics.
- Relate example graphics to example text materials.
- Design and present an illustrated oral presentation.

SUBJECT MATTER

I. Technical writing and presentation style.

  A. Principles of good technical communications.

  B. "Scientific attitude."

  C. Reader adaptation - audience identification.

    1. Written presentation.

    2. Oral presentation.

  D. The mechanics of style.

    1. Use of abbreviations.

    2. Use of numbers.

    3. Use of symbols.

    4. Word forms.

    5. Punctuation.

      a. Capitals.

      b. Italics (underlining).

      c. Others.

  E. Outlining.

  F. Abstracts.

    1. Descriptive.

    2. Informational.

II. Graphics in technical presentations.

  A. Relationship to text.

  B. Simplification.

  C. Formats.

  D. Graphics as visual aids.

FAMILIARIZATION WITH HANDBOOK OF CHEMISTRY AND PHYSICS (TC-04)

Module Outline

COURSE: Technical Communications I.

CONTACT HOURS: Lecture - 3 hours.
Laboratory - none.

INTRODUCTION

This module introduces the student to the Handbook of Chemistry and Physics* and explains its uses. The student is apprised of those segments of the Handbook most relevant to his or her selected technical specialty and is led to develop a working inventory of its special terminology, resources and applications.

PREREQUISITES

The student should have completed Module TC-02, "Reviewing Language Usage."

OBJECTIVES

Upon completion of this module the student should be able to find the following:

- Relevant mathematical tables.
- Relevant items from the section on "The Elements and Inorganic Compounds."
- Relevant items from the section on "Organic Compounds."
- Relevant information regarding general chemicals.
- Required general physical constants.
- Relevant chemical or physical data from the "Miscellaneous" section.
- Specific references noted in the index.

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*Handbook of Chemistry and Physics, CRC Press. Latest Edition.

SUBJECT MATTER

I. Relevance to technical communications.
   A. General uses of references and resources.
   B. Specific uses of the Handbook.
II. How to find things in reference.
   A. Table of contents.
   B. Index.
III. Handbook exercises.
   A. Mathematical tables.
   B. Elements.
   C. Inorganic compounds.
   D. Organic compounds.
   E. Chemicals.
   F. Physical constants.

USING MANUALS AND GUIDES (TC-05)

Module Outline

COURSE: Technical Communications I.

CONTACT HOURS: Lecture - 9 hours.
Laboratory - none.

INTRODUCTION

Good communication is as dependent upon receiving and interpreting information as it is upon presenting information; therefore, this module concentrates upon good habits and procedures for assimilating and applying useful information from common sources.

PREREQUISITES

None.

OBJECTIVES

Upon completion of this module the student should be able to:

- Identify sources of materials indices.
- Identify sources of vendor indices.
- Read and interpret vendors' parts catalogs.
- Read and interpret equipment maintenance manuals.
- Read and follow equipment/systems operating instructions.
- Read and follow specifications for equipment, components, parts and processes.

SUBJECT MATTER

I. How to find information.
   A. Vendor indices.
   B. Materials indices.

II. How to select useful information.

III. How to read and interpret.

   A. Parts catalogs.
   B. Maintenance manuals.
   C. Operating instructions.
   D. Specifications.
   E. Engineering drawings.

POWER PLANT FUNDAMENTALS AND SYSTEMS I

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 4 hours per week.

Laboratory - 3 hours per week.

PRESENTATION

This course is designed to be presented in the second quarter of instruction.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

Power Plant Fundamentals and Systems I is designed to give the student an overview of the various systems of a power plant and what takes place in each system during power generation. It includes power plant thermodynamics, mechanical equipment, electrical equipment and plant maintenance.

MODULE TITLES

- Power Plant Fundamentals (FS-01).
- Power Plant Thermal Cycles (FS-02).
- Boilers (FS-03).
- Turbines and Generators (FS-04).
- Auxiliary Systems (FS-05).

POWER PLANT FUNDAMENTALS (FS-01).

Module Outline

COURSE: Power Plant Fundamentals and Systems I.

CONTACT HOURS: Lecture - 8 hours.
Laboratory - none.

INTRODUCTION

This module explains physical and mathematical properties using heat energy to transform water to steam.

PREREQUISITES

Student should have completed Math I and Fundamentals of Electricity/Electronics.

OBJECTIVES

Upon completion of this module the student should be able to:

- Briefly summarize the development, harnessing, cause and effect of steam power.
- Discuss the phenomenon of boiling water.
- Describe the basic coal-fired steam system.
- List basic interactions between main components of a coal-fired steam system.

SUBJECT MATTER

I. *The evolution of steam.*

II. Power plant layout.
   A. Major subsystems.
   B. General systems.

POWER PLANT THERMAL CYCLES (FS-02)

Module Outline

COURSE: Power Plant Fundamentals and Systems I.

CONTACT HOURS: Lecture - 8 hours.
Laboratory - 8 hours.

INTRODUCTION

Emphasis in this module is on basic laws and processes governing thermal cycles in power plants. Brief discussions are provided for energy and work forms of energy, thermodynamic cycles, heat balance and efficiency.

PREREQUISITES

Student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define or describe:
  --Energy.
  --Work.
  --Mechanical energy (E_m).
  --Flow work.
  --Heat.
  --Thermodynamics.
  --First law of thermodynamics (describe).
  --Second law of thermodynamics (describe).
  --Properties.
  --Enthalpy.
  --Latent heat of vaporization.
  --Entropy.
  --Specific heat.

--Specific volume.

--Saturation temperature.

--Superheat.

--Carnot cycle (describe).

--Rankine cycle (describe).

--Thermal efficiency.

--Saturated liquid.

--Saturated vapor.

--Carryover.

--Heat balance.

- Identify different types of energy discussed in this module.
- Use the steam table to obtain properties of steam and water at different pressures and temperatures.
- Explain, with the aid of P-V and T-S diagrams, why lowering condenser coolant temperature and raising steam pressure and temperature increases thermal efficiency of a steam electric plant.
- By using the steam table and equations supplied in this module, perform simple heat balance and efficiency calculations.
- List areas of energy losses and internal power consumption within a steam electric plant.
- Calculate energy efficiency of a steam electric power plant given appropriate data regarding energy loss and internal power consumption.

SUBJECT MATTER

I. Energy and work.

   A. Definitions.

   B. Calculations.

II. Thermodynamics.

   A. Laws and processes.

   B. Cycles.

      1. Carnot.

      2. Rankine.

   C. Efficiency.

      1. Factors.

      2. Calculations.

LABORATORY

To be specified.

BOILERS (FS-03)

Module Outline

COURSE: Power Plant Fundamentals and Systems I.

CONTACT HOURS: Lecture - 8 hours.
Laboratory - 8 hours.

INTRODUCTION

Characteristics and basic operating procedures of fossil fuel plants are described in this module, including five boiler designs, classification of fuels, heating values and a discussion of combustion.

PREREQUISITES

Student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define economizers, superheaters, reheaters, blowdown vapor separators, supercritical.
- List major types of boiler designs.
- List major classifications of coal; give characteristics of each type.
- Discuss how heating value is determined and why.
- Demonstrate a knowledge of the combustion reactions taking place in a boiler.

SUBJECT MATTER

I. Boiler design.
   A. Water tube boiler.
   B. Straight tube boiler.
   C. Bent tube boiler.

D. Shell boiler.

E. Fire tube boiler.

II. Boiler auxiliaries.

A. Economizer.

B. Superheater.

C. Reheater.

III. Combustion.

A. Fuel.

B. Reactions.

C. By-products.

LABORATORY

To be specified.

TURBINES AND GENERATORS (FS-04)

Module Outline

COURSE: Power Plant Fundamentals and Systems I.

CONTACT HOURS: Lecture - 8 hours.
Laboratory - 8 hours.

INTRODUCTION

This module describes the major classification of turbines, construction features, generator types and components, general operating procedures and maintenance. Also included are applicable auxiliary equipment and systems.

PREREQUISITES

Student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define and classify basic types of steam turbines found in solid-fueled power generating plants; describe operating principles of each.
- Describe major mechanical components, control systems, auxiliary systems and protection and safety devices and systems of a typical steam turbine.
- Identify various types of supervisory instruments necessary for turbine control.
- Discuss turbine operating procedures and prescribe general turbine maintenance requirements.
- Define and classify basic types of generators used to generate electricity in a solid-fueled power plant.
- Describe major mechanical components of a typical generator.
- Identify various auxiliary systems and components associated with a typical generator, including instrumentation.

- Discuss generator operating procedures and prescribe general generator maintenance.

SUBJECT MATTER

I. Turbines.

   A. Types.

   B. Construction.

   C. Operation.

   D. Auxiliary systems.

      1. Lubrication and hydraulic systems.

      2. Shaft sealing steam system.

      3. Supervisory instrumentation.

      4. Protective devices.

   E. Maintenance.

II. Generators.

   A. Types.

   B. Construction.

   C. Operation.

   D. Auxiliary systems.

      1. Seal-oil systems.

      2. Stator cooling system.

      3. Hydrogen cooling system.

      4. Air cooling system.

      5. Excitation system.

      6. Protective devices.

   E. Maintenance.

AUXILIARY SYSTEMS (FS-05)

Module Outline

COURSE: Power Plant Fundamentals and Systems I.

CONTACT HOURS: Lecture - 8 hours.
Laboratory - 8 hours.

INTRODUCTION

This module discusses plant auxiliary systems and their relationship and interactions with major components.

PREREQUISITES

Student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Identify the plant auxiliary systems.
- Describe the function of each of the auxiliary systems.
- Outline occurrences in each system during steam production.
- List areas where failures might occur if the ECAT fails to do his job properly in the following areas:

  --Water analysis.

  --Fuel analysis.

  --Water treatment.

  --Mixing chemicals for acid cleaning.

  --Stack analysis.

SUBJECT MATTER

I. General overview of plant auxiliaries.

II. Boiler auxiliaries.
   A. Feedwater system.
   B. Water treatment system.
   C. Fuel and ash handling systems.
   D. Pollution control apparatus.
   E. Softeners, economizers, air heaters.

III. Turbines and generators.
   A. Electrical auxiliaries.
   B. Main switchgear.
   C. Protective gear and voltage regulators.

IV. Auxiliary interactions.

ENVIRONMENTAL CHEMISTRY II

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 5 hours per week.

PRESENTATION

This course is designed to be presented in the first year, following Environmental Chemistry I.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

This course includes a discussion of the chemistry of gases, solutions and metals. Acids, bases, electrochemistry and energy also are considered. Laboratory work includes some of the basic analytical techniques used in industrial laboratories.

MODULE TITLES

- Gases (CH-06).
- Solutions (CH-07).
- Acids, Bases and Electrochemistry (CH-08).
- Metals (CH-09).
- Energy, Kinetics and Equilibrium in Chemical Systems (CH-10).

GASES (CH-06)

Module Outline

COURSE: Environmental Chemistry II.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 10 hours.

INTRODUCTION

This module discusses the gaseous elements, the characteristics and laws of gases, sampling techniques and air pollution.

PREREQUISITES

The student should have completed Technical Math I and Environmental Chemistry I.

OBJECTIVES

Upon completion of this module the student should be able to:

- Describe the general characteristics of gases as compared with other states of matter.
- Use the gas laws to calculate relationships of pressure, volume and temperature.
- Define the following terms:

  --States of matter.

  --Diffusion.

  --Barometer.

  --STP.

  --Absolute temperature.
- List major assumptions of the kinetic theory of gases.
- List names and chemical formulas of the more important pollutant substances present in the atmosphere.
- List pollutants characteristic of coal combustion and describe how they are formed.

- Identify four different units for measuring pressure.
- Describe a method of sampling gases.

SUBJECT MATTER

I. Characteristics of gases.
   A. Expansion.
   B. Compression.
   C. Diffusion.

II. Pressure.
   A. Atmospheric pressure.
   B. Barometer.

III. Gas laws.
   A. Pressure-volume relationships.
   B. Standard pressure.
   C. Temperature-volume relationships.
   D. Absolute temperature scale.
   E. Pressure-temperature relationships.
   F. Ideal gas laws.
   G. Law of partial pressures.
   H. Law of diffusion.

IV. Kinetic theory of gases.

V. Air pollution.
   A. The atmosphere.
   B. Particulates.
   C. Smog.
   D. Sulfur dioxide.
   E. Nitrogen oxides.
   F. Carbon monoxide.
   G. Hydrocarbons.
   H. Ozone.
   I. Carbon dioxide.

VI. Methods of sampling gases.

MATERIALS FOR LABORATORY PROCEDURES

- Laboratory 1
  --400-ml beaker.
  --#4 one-hole rubber stopper.

--125-ml Erlenmeyer flask.

--Pneumatic trough.

--Ice.

--Thermometer.

--5-cm length of glass tubing.

--50-ml graduated cylinder.

--Tongs.

--Burner.

- Laboratory 2

--125-ml Erlenmeyer flask.

--25-cm square of aluminum foil.

--400-ml beaker.

--Burner.

--Ring stand and ring.

--Wire gauze.

--2 ml of an unknown organic liquid - any one of the following: benzene, carbon tetrachloride, ethyl acetate, cyclohexane, or dichlorethene.

--Analytical balance.

- Laboratory 3

--Materials to be specified.

LABORATORY PROCEDURES

Laboratory 1 - Determination of Absolute Zero.

In this experiment the relationship between gas volume and temperature at constant pressure is investigated. The data collected will be used for estimation of absolute zero through extrapolation of data collected at temperatures ranging from 0°C to 100°C.

Laboratory 2 - Molecular Weight of a Vapor.

This experiment illustrates a practical use of the ideal gas law, namely, determination of the molecular weight of a volatile compound. The weight of vapor required to occupy a known volume at a measurable pressure and temperature is determined. From this information, the molecular weight is calculated.

Laboratory 3 - Laboratory to be specified.

REFERENCES

1. "Air Pollution and Future Climates," Chemistry. January, 1971.

2. "Air Pollution Costs High," Chemical and Engineering News. February 7, 1972.

3. American Chemical Society. Cleaning Our Environment: The Chemical Basis for Action. American Chemical Society, Washington, DC.

4. "Robert Boyle," M. B. Hall, Sci. American. August , 1967.

5. Tabor, D. "Gases, Liquids, and Solids." Penguin Press, Baltimore, 1969.

SOLUTIONS (CH-07)

Module Outline

COURSE: Environmental Chemistry II.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 10 hours.

INTRODUCTION

This module will consider some of the basic properties of liquids: evaporation, condensation, vapor pressure, boiling point, freezing point, and heat of vaporization. It also will include a discussion of suspensions, solutions, colloids and a discussion of treatment of water and wastewater.

PREREQUISITES

The student should have completed Technical Math I, Environmental Chemistry I and the previous modules of this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define the following terms:

  --Boiling point.
  --Vapor pressure.
  --Surface tension.
  --Molarity.
  --Normality.
  --Solvent.
  --Solute.
  --Saturated solution.
  --Unsaturated solution.
  --Supersaturated solution.

- Discuss the cycle involved in the cooling process of the refrigerator.

- Distinguish between dilute, concentrated, weak and strong solutions.

- Predict the effect of solute concentration on vapor pressure, freezing point and boiling point.

- Discuss effects of pressure and temperature on solubilities.

- Solve problems concerned with concentration of solutions.

- List and explain the various stages of treatment that can be used in treating a fresh water supply.

- List and explain additional stages of water treatment needed to purify water to be used in a power plant.

- List and explain the various stages used in treatment of wastewater.

- Distinguish between suspensions, colloids and solutions.

- Make up and standardize solutions.

SUBJECT MATTER

I. Liquids.
   A. Liquid state - kinetic molecular theory.
   B. Evaporation.
   C. Condensation.
   D. Vapor pressure.
   E. Boiling point.
   F. Heat of vaporization.
   G. Osmotic pressure.
   H. Surface tension.

II. Refrigeration.
   A. Refrigeration cycle.
   B. Heat of vaporization.
   C. Refrigerants.

III. Solutions.
   A. Dispersions.
   B. Kinds of solutions.
   C. Solvent - solute.
   D. Saturated and unsaturated solutions.
   E. Solubility.
   F. Pressure - temperature effects.
   G. Supersaturated solutions.

IV. Concentrations of solutions.

A. Physical units.

B. Dilute-concentrated solutions.

C. Molar solutions.

D. Normal solutions.

E. Specific gravity.

V. Laboratory solutions.

A. Make-up of solutions.

B. Stock solutions.

C. Dilution of solutions.

D. Standardizing solutions.

VI. Water treatment.

A. Water pollution.

B. Fresh water treatment.

C. Power plant water treatment.

D. Wastewater treatment.

VII. Colloids.

A. Types.

B. Characteristics.

C. Dialysis.

D. Coagulation.

E. Emulsions.

F. Gels.

MATERIALS FOR LABORATORY PROCEDURES

Laboratory 1

--Large test tube.

--Ring stand.

--Clamp.

--Asbestos wire gauze.

--400-ml beaker.

--Thermometer.

--Glass stirring rod.

--Pipetter, 10 ml, graduated.

--Balance.

--Potassium nitrate.

--Sodium nitrate.

--Potassium chlorate.

--Distilled water.

- Laboratory 2

--Test tubes.

--Small funnel.

--Stirring rod.

--Bunsen burner.

--Calcium sulfate.

--Magnesium sulfate.

--Sodium carbonate.

--Limewater.

--Distilled water.

--Soap solution (40 ml of liquid soap in 160 ml distilled water).

--250-ml graduate.

--Aluminum sulfate solution (20 g/liter).

--Fine clay.

- Laboratory 3

--Materials to be specified.

LABORATORY PROCEDURES

Laboratory 1 - Solubility Curves.

In this experiment the solubilities of potassium nitrate, sodium nitrate and potassium chlorate are determined at several temperatures. A solubility curve (plot of solubility versus temperature) will be constructed for each compound.

Laboratory 2 - Purification of Water.

The differences between soft water, hard water and permanent hard water will be investigated. The effect of these waters upon a soap solution will be determined. The use of alum to purify water by coagulation will be experimentally investigated.

Laboratory 3 - Laboratory to be specified.

REFERENCES

1. Bernal, J.D. "The Structure of Liquids," Sci. American, Aug., 1960, p. 124.

2. Dowry, B. "Halogenated Hydrocarbons in New Orleans Drinking Water," Science, Vol. 187 (1975).

3. Hauser, E. A. "The History of Colloid Science," J. Chem. Educ., 32, 2 (1955).

4. Roselaar, L.C. "Solubility of Salts," Educ. in Chemistry, 2, 135 (1965).

5. Slabaugh, W.H. "Clay Colloids," Chemistry, Vol. 43 (1970).

ACIDS, BASES AND ELECTROCHEMISTRY (CH-08)

Module Outline

COURSE: Environmental Chemistry II.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 10 hours.

INTRODUCTION

Some of the properties of acids, bases and salts will be studied as well as the important laboratory technique of acid-base titrations. Measurement of hydrogen ion concentration (pH) and the concentration of other ions will be considered. Basic principles of voltaic and electrolytic cells will be examined and examples of various cells and batteries will be cited. The electrochemistry or corrosion and cathodic protection will be studied and the important method of protecting metals through electroplating will be discussed.

PREREQUISITES

The student should have completed Technical Math I, Environmental Chemistry I and the previous modules of this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Assign oxidation numbers to atoms in molecules and ions.
- Define and give an example of an acid and a base according to Arrhenius, Bronsted-Lowry and Lewis theories.
- Describe the method of conducting an acid-base titration.
- Explain what is meant by pH and give the mathematical expression for pH.
- Describe the electrochemical process for corrosion, using an example from a power plant system.

- Explain how cathodic protection can be used to protect a steel tank or pipeline.
- Complete and balance oxidation-reduction equations.
- Calculate the third quantity, having been given any two of the following: time, current, amount of substance produced or consumed in a redox reaction.
- Describe some widely used cells and batteries.
- Describe some electroplating processes.
- Define the following terms:

  --Anode.

  --Cathode.

  --Cathodic protection.

  --Corrosion.

  --Fuel cell.

  --Solar battery.

  --pH.

  --Specific ion electrode.

  --Oxidation.

  --Reduction.
- List specific ion electrodes used in power plants and tell how they are used.

SUBJECT MATTER

I. Acids and bases.

   A. Properties of acids and bases.

   B. Theories of acids and bases.

      1. Arrhenius theory.

      2. Bronsted-Lowry theory.

      3. Lewis theory.

   C. Acid-base neutralizations.

   D. Specific ion concentrations.

      1. Hydrogen ion (pH).

      2. Other specific ions.

   E. Properties of salts.

II. Oxidation-reduction.

   A. Definitions.

      1. Oxidation.

      2. Reduction.

B. Half-reactions.

C. Balancing equations.

III. Electrochemistry.

A. Electrolysis.

1. Molten sodium chloride.
2. Aqueous hydrochloric acid.
3. Aqueous sodium chloride.
4. Aqueous sulfuric acid.
5. Refining of metals.
6. Faraday's law of electrolysis.

B. Electrode potentials.

1. Single electrode potentials.
2. Electromotive series.
3. Nernst equation.

C. Primary cells.

D. Secondary cells.

E. Corrosion.

F. Solar battery.

G. Electroplating.

H. Conductivity.

MATERIALS FOR LABORATORY PROCEDURES

- Laboratory 1

--Clean, bright nails.
--Test tubes.
--0.1 M NaOH.
--0.1 M $Na_2Cr_2O_7$.
--0.1 M NaCl.
--0.1 M HCl.
--0.1 M KOH.
--0.1 M Na_2CO_3.
--0.1 M KNO_3.
--0.1 M HNO_3.
--0.1 M Na_3PO_4.
--0.1 M KSCN.
--0.1 M $Na_2C_2O_4$.
--0.1 M H_2SO_4.

--pH paper.
--Test tube rack.
--0.1 M potassium hexacyanoferrate, $K_3Fe(CN)_6$.
--0.1 M iron (II) sulfate.
--Agar.
--Burner.
--1% phenolphthalein indicator.
--Petri dish.
--Copper wire.
--Zinc strip or mossy zinc.

- Laboratory 2

--0.2 N sodium hydroxide, standardized.
--10-ml pipette.
--Distilled water.
--50-ml buret.
--250-ml Erlenmeyer flask.
--Phenolphthalein indicator.
--Buret holder.
--White table vinegar (approximately 5%).

- Laboratory 3

--Materials to be specified.

LABORATORY PROCEDURES

Laboratory 1 - Corrosion of Iron.

The corrosion of nails in acids, bases and salts will be investigated to determine the extent of chemical action. In addition, reactions of metals in contact with each other will be studied as an example of electrochemical corrosion.

Laboratory 2 - Percentage of Acetic Acid in Vinegar.

In this experiment, techniques of acid-base titrations will be learned. The percentage of acetic acid in a sample of commercial vinegar will be determined by titration with a standardized sodium hydroxide solution.

Laboratory 3 - Laboratory to be specified.

REFERENCES

1. Drago, Russell S., and Matwiyoff, Nicholas A. Acids and Bases. Boston, MA: D.C. Heath and Co., 1968.

2. Hall, F.M. "The Theory of Acids and Bases," Educ. in Chemistry I, 91 (1964).

3. MacInnes, D.A. "pH," Scientific American, 184, 1, Jan. 1951.

4. Shen, S.Y. "What is the Real Value of a Faraday?" Chemistry, 39, Feb. 1966.

5. Taube, Henry. "How do Redox Reactions Take Place?" Chemistry, 38, 3, Mar. 1965.

METALS (CH-09)

Module Outline

COURSE: Environmental Chemistry II.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 10 hours.

INTRODUCTION

This module will discuss the importance, occurrence and physical and chemical properties of metals.

PREREQUISITES

The student should have completed Technical Math I, Environmental Chemistry I and the previous modules of this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- List some properties unique to solids.
- Explain differences between crystalline and amorphous solids.
- Define the following terms:
  --Melting point.
  --Heat of fusion.
  --Sublimation.
  --Freezing point.
  --Ductility.
  --Malleability.
  --Alloy.
- Describe some of the mechanical, physical and corrosive properties of metals.
- Describe the type of bonding that occurs in metals.

- List some advantages of alloys over pure metals.
- Outline general steps in obtaining a metal from its ore.
- Match types of steel with their chemical composition or physical properties.

SUBJECT MATTER

I. Solids.
   A. General characteristics, properties.
   B. Types of bonding in solids.
   C. Melting point.
   D. Sublimation.
   E. Heat of fusion.

II. Properties of metals.
   A. Chemical.
   B. Physical.
   C. Mechanical.
   D. Corrosive.

III. Metallurgy.
   A. Metals from ores.
      1. Mechanical preparation.
      2. Flotation.
      3. Roasting.
      4. Smelting.
   B. Refining metals.

IV. Alloys.
   A. Examples.
   B. Advantages of alloys.

V. Types of steel.
   A. Carbon.
   B. Alloy.
   C. High alloy.
   D. Tool steel.

VI. Some important metals.
   A. Copper.
   B. Silver.
   C. Gold.
   D. Zinc family.
   E. Aluminum family.
   F. Tin, lead and titanium.

LABORATORY PROCEDURES

- Laboratory 1
  - --Test tubes, 10.
  - --Test tube rack.
  - --5 strips of copper, about 2 x ½ inches.
  - --5 strips of zinc, about 2 x ½ inches.
  - --Glass rod.
  - --Lead nitrate, 5% solution.
  - --Zinc nitrate, 5% solution.
  - --Mercurous nitrate, 5% solution.
  - --Silver nitrate, 5% solution.
  - --Copper nitrate, 5% solution.
- Laboratory 2
  - --100-ml beaker.
  - --Test tubes, small.
  - --6 M HCl.
  - --0.1 M $AgNO_3$.
  - --0.1 M $Hg_2(NO_3)_2$.
  - --0.1 M $Pb(NO_3)_2$.
  - --Medicine dropper.
  - --0.1 M K_2CrO_4.
  - --6 M NH_4OH.
  - --6 M HNO_3.
  - --Unknown solution containing any combinations of silver, lead and mercury ions.
- Laboratory 3
  - --Materials to be specified.

LABORATORY PROCEDURES

Laboratory 1 - Reactions of Metals with Salt Solutions.

In this experiment, the reaction of metals with salt solutions is observed. The metals then are arranged in an activity series.

Laboratory 2 - Qualitative Analysis of Metals.

Qualitative analysis of metals will be demonstrated using the three metals that form insoluble chlorides; namely silver, mercury and lead. After observing reactions of the three ions, the student will qualitatively determine the composition of an unknown.

Laboratory 3 - Laboratory to be specified.

REFERENCES

1. Bachmann, H.G. "The Origin of Ores," Scientific American, 202, 146, June, 1960.

2. Cottrell, A.H. "The Nature of Metals," Scientific American, 218, Sept., 1967.

3. Mott, Sir Nevill. "The Solid State," Scientific American, 217, Sept., 1967.

4. Pascoe, K.J. An Introduction to the Properties of Engineering Materials. New York: Interscience Publishers, Inc., 1961.

5. Rogers, Bruce A. The Nature of Metals. Ames, IO: Iowa State University Press, 1964.

6. Van Vlack, L.H. Elements of Material Science. Reading, MA: Addison-Wesley Publishing Co., Inc., 1959.

ENERGY, KINETICS AND EQUILIBRIUM IN CHEMICAL SYSTEMS (CH-10)

Module Outline

COURSE: Environmental Chemistry II.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 10 hours.

INTRODUCTION

This module will define energy, kinetics and equilibrium and the importance of energy in chemical reactions.

PREREQUISITES

The student should have completed Technical Math I, Environmental Chemistry I and the previous modules of this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Calculate energy required for phase changes.
- Distinguish between types of energy.
- Define the following terms:
  --Energy.
  --Exothermal reaction.
  --Endothermal reaction.
  --Kinetic energy.
  --Potential energy.
  --Catalyst.
  --Chemical equilibrium.
- Write the equilibrium expression for a balanced chemical reaction.
- Explain how quantities of reactants and products are changed by temperature, pressure or concentrations.

- Describe the effect of a catalyst upon a chemical reaction.
- Write the solubility-product constant for a balanced chemical equation.
- Explain what is meant by the common ion effect.
- Name and explain the effect of several factors influencing the rate of a chemical reaction.

SUBJECT MATTER

I. Energy.
   A. Potential energy.
   B. Kinetic energy.
   C. Energy changes in chemical reactions.
   D. Heats of formation.
   E. Calorimetry.
   F. Solar energy.

II. Kinetics.
   A. Factors affecting rate of chemical reaction.
      1. Nature of substance.
      2. Size of particles.
   B. Temperature.
   C. Catalysts.
   D. Concentration.

III. Equilibrium.
   A. Factors affecting equilibrium in a chemical system.
      1. Concentration.
      2. Pressure.
      3. Temperature.
      4. Catalysts.
   B. Equilibrium constants.
      1. Equation.
      2. Solubility product.
      3. Common ion.

MATERIALS FOR LABORATORY PROCEDURES

- Laboratory 1

--Test tubes.
--Graduated cylinder, 50 ml.
--Beaker, 400 ml.
--Ring and ring stand.
--Wire gauze.
--Bunsen burner.
--Watch with second hand.
--Iron nails (2" finishing nails).
--Iron filings.
--0.0015 M $KMnO_4$.

- Laboratory 2

--Test tubes.
--Test tube rack.
--Medicine dropper.
--0.015 M $Fe(NO_3)_3$.
--0.015 M KSCN.
--Solid NH_4SCN.
--1.0 M K_2CrO_4.
--0.5 M K_2CrO_7.
--3.0 M H_2SO_4.
--6 M NaOH.
--$Cu(NO_3)_2$.
--HCl, conc.

LABORATORY PROCEDURES

Laboratory 1 - Chemical Reaction Rates.

Effects of temperature, concentration and surface area on rate of chemical reaction are determined in this experiment. The reaction to be studied in reduction of permanganate ion by iron in an acid solution of sulfuric acid.

Laboratory 2 - Chemical Equilibrium.

The effect of changing concentrations in three equilibrium systems will be determined. This experiment illustrates LeChatelier's principle which states that, if a system at equilibrium is subjected to a change of conditions, the system will react to counteract the imposed change.

REFERENCES

1. Boyd, R.N. "A Procedure for Solving Equilibrium Problems," Journal of Chemical Education, 29, 198, 1952.

2. Campbell, J. Arthur. Why Do Chemical Reactions Occur. Englewood Cliffs, NJ: Prentice-Hall, 1965.

3. "LeChatelier's Principle and the Equilibrium Constant," Journal of Chemical Education, 31, 455, 1954.

GRAVIMETRIC AND VOLUMETRIC ANALYSIS

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.

Laboratory - 6 hours per week.

PRESENTATION

This course is designed to be presented in the second quarter of the first year of instruction, following the course entitled Enviromental Chemistry I.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW)

COURSE DESCRIPTION

Much of the work performed by an Environmental and Chemical Analysis Technician is quantitative analysis. This course in analytical chemistry is designed to familiarize students with procedures, techniques and methods of gravimetric and volumetric analysis. Laboratories stress those techniques used most often in power plant laboratories.

MODULE TITLES

- Apparatus and Techniques of Gravimetric Analysis (GV-01).
- Sampling and Sample Preparation (GV-02).
- Precipitation, Other Separation Techniques and Calculations (GV-03).
- Apparatus and Techniques of Volumetric Analysis (GV-04).
- Acid-Base Titrations (GV-05).
- Oxidation-Reduction Titrations (GV-06).
- Precipitation and Complexometric Titrations (GV-07).

APPARATUS AND TECHNIQUES OF GRAVIMETRIC ANALYSIS (GV-01)

Module Outline

COURSE: Gravimetric and Volumetric Analysis.

CONTACT HOURS: Lecture - 4 hours.
Laboratory - 8 hours.

INTRODUCTION

The apparatus and techniques of gravimetric analysis are introduced in this module. Proper use of the "tools" of gravimetric analysis is required for obtaining accurate results.

PREREQUISITES

The student should have completed Environmental Chemistry I and Technical Math I.

OBJECTIVES

Upon completion of this module the student should be able to:

- List the major steps in a gravimetric analysis.
- Describe the method of "weighing by difference."
- List five precautions to be observed in using an analytical balance.
- Describe the methods used for igniting precipitates.
- List at least six rules for keeping laboratory notebooks.
- Burn off filter paper from a precipitate.
- Transfer a precipitate from a beaker to a filtering crucible.

SUBJECT MATTER

I. Overview of analytical chemistry.
   A. Gravimetric analysis.
   B. Volumetric analysis.
   C. Instrumental methods of analysis.

II. Techniques and apparatus.
   A. Analytical balance.
   B. Precipitation.
   C. Filtering.
   D. Washing precipitate.
   E. Glassware.
      1. Types.
      2. Cleaning.
      3. Marking.
   F. Evaporation.
   G. Drying and igniting precipitates.

III. The laboratory notebook.

LABORATORY

<u>Laboratory 1 - The Gravimetric Determination of Water in Barium Chloride Dihydrate</u>.

<u>Laboratory 2 - The Gravimetric Determination of Sulfate</u>.

SAMPLING AND SAMPLE PREPARATION (GV-02)

Module Outline

COURSE: Gravimetric and Volumetric Analysis.

CONTACT HOURS: Lecture - 4 hours.
Laboratory - 8 hours.

INTRODUCTION

An extremely important step in gravimetric analysis, namely, sampling, will be studied in this module along with methods of sample preparation prior to analysis.

PREREQUISITES

Student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Explain what is meant by a "representative" sample and the methods used for obtaining such a sample.
- Obtain a liquid sample from a bulk container.
- Distinguish between various grades of commercial chemicals.
- List equipment and apparatus which can be used to reduce the size of particles in a sample.
- List the steps involved in drying a sample prior to weighing.
- Describe the method of pyrosulfate fusion for dissolving samples.
- Describe the method of "grab sampling" a gas.
- Identify solvents which would be suitable for dissolving particular types of samples.

SUBJECT MATTER

I. Sampling.
   A. Solids.
      1. Solid reduction.
      2. Sieving.
   B. Liquids.
   C. Gases.

II. Sample drying.

III. Sample dissolution.
   A. Reagents.
   B. Fusions.

IV. Handling analytical reagents and solutions.

LABORATORY

Laboratory 1 - Pyrosulfate fusion for dissolving an insoluble inorganic sample.

Laboratory 2 - Analytical determination of iron in iron oxide.

Laboratory 3 - Analytical determination of calcium in calcium compounds.

PRECIPITATION, OTHER SEPARATION TECHNIQUES AND CALCULATIONS (GV-03)

Module Outline

COURSE: Gravimetric and Volumetric Analysis.

CONTACT HOURS: Lecture - 4 hours.
Laboratory - 8 hours.

INTRODUCTION

Properties of precipitates and conditions for precipitation are considered in this module. Other analytical separation techniques will also be studied. Also, the quantitative basis for gravimetric analysis will be studied.

PREREQUISITES

Student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- List the three major concerns in a precipitation process.
- Describe the common ion effect and the diverse ion effect.
- List four rules for conducting analytical precipitations.
- Perform five separation techniques used in gravimetric analysis procedures.
- Given the sample weight and precipitate weight, calculate the percentage of an unknown in an analytical determination.
- Calculate the gravimetric conversion factor given the chemical equation for an analytical determination.

SUBJECT MATTER

I. Precipitation.
   A. Solubility of the precipitate.
   B. Physical character of the precipitate.
   C. Purity of the precipitate.

II. Rules for analytical precipitations.

III. Calculations of gravimetric analysis.
   A. Percentage calculations.
   B. Gravimetric factors.
   C. Factor weights.

IV. Separation methods.
   A. Precipitation.
   B. Electrolysis.
   C. Volatilization.
   D. Extraction.
   E. Chromatography.

LABORATORY

Laboratory 1 - Gravimetric analysis of magnesium.

Laboratory 2 - Gravimetric determination of nickel in steel.

APPARATUS AND TECHNIQUES OF VOLUMETRIC ANALYSIS (GV-04)

Module Outline

COURSE: Gravimetric and Volumetric Analysis.

CONTACT HOURS: Lecture - 4 hours.
Laboratory - 8 hours.

INTRODUCTION

The apparatus and techniques of volumetric analysis are introduced in this module. Proper use of the "tools" of volumetric analysis is required for obtaining accurate experimental results.

PREREQUISITES

Student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- List the major steps in a volumetric analysis.
- Describe the use of burets, pipets, and volumetric flasks in volumetric analysis.
- List the major types of volumetric analysis.
- Define the following terms:
  --Titration.
  --Indicator.
  --End point.
  --Primary standard.
  --Back-titration.
  --Standard solution.
- List four properties of an ideal standard solution.
- Explain the marking TD and TC on volumetric glassware.

- Demonstrate the proper use of a pipet.
- Demonstrate several cleaning methods for volumetric glassware.

SUBJECT MATTER

I. Volumetric apparatus.
   - A. Volumetric flasks.
   - B. Powder funnel.
   - C. Pipets.
   - D. Burets.

II. Cleaning volumetric apparatus.

III. Buret.
   - A. Preparing for use.
   - B. Reading a buret.
   - C. Operating the buret.

IV. Calibration of volumetric ware.

V. Standard solutions.

VI. Types of reactions in volumetric analysis.

LABORATORY

Laboratory 1 - Calibration of a buret.

Laboratory 2 - Preparation and standardization of a hydrochloric acid solution.

Laboratory 3 - Preparation and standardization of a sodium hydroxide solution.

ACID-BASE TITRATIONS (GV-05)

Module Outline

COURSE: Gravimetric and Volumetric Analysis.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 9 hours.

INTRODUCTION

The theory and practice of acid-base titrations are studied in this module.

PREREQUISITES

Student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Write the mathematical expression for pH.
- List several acids and bases used in neutralization reactions.
- Identify three indicators which are used in acid-base titrations.
- Explain the function of a buffer solution.
- Convert hydrogen ion concentration into pH, and pH into hydrogen ion concentration.
- List the requirements for a primary standard in acid-base titrations.
- Draw the titration curve for the titration of a base with an acid.

SUBJECT MATTER

I. Definitions of acids and bases.

II. *Hydrogen ion concentration and pH.*

III. Strength of acids and bases.

   A. K_a for acids.

   B. K_b for bases.

IV. Titrations.

   A. Strong acid with a strong base.

   B. Strong base with a strong acid.

   C. Weak acid with a strong base.

   D. Weak base with a strong acid.

   E. Weak acid with a weak base.

   F. Dibasic and tribasic acid titration.

V. Buffer mixtures.

VI. The practice of neutralization reactions.

   A. Primary standard acids and bases.

   B. Standard solutions of acids and bases.

LABORATORY

Laboratory 1 - The determination of replaceable hydrogen in an acid.

Laboratory 2 - Determination of the alkalinity of a mixture containing sodium carbonate.

Laboratory 3 - Determination of acid-base ratio.

OXIDATION-REDUCTION TITRATIONS (GV-06)

Module Outline

COURSE: Gravimetric and Volumetric Analysis.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 9 hours.

INTRODUCTION

The theory and practice of oxidation-reduction titrations are studied in this module.

PREREQUISITES

Student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Balance oxidation-reduction equations.
- Demonstrate the techniques used for the preparation, standardization, and storage of permanganate solutions.
- Describe the means of detecting the end point in oxidation-reduction titrations.
- Describe the method and purpose of using an external indicator.
- Explain the purpose of oxidations or reductions prior to titrations.
- Define the following terms:

  --Oxidation.

  --Reduction.

  --Self-indicator.

  --End point.

  --Equivalence point.

SUBJECT MATTER

I. Oxidation and reduction.

II. Balancing oxidation-reduction equations.

III. Applications of oxidation-reduction titrations.

   A. Potassium permanganate.

      1. Standardization.

      2. Titrations.

   B. Potassium dichromate.

      1. Standardization.

      2. Titrations.

   C. Iodine.

      1. Standardization.

      2. Titrations.

IV. External indicators.

V. End point detection in oxidation-reduction titrations.

LABORATORY

Laboratory 1 - The determination of iron in a ferrous salt using potassium permanganate.

Laboratory 2 - The determination of iron using potassium dichromate.

Laboratory 3 - The determination of copper in an ore using sodium thiosulfate.

Laboratory 4 - The iodometric determination of arsenic.

PRECIPITATION AND COMPLEXOMETRIC TITRATIONS (GV-07)

Module Outline

COURSE: Gravimetric and Volumetric Analysis.

CONTACT HOURS: Lecture - 4 hours.
Laboratory - 8 hours.

INTRODUCTION

The theory and practice of precipitation and complexometric titrations are studied in this module.

PREREQUISITES

Student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Write chemical equations illustrating precipitation and complex formation reactions.
- Define the following terms:
  --Chelate.
  --Coordination number.
  --Complexometric titration.
- Determine hardness in water using EDTA in a complex formation titration.
- Given the experimentally determined data from a precipitation or complexometric titration, calculate the percentage of the substance being sought.
- List four elements which are commonly determined using precipitation titrations.
- List three means of detecting the end point in the titration of chloride with silver ion.

SUBJECT MATTER

I. Precipitation titrations.
   A. Determination of silver by Volhard method.
   B. Determination of chloride by Mohr method.
   C. Determination of chloride by Fajans' method.
   D. Primary standards, standard solutions, and indicators.

II. Complexometric titrations.
   A. EDTA structure and function.
   B. Titrations with mercuric nitrate.
   C. Titrations with silver nitrate.
   D. Titrations with EDTA.

III. Calculations for precipitation and complexometric titrations.

IV. Other applications of precipitation and complexometric titrations.

LABORATORY

Laboratory 1 - Determination of silver by Volhard method.

Laboratory 2 - Determination of chloride by Mohr method.

Laboratory 3 - Determination of chloride by Fajans' method.

Laboratory 4 - Determination of hardness in water by EDTA method.

PROPERTIES AND REACTIONS OF ORGANIC MATERIALS

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 6 hours per week.

PRESENTATION

This course is designed to be presented in the first year, following Environmental Chemistry I and II.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

This course is an introduction to organic chemistry, which is the study of the compounds of carbon. The student will consider the hydrocarbons, fuels, plastics, and several substituted hydrocarbons. Emphasis will be placed on occurrence, sources, chemical reactions, physical properties, naming of organic compounds, and uses.

MODULE TITLES

- Compounds of Carbon and Hydrogen (CH-11).
- Fuels (CH-12).
- Halogens, Alcohols, Phenols, Ethers (CH-13).
- Aldehydes, Ketones, Acids. Esters, Anhydrides (CH-14).
- Amines, Amides, Nitriles, Sugars, Alkaloids, Nucleic Acids (CH-15).
- Plastics (CH-16).

COMPOUNDS OF CARBON AND HYDROGEN (CH-11)

Module Outline

COURSE: Properties and Reactions of Organic Materials.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

This module discusses the scope and importance of organic chemistry and includes examples of some organic compounds encountered in everyday life.

PREREQUISITES

The student should have completed Technical Math I and Environmental Chemistry II.

OBJECTIVES

Upon completion of this module the student should be able to:

- Discuss chemical reactivity of hydrocarbons in terms of their bonding.
- List general differences between organic and inorganic compounds.
- Name two factors that account for the large number of organic compounds.
- List the names of the first ten numbers of the alkane series of hydrocarbons.
- Give three examples of substitution of an aromatic compound.
- Complete the writing of addition reactions of alkenes and alkynes, showing structural formulas of reactants and products.
- Identify major reactions of the hydrocarbons.
- Write and name isomers of the alkanes up to octane.

- Define the following terms:
  --Hydrocarbon.
  --Isomer.
  --Alkane.
  --Alkene.
  --Alkyne.
  --Aromatic hydrocarbon.
  --Cycloalkane.
  --Unsaturated hydrocarbon.

SUBJECT MATTER

I. Introduction to organic chemistry.
   A. Differences between organic and inorganic compounds.
   B. Why there are so many organic compounds.

II. Aliphatic hydrocarbons.
   A. Alkanes.
      1. Occurrence/sources.
      2. Chemical reactions.
      3. Physical properties.
      4. Naming of alkanes.
   B. Cycloalkanes.
      1. Occurrence/sources.
      2. Chemical reactions.
      3. Physical properties.
      4. Naming of cycloalkanes.
   C. Alkenes.
      1. Occurrence/sources.
      2. Chemical reactions.
      3. Physical properties.
      4. Naming of alkenes.
   D. Alkynes.
      1. Occurrence/sources.
      2. Chemical reactions.
      3. Physical properties.
      4. Naming of alkynes.
   E. Aromatic hydrocarbons.
      1. Benzene structure.
      2. Naming aromatic compounds.

3. Isomerism.
4. Reactions of aromatic hydrocarbons.
5. Occurrence/sources.
6. Physical properties.

MATERIALS FOR LABORATORY PROCEDURES

- Laboratory 1

--Test tubes.
--Test tube rack.
--Dropper.
--Ice.
--Burner.
--400-ml beaker.
--Ring and ring stand.
--Petroleum ether.
--Bromine in carbon tetrachloride.

- Laboratory 2

--Distilling flask, 125 ml.
--Separatory funnel.
--Glass tubing.
--Gas bottles.
--Test tubes.
--Water trough.
--Calcium carbide.
--Bromine in carbon tetrachloride.
--Potassium permanganate solution 0.5%.

LABORATORY PROCEDURES

Laboratory 1 - Reactions of Hydrocarbons.

Alkanes, alkenes, alkynes, and aromatic hydrocarbons will be reacted with bromine, sulfuric acid and aqueous potassium permanganate. The experiment will indicate the variable reactivity of these classes of hydrocarbons.

Laboratory 2 - Preparation and Reactions of Acetylene.

Acetylene will be prepared by the reaction of calcium carbide with water. The acetylene then will be used in a variety of reactions to indicate the presence of the triple bond.

REFERENCES

1. Fieser, L.F. and Fieser, M. Introduction to Organic Chemistry. Boston, MA: D.C. Heath and Co., 1957.

2. Morrison, R.T. and Boyd, R.N. Organic Chemistry. Boston, MA: Allyn and Bacon, Inc., 1966.

3. Smith, L.O., Jr., and Cristol, S.J. Organic Chemistry. New York: Reinhold Publishing Co., 1966.

4. Zimmerman, Henry, and Zimmerman, Isaak. Elements of Organic Chemistry. Encino, CA: Glencoe Press, 1977.

FUELS (CH-12)

Module Outline

COURSE: Properties and Reactions of Organic Materials.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

This module provides an overview of the energy crises and notes the importance of petroleum and fuels in our everyday lives.

PREREQUISITES

The student should have completed Technical Math I, Environmental Chemistry II and the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- List characteristics of a good fuel.
- Compare composition, properties and fuel values of anthracite, bituminous and lignite coal.
- Identify major constituents of gasoline.
- Write the chemical reaction for combustion of fuels.
- List major fractions obtained in petroleum refining.
- List and explain the purpose of processes used to increase yield of gasoline.
- Define the following terms:

  --Petroleum.

  --Octane number.

  --Cracking.

  --Antiknock agent.

--Refining.

--Polymerization.

--Lignite.

- Identify several "alternative" energy sources.

SUBJECT MATTER

I. Uses and sources of fuels.

II. Gaseous fuels.

A. Natural gas.

B. LPG.

C. Coal gas.

D. Water gas.

E. Producer gas.

III. Liquid fuels.

A. Petroleum.

1. Composition/products.

2. Refining petroleum.

B. Octane.

C. Combustion.

D. Synthetic liquid fuels (coal liquification).

IV. Solid fuels.

A. Coal.

B. Products from coal.

V. Alternate energy sources.

A. Hydrogen.

B. Methanol.

C. Ethanol.

D. Biomass.

MATERIALS FOR LABORATORY PROCEDURES

- Laboratory 1

--50-ml round-bottom distilling flask.

--Water condenser.

--Adapter.

--Thermometer.

--3 corks.

--Ring stand.

--RIng.

--Clamp.

--Wire gauze.

--Burner.

--50-ml Erlenmeyer flask.

--Rubber tubing.

--Boileezers.

--Carbon tetrachloride.

--Long-stem funnel.

--Acetone.

- Laboratory 2

--Test tubes.

--Glass tubing.

--Ring stand.

--Clamp.

--Burner.

--Wood (splinters and excelsior).

--Soft coal.

--Litmus paper.

LABORATORY PROCEDURES

Laboratory 1 - Fractional Distillation.

The important organic laboratory and industrial technique of fractional distillation is utilized in this experiment. An acetone-water mixture is separated by the technique.

Laboratory 2 - Destructive Distillation.

Destructive distillation is used industrially to produce gaseous fuels from wood and coal. In this experiment the student will destructively distill both wood and soft coal.

REFERENCES

1. Nelson, T.W. "The Origin of Petroleum," Journal of Chemical Education. 31, 399, 1954.

2. Rossini, F.D. "Hydrocarbons in Petroleum," Journal of Chemical Education, 37, 354, 1960.

3. Yohe, G.R. "Coal," Chemistry, 40, Jan. 1967.

HALOGENS, ALCOHOLS, PHENOLS, AND ETHERS (CH-13)

Module Outline

COURSE: Properties and Reactions of Organic Materials.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

This module includes a discussion of the halogens, alcohols, phenols, and ethers. The preparation, sources, nomenclature, structure, and reactions of these substituted hydrocarbons are considered.

PREREQUISITES

The student should have completed Technical Math I, Environmental Chemistry II and the previous modules of this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Identify some of the uses of halogens, alcohols, phenols, and ethers.
- Complete the chemical equation for reactions involving halogens, alcohols, phenols, and ethers.
- Identify the functional group present in halogens, alcohols, phenols, and ethers.
- Identify the source of some of the halogens, alcohols, phenols, and ethers.
- Given its name, write the formula of halogens, alcohols, phenols, and ethers.

SUBJECT MATTER

I. Organic halogen compounds.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

II. Alcohols.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

III. Phenols.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

IV. Ethers.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

LABORATORY

Laboratory 1 - Preparation and reactions of organic halides.

Laboratory 2 - Properties and reactions of alcohols.

ALDEHYDES, KETONES, ACIDS, ESTERS, AND ANHYDRIDES (CH-14)

Module Outline

COURSE: Properties and Reactions of Organic Materials.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

Aldehydes, ketones, acids, esters, and anhydrides are discussed in this module. The preparation, sources, nomenclature, structure, and reactions of the substituted hydrocarbons are considered.

PREREQUISITES

The student should have completed Technical Math I, Environmental Chemistry II and the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Identify some of the sources of aldehydes, ketones, acids, esters, and anhydrides.
- Given its name, write the formula of aldehydes, ketones, acids, esters, and anhydrides.
- Identify some of the uses of aldehydes, ketones, acids, esters, and anhydrides.
- Identify the functional group present in aldehydes, ketones, acids, esters, and anhydrides.
- Complete the chemical equation for reactions involving aldehydes, ketones, acids, esters, and anhydrides.

SUBJECT MATTER

I. Aldehydes.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

II. Ketones.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

III. Acids.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

IV. Esters.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

V. Anhydrides.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

LABORATORY

Two laboratory exercises concerning the reactions of the organic compounds considered in this module will be included.

AMINES, AMIDES, NITRILES, SUGARS, ALKALOIDS, NUCLEIC ACIDS (CH-15)

Module Outline

COURSE: Properties and Reactions of Organic Materials.

CONTACT HOURS: Lecture - 5 hours.

Laboratory - 10 hours.

INTRODUCTION

Amines, amides, nitriles, sugars, alkaloids, and nucleic acids are discussed in this module along with other nitrogen containing organic compounds. The preparation, sources, nomenclature, structure, and reactions of these substituted hydrocarbons are considered.

PREREQUISITES

The student should have completed Technical Math I, Environmental Chemistry II and the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Complete the chemical equation for reactions involving amines, amides, nitriles, sugars, alkaloids, and nucleic acids.
- Identify some of the uses of the substituted hydrocarbons studied in this module.
- Identify the functional group present in nitriles, amines, amides, sugars, alkaloids, and nucleic acids.
- Identify some of the sources of amines, amides, nitriles, sugars, alkaloids, and nucleic acids.
- Given its name, write the formula of amines, amides, nitriles, sugars, alkaloids, and nucleic acids.

SUBJECT MATTER

I. Amines.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

II. Amides.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

III. Nitriles.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

IV. Sugars.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

V. Alkaloids.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

VI. Nucleic acids.
   A. Nomenclature.
   B. Preparation/sources.
   C. Structure.
   D. Reactions.

LABORATORY

Two laboratory exercises concerning the reactions of the organic compounds considered in this module will be included.

PLASTICS (CH-16)

Module Outline

COURSE: Properties and Reactions of Organic Materials.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

This module includes the identification, uses, hazards, and environmental effects of plastics found in a solid-fueled power plant.

PREREQUISITES

The student should have completed Technical Math I, Environmental Chemistry I & II, and the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Identify some commonly used plastics by examination or simple chemical and physical tests.
- Describe some uses and limitations of plastics in power plants.
- List and describe several environmental effects on plastics.
- Identify a common use for the following plastics:
  --Polyethylene.
  --Polystyrene.
  --Polyvinyl chloride.
  --Teflon.
  --Polymethyl methacrylate (Plexiglas).
- Define the following terms:
  --Monomer.
  --Polymer.

--Thermoplastic.
--Thermosetting plastic.
--Copolymer.
--Stabilizer.
--Plasticizer.
--Glass transistion temperature.

SUBJECT MATTER

I. Textiles.
   A. Natural textiles.
   B. Rayon.
   C. Nylon.
   D. Acrylic.
   E. Polyester.

II. Plastics.
   A. Introduction/definitions.
   B. Phenol-formaldehyde.
   C. Methyl methacrylate.
   D. Polystyrene.
   E. Polyethylene.
   F. Polyvinyl.
   G. Teflon.

III. Silicones.
   A. Plastics.
   B. Oils/fluids.
   C. Rubber.

IV. Rubber.
   A. Neoprene.
   B. Butadiene.

V. Processing of plastics.

MATERIALS FOR LABORATORY PROCEDURES

- Laboratory 1

--Glycerol.
--Phthalic anhydride, powder.
--50-ml beaker.
--Glass stirring rod.

--Watch glass.
--Electric hot plate.
--Mortar.
--40% formaldehyde solution (Formalin).
--Test tube.
--Saturated aqueous solution of aniline hydrochloride.
--Lucite or plexiglas pellets or chips.
--100-ml distilling flask.
--Condenser.
--Heating mantle.
--Thermometer.
--Expendable glass jar.
--Benzoyl peroxide.
--Aluminum foil.
--Hot-water bath.

- Laboratory 2

--Castor oil.
--Glycerol.
--Stannous octoate.
--Silicone oil (Dow-Corning 202).
--4-methyl-m-phenylene diisocyanate (Tolylene-2, 4-diisocyanate).
--Paper cups or milk cartons.
--Sebacoyl chloride (5% in carbon tetrachloride).
--Hexamethylene diamene (5% in water).
--Dropper.
--Glass rod.
--Small vial (such as a litmus paper vial).
--Ring stand.
--Clamp.
--600-ml beaker.
--Test tube.

- Laboratory 3

--150-ml beaker.
--400-ml beaker.
--125-ml and 250-ml Erlenmeyer flasks.
--Dropper.
--Separatory funnel.

--Ring and ring stand.
--Litmus paper.
--Dimethyldichlorosilane.
--Ether.
--$NaHCO_3$, saturated solution.
--Boric oxide.
--Na_2SO_4, anhydrous.
--Oil bath.
--Hot plate.

LABORATORY PROCEDURES

Laboratory 1 - Polymerization, part 1.

In the experiment a polyurethane foam will be produced from castor oil and glycerol. In addition, Nylon 6-10 will be prepared from sebacoyl chloride and hexamethylenediamine.

Laboratory 2 - Polymerization, part 2.

In the experiment a polyester resin is produced using a condensation reaction. Another condensation polymer is produced which is an amine-aldehyde type polymer similar to Bakelite. Finally, an addition polymer, methyl methacrylate, will be produced. This polymer is marketed under the trade names of Lucite and Plexiglas.

Laboratory 3 - Preparation of a Polymeric Silicone.

To illustrate polymerization of silicones, the polymeric silicone known as "Silly Putty" will be prepared.

REFERENCES

1. Factor, A. "The Chemistry of Polymer Burning and Flame Retardance," Journal of Chemical Education, 51, No. 7, 1974.

2. Kaufman, M. "Giant Molecules." New York: Doubleday, 1968.

3. Mark, H.F. "The Nature of Polymeric Materials," Scientific American, Vol. 197, No. 3, 1957.

4. Tobolsky, Arthur V. "Revolution in Polymer Chemistry," American Scientist, 45, 1957.

TECHNICAL MATH II

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 3 hours per week.

PRESENTATION

This course is designed to be presented in the last part of the first year.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

Technical Math II is intended to provide the student with the math background necessary for performing various environmental and chemical analyses. Subjects covered range from plane geometry to trigonometric functions. The laboratory will stress technical calculations encountered in upper level courses.

COURSE OUTLINE

I. Geometry.
   A. Plane figures.
      1. Lines.
      2. Angles.
      3. Polygons.
   B. Measurement of plane figures.
      1. Perimeter.
      2. Area.
      3. Use of Planimeters.

C. Right angles.

1. Pythagorean theorem.

2. Triangles.

D. Circles.

1. Terms.

2. Measurements.

a. Circumference.

b. Area.

E. Solids.

1. Polyhedrons.

a. Volume.

b. Lateral area.

2. Cylinders.

a. Volume.

b. Lateral area.

3. Pyramids.

a. Volume.

b. Lateral area.

4. Cones.

a. Volume.

b. Lateral area.

5. Spheres.

a. Volume.

b. Lateral area.

II. Logarithms.

A. Logarithms and antilogarithms.

B. Common logs.

C. Natural logs.

D. Exponential equations and power of numbers.

III. Trigonometry.

A. Ratios.

1. Angles.

a. Types.

b. Measurement.

2. Trigonometric functions.

B. Trigonometric tables.

C. Right triangles.

1. Trigonometric functions.

2. Logarithms of functions.

D. Functions of angles.
    1. Finding angle on coordinate system.
        a. First quadrant.
        b. Second quadrant.
        c. Third quadrant.
        d. Fourth quadrant.
    2. Finding angle given function.

E. Radian measure.

F. Vectors.
    1. Calculation.
    2. Representation.
    3. Multiple vectors.

G. Graphs.
    1. Sine curve.
        a. Cycle.
        b. Frequency.
        c. Period.
    2. Cosine curve.

IV. Descriptive statistics.

A. Averaging techniques.

B. Mean, median and mode.

C. Standard deviation.

D. Statistical data analysis.

E. Graphic illustration of data.

FUNDAMENTALS OF ELECTRICITY AND ELECTRONICS

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 5 hours per week.

PRESENTATION

This course should be presented in the first year, prior to Instrumental Analysis.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

Fundamentals of Electricity and Electronics is designed to provide the student with basic knowledge and skills in ac and dc electrical circuits to include circuit analysis, recognition and use of electrical components and electrical measurement instruments. Topics presented include voltage, resistance, current, power, Ohm's Law, inductors, capacitors, series and parallel circuits, phase resonance and circuit transients.

COURSE OUTLINE

I. Direct current circuits.
   A. Definition and use of terms and components.
      1. Voltage, current, resistance and power.
      2. Voltage sources, conductors, resistors and resistor color code.
      3. Measurement of current, voltage and resistance.
   B. Direct current circuit analysis.
      1. Ohm's law.
      2. Resistors and voltage sources in series and parallel.

II. Alternating current circuits.

   A. Definition and use of terms and components.

      1. Sine wave, amplitude, frequency and phase.

      2. Inductors, capacitors, oscilloscope and frequency generators.

      3. Measurement of ac voltage, current, impedance, power and power factor.

   B. Alternating current circuit analysis.

      1. Inductors and capacitors in series and parallel.

      2. Resonance.

III. Circuit transients.

   A. Transients in dc circuits - time constants.

   B. Transients in ac circuits.

POWER PLANT FUNDAMENTALS AND SYSTEMS II

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 3 hours per week.

PRESENTATION

This course is designed to be presented in the first quarter of the second year of instruction.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

This course is a continuation of Power Plant Fundamentals and Systems I. Its main emphasis is on mechanical equipment and quality assurance and quality control.

MODULE TITLES

- Pumps (FS-06).
- Valves and Piping (FS-07).
- Heat Exchangers and Condensers (FS-08).
- Quality and Process Control (FS-09).

PUMPS (FS-06)

Module Outline

COURSE: Power Plant Fundamentals and Systems II.

CONTACT HOURS: Lecture - 8 hours.
Laboratory - 8 hours.

INTRODUCTION

This module describes in detail the three major types of pumps found in a modern steam plant.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- List three major types of pumps; give at least three examples of each from this module.
- List pump components; discuss the function of each component.
- Determine at least four of six pump characteristics from literature or lab experiments.
- Given a typical pump system, select the most appropriate type of pump(s) for the job.
- Using a typical pump or pumps, determine the following characteristics: flow, heat, power requirements and net positive suction head.
- Disassemble a typical pump, indicate all parts and reassemble in correct working order.

SUBJECT MATTER

I. Centrifugal pumps.
   A. Types.
      1. Volute.
      2. Diffuser.
      3. Mixed flow.
      4. Axial flow.
      5. Turbine.
   B. Components.
   C. Characteristics.
   D. Uses.

II. Rotary pumps.
   A. Types.
      1. Gear.
      2. Vane.
      3. Cam and piston.
      4. Screw.
   B. Components.
   C. Characteristics.
   D. Uses.

III. Reciprocating pumps.
   A. Types.
      1. Direct acting.
      2. Power.
      3. Crank.
   B. Components.
   C. Characteristics.
   D. Uses.

LABORATORY

To be specified.

VALVES AND PIPING (FS-07)

Module Outline

COURSE: Power Plant Fundamentals and Systems II.

CONTACT HOURS: Lecture - 8 hours.
Laboratory - 8 hours.

INTRODUCTION

This module presents a detailed, illustrated discussion of valve types, components, flow characteristics, operation, safety requirements and types of actuators. Descriptions of pipes and fittings used include their sizes, schedules, safety classes, hangers, materials and expansion joints.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- List the six major valve classifications (by function).
- Identify and describe each component or part of any valve used in a solid-fueled power plant.
- Identify the two major problems associated with valve care and maintenance.
- Identify valves according to the thirteen major generic groupings.
- List and describe five means of actuating (operating) a valve.
- Discuss knowledgeably the two major classifications that influence valve selection.
- Describe the two types of valves serving "safety only" functions in a power plant.

- List, as described in this module, the seven different basic materials from which pipes are fabricated; describe the application of each kind of pipe.
- Classify pipe according to pipe "schedules."
- List and identify by function the major kinds of pipe fittings.

SUBJECT MATTER

I. Valves.
   A. Classifiction by function.
   B. Components.
   C. Care.
   D. Major valve groupings.
      1. Description.
      2. Function.

II. Piping.
   A. Materials.
   B. Uses.
   C. Fittings.

LABORATORY

To be specified.

HEAT EXCHANGERS AND CONDENSERS (FS-08)

Module Outline

COURSE: *Power Plant Fundamentals and Systems II.*

CONTACT HOURS: Lecture - 7 hours.
Laboratory - 7 hours.

INTRODUCTION

This module discusses heat exchange as the basis upon which a power plant operates.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Identify and discuss each of the terms of the basic heat transfer formula and how they relate to heat exchanges found in power plants.
- Draw the heat transfer curve, define each area and describe the heat transfer mode and characteristics in each region.
- Describe basic operation of each of the heat exchangers normally found in solid-fueled power plants.

  --Shell and tube heat exchangers.

  --Main condensers.

  --Feedwater heaters.

  --Cooling towers.

  --Spray ponds.

SUBJECT MATTER

I. Heat exchangers.
   A. Theory.
   B. Types.
   C. Uses.

II. Condensers.
   A. Theory.
   B. Types.
   C. Use.

LABORATORY

To be specified.

QUALITY AND PROCESS CONTROL (FS-09)

Module Outline

COURSE: Power Plant Fundamentals and Systems II.

CONTACT HOURS: Lecture - 7 hours.
Laboratory - 7 hours.

INTRODUCTION

This module introduces the student to an organization used in industry that monitors, polices and controls the quality of product. Three distinct departments are describe - Quality Assurance, Quality Control and Process Control - and their interactions are delineated. Specific forms to be completed at required control points are introduced, as well as the environmental regulations.

PREREQUISITES

The student should have completed general courses in Environmental Chemistry, Unified Technical Concepts and Gravimetric and Volumetric Analysis and one year of high school algebra.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define the responsibilities of the Quality Assurance, Quality Control and Process Control Departments.
- Draw an organization chart of typical quality responsibilities in a modern power plant.
- List inspection devices and systems required in the following power plant departments:

  --Incoming fuel storage.

  --Cooling water to main condensers.

  --Combustion areas.

  --Smokestack.

  --Maintenance department.

- Describe three different types of process control forms used in a modern power plant laboratory.
- List Federal requirements under which a modern power plant must operate.
- Describe air pollution control equipment provided at a modern power plant.

SUBJECT MATTER

I. Quality assurance.
   A. Systems.
   B. Responsibilities.
   C. Standards.

II. Quality control.
   A. Systems.
   B. Responsibilities.
   C. Standards.

III. Process control.
   A. Systems.
   B. Responsibilities.
   C. Standards.

IV. Inspection devices.
   A. Environmental.
   B. Process.
   C. Mechanical.

V. Forms and controls.
   A. Receiving.
   B. In-process.
   C. Delivery.

VI. Regulations.
   A. Federal.
   B. State.
   C. City.

VII. Environmental inpact.
   A. NEP Act, 1969.
   B. Environmental impact statement.
   C. Clean Air Act, 1970.
   D. Water quality.
   E. Acoustics.

F. Toxic substances.

G. Hazardous substances.

MATERIALS FOR LABORATORY PROCEDURES

To be specified.

LABORATORY PROCEDURES

Laboratory 1

Visit a local power plant process control laboratory. Review with the supervisor any of the process controls performed by the laboratory, where they are taken, how they are performed and what the acceptable standards are.

Laboratory 2

Visit a library and write a report on all of the different types of air pollution control equipment that may be found at a power plant.

REFERENCES

1. Cross, F.L. and Hesketh, H.E., Eds. Handbook for the Operation and Maintenance of Air Pollution Control Equipment. Westport, CT; Technomic Publishing Co., Inc., 1975.

2. Rosen, S.J. Manual for Environmental Impact Evaluation. Englewood Cliffs, NJ: Prentice-Hall, Inc., 1976.

3. Woodruff, E.B. and Lammers, H.B. Steam Plant Operation. New York: McGraw-Hill Book Co., 1977.

ENVIRONMENTAL BIOLOGY

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 3 hours per week.

PRESENTATION

This course is designed to be presented in the second year of instruction, prior to the courses entitled Environmental Analysis and Water Treatment.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

Environmental Biology is designed to give the Environmental and Chemical Analysis Technician student the biology background needed to better understand relationships between living and nonliving environments. It stresses ways in which coal-fired power plants interact with natural systems.

MODULE TITLES

- Biology Basics (EB-01).
- Microbiology (EB-02).
- Botany (EB-03).
- Zoology (EB-04).
- Physiology (EB-05).
- Ecology (EB-06).

BIOLOGY BASICS (EB-01)

Module Outline

COURSE: Environmental Biology.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 5 hours.

INTRODUCTION

This module discusses the broad field of biology. It gives distinguishing characteristics of living things and generalizations concerning living things which are fundamental to all biology.

PREREQUISITES

None.

OBJECTIVES

Upon completion of this module the student should be able to:

- List the eight characteristics of living things; discuss briefly.
- Discuss the cell concept.
- Discuss the gene concept.
- Discuss the mutation theory.
- Discuss natural selection.
- Discuss importance of ecological interrelationships.

SUBJECT MATTER

I. Biology defined.

II. Characteristics of living things.
   A. Structural organization.
   B. Metabolism.

C. Excretion.

D. Reproduction.

E. Sensitivity.

F. Movement.

G. Adaption.

H. Death and disintegration.

III. Major generalizations of biology.

A. Cell concept.

B. Gene concept.

C. Mutation theory.

D. Natural selection and evolution.

E. Ecological interrelationships.

MICROBIOLOGY (EB-02)

Module Outline

COURSE: Environmental Biology.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 5 hours.

INTRODUCTION

This module discusses microscopic organisms. It specifically talks about those organisms that live in water that are of interest in environmental analysis and water treatment.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- List ten microorganisms that are indications of clean water.
- List five microorganisms that are indicators of pollution.
- List five microorganisms that are considered hazards in water supplies.
- Demonstrate procedure for using a microscope.
- Correctly identify at least fifteen of twenty microorganisms of interest in environmental analysis or water treatment, from prepared slides or pictures.

SUBJECT MATTER

I. Use of microscope.

II. Microorganisms.

   A. Algae.

   B. Fungi.

C. Bacteria.

D. Virus.

III. Common aquatic species.

A. Clean-water indicators.

B. Pollution indicators.

C. Harmful organisms.

BOTANY (EB-03)

Module Outline

COURSE: Environmental Biology.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 5 hours.

INTRODUCTION

This module discusses environmental effects on plants.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Differentiate between monocots and dicots.
- Discuss photosynthesis.
- Discuss effects of air pollution on plants.
- Discuss plant requirements for growth.
- Discuss plant-indicator species.

SUBJECT MATTER

I. Botany basics.

II. Plants.
   A. Photosynthesis.
   B. Nutrient requirements.

III. Pollution and plants.
   A. Effects of pollution on plants.
   B. Effects of plants on pollution.
   C. Plant indicators.

ZOOLOGY (EB-04)

Module Outline

COURSE: Environmental Biology.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 5 hours.

INTRODUCTION

This module discusses the relationship between environment and animals, including man. Environmental health problems caused by coal-fired power plants are a major concern in this module.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Discuss the relationship between animals and their environment.
- Outline possible effects of use of coal in generation of electricity on animal populations, starting from the mining of the coal.
- Describe methods for discovering tolerance limits.
- Outline procedure for a bioassay.

SUBJECT MATTER

I. Zoology defined.

II. Animals and the environment.
   - A. Requirements.
   - B. Adaptation.
   - C. Extinction.

III. Environmental standards.

A. Use of animals to determine health hazards.

B. Use of animals to set standards.

PHYSIOLOGY (EB-05)

Module Outline

COURSE: Environmental Biology.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 5 hours.

INTRODUCTION

This module defines the realm of physiology and describes how environmental changes affect physiological functions. Emphasis is given to physiological changes brought about by coal-fired power plants.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Discuss three examples of physiological changes due to environmental disruptions by coal-fired power plants.
- Discuss importance of physiological change.
- Define physiological limits.
- Define thermal pollution.

SUBJECT MATTER

I. Physiology defined.

II. Environmental disruption.

  A. Introduction to foreign substances.

  B. Thermal pollution.

III. Physiological changes.

A. Respiration.

B. Reproduction.

C. Movement.

D. Growth rate.

ECOLOGY (EB-06)

Module Outline

COURSE: Environmental Biology.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 5 hours.

INTRODUCTION

This module introduces important ecological concepts. It discusses interrelationships between organisms in a community and their interactions with the environment.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define:
  - --Food web.
  - --Biological magnification.
  - --Species diversity.
  - --Monoculture.
  - --Biome.
  - --Producers.
  - --Consumers.
  - --Niche.
  - --Habitat.
  - --Succession.
  - --Homeostasis.
  - --Biogeochemical cycles.

- Outline successional stages on reclaimed strip-mined land.
- Discuss benefits of species diversity in a natural system.
- Given that the runoff from a slag pond kills half of the species of grasses growing downstream, outline in general terms what effect this will have on the food web.

SUBJECT MATTER

I. Introduction to ecology.

II. The ecosystem.
  A. Concept of the ecosystem.
  B. Production and decomposition in nature.
  C. Homeostasis of the ecosystem.

III. Energy in ecological systems.
  A. Energy environment.
  B. Productivity.
  C. Food chains and food webs.
  D. Trophic structure.

IV. Biogeochemical cycles.
  A. Basic biogeochemical cycles.
  B. Nonessential elements cycling.
  C. Organic nutrient cycling.

V. Community organization.

VI. The individual in the ecosystem.
  A. Habitat.
  B. Niche.
  C. Behavior.

VII. Development of the ecosystem.
  A. Succession.
  B. Climax.

VIII. Applications.
  A. Resources.
  B. Pollution.
  C. Ecosystem management.

INSTRUMENTAL ANALYSIS I

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 6 hours per week.

PRESENTATION

This course is designed to be taught in the second year, following the courses entitled Properties and Reactions of Organic Materials, and Gravimetric and Volumetric Analysis.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

This course is designed to give the Environmental and Chemical Analysis Technician a working understanding of the instruments used for chemical analysis in coal-fired power plants. The student learns how to operate and calibrate relevant instruments as well as make minor adjustments to maintain the instruments.

MODULE TITLES

- Measurement and Recording Systems (IA-01).
- Visible and Ultraviolet Spectroscopy (IA-02).
- Infrared Spectroscopy (IA-03).
- Atomic Absorption and Flame Emission Spectroscopy (IA-04).
- Fluorimetry, Turbidimetry, Nephelometry, and Refractometry (IA-05).
- Miscellaneous Advanced Techniques (IA-06).

MEASUREMENT AND RECORDING SYSTEMS (IA-01)

Module Outline

COURSE: Instrumental Analysis I.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

In this module the student is introduced to measurement and recording systems found in the modern power plant.

PREREQUISITES

The student should have completed Environmental Chemistry I and II, and Gravimetric and Volumetric Analysis.

OBJECTIVES

Upon completion of this module the student should be able to:

- List two methods of coal measurement.
- Describe several methods of water flow measurement.
- Identify three pressure measurement methods.
- Describe three temperature measurement methods for plant cooling water and condenser systems.
- Identify and describe data recording methods including chart recorders, magnetic tape recorders, and data recorders.

SUBJECT MATTER

I. Fuel measurement.
   A. Coal flow.
   B. Calorific value.

II. Water flow measurement.
  A. Orifice plates.
  B. Venturi tubes.
  C. Manometers.
  D. Calibration.

III. Pressure measurement.
  A. Bourdon tube.
  B. Pressure transducers.
  C. Mercury columns.
  D. Calibration.

IV. Temperature measurement.
  A. Mercury in glass thermometers.
  B. Thermocouples.
  C. Calibration.

V. Recording devices.
  A. Chart recorders.
  B. Magnetic tape recorders.
  C. Data processors.

VISIBLE AND ULTRAVIOLET SPECTROSCOPY (IA-02)

Module Outline

COURSE: Instrumental Analysis.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

In this module the student is introduced to spectroscopy as well as to visible and ultraviolet spectroscopy.

PREREQUISITES

The student should have completed Environmental Chemistry I & II, and Gravimetric and Volumetric Analysis.

OBJECTIVES

Upon completion of this module the student should be able to:

- Characterize visible and ultraviolet spectroscopy according to the type of radiation utilized, the phenomenon occurring in the molecules, and the type of information obtained.
- Utilize Beer's law to make calculations given any three of the following: concentration, sample thickness, absorptivity, or absorbance.
- Define the following terms:

  --Absorbance.

  --Absorptivity.

  --Beer's law.

  --Transmittance.

  --Wavelength.

  --Frequency.

  --Wave number.

- Use a colorimeter for analysis.
- Identify the types of materials which can be analyzed utilizing visible and ultraviolet spectroscopy.

SUBJECT MATTER

I. Fundamentals of spectroscopy.
   A. Properties of electromagnetic radiation.
   B. The electromagnetic spectrum.
   C. The interaction of radiation with matter.
      1. Transmission.
      2. Absorption.
      3. Polarization.

II. Components of spectrophotometers.
   A. Radiation sources.
   B. Dispersing element.
   C. Sample holding system.
   D. Detector.
   E. Signal indicator.

III. Types of available instruments.
   A. Visible spectrophotometers.
   B. Ultraviolet spectrophotometers.

IV. Applications of visible and ultraviolet spectroscopy.
   A. Qualitative.
   B. Quantitative.
   C. Photometric titrations.

LABORATORY

<u>Laboratory 1 - Colorimetric determination of manganese in steel</u>.

<u>Laboratory 2 - Ultraviolet analysis of hydrocarbons</u>.

INFRARED SPECTROSCOPY (IA-03)

Module Outline

COURSE: Instrumental Analysis I.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

The theory and application of infrared spectroscopy are considered in this module.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Identify the molecular phenomenon responsible for causing infrared radiation to be absorbed.
- Use the proper methods to obtain the infrared spectrum of gases, solids, and liquids.
- Describe the use of correlation charts in infrared spectroscopy.
- Given unknown spectra, to be able to identify the major functional groups in the molecules from which spectra are obtained.
- List some of the precautions to be observed in using infrared cells.

SUBJECT MATTER

I. Theory of infrared spectroscopy.
   A. Spectral plots.
   B. Molecular vibrations.

II. Infrared instruments.
   A. Radiation source.
   B. Sample holder.
   C. Detector.

III. Infrared sampling techniques.
   A. Liquids.
   B. Gases.
   C. Solids.

IV. Identifying infrared spectra.
   A. Functional group absorption.
   B. Correlation charts.

LABORATORY

Laboratory 1 - Obtaining infrared spectra.

In this experiment the student will obtain infrared spectra using a variety of sample preparation techniques.

Laboratory 2 - Identification of unknown organic materials.

ATOMIC ABSORPTION AND FLAME EMISSION SPECTROSCOPY (IA-04)

Module Outline

COURSE: Instrumental Analysis I.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

The theory and applications of atomic absorption and flame emission spectroscopy are considered in this module.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Describe the processes occurring in atomic absorption and flame emission spectroscopy.
- Describe the scope of application of the atomic absorption and flame emission techniques.
- List advantages and disadvantages of the total consumption and premix burners.
- Explain the function of the flame in atomic absorption and flame emission spectroscopy.
- Describe the technique of standard additions.
- Describe "flameless" atomic absorption.

SUBJECT MATTER

I. Principles of atomic absorption.
   A. Atomic absorption spectra.
   B. Measurement of atomic absorption.

II. Atomic absorption instrumentation.
   A. Radiation source.
   B. Detectors.
   C. Types of burners.
   D. Oxidants and fuels.

III. Applications.
   A. Extent of usefulness.
   B. Interferences.
   C. Calibration curves.
   D. Accuracy.

IV. Principles of flame emission spectroscopy.
   A. Flame characteristics.
   B. Chemical reactions in flames.

V. Flame spectrophotometers.
   A. Comparison to atomic absorption instruments.
   B. Burners.

VI. Quantitative analysis by flame emissions.
   A. Calibration curves.
   B. Standard addition method.
   C. Internal standard method.

LABORATORY

Laboratory 1

The determination of iron in water by atomic absorption spectroscopy. Standard methods for the examination of water and wastewater.

Laboratory 2

The determination of soidum content of water by flame emission spectroscopy.

FLUORIMETRY, TURBIDIMETRY, NEPHELOMETRY, AND REFRACTOMETRY (IA-05)

Module Outline

COURSE: Instrumental Analysis I.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

The theory and practice of fluorimetry, turbidimetry, nephelometry, and refractometry are considered in this module.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Briefly describe the theory of fluorimetry, turbidimetry, nephelometry, and refractometry.
- Identify the principle uses of each of the techniques studied in this module.
- Perform the steps involved in the analytical uses of each of the techniques studied in this module.
- Describe the data obtained from each of the techniques studied in this module and how it is utilized.

SUBJECT MATTER

I. *Refractometry.*
   A. Index of refraction.
   B. Instruments.
   C. Applications.

II. Fluorimetry.

   A. Fluorescence.

   B. Measurement.

   C. Applications.

III. Methods based on light scattering.

   A. Nephelometry.

   B. Turbidimetry.

   C. Applications.

LABORATORY

Laboratory 1 - ASTM Colometric Determination of Hydrazine in water.

Laboratory 2 - Determination of Water Turbidity by Nephelometric method.

(Standard methods for the examination of water and wastewater.)

MISCELLANEOUS ADVANCED TECHNIQUES (IA-06)

Module Outline

COURSE: Instrumental Analysis I.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

In this module the student is introduced to emission spectrography, x-ray analysis, nuclear magnetic resonance spectroscopy, mass spectroscopy and microscopy.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Identify three ways in which x-rays are obtained for use in analysis.
- List the three x-ray techniques used to analyze materials.
- Describe the three methods used for x-ray detection.
- Identify types of materials which can be analyzed using x-ray methods.
- Describe the emission process used in emission spectroscopy.
- Indicate the extent of application of emission spectroscopy to elemental analysis.
- Briefly describe the emission spectroscopic equipment and procedures.
- Briefly describe the NMR instrument and technique.
- Using ethyl alcohol as an example, describe the type of spectra obtained in NMR spectroscopy, and the use of the spectra for structure determinations.

- Explain what is meant by chemical shift in NMR analysis.
- Draw a schematic diagram of a mass spectrometer, illustrating the analysis technique.
- List three isotopes which can be used in NMR, in addition to the proton.
- Indicate the type of data obtained from the mass spectrometer.
- Describe the technique of microscopy as used for analytical determinations.

SUBJECT MATTER

I. Emission spectrography.
   A. Emission process.
   B. Instrumentation and techniques.
   C. Sources and detectors.
   D. Applications of emission spectrography.

II. X-ray methods.
   A. Sources of x-rays.
   B. X-ray absorption.
   C. X-ray diffraction.
   D. X-ray emission.
   E. Applications.

III. NMR theory.
   A. Resonance.
   B. Chemical shift.

IV. NMR instrumentation.

V. Applications of NMR spectroscopy.
   A. Qualitative analysis.
   B. Quantitative analysis.
   C. Other isotopes.

VI. Electron spin resonance.

VII. The mass spectrometer.
   A. Sample handling.
   B. Magnetic deflection.
   C. Time-of-flight.

VIII. Mass spectra.
   A. Fragmentation patterns.
   B. Qualitative analysis.
   C. Quantitative analysis.

IX. Microscopy.

LABORATORY

The laboratory periods for this module could be used for field trips to industrial labs which use the type of instruments included in the module, or the instructor may use the periods to allow the students to solve spectral interpretation problems such as those found in Spectral Analysis of Organic Compounds by Creswell, Runquist, Campbell or the Sadtler Spectral Workbooks.

TECHNICAL COMMUNICATIONS II

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - none.

PRESENTATION

This course is designed to be taught in the fourth quarter (i.e., the first quarter of the second year of instruction).

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

Technical Communications II is intended to provide the student with background knowledge of, as well as experience in, descriptive techniques and processes, and in the preparation and proper use of specifications. Finally, instruction and experience in structuring and presentation of written and oral reports are presented.

MODULE TITLES

- Describing Devices (TC-06).
- Describing Processes (TC-07).
- Writing Specifications (TC-08).
- Structuring and Presenting a Written Report (TC-09).
- Structuring and Presenting an Oral Report (TC-10).

DESCRIBING DEVICES (TC-06)

Module Outline

COURSE: Technical Communications II.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - none.

INTRODUCTION

This module explains the step-by-step procedure for describing 1) what a device is, 2) what a device looks like and 3) what it does - its purpose.

PREREQUISITES

The student should have completed Module TC-01, "Reviewing Language Structure," TC-02, "Reviewing Language Usage," and Module TC-03, "Technical Writing Style and Graphics."

OBJECTIVES

Upon completion of this module the student should be able to write a concise, precise description of a device, explaining what it is, what it does and what it looks like.

SUBJECT MATTER

I. Introducing the device.
   A. What is it?
   B. What is its purpose?
   C. What does it look like?

II. Part-by-part description.
   A. Shape.
   B. Size.
   C. Relationship to other parts.
   D. Methods of attachment.
   E. Material(s) of which it is made.
   F. Finish.

DESCRIBING PROCESSES (TC-07)

Module Outline

COURSE: Technical Communications II.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - none.

INTRODUCTION

This module identifies and defines the two types of processes and provides the step-by-step approach to describing each.

PREREQUISITES

The student should have completed Module TC-01, "Reviewing Language Structure," TC-02, "Reviewing Language Usage," and Module TC-03, "Technical Writing Style and Graphics."

OBJECTIVES

Upon completion of this module the student should be able to:

- Define the two types of processes described in this module.
- Write a concise, precise description of a process in which an operator plays a conspicuous role.
- Write a concise, precise description of a process in which an operator does not play a conspicuous role.

SUBJECT MATTER

I. Definitions of processes.

II. Process in which an operator plays a conspicuous role.

  A. Introduction to description.

    1. What is process?
    2. Who performs process?
    3. Why is process performed?

4. What are main steps in process?
5. Why is process described?

B. Descriptive steps of action.

III. Process in which an operator does not play a conspicuous role.

A. Conspicuous role.
1. What is process?
2. Who performs process?
3. Why is process performed?
4. What are main steps in process?
5. Why is process described?

B. Descriptive steps of action.

WRITING SPECIFICATIONS (TC-08)

Module Outline

COURSE: Technical Communications II.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - none.

INTRODUCTION

Specifications must be written so clearly that no one can misinterpret any part of one. This module describes the techniques for writing explicit specifications.

PREREQUISITES

The student should have completed Modules TC-01, "Reviewing Language Structure," TC-02 "Reviewing Language Usage," TC-03, "Technical Writing Style and Graphics," TC-06, "Describing Devices," and TC-07, "Describing Processes."

OBJECTIVES

Upon completion of this module the student should be able to:

- List the two general sources of specifications.
- Tabulate the contents of a well written Government specification.
- Tabulate the contents of a well written industrial specification.
- Compare and contrast:
  --Equipment specifications.
  --Process specifications.
  --Project specifications.

SUBJECT MATTER

I. Definition of a specification.

II. Sources of specifications.
   A. Government.
   B. Industry.

III. Categories of specifications.

   A. Equipment.

      1. Manufacturing specifications.

      2. Operating specifications.

      3. Maintenance specifications.

   B. Processes.

      1. Action specifications.

      2. Schedule specifications.

   C. Projects.

      1. Action specifications.

      2. Schedule specifications.

      3. Product specifications.

IV. Specification format and style.

   A. Detailed.

   B. Exact.

   C. Properly sequenced.

STRUCTURING AND PRESENTING A WRITTEN REPORT (TC-09)

Module Outline

COURSE: Technical Communications II.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - none.

INTRODUCTION

This module describes the mateials and procedures required for structuring a written technical presentation.

PREREQUISITES

The student should have completed modules TC-01, "Reviewing Language Structure," TC-02, "Reviewing Language Usage," TC-03, "Technical Writing Style and Graphics," TC-06, "Describing Devices," and TC-07, "Describing Processes."

OBJECTIVES

Upon completion of this module the student should be able to develop a complete, effective, written technical presentation, including:

- A pre-emptive introduction.
- A logically sequenced dissertation of relevant information, supported, as needed, by graphics.
- A sound concluding statement based upon the stated information.
- A recommendation (if pertinent) supported by the stated information.

SUBJECT MATTER

I. Elements of a written technical presentation.
   A. Introduction.
      1. Purpose.
      2. Scope.
      3. Summary.

B. Body of presentation.

   1. Relevance of information.

   2. Sequence of information.

   3. Graphic support.

C. Conclusion.

   1. Summary.

   2. Recommendations.

II. Types of written technical presentations.

A. Reports.

   1. Progress reports.

   2. Status reports.

   3. Recommendation reports.

B. Proposals.

C. Journal articles.

STRUCTURING AND PRESENTING AN ORAL REPORT (TC-10)

Module Outline

COURSE: Technical Communications II.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - none.

INTRODUCTION

This module describes the materials and procedures required for structuring an oral technical presentation.

PREREQUISITES

The student should have completed Modules TC-01, "Reviewing Language Structure," TC-02, "Reviewing Language Usage," TC-03, "Technical Writing Style and Graphics," TC-06, "Describing Devices," and TC-07, "Describing Processes."

OBJECTIVES

Upon completion of this module the student should be able to develop a complete, effective oral technical presentation, including:

- A pre-emptive introduction.
- A logically sequenced dissertation of relevant information, supported, as needed, by graphics.
- A sound concluding statement based upon the stated information.
- A recommendation (if necessary) supported by the stated information.

SUBJECT MATTER

I. Elements of an oral technical presentation.
   A. Introduction.
      1. Purpose.
      2. Scope.
      3. Summary.

B. Body of presentation.

1. Relevance of information.
2. Sequence of information.
3. Graphic support (visual aids, realia, etc.).

C. Conclusion.

1. Summary.
2. Recommendation.

II. Types of oral technical presentations.

A. Reports.
B. Elements of a "speech."
C. Conference papers.

BLUEPRINT AND SCHEMATIC READING

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 1 hour per week.
Laboratory - 3 hours per week.

PRESENTATION

This course is designed to be taught in the first quarter of the second year of instruction, concurrent with the course entitled Power Plant Fundamentals and Systems II.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

Blueprint and Schematic Reading is designed to familiarize the student with structural blueprints, electrical, mechanical, hydraulic and pneumatic systems, symbols and techniques. The laboratory stresses the identification of parts and the relationship of the schematic or blueprint to the power plant system it describes.

COURSE OUTLINE

I. Blueprints.
   A. Frame construction.
   B. Heating, ventilating and air conditioning.
   C. Plumbing.
   D. Structural steel.
   E. Concrete and masonry.

II. Mechancial schematics.

   A. Schematics of mechanical parts.
   B. Dimensions and tolerances.
   C. Orthographic projections.
   D. Standard symbols in hydraulics and pneumatics.

III. Electronic schematics.

   A. Standard symbols in schematics.
   B. Reading electrical schematics.
   C. Circuit layout and component identification.
   D. Schematics for electronic instrumentation.
   E. Residential electrical circuits.
   F. Electrical power distribution systems.

IV. Other figures.

   A. Engineering drawings.
   B. Logic diagrams.
   C. Flow diagrams.

POWER PLANT CHEMISTRY

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 5 hours per week.
Laboratory - 6 hours per week.

PRESENTATION

This course is designed to be presented in the last quarter of the second year of instruction, after the student has a firm grasp of analytical chemistry methods, and following the course called Power Plant Fundamentals and Systems I & II.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

This course is an in-depth study of chemical analyses performed by an Environmental and Chemical Analysis Technician at a coal-fired power plant. The course is designed to provide theoretical background to enable the student to understand observed phenomena. Laboratories include volumetric, gravimetric and instrumental analyses. Fuel analyses also are included, along with water chemistry.

MODULE TITLES

- Coal Properties and Analysis (PC-01).
- Corrosion in a Power Plant (PC-02).
- Water Chemistry and Analysis I (PC-03).
- Water Chemistry and Analysis II (PC-04).
- Air Emission Monitoring (PC-05).
- Lubricating Oils and Greases and Insulating Oils (PC-06).

COAL PROPERTIES AND ANALYSIS (PC-01)

Module Outline

COURSE: Power Plant Chemistry.

CONTACT HOURS: Lecture - 8 hours.
Laboratory - 10 hours.

INTRODUCTION

This module discusses the types of coal, its properties and the analyses that are required in a power plant.

PREREQUISITES

The student should have completed Properties and Reactions of Organic Materials.

OBJECTIVES

Upon completion of this module the student should be able to:

- List the major coals and give several distinguishing characteristics.
- Take a coal sample.
- Perform the following proximate analyses:
  --Moisture.
  --Volatile matter.
  --Fixed carbon.
  --Ash.
  --Grindability.
  --Ash fusion temperature.
- Perform the following ultimate analyses:
  --Sulfur.
  --Hydrogen.
  --Carbon.
  --Nitrogen.
  --Oxygen.

- Determine the heating value of a given coal sample.
- Discuss the combustion process of coal.

SUBJECT MATTER

I. The environmental and chemistry labs.

II. Coal properties.
   A. Major coals.
   B. Coal sources.

III. Coal testing.
   A. Sampling and sizing.
   B. Proximate analysis.
      1. Moisture.
      2. Volatile matter.
      3. Fixed carbon.
      4. Ash.
      5. Grindability.
      6. Ash fusion temperature.
   C. Ultimate analysis.
      1. Sulfur.
      2. Hydrogen.
      3. Carbon.
      4. Nitrogen.
      5. Oxygen.
   D. Heating value determination by using bomb calorimeter.

IV. Combustion chemistry.

CORROSION IN A POWER PLANT (PC-02)

Module Outline

COURSE: Power Plant Chemistry.

CONTACT HOURS: Lecture - 9 hours.
Laboratory - 10 hours.

INTRODUCTION

This module discusses the chemistry of corrosion and problems that are caused by corrosion in a power plant.

PREREQUISITES

The student should have completed Environmental Chemistry I & II.

OBJECTIVES

Upon completion of this module the student should be able to:

- Describe the various corrosion processes.
- Discuss problems caused by corrosion in a power plant.
- Outline procedures for protecting plant equipment from corrosion.

SUBJECT MATTER

I. Electrochemical cells.

II. Corrosion.
   A. General.
   B. Galvanic.
   C. Pitting.
   D. Chloride stress corrosion.
   E. Rates.

III. Hydrogen embrittlement.

IV. Corrosion in power plants.

  A. Condenser.
  B. Turbine.
  C. Feedwater heaters.
  D. Boiler.
  E. Cooling water systems.

V. Protective measures.

  A. Passivation.
  B. Selection of materials.
  C. Nitrogen purging.
  D. Chemical protection.
  E. Deaereation.
  F. Reducing atmosphere.

WATER CHEMISTRY AND ANALYSIS I (PC-03)

Module Outline

COURSE: Power Plant Chemistry.

CONTACT HOURS: Lecture - 8 hours.
Laboratory - 10 hours.

INTRODUCTION

This module discusses the use of water in power plants.

PREREQUISITES

The student should have completed Environmental Chemistry I & II.

OBJECTIVES

Upon completion of this module the student should be able to:

- List the sources of water used in a power plant.
- Discuss the uses of water in a power plant.
- Discuss boiler and feedwater and describe their characteristics.

SUBJECT MATTER

I. Water sources for power plants.

II. Water uses in power plants.

III. Boiler water.

   A. Scale formation.

   B. Phosphate treatment.

   C. Acidity and alkalinity.

   D. Dissolved oxygen and its removal.

      1. Sodium sulfite.

      2. Hydrazine.

   E. Silica.

   F. Chloride.

IV. Feedwater.

A. Dissolved oxygen.

B. pH.

C. Ammonia.

D. Hydrazine.

WATER CHEMISTRY AND ANALYSIS II (PC-04)

Module Outline

COURSE: Power Plant Chemistry.

CONTACT HOURS: Lecture - 9 hours.
Laboratory - 10 hours.

INTRODUCTION

This module discusses the sampling and analyses of plant water.

PREREQUISITES

The student should have completed Module PC-03, "Water Chemistry *and* Analysis I."

OBJECTIVES

Upon completion of this module the student should be able to:

- Demonstrate the sampling procedures for the following power plant water:
  --Boiler water.
  --Steam.
  --Feedwater.
  --Condenser water.
- Perform the following water analyses:
  --Conductivity measurements.
  --pH.
  --Dissolved oxygen.
  --Solids.
  --Irons.
  --Chlorine.
  --Turbidity.
  --Hardness.
  --Carbon dioxide.

--Alkalinity.

--Ammonia.

--Hydrogen sulfide.

--Hydrazine.

--Silica.

--Sulfate.

SUBJECT MATTER

I. Water sampling.

    A. Boiler water.

    B. Steam

    C. Feedwater.

    D. Condenser water.

II. Water analysis procedures.

    A. Conductivity measurements.

    B. pH.

    C. Dissolved oxygen.

    D. Solids.

    E. Iron.

    F. Chlorine.

    G. Turbidity.

    H. Hardness.

    I. Carbon dioxide.

    J. Alkalinity.

    K. Ammonia.

    L. Hydrogen sulfide.

    M. Hydrazine.

    N. Silica.

    O. Sulfate.

AIR EMISSION MONITORING (PC-05)

Module Outline

COURSE: Power Plant Chemistry.

CONTACT HOURS: Lecture - 8 hours.
Laboratory - 10 hours.

INTRODUCTION

This module discusses air emission monitoring.

PREREQUISITES

The student should have completed Module PC-01, "Coal Properties and Analyses."

OBJECTIVES

Upon completion of this module the student should be able to:

- Outline air sampling procedures used for stack emission.
- Perform the following analyses:
  --Particulates.
  --SO_X.
  --NO_X.
  --CO.
  --Oxidants.
  --Hydrocarbons.
- Discuss the purpose of air analyses.

SUBJECT MATTER

I. Purpose of monitoring air emissions.
II. Air sampling techniques.

III. Analysis procedures.

A. Particulates.

B. SO_X.

C. NO_X.

D. CO.

E. Oxidants.

F. Hydrocarbons.

LUBRICATING OILS AND GREASES, AND INSULATING OILS (PC-06)

Module Outline

COURSE: Power Plant Chemistry.

CONTACT HOURS: Lecture - 8 hours.
Laboratory - 10 hours.

INTRODUCTION

This module is a consideration of lubricating oils and greases used in the modern power plant. In addition transformer oils are considered.

PREREQUISITES

The student should have completed Properties and Reactions of Organic Materials.

OBJECTIVES

Upon completion of this module the student should be able to:

- Discuss the function of additives and inhibitors found in modern lubricating oils.
- Decribe methods and precautions to be observed in sampling oils.
- Describe and perform the following laboratory tests:

  --Viscosity.

  --Water content.

  --Total acidity.

  --Oxidation stability.

  --Pour point.

  --Flash point.
- Describe methods used to purify lubricating oils.
- Identify five properties of a grease which are important in power plant uses.
- Conduct transformer gas analysis.

- Conduct the following tests on insulating oils:
  --Oxidation.
  --Flash point.
  --Viscosity.
  --Pour point.
  --Electric strength.
  --Acidity.
  --Free water.

SUBJECT MATTER

I. Lubricating oils.
   A. Additives and inhibitors.
      1. Oxidation and rush inhibitors.
      2. Detergents.
      3. Viscosity index improvers.
      4. Pour point depressant.
      5. Emulsifying agents.
      6. Anti-foam agents.
   B. Sampling techniques.
   C. Oil tests.
      1. Viscosity.
      2. Acidity.
      3. Water content.
      4. Oxidation stability.
      5. Flash point.
      6. Pour point.
   D. Oil purification.

II. Greases.
   A. Types of grease.
   B. Grease tests.

III. Insulating oils.
   A. Sampling techniques.
   B. Oil properties.
      1. Acidity.
      2. Electric strength.
      3. Water.

IV. Transformer gas analysis.

ENVIRONMENTAL ANALYSIS

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.

Laboratory - 6 hours per week.

PRESENTATION

This course is designed to be presented in the second quarter of the second year of instruction, after the student has completed the analytical chemistry required for environmental analysis procedures.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

This course covers standard procedures for measuring air and water emissions from a plant. It demonstrates those pollutants common to coal-fired power plants, which provides an insight into how they are formed in the plant. Lectures also cover reasons for monitoring plant discharges, government regulations concerning various pollutants and effects these pollutants have on the outside environment. The laboratories include sampling techniques and standard procedures for analyses.

MODULE TITLES

- Introduction to Environmental Analysis (EA-01).
- Air Analysis - Particulates (EA-02).
- Air Analysis - Gaseous Pollutants (EA-03).
- Water Analysis (EA-04).
- Solid Wastes (EA-05).

INTRODUCTION TO ENVIRONMENTAL ANALYSIS (EA-01)

Module Outline

COURSE: Environmental Analysis.
CONTACT HOURS: Lecture - 6 hours.
Laboratory - 6 hours.

INTRODUCTION

This module introduces the student to the broad field of environmental analysis and specifically to that portion of environmental analysis with which an Environmental and Chemical Analysis Technician would be involved at a coal-fired power plant.

PREREQUISITES

The student should have completed the courses entitled Properties and Reactions of Organic Materials and Gravimetric and Volumetric Analysis.

OBJECTIVES

Upon completion of this module the student should be able to:

- Briefly outline the scope of environmental analysis.
- Describe the three main areas of environmental analysis relating to coal-fired power plants.
- List at least five reasons environmental analysis is important in today's world.
- Discuss different levels of environmental pollution.

SUBJECT MATTER

I. Environmental analysis.
   A. Definition.
   B. Scope.

II. Environmental degradation.

A. Levels.

1. Local.
2. Regional.
3. National.
4. Continental.
5. Global.

B. Effects.

1. On man.
2. On animals.
3. On vegetation.
4. On nonliving materials.

LABORATORY

To be specified.

AIR ANALYSIS - PARTICULATES (EA-02)

Module Outline

COURSE: Environmental Analysis.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 12 hours.

INTRODUCTION

This module introduces air pollution in general, and specifically those problems dealing with particulates. The module describes methods used for collecting and analyzing particulates.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define:
  --Air pollution.
  --Air contaminants.
  --Primary pollutant.
  --Secondary pollutant.
  --Photochemical reaction.
  --Particulate.
  --Gaseous pollutants.
  --Source sampling.
  --Aerosol.
  --Fixed source.
  --Mobile source.
- Discuss hazards associated with particulates.

- Discuss the purpose of particulate stack sampling.
- List and describe the five major components of the sampling train.
- Discuss the nature of particulates in a coal-fired power plant stack, including size, composition and formation.
- Give the government standard for particulate emission.

SUBJECT MATTER

I. Air pollution.
   A. Definitions.
   B. Classifications.
   C. Sources.
   D. Effects.

II. Particulates.
   A. Classification by size.
   B. Sources.
   C. Hazards.

III. Analysis procedures.
   A. Atmospheric.
      1. Gravity technique.
      2. Filtration technique.
      3. Inertial technique.
      4. Precipitation technique.
   B. Stack sampling.
      1. Purpose.
      2. Consideration.
      3. Equipment.

LABORATORY

To be specified.

AIR ANALYSIS - GASEOUS POLLUTANTS (EA-03)

Module Outline

COURSE: Environmental Analysis.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 18 hours.

INTRODUCTION

This module discusses gaseous pollutants, their formation, reactions, effects on man and environment, and measurement techniques. Special attention is given to those pollutants formed from the combustion of coal.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define:
  - --Inorganic gases.
  - --Organic gases.
  - --Photochemical oxidant.
  - --Absorption sampling.
  - --Adsorption sampling.
  - --Oxygenated hydrocarbons.
  - --Halogenated hydrocarbons.
- List the six groups of inorganic gaseous pollutants.
- Briefly discuss effects of gaseous pollutants on man and the environment.
- Perform the four sampling techniques for gaseous pollutants.
- Demonstrate procedures for analyzing gaseous pollutants.

- Discuss formation of three of the gaseous pollutants during coal combustion.

SUBJECT MATTER

I. Gaseous pollutants.

  A. Inorganic gases.

    1. Sulfur compounds.
    2. Nitrogen compounds.
    3. Chloride compounds.
    4. Fluoride compounds.
    5. Carbon compounds.
    6. Oxidants.

  B. Organic gases.

    1. Hydrocarbons.
    2. Hydrocarbon derivatives.

II. Formation of gaseous pollutants.

III. Hazards.

  A. Effects on man.

  B. Effects on environment.

IV. Sampling techniques.

  A. Absorption sampling.

  B. Adsorption sampling.

  C. Condensation sampling.

  D. Grab sampling.

V. Analysis of specific gases.

  A. NO_X.

  B. SO_X.

  C. CO.

  D. Hydrocarbons.

LABORATORY

To be specified.

WATER ANALYSIS (EA-04)

Module Outline

COURSE: Environmental Analysis.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 18 hours.

INTRODUCTION

This module discusses the various water analyses that may be required in order for a power plant to maintain its permits to discharge water into the environment.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Give the major classifications of water pollutants and describe the effects of each.
- Perform tests or procedures for each of the following water analyses that are most often required by law.
  - --BOD.
  - --COD.
  - --Fecal coliform.
  - --Hardness.
  - --Chlorine.
  - --Total solids.
  - --pH.
  - --Temperature.

SUBJECT MATTER

I. Major classifications of water pollutants.

A. Types.

B. Sources.

C. Effects.

II. Regulation of water discharge.

A. Local.

B. State.

C. Federal.

III. Sampling techniques.

IV. Specific analyses.

A. DO.

B. BOD.

C. COD.

D. Total suspended solids.

E. pH.

F. Chlorine.

G. Hardness.

H. Total iron.

I. Fecal coliform.

SOLID WASTES (EA-05)

Module Outline

COURSE: Environmental Analysis.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 6 hours.

INTRODUCTION

This module discusses the problems associated with the large amounts of solid wastes that are produced in a power plant.

PREREQUISITES

The student should have completed the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- List the main components of solid waste produced in a coal-fired power plant.
- Describe the most common methods of disposal for this waste.
- Discuss recycling as a method of waste disposal.
- List government regulations concerning solid waste disposal.

SUBJECT MATTER

I. Solid waste.
   A. Types.
   B. Sources.

II. Problems.
   A. Aesthetics.
   B. Health hazard.
   C. Pollution.

III. Methods of disposal.

A. Landfill.

B. Incineration.

C. Open dumps.

D. Recycling.

IV. Considerations.

A. Government regulations.

B. Economics.

C. Environment.

PLANT AND LABORATORY SAFETY

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 3 hours per week.

PRESENTATION

This course is designed to be presented in the second year of instruction.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

This course is an overview study of practical safety requirements related to a power plant and an in-depth study of the principles, concepts and applications of laboratory safety needs as encountered by Environmental and Chemical Analysis Technicians in a modern power plant system.

Plant and Laboratory Safety is divided into five modules of instruction covering safety principles for both plant and laboratory, industrial fire protection, first aid and noise measurement and control. The procedures (laboratory) section of the modules will emphasize practical applications of the safety principles, certification in the American National Red Cross "first aid" training program and noise measurement.

MODULE TITLES

- Laboratory Safety and Hazardous Materials (PS-01).
- Power Plant Accident Prevention (PS-02).
- Fundamentals of Fire Prevention (PS-03).
- First Aid (PS-04).
- Noise Measurement and Control (PS-05).

LABORATORY SAFETY AND HAZARDOUS MATERIALS (PS-01)

Module Outline

COURSE: Plant and Laboratory Safety.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 6 hours.

INTRODUCTION

This module emphasizes the importance of chemical laboratory safety to both the individual and plant by identifying hazards and recommending their control.

PREREQUISITES

Completion of general chemistry courses and one year of high school algebra.

OBJECTIVES

Upon completion of this module the student should be able to:

- Write a definition for each of the following:
  - --Dusts.
  - --Fumes.
  - --Smoke.
  - --Aerosols.
  - --Mists.
  - --Gases.
  - --Vapors.
  - --Hazardous materials.
  - --Flammable.
  - --Flash point.
  - --Toxicity.
  - --Pyrophoric.
  - --Acute.
  - --Chronic.

- List hazards associated with the following items found in or associated with a chemical laboratory:

  --Acids.

  --Alkalis.

  --Solvents.

  --Gases.

  --Glassware.

  --Ignition devices.

  --Electrical apparatus.

  --Cryogenics.

  --Compressed gases.

- Describe when the following personal protective equipment should be used:

  --Safety glasses.

  --Safety goggles.

  --Safety shields.

  --Safety shoes or boots.

  --Gloves.

  --Arm protection.

  --Body aprons.

  --Eye fountains.

  --Body showers.

  --Earplugs.

  --Hard hats.

- Describe the three routes of entry of toxic substances into the body and discuss preventive action to be taken for each route named.

- Describe major types of respiratory protective equipment and the application of each type.

- Describe, with the aid of sketches, the correct laboratory location of exhaust systems and hoods.

- Describe basic fire chemistry and list the four components necessary to produce combustion.

- List the four classes of fires and associated use of correct fire extinguishers.

SUBJECT MATTER

I. Basic laboratory safety rules.
   A. Types of hazards.
   B. Identification of hazards.
   C. Control of hazards.

II. Personal protective equipment.
   A. Safety glasses, goggles and shields.
   B. Gloves and arm protection.
   C. Hard hats.
   D. Protective footwear.
   E. Earplugs.

III. General laboratory safety equipment.
   A. Eye fountains and body showers.
   B. Fire extinguishers.
   C. Respiratory apparatus.
   D. Fume hoods and exhaust fans.

IV. Toxic hazards.
   A. Toxic chemicals.
   B. Entry routes for toxic chemicals.
   C. Acute/chronic poisoning.
   D. Lethal doses.
   E. Threshold limit values (TLV).
   F. Hazardous materials information sheets.

V. Fire hazards.
   A. Elements of fire.
   B. Fire chemistry.
   C. Fire prevention and check lists.
   D. Sources of ignition.
   E. Fire extinguishing.

VI. Electrical and special hazards.
   A. Common electrical hazards.
   B. Effects of current/voltage/resistance.
   C. Precautions (electrical).
   D. Compressed gases.
   E. Cryogenics.
   F. Waste disposal.

MATERIALS FOR LABORATORY PROCEDURES

- 1 set of personal protective devices common to the laboratory needs, for example:

  --Safety goggles.

  --Rubber gloves.

  --Face and eye shield.

  --Earplugs.

  --Safety shoes, etc.

- 1 set of respiratory protective equipment common to the laboratory needs, for example:

  --Filter respirator.

  --Gas mask.

  --Self-contained breathing apparatus.

- 1 set of fire extinguishers suitable for fighting Class A, B, C and D fires.

LABORATORY PROCEDURES

- Prepare a sketch of the laboratory (to scale); locate on the sketch the following and post in a prominent location:

  --Doors, windows, telephones and exits.

  --Storage areas for hazardous and toxic materials.

  --Fire alarms and extinguishers.

  --Eye fountains, body showers and exhaust devices.

  --High-pressure gases and cryogenic materials.

  --Egress routes in the event of disaster.

  --Emergency telephone numbers.

- Prepare a hazardous materials information sheet for both a liquid and a solid material.

- Demonstrate the correct method of wearing and cleaning selected personal protective equipment, including eye and body wash facilities.

- Demonstrate correct use of fire extinguishers on actual Class A, B, C and D fires.

- Demonstrate selection and use of personal respiratory equipment for at least three major fume producing chemicals stored in the laboratory.

REFERENCES

1. Fundamentals of Industrial Hygiene. National Safety Council, 1977.

2. The Handbook of Laboratory Safety. Cleveland, OH: Chemical Rubber Co.

3. Meyer, Eugene. Chemistry of Hazardous Materials. Englewood Cliffs, NJ: Prentice-Hall, 1977.

4. Safety in the Chemical Laboratory. 16 mm film. Washington, D.C.: Manufacturing Chemists' Association, Inc.

POWER PLANT ACCIDENT PREVENTION (PS-02)

Module Outline

COURSE: Plant and Laboratory Safety.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 6 hours.

INTRODUCTION

This module emphasizes the importance of plant safety to both the individual and industry so that an Environmental and Chemical Analysis Technician will observe plant safety rules in performance of duties outside the laboratory - being able to identify hazards, take required corrective action and recommend control measures.

PREREQUISITES

Completion of Power Plant Fundamentals and Systems I & II, Power Plant Chemistry, Fundamentals of Electricity/Electronics and one year of high school algebra.

OBJECTIVES

Upon completion of this module the student should be able to:

- Describe why accident prevention is necessary in an industrial plant.
- Define the following terms:

  --OSHA.

  --Workmen's compensation.

  --Hazards.

  --Unsafe conditions.

  --Unsafe act.

  --Safety inspection.
- Describe responsibilities with regard to safety of the following (as defined by the OSHAct):

  --Company.

  --Employee.

- Describe how job safety analysis assists in safety training.
- Describe how industrial hygiene differs from industrial safety; list at least six subjects that are listed under each responsibility.
- Describe at least 10 items of personal protective equipment and their associated hazard protection.
- Describe how plant housekeeping can reduce accidents; prepare a plant housekeeping inpsection list.
- Write a procedure for the correct method of lifting a heavy box (approximately 30-lb weight, measuring 12 in x 16 in x 24 in) from the floor to a table.
- List at least five major methods of mechanical material handling devices commonly found around a power plant.
- Define the principle of guarding machinery; sketch an example of a vee belt guard on a motor/air blower set.
- Describe a lockout procedure for maintenance of a pump motor.
- List the four basic safe practices applied to hand and portable tools.
- Describe five unsafe practices generally attributed to an untrained employee working with hand tools, and the corrective action recommended for each.

SUBJECT MATTER

I. Cost of accidents.
   A. Accidents and work efficiency.
   B. Accidents and morale.

II. Plant accident prevention.
   A. Occupational Safety and Health Act.
   B. Workmen's compensation.
   C. Identifying job hazards.
   D. Safety inspection procedures.
   E. Unsafe conditions/acts.
   F. Safety performance records and costs.

III. Safety instructions.
   A. Job safety analysis.
   B. Identification of potential accidents.
   C. Standard operating safety instructions.

IV. Industrial hygiene.
   A. Chemical.
   B. Airborne materials.
   C. Solvents.
   D. Particulates.
   E. Temperature stress.
   F. Noise.
   G. TLV.
V. Personal protective equipment.
   A. Eyes.
   B. Face.
   C. Feet and legs.
   D. Ear protection.
   E. Respiratory protective equipment.
   F. Safety belts and harnesses.
   G. Hard hats.
VI. Plant housekeeping.
   A. Cleanup.
   B. Inspection techniques.
   C. Structures, floors, aisles and storage areas.
   D. Use of signs, barriers and color codes.
VII. Material handling and storage.
   A. Lifting and carrying (manual).
   B. Hand trucks (powered and nonpowered).
   C. Industrial trucks.
   D. Conveyor belts.
   E. Cranes.
   F. Railroad cars.
   G. Chains and chain slings.
   H. Materials storage.
VIII. Machine guards.
   A. Principles of guarding.
   B. Machine guards.
   C. Mechanism guards.
   D. Maintenance and repair.
   E. Lock-out procedures.
   F. Hazard containment.

IX. Hand and portable power tools.

A. Use of hand tools.

B. Maintenance and repair.

C. Power tools (electric).

D. Power tools (air).

MATERIALS FOR LABORATORY PROCEDURES

- Note pad.
- 6-inch rule.
- 10-foot tape.
- Personal safety equipment as required by area of inspection.

LABORATORY PROCEDURES

- Calculate true cost of recent accident that occurred in the plant. (Instructor will prepare a scenario.) Take into account such hidden items as: machine down time, retraining new employee, lost time costs, supervisor's additional training time, hospital and doctor costs, etc. Calculate how many dollars could have been saved if the employee were better trained.
- Prepare a safety inspection check-off list for a small section of the school's power plant. Base items on what is required by OSHA and the school. Perform inspection; discuss findings objectively with safety supervisor and instructor.
- Perform inspection of a school shop (metal work, wood work, auto, etc.); list personal protective equipment being used by everyone in the area. Compare this actual list with a list prepared in accordance with regulations.
- Visit school maintenance shop, machine shop or carpenter shop. Inspect small hand tools being used; make a list of items that need both repair and rework to make the safe for use. Discuss results with instructor and shop supervisor.

REFERENCES

1. Accident Prevention Manual for Industrial Operations. Chicago, IL: National Safety Council, 1978.

2. Films to be specified.

3. Supervisors Safety Manual. Chicago, IL: National Safety Council, 1978.

FUNDAMENTALS OF FIRE PREVENTION (PS-03)

Module Outline

COURSE: Plant and Laboratory Safety.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 6 hours.

INTRODUCTION

This module introduces the student to the role of fire prevention in plants and chemical laboratories and the severity of fire and losses of both life and productivity. Hazards of plant systems are identified, with associated controls in the form of inspection type procedures. In-depth chemical laboratory hazards are identified; control devices are reviewed with emphasis on fire suppression.

PREREQUISITES

The student should have completed Environmental Chemistry I & II, Properties and Reactions of Organic Materials, Power Plant Fundamentals and Systems I & II, and Unified Technical Concepts.

OBJECTIVES

Upon completion of this module the student should be able to:

- Discuss the need for plant fire prevention.
- List previous plant fires involving loss in excess of $1,000.00; tell what corrective action took place to prevent recurrence.
- Describe important points of fire chemistry, introducing effects of at least six major classes of fires.
- List fire hazards of at least five major material items used in a plant's combustion system.
- Describe important items of a plant's fuel burning systems and their effect on fire hazards.

- List eight types of hazards that may be found in a plant chemical laboratory; prescribe corrective action for each.
- Describe at least seven items to be considered under fire protection services and practices.
- List six common fire extinguishing agents and the extinguishing devices in which they are to be found.
- Describe a typical plant/chemical laboratory fire protection service; tell what role each plays.
- Prepare a fire hazard check-off list for a typical plant and laboratory area.

SUBJECT MATTER

I. Introduction to fire prevention and protection.
   A. Plant losses by fire.
   B. Fire investigation and reporting.

II. Chemistry and physics of fire.
   A. Definitions.
   B. Reactions.
   C. Combustion.
   D. Heat transfer.
   E. Ignition.
   F. Explosions.
   G. Smoke.

III. Material hazards.
   A. Chemicals.
   B. Gases.
   C. Dusts.
   D. Flammable and combustible liquids.
   E. Identification of hazardous materials.

IV. Industrial fire hazards.
   A. Boilers/furnaces.
      1. Coal.
      2. Oil.
      3. Gas.
   B. Fuel burning systems.
      1. Air supply.
      2. Fuel supply.
      3. Pulverizers.

4. Atomizing.
5. Ignition.
6. Combustion control system.

V. Chemical laboratory hazards.
   A. Material storage (hazardous).
   B. Housekeeping/spills.
   C. Movement of materials.
   D. Acids/alkalis.
   E. Liquids/flammable.
   F. Explosives.
   G. Pyrophorics.
   H. Ignition.

VI. Fire protection.
   A. Alarms (heat/smoke).
   B. Fire-retardant materials.
   C. Indoor/outdoor practices.
   D. Egress design.
   E. Gas-vapor detection.
   F. Ventilation.
   G. Drills.

VII. Extinguishing agents.
   A. Water/water additives.
   B. Foams.
   C. CO_2.
   D. Halogenated.
   E. Dry chemicals.
   F. Extinguishing agents for combustible metals.

VIII. Extinguishing devices.
   A. Hoses.
   B. Sprinkler systems (automatic).
   C. Extinguishing agent systems.
   D. Extinguishers (portable).
   E. Fire-retardant blankets.

IX. Industrial fire protection.
   A. Public fire department.
   B. Plant fire brigade.
   C. Disaster control.

MATERIALS FOR LABORATORY PROCEDURES

Laboratory 1

None.

Laboratory 2

None.

Laboratory 3

- Notebooks.
- Miscellaneous portable fire extinguishers.
- Oil-soaked rags, paper, wood.
- Lubricating oil.
- White oil.
- Small quantity (½ oz) of gasoline in a certified container.
- Personal safety protection devices as required by instructor.

LABORATORY PROCEDURES

Laboratory 1

The student will visit a public fire department to observe a) their industrial fire fighting procedures and b) how the public fire fighting department works with local plant fire brigades. Student will prepare a report on the visit to highlight industrial fire fighting.

Laboratory 2

The student will visit a local power plant and report on their fire prevention status and at least the following items:

- Type and size of fire brigade.
- Fire brigade training.
- List of various types of fire fighting devices.
- List of types of portable fire extinguishers.
- Is a disaster plan available for review?
- Do they have special fire hazards to be considered? List them.

Laboratory 3

The student will visit a local chemical plant or laboratory and report on its fire prevention status and at least the following items:

- List different types of hazardous materials.
- Are their storage and labeling adequate?
- Fire fighting devices available and their types.
- Disaster plan.
- Fire brigade and frequency of training.

Laboratory 4

Based on instructor's scenario, the student will actually practice putting out fires using portable extinguishers.

REFERENCES

Books

1. Fire Protection Handbook. Boston, MA: National Fire Protection Association.

2. Fire Protection Guide on Hazardous Materials. Boston, MA: National Fire Protection Association.

3. Handbook of Industrial Loss Prevention, 2nd ed. New York: McGraw-Hill, 1967.

4. Robertson, James C. Introduction to Fire Prevention. Beverly Hills, CA: Glencoe Press, 1975.

5. National Fire Protection Codes, Standards and Recommended Practices. See latest National Fire Protection Associations and Visual Aids Catalogs.

Films

1. ABC&D of Portable Fire Extinguishers. Hollywood, CA: Film Communicators.

2. Extinguish That Fire. Hollywood, CA: Film Communicators.

3. Flammable Liquid Fire Safety. Evanston, IL: Journal Films, Inc.

4. Stop the Fire Before It Starts. Evanston, IL: Journal Films, Inc.

FIRST AID (PS-04)

Module Outline

COURSE: Plant and Laboratory Safety.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 6 hours.

INTRODUCTION

This module will familiarize the student with the needs and value of first aid training required for emergency care of the injured until a physician arrives. It also will create an active interest in the prevention of accidents by elimination of cause and enable the student to react to emergency situations that may be encountered in the workplace requiring satisfactory performance.

PREREQUISITES

None.

OBJECTIVES

Upon completion of this module the student should be able to:

- Demonstrate first aid for wounds and shock and demonstrate artificial respiration.
- Demonstrate first aid for poisoning, burns, effects of heat and cold, head injury, internal injury and gunshot wounds.
- Demonstrate first aid for infection, tetanus and animal bites.
- Demonstrate first aid for heat attack, apoplexy, fainting and epilepsy.
- Demonstrate first aid for foreign objects in the eye, air and food passages.
- Demonstrate the correct way to rescue and transfer an injured person.
- Achieve certification in the National Red Cross Multi-Media First Aid.

SUBJECT MATTER

I. Introduction to first aid.
   A. Wounds.
   B. Tourniquet.
   C. Direct pressure.

II. Shock.
   A. Symptoms.
   B. Treatment.

III. Artificial respiration.
   A. Adult and child rate.
   B. Manual method.
   C. Mouth-to-mouth method.
   D. Drowning.
   E. Electric shock, poisoning.

IV. Poisoning.
   A. Causes.
   B. Antidotes.

V. Burns.
   A. Degree.
   B. Shock/pain.
   C. Contamination prevention.

VI. Effects of hot and cold atmospheres.
   A. Heat exhaustion.
   B. Heat stroke.
   C. Treatment.
   D. Frostbite.
   E. Care.

VII. Injury.
   A. Head.
   B. Internal.
   C. Treatment.
   D. Bandaging.
   E. Splinting.

VIII. Infection.
   A. Signs.
   B. Treatment.
   C. Tetanus.
   D. Rabies.

IX. Immobilization.
   A. Purpose.
   B. Fracture (open/closed).
   C. Sprain.
   D. Dislocation.
X. Heat attack.
   A. Symptoms.
   B. Treatment.
   C. Breathing.
XI. Apoplexy.
   A. Symptoms.
   B. Treatment.
XII. Fainting/epilepsy.
   A. Treatment.
   B. Convulsions.
XIII. Foreign objects.
   A. Eyes.
   B. Treatment.
   C. Air passages.
   D. Treatment.
   E. Food passages.
   F. Treatment.
XIV. Rescue.
   A. Transporting.
   B. Extent of injury.
   C. Fire/smoke.
   D. Auto/truck.
XV. Drowning, water accidents and resuscitations.
   A. Types.
   B. Treatment.

MATERIALS FOR LABORATORY PROCEDURES

A list of reusable and expendable supplies is given in the American National Red Cross Standard First Aid Course - Instructor's Outline ARC 2129.

LABORATORY PROCEDURES

- Each of the (4) American National Red Cross multi-media sections required practice sessions (laboratory). These are delineated in the "Standard First Aid Course, Multi-Media System," Instructor's Outline, ARC 2129.
- Students will perform rescue and transfer procedures using stretchers and backboards.
- Students will perform emergency extrication procedures on simulated victims trapped in plant areas.

REFERENCES

1. First Aid Textbook. ARC stock No. 321011.

2. Standard First Aid Course - Multimedia System. ARC stock No. 321155.

3. Standard First Aid Course - Multimedia System, 16 mm color film. ARC stock No. 321613.

NOISE MEASUREMENT AND CONTROL (PS-05)

Module Outline

COURSE: Plant and Laboratory Safety.

CONTACT HOURS: Lecture - 6 hours.
Laboratory - 6 hours.

INTRODUCTION

This module introduces the student to methods of measuring noise levels and engineering controls for attenuation. Types, correct use and cleaning of personal protective equipment are covered. Sound survey meters and their use are described.

PREREQUISITES

The student should have completed general courses in Power Plant Fundamentals and Systems I & II and Unified Technical Concepts and one year of high school algebra.

OBJECTIVES

Upon completion of this module the student should be able to:

- Describe how noise is produced; include definition of decibel and frequency.
- Sketch a diagram of the human ear and label auditory items.
- Describe how an employee's hearing can be tested.
- Describe OSHA noise criteria and methods of measurement.
- Describe three types of sound survey instruments; list advantages and disadvantages of each.
- List several methods of industrial noise control; describe how each could be used.
- Give examples of five types of industrial noise sources in a power plant.

- Describe an industrial hearing conservation program that could be implemented in an industrial power plant.

SUBJECT MATTER

I. Industrial noise.

A. Properties and definitions.

B. Decibel.

C. Frequency.

II. Effect on the human ear.

A. Hearing.

B. Hearing loss.

C. Testing/audiology.

D. Damage risk criteria.

III. Noise measurement and instrumentation.

A. OSHA noise criteria.

B. What is to be measured.

C. How it is to be measured.

D. In-plant/outdoors.

E. Installed machinery.

F. Housing areas.

G. Sound level meters.

H. Octave band analyzers.

IV. Environmental noise control.

A. Acoustic materials.

B. Vibration-damping materials.

C. Vibration-isolation materials.

D. Machine elements.

V. Industrial applications.

A. Fan and flow systems.

B. Combustion and furnace noise.

C. Fluid piping noise.

D. Pump and valve noise.

E. Plant periphery assessment.

VI. Hearing conservation program.

A. Personal protective equipment.

1. Noise reducers.

2. Earplugs.

3. Earmuffs.

4. Acoustic curtains and panels.
5. Employee testing.

B. Plant-noise survey forms.
1. Design.
2. Survey methods.
3. Duration.
4. Impact assessment.

MATERIALS FOR LABORATORY PROCEDURES

- Battery-operated bell or buzzer.
- Miscellaneous tiles of acoustic materials.
- Calibrated sound level meter (decibels).
- 36-inch rule.
- Sets of earplugs from various manufacturers.

LABORATORY PROCEDURES

Laboratory 1

Fabricate a noise attenuation box, whereby different sound-absorbing materials may be inserted for testing. Use as a sound source a battery-operated bell so that no wires penetrate the box. Measure the intensity of ringing noise for several different materials with a calibrated sound-level meter (fixed location).

Laboratory 2

With instructor's assistance, demonstrate a method used to find correct size of earplugs and how plugs are correctly inserted and removed.

Laboratory 3

Using an approved plant-noise survey form (obtainable from General Radio or equivalent) and a hand-held sound-level meter, perform a sound survey of two school shops (i.e., metalworking and power plant).

REFERENCES

1. Faulkner, L.L., Ed. Handbook of Industrial Noise Control. New York: Industrial Press, 1976.

2. Industrial Noise and Hearing Conservation. Chicago, IL: National Safety Council, 1978.

3. Part 1910, Occupational Safety and Health Standards. Chapter XVII. OSHA. Department of Labor, Title 29 - Labor. Superintendent of Documents, Washington, D.C.

POLLUTION CONTROL FOR COAL-FIRED POWER PLANTS

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 2 hours per week.

PRESENTATION

This course is designed to be taught in the final quarter of the second year of instruction, following the course entitled Environmental Analysis.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

This course covers accepted chemical and mechanical methods for removing or reducing harmful components of stack emissions and water discharges. Devices described and discussed include electrostatic precipitators, settling chambers, bag houses, filters and scrubbers. The laboratories include field trips designed to allow the student to observe these devices in service.

COURSE OUTLINE

I. Introduction to pollution control.
   A. Pollution defined.
   B. Determination of quality standards.
   C. Federal environmental legislation.

II. Air pollution.
   A. Pollutants from coal combustion.
   B. Interpreting stack analyses.
   C. Choosing a system.

III. Air pollution control devices.
   A. Electrostatic precipitators.
      1. Effectiveness.
      2. Operation.
      3. Limitations.
   B. Settling chambers.
      1. Effectiveness.
      2. Operation.
      3. Limitations.
   C. Bag houses.
      1. Effectiveness.
      2. Operation.
      3. Limitations.
   D. Filters.
      1. Effectiveness.
      2. Operation.
      3. Limitations.
   E. Scrubbers.
      1. Effectiveness.
      2. Operation.
      3. Limitations.

IV. Water pollution.
   A. Major contaminants from power plants.
   B. Interpreting effluent analyses.
   C. Choosing a system.

V. Water treatment.
   A. Primary treatment.
   B. Secondary treatment.
   C. Tertiary treatment.

VI. Solid wastes.
   A. Types.
   B. Problems.
   C. Disposal/utilization.
      1. Landfill.
      2. Incineration.
      3. Recycling.

WATER TREATMENT

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 6 hours per week.

PRESENTATION

This course is designed to be taught in the final quarter of the second year of instruction, following the course entitled Power Plant Chemistry.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

This course provides the Environmental and Chemical Analysis Technician student with the various methods of treating water (to be used in power plants) to remove impurities. Problems caused by impurities, such as corrosion, scale and deposits are covered, as well as preventive actions.

COURSE OUTLINE

I. Industrial water problems.
   A. Boiler water problems.
   B. Steam and condensate problems.
   C. Cooling water problems.
   D. Preliminary treatment problems.
   E. General problems.

II. Wastewater problems.
   A. Health hazard.
   B. Odors.
   C. Toxic materials.

III. Methods of treating water.

   A. Filtration.
   B. Coagulation.
   C. Settling.
   D. Chlorination.
   E. Adsorption.
   F. Demineralization.
   G. Distillation.
   H. Softening.
   I. Anion exchange.
   J. Cation exchange.
   K. Neutralization.
   L. Aeration.
   M. Deaeration.
   N. Hot process removal.
   O. Baffle separation.
   P. Strainers.
   Q. Chemical treatment.

IV. Designing a treatment system.

   A. Analyses of water.
   B. Analyses of plant operating condition.
   C. Efficiency.
   D. Economics.

MODULE OUTLINES

To be developed.

INSTRUMENTAL ANALYSIS II

Recommended Course Design

STUDENT CONTACT HOURS

Lecture - 3 hours per week.
Laboratory - 6 hours per week.

PRESENTATION

This course is designed to be taught in the second year of instruction following the course entitled Instrumental Analysis I.

PRODUCTION

Instructional materials for this course will be produced in modular form or identified by Center for Occupational Research and Development (formerly TERC-SW).

COURSE DESCRIPTION

This course is a continuation of Instrumental Analysis I. The more sophisticated instruments used in environmental and chemical analysis are discussed.

MODULE TITLES

- Potentiometric Methods (IA-07).
- Electrodeposition and Coulometry (IA-08).
- Conductivity and Polarography (IA-09).
- Chromatographic Methods (IA-10).
- Radiochemical Methods (IA-11).
- Thermal Methods of Analysis (IA-12).

POTENTIOMETRIC METHODS (IA-07)

Module Outline

COURSE: Instrumental Analysis II.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

This module introduces the student to potentiometric methods of analysis.

PREREQUISITES

The student should have completed Instrumental Analysis I.

OBJECTIVES

Upon completion of this module the student should be able to:

- Compare and contrast the following types of electrodes:
  --Metal electrodes.
  --Membrane electrodes.
  --Glass electrodes.
- Discuss how a pH electrode works.
- Discuss the measurement of specific ion concentration.
- Describe the potentiometric titration procedure.

SUBJECT MATTER

I. Electromechanical cells.
   A. Cell components.
   B. Electrode potentials.
   C. Standard hydrogen electrode.
   D. Other reference electrodes.

II. Electrodes.

   A. Metal electrodes.

   B. Membrane electrodes.

   C. Glass electrode.

   D. pH.

   E. Specific ion.

III. pH measurement.

IV. Specific ion measurement.

V. Potentiometric titrations.

   A. Complex formation.

   B. Neutralization.

   C. Oxidation-reduction.

   D. Automatic.

ELECTRODEPOSITION AND COULOMETRY (IA-08)

Module Outline

COURSE: Instrumental Analysis II.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

This module describes the instrumentation and techniques for electrodeposition and coulometry.

PREREQUSITES

The student should have completed Instrumental Analysis I and the previous modules of this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define:
  --Constant current electrolysis.
  --Constant potential electrolysis.
  --Coulometry.
  --Electrodeposition.
- List applications for electrogravimetric analysis.
- Outline the procedure for coulometric titration.
- Compare and contrast the instrumentation used in electrogravimetric method and coulometry.

SUBJECT MATTER

I. Electrogravimetric methods.

A. Constant current electrolysis.

B. Constant potential electrolysis.

C. Other variables in electrogravimetric methods.

D. Instrumentation.

E. Applications.

II. Coulometry.

A. Constant potential.

B. Instrumentation.

C. Coulometric titrations.

1. Instrumentation.

2. Applications.

CONDUCTIVITY AND POLAROGRAPHY (IA-09)

Module Outline

COURSE: Instrumental Analysis II.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

This module discusses polarography, conductivity and amperometric titrations.

PREREQUISITES

The student should have completed Instrumental Analysis I and the previous modules in this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define electrolytic conductance and describe how it is measured.
- Perform conductometric and amperometric titrations.
- Discuss polarography and its applications.
- Interpret given polarographs indicating wave patterns on which you based your interpretation.

SUBJECT MATTER

I. Conductivity.
   A. Electrolytic conductance.
      1. Conductance.
      2. Specific conductance.
      3. Equivalent conductance.
   B. Measurement of conductance.
      1. Resistance bridges.

2. Conductance cells.

3. Applications.

C. Conductometric titrations.

II. Polarography.

A. Cells.

B. Instrumentation.

C. Interpretation of polarographic waves.

D. Applications.

1. Inorganic analysis.

2. Organic analysis.

E. Other polarographic methods.

III. Amperometric titrations.

A. Apparatus.

B. Applications.

CHROMATOGRAPHIC METHODS (IA-10)

Module Outline

COURSE: Instrumental Analysis II.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

This module discusses chromatographic methods with special emphasis on gas chromatography.

PREREQUISITES

The student should have completed Instrumental Analysis I and the previous modules of this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Outline the procedure and give application and limitations for each of the following:

  --Partition chromatography.

  --Adsorption chromatography.

  --Ion-exchange chromatography.

  --Paper chromatography.

  --Thin-layer chromatography.

  --Gas chromatography.

- Explain the theory behind a gas chromatograph.
- Analyze given samples using a gas chromatograph.
- Define electrophoresis.

SUBJECT MATTER

I. Fractionation processes.

II. Partition chromatography.

III. Adsorption chromatography.

IV. Ion-exchange chromatography.

V. Paper chromatography.

VI. Thin-layer chromatography.

VII. Electrophoresis.

VIII. Gas chromatography.

- A. Principles.
- B. Column efficiency.
- C. Carrier gas.
- D. Sample inlet system.
- E. Detectors.
- F. Applications.
  - 1. Qualitative.
  - 2. Quantitative.

RADIOCHEMICAL METHODS (IA-11)

Module Outline

COURSE: Instrumental Analysis II.
CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

This module discusses methods of radiochemical analysis.

PREREQUISITES

The student should have completed Instrumental Analysis I and the previous modules of this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Define:
  --Alpha particle.
  --Beta particle.
  --Gamma ray.
  --Half-life.
  --Radioactive decay.
  --Isotope.
- Distinguish between the three types of radioactivity detectors.
- Outline the procedure for neutron activation analysis.
- Explain how isotopic and radiometric analyses work.

SUBJECT MATTER

I. Radioactive decay.
   A. Particle properties.
   B. Units of radioactivity.
   C. Decay law.
II. Radiation detectors.
   A. Photographic.
   B. Ionization.
   C. Scintillation.
III. Neutron activation analysis.
   A. Destructive methods.
   B. Nondestructive methods.
   C. Applications.
IV. Isotopic dilution methods.
V. Radiometric methods.

THERMAL METHODS OF ANALYSIS (IA-12)

Module Outline

COURSE: Instrumental Analysis II.

CONTACT HOURS: Lecture - 5 hours.
Laboratory - 10 hours.

INTRODUCTION

This module discusses thermal methods of analyses.

PREREQUISITES

The student should have completed Instrumental Analysis I and the previous modules of this course.

OBJECTIVES

Upon completion of this module the student should be able to:

- Describe five methods of thermal analysis.
- Discuss combustion analysis including:
  --Procedure.
  --Theory.
  --Applications.
- Find the specific heat of a given sample using a bomb calorimeter.

SUBJECT MATTER

I. Melting point.
II. Pyrolysis.
III. Thermal stability testing.
IV. Calorimetry.
  A. Specific heat.
  B. Bomb calorimeter.

V. Differential thermal analysis.
VI. Differential scanning calorimeter.
VII. Thermogravimetric analysis.
VIII. Thermomechanical testing.