A NON-SITE-SPECIFIC TEST PLAN

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Abstract

An environmental assessment of a fuel conversion technology, such as Low-Btu Gasification, requires a test plan that addresses all areas of that technology. Such a plan can not be site-specific since it must be applicable to the many processes and varied operations within the technology. The plan must therefore be broad in scope. However, it must also be specific in content so that it will be applicable to the needs and problems of an actual test.

To meet this requirement, a non-site-specific test plan manual has been developed for use with low-Btu coal gasification. The manual provides basic information and procedural guidelines for the preparation and implementation of environmental assessment test plans. It defines four basic operations in test plan development. These are:

- *an engineering analysis,*
- *the definition of test purpose and test method,*
- *the selection of sampling methods, and*
- *the selection of analysis methods.*

Emphasis is placed on the development of the test method which involves defining the test's requirements and relating these requirements to the available information sources to formulate a practical test plan.

This presentation will provide a description of a non-site-specific test plan and will show how the plan can be used for a site-specific test.

INTRODUCTION

An environmental assessment of a fossil energy conversion facility should be based on valid data which accurately defines the emissions from the operation in terms of the mass and composition of the pollutants emitted. To be valid, the data used for the assessment must have been obtained under representative operating conditions by skilled technicians using reliable sampling and analytical procedures. When such data are not available in the technical literature, it must be obtained by means of an onsite test.

A program for an onsite test consists of four basic tasks involving:

- preparation,
- sampling,
- analyses, and
- data interpretation.

The preparation task is of major importance because without adequate preparation major oversites can occur which can impede the program, magnify costs, and contribute to questionable results. The preparation task should be done prior to initiating the sampling and analyses tasks.

The preparation task can be broken down into four subtasks as follows:

- defining the problem,
- reviewing the available process data,
- inspecting the plant, and
- preparing a site-specific test plan.

Major attention must be devoted to problem definition in order to avoid false starts and wasted effort.

A poorly defined problem can result in a test plan with inadequate methods, resulting in a site test that produces little useable data. Since sampling and analysis procedures are relatively problem specific they must be chosen to fit the application and to provide the level of accuracy that is required. Process data must be studied to gain an understanding of the process after which the concepts should be validated by a plant visit.

Because of the many different unit operations within a Low-Btu gasification and utilization process, the many types of processes for each operation and the many variations within any given process, a large number of site-specific test plans will be needed to assess the entire Low-Btu technology. In order to maintain a semblance of consistency in the test approach a philosophy and strategy for testing has been defined in a non-site-specific test manual. This document was developed to serve as a guide for the preparation of environmental assessment test plans for low- and medium-

Btu gasification plants. This manual does not provide the actual procedures required for a given test. It provides instead, background information and procedural guidelines which will serve as the foundation for the development and implementation of successful site-specific test plans.

This presentation will provide a description of a test plan which in this case is non-site-specific and will describe how the test plan manual is used in the preparation of a test plan for a specific site.

TEST PLAN PREPARATION

The preparation of a test plan involves operations in four areas of endeavor as follow:

- engineering analysis,
- definition of test purpose and test method,
- selection of sampling methods, and
- selection of analysis method.

The relationship between these four operations is illustrated diagramatically in Figure 1.

The engineering analysis is needed to provide information about the plant such as its physical layout and its process chemistry. This information must be reduced to a useable form. The engineering analysis includes three steps:

- review and simplify process flowsheets,
- define process modules, and
- identify streams of interest and their probable composition.

The test purpose defines the test objectives which may be any or all of the following:

- an environmental assessment,
- a control technology assessment,
- a material balance to determinetransport and fate of selected species, and
- a characterization of stream composition.

Although the purpose of the test is fixed by the information needs of a program, it has a profound effect on the detail of the test method which defines:

- the streams to be sampled,
- the species to be analyzed,
- sampling frequency,
- sampling duration,
- precision and accuracy during sampling, and
- process conditions during sampling.

The test method in turn establishes a basis for selecting methods for sampling and analysis, since the respective methods must meet the requirements set by the test method.

The sampling plan must address four major areas of activity as follows:

- preparation which includes:
  - equipment,
  - manning,
  - check-out, and
  - scheduling.
- sample collection requiring consideration of:
  - source type,
  - sample composition,
  - process conditions, and
  - information sought.
- sample preservation, and
- adaptation to deal with the unexpected.

The analysis plan must take into consideration the following:

- location - onsite or offsite analyses,
- type of samples,
- preseparations required,
- techniques of identification or quantification, and
- data validations and interpretation while on site.

The completed test plan however is not just a combination of an engineering analysis, a test method, a sampling plan, and an analysis plan. Although each of these areas of activity is distinct, they are interdependent as illustrated by the diagram in Figure 1. The decisions within each area are influenced by the test purpose and the test method which is in turn influenced by the limitations that are inherent within any or all of the involved areas.

Because of this interdependency between the respective areas, the respective plans should be prepared concurrently using corrective feedback such that the selections made for each area are made with full regard for the potential interaction with other areas. Since the scope of a site-specific test plan is defined by the test method, first attention should be devoted to its preparation. However, little can

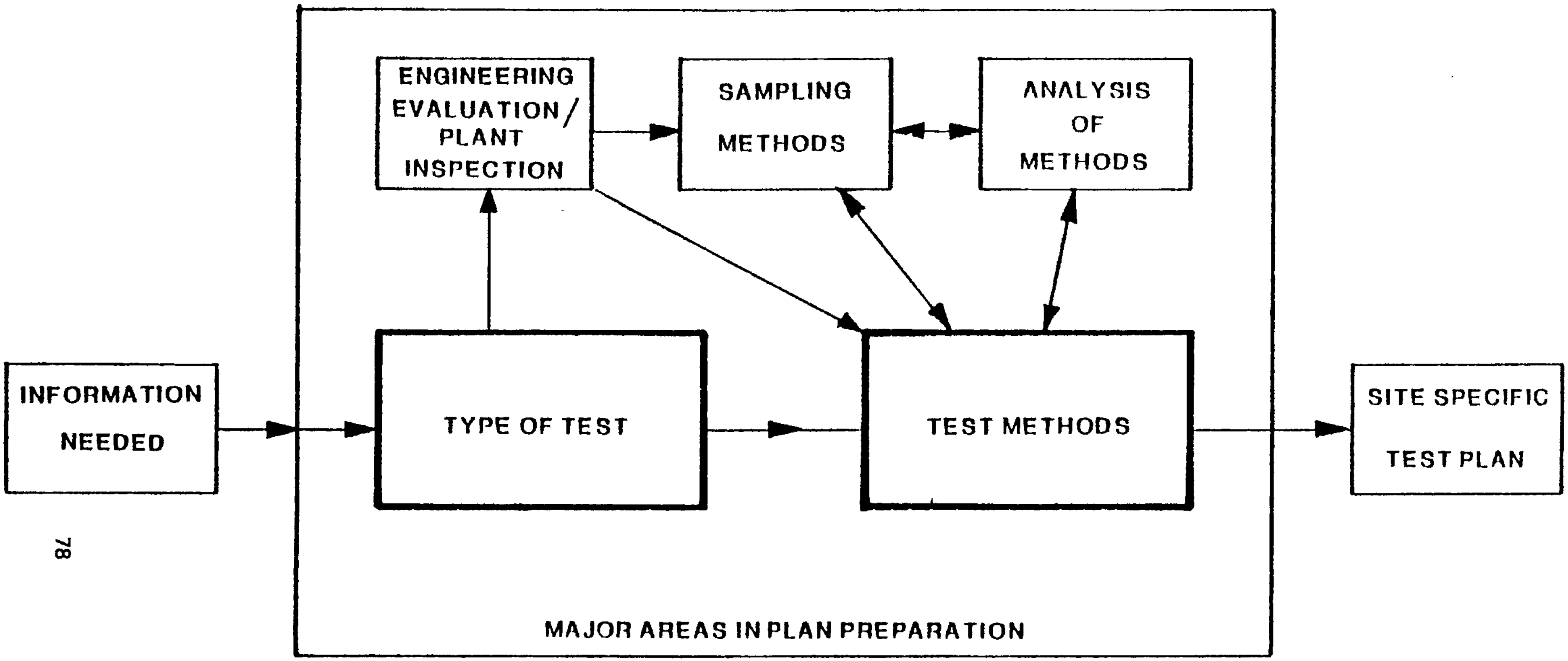

Figure 1. Information flow diagram for the preparation of a site-specific test plan showing the interdependency of the major areas of endeavor.

be done without adequate information about the site to be tested. This information can be gained from the engineering analysis of appropriate flow sheets in the technology file using the guidelines presented in the test plan manual.

ENGINEERING ANALYSES

The engineering analysis is begun with a review of process flow sheet. If flow sheets for the specific site are not available during the initial phase of test plan development, generic diagrams of similar processes can be used until they can be replaced by authenic ones from the test site or until the generic plans can be authenticated by a site visit. In this presentation a diagram from a Lurgi plant will be used to illustrate the steps in an engineering analysis. The plans shown in Figure 2 represent a Lurgi Low-Btu coal gasification plant. In the form shown the diagram is too cumbersome to be used effectively in preparing a test plan for an environmental assessment. It should be simplified. Simplification can be accomplished by dividing the complex integrated process into unit operations and modules, e.g.

- process operations:
  - coal pretreatment and handling,
  - coal gasification,
  - gas cleaning and purification, and
  - gas utilization.
- effluent control operations:
  - air pollution controls,
  - water pollution controls, and
  - solid waste controls.

The operation should then be subdivided into modules. For example, coal preparation can be divided into the following modules:

- drying,
- partial oxidation,
- crushing and sizing,
- pulverizing, and
- briquetting,

or the gas purification operation can be divided into:

- particulate removal,
- gas quenching, and
- acid gas removal.

Any emission control module that is associated with an operation can also be identified in this step. Detailed flow sheets for each operation of interest should be acquired in order to identify all influent and effluent streams as well as the types of emissions that are anticipated. The concept is illustrated by Figure 2. The area within the block in Figure 2 identifies the gas purification process that is expanded into a detailed flow sheet in Figure 3. The flow sheet is used to prepare a schematic diagram of the type shown in Figure 4 which identifies the types of emissions from each module. An analytical block diagram of the type shown in Figure 5 is then prepared for each module identifying each influent and effluent stream as either a process or an emission stream. (The analytical block diagram is a key tool in the engineering analyses because it provides the maximum amount of relevant information in the simplest form.) In this step the emission streams are identified and characterized as far as is possible using the data that are available.

DEFINITION OF THE TEST PURPOSE AND TEST METHOD

Test Purpose

The first and major step in the preparation of a test plan for an environmental assessment is to define the purpose of the test that may be required to obtain any or all of the following types of information about the site of interest:

- pollutant emission level,
- transport and fate of selected pollutants as they advance through the process,
- control response characteristics of operating units, and
- characterization of stream composition.

Specific requirements unique to each category, must be met by the test plan in order to obtain each type of information. (That is to say, a different type of test is needed to obtain each type of information.) For example, to determine pollutant levels one should first establish that pollutants are present. For this purpose, a comprehensive survey type of test is needed. (In such a test only minor emphasis need be placed on process conditions, sampling or analytical accuracy.) Then to obtain information on the transport and fate of a known pollutant, a more sophisticated test is needed.

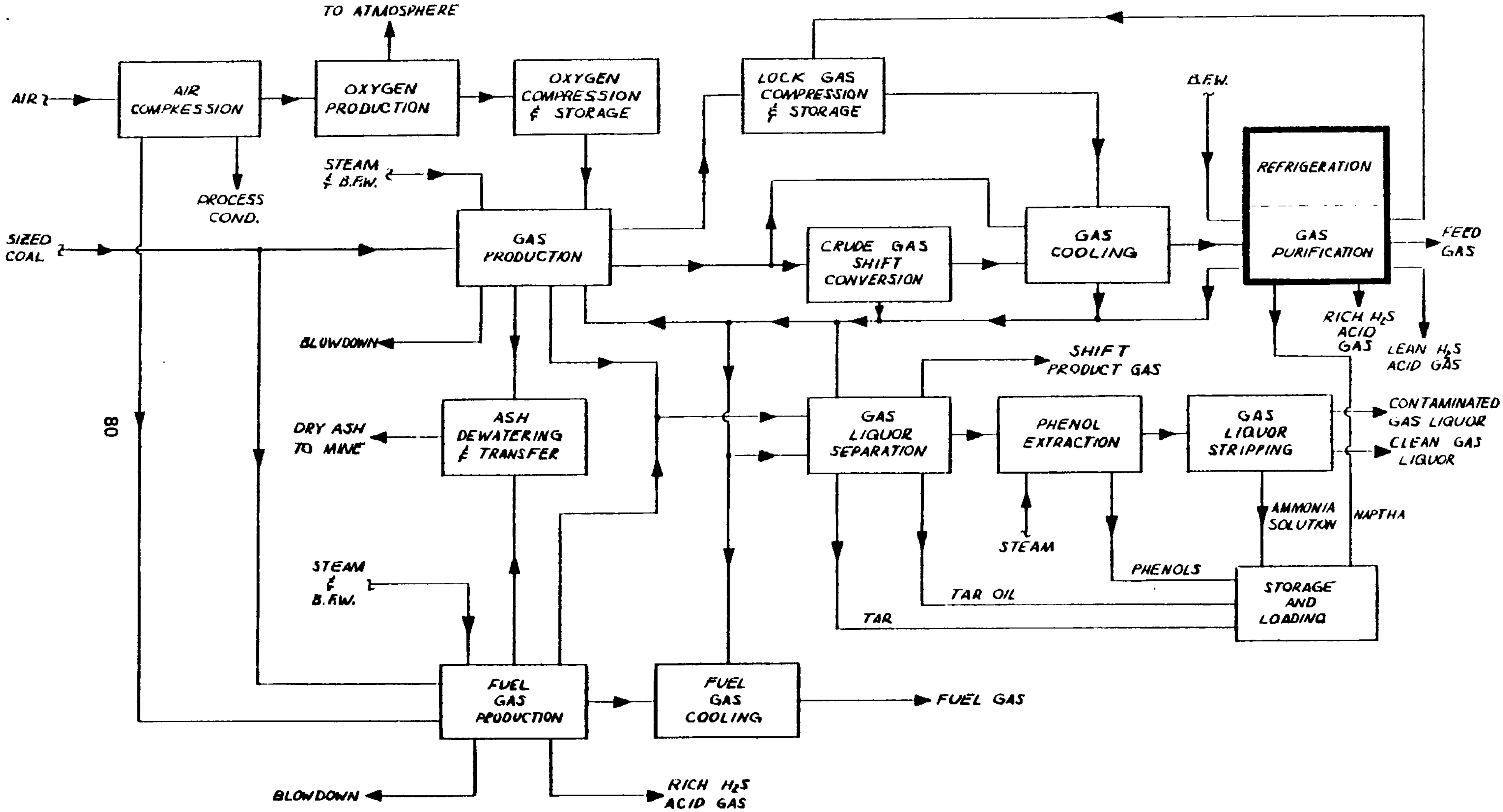

Figure 2. Flow diagram of a coal gasification plant.

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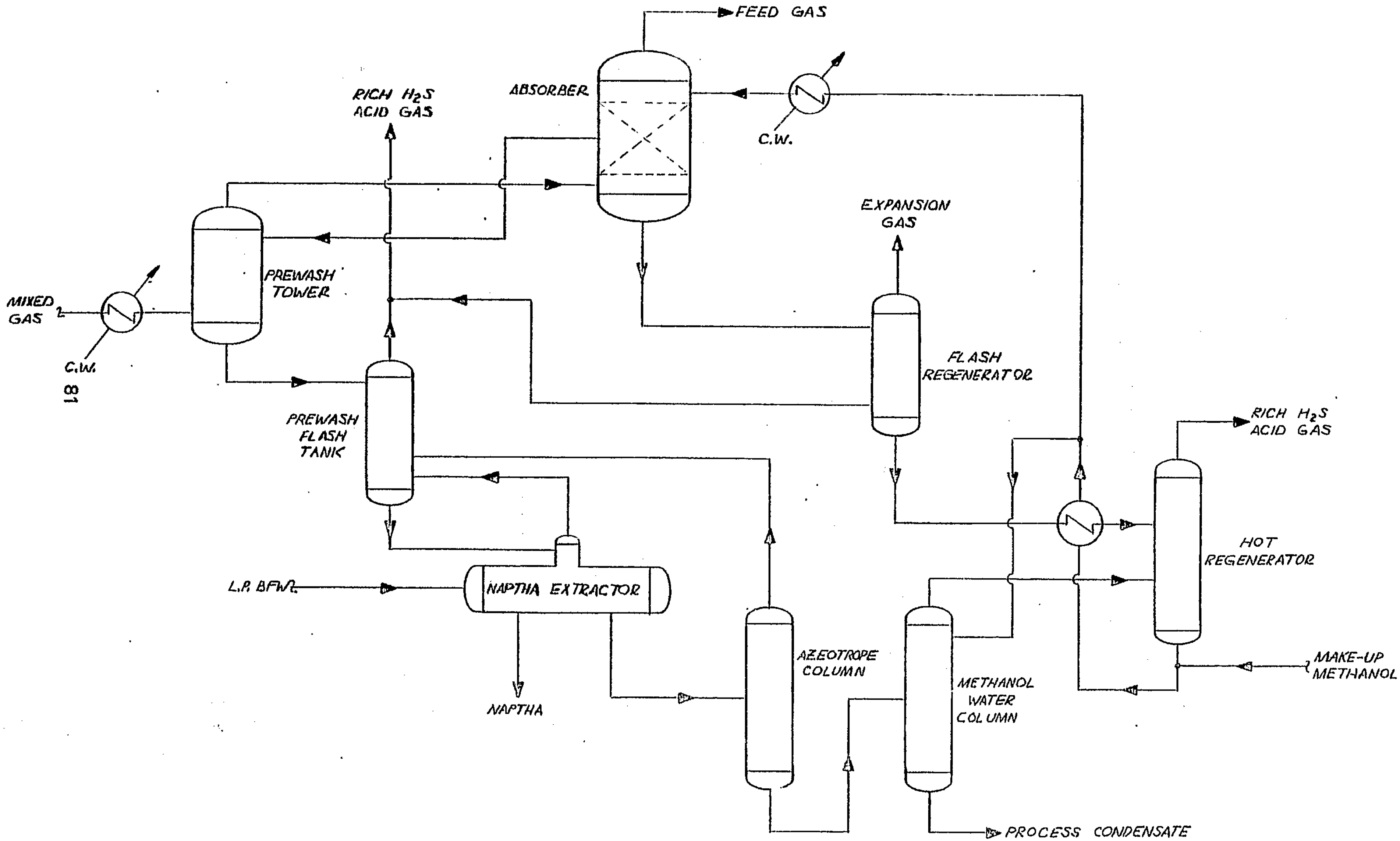

Figure 3. Gas purification and refrigeration.

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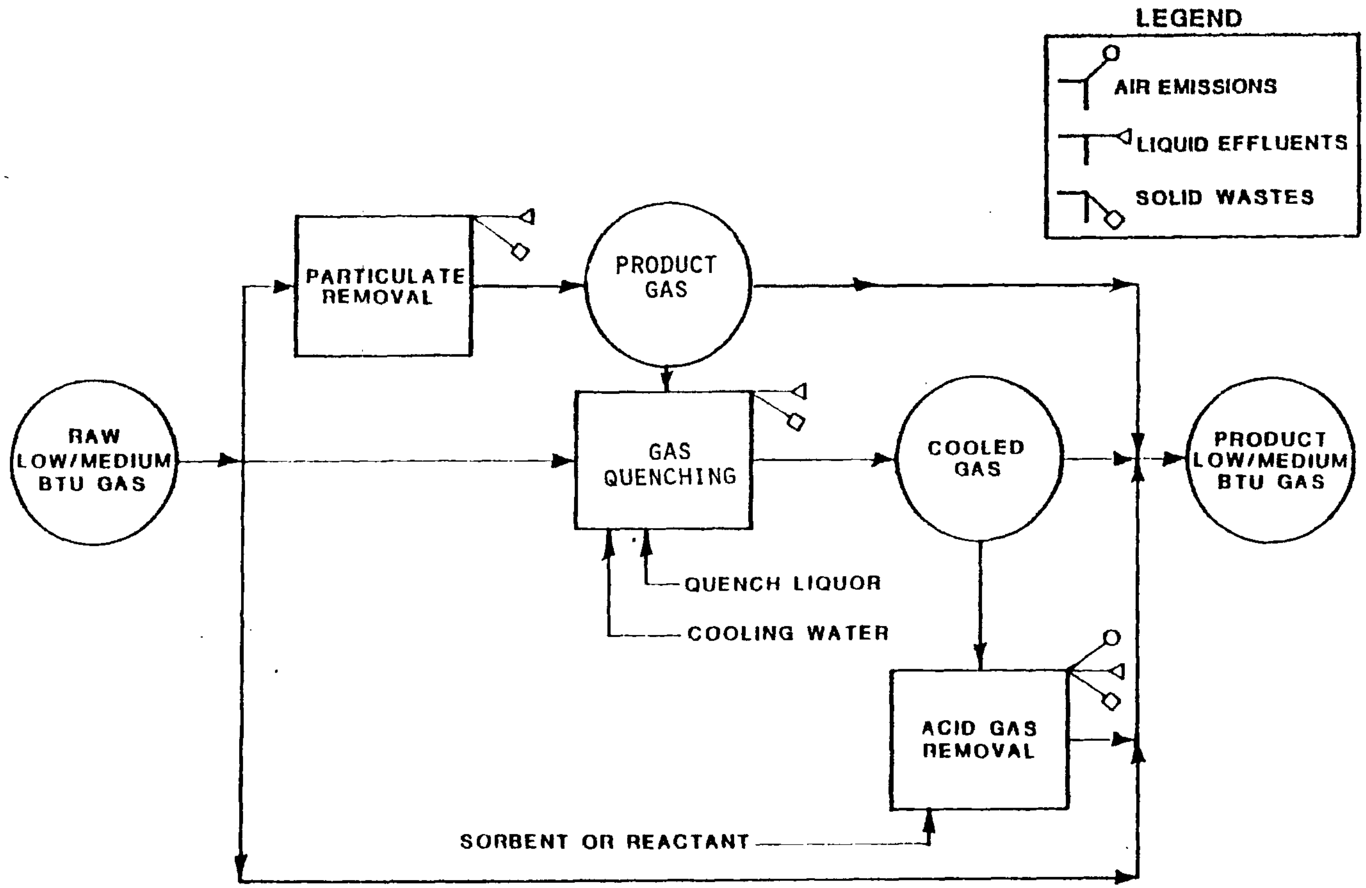

Figure 4. Flow diagram for the modules in the gas purification process.

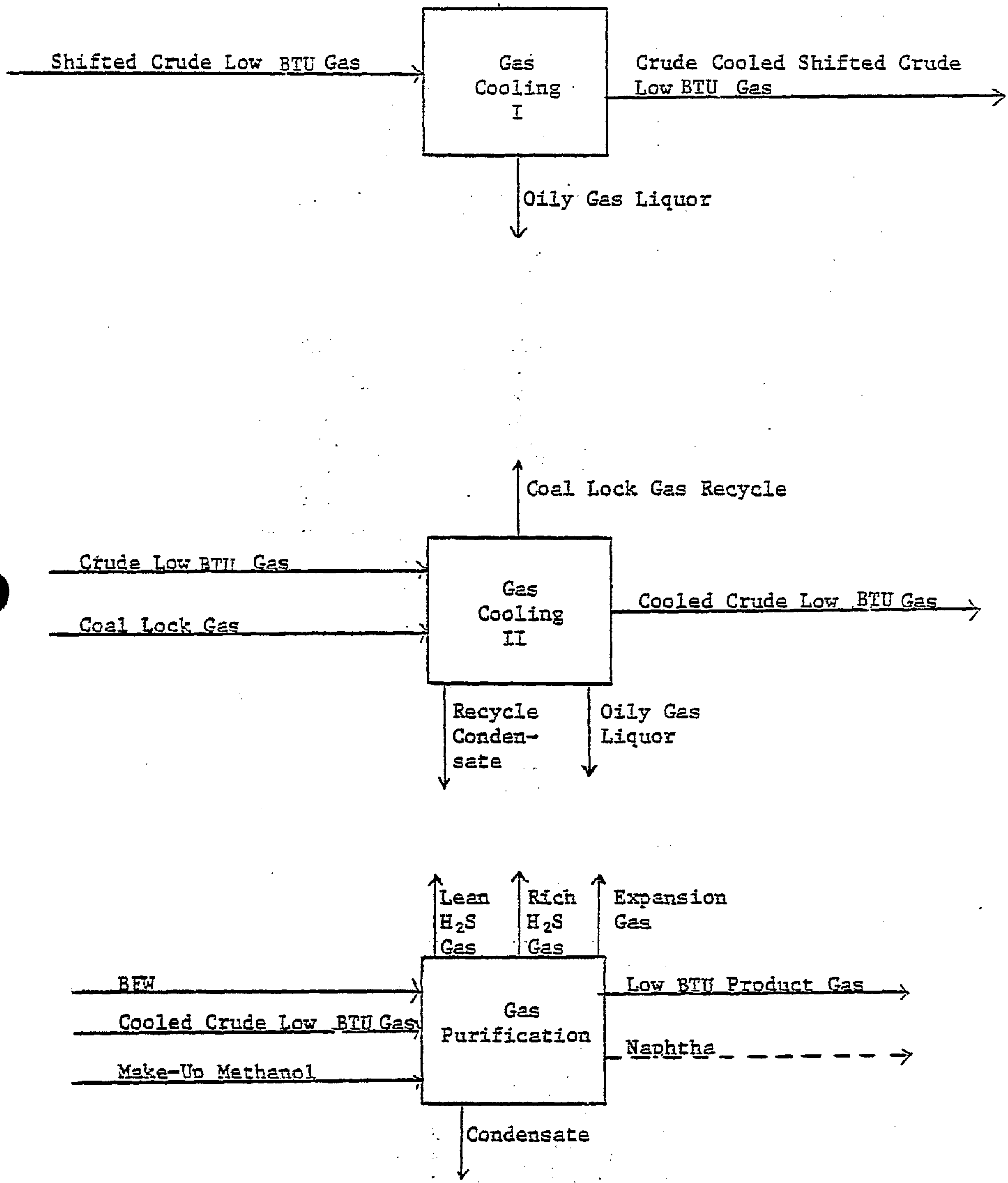

Figure 5. Analytical modules for the gas purification operation at the El Paso Burnham complex.

This test should be made at conditions that are as near to steadystate as is feasible. Samples should be composited in order to level out the effects of minor variations. Replicate samples should be taken to increase credibility and analyses methods of high accuracy should be used so that the material balance can be closed (i.e. input = output). In contrast to either of the above, a control response test can best be done with a continuous monitor or with high frequency sampling to identify process variations. When possible the process operating conditions should be varied around the control point in order to identify trends and establish the effects of the control variables on emissions. In many cases, analysis methods providing comparatively low accuracy can be used for this application. Indeed methods of low accuracy and only acceptable reproducibility, but with rapid response, are preferred to highly accurate methods which cannot be used continuously or in real time. While an attempted material balance focuses on a fixed point in time (just as a balance sheet in a business operation), the control response test is carried out over an extended period of time and focuses on the relationship between control variables and emission response.

These concepts are illustrated diagramically in Figure 6. The concept of the control function and the balance are illustrated in Figure 6C and 6B respectively. The diagram in Figure 6A illustrates the emission level test in which attention is focused on the magnitude and type of emission without an intrinsic need for the information on the composition of either the feedstock or product. As a practical matter however, feedstock and product analyses are often included in a test program because most test programs are designed to serve a broad purpose and thereby obtain more than one type of information. Each of the various types of information is considered separately here in order to focus attention on the test's requirements which establishes its identity. Although tests for each type of information can be done separately, in practice they may be done concurrently with varying degrees of overlap. When they are integrated into a single program, care must be taken to satisfy the test requirements for each type of information sought lest the results be invalid.

Test Method

The test method defines the criteria for the test. These criteria must be met in order to obtain valid data from each of the respective information areas specified by the test's purpose. The test criteria include:

- level of accuracy and reproducibility,
- process operating conditions,
- process data requirements,
- stream selection,
- sampling frequency and duration, and
- analysis parameters.

Although the test purpose is intrinsically related to an environmental or a control technology assessment the data requirement and therefore the test criteria will vary with the data needs.

THE PHASED APPROACH OF ENVIRONMENTAL TESTING

The objective of an environmental test is to assess the pollution potential of a source. A comprehensive multimedia environmental assessment requires a comprehensive and potentially costly test program. It requires highly accurate test methods capable of characterizing a wide range of samples for a potentially broad spectrum of species from a wide variety of sources. As a means of approaching the problem in a cost effective manner, the Environmental Protection Agency has established a phased approach to environmental assessment testing which enables the tester to locate the problem area before expending costly effort to characterize it. The approach utilizes three levels of testing which are characterized as follows:

Level I: Identify problem areas using survey methods of moderate accuracy.

Level II: Characterize problem areas by identifying and accurately quantifying hazardous species in order to assess environmental burden.

Level III: Monitor selected indicator compounds to facilitate the establishment of a control technology.

This phased approach is intended to avoid the costly pitfall in an environmental assess-

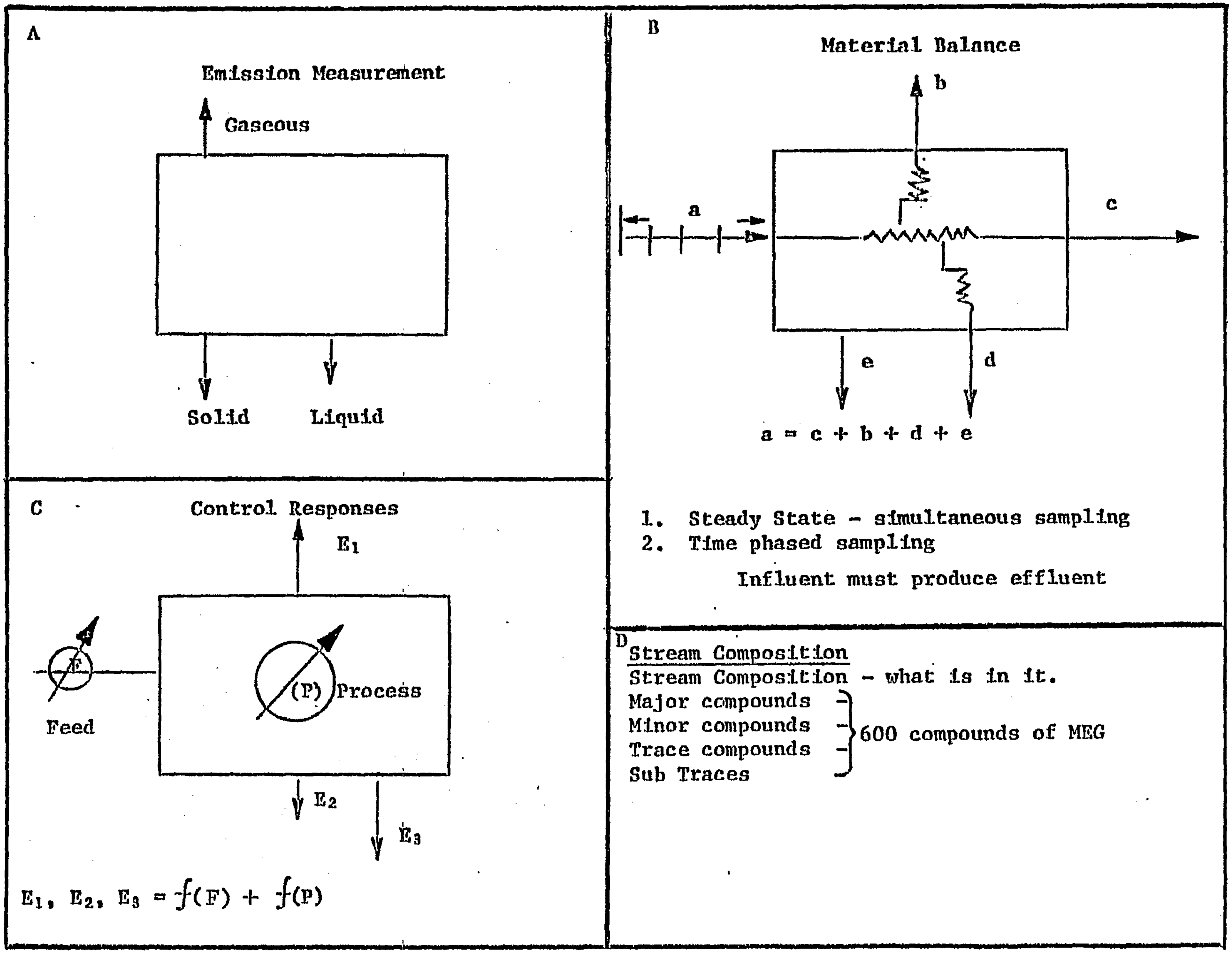

Figure 6. Diagramatic illustration of the four types of information identifying the test's purpose.

ment test program, e. g.

- wasted effort on pollutant free emission streams or sought after pollutants that were not present,
- missed pollutants because of oversights in test planning and preparation.

The following text provides a discussion of the interrelationship between the EPA phased approach and the Non-Site-Specific Test Plan.- The Non-Site-Specific Test Plan utilizes the phased approach and uses the criteria defined by the Procedures Manual (L8501) for a Level I assessment as the basis for the initial phase. The criteria for the second and third phases of the EPA approach are at present undefined. The Non-Site-Specific Test Plan therefore provides guidelines that are based on established test procedures such that when a data need is defined and the streams of interest identified, the test specifications can be set and the respective sampling and analyses procedures chosen.

The EPA Level III test has characteristics in common with the control technology test as defined by the Non-Site-Specific Test Plan. Test methods for a control technology assessment are needed to determine the effectiveness of an emission control module.* Such a test is problem specific as well as site-specific. The Non-Site-Specific Test Plan provides a means of defining test parameters. In addition to the criteria listed previously, attention must be directed to the following factors:

- cause-effect relationships,
- process purterbations — controlled vs uncontrolled variations,
- process response time,
- interactions — dependent vs independent variables,
- process hysteresis,
- process design limitations,
- analysis response time, and
- prioritization of control variables.

The material balance is also a valuable tool for a control technology assessment since the fate of a pollutant is an integral concern with a pollution control module. At the present time use of the material balance is limited to strategic elements such as sulfur, nitrogen, and phosphorous as well as the more toxic so-called trace elements*.

Relationship Between Approaches

The three levels of the phased approach can be harmonized with the four types of information that characterize the test purpose. The relationship is shown in Table 1.

A question mark has been placed under stream composition because it is not clear whether this type of analysis will fit into the EPA strategy. An analysis of this type is highly problem specific. It can vary from a need to identify a multitude of species in a complex mixture to the need to seek out a trace of an objectionable component that interferes with the performance of an emission control module. Stream characterization can be a costly task and should be done with discretion.

Test Method Preparation

The first step in the actual preparation of the test method is to utilize the data from the engineering analysis which should enable the planner to:

- anticipate pollutants,
- identify potential fugitive emission sources,
- predict the effects of operating conditions on the flow rates and the composition of relevant streams, and
- determine if the data available is adequate to proceed to a more advanced test phase, e.g. Level II or III.

Based on the results from the engineering analysis the planner progresses with the development of the test method by defining the criteria for the test. He must bear in mind the potential restrictions that may be imposed by the sampling and analytical methods as well as by the emission source itself.

SAMPLING METHODS

Following the definition of the criteria for the test, the next major step is to develop a detailed sampling plan for the site that is to be tested.

*Consideration should also be given to the use of the process as a control module. See Figure 6C. Indeed a strategic control variable can exert a profound effect on the emission rate of a pollutant from a process. Several processes used in Low-Btu technology are subject to such a relationship.

TABLE 1

RELATIONSHIP BETWEEN THE TYPE OF INFORMATION SOUGHT AND THE TEST LEVEL

Type of Information	Level 1	2	3
Pollutant level	X	X	-
Fate of pollutant	-	X	-
Control response	-	-	X
Stream composition	-	?	-

The task involves specifying the locations of sampling points and selecting sampling methods. It should also include processes for sample handling.

Some considerations for sample port locations are:

- accuracy level defined by the test method,
- locations of existing ports, valves, and monitors,
- sampling practice in the test site,
- stream characteristics,
- effect of sampling on process operation, and
- safety and work area requirements.

Some considerations for sampling methods are:

- criteria defined by the test method,
- sample source,
- sample type,
- sampling techniques,
- analyses parameters, and
- external limitations.

These considerations may be expanded as follows:

- criteria defined by the test method
  - level of accuracy required,
- sample source
  - type of stream - process stream, regular or fugitive omission,
  - composition of stream,
  - temperature,
  - pressure,
  - flow,
  - type of vehicle - pipe, duct, tank, or sluice,
  - location - accessability,
  - type of port,
    valve port,
    hatch,
    blind flange,
    gas duct,
    conveyor,
    outflow pipe or wier,
    open pit, sump, or pond.
- sample type
  - gas, liquid, solid or a mixture e.g.
    - gas and vapor,
    - gas and particulate,
    - liquid and solid (slurry),
  - regular or fugitive emissions.
- sampling techniques to get a representative sample
  - grab,
  - grab and composite,
  - impinger,
  - continuous monitor.
- analytical parameters
  - collection via fixation,
  - preservation - storage and transport,
  - free from contamination,
  - optimization for the analysis.
- other limitations
  - time,
  - manpower,
  - cost,
  - equipment,
  - safety,
  - plant regulations.

Provision must also be made to obtain relevant sampling data which should include the following:

- stream data
  - flow rate,
  - port location,
  - stream temperature.
- stream pressure
  - date and time of collection,
  - quantity of sample,
  - sampling method,
  - sampling handling and technique utilized for preparation,
  - sample preservation (if any).

ANALYSIS METHODS SELECTION

The final step in the preparation of the test plan is the selection of methods for the analyses. Several factors must be considered during the selection process e.g.

- the criteria fixed by the test method
  - level of accuracy,
  - species of interest,
  - type of assessment - (Level 1, 2, or 3).
- the concentration level of the species of interest,
- the presence of interfering species,
- the sampling method,
- time limitations,
- Equipment limitations, and
- cost factors.

If a Level 1 assessment is being made, the methods of analyses are specified by the Level 1 Environmental Assessment Manual (L8501). The diagram in Figure 7 outlines the approach of the Level 1 method. The diagrams in Figures 8 and 9 outline the respective approaches to inorganic and the organic analyses. These methods are still in a state of evaluation and are subject to modification. The methods for Level 2 analyses have not yet been specified. However, as greater specificity and accuracy is required, methods must be selected that are capable of meeting the higher requirements. In place of spark source mass spectrometry, which is an ideal survey tool for trace elements, a combination of techniques may be required. The diagram in Figure 10 shows an approach that can be used to determine 31 different elements on samples such as those obtained from a Low-Btu gasification process.

The approach to the determination of individual species of organic compounds is even more complex than that for inorganic species. A worthy objective is to preseparate the samples into acidic, basic, and neutral fractions for subsequent analyses of "volatile and semivolatile" species by GC-MS. This approach provides access to the extensive computerized data banks that are commercially available. Nonvolatile substances of interest can be further characterized by auxilliary techniques. Following separation by High Performance Liquid Chromatography, fractions can be characterized by IR, FTIR, NMR, and UV and fluorescence spectrometry or such other techniques as are justified.

This approach, outlined in Figures 11 and 12, is completely modular and separates the sample into 9 fractions, seven of which (with the exception of macromolecules) can be characterized to a large extent by GC-MS.

Whether the approach be to characterize a sample in order to determine "what it contains" or to analyze it for specified environmentally hazardous species, the modular scheme provides a most versatile approach that can be adapted to a wide range of conditions.

SUMMARY

The Non-site-specific Test Plan provides a systematic approach to environmental test preparation. This approach makes it possible to anticipate many of the problems that would be encountered at a test site. It also makes it possible to give prior considerations to the potential solutions to these problems. A manual has been developed that provides guidelines for these considerations.

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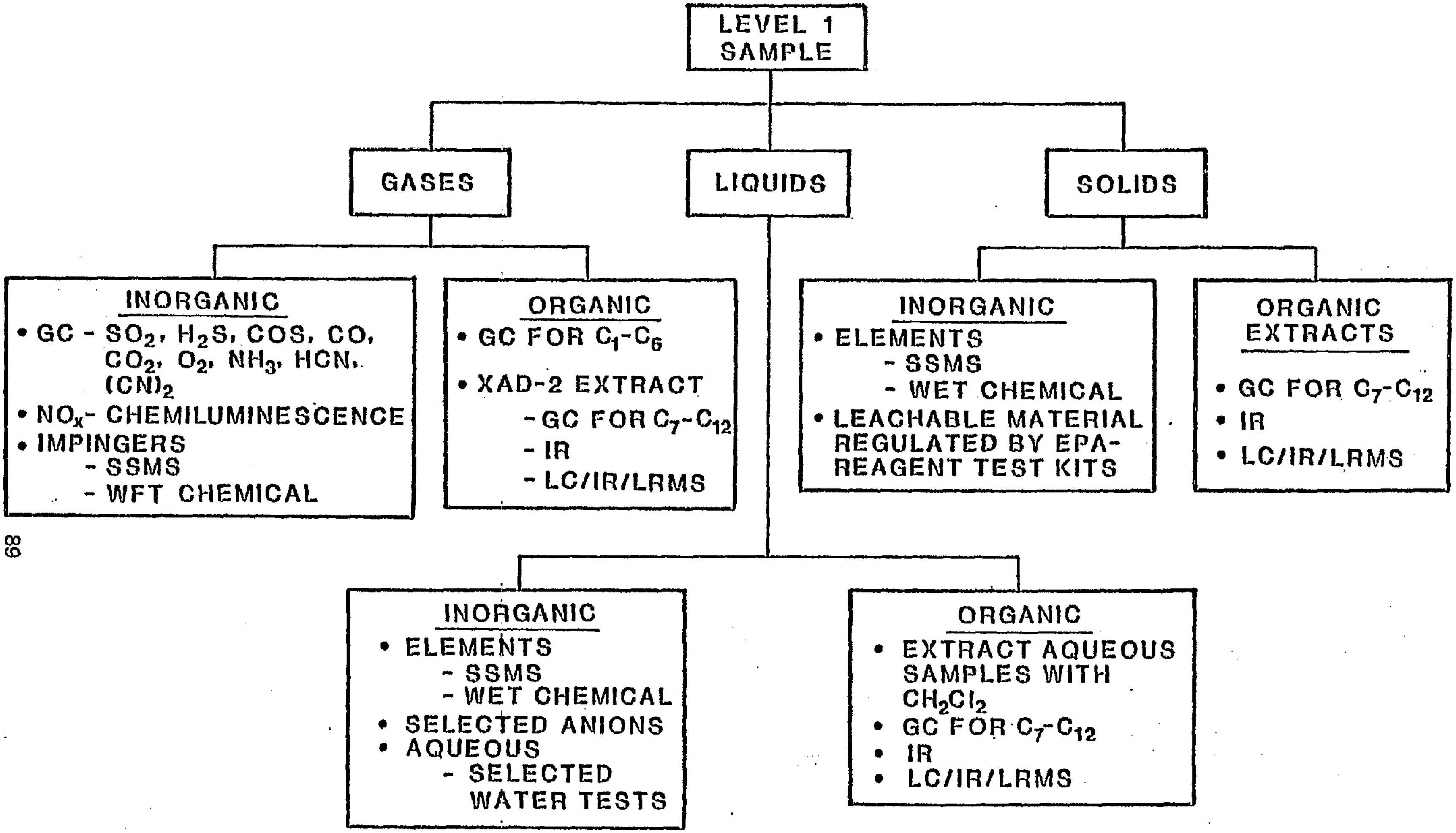

Figure 7. Outline of Level 1 analysis.

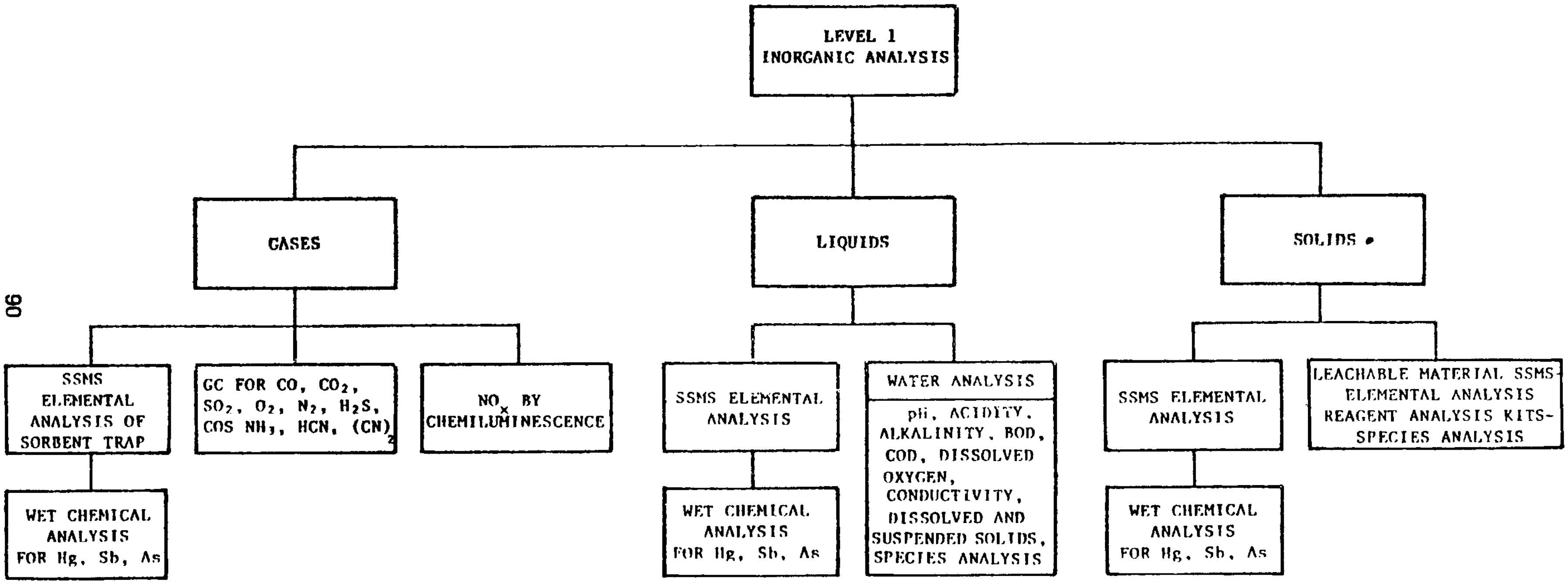

Figure 8. Outline of Level 1 inorganic analysis.

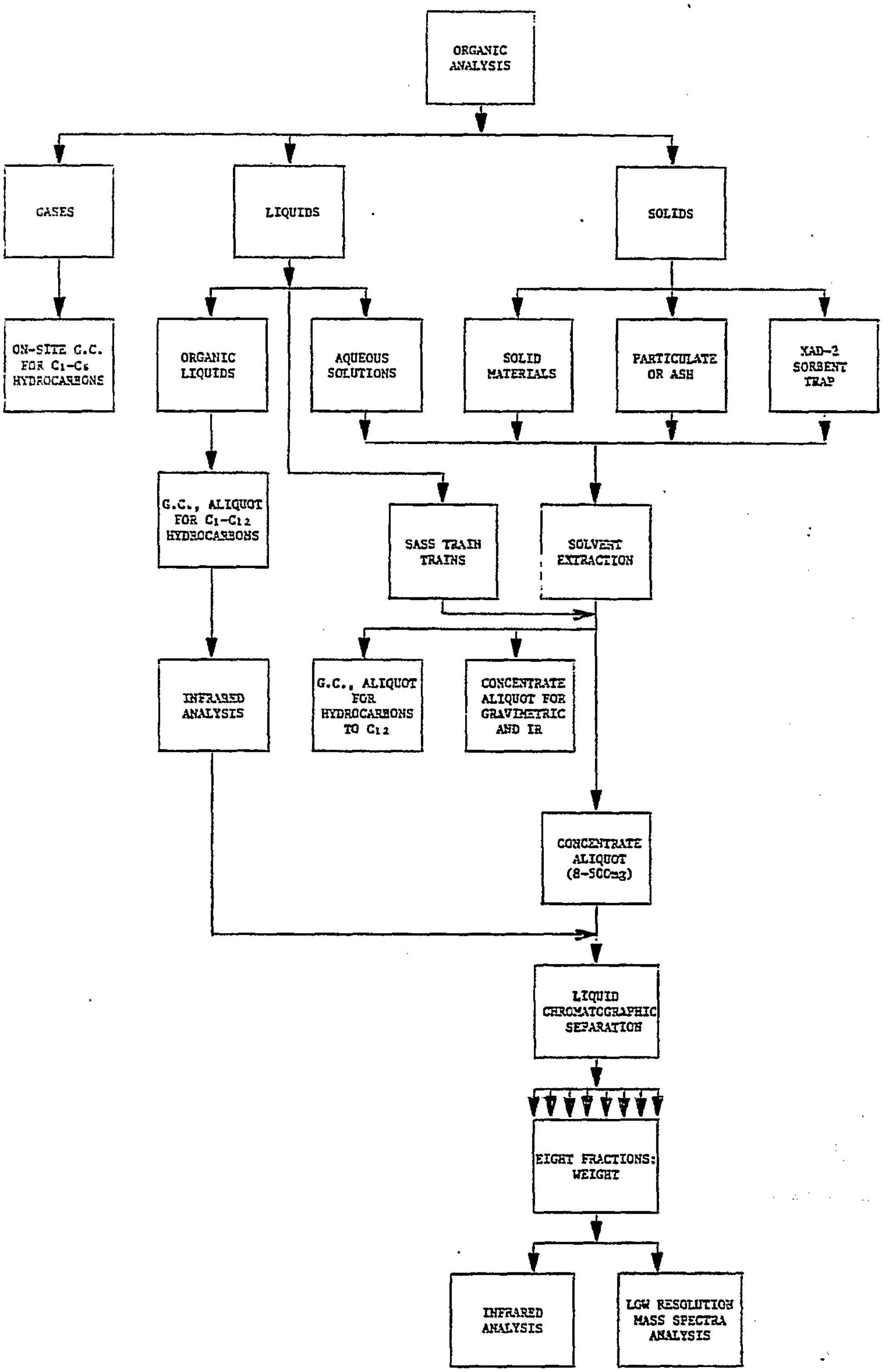

Figure 9. Outline of level 1 organic analyses.

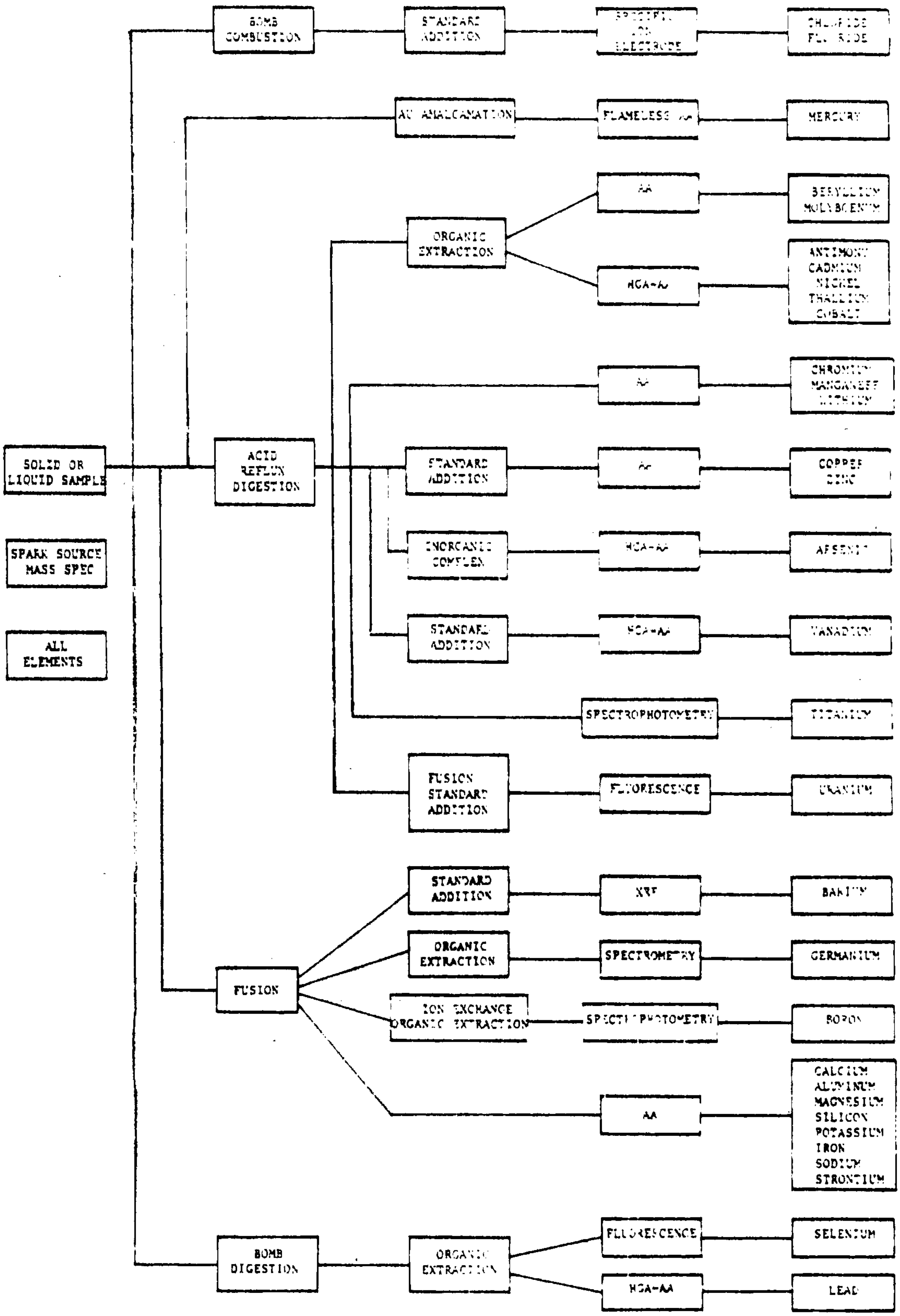

Figure 10. Analysis of inorganic elements.

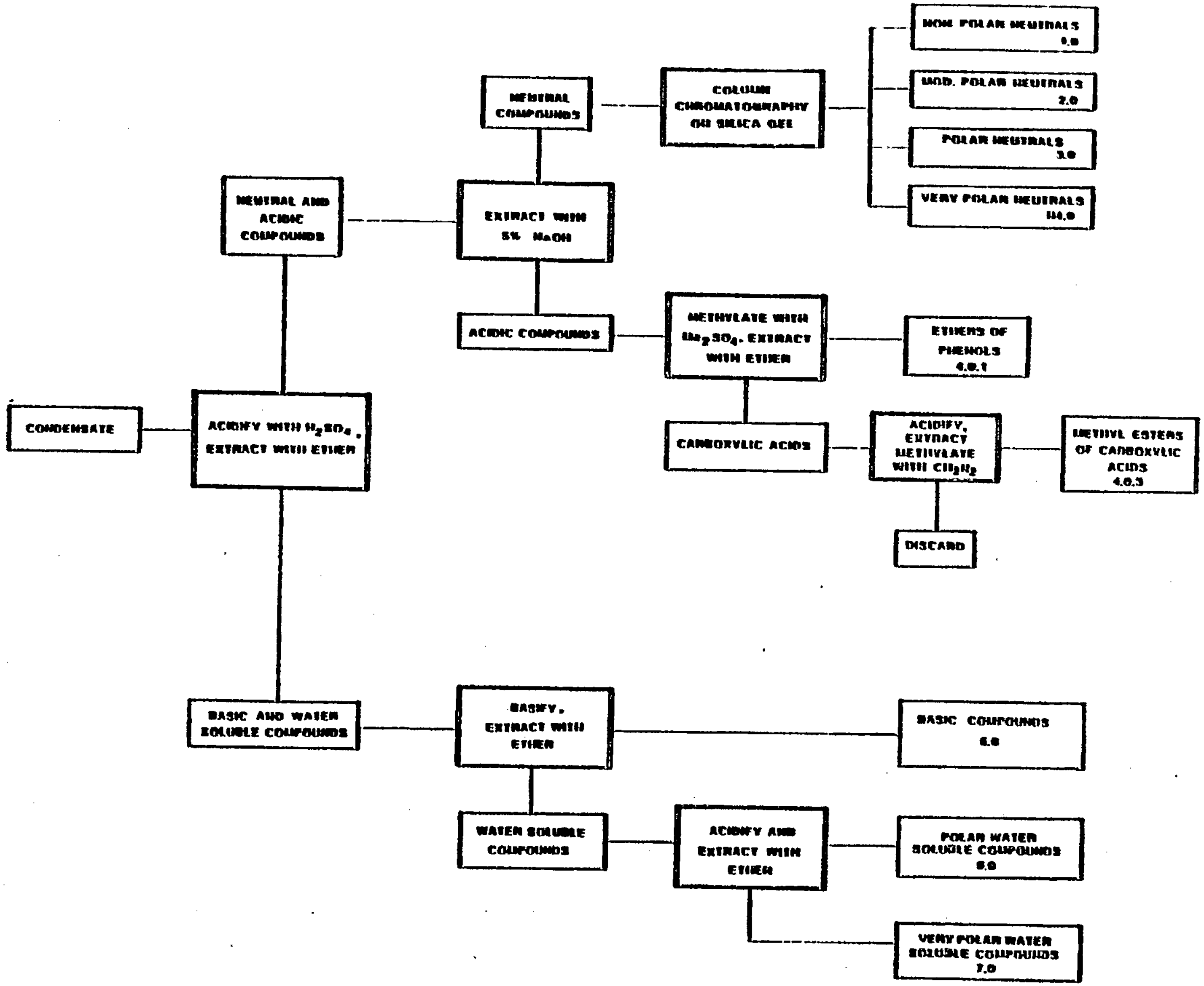

Figure 11. Separation of trace organic species.

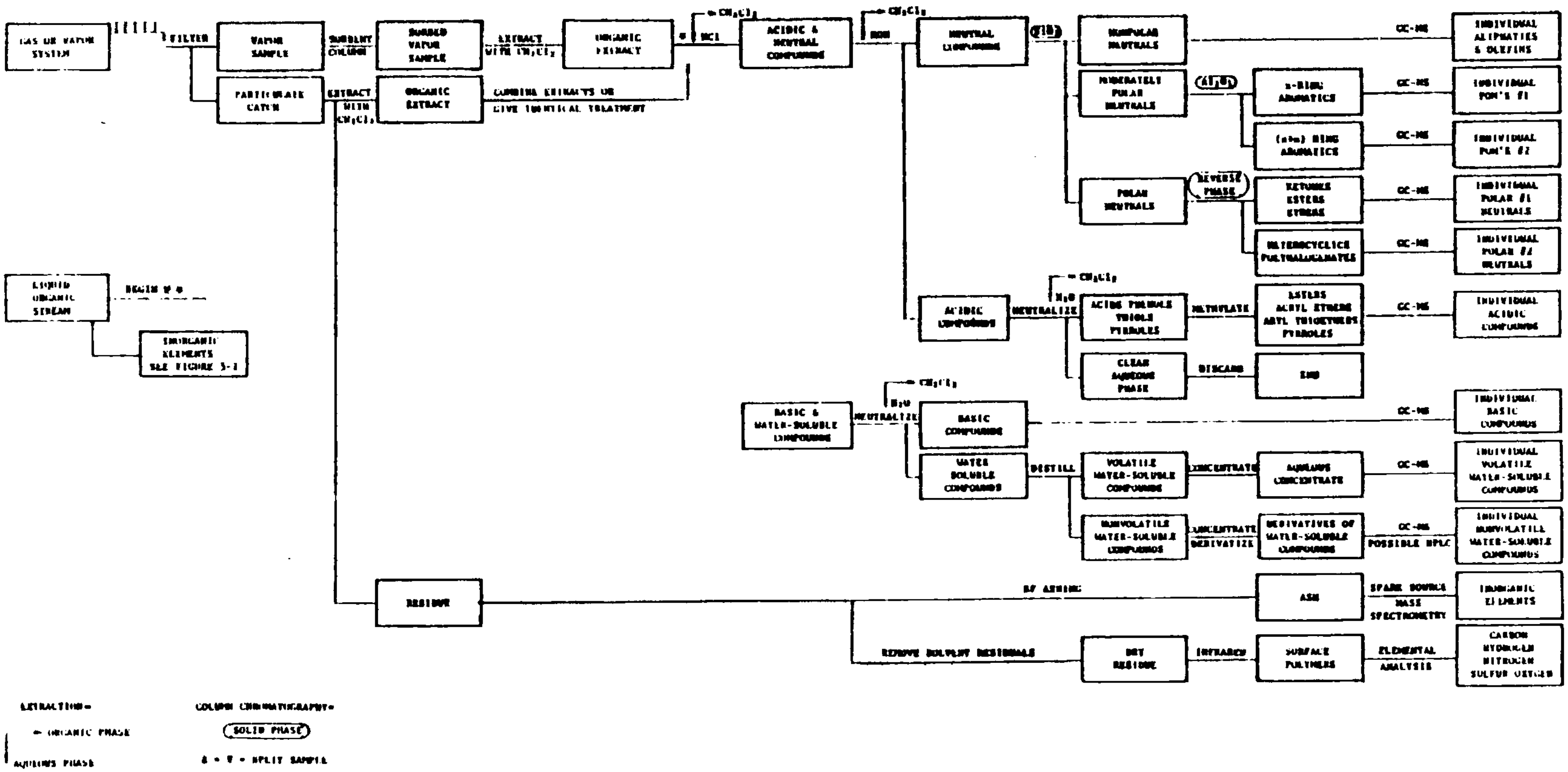

Figure 12. Separation and analysis of trace organic species.