STANDARDS SUPPORT PLAN FOR ENVIRONMENTAL ASSESSMENT OF CONVERSION OF BIOMASS TO ENERGY GASOHOL

W. C. Kuby, N. L. Concion, G. R. Offen, R. D. Shelton

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February 1980

Prepared for
R. E. Mournighan — Technical Project Monitor

Environmental Protection Agency
Industrial Environmental Research Laboratory
5555 Ridge Avenue
Cincinnati, Ohio 45268

Contract 68-03-2567

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DISCLAIMER

ABSTRACT

Fuels containing non-petroleum-based alcohols, such as gasohol, can provide one effective approach for limiting the increasing dependence by the United states on foreign oil. Currently, ethanol is the only commercially available alternate fuel and will remain the only one available in significant quantities prior to 1985. The Environmental Protection Agency (EPA) is the Federal organization with primary responsibility for controlling adverse environmental effects of pollutant emissions. This Standards Support Plan (SSP) shows how EPA's Office of Research and Development (ORD) plans to support the media Program Offices and the Regional Offices in setting standards for the emission effluents from fuel-grade alcohol production facilities. Since it is anticipated that ethanol will be the only alcohol produced in significant quantities until 1985, this SSP is limited to ethanol production.

There are several aspects to the environmental impact of gasohol production and use, namely the production of the feedstock; transportation; transfer, storage, and blending of the alcohol with gasoline; and end-use combustion in mobile sources. This study by ORD's Industrial Environmental Research Laboratory at Cincinnati, Ohio (IERL-Ci) is limited to fuel-grade alochol production, from feedstock preparation to the generation of 200-proof alcohol. Other aspects need to be reviewed by other cognizant ORD laboratories.

In this SSP, a detailed plan pertaining to the fuel-grade alcohol industry is developed for activities over the next 2 years. This report also projects a continuing activity resulting from the monitoring of growth and development of other alcohol production technologies. Thus, this SSP is a practical working document. It presents the Agency's program for determination of the emissions from gasohol facilities and the approach necessary to define these emissions. The studies planned are to be done concurrently and in coordination with a schedule put forth by the Program Offices for determining the appropriateness of standards and for setting those standards required; as such it represents a consensus plan between the ORD study and each of the Program Offices.

Region VII personnel have also participated in formulating the plan. The programs developed in cooperation with Region VII will serve as a model for the other regions and will be adapted where there is an interest and a need.

CONTENTS

SECTION 1

INTRODUCTION

Fuels containing nonpetroleum-based alcohols can provide one effective approach for limiting the increasing dependence by the United States on foreign oil. Gasohol, a blend of 10 percent ethanol produced from agricultural and waste feedstocks and 90 percent unleaded gasoline, is the most promising, near-term application of alcohol fuels. Currently, ethanol is the only commercially available alternate fuel and will remain the only one available in significant quantities prior to 1985. Production of ethanol fuel through 1985 will be limited by the capacity to convert agricultural and waste materials to ethanol, rather than by the availability of feedstock. Although alcohol fuels are not expected to totally eliminate our nation's dependency on foreign oil sources, they could become an important part of the national plan to stabilize our energy balance.

The Environmental Protection Agency (EPA) is the Federal organization with primary responsibility for controlling adverse environmental effects of pollutant emissions. This Standards Support Plan (SSP) shows how EPA's Office of Research and Development (ORD) plans to support the media Program Offices and the Regional Offices in setting standards for the emission effluents from fuel-grade alcohol production facilities. Since it is anticipated that ethanol will be the only alcohol produced in significant quantities until 1985, this SSP is limited to ethanol production.

There are several aspects to the environmental impact of gasohol production and use, namely the production of the feedstock; transportation; transfer, storage, and blending of the alcohol with gasoline; and end-use combustion in mobile sources. Although there could be significant environmental problems in each of these areas, this study by ORD's Industrial Environmental Research Laboratory at Cincinnati, Ohio (IERL-Ci) is limited to fuel-grade alcohol production, from feedstock preparation to the generation of 200-proof alcohol. Other emissions, including end-use emissions, need to be reviewed by the ORD laboratories with direct responsibilities in these areas of concern.

In this SSP, a detailed plan pertaining to the fuel-grade alcohol industry is developed for activities over the next 2 years. This report also projects a continuing activity resulting from the monitoring of growth and development of other alcohol production technologies. The purpose and content of this SSP are as follows:

- To explain the Agency's standards development and supporting R&D program, with special emphasis on sampling and analysis for emission/effluent and treatability/control data at fuel-grade ethanol plants
- To show how the ORD/IERL-Ci component of this program is integrated with the efforts being conducted by the media Program Offices, namely, the Office of Air Quality Planning and Standards (OAQPS), the Office of Solid Wastes (OSW), and the Office of Water Planning and Standards (OWPS)
- To relate the overall data collection program to the media offices' timelines for setting standards and the Regional Offices' requirements for permitting new sources
- To establish the various agency activities and the responsibilities for each of those activities in terms of the overall plan and timeline for occurance of various elements of the studies
- To present other information to allow the reader to gain a knowledgeable perspective on the industry being studied and the methodology of setting standards

Thus, this SSP is a practical working document. It presents the Agency's program for determination of the emissions from gasohol facilities and the approach necessary to define these emissions. In terms of a sampling and analysis program, it details the test plan, including the sites, number of samples to be collected, pollutants to be sampled, and analyses to be performed. The results of this sampling and analysis program, as well as other studies that will be done concurrently, are coordinated with a schedule put forth by the Program Offices for determining the appropriateness of standards and for setting those standards required.

To facilitate the generation of a consensus plan leading to a coordinated effort between the ORD study and each of the Program Offices as they move toward the development of standards, a series of meetings were held between IERL-Ci personnel and staff members from the Effluent Guidelines Division (EGD) of OWPS, the Emission Standards and Engineering Division (ESED) of OAQPS, and the Hazardous and Industrial Waste Division (HIWD) of OSW. Since the major impetus for the interest in fuel-grade alcohol production came from an increase in permit requests in Region VII for on-farm facilities, Region VII personnel have also participated in formulating the plan. The programs developed in cooperation with Region VII will serve as a model for the other regions and will be adapted where there is an interest and a need.

SECTION 2

ALCOHOL FUELS PRODUCTION

The following section is a technical description of the commercial and on-farm processes used for alcohol fuels production. The major emphasis is on ethanol production by biological conversion of various feedstocks. However, two other alcohol fuel production technologies, namely the production of methanol from synthesis gases (carbon monoxide and hydrogen) and butanol via biological conversion, are included. The discussion for each technology provides specific examples of the air emissions and liquid and solid effluents, pollution control systems, disposal of wastes from air, liquid and solid streams, and new technologies for alcohol production facilities. In each instance, the description will focus on current practices used in operating facilities. A salient goal of the EPA Gasohol Program is, however, to develop in-plant strategies that minimize potential environmental concerns and, therefore, minimize the need for sophisticated and expensive control systems.

The first portion of the discussion describes both commercial-scale and on-farm ethanol production technologies via biological conversion of feedstocks. Three specific feedstocks were chosen because they are typical of currently used or anticipated feedstocks for ethanol production and are representative of the types used in the production facilities to be studied in the sampling and analysis portion of this plan. These are:

- Corn, a starch
- Corn stover, a cellulose
- Cheese whey, a sugar

The methanol and butanol production processes are included as technologies of the future.

2.1 COMMERCIAL-SCALE ETHANOL PRODUCTION

Fuel-grade ethanol can be produced from a variety of carbohydrate feedstocks via biological conversion. These feedstock materials can be broadly classified as starches, celluloses and sugars. The following items are discussed for each feedstock:

- Process description
- Air emissions and liquid and solid effluents
- Pollution control systems
- Disposal of wastes from air, liquid and solid streams
- New and emerging technologies

2.1.1 Ethanol from Starches

Starches (polysaccharides) are present in a wide variety of food crops, such as rice, wheat, potatoes, and corn. This discussion uses corn as a representative starch feedstock.

2.1.1.1 Process Description

Figure 2-1 is a flow diagram of a typical ethanol from corn process. Production begins by grinding the grain in a milling process (e.g., a hammermill) and slurrying the grain with water to form a mash. The mash is cooked by injecting steam (at approximately 150°C) to solubilize the starches. After the mash is cooled, enzymes are added to transform the complex starches into fermentable sugars.

When the mash enters the fermentation vessels, yeast converts the sugars to alcohol and carbon dioxide. The fermented mash (approximately 10 percent alcohol) is then pumped to the alcohol stripping column. This distillation column removes the solids and most of the water, producing a stream that contains 80 percent ethanol, 19 percent water, and about 1 percent impurities (fusel oils and aldehydes).

The product stream is purified in a rectification column, producing a 95 percent ethanol, 5 percent water azeotrope. The fusel oil and aldehyde impurities, separated and removed in a side stream, can be combined with the final ethanol fuel product.

Dehydration of the ethanol-water azeotrope is necessary to produce an anhydrous product. A dehydrating agent (benzene) is added to the azeotrope in the dehydration column. The column produces two streams: one of anhydrous ethanol and one containing benzene, ethanol, and water. The latter is treated in a chilled separator, producing an ethanol/benzene-rich stream that is recycled to the dehydration column and an ethanol/water-rich stream. Ethanol and trace benzene are recovered from the ethanol/water-rich stream in the benzene recovery column, then returned to the dehydration column (stream E). The separated water is sent to the wastewater treatment facility.

Typically, the byproduct stillage (stream A) from the alcohol stripping column is treated to recover the solids (stream C), rather than used directly

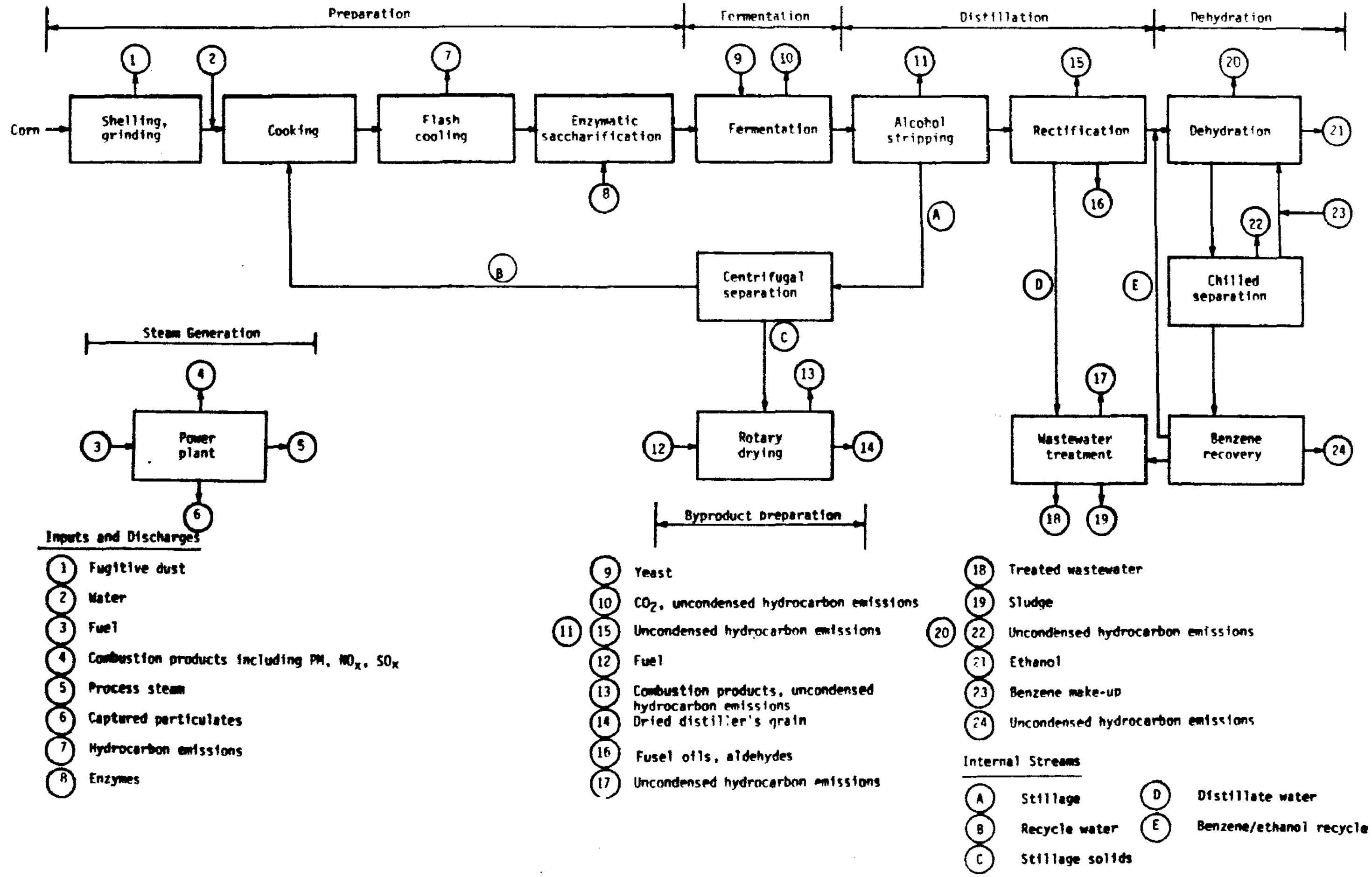


Figure 2-1. Typical ethanol production from corn feedstock.

or processed in wastewater treatment. Water is removed from the stream using centrifugation and evaporation. The water from centrifugation is recycled to the cooker (stream B) or evaporated. The solid product, containing proteins and dead yeast, is used as a cattle feed supplement, e.g., dried distillers grain (DDG). The DDG drying operation may be fueled by oil or gas. Process steam is produced on-site by a boiler, typically oil- or coal-fired.

2.1.1.2 Air Emissions and Liquid and Solid Effluents

The majority of the air pollutants from this process are produced by fuel combustion in the boiler and rotary dryer (see streams 5 and 13 in Figure 2-1) and consist mainly of particulates, SO_x, and NO_x. Fugitive hydrocarbon (gaseous and condensed) emissions are produced by flash cooling, fermentation, alcohol stripping, rectification, dehydration, chilled separation, benzene recovery, wastewater treatment, and rotary drying process (streams 7, 10, 11, 13, 15, 17, 20, 22, and 24). Fugitive particulates are produced by corn shelling and grinding (stream 1).

All liquid effluents from the plant pass through wastewater treatment (stream 18) before being discharged to a waterway. The cooling tower blowdown and the rectification and benzene recovery columns produce most of the wastewater. Equipment washes also periodically add to the wastewater. The treated water may be recycled and used in the process again if it is sufficiently cleansed of contaminants to the emzymes and yeasts. Recycling lowers the fresh water input to the process (stream 2).

Solid wastes include collected coal dust flyash from the coal-fired boiler, sludge from wastewater treatment (stream 19), and collected grain dust from the grinding process (stream 1).

2.1.1.3 Pollution Control Systems

Mechanical particulate collectors or wet scrubbers for flue gas cleaning are used on the boiler and rotary dryer. Mechanical collectors are also used to capture and recycle dust emissions from milling operations. Condensers are placed on the vents to reduce hydrocarbon emissions from the fermentation tank, columns, and separator. Condensates from these vents are returned to the associated processes. Based on measurements at distilleries, these hydrocarbon emissions are minimal and of little concern.

The wastewater treatment system employed is an extended aeration activated sludge unit. This technology was selected primarily because it reflects current operating practices in the beverage-grade alcohol industry. Mean cell residence times of 20 to 30 days (hydraulic retention time of 18 to 36 hours) are typical for this type of unit with a biochemical oxidation demand (BOD) removal efficiency of 75 to 79 percent. The wastewater can be recycled to the process if it has been sufficiently cleansed of contaminants.

2.1.1.4 Disposal of Wastes from Air, Liquid and Solid Streams

The liquid effluent from wastewater treatment can be discharged to a waterway or, if sufficiently uncontaminated, recycled to the process. As stated earlier, the stillage can be used as a cattle feed supplement. In addition, the collected grain dust from milling can be added to the stillage to improve the nutrient value of the supplement or returned to the feed stream. The wastewater sludge must be disposed of via landfilling or land spreading.

The treatment of air streams produces two solid wastes: captured flue gas particulates (flyash) and coal dust collected from coal storage and handling. Both are disposed of via landfills.

2.1.1.5 New and Emerging Technologies

It is not possible to fully assess the impacts of new and emerging technologies on air emissions and liquid and solid effluents. However, there are several new technologies that could affect the efficiencies and yields of the ethanol fermentation process. For instance, gasoline has been substituted for benzene as the dehydrating agent, and other dehydrating chemicals are also under investigation. Use of these alternatives could remove the potential for emissions of benzene, a hazardous pollutant. Alternate alcohol/solids/water separation technologies, such as selective adsorption, membrane separation, and supercritical fluid extraction, are being investigated to replace the distillation step.

Continuous fermentation with yeast recycle is possible. In addition, vacuum distillation can be coupled to the process, permitting continuous alcohol removal from the fermenter. New strains of yeasts and better saccharification enzymes are being developed to increase yields.

Finally, anaerobic digestion of the stillage can be implemented, eliminating drier energy consumption and producing methane that can be burned for process steam generation. Anaerobic digestion of stillage is not a common industry practice, but it is a well understood technology that could be easily adapted to the alcohol production process. The stillage from the alcohol stripper can also be used without drying as a feed supplement, further reducing energy consumption and related emissions. However, wet stillage must be used immediately since even short-term storage causes the material to become rancid.

2.1.2 Ethanol from Celluloses

Cellulose is the structural fiber in trees, herbaceous plants, and paper products. This discussion focuses on corn stover as a representative cellulosic feedstock.

2.1.2.1 Process Description

Figure 2-2 is a conceptual flow diagram for a typical ethanol from corn stover process. The first step is to reduce the stover size and break down cellulose into fermentable simple sugars by acid hydrolysis using dilute sulfuric acid ($\leq$ 5 percent). This process produces furfural in addition to simple sugars. The solubilized products are separated (stream B) in a flash distillation step. The sugars are neutralized to remove the contaminants

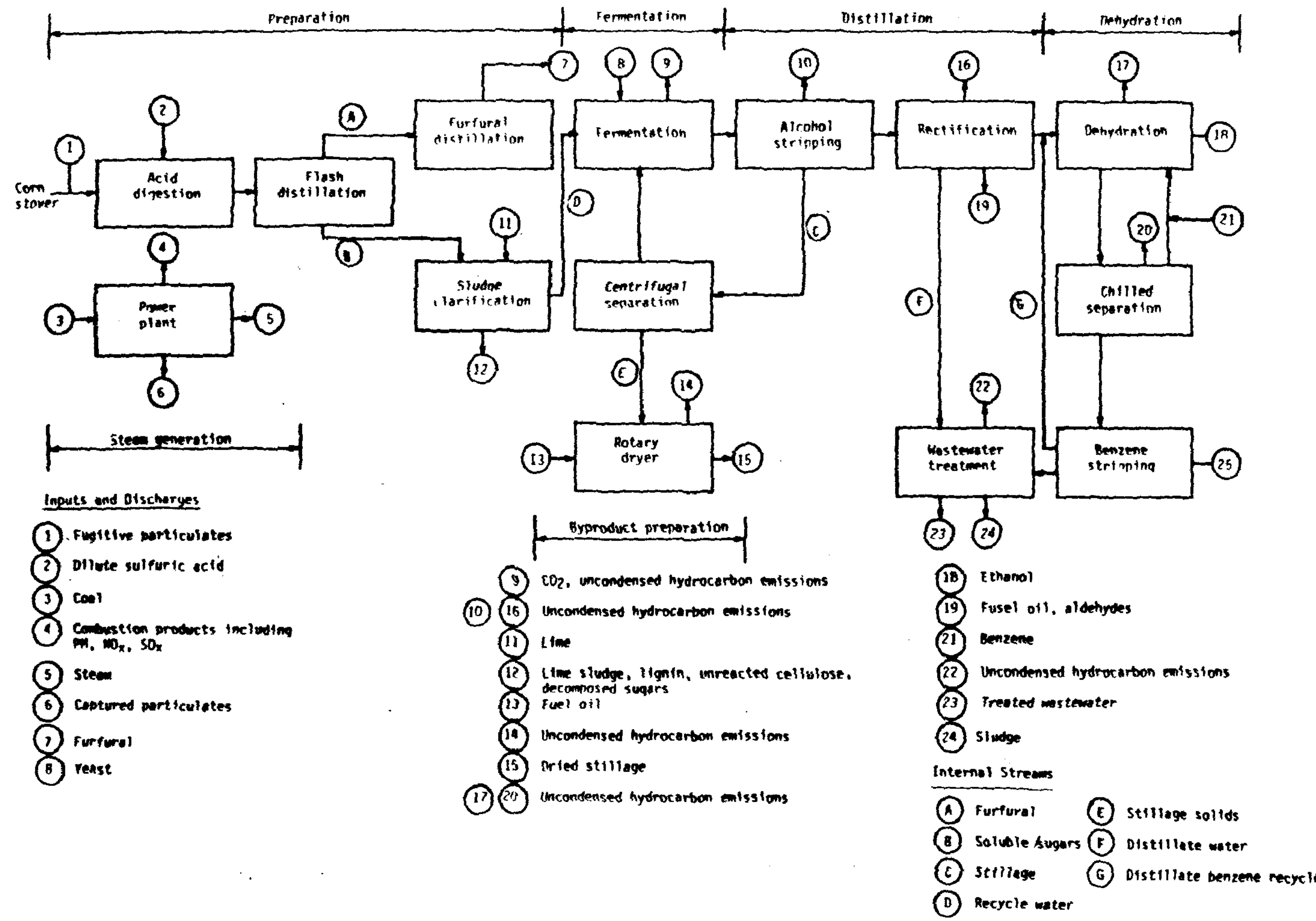


Figure 2-2. Typical ethanol production from corn stover cellulosic feedstock.

(lignin, etc.) and to alter the pH to provide a proper environment for the fermentation yeast.

The simple sugars are converted to alcohol and carbon dioxide by the metabolic processes of the yeasts. The fermented mash (approximately 10 percent alcohol) is then pumped to the alcohol stripping column. This distillation column removes the solids and most of the water, producing a stream containing 80 percent ethanol, 19 percent water, and about 1 percent impurities (fusel oils and aldehydes).

The product stream is purified in a rectification column, producing a 95 percent ethanol, 5 percent water azeotrope. The fusel oil and aldehyde impurities, separated and removed in a side stream, can be combined with the final ethanol fuel product.

Dehydration of the ethanol-water azeotrope is necessary to produce an anhydrous product. A dehydrating agent (benzene) is added to the azeotrope in the dehydration column. The column produces two streams: one of anhydrous ethanol and one containing benzene, ethanol, and water. The latter is treated in a chilled separator, producing an ethanol/benzene-rich stream that is recycled to the dehydration column and an ethanol/water-rich stream. Ethanol and trace benzene are recovered from the ethanol/water-rich stream in the benzene recovery column, then returned to the dehydration column (stream G). The separated water is sent to the wastewater treatment facility.

Typically, the byproduct stillage (stream C) from the alcohol stripping column is treated to recover the solids, rather than used directly or processed in wastewater treatment. Water is removed from the stream using centrifugation and evaporation. The water from centrifugation is recycled to the fermentation tank (stream D) or evaporated. The solid product (stream E), containing unconverted materials and dead yeast, is low in nutrient value and not typically used as a food supplement. If no byproduct use is available, this stillage is disposed of as solid waste. The drying operation may be fueled by oil or gas. Process steam is produced on-site by a boiler, usually oil- or coal-fired.

2.1.2.2 Air Emissions and Liquid and Solid Effluents

The majority of the air pollutants from this process are produced by fuel combustion in the boiler and rotary dryer (streams 4, 19) and consist mainly of particulates, SO_x, and NO_x. Fugitive hydrocarbon (gaseous and condensed) emissions are produced by flash cooling, fermentation, alcohol stripping, rectification, dehydration, chilled separation, benzene recovery, wastewater treatment, and rotary drying (process streams 9, 10, 16, 17, 19, 20, 22, and 25). Fugitive particulates are produced by stover preparation (stream 1).

All liquid effluents pass through wastewater treatment before leaving the plant. The cooling tower blowdown contributes the major volume of wastewater. The rectification and benzene recovery columns and equipment washes also produce wastewater. The treated water may be recycled and used in the process again if sufficiently cleansed of contaminants to the enzymes and yeasts. Recycling lowers the fresh water input of the process (e.g., stream 2). The distilled furfural can be sold (stream 7).

Solid wastes include collected coal dust, flyash from the coal-fired boiler, sludge from wastewater treatment, and collected stover dust from the preparation process. Sludge is produced from the neutralization of the hydrolyzed cellulose (stream 12).

2.1.2.3 Pollution Control Systems

Mechanical particulate collectors and wet scrubbers for flue gas cleaning are used on the boiler and rotary dryer. Mechanical collectors are also used to capture and recycle dust emissions from stover preparation. Condensers are placed on the vents to reduce hydrocarbon emissions from the columns, fermentation tank, and separator. Condensates from these vents are returned to the associated processes. Lime addition and sludge clarification are used to capture the unusable fraction of the hydrolyzed wood.

The wastewater treatment system employed is an extended aeration activated sludge unit. This technology was selected primarily because it reflects current operating practices in the beverage-grade alcohol industry. Mean cell residence times of 20 to 30 days (hydraulic retention time of 18 to 36 hours) are typical for this type of unit with a BOD removal efficiency of 75 to 79 percent. The wastewater can be recycled to the process if it has been sufficiently cleansed of contaminants.

2.1.2.4 Disposal of Wastes from Air, Liquid and Solid Streams

The liquid effluent from wastewater treatment can be discharged to a waterway or, if it sufficiently uncontaminated, recycled to the process. The solid wastes, lime sludge, stillage, and wastewater sludge (streams 12, 15, and 24) must be disposed of via landfilling or land spreading.

The treatment of air streams produces three solid wastes: captured flue gas particulates (flyash), coal dust collected from coal storage and handling, and corn stover dust collected from stover handling and preparations. These are disposed of via landfills.

2.1.2.5 New and Emerging Technologies

There are several new and developing technologies for increasing the yields and efficiencies of conversion of cellulose to ethanol. For example, there are many different types of hydrolysis, including weak acid pretreatment, strong acid hydrolysis, and enzymatic hydrolysis. An explosive defibration technique to thermo-mechanically break down the cellulose from its contaminants (lignin) is under development. In addition, solvent removal of lignin prior to acid digestion is being investigated. Improved fermentation and alcohol separation technologies that are applicable to starch feedstocks are also applicable to cellulosic alcohol production.

2.1.3 Ethanol from Sugars

Sugars (mono- and disaccharides) are present in many foods, including fruits, sugar beets, sugar cane, and milk. Most sugars can be converted directly to ethanol by yeast. This discussion focuses on lactose from the industrial waste cheese whey as a representative sugar feedstock.

2.1.3.1 Process Description

Figure 2-3 is a flow diagram for an ethanol from cheese whey process. The process begins with raw cheese whey, which is a byproduct of the cheese industry. Whey is converted to a variety of products including animal feed supplement, lactose, and food grade whey. Unconverted cheese whey is disposed of via municipal treatment, land spreading, or land filling. Typical cheese whey consists of water, lactose, and small amounts of proteins and fats. The fats and proteins are precipitated from the lactose solution by controlled heating and pH adjustment. This eliminates the need for solids removal in the distillation operations. The lactose solution is cooled and sent to the fermentation tank where it is converted to alcohol and carbon dioxide by added yeast.

The fermented product (approximately 10 percent alcohol) is then pumped to the alcohol stripping column. This distillation column removes the solids and most of the water, producing 80 percent ethanol, 19 percent water, and about 1 percent impurities (fusel oils and aldehydes).

The product stream is purified in a rectification column, producing a 95 percent ethanol, 5 percent water azeotrope. The fusel oil and aldehyde impurities, separated and removed in a side stream, can be combined with the final ethanol fuel product.

Dehydration of the ethanol-water azeotrope is necessary to produce an anhydrous product. A dehydrating agent (benzene) is added to the azeotrope in the dehydration column. The column produces two streams: one of anhydrous ethanol and one containing benzene, ethanol, and water. The latter is treated in a chilled separator, producing an ethanol/benzene-rich stream that is recycled to the dehydration column and an ethanol/water-rich stream. Ethanol and trace benzene are recovered from the ethanol/water-rich stream in the benzene recovery column, then returned to the dehydration column (stream 8). The separated water is sent to the wastewater treatment facility. Process steam is produced on-site by a boiler, typically oil- or coal-fired.

2.1.3.2 Air Emissions and Liquid and Solid Effluents

The majority of the air pollutants from this process are produced by fuel combustion in the boiler (stream 3) and consist mainly of particulates, SO_x, and NO_x. Fugitive hydrocarbon emissions are produced by flash cooling, fermentation, alcohol stripping, rectification, dehydration, chilled separation, benzene recovery and wastewater treatment (streams 7, 8, 9, 12, 14, and 17).

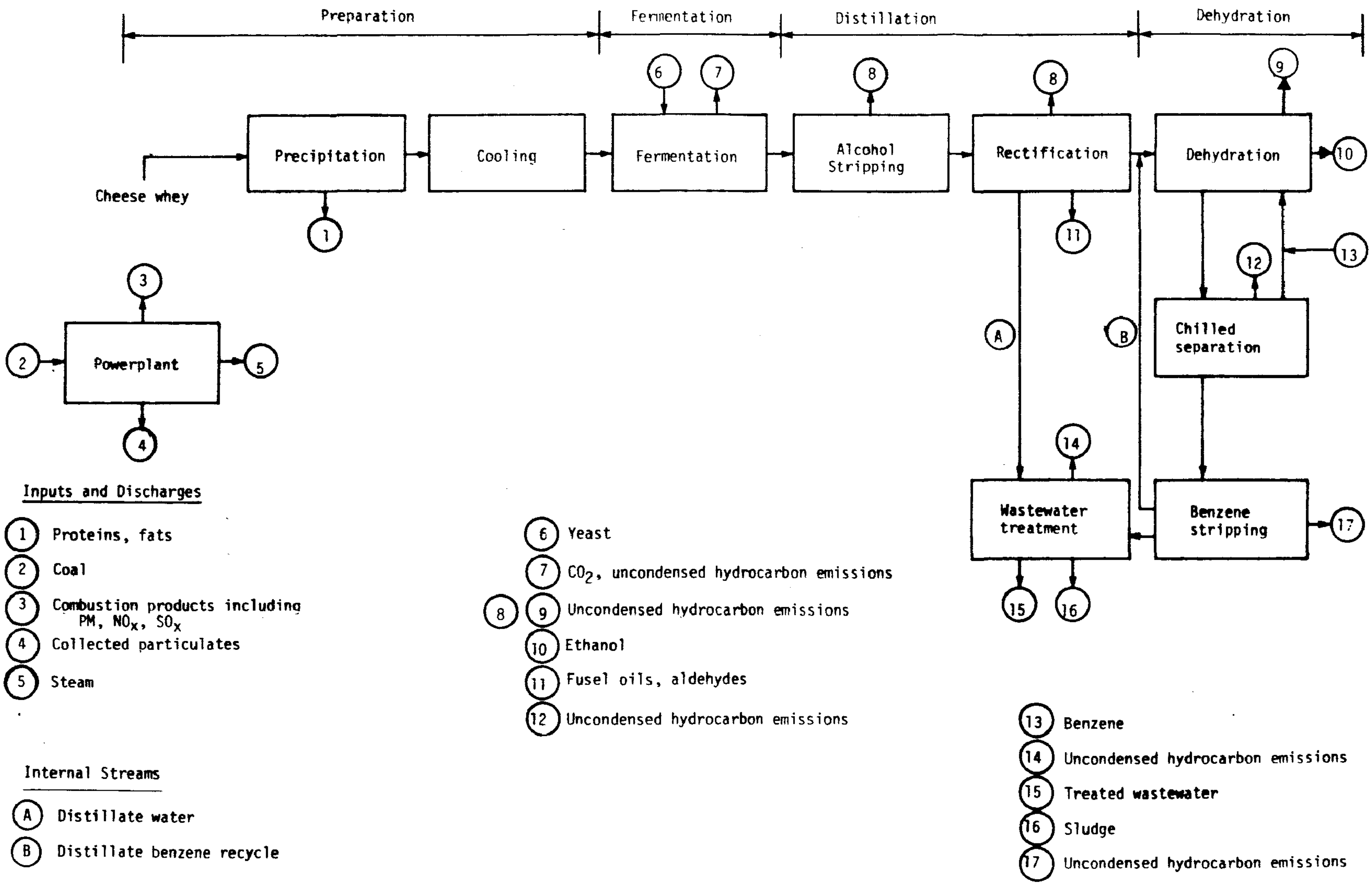


Figure 2-3. Ethanol production from whey sugars.

All liquid effluents pass through wastewater treatment before leaving the plant. The cooling tower blowdown contributes the major volume of wastewater. The rectification and benzene recovery columns and equipment washes also produce wastewater. The treated water may be recycled and used in the process again if sufficiently cleansed of contaminants to the enzymes and yeasts. Recycling lowers the fresh water input of the process (e.g. stream 2).

Solid wastes include collected coal dust, flyash from the coal-fired boiler, sludge from wastewater treatment, and precipitated proteins and fats from the whey (streams 1, 3, and 16).

2.1.3.3 Pollution Control Systems

This process includes the use of mechanical particulate collectors or wet scrubbers for flue gas cleaning at the boiler. Condensers are placed on the vents to reduce hydrocarbon emissions from the fermentation tank, columns, and separator. Condensates from these vents are returned to the associated processes.

The wastewater treatment system employed is an extended aeration activated sludge unit. This technology was selected primarily because it reflects current operating practices in the beverage-grade alcohol industry. Mean cell residence times of 20 to 30 days (hydraulic retention time of 18 to 36 hours) are typical for this type of unit with a BOD removal efficiency of 75 to 79 percent. The wastewater can be recycled to the process if it has been sufficiently cleansed of contaminants.

2.1.3.4 Disposal of Wastes from Air, Liquid and Solid Streams

The liquid effluent from wastewater treatment can be discharged to a waterway, or if sufficiently uncontaminated, recycled to the process. The wastewater sludge and precipitated fats and proteins must be disposed of via landfilling or land spreading.

The treatment of air streams produces two solid wastes: captured flue gas particulates (flyash) and coal dust collected from coal storage and handling. Both are disposed of via landfilling.

2.1.3.5 New and Emerging Technologies

It is not possible to fully assess the impacts of new and emerging technologies on emissions and effluents. However, there are several new technologies that could affect the efficiencies and yields of the ethanol fermentation process. For instance, gasoline has been substituted for benzene as the dehydrating agent, and other dehydrating chemicals are also under investigation. Alternate chemicals could remove the potential for benzene emissions. Alternate alcohol/solids/water separation technologies, such as selective adsorption, membrane separation, and supercritical fluid extraction, are being investigated to replace the distillation steps.

Continuous fermentation with yeast recycle is possible. In addition, vacuum distillation can be coupled to the process, permitting continuous alcohol removal from the fermenter. New strains of yeasts and better saccharification enzymes are being developed to increase yields.

2.2 ON-FARM ETHANOL PRODUCTION

In general, on-farm ethanol production will use technologies identical to those used in commercial-scale production. However, the smaller size of the on-farm process causes some notable differences, especially in regard to pollution control equipment.

2.2.1 Process Description

In the near-term, on-farm ethanol production will use corn as a feedstock. The process will be identical to the commercial process, except for the following:

1. A low-pressure boiler (firetube) will be used to allow easy operation by a farmer. It will be oil-, gas-, or waste-fired in most cases.

2. If corn is used as the feedstock, the stillage from the alcohol stripping column will not be dried. It will be used directly as a cattle feed supplement. This neccesitates immediate usage since even short-term storage will cause the stillage to become rancid.

3. Wastewater and stillage will not be treated on-site.

2.2.2 Emissions and Effluents

The emissions and effluents from the on-farm process will be the same as in commercial production, except there will be no drier emissions.

2.2.3 Pollution Control Systems

The on-farm process will be very small and will have few pollution control systems. Because of the small size of the boiler, it will be uncontrolled. Condenser vents will not be placed on the fermentation tank and distillation/dehydration columns, and dust collection devices will not be used. Wastewater will be discharged to an existing wastewater system; on-site wastewater treatment will not be available.

2.2.4 Liquid and Solid Waste Disposal

The stillage, although undried, will be disposed of as on-site cattle feed if feasible. Wastewater will be discharged and not treated on-site.

2.2.5 New and Emerging Technologies

The new technologies potentially affecting on-farm ethanol production are the same as those in commercial application, with the exception of supercritical fluid extraction of ethanol. This process is not applicable to on-farm processes because of its complexity and cost. Increased automatic control (especially with a continuous fermentation system) would be a major improvement, but this would not alter the process or effluents.

2.3 OTHER ALCOHOL FUELS PRODUCTION

The production of methanol and butanol fuels is technically feasible, although the technologies are not as ready for commercialization as ethanol production technologies. This section describes the production of methanol via catalysis of synthesis gas and the production of butanol via biological conversion.

2.3.1 Methanol Via Catalysis of Synthesis Gas

Methanol is produced by the catalytic reaction of hydrogen and carbon monoxide (currently derived from natural gas) at a temperature of approximately 315°C and a pressure of 105 to 350 kg/cm^2 ($2H_2 + CO \rightleftharpoons CH_3OH$). The hydrogen and carbon monoxide precursors can also be generated in other ways. The gases are available from industrial off-gases or from the gasification of carbonaceous feedstocks. These carbonaceous feedstocks include coal, lignite, peat, and the celluloses: wood, wood wastes, refuse-derived fuel, and biomass. Present plans emphasize the use of coal as the primary feedstock in the future.

The gasification of these feedstocks can occur at different temperatures and pressures. This discussion focuses on atmospheric pressure, air-fed gasifiers, which have been demonstrated with all of the carbonaceous feedstocks. The gasifiers reform the carbonaceous feedstock into a crude gas, consisting mainly of hydrogen, carbon monoxide, and carbon dioxide. The crude gas is scrubbed to remove organics and then compressed to approximately 10 kg/cm^2. The gas is subsequently passed through a hot potassium carbonate scrubber and a monoethanolamine scrubber to remove the carbon monoxide.

The CO_2-free gas is treated cryogenically to remove methane, hydrocarbons, and nitrogen. The gas is compressed to approximately 30 kg/cm^2 and reacted over an iron catalyst used in the water shift reaction. Water vapor and carbon monoxide are reacted to form hydrogen. Enough gas is reacted until the requisite hydrogen-carbon monoxide ratio is reached (2:1).

The CO_2 produced during this shift catalysis is removed in another potassium carbonate scrubber. The synthesis gas is compressed to approximately 175 kg/cm^2 and fed to the nickel chrome catalytic reactor. These reactor products are distilled in two columns to remove the light ends and higher alcohols from the methanol product.

The major effluent from this process is the solid residue from the feedstock gasification, which contains feedstock inerts and some carbon. This is disposed of by landfill. The major source of wastewater is from the hydrocarbon scrubber just downstream of the gasifier. This water contains particulates as well as hydrocarbons and requires appropriate wastewater treatment.

Condenser vents will be used to control fugitive hydrocarbon emissions from the distillation columns and scrubbers.

2.3.2 Butanol Production Via Biological Conversion

Butanol can be produced biologically from pentoses (simple sugars) in a process similar to ethanol production. Pentoses are produced via hydrolysis of pentosans found in cellulosic wastes or grain. These simple sugars are fermented with a select strain of yeast that enzymatically converts the five-carbon sugar into butanol, carbon dioxide, and hydrogen. Subsequent process steps refine the alcohol and remove the water, solids, and other hydrocarbons. Fuel-grade butanol, carbon dioxide, and hydrogen are the final products.

Since this alcohol production technology is in the early stages of development, the exact process characteristics are not certain. However, because the process is very similar to ethanol fermentation from cellulosic feedstocks, it is expected that the emissions and effluents, control technologies, and disposal characteristics will also be similar.

SECTION 3

THE STANDARDS SUPPORT SCHEDULE

3.1 DESCRIPTION OF THE SCHEDULE

The heart of an SSP is the schedule showing the temporal relationships among the various activities required to develop standards for a source category. Specifically, the schedule shows how IERL-Ci will support the development of standards by indicating the laboratory's commitment to carry on various research activities prior to and concurrent with Program Office dates for the development of standards. As a result of these efforts, several reports will be prepared and a sampling and analysis (S&A) program on fuel-grade alcohol production facilities will be carried out. The timeline for the various studies and the content of each of the activities are discussed in Section 3.2. Section 3.3 explains the responsibilities and working interactions between IERL-Ci, Region VII, and the various Program Offices.

As indicated previously, this SSP was developed with the consensus of the cognizant Program Offices: OWPS/EGD, OAQPS/ESED, and OSW/HIWD. Since the original impetus for such a study came from an increase in requests for permits for fuel-grade alcohol production facilities on the farms in Region VII, representatives of Region VII also participated in the development of the plan. Through a series of meetings the salient elements and requirements of the research study in terms of Program Office needs were discussed. Based on these discussions, the time framework for the various studies and an S&A program were developed for both commercial and on-farm fuel-grade alcohol producing facilities. Additionally, responsibilities for certain elements of the plan were delegated. The specific details of the time framework of and responsibilities within the IERL-Ci research program are discussed in Section 3.2.

3.2 PROGRAM SCHEDULE

As a result of a series of meetings among IERL-Ci, the Program Offices, and Region VII, a program schedule evolved for the research effort required to establish the need and/or basis for environmental standards applied to fuel-grade alcohol production. Initially, the production of ethanol, methanol, and butanol was considered; however, the current plan has been limited to ethanol production, which will dominate in the near term. As will be discussed, future consideration will be given to the other two alcohol fuels.

There are four important phases to this research plan: (1) information surveys of the processes, (2) engineering analysis, (3) environmental data acquisition, and (4) documentation including a Pollution Control Guidance Document (PCGD) and an Environmental Assessment Report (EAR). Based on the above, the Program Offices will determine the appropriate standards as required. Figure 3-1 shows the schedule for the various activities and the relationships agreed upon by the agency offices.

The activities discussed in this SSP are limited to the production of ethanol; they focus on processes using grain as a feedstock, but also include those which use industrial waste stocks, such as cheese whey and cellulosic materials, as inputs. The program distinguishes between commercial production and on-farm production for private use by an individual farmer. The latter appears to be increasingly important as more farmers are turning to alcohol fuel to ensure an adequate energy supply for their needs.

The following briefly describes each of the elements of the Gasohol program shown in Figure 3-1.

- Information Surveys

  -- The Gasohol Overview Report is an update of similar overview reports by the Office of Technology Assessments (OTA) and the Department of Energy (DOE), but from an EPA perspective. This report focuses on an examination of the state-of-the-art technology, the economics, environmental issues, impediments to wide-spread use, and Federal initiatives to promote gasohol's use.

  -- A review of major existing ethanol production facilities lists the major U.S. producers of ethanol, whether the product is used for fuel or not (i.e., includes some distilleries) and gives the salient information about each operation.

  -- The transcript of a meeting at Region VII, Kansas City, presents an overall discussion and information transfer on the subject of gasohol, including environmental, economic, and energy issues.

- Engineering Analyses

  -- IERL-Ci has previously supported a study at Midwest Solvents (MWS) plant. Information developed in that study was the basis for the analysis to determine the extent of the potential environmental problems associated with fuel-grade alcohol production and the media specific priorities and analytical detail required in continued research directed toward these facilities.

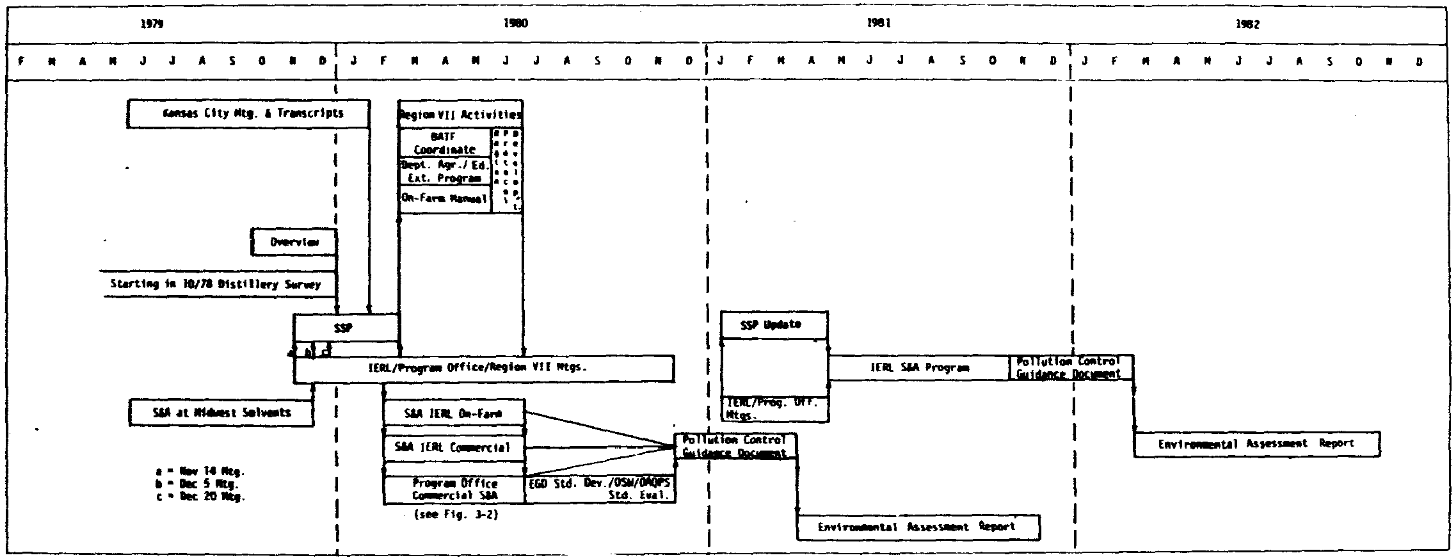


Figure 3-1. IERL program schedule for gasohol.

-- Based on the review of major existing ethanol production facilities, the important characteristics of near-term technologies and feedstocks were determined and typical facilities identified for continued study.

- Environmental Data Acquisition

  -- An S&A program has been planned for each of the three media: water, solid, and air discharges. The IERL S&A program was developed in consensus with the three Program Offices and Region VII. The data provided by this program can be used in the preparation of a PCGD if required -- see below -- and will be of assistance in permit writing and standards development. The choice of commercial facilities resulted from a review of the existing facilities listed in the ethanol production survey. The facilities selected by IERL and the Program Offices are shown in Table 3-1. It should be noted that the MWS plant had previously been studied by IERL, except for trace metals. Additional samples will be obtained by Region VII and analyzed for trace metals by EGD. Two on-farm facilities will be investigated in addition to the commercial plants. Table 3-2 lists agency office responsibilities by activity and agency office. The test matrix is shown in Table 3-3. The bases for this matrix are the results obtained at MWS.

  -- The sampling and analysis will be coordinated with the Program Office efforts. Figure 3-2 shows a schedule for effluent guidelines development leading to the establishment of water effluent standards, if warranted. OSW will establish priorities based on this S&A program regarding future standards that may be enforced through their permitting system. OAQPS will use the results to establish the need for developing a New Source Performance Standard (NSPS) for ethanol production. At present, however, they do not anticipate a need for an additional NSPS since the steam boiler, which is the major source of emissions, will be controlled under an NSPS for industrial boilers currently under development.

- Documentation

  -- The PCGD report will define the processes currently in use (both commercial and on-farm), characterize the process flow and emission streams, identify options for management and control of waste streams, and provide information on expected environmental control costs. The PCGD will be based on the results of the S&A program and the engineering analyses. As shown in Figure 3-2, EGD plans to publish a draft Development Document (DD) based on their standards development activities prior to the planned start of the PCGD. Before actually starting the PCGD, the DD will be reviewed to determine its adequacy in replacing (eliminating the need for) the PCGD.

TABLE 3-1. SUMMARY OF S&A INTEREST IN ALCOHOL PRODUCTION PLANTS BY PROGRAM OFFICES/ORD

Plant	Program Office/ORD/Regional Involvement[a]				
	OWPS/EGD	OSW/HIWD	OAQPS/ESED	ORD/IERL-Ci	Regions
Midwest Solvents	C*	C	C	C*	C*
Georgia-Pacific	I	NI	NI	I	I
American Distilling	I	I	C	I	I
Milbrew	I	I	I	I	I
Grain Processing	I	I	I	I	I
Natick Army Labs	I	I	NI	I	I
ADM	I	NI	NI	I	I
Jacquins	I	I	NI	I	I
On-Farm (2)				I	I

[a]Legend
I -- Interested
NI -- No interest
C -- Sufficient testing completed
* -- Need trace metal analysis for completion; to be sampled by Region VII and analyzed by EGD

TABLE 3-2. AGENCY OFFICE RESPONSIBILITIES

Activity	Responsible Agency Office
Overview Report	ORD/IERL-Ci
Alcohol Production Survey	ORD/IERL-Ci
Information Transfer Meeting at Kansas City	ORD/IERL-Ci & Region VII
S&A Study at Midwest Solvents	ORD/IERL-Ci
SSP for Ethanol Production (Meeting of Agency Offices)	ORD/IERL-Ci
S&A On-Farm Facilities	ORD/IERL-Ci & Region VII
S&A Commercial Facilities (Air)	ORD/IERL-Ci
S&A Commercial Facilities (Water & Solids)	OWPS/EGD & ORD/IERL-Ci
Standards Development	Program Offices
Regional Enforcement Model with BATF	Region VII
Farm Environmental Operations Manual	Region VII
Department of Agriculture Liaison	Region VII
Adaptation of Regional Model to other Regions	Regions & ORD/IERL-Ci
PCGD	ORD/IERL-Ci
EAR	ORD/IERL-Ci
Continued Research	ORD/IERL-Ci

TABLE 3-3. SAMPLING AND ANALYSIS PROGRAM MATRIX FOR EACH SITE

I. On-Site Sampling/Analysis*

Solids: Two locations -- dryer waste, coal

Sample dryer waste five times/day for 3 days, therefore, 15 samples or three daily composites

Sample one coal/test

Liquids: Four locations -- influent, effluent, sludge, makeup

Each location sampled five times/day for 3 days, therefore, five samples/day x 3 days/plant x four locations = 60 samples or three daily composites at each location

Air: Two locations (i.e., dryer vent and grain handling)

Test each location once/day for 3 days

Test Type	Method
Particulate	EPA Method-5
NO_x	EPA Method-7
SO_2	EPA Method-6
CO, CO_2, O_2	EPA Method-3
Hydrocarbons	GC w/FID

II. Laboratory Analysis

Solid Streams: Phenols, Cyanides, Ammonia Sulfate, Sulfites, Nitrates, 22 Metals,** Including Solid Extraction

Organics by GC/MS, Acid Fraction, Base Neutral Fraction, Pesticides

Liquid Stream: Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Organic Carbon (TOC), Total Suspended Solids (TSS), Phenols, Cyanides, Ammonia

Nitrates, Sulfates, Sulfites, 22 Metals**

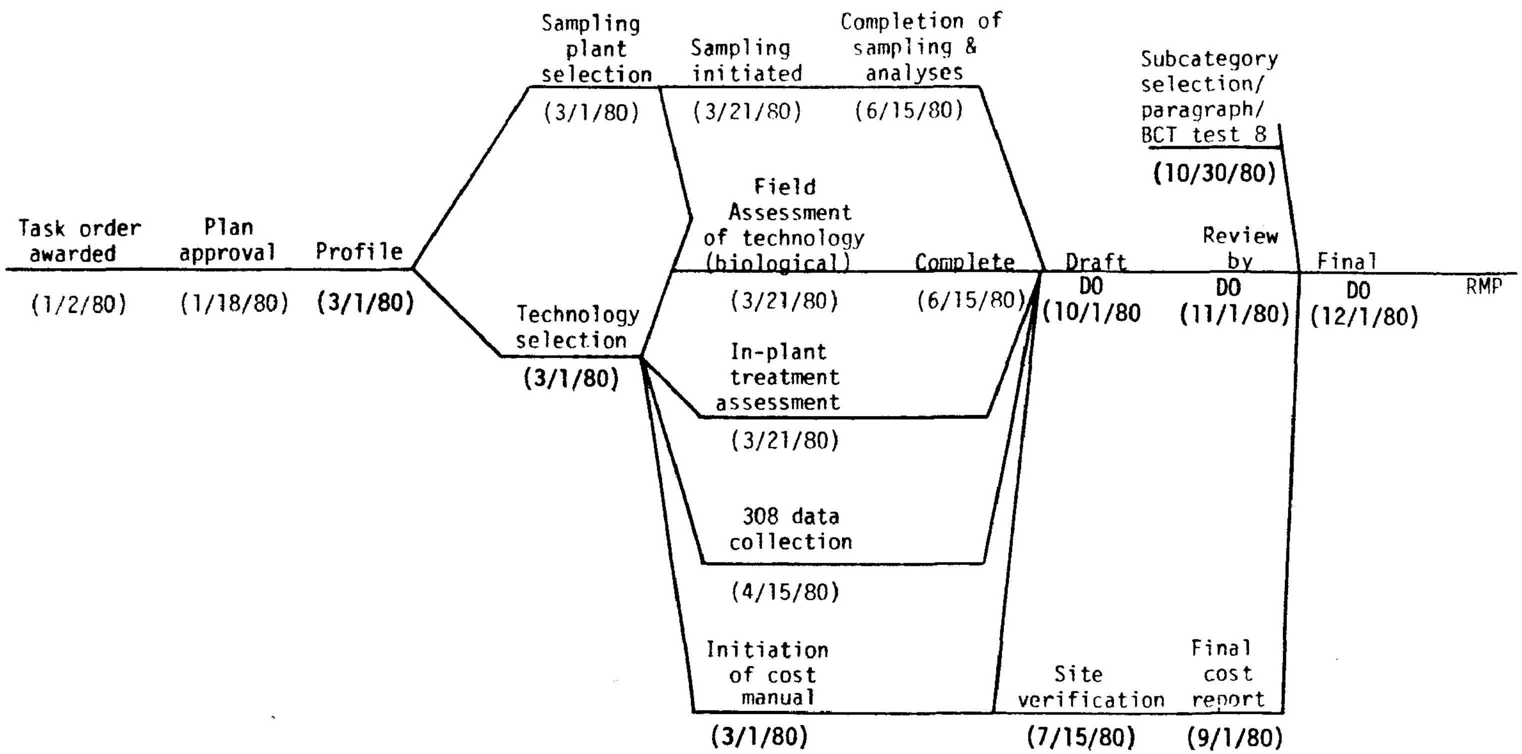
Organics by GC/MS, Volatile Organic Analysis (VOA),

Acid Fraction, Base Neutral Fraction, Pesticides

Air Stream: Particulate -- Sulfates, Nitrates

*The sample frequency is site specific; the above is only typical of the level of effort.

**The 22 metals include Al, Bi, Ca, Fe, Mg, Mn, Y, Ti, Sb, As, Be, Cd, Cr, Cu, Pb, Hg, Ni, Se, Ag, Tl, Zn, and B.



Approximately eight plants will be sampled.
One EGD and one IERL-Ci project officer
full time are required.

Figure 3-2. Gasohol effluent guidelines development.

However, since the DD will be essentially a waste water document, the PCGD may still be required to discuss the solid waste and air emissions management concerns, in-plant strategies that might be employed for each media to minimize effluent controls, and the role of new technologies for ethanol production which are not currently covered in this plan. The PCGD could also provide engineering analysis of emerging technologies for other alcohols to establish the need for an SSP update and continued research.

-- The Farm Environmental Operations Manual will provide guidance to the BATF on what environmental questions should be examined when issuing their permit for a still and practical advice to the farmers on how to manage wastes from their on-farm processes. As part of this activity, Region VII will establish a liaison with the Department of Agriculture/Educational Extension to develop a program assuring farmer awareness of the environmental impacts and proper operational practices to acceptably minimize these impacts.

-- A Regional Enforcement Model will be developed by Region VII with the cooperation of the BATF. The BATF is developing a new permitting system for alcohol fuel producers (see Section 4.2) to replace the present cumbersome and outdated system now in use. In order to access environmental information about the site and the production system, the permit applicant will be required, as part of the permitting procedure, to provide information about their facility of an environmental nature, (size, discharge, solid waste handling and disposal, etc.) Region VII, BATF and IERL-Ci are cooperating in developing exactly what kind and type of information is needed to optimize the quality of the information gathered. The Farm Environmental Operations Manual (mentioned above) will contain guidance to the farmer as to his response to these questions as well as how to operate the system in an environmentally safe manner.

The responses to the environmental portion of the permit will be reviewed by a BATF inspector, who will be informed in methods designed to detect situations potentially harmful to the environment. The information necessary to perform this task will be provided in a document called the "BATF Environmental Information Manual for On-farm Alcohol Production Systems."

The remaining task in this area will be to develop the mechanism by which BATF will alert the state and EPA Region as to a potential problem situation. This task will be the joint responsibility of EPA Region VII, BATF, and IERL-Ci.

-- The results of the IERL program will form the basis for the preparation of an EAR. Environmental Assessment Reports are designed to provide a comprehensive overview for a given technology. An EAR dealing with alternative modules that comprise a given system within a given technology is prepared by drawing together technical, economic, and environmental impact data for that system. The major topics addressed are process description, characterization of input materials, products and waste streams, performance and cost of control alternatives, analysis of regulatory requirements, and environmental impacts.

As a result of the meetings between IERL-Ci, the Program Offices, and Region VII, responsibilities for the various activities identified in this SSP were assigned. IERL-Ci and EGD will perform the solid and liquid waste S&A program for the commercial units. This program will include air emissions sampling at two of the commercial units. A complete sampling program for solid, liquid, and air effluents will be carried out at two on-farm facilities. Responsibility for this program lies with IERL-Ci. A manual will be produced to serve as a guideline to the farmers who construct or install fuel-grade alcohol production facilities and to the Bureau of Alcohol, Tobacco and Firearms (BATF) who issues permits with respect to BATF regulations. The preparation of this manual will be the responsibility of IERL in conjunction with Region VII. Region VII is also responsible for developing cooperation between the Department of Agriculture/Educational Extension and the BATF. Through the establishment of these contacts and the development of a regulatory procedure, Region VII will serve as a model region with respect to the control of on-farm facilities.

As stated previously, the IERL program has focused on current technology for the production of ethanol. As the alcohol fuels industry progresses, additional technologies and feedstocks will be developed for ethanol production, and other alcohols, e.g. methanol and butanol, may become more important. For these reasons, the IERL program will continue beyond that currently planned in the SSP. Since several of the developments indicated are expected to be, at least, in pilot-plant stage by 1981-1982, it may be necessary that a second SSP on fuel-grade alcohol production be prepared in early 1981, followed by a second PCGD presenting an engineering analysis of emerging production capabilities.

3.3 RESPONSIBILITIES AND WORKING INTERACTIONS

The responsibilities and working interactions that have been developed under this SSP stem from the overall mission of each group involved. These are shown in Table 3-2. ORD's role is to respond to the needs of the Program Offices and Regional Offices to obtain the data necessary for those offices to establish appropriate standards. In addition, they are to provide guidance to the users of alcohol facilities, the Regions, and the Program Offices to quantify effects, beyond those required by the Program Offices, in order to fully understand the environmental impact of the facilities under study. The responsibilities developed during the organization meetings clearly respond to these missions.

IERL-Ci is responsible for the generation of the background data and the appropriate S&A program, both of which will lead to the generation of a PCGD and an EAR. Additionally, at the completion of the program outlined in this SSP, IERL will be involved in looking at the emerging technologies for fuel-grade alcohol production. Should these appear important, more SSP's and/or PCGD's may be required.

The Program Offices are required to establish the appropriateness of emissions standards to assure that no significant environmental damage will result from the facilities under study. They also must develop data of a type and quality needed for legally defensible standards and to ultimately promulgate the standards required. Since OAQPS does not anticipate needing standards in this area, their responsibilities to the program are minimal. However, for solid and liquid wastes, EGD will assume the responsibility for carrying out a portion of the S&A program. These activities, occurring at the commercial facilities identified, result from general interest in promoting the new development of these sources and the immediacy of obtaining data to assess their impact.

The Regions have the responsibility of enforcing the standards, normally through permits (such as under the National Pollution Discharge Elimination Systems, or NPDES, for sources discharging a liquid), and putting into place mechanisms to alert the EPA to potential problems due to the proliferation of fuel-alcohol facilities. As part of this role, they are developing liaisons with both the Agricultural Department/ Educational Extension and the BATF, assisting with the development of the Environmental Operations Manual, and identifying the on-farm facilities to be studied. These liaisons and the resulting mechanisms developed in Region VII will serve as a model for other regions dealing with the buildup of fuel-grade alcohol facilities on the farm.

The organizational units involved in this study have designated individuals as principal contacts for the program. Table 3-4 lists the organizational unit, the responsible person, and the address and phone number for that person.

TABLE 3-4. ALCOHOL FUEL/ENERGY COORDINATORS/CONTACTS

ORD/IERL-Ci	Robert Mournighan	(513) 684-4334
OAQPS/ESED	Dave Markwordt	(919) 629-5371
OWPS/EGD	John Lum	(202) 426-4617
OSW/HIWD	Bill Kline	(202) 755-9200
ORD/EPD	David Berg	(202) 755-0205
Regional Services Staff	Joseph Roesler	(513) 684-7285
Region 1	Dick Keppler	(617) 223-3477
Region 2	Paul Pruchan	(212) 264-7665
Region 3	Bernard Turlinski	(215) 597-9944
Region 4	Bob Humphries/Dave Hopkins	(404) 257-3004
Region 5	Jim Phillips/Cliff Risley	(213) 886-6054
Region 6	John Accardi	(214) 729-2650
Region 7	Charles Hajinian	(816) 758-2921
Region 8	Terry Thoem	(303) 327-5914
Region 9	Carl Kohnert	(415) 556-7858
Region 10	George Hofer	(206) 399-1125

SECTION 4

DISCUSSION OF THE STANDARDS SUPPORT PLAN ELEMENTS

To provide a perspective on the future importance and potential environmental impact of this source category, the status and projected development of the alcohol-for-fuels industry is described in Section 4.1. Regulatory requirements for EPA and the Bureau of Alcohol, Tobacco and Firearms (BATF) that could apply to these sources under existing statutes are discussed in Section 4.2, as are the responses of these agencies to these legislative mandates.

4.1 ALCOHOL FUELS DEVELOPMENT

Alcohol fuels represent an important source of domestic renewable energy. The use of alcohol in motor vehicles is not a new technology. The Model T Ford was designed to run on alcohol, gasoline, or any mixture of the two fuels. However, as gasoline became relatively inexpensive and plentiful, the market for alcohol fuels diminished. The recent increases in the price of petroleum products and the planned reduction of United States dependency on foreign sources of energy has led to an increase in the demand for alcohol fuels. (For Section 4.1, see References 4-1, 4-2, and 4-3.)

4.1.1 Potential Oil Savings from Alcohol Fuels

The amount of oil that alcohol fuels can displace is equal to the amount of oil they save or replace in combustion processes minus any difference in the amount of oil used to produce each fuel. Two alcohol fuels, ethanol and methanol, are commercially available today. In the near term (1980 to 1985), ethanol will be the alcohol fuel available in significant quantity for use in the commercial fuel market. A mixture of 10 percent ethanol and 90 percent gasoline, called gasohol, can be used in motor vehicles without engine modifications.

Ethanol used in gasohol not only extends gasoline supplies by replacing 1 gallon of gasoline for every 10 gallons of fuel consumed, but also acts as an octane enhancer. Since the presence of alcohol in gasohol increases the octane rating, the reforming requirements for the production of the unleaded fuel are reduced. This reduction increases the production yield and decreases the amount of heating oil required in the reforming process. The combined effect of these two savings further increases alcohol's value relative to gasoline. Industry estimates that these effects merit a premium of roughly $0.10 per gallon of alcohol.*

4.1.2 Supply and Demand

Current demand for gasohol is increasing. The National Gasohol Commission estimates that the number of retail outlets selling gasohol have increased from 500 in March 1979 to about 2,000 in October 1979. Three factors contribute to the increase in demand for gasohol. These are:

- Driver perceived improved vehicle performance from higher octane ratings than those of unleaded gasolines
- Consumer preference (particularly by residents of farm states) for vehicle fuels derived from renewable agricultural products
- Lower selling price at the pumps than higher octane unleaded gasolines because the $0.04 Federal tax is not applied to gasohol
- Government incentives including eligibility of alcohol fuels for DOE entitlements worth approximately 2 to 3 cents per gallon. U.S. Department of Agriculture has made loan guarantees available for alcohol pilot plants.

The U.S. is currently producing 80 million gallons of ethanol for fuel use per year (4,000 barrels per day). By 1982 ethanol production is expected to reach 300 million gallons per year (20,000 barrels per day). Increased ethanol production will come primarily from excess distillery capacity and expansions in currently operating facilities. By 1985, if the proposed Federal incentives materialize, ethanol production could reach 500 to 600 million gallons per year. This level of production is beyond the capacity of existing facilities and would occur only with the construction of new facilities. The design, construction, and startup of a new ethanol facility can take 1 to 3 years, depending on the size of the plant.

Wine producers throughout the United States are currently investigating the feasibility of producing fuel-grade alcohol. At this time, it is not possible to accurately project what impact these facilities would have on the alcohol fuels industry. However, a number of refineries have the capacity to produce 100 million gallons of alcohol per year.

Beyond 1985 ethanol production will depend on:

- The availability of inexpensive feedstocks
- New technological developments that decrease capital and energy requirements and, therefore, the cost of conversion
- The relative cost of competing fuels

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*At 1979 prices.

Methanol derived from coal is also an attractive alternative for extending U.S. supplies of high quality liquid fuels. However, it is unlikely that methanol will be used extensively before 1990, when new conversion facilities should be operating. At present economies of scale, profitable plants must be large, producing 20,000 to 50,000 barrels per day. A plant of this size requires an investment of $500 million to $1 billion and can take up to 4 years to build. Once such facilities are in operation, methanol could be produced more economically and in larger quantities than ethanol.

Originally methanol was made from wood, hence the common name wood alcohol. Today methanol is made almost entirely from natural gas and oil. In 1976 the U.S. produced 1.2 billion gallons of methanol, primarily from these fossil fuels. In the future production of methanol will most likely come from coal, wood, and agricultural residues.*

Methanol has essentially the same octane enhancing characteristics as ethanol. However, the use of methanol in quantities greater than several percent requires modifications to existing engines.

In the long term (late 1980's and beyond) methanol is being considered for use in gas turbines and may also be used as a petrochemical feedstock. Diesel engines, boilers, and utility fuel cells may be potential future uses for methanol, but additional research and development are required.

If adapting motor vehicles and/or distribution systems to accommodate methanol proves to be difficult, it may be converted directly to high quality gasoline or methyl tertiary butyl ether (MTBE), which is chemically closer to petroleum. Methanol/ethanol/gasoline blends are also under consideration; however, at this point it is impossible to project what the proportions of each fuel might be and what the market penetration will be in 1985 and beyond.

4.1.3 Biomass Availability

Approximately 800 million dry tons of biomass are available annually for alcohol production. By the year 2000 it is projected that over 1.1 billion tons will be available. Available feedstocks are generally those feedstocks that are noncompetitive. For example, "available wood" does not include wood that would be used for lumber or paper. Available grain crops are residues and grains not needed for projected demands of food, feed, or for export. A breakdown of the projected biomass resource availability is shown in Table 4-1.

In order to estimate the amount of alcohol fuels that could be produced from available feedstocks, it is necessary to consider the conversion

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*Methanol produced by the liquefaction of coal and gasoline produced from such coal-derived methanol are under investigation by EPA as part of the Indirect Liquefaction Program. These processes will be the subject of separate PCGDs and EARs.

TABLE 4-1. PROJECTED MAXIMUM U.S. BIOMASS AVAILABLE FOR ALCOHOL PRODUCTION[a]
(million dry tons per year)

	1980		1985		1990		2000	
Biomass Source	Quantity	Percent	Quantity	Percent	Quantity	Percent	Quantity	Percent
Wood[b]	499	61	464	56	429	49	549	48
Agricultural residues	193	23	220	26	240	28	278	24
Grains[c]	38	5	38	5	28	3	23	2
Sugars[c]	--	--	8	1	69	8	172	15
Municipal solid waste (MSW)	86	10	92	11	99	11	116	10
Food processing wastes	6	1	7	1	8	1	10	1
Total	822	100	829	100	873	100	1,148	100

[a]Reference 4-1
[b]Assumes wood from sivicultural energy farms starting in 1995
[c]Estimates for grains and sugars assume development program to establish sweet sorghum as a cash crop

processes currently demonstrated, those expected to be demonstrated in the future, and the resulting conversion efficiencies of each process.

Conversion of all grains, sugar crops, and food processing wastes could yield a maximum of 4.4 billion gallons of ethanol per year by 1980, rising to 12.2 billion gallons in the year 2000. Ethanol production potential could be greatly increased by conversion of wood, agricultural residues, and municipal solid waste (MSW) to ethanol. In 1980 ethanol production could reach 39.2 billion gallons per year, rising to 54.0 billion gallons per year by 2000.

Table 4-2 shows the projected maximum alcohol production from U.S. biomass resources. It is important to note that the ethanol and methanol quantities cannot be added because the same feedstock resources are assumed to be used for one or the other. Conversion of wood, agricultural residues, and MSW could produce 128.3 billion gallons of methanol by 1980. However, due to the lack of existing facilities, it is highly unlikely that there will be significant methanol production before 1990. In the year 2000 sufficient biomass could be available to produce either 54.0 billion gallons of ethanol or 154.7 billion gallons of methanol. These figures represent a physical -- though not necessarily economic -- possibility of alcohol fuels production. Actual alcohol fuels production will be considerably less than physical capacity. In fact, the President's Program for Ethanol Production has actual production goals of less than 1 percent of the maximum production in 1980 and approximately 5 percent of the maximum production in 1983.

4.2 REGULATORY REQUIREMENTS AND PLANS, BUREAU OF ALCOHOL, TOBACCO, AND FIREARMS

The BATF is responsible for administering the laws in the Internal Revenue Code relating to distilled spirits (alcohol). The code (26 U.S.C., Section 5002) defines distilled spirits as those substances known as ethyl alcohol, ethanol, or spirits of wine, including all dilutions and mixtures thereof, from whatever source, by whatever process produced. Although these laws relate primarily to the beverage alcohol industry, all producers of alcohol must comply with them. The primary responsibility of BATF is to protect revenue. (For Section 4.2, see References 4-4 and 4-5.)

There are two types of distilled spirits plants (DSP's) currently authorized by law: commercial DSP's and experimental DSP's. Under the law, a commercial facility can produce beverage or industrial alcohol. Qualification as a commercial facility requires registering the plant, obtaining an operating permit, filing a bond, having a continuous and closed distilling system, and providing adequate facilities for all operations including production, warehousing, denaturation, and bottling. Extensive requirements also govern the location, construction, arrangement, and protection of the facility. These commercial facilities are areas under direct onsite supervision by BATF inspectors. The law also requires that in order for alcohol to be removed from the facility free of tax, it must be denatured; this denaturation renders the alcohol unfit for beverage use.

The second type of DSP, the experimental facility, is authorized by law to produce alcohol for experimental or developmental purposes only; no alcohol

TABLE 4-2. PROJECTED MAXIMUM ALCOHOL PRODUCTION FROM U.S. BIOMASS RESOURCES[a]
(billion gallons per year)

	1980		1985		1990		2000	
Biomass Source	Ethanol	Methanol	Ethanol	Methanol	Ethanol	Methanol	Ethanol	Methanol
Wood	23.5	86.3	21.8	80.2	20.2	74.2	25.8	95.0
Agricultural residues	9.1	33.4	10.3	38.1	11.3	41.5	13.1	48.1
MSW	2.2	8.6	2.3	9.2	2.5	9.9	2.9	11.6
Subtotal	34.8	128.3	34.4	127.5	34.0	125.6	41.8	154.7
Sugars	--	--	0.4	--	3.7	--	9.0	--
Grains	3.9	--	3.8	--	2.8	--	2.3	--
Food processing wastes	0.5	--	0.6	--	0.7	--	0.7	--
Subtotal	4.4	--	4.8	--	7.2	--	12.2	--
Total	39.2	128.3	39.2	127.5	41.2	125.6	54.0	154.7

[a]Reference 4-1

may be sold or given away. Generally the duration of the operating permit is 2 years. Because of these limitations, the experimental DSP is not subject to the extensive controls and requirements mandated for a commercial facility.

In the first 7 months of 1979, BATF received over 2,000 applications for experimental DSP's. All of these applications were for production of fuel-grade alcohol, and most were by individuals who wanted to produce fuel-grade alcohol for their personal use. Although it is not clear if the use of the experimental provision was intended for the production of fuel-grade alcohol, BATF has moved to approve these applications since there is no other provision under current law, and they do not wish to hinder the production of fuel-grade ethanol.

In an effort to provide a long-term solution to regulation of the production of fuel-grade alcohol, BATF has presented to Congress changes to the Internal Revenue Code. The submitted proposal will provide BATF with the flexibility required to meet the needs of the alcohol fuels industry. The proposed changes establish a third type of DSP, the fuel producer.

Under the proposed plan, the fuel producer will be regulated in direct proportion to the danger of loss of revenue, based on production. There will be three categories, or sizes, of producers. They are:

- Small producers -- producing less than 5,000 (100 proof) gallons of alcohol per year

- Medium producers -- producing less than 100,000 (100 proof) gallons of alcohol per year

- Large producers -- producing over 100,000 (100 proof) gallons of alcohol per year

While specific regulatory controls will vary at each level of production, all fuel alcohol plants will be required to: file a simplified application; denature their alcohol; maintain security necessary to prevent diversion of alcohol to uses other than fuel; and maintain limited records with respect to production and disposition of the alcohol. The small producer would not be required to file a surety bond, but the medium and large producers will.

Commercial distillers are currently required to denature alcohol using specified formulae requiring substances such as gasoline, kerosene, and other chemicals. Denaturation must be conducted under the direct supervision of BATF inspectors or through metered systems. Under the proposal, BATF will work with the fuel producer to develop an acceptable formula that will meet the needs of the individual producer.

As previously mentioned, the primary responsibility of BATF is to protect revenues. However, BATF has certain responsibilities under the National Environmental Policy Act (NEPA) of 1969, the Federal Water Pollution Control Act of 1972 (FWPCA) as amended in 1977, and the National Historic Preservation Act (NHPA) of 1966 as amended. BATF has published a handbook on environmental protection that serves as a guideline for BATF personnel to ensure compliance with the above mentioned laws. The IERL program for gasohol calls for publication of an Environmental Operations Manual to guide BATF as to what environmental questions to examine when issuing permits for a DSP. In practice it will also serve as a guide to farmers on how to manage wastes from their on-farm processes. This manual will be a cooperative effort between BATF and EPA.

REFERENCES FOR SECTION 4

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