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Environmental Development Plan (EDP)

Magnetohydrodynamics Program

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FY 1977

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U.S. Department of Energy
Assistant Secretary for Energy Technology
Assistant Secretary for Environment

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Environmental Development Plan

for the

Magnetohydrodynamics Program

September 1977

Energy Research and Development Administration

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FOREWORD

Environmental Development Plans (EDP's) were conceived and prepared as basic documents for planning and managing environmental requirements of energy technology development. Approximately 30 EDP's covering major developing energy technologies were prepared prior to the establishment of the Department of Energy (DOE). Elements of various organizations were involved in the preparation and review of these plans but reorganization of program responsibilities has made it impossible to complete the formal review and concurrence process as originally planned.

These EDP's are now being distributed so that all having interests and responsibilities may assist in a revision and update which we plan to initiate in DOE along with preparation of EDP's covering environmental aspects of additional DOE programs.

James L. Liverman
Acting Assistant Secretary
for Environment

Robert D. Thorne
Acting Assistant Secretary
for Energy Technology

PREFACE

The Environmental Development Plan (EDP) is the basic environmental planning document identifying environmental issues and scheduling suggested related research, analysis, and other activities for energy systems being developed by ERDA. Both the Assistant Administrator for Fossil Energy and the Assistant Administrator for Environment and Safety have research, development and demonstration (RD&D) programs for which they are separately responsible and to which the EDP is a joint input. The EDP is a common basis for planning environmental programs and is one component (along with Program Plans, Program Approval Documents, etc.) of the overall program planning, budgeting, and review (PPBR) cycle which determines the actual funding of environmental activities.

To supplement this document, some of the current and completed environmental research projects related to MHD are included under separate cover as Attachment A.

The EDP was cooperatively coordinated by staff of Fossil Energy (AFE) and Environment and Safety (AES) and was prepared by representatives from the Division of Environmental and Socioeconomic Programs (AFE) and the Division of Technology Overview (AES). Staff from the following organizations assisted:

The Montana Energy and MHD Research and Development Institute, Inc., Butte, Montana

Energy and Environmental Analysis, Inc., Arlington, Va.

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The Mitre Corporation

Argonne National Laboratory

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1. INTRODUCTION

1.1 Legislative Background

The Energy Research and Development Administration (ERDA) is responsible for researching, developing, and demonstrating new energy technologies in order to provide a broad range of environmentally acceptable energy choices for the future. In the Energy Reorganization Act of 1974[1/] and the Federal Nonnuclear Energy Research and Development Act of 1974,[2/] Congress emphasized the importance of environmental issues in making decisions and required that energy technologies developed by ERDA be environmentally acceptable. In addition, the National Environmental Policy Act of 1969[3/] (NEPA) requires that Federal agencies consider the potential environmental effects of their proposed actions at the earliest possible time. As a result of these mandates, ERDA recognizes that it must identify, assess, and control potential harmful environmental impacts of its developing energy technologies and integrate environmental considerations into decision-making at all stages of technology development.

1.2 Purpose

On December 14, 1976, ERDA issued Immediate Action Directive (IAD) #0500-4 initiating the Environmental Development Plan (EDP) process. EDP's are the basic ERDA planning documents for the planning, budgeting, managing, and reviewing of the broad environmental implications of each energy technology alternative. EDP's are designed to provide the framework for the following:

1. Incorporating environmental considerations into agency planning processes at the earliest stages;

2. Resolving environmental issues concurrently with energy technology development; and

3. Assuring that environmental issues are competitive with technological, economic, and institutional issues in decision-making.

This magnetohydrodynamics (MHD) EDP identifies and examines the environmental, health, and safety issues concerning the development of the ERDA Magnetohydrodynamics Program, the environmental activities needed to resolve these issues, applicable ongoing and completed research, and a time-phased action plan for the

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evaluation and mitigation of environmental impacts. A schedule for environmental research, assessment, and other activities is laid out. The purpose of the EDP is to identify environmental issues and to specify actions to ensure the environmental acceptability of commercial energy technologies being developed by ERDA. The EDP also will assist in coordinating ERDA's environmental activities with those of other government agencies. This EDP will be updated and revised annually to take into account the progress of technologies toward commercialization, the environmental work accomplished, and the resolution of outstanding environmental issues concerning the technologies.

1.3 Scope

This document addresses the following technologies associated with ERDA's MHD program:

- Open-Cycle Magnetohydrodynamics;
- Closed-Cycle Plasma Magnetohydrodynamics; and
- Closed-Cycle Liquid Metal Magnetohydrodynamics.

For each developing technology, the EDP discusses the environmental, health, and safety issues which need to be addressed. The requirements and needs for new environmental research are defined and the environmental work program is laid out, taking into consideration work which has been accomplished or is underway. Environmental assessment activities mandated by NEPA (environmental impact statement -- EIS -- preparation) and the Federal Nonnuclear Energy Research and Development Act (water resource assessments) also are scheduled along with the collection of data needed by other Federal agencies (e.g., the Environmental Protection Agency -- EPA -- and the Occupational Safety and Health Administration -- OSHA).

The environmental, health, and safety problems considered in this EDP are limited to the fuel combustion process, electricity generation, and the emissions and impacts relative to air, water, human health, and the physical environment. The mining and transportation of coal and the end use of the power produced are outside the scope of this EDP. The seed regeneration unit and associated environmental controls unique to MHD are important and warrant assessment in future editions of the EDP when more information concerning selection of a seed regeneration system is available.

1.4 Organization

Section 2 describes the energy technology program being conducted by ERDA under the MHD Program. Each technology is described briefly, and a milestone chart for the major program, open-cycle MHD, is given. Section 3 discusses the environmental issues which may be anticipated from each technology and the requirements and research needs which are necessary to address these issues. Section 4 is the environmental action plan which describes ongoing and completed research and future research needs. Section 5 discusses ERDA's management strategy for conducting the environmental research program in coordination with the development schedule for each technology.

1.5 Executive Summary

The range of pollutants from an MHD system is expected to be similar to the range of those associated with direct combustion processes. However, due to the extremely high temperatures required in the MHD process as compared to the relatively low-temperature direct combustion technology, significantly different relative amounts of the various effluents will be emitted. Due to the higher overall plant efficiencies of an MHD/steam turbine power plant (50 percent or greater compared to about 33 to 40 percent for conventional coal-fired power plants), and due to the nature of the MHD process, pollutants such as SO_2, thermal discharges and solid wastes, and their associated environmental impacts are expected to be less per unit of electrical power produced than those from a conventional coal-fired power plant of comparable generating capacity.

Although the actual levels of air emissions are not yet established, preliminary work indicates that MHD has a low air pollution potential when proper control techniques are used. The open-cycle MHD process has a thermodynamic advantage for sulfur removal because the potassium seed injected into the combustion gas to increase its conductivity also combines with sulfur to form potassium sulfate, which precipitates out in the slag or can be removed by particulate control devices for eventual reprocessing and recycling. Experimental results indicate that SO_2 emissions can be controlled in this manner to levels well below existing New Source Performance Standards. The very high combustion temperatures used can result in the formation of greater quantities of NO_x and fine particles. The control of NO_x and fine particulate emissions is still to be resolved and is in an early stage of evaluation. The combustion conditions in the MHD process also indicate that emissions of CO and hydrocarbons will be very low.

For NO_x, combustion modification (e.g., initial fuel rich combustion, downstream adjustment of the fuel-air mixture to make it air rich, and increasing downstream residence time of the exhaust gas) are the preferred control techniques. Work should continue to ensure that NO_x can be controlled effectively at larger, more advanced facilities. For particulates, fabric filters and electrostatic precipitators are currently the most efficient control techniques for removing fine particulates. However, it is not yet certain whether they will be adequate to control the larger proportion of fine particulates expected from the open-cycle MHD process. The extent to which fine particle emissions will be a problem must be assessed, and if necessary, improved control technologies developed.

The water use and effluents related to MHD are expected to be similar to those from conventional coal-fired power plants. As at conventional power plants, most water used at MHD facilities is for cooling purposes; however, water use at MHD facilities is expected to be less due to MHD's higher thermal efficiency. Effluents will result from coal storage and preparation areas, boiler cleaning, wet cooling systems, if used, and feedwater treatment processes which are not unique to MHD, as well as from the MHD seed regeneration system. Water effluent streams must be characterized to ensure that they do not contain any unexpected hazardous pollutants or excessively high potassium levels.

MHD solid wastes should consist of slag, fly ash, and spent seed material containing primarily unrecoverable potassium compounds and inorganic elements from coal. Regeneration of spent seed for reuse, for economic as well as environmental reasons, will reduce the quantity of solid waste requiring disposal.

Many of the occupational health and safety hazards that can occur at MHD facilities will be similar to those of conventional coal-fired power plants, and can be mitigated by following good operating and safety procedures. The unique hazards which may pose a threat to the health of workers in MHD facilities are exposure to magnetic fields, noise, vibration, and fine particulates containing toxic trace elements and seed material. While adverse effects of magnetic fields on human health have been reported, no clear-cut information exists on dose-response relationships. This area requries immediate attention. Because of the unique characteristics of MHD facilities and the general spontaneous combustible nature of coal dust, the primary safety hazards may be explosion, fire, or the potentially hazardous high voltage.

Many of the above issues are presently being studied; however, several of these issues will require further assessment and research and development to determine their significance and to develop methods to control or mitigate adverse environmental impacts. In defining work which needs to be carried out to ensure the environmental acceptability of MHD technology development, ongoing and completed research has been considered. An integrated environmental action plan is presented in this document as a guide to the type and level of work which needs to be conducted in response to the environmental health and safety issues and requirements identified for the developing MHD technology.

The proposed environmental action plan is designed to meet the following objectives:

- develop methods for monitoring and measuring emissions;
- characterize air emissions, water effluents, and solid wastes from MHD;
- determine potential environmental impacts and health hazards associated with MHD;
- model pollutant transport and transformation;
- ensure adequate control of pollutant emissions;
- identify and minimize occupational health and safety hazards;
- prepare NEPA compliance documents; and
- assess the environmental, health, and safety impacts of the commercialized industry.

Seventeen projects have been proposed that would resolve these issues in a time frame consistent with the technology development milestones. The actual scheduling and scope of work carried out at specific MHD facilities, however, will be determined during implementation of this plan.

2. TECHNOLOGY OVERVIEW

2.1 Background

Magnetohydrodynamics (MHD) is a mid-term, energy alternative in which electricity is generated directly from thermal energy, thus eliminating the conversion step of thermal to mechanical energy encountered in conventional steam electric generators. The efficiency of the combined MHD/steam plant is predicted to be about 50 percent or greater, as compared to 33 to 40 percent for conventional fossil-fueled power plants.

There are three types of MHD systems: open-cycle, closed-cycle plasma, and closed-cycle liquid metal. In all of these systems, an electrically conductive fluid (either gaseous or liquid) is passed through a magnetic field, thereby inducing a voltage drop across the gas stream. Electrodes convey the electricity to an inverter where the direct current power naturally produced by the system is transformed to alternating current, which can be transmitted directly into an electric power grid. A combined open-cycle MHD/steam generator system offers the greatest potential to improve electricity generation plant efficiency and cost performance.

Initial development of MHD began during the late 1950's. Programs exist both in this country and abroad, notably in Japan and the U.S.S.R. The basic distinction between the U.S. and foreign programs is the emphasis abroad on "clean" fuels usage; that is, natural gas in the U.S.S.R. and fuel oils in Japan. In the United States, emphasis is on coal as the primary fuel. The abundance of domestic coal and the simplicity with which it can be used, make it an attractive candidate fuel for MHD power generation.

MHD could be commercially available in the late twentieth century. ERDA has the lead in MHD development in the U.S., but other government agencies such as the Environmental Protection Agency, the National Science Foundation, the National Aeronautics and Space Administration, and the Office of Naval Research, as well as the Electric Power Research Institute in the private sector, also fund research on various aspects of MHD development and impacts.

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2.2 MHD Technology

2.2.1 Open-Cycle MHD

MHD power generation is based on the direct conversion of heat to electricity by passing a high temperature, high velocity, electrically conducting fluid through a magnetic field. The principle is similar to a conventional turbine-generator system, the difference being that the rotating conductors of a turbo-generator are replaced by a partially ionized combustion gas which is accelerated to interact with the magnetic field. The interaction of the accelerated conducting fluid with the intense transverse magnetic field induces an electric field within the fluid. If electrodes are present to collect the current, then electric power can be supplied through an inverter to a utility power grid. (See Figure 2-1.)

By seeding the combustion gas with easily ionized materials such as potassium or cesium, the electrical conductivity sufficient for the process can be obtained at somewhat lower temperatures (4500°-$5000^{\circ}F$) than would be required otherwise. From an economic as well as environmental standpoint, potassium -- in the form of potassium carbonate (K_2CO_3) -- is the preferred seed material for open-cycle MHD. The potassium seed not only enhances the conductivity of the combustion gas but also provides a unique built-in capability for removing sulfur products released during the combustion of sulfur-bearing fuels (in particular, high sulfur coal). The potassium seed reacts preferentially with the sulfur at high temperatures and later precipitates out as potassium sulfate (K_2SO_4) when the combustion gas cools. The potassium sulfate can be removed from the system along with the ash by particulate control devices and then be regenerated to yield potassium carbonate, which is recycled.

A typical open-cycle MHD topping cycle with a conventional steam turbine bottoming cycle is illustrated schematically in Figure 2-2. Preheated, compressed air and fuel are burned in a fuel-rich environment under pressure and at very high temperatures (4500°-$5000^{\circ}F$) in the combustor. The seed is injected, and the combustion gas/seed mixture is fed into the MHD channel which produces DC electrical power which is then converted to AC power. The combustion gases then pass through a diffuser where the remaining kinetic energy is recovered. The exhaust gases leaving the MHD generator are still at high temperatures (3300°-$3700^{\circ}F$). This residual heat can be utilized downstream of the MHD generator to generate additional power in conventional steam or gas turbine power plants. To recover this waste heat for downstream use, the combustion gas is passed through a radiant steam boiler where

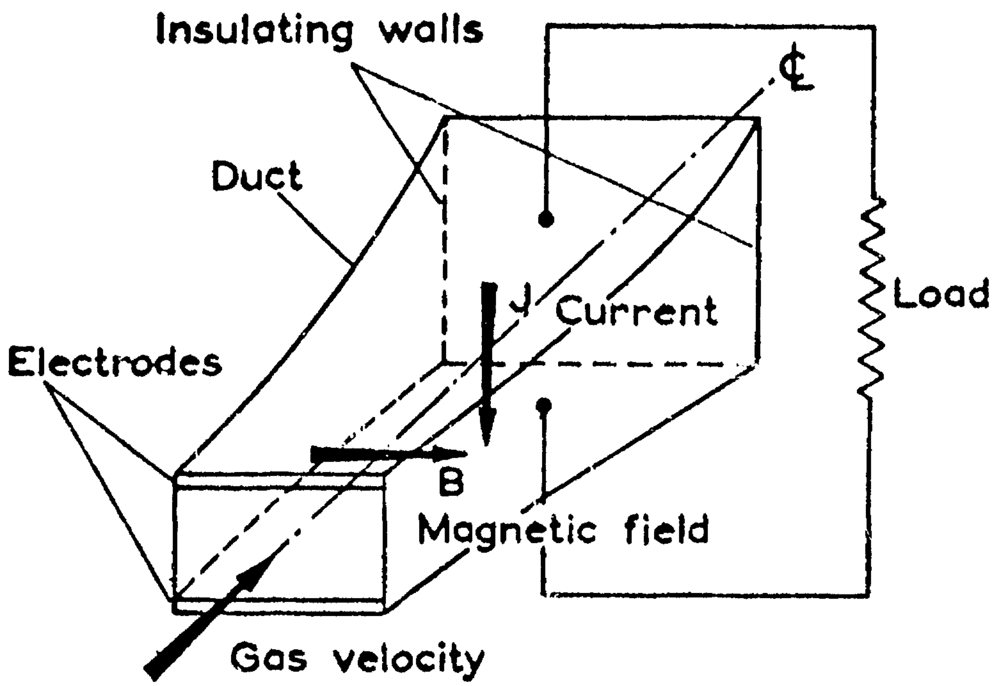


FIGURE 2-1 SCHEMATIC ARRANGEMENT OF AN MHD DUCT

the gas is cooled slowly to reduce NO_x to an acceptable level before additional air is added and combustion is completed. The combustion gas then flows to the air preheaters where heat is extracted and used to preheat the air which is fed to the combustor. Heat from the walls of the radiant boiler is used to heat steam, which then is super-heated and used in the steam turbines. Most of the spent seed is condensed from the gas as potassium sulfate. After leaving the air and steam heaters, most of the combustion gases flow through the economizers and to particulate control devices where additional seed material is collected before leaving the stack.

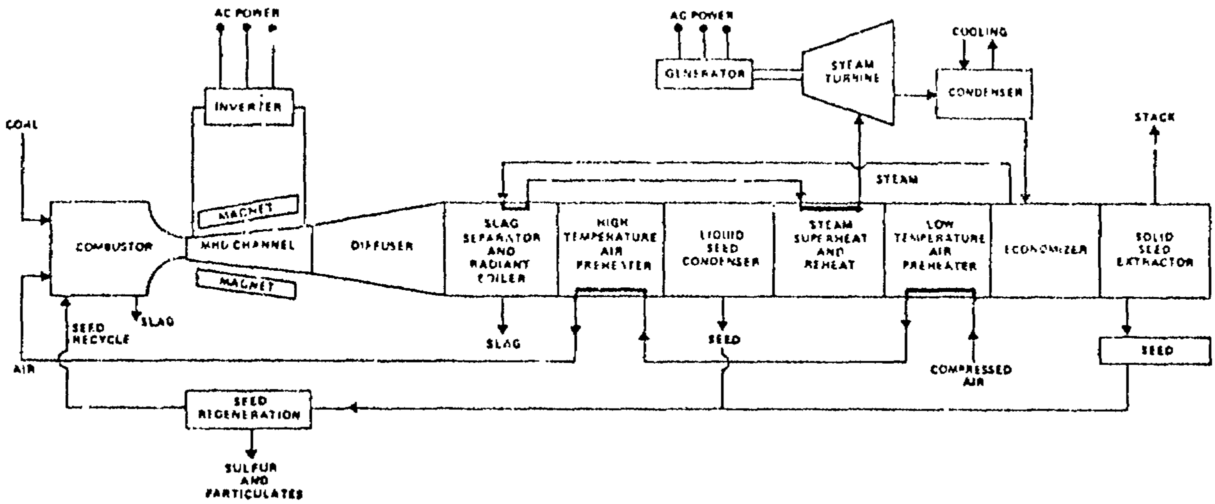
2.2.2 Closed-Cycle MHD

In the closed-cycle MHD processes the basic energy conversion process is the same as that for open-cycle MHD (i.e., motional electromagnetic induction). However, in the closed-cycle processes, the working fluid is in a closed-loop system and receives the heat energy indirectly from a primary source through a heat exchanger. The primary heat source can be from the combustion of coal, other fossil fuels, or from a nuclear reactor. Because the working fluid is recycled in closed-cycle systems, there is more latitude available in choosing the working fluid and in obtaining electron densities that give sufficient conductivity. As a result, somewhat lower temperatures than those required in open-cycle systems are necessary to obtain sufficient conductivity for the MHD process. The extraction of thermal energy from the working fluid and its conversion to electricity in an MHD channel and conventional steam-bottoming plant are similar for open- and closed-cycle systems. There are two major approaches to closed-cycle MHD technology: plasma systems and liquid metal systems.

In a closed-cycle plasma MHD system, the working fluid is a noble gas, such as argon, which is seeded with an easily ionized material such as cesium. Figure 2-3 is a schematic diagram of a closed-cycle plasma MHD system. Air is preheated prior to entering the combustor. The hot combustion gas is ducted to heat exchangers which transfer heat to the argon working fluid. After leaving the heat exchangers, the combustion gas passes through an air preheater prior to being exhausted out the stack. Argon is the working fluid used in the MHD loop. The argon gas is expanded through a nozzle where it is seeded with cesium. The argon/cesium gas passes through the MHD generator which, as in open-cycle MHD, produces DC power. After passing through a diffuser, the gas flows through an unfired steam generator. The cesium is condensed into liquid in the precooler, purified, and then reinjected at the nozzle. The argon is

FIGURE 2-2

OPEN-CYCLE COAL-FIRED MHD SYSTEM



SOURCE: Fossil Energy Research Program of the Energy Research and Development Administration, FY 1978, ERDA 77-33, April 1977 compressed, purified, and recycled to the high-temperature heat exchanger. The steam turbine plant produces substantial electric power and drives the argon compressor.

Liquid metal systems are very similar to closed-cycle plasma systems, with one major exception: a gas-liquid metal froth is used as the working fluid rather than a noble gas. Liquid metal systems have high electrical conductivities compared to totally gaseous systems, the possibilities of lower temperatures, and the applicability of lower magnetic fields. As a result, a smaller plant and higher extraction efficiencies may be possible. Figure 2-4 is a schematic diagram of a liquid metal MHD system. The pressurized liquid metal (usually sodium) is heated to peak cycle temperature in an externally heated heat exchanger fired by a fluidized-bed coal combustor and then flows to a mixer where heated helium is injected as a uniform dispersion of bubbles. Heat is transferred from the liquid to the gas, resulting in nearly isothermal expansion as the fluid passes through the MHD generator. After leaving the generator, the gas and liquid are separated and the liquid is recirculated back to the mixer. The gas passes through the diffuser to a steam bottoming plant where its heat is utilized. The helium then is compressed and recycled to the heat exchanger and the mixer.

2.3 ERDA's MHD Program

The relationship of the MHD program to ERDA's Fossil Energy Program is illustrated in Figure 2-5. ERDA's MHD program is directed toward the attainment of a major ERDA Fossil Energy goal: to more effectively utilize coal directly in the production of electrical power. MHD power generation offers three potential advantages of major significance to the National Fossil Energy Program:

1) Direct conversion of the thermal energy of coal to electrical power;

2) Improved overall coal pile-to-busbar power conversion efficiencies; and

3) Unique characteristics which can potentially minimize environmental effects.

The current MHD subprogram is directed primarily toward the development of the open-cycle, coal-fired MHD system and is based on supporting science and technology activities, including laboratory scale testing and preliminary engineering studies. The

FIGURE 2-3
SIMPLIFIED SCHEMATIC OF CLOSED CYCLE INERT GAS MHD TOPPING CYCLE

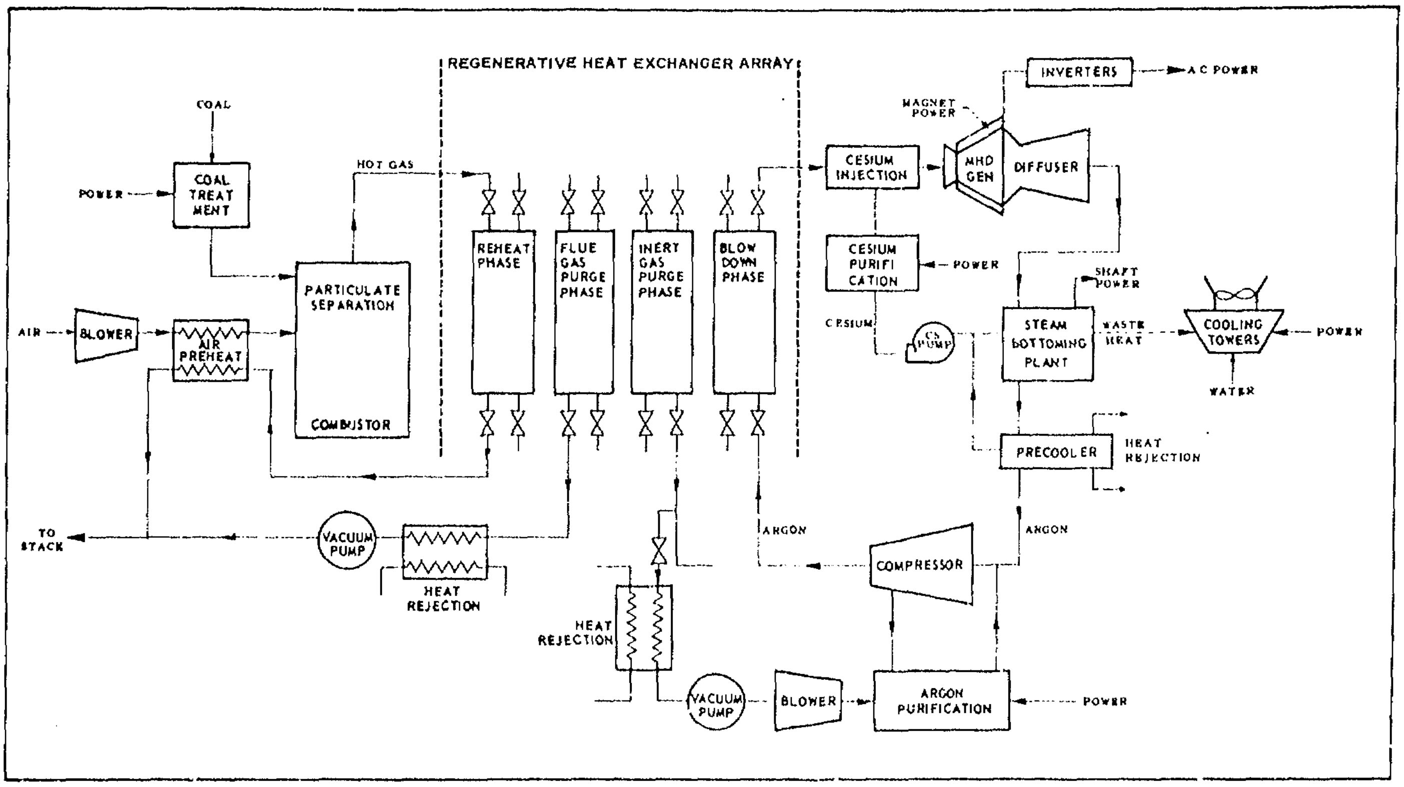
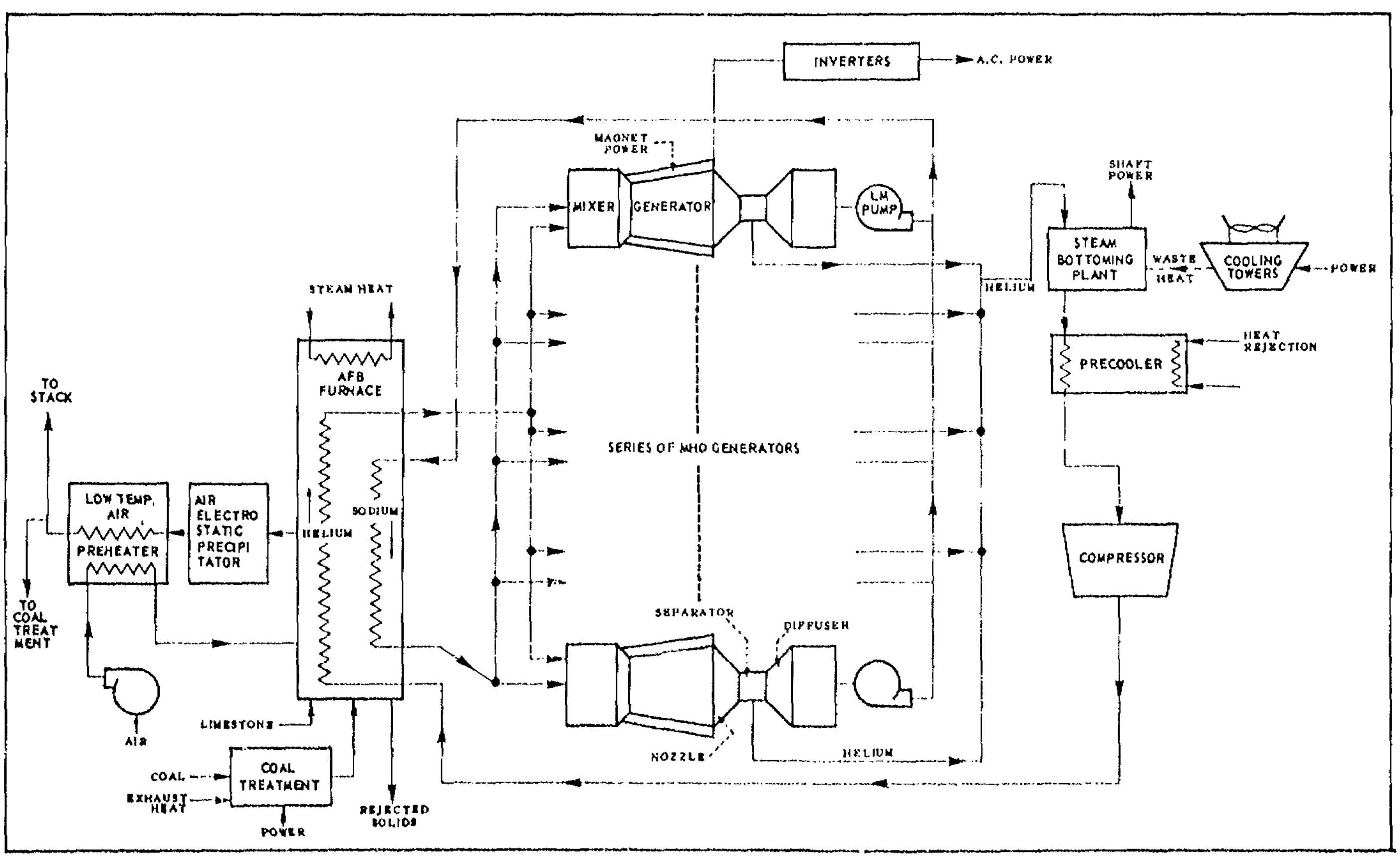


FIGURE 2-4
SIMPLIFIED SCHEMATIC OF CLOSED CYCLE LIQUID METAL MHD TOPPING CYCLE FIRED BY FLUIDIZED COMBUSTOR



SOURCE: Jackson, W.D., "MHD Electrical Power Generation; Prospects and Issues," AIAA Paper No. 76-309, AIAA 9th Fluid and Plasma Dynamics Conference, San Diego, Calif., July 14–16, 1976.

closed-cycle concept is not as technically advanced as the open-cycle technology, and near-term closed-cycle work will emphasize basic research and feasibility, experimental, and system evaluation studies.

The primary objective of the Magnetohydrodynamics Program is to develop the technology required to build and operate safely an economically and environmentally acceptable coal-fired, commercial-scale, demonstration MHD electric power plant. To achieve this objective, two major interim objectives have been established:

- The near-term objective (1985) of the MHD Program is to design and test MHD components and subsystems, and to integrate these into complete system tests to be conducted in a pilot-scale engineering test facility.

- The mid-term objective (2000) of the MHD Program is to continue development of the MHD technology to improve the performance, reliability, and benefits to demonstrate the readiness for commercialization of MHD in the 1990's.

These interim technical objectives can be verified before large expenditures are made for commercial-scale power plants.

The program strategy is to progress through three overlapping phases of development, each focused on specific development requirements for commercial application (see Figure 2-6). The first two phases relate to engineering development, and the third phase is the demonstration phase for commercial feasibility for power station applications in baseload and/or intermediate service. The major objectives of ERDA's MHD test facilities are summarized in Table 2-1. Figure 2-7 illustrates the relationship of supporting facilities to the three phases of MHD facility development. Engineering and environmental data developed at these facilities will be useful in making decisions regarding the development of ERDA's MHD program. Figures 2-8 and 2-9 summarize the MHD program milestones.

Supporting facilities which currently provide engineering data include: the University of Tennessee Space Institute (UTSI), Pittsburgh Energy Research Center, Westinghouse Research Laboratories, Reynolds Metals, and the U.S.S.R. U-02 facility. The University of Tennessee MHD test facility at Tullahoma is supplying data on small scale (relative to the CDIF), directly coal-fired MHD generators with 100 percent ash carryover. AVCO/Everett Laboratory, using oil-fired combustors with coal slag

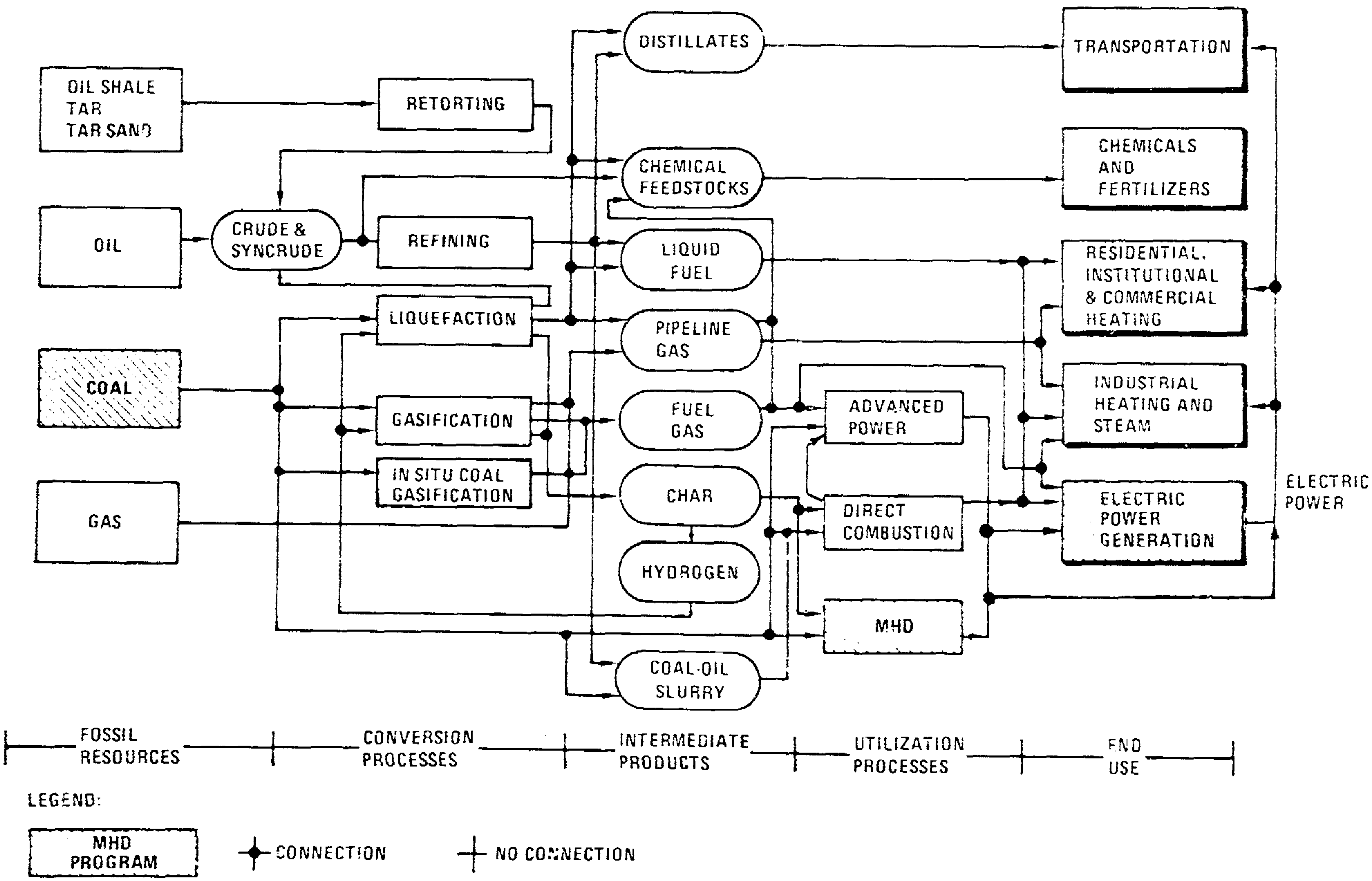


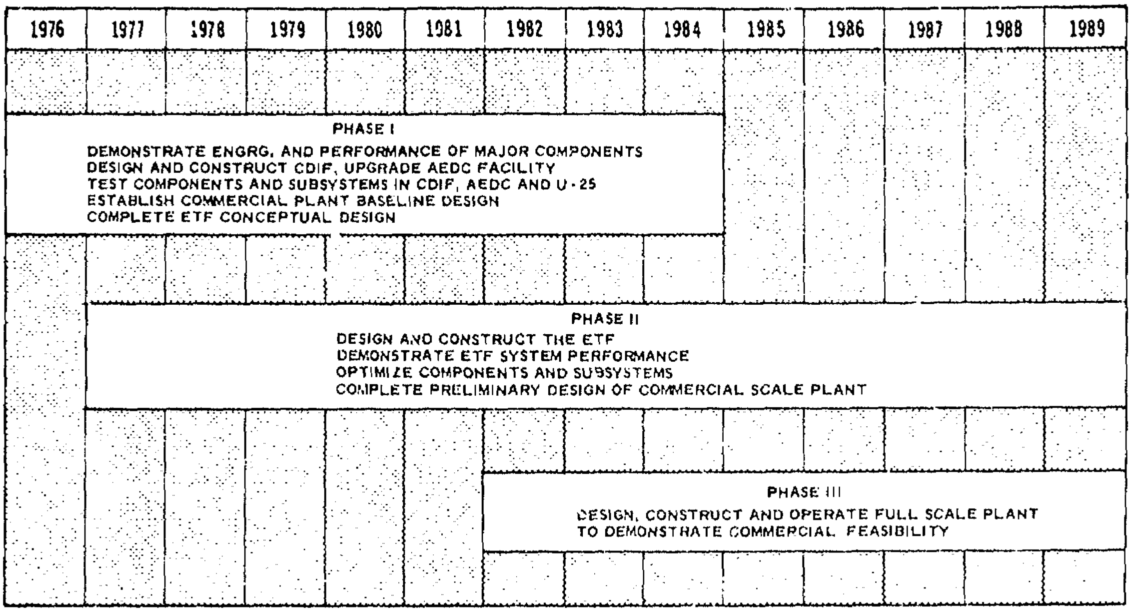
FIGURE 2–5 ERDA FOSSIL ENERGY PROGRAM SUMMARY

TABLE 2-1
OBJECTIVES OF ERDA's MHD FACILITIES

TEST FACILITY	OBJECTIVES
Component Development and Integration Facility (CDIF)	• Test Components in 50 MW_t Range • Test Individually or in Subsystem Test Train • Verify MHD/Steam Cycle Components
Engineering Test Facility (ETF)	• Provide Design and Operation Data for MHD/Steam Power Plant • To Verify Component Performance at 250 MW_t Scale at Commercial Operating Durations • Provide Scale-up Data for MHD Baseline Plant • Provide Advanced Systems Integration
Commercial Demonstration (CDP)	• Demonstrate Direct Coal-Fired, Open-Cycle MHD Power Generation Ready for Commercial Application

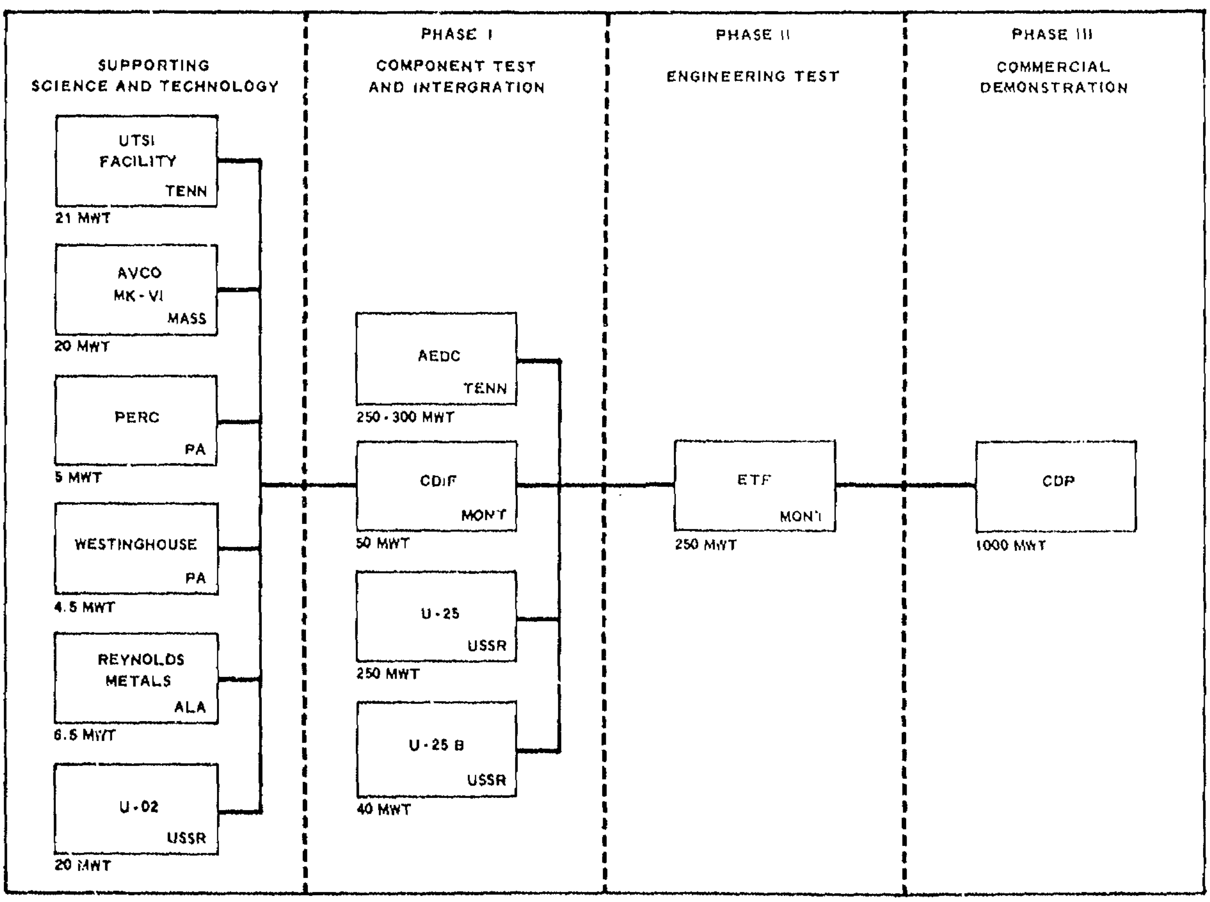
Source: Jackson, W.D., "MHD Electrical Power Generation: Prospects and Issues," AIAA Paper No. 76-309, AIAA 9th Fluid and Plasma Dynamics Conference, San Diego, California, July 14-16, 1976.

FIGURE 2-6
MAJOR MAGNETOHYDRODYNAMICS DEVELOPMENT PHASES



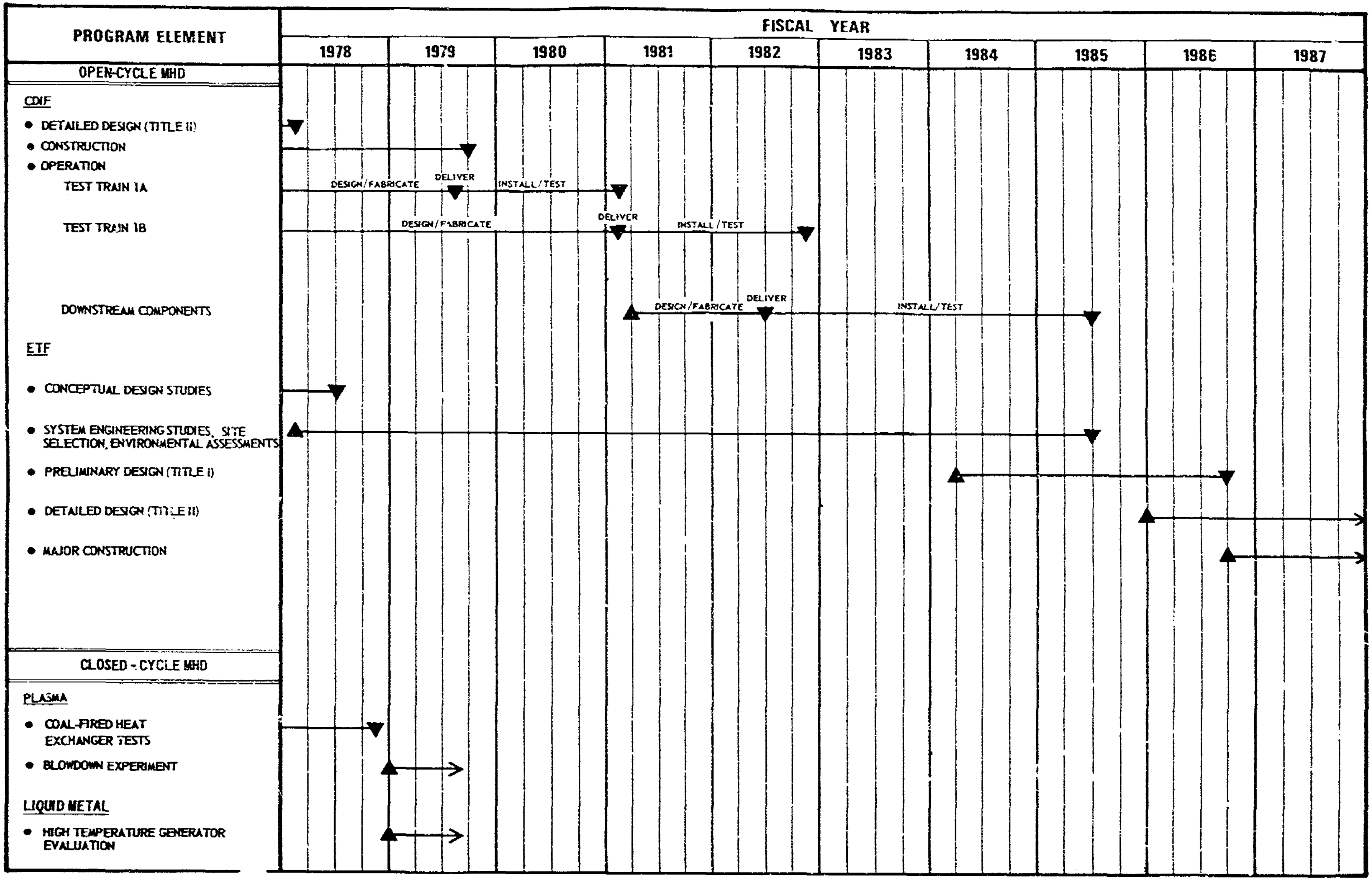
SOURCE: ERDA, Draft Program Plan for Magnetohydrodynamics, August 15, 1977.

FIGURE 2-7
MHD FACILITIES DEVELOPMENT SEQUENCE



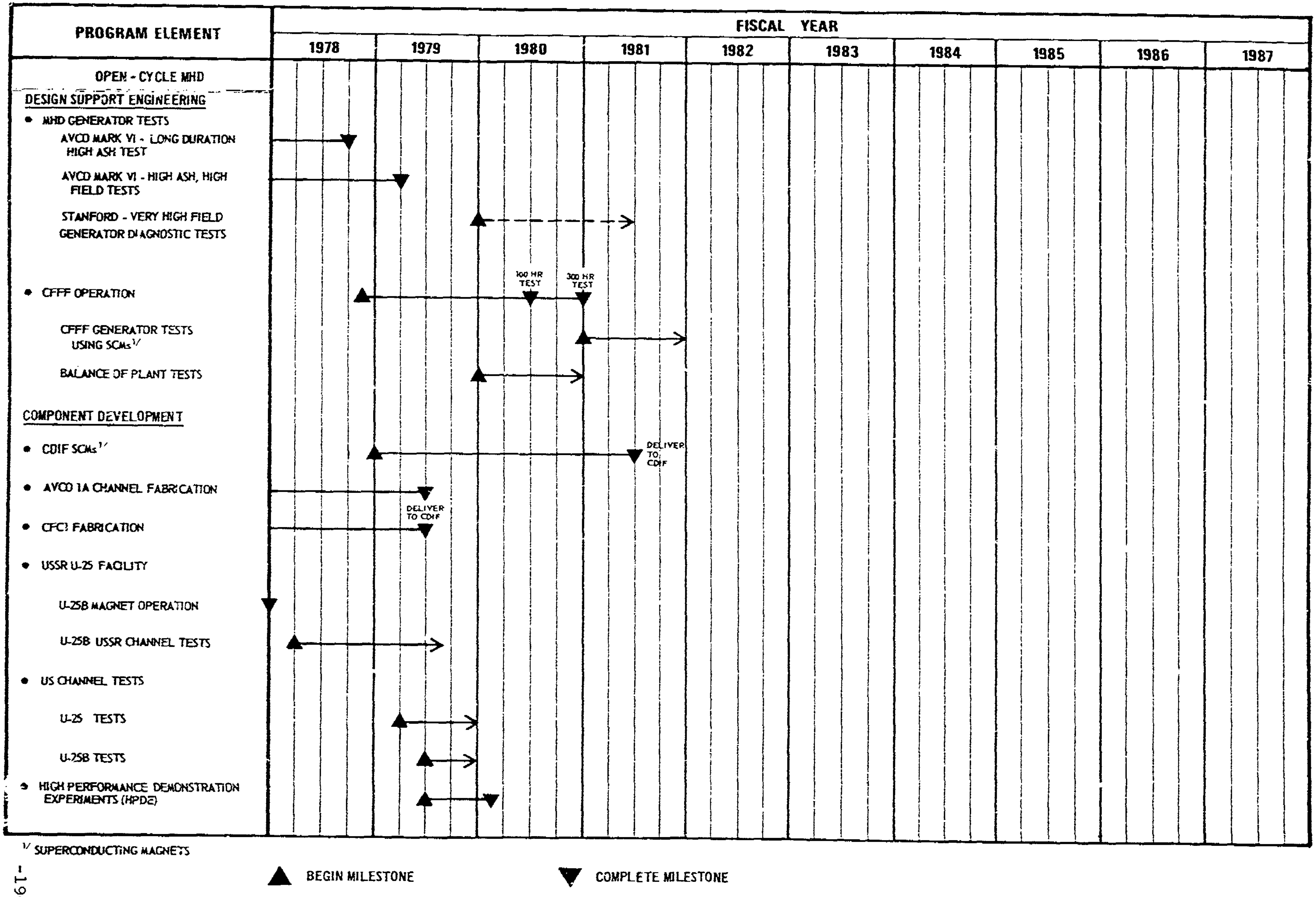
SOURCE: ERDA, Draft Program Plan for Magnetohydrodynamics, August 15, 1977.

FIGURE 2-8
MHD TECHNOLOGY MILESTONES



▲ BEGIN MILESTONE ▼ COMPLETE MILESTONE

FIGURE 2-9
MHD PROGRAM SUPPORTING ACTIVITIES



injection in their Mark VI facility, is testing various channel designs and performing supporting activities. Pittsburgh Energy Research Center (PERC) is conducting design and testing research on multi-stage coal combustors. Others have contributed to evaluation of materials under simulated coal-fired MHD conditions. These include Westinghouse Research Laboratory near Pittsburgh and Reynolds Metals facility in Alabama. The Institute of High Temperatures of the Soviet Academy of Sciences in Moscow operates the U-02 facility which is available for limited testing through the U.S.-U.S.S.R. cooperative program. Recently the U-25 facility has also been made available.

2.3.1 Phase I - Component Development and Integration

Phase I is based on the preliminary engineering information derived from smaller scale prior activities and is centered on the engineering development, integration, and testing of major components and subsystems in the Component Development and Integration Facility (CDIF). The major components and subsystems to be evaluated are coal processing and feed systems, combustors, generators, superconducting magnets, control systems and inverters, seed/slag management systems, and radiant boilers. The purpose is to develop and test MHD and supporting flow train components at approximately the 50 MW_t level. From engineering data thus obtained, a pilot scale facility of about 250 MW_t capacity can be designed as the next step.

The testing in the CDIF initially is planned to consist of Phase 1A and 1B, and will begin in FY 1979. Phase 1A will use a conventional magnet and a power channel. One bay (Phase 1A) will use an oil-fired, slag injected combustor. The second bay (Phase 1B) will use a coal-fired combustor and a superconducting magnet. Future testing may include a second phase, Phase 2, which will test advanced versions of the hot gas test train. All channel testing will be performed using a superconducting magnet. Components downstream of the generator will also be added and tested, including a steam boiler, other heat exchangers, and a slag-seed removal system. High temperature air preheaters will also be tested in this phase. This system will be used for evaluating subprototype ETF components, closing various thermodynamic loops, simulating ETF system operation, identifying system control requirements, and training ETF operators. The CDIF will be operated for limited periods (up to 100 hours), and a life of fifteen years is envisioned.

2.3.2 Phase II - Engineering Test

The primary purpose of Phase II is the design, construction, and operation of a fully integrated, combined-cycle MHD/steam system pilot-scale demonstration plant of approximately 250 MW_t which has been designated as the Engineering Test Facility (ETF). The size of the ETF is considered to be the minimum necessary to provide a reliable demonstration of the overall operational capabilities of an MHD system at a power level and duration which can be scaled to electric utility base load service. The necessary environmental assessments and impact statement will be prepared.

The specific goals of the ETF are: 1) to test a coal-fired combined MHD/steam system in an integrated configuration, 2) to provide design and operation data appropriate for scale-up to a commercial demonstration plant, 3) to evaluate component interactions, control characteristics, and performance capabilities, and 4) to establish environmental performance.

The ETF will consist of an MHD system including a coal processing and feed system, high temperature air heaters, MHD generator channel, superconducting magnet, inverter, bottoming steam plant, slag removal system, seed recovery and regeneration system, cooling systems, and pollution control systems.

2.3.3 Phase III - Commercial Demonstration

The commercial feasibility will be demonstrated in Phase III with the Commercial Demonstration Plant (CDP), if needed. This will be a complete plant as expected in actual commercial operation. The size of the plant will be between that of the ETF and a regular commercial version based on the data obtained at the ETF.

The plant as a whole may not be much different than the ETF from the components point of view, but the size of the components will be larger. It is anticipated that some systems problems may occur due to the physical size of the components.

2.3.4 International Programs

The program is based on the complementary nature of the development of MHD in the U.S. and the U.S.S.R. In the U.S., emphasis in MHD has been in gaining a scientific understanding of the process and through this, learning how to predict the behavior of the key components, especially the MHD generator channel itself. In the Soviet Union, emphasis has been on the modeling and construction of plants of increasing size and complexity. A further balancing factor is the concentration by the Soviet Union on natural gas as a fuel for MHD while the U.S. emphasis has increasingly moved to the utilization of coal as the primary fuel. The objectives of the cooperative program are to obtain jointly as much engineering experience as possible, utilizing both U.S. and Soviet facilities where practical for testing components and materials, and to share the techniques developed for the analysis of key MHD components. Two significant installations developed in the Soviet Union are the U-02 MHD systems test facility and the U-25 MHD pilot plant, both located in Moscow.

The Joint NEA/IAEA International Liaison Group on MHD electrical power generation consists of 19 nations which meet at regular intervals for exchange of information. There are now bilateral and multilateral agreements between individual scientists as well as scientific organizations in a number of countries.

3. ENVIRONMENTAL, HEALTH, AND SAFETY ISSUES AND REQUIREMENTS

3.1 Introduction

The consideration of environmental, health, and safety problems created by an emerging technology should proceed in parallel with the development of the technology itself. This section discusses the major environmental impacts expected to result from the technologies being developed in the Magnetohydrodynamics (MHD) Program and identifies the major issues which need to be addressed to resolve potential environmental problems. The definition and appreciation of these issues is prerequisite to the planning and structuring of any efforts to mitigate adverse environmental impacts and to assure a safe work environment. This discussion is followed by a summary of the research requirements necessary to ensure the environmental acceptability of the ERDA MHD technologies at all stages of their development.

Congress has passed laws designed to protect aspects of the environment potentially affected by energy development. These laws must be considered in any assessment of energy-related environmental impacts, since widespread commercialization will be predicated on the ability of evolving energy technologies to meet national standards and criteria. Federal environmental legislation and its applicability to MHD are listed in Appendix A at the end of this document.

The environmental impacts of any energy technology can be grouped into four general classes: 1) pollutant releases; 2) physical disturbances; 3) socioeconomic disturbances; and 4) environmental, health and safety impacts. Air emissions and water effluent streams may affect air and water quality in the general area of the facility site; solid wastes generated during coal combustion, effluent control, and seed regeneration will require effective, environmentally acceptable methods of disposal. Physical disturbances may include the impacts of water use, the appropriation of land area for disposal of solid wastes, the generation of noise and/or odors, and the potential disruption of local ecosystems. Socioeconomic disturbances can include a wide range of impacts on social, political, and economic structures. Effluents from energy facilities may affect the health and safety of both the workers and area residents. These areas of environmental concern are discussed in detail specific to MHD in the following paragraphs. Figure 3-1 presents a typical MHD process flow chart showing the sources and make-up of discharge streams, and Tables 3-1 and 3-2 summarize the potential environmental problems associated with the components in the CDIF and ETF, respectively.

Because open-cycle MHD technology has developed further than the closed-cycle plasma or liquid metal MHD technologies, and the ERDA MHD Program emphasizes open-cycle MHD, this discussion focuses primarily on the environmental concerns associated with open-cycle MHD. For closed-cycle systems under normal operating conditions, the effluents associated with coal combustion (e.g., SO_2, NO_x, hydrocarbons, CO, trace elements, particulates, ash residue, etc.) may be similar to those of conventional boilers and will not be discussed further.

3.2 Impacts and Issues

The range of pollutants from an MHD system is expected to be similar to the range of those associated with direct combustion processes. However, due to the extremely high temperatures required in the MHD process as compared to the relatively low temperatures of direct combustion technologies, significantly different relative amounts of the various effluents will be emitted. Due to the higher overall plant efficiencies of MHD power generation, less coal input is needed per unit electrical output; therefore, pollutants, such as SO_2 emissions, thermal discharges and solid wastes, and their associated environmental impacts are expected to be less than those from a conventional coal-fired power plant of comparable generating capacity. However, sufficient experimental data are not yet available to verify this. The following sections address known and anticipated environmental, health, and safety issues associated with MHD technology and are organized around the following problem areas:

- air emissions;
- water use and effluents;
- solid waste;
- control technology;
- occupational health and safety;
- general population health effects;
- effects on terrestrial and aquatic ecosystems;
- physical disturbances; and
- social, socioeconomic, and institutional considerations.

3.2.1 Air Emissions

The primary air emissions of concern are stack emissions, although fugitive emissions are a potential hazard to worker health and safety. At the higher

FIGURE 3-1 EFFLUENT STREAMS FOR A TYPICAL MHD POWER PLANT

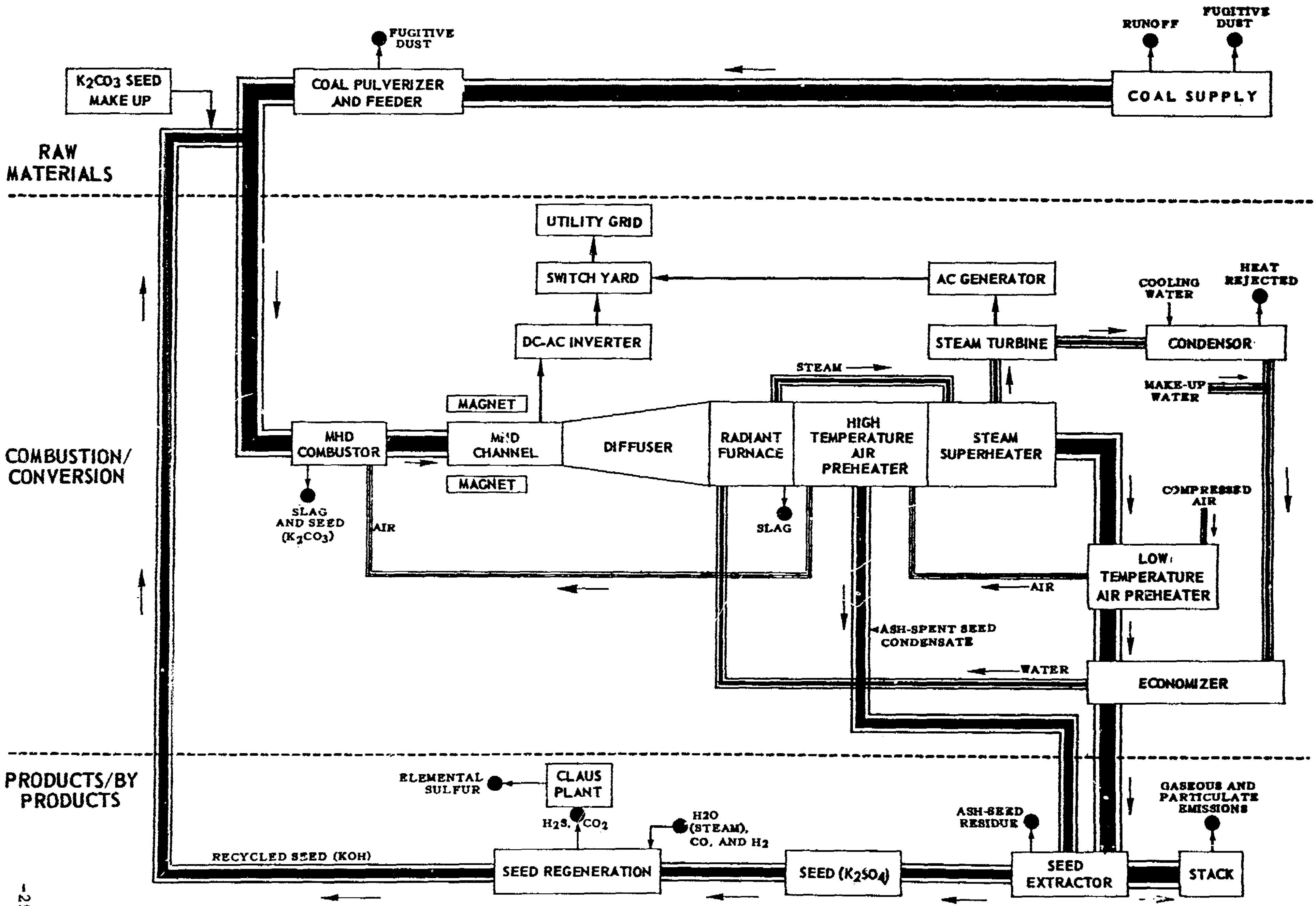


TABLE 3-1

POTENTIAL ENVIRONMENTAL PROBLEMS WITH MHD COMPONENTS--CDIF*

Acitivity or Component	Potential Environmental Problems to be Examined
Coal handling, preparation, and storage	Dust, particulate matter, noise, water vapor due to coal drying
Seed handling and preparation	Particulate matter, noise, fugitive dust
Compressors, coal and seed feed systems	Noise, vibrations, particulate matter, explosion hazard
Metallic heater (Low temperature pre-heater)	Noise, exhaust of combustion gases, (CO_2, CO, H_2O, SO_2, etc.)
Vitiated heater (High temperature pre-heater)	Noise, NO_x, CO_2, CO, H_2O, sulfur products, combustion products in main air supply, heat
Combustor (oil)	Noise, NO_x, CO_2, CO, H_2O, seed volatilization, sulfur products in main air supply, heat, explosion hazard
Combustor (coal)	Noise, NO_x, CO_2, CO, H_2O, slag, sulfur products, trace elements in gases, seed volatilization, particulate matter, hydrocarbons, explosion hazard
MHD Channel	Noise, products of erosion of electrodes and walls, molten slag and molten seed
Magnet	Effect on humans, safety problems
Exhaust gas cooling and clean-up systems	Exhaust gases, high water vapor, particulate matter, liquid and solid waste removal, trace elements, NO_x, if quick quench is used, scrubber sludge
Cooling towers	Cooling, water use, water vapor
Settling ponds	Water vapor, land use, disposal of solid waste

* For site specific problems see References 42 and 43.

TABLE 3-2

POTENTIAL ENVIRONMENTAL PROBLEMS WITH MHD COMPONENTS--ETF

Activity or Component	Potential Environmental Problems to be Examined
Coal handling, preparation and storage Seed handling and preparation Compressors, coal and seed feed systems	The same as in CDIF, except the components are larger in size and capacity
High temperature pre-heater	NO_x, slag
Combustor MHD channel Magnet	The same as in CDIF, except the components are larger in size and capacity
Radiant boiler(s) and slag separator	NO_x, slag deposition, seed material, slag removal
Liquid seed condenser	Seed separation and removal
Steam superheat and reheat Low temperature air-preheater Economizers	Standard steam plant components, erosion and corrosion due to seed material and fly ash
Solid seed extractor	Seed separation and extraction
Seed regeneration	Disposal of sulfur and particulates, evaporation ponds, water vapor
Scrubbers and precipitators	Solid waste disposal
Cooling towers	Cooling water use, water vapor

temperatures peculiar to MHD, nitrogen oxide (NO_x) production is increased while the production of organic effluents, particularly the condensed poly-cyclic organic molecules (POM's), is decreased. The high temperature may also radically alter both the physical and chemical formation of fly ash, as well as the selective enrichment of various trace elements in the fly ash particles. Because of the nature of slag-seed reactions unique to MHD processes, quantities of sulfur oxides (SO_x) are likely to be much lower in the effluents of an MHD facility than in a standard commercial coal-fired power plant. The following discussion of air emissions is organized around these topics:

- SO_x;
- NO_x;
- particulate matter;
- trace elements;
- radioactive compounds; and
- other emissions.

A positive feature of the MHD power generator is that a self-contained sulfur removal system is inherent in the system design. The K_2CO_3 seed, used to increase the conductivity of the working fluid, will combine with the SO_2 to form a sulfate or sulfite which will be removed with the slag, in the seed condensor, and/or by particulate control devices. Experimental results indicate that by increasing the quantity of seed material, the sulfur oxides produced in coal combustion may be removed to any desired degree (preliminary experimental results show that 99+ percent of the SO_2 can be removed[4/]). MHD technology should appear very attractive in areas where nondegradation of existing air quality is mandated or where SO_2 levels are near existing ambient standards. It appears that the most stringent SO_2 pollution regulations can be met with MHD technology with only a very small loss in efficiency, even using high sulfur coals which presently are environmentally unsuitable for use in conventional power plants.[5/] However, monitoring of stack emissions and testing of sulfur removal efficiencies must continue in the more advanced facilities to ensure that adequate SO_2 control is achievable at all stages of MHD development, through commercialization.

The high combustion temperatures (4500-5000°F) used in open-cycle MHD could produce up to 10 times the nitrogen oxide (NO_x) emissions produced in conventional coal combustion.[6/] NO_x is an important pollutant both in the direct effect of NO_x on plants and animals and the role of NO_x in the photochemical smog cycle. Thus, NO_x has the potential for being the most important emission problem in the MHD system. Two methods of NO_x control have been identified: minimize NO_x in the effluent gas, or maximize NO_x in the effluent to recover nitrogen products (e.g., fertilizer).[7/] Presently it appears that NO_x emissions will be controlled by the first technique through combustion modification. Combustion modification includes techniques such as initial fuel rich combustion, downstream adjustment of the fuel-air mixture to make it air rich, and regulation of exhaust gas residence times in downstream components to enhance decomposition of NO_x. As the technology evolves or efficiency considerations become important, it may become necessary to resort to other control means to meet current standards as well as any stricter NO_x emission standards which may be in effect at the time of commercialization.

It is expected that particulate matter existing in the exhaust gases will consist of seed material (potassium carbonate and potassium sulfate), fly ash, and possibly eroded insulation and electrode materials. Fly ash emissions from MHD are expected to consist of a greater proportion of fine particulate matter compared to particulates produced in conventional coal-fired power plants due to the very high combustion temperatures characteristic of MHD, and possibly due to the effects of superconducting magnets[8/] and NO_x controls[9/]. These fine particles (<3 microns) can present a hazard to human health because they can enter and be retained in the lungs. Emission of particulate sulfates, especially spent seed material, is a potential problem with MHD. Atmospheric sulfates have been implicated in adverse environmental effects including acid rains as well as particulate sulfates modifying weather, visibility, and climate.

The environmental impact of trace element emissions from a coal-fired MHD facility depends on coal quality, the way the coal is burned, power plant size and location, emission control technologies, and weather conditions. When the coal is burned, the trace elements will 1) be trapped in bottom slag; 2) be collected in the emission control device as particulate ash; 3) escape through the stack as a gas or adhering to effluent particles; or 4) escape as fugitive emissions within the facility environment. While a substantial fraction of trace elements present in the coal is retained with the fly ash and slag removed by control devices, significant quantities of trace elements may still be emitted as or on submicron-size particles because of collection inefficiencies in the small particle range inherent in these devices. Potassium and radioactive compounds, as well as trace elements, adhere to the surfaces of particulates. Volatilization of trace elements during coal combustion and their release to the atmosphere in the gaseous phase also occur. This may be of particular concern in MHD because of its characteristically high temperatures.

Coal contains virtually all the naturally occurring elements.[10/] Trace element emissions which may be of concern from MHD facilities include the following: mercury (Hg), antimony (Sb), selenium (Se), arsenic (As), zinc (Zn), barium (Ba), copper (Cu), cobalt (Co), lead (Pb), manganese (Mn), nickel (Ni), chromium (Cr), cadmium (Cd), vanadium (V), tin (Sn), beryllium (Be), boron (B), and titanium (Ti). The degree to which the seed material will absorb trace elements in addition to SO_2 is not known. Multi-element mass balance studies conducted at conventional coal-fired power plants[11-15/] indicate that certain trace elements, many of which are toxic, concentrate preferentially on the large surface area (relative to volume) of sub-micron size particles, which are difficult to collect.[16/] Because trace elements and fine particulates are potentially hazardous to human health and ecosystems, their presence at MHD facilities must be analyzed and assessed for potential impacts.

Radioactive compounds in coal may also be released during coal combustion. Western coals generally have greater concentrations of radioactive compounds than do eastern coals. Radioactive compounds retained in the fly ash can be removed to a large extent by particulate control devices. The radioactive emissions from coal-fired facilities are primarily a function of the radioactive content of the coal burned. Because the higher thermal efficiency of MHD permits less coal combustion per unit electrical output, MHD will produce fewer radioactive emissions per Btu output than conventional coal-fired facilities.

Other potential emissions which may be significant environmentally in the various phases of MHD development include hydrocarbons, carbon monoxide, and elements in gaseous form. At the expected temperatures of MHD combustion, decomposition of all unburned hydrocarbons to their oxidized forms (CO_2 and H_2O) is expected. However, the fuel-rich first stage of combustion, the short residence time in the combustor, and off-design operating conditions may allow the production and/or escape of some of the complex organic compounds. Typically, heavier molecular weight organics (e.g., polynuclear aromatic hydrocarbons) pose a greater threat to human health than the straight chain organic species.

In the CDIF, a very short combustion residence time could affect the formation of CO and the release of unburned hydrocarbons. Due to the experimental nature of the test facility, the probability of CO and hydrocarbon emission occurring is considerably higher than is expected for later MHD developmental facilities. Preliminary tests indicate that CO emissions can be eliminated during second-stage combustion by increasing the air supply.[4/] Stack sampling for CO and hydrocarbons should be conducted to determine their significance and need for control. Identification of individual hydrocarbon compounds, if they are released, will be necessary to assess their potential environmental effects.

Increasing concentrations of CO_2 in the atmosphere are a global concern associated with fossil fuel combustion. However, CO_2 emissions from MHD will be less on a per unit electrical output basis than from conventional coal-fired power plants due to the higher conversion efficiencies of MHD units.

For open-cycle MHD to be economically feasible, the spent seed must be recovered, separated from the slag and fly ash, and regenerated. Air emissions may result from seed regeneration processes. The existing seed regeneration processes are being evaluated, but a specific process has not yet been selected; therefore, associated pollutants and impacts from seed regeneration units will be discussed in later versions of the EDP.

Emission of water vapor in exhaust gases is expected to be a problem peculiar to the CDIF and will be contingent on the type of water-quench stack gas cleanup system used. This will not be a problem in the commercial process. Stack gases from the CDIF will be extremely wet, containing about 70 percent H_2O vapor by volume. Depending on local meteorological conditions, restricted visibility and ice deposition could become a problem. Water evaporated at the cooling towers could amplify this problem.

3.2.2 Water Use and Effluents

The majority of the water used at MHD as well as at conventional power plants is for cooling purposes. With the higher thermal efficiency of MHD, less waste heat ends up in the cooling water. Preliminary studies indicate that thermal discharges from a first generation MHD plant of 52 percent efficiency will be approximately 73 percent of the thermal discharges from a modern conventional coal-fired power plant of 40 percent efficiency.[6/] As a result, less cooling water will be needed and the total water requirements for an MHD facility should be less than for a conventional coal-fired power plant of the same generating capacity. In addition, MHD system efficiency may be further increased and thermal discharges decreased if the remaining waste heat from the steam bottoming cycle is utilized. Economically and environmentally acceptable uses of this waste heat have not been identified for MHD facilities, but will vary with the characteristics of the potential sites.

Consumptive uses of water other than for cooling systems include the use of a wet scrubber system for particulate control and associated solid waste disposal at the CDIF. At more advanced facilities, water will be used to extract K_2SO_4 from the fly ash/spent seed residue collected by particulate control devices and in the regeneration of spent seed. During seed extraction and regeneration there is a potential for leaching of trace elements and other compounds contained in the seed and fly ash mixture.

Effluents will result from boiler cleaning, cooling systems, and feedwater treatment processes which are not unique to the MHD technologies themselves but exist in conventional boilers as well. Secondary water pollution can result from runoff and leaching from solid waste disposal sites if appropriate control measures are not taken. No data are currently available on the leachability of specific compounds and trace elements contained in MHD slag and fly ash. It is expected that the trace elements potentially found in MHD effluent streams and solid waste leachate will be similar to those identified for air emissions. Effluents resulting from MHD processes, seed regeneration and solid waste disposal need to be characterized and assessed to ensure that they do not contain any unexpected hazardous pollutants or excessively high potassium levels, and that they will meet applicable water quality standards.

3.2.3 Solid Waste

MHD will produce slag, fly ash, and particulates containing primarily seed material and inorganic elements from coal. It is expected that in order for open-cycle MHD to be acceptable, both environmentally and economically, the K_2CO_3 seed material must be recovered, regenerated, and recycled. Regeneration of the spent seed will reduce the amount of solid waste requiring disposal. The K_2SO_4 and K_2CO_3 recovered with fly ash by particulate control devices can be sent through a seed regeneration unit to recover the potassium seed for reuse in removing the sulfur. An insoluble potassium-containing fly ash residue remains which can either be recycled back to the MHD coal-combustion unit, where a certain portion of the unextracted seed will eventually be lost in the slag, or it can be disposed of, if the seed loss is not economically significant or environmentally damaging.

Disposal of solid wastes from MHD facilities may be similar to the fly ash disposal problem of conventional coal-fired power plants and may preempt other land uses. A potential difference in the solid wastes from an MHD facility will be the presence of potassium sulfates and other potassium salts in the slag and collected particulate. In addition to seed material, trace elements released at high combustion temperatures may be adsorbed onto or absorbed into the spent seed material. It is not known whether these elements will pose leaching or site reclamation problems. These and other differences will be studied in detail during the developmental stages of MHD.

A search for any potential uses for the solid waste material may be warranted. A periodic update on research for potential new uses could provide timely solutions to the waste disposal problem anticipated with full-scale commercialization of MHD. MHD plants should have less solid waste per unit of electrical power produced than conventional plants using similar coal -- again due to the higher thermal-to-electric efficiency of MHD systems.

3.2.4 Control Technology

Due to the very high operating temperatures and components unique to MHD, new or improved techniques may be necessary to evaluate, monitor, and control the undesirable compounds in the components of MHD facilities. For commercial operation, less sophisticated techniques ultimately will have to be developed to be compatible with the operator's training. In addition, to avoid a trial and error approach to selecting pollution control equipment, development of instrumentation, sampling techniques, and measurement methods unique to the MHD process may be necessary for providing a sound data base.

Work which has been performed to date on SO_2, NO_x, and CO control technologies for MHD indicate that these pollutants can be effectively controlled to levels at or below current New Source Performance Standards (NSPS) for coal-fired steam electric power plants. Open-cycle MHD has a built-in sulfur control technology; the potassium carbonate (K_2CO_3) seed, which is injected into the combustion gas passing through the MHD generator to enhance its conductivity, also combines with SO_2 to form potassium sulfate (K_2SO_4) which later precipitates out at lower temperatures and can be removed by particulate control devices. Experimental tests have achieved 99+ percent SO_2 removal from the effluent gas.[4/]

Two routes of NO_x emission control are available: 1) minimizing NO_x in the effluent, or 2) maximizing NO_x in the effluent so that recovery of fixed nitrogen (for fertilizer) becomes economically attractive. Most of the research has been directed toward the former, reducing emissions, and presently it appears that NO_x emissions from MHD will be controlled by combustion modification. Test results indicate that NO_x emissions should be effectively controlled below current NSPS levels through combustion modification by controlling the fuel-to-air-ratio, the temperature at which secondary air is added, and the residence time of the exhaust gas in the downstream components. Secondary air admitted downstream from the high temperature zone also tends to complete combustion of CO and unidentified aromatic hydrocarbons. At the same time, however, there may be a trade-off in the increase in the production of NO_x. Although preliminary work indicates that these control methods are effective, testing of their effectiveness at more advanced MHD facilities must continue to ensure that adequate controls will be available for commercial MHD facilities.

Research is needed to determine the extent to which fine particle emissions from MHD will be a problem. Efficient removal of particulate matter is necessary for MHD to be economically as well as environmentally acceptable. Development of technologies to control fine particulate matter[17/] may be necessary if a significant portion of the spent seed and/or trace elements are emitted in the form of fine particulates. Within the time frame projected for MHD development, electrostatic precipitators, high energy wet scrubbers, and fabric filters are the primary commercially available types of particulate control devices which exhibit greater collection efficiencies for the fine particulates (< 3 microns). However, collection efficiency of scrubbers and to a lesser extent electrostatic precipitators, decreases rapidly with decreasing particle size.[17, 18/] Baghouses generally exhibit high collection efficiencies over the entire spectrum of particle sizes, but are limited to a rather narrow range of temperature and humidity constraints. Although a 99 percent efficient collector seems impressive, the efficiency is determined by weight, and the remaining 1 percent of the total particulate weight can represent an enormous number of submicron particles. Fine particle emissions are a problem in direct combustion technologies and are not unique to MHD. Research and development of novel devices and emerging technology which appears promising for controlling fine particulate emissions should be pursued.

Experiments indicate that seed loss to the slag can be reduced significantly by removing most of the slag from the combustor before the seed is injected into the combustion gas. Potassium recoveries exceeding 99 percent have been obtained for a slag rejection above 90 percent.[4/] Work in this area should continue to minimize seed losses in advanced MHD facilities.

Conventional control technologies are expected to be adequate for controlling thermal discharges, water effluents, and runoff and leachate from solid waste disposal areas. However, further research is necessary to verify this and/or identify and resolve potential control problems at advanced MHD facilities.

3.2.5 Occupational Health And Safety

Many of the occupational health and safety hazards occurring at MHD facilities can be mitigated by following good operating and safety procedures. Hazards that may pose a threat to the health of workers in the MHD facility environment may be identified as exposure to magnetic fields, noise, vibration, radiant heat, steam, NO_x, some unidentified volatile components, lower molecular weight organic species and fine particulates containing toxic trace elements, coal or other inorganic dust, and alkali seed materials. Because of the high temperature and pressure characteristics of MHD facilities and the general spontaneous combustible nature of coal dust, the primary safety hazards in the occupational environment may be explosion, fire, and a potential high voltage hazard.

Chronic exposure to magnetic fields may pose a threat to the health of workers. Shielding of magnetic fields will reduce but may not eliminate risks of exposure. Magnetic fields have been reported to have apparent effects on the human nervous system, the blood, and cardiovascular and other functions. While such adverse magnetic field effects on human health have been documented at the Stanford Linear Accelerator Center[19/] and in the Soviet Union,[20/] no clear-cut information regarding the total duration of exposure and the significance of an exposure-effect relationship has been reported. Moreover, little information relating potential human injury to field gradient and field strength is available. Results from animal experiments have generally lacked sufficient reproducibility and reliability to warrant extrapolation to humans. Epidemiological studies coupled with biomedical monitoring of humans subject to magnetic field exposure are required to assess health risks, interpret dose/response relationships, and establish occupational health guidelines. The magnetic field to be encountered in the MHD development process will be in the range of 3-6 Tesla* at source, tapering off very rapidly by the inverse of the distance cubed. Exposure of workers to magnetic field intensities much higher than field intensities that have been reported to cause apparent effects in humans is a potential concern. Consequently, quantitative study to establish biomagnetic effects of high field intensities and the establishment of exposure-effect relationships require immediate attention.

Acceleration of the working fluid at high velocity through the MHD channel may cause high noise levels and vibration. Noise and vibration may also be problems in the pulverizer and baghouse areas. Noise standards exist for conventional facilities and must be defined for MHD.

In the event of incomplete combustion due to accidentally low combustion temperatures or air supply, coal tar and light oil may be formed, separated out from the coal gas in the cyclone gasifier, and removed with the slag from the first-stage combustor. Handling and removal of slag may then be subject to the hazard of dermal contact with coal tar and light oil. Specifically, the coal tar has been listed by the National Cancer Institute (NCI) as an agent causing skin cancer.

The occupational health hazards associated with the bottoming cycle are very different for the CDIF compared to more advanced MHD facilities, because the CDIF does not utilize its waste heat in a steam bottoming cycle. Instead, the heat is dissipated in a heat quench system. In the CDIF radiant heat from the water-quenching chamber may become a problem only if the cooling system is not adjusted properly. Material design of the chamber to avoid corrosion from sulfuric acid is vital in the containment of noxious combustion products. Handling the water slurry from the quenching system and from the Venturi system for removal may result in dermal absorption of some of the trace elements like As, Ni, Hg, Th, Zn, and uranyl ions.

The occupational health hazards that may be encountered in the bottoming cycle of the ETF, and more advanced facilities, stem primarily from the efficiencies of the cleaning system and the safety features of the components guarding against leakage. The radiant boiler, high-temperature air preheater (direct or indirect), superheater, and reheater, however, may be potential sources of heat stress. Removal of soot from

* 1 Tesla = 10^4 gauss.

the radiant boiler may cause a skin cancer hazard to workers subject to chronic exposure. The primary hazard in handling and removing slag from the slag separator may be the potential contact with the dermally absorbable trace elements as described above. When an indirectly fired, high-temperature air preheater is used in the testing stage, potentially hazardous emissions may be CO and CH_4 from combustion of clean fuels, if not properly removed with a local exhaust ventilator. The directly fired preheater and superheater, however, may be subject to corrosion problems from the seed/slag. Potential leakage of combustion products could occur at the superheater if special material and cleaning devices are not used. The hazards of electrostatic precipitators (ESP's) at MHD facilities are similar to those at conventional coal-fired power plants. Inhalation and dermal contact hazards of the fine particulates exist during cleaning of ESP's. The hot exhaust gas, which goes to a mill for coal drying, may cause a potential hazard to the workers as a result of the inhalation of SO_2, NO_x, CO, lower molecular weight aromatic compounds, fine particulates containing coal dust or silica dust, and trace elements. Health hazards unique to MHD facilities can be identified by careful monitoring of working conditions and worker health and can be mitigated by standard occupational health measures including safe operating procedures and protective clothing and devices.

The major occupational safety issues that should be considered include: explosion hazard, high-voltage hazard, component rupture, and materials failure. The safety requirements to prevent rupture of the combustor, hazards involved in the confined space of the combustor pit, the potential explosion in the coal feed system, and high voltage shock in ungrounded portions of the test train have been described in detail for the CDIF in the Safety Considerations Report prepared by Gilbert/Commonwealth.[21,22/] Increasing the size of the magnet and the use of higher voltage applied across the combustor-channel portion as will occur in ETF and CDP stages, could increase the potential for exposure to safety hazards as the technology progresses.

Factors which create a potential for materials failure in open-cycle MHD systems include extremely high temperatures of the plasma which enhance corrosion and erosion of materials, and high velocity gas/solid (slag and seed) flows which may induce vibration (leading to material fatigue) and cause erosion. In pressurized regions of open-cycle MHD systems, the potential for materials failure and explosion exists. Explosion hazards may also exist in the coal feed system, due to the combustible atmosphere or to backfire from the combustor. In addition, failure in the cooling system for the superconducting magnet could result in the release of stored energy.

Other potential sources of safety hazards are the air preheater, seed regeneration and sulfur recovery units, as well as systems common to conventional coal-fired power plants (e.g., fuel storage facilities, and coal transport, pulverizing, and feed systems).

Any failure in the pressurized systems or in the control devices may result in the release of hazardous material into the occupational environment and/or in some physical stress to the workers. In case of an accident or leakage in the system, the potentially hazardous substances such as insulation and electrode materials, gaseous compounds, fine particulates, trace elements, and the proven carcinogens including the polycyclic aromatic hydrocarbons, may be released into the occupational environment. At high temperatures most of the trace elements will be vaporized and may condense on the fine particulates as lower temperatures are reached. Failure of the water cooling system installed around the combustor, the MHD generator, and the diffuser would lead to heat stress problems, particularly in the confined space in the combustor pit. Adherence to standard operating procedures and safety standards for combustion and chemical processing facilities will help minimize the occupational safety hazards of MHD facilities.

3.2.6 General Population Health Effects

Effects on the general population from the use of MHD technology could differ from those resulting from conventional coal-fired power plants if NO_x and fine particle emissions, especially particulate sulfates, are not controlled effectively. SO_2 emissions are expected to be lower due to the unique seeding procedure used in MHD. As discussed in the above sections, effluents and solid wastes from MHD facilities should be monitored and characterized to identify and analyze potential problems unique to MHD which could affect the general population.

Because of the lack of success in simulating conditions of chronic exposure to complex mixtures of air pollutants, the biologic effects of air pollutants are often deduced from epidemiological evidence. A partial list of the air pollutant-caused pathologies include the following:

a) increased respiratory distress;

b) increased susceptibility to infection, particularly in the lungs; a strong correlation has been established between concentration of SO_2 and particulates and the frequency of respiratory infections;

c) degenerative processes which cause the lung tissue to lose its elasticity and, thus, develop into an emphysema-like disease;

d) disruption of the mechanics of air distribution; and

e) SO_x also can damage the alveolar-capillary membrane which, with pathologies c and d, lead to a general interference with the oxygenation of tissues.

Trace elements are implicated as causes of cancer and birth defects.

3.2.7 Effects on Terrestrial and Aquatic Ecosystems

Much of the air pollutant research has dealt with the effects of SO_2 emissions on vegetation. Sulfur oxides are highly toxic to plants and appear to be one of the most important pollutants affecting trees.[23/] NO_x ecological effects research is not nearly as extensive. There is some evidence that excessive amounts of NO_2 significantly affect photosynthesis.[24/] SO_2 and NO_x emissions may not be a problem, but a well-defined research program should be developed to document this.

The emission of particulates into the atmosphere can cause a variety of problems by physically interfering with normal respiration processes of plants and animals. Fine particle emissions may be the greatest single emission problem if appropriate pollution control devices are not incorporated into the system. The ecological effects of potassium compounds which may be emitted from MHD facilities are not known and should be investigated. Baseline ecological data should be collected prior to construction and compared to data collected during and after facility operation to establish ecological effects. Particularly, trace element analysis should be conducted on soil, vegetation, and animals.

Noise levels at MHD facilities may cause some disturbance to wildlife in the near vicinity of the plants. Potential pollutants unique to MHD, (e.g., seed material, sulfates, certain trace elements or hydrocarbons, eroded or corroded electrode material, or solid waste leachate) could have adverse effects on terrestrial and aquatic ecosystems. Their potential impacts on ecosystems should be investigated to determine their extent and severity.

3.2.8 Physical Disturbances

The physical disturbances created by the construction and operation of MHD facilities are expected to be similar to those associated with conventional coal-fired power plants. Potential disturbances could result from water use, particularly in the semi-arid and arid regions of the West, and preemptive land use for solid waste disposal and the plant site. The reclamation potential of MHD solid waste disposal sites is not known and should be investigated to determine potential land use impacts. The potential of MHD facilities to increase the incidence of fine fogs, probably only from the CDIF, resulting from water vapor emitted in the stack gases should also be investigated along with any other potential change in microclimate.

Physical disturbances created by an MHD facility usually are associated with its siting and subsequent construction and operation. There are two general issues which traditionally have not been sufficiently addressed from an environmental perspective in the siting of conventional coal-fired power plants. The first is whether to select a mine-mouth or load-center location. This decision usually has been based on economics rather than overall environmental benefit. Siting studies should include the evaluation of mine-mouth vs. loadcenter sites rather than similar alternatives (e.g., solely alternative mine-mouth locations). Secondly, the scaling of commercial plants has been based historically on economics. Environmental and social costs have not been included in this analysis. Methodologies which ensure inclusion of external costs into scale optimization of MHD facilities should be identified prior to scaling the CDP and commercial facilities. External considerations should include the relative system energy efficiency (including utilization of waste heat) and environmental community impact for varied sizes of facilities.

The severity of construction and operation impacts of MHD facilities will vary with site-specific characteristics. Assessing the impact of a major facility on the environment of specific sites must be completed prior to construction.

3.2.9 Social, Socioeconomic, and Institutional Considerations

The socioeconomic impacts of MHD power generation facilities will vary with the size and location of the facility, but should not differ significantly from those created by a comparable conventional coal-fired power plant. The social impact of the termination of an ERDA MHD test facility (CDIF and ETF) which has a design life of only 15 years, however, should be studied. As in all construction projects, mitigating measures should be identified to reduce the construction employment demand peak in order to minimize the need for temporary housing and services. Although ERDA expresses the desire to address public concerns and social acceptability of its actions,[25/] the procedure for doing so is not clear.

3.3 Research Requirements

MHD technologies generally develop from conceptualization through a series of stages, e.g., technology development, component development, pilot, demonstration, and commercial-scale units. Environmental research and environmental assessment activities follow much the same pattern. At each stage of technology development and testing, environmental data are compiled and assessed so that environmental considerations are included in the decision-making process leading to commercialization of the technology.

ERDA guidelines require that ERDA prepare a site-specific Environmental Impact Assessment (EIA) and, if necessary, an Environmental Impact Statement (EIS) for all Federal actions which may have a significant impact on the environment. In addition, the Federal Nonnuclear Research and Development Act calls for the preparation of water availability assessments for new energy technologies and commercial scale and demonstration plants which may have a significant impact on water availability. ERDA facilities must comply with all Federal, State, and local standards applicable to the facilities at the time of their construction. To ensure that the alternative energy technologies being developed are environmentally acceptable at the time of their commercialization, ERDA not only must comply with the environmental regulatory requirements mentioned above, but must also address the potential environmental issues and concerns discussed in Section 3.2. Table 3-3 lists the environmental research which must be conducted at various stages of technology development to ensure that the environmental issues and concerns associated with MHD are addressed and resolved and that MHD develops through commercialization as an environmentally acceptable technology.

TABLE 3-3

ENVIRONMENTAL ISSUES AND REQUIREMENTS

Environmental Issue	Research Category	R&D Requirements
I. Impact on Air Quality	A. Characterization	1. Characterize particulate effluents as a function of operating conditions and feedstock according to: • size distribution; • mass respirable distribution; • chemical composition and form of each size fraction; and • physical and morphological properties of the fly ash particles. Compare with similar studies at conventional coal-fired power plants.
		2. Perform multi-element mass balance studies at selected MHD facilities and compare with similar studies done at conventional coal-fired power plants. Future studies will expand mass-balance analysis to include flow to air, water, and solid waste.
		3. Study in detail the formation and chemical composition of fine particles in the MHD process. Establish which trace elements may be preferentially enriched.
		4. Characterize ducted and fugitive emissions from total process and supporting operations (e.g., coal preparation and seed regeneration).
		5. Characterize by-product emissions from the seed regeneration process.
		6. Assess possible emission of polycyclic aromatic hydrocarbons and organometallics.
	B. Modeling and Monitoring	1. Develop analytical characterization models which can accurately predict emissions, both organic and inorganic.
		2. Establish baseline ambient air quality data for selected trace elements, SO_2, NO_x, particulates, radioactive compounds, hydrocarbons, and other regulated pollutants.

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I. Impact on Air Quality (continued)	B. Modeling and Monitoring (continued)	3. Monitor in-stack, in-plant and ambient air for trace elements, SO_2, NO_x, CO, hydrocarbons, particulates, radioactive compounds, and other regulated pollutants during and after operation. Identify individual hydrocarbon compounds emitted.
		4. Quantify CO_2 emissions from proposed MHD facilities and compare with conventional coal-fired power plants.
		5. Quantify thermal discharges from proposed MHD facilities and compare with conventional coal-fired power plants.
		6. Measure and establish the following meterological parameters: air-flow characteristics (wind rose data), atmospheric thermal stratification (duration and intensity of low level inversions), precipitation, evaporation (ice deposition and fog), and statistical evaluation of dispersion coefficients, and stability categories.
		7. Improve atmospheric transport and dispersion models.
	C. Health Effects	1. Establish health effects of pollutants identified in stacks and fugitive air emissions from MHD facilities.
II. Impact of Water Use and Effluents	A. Characterization and Monitoring	1. Obtain baseline water quality data from selected MHD facilities.
		2. Characterize and monitor ambient water quality and quantity during construction and operation.
		3. Characterize and monitor water effluent and thermal discharges from MHD facilities as a function of operating conditions and feedstocks, and identify differences in the effluent from conventional coal burning facilities.
		4. Determine optimal use of MHD waste heat based on system energy efficiency, economics, and environmental impact.

II. Impact of Water Use and Effluents (continued)	A. Characterization and Monitoring (continued)	5. Identify potential water pollution problems associated with the disposal of solid wastes from MHD facilities (i.e., leaching and run-off): ● trace elements ● soluble spent seed compounds.
	B. Health Effects	1. Assess health effects of MHD effluent pollutants.
	C. Resource Requirements	1. Assess water resource requirements for MHD and identify and develop methods to reduce fresh water use by MHD facilities.
III. Solid Waste	A. Characterization and Monitoring	1. Characterize process solid wastes: ● slag; ● fly ash; and ● spent seed, as a function of operating conditions and feedstocks.
		2. Characterize and monitor water effluents from selected solid waste disposal sites.
		3. Determine mechanisms of transport and fate of trace elements leached from solid waste.
	B. Health Effects	1. Determine health effects of chemical compounds identified in solid wastes from MHD facilities.
	C. Resource Utilization	1. Develop uses for MHD solid waste.
		2. Identify and assess potential markets for MHD solid waste.
		3. Identify and assess the potential secondary environmental impacts from such uses.
		4. Develop and evaluate options for efficient, economic seed recovery and regeneration processes.
IV. Occupational Health and Safety Hazards	A. Characterization and Monitoring	1. Identify and monitor for potential in-plant air pollutants that would pose health hazards to employees, visitors, and/or neighboring personnel areas, including: ● micron and sub-micron particulate matter; ● gases, vapors, mists, and fumes; ● known or suspected carcinogenic mutagenic, teratogenic, and other toxic substances.

IV. Occupational Health and Safety Hazards (continued)	A. Characterization and Monitoring (continued)	2. Identify and monitor other potential health hazards, including: • noise; • heat stress; • vibration; • electric field forces; and • capacitor charges.
		3. Assess compliance with the standards and protect worker's health by developing monitoring and control measure systems in the occupational environment.
		4. Develop a dosimeter for monitoring magnetic field.
		5. Monitor the magnetic fields generated by the superconducting magnets and the magnetic separation units used in coal preparation.
		6. Monitor workers at MHD facilities to identify potential health hazards, particularly those associated with superconducting magnets.
		7. Identify potential safety hazards: • areas of potential mechanical failure; • combustion or explosion hazards, including - overheating of superconducting magnets and - thermal drying of coal; • high voltage shock potential at the combustor-channel area; • stresses from overheating, erosion or corrosion of combustor, channel, and pipe areas.
		8. Develop data to assess safety control requirements to prevent rupture of the combustor, explosion in the coal-fired system, in the superconducting magnets, or in the oxygen feed system, and high voltage shock at the combustor-channel portions.
	B. Health Effects	1. Assess the adverse effects of magnetic fields encountered in pyrite and tramp metal removal processes, and develop control or alternative technology.

IV. Occupational Health and Safety Hazards (continued)	B. Health Effects (continued)	2. Perform epidemiologic studies to determine health effects of MHD facilities: • retrospectively--by collecting available data on workers exposed at the existing foreign MHD facilities or other operations that involve magnetic fields of high intensity; • prospectively--by designing comprehensive epidemiologic strategies to evaluate cause-effect relationship in the future commercialized MHD facilities. 3. Conduct studies to determine potential health effects of high intensity magnetic fields, such as: • <u>In-vitro</u> studies of possible biomagnetic effects on structure/morphology, properties, and function of macromolecules, cell organelles (including membranes), and cells. • Animal studies to characterize quantitatively the potential systemic effects of magnetic fields on, but not limited to, hematopoetic and neurological systems, and to assess potential carcinogenicity, teratogenicity, and mutagenicity of magnetic field effects. • Extrapolation of the quantitative biological dose/response data for animals to humans. • Effects on metal dental and medical implants. 4. Assess carcinogenicity, teratogencity, and mutagenicity of the identified trace elements and organic compounds. 5. Define acceptable levels of exposure to magmetic fields and identified in-plant pollutants and health hazards; identify existing applicable regulations.
	C. Mitigating Measures	1. Evaluate, develop and enforce health protection procedures for workers at MHD facilities, such as: • Use of protective clothing, polyurethane gloves, and face shields by workers handling and removing slag and water slurry; • Use of protective breathing apparatus by workers in the processes such as, but not limited to: - coal preparation - thermal drying, and - soot removal from boilers and particulate control devices;

IV. Occupational Health and Safety Hazards (continued)	C. Mitigating Measures (continued)	• Use of protective clothing for work such as removing soot from boilers, and particulate control devices.
		2. Assess shielding of the high intensity magnetic field generated by the superconducting magnets.
		3. Develop modifications of hazardous components, processes and systems to minimize safety hazards.
V. Impacts on Ecosystems	A. Characterization and Monitoring	1. Establish baseline, operating, and post-operating ecological data at MHD facilities, including: • Analysis of soil, vegetation and animals for SO_2, NO_x, trace elements and other regulated or potential pollutants; • A reference collection of soil, plant, and animal samples; • Infrared color slides before operation of facility to eventually establish degree of vegetational damage, if any; • Establishment of structure of various ecological communities before the MHD facility is operated for the first time.
	B. Ecological Effects	1. Assess effects of MHD pollutant releases on ecosystems near the MHD facility during and after operation through analysis of baseline and operation and post-operation data.
		2. Determine synergistic effects of air emissions from MHD facility with ambient air and its effect on the ecosystems.
VI. Adequacy of Control Technology	A. Air Emissions	1. Compare commercially available control equipment and evaluate novel control devices applicable to MHD processes.
		2. Develop alternative plans for controlling SO_2 and NO_x emissions from MHD, should additional secondary controls become necessary.
		3. Identify applicable existing and proposed ambient air and emission standards for MHD technology. Assess ability of MHD technologies to meet current and proposed standards.

VI. Adequacy of Control Technology	A. Air Emissions (Continued)	4. Develop and test control technologies for particulate removal as follows: • For efficient and economic seed recovery; • For efficient removal of sub-micron size particles; • For simplicity and reliability of equipment; and • Include assessment of - Baghouses, - Electrostatic precipitator, - Venturi scrubber system, and - Reinluft system.
		5. Develop, test, and evaluate potential economics of NO_x control options. • Assess process modifications, including: - multi-stage combustion, - gas cooling rates, and - fuel-to-air ratio; • Assess control options of absorption and adsorption (solid and liquid); and • Study NO_x maximization and processes for fixed nitrogen by-products.
		6. Assess potential emissions and control system efficiency during startup, shut-down, maintenance, and design operating conditions.
		7. Assess secondary impacts associated with identified control options (e.g., seed regeneration, use of Claus plant for elemental sulfur recovery).
		8. Develop cost/control curves for various emissions streams.
	B. Water Effluents	1. Determine and test effluent controls needed to meet current and proposed standards.
		2. Assess the ability of MHD to reduce thermal pollution compared to conventional coal-fired power plants.
		3. Develop cost/control curves for identified effluent streams.

VI. Adequacy of Control Technology (continued)	C. Solid Waste	1. Investigate new methods of solid waste stabilization to control runoff from disposal sites. 2. Establish site selection and operation criteria for land disposal of solid wastes. 3. Determine land requirements for disposal of solid waste.
VII. Physical Disturbances Created by MHD Development	A. Characterization and Monitoring	1. Identify noise disturbances from MHD operation and develop procedures to mitigate them. 2. Identify potential disturbances caused by electromagnetic fields. 3. Determine long-term land use impacts from plant siting, air and water effluents, and solid waste disposal. 4. Determine the impact of MHD water requirements on water supplies and water use at proposed sites.
VIII. Socio-economic Effects Created by MHD Development	A. General	1. Identify any socioeconomic impacts of MHD facilities and develop ways to mitigate adverse impacts, such as developing a methodology for selecting local indirect employment and income multipliers.
IX. Regulatory Requirements	A. General	1. Prepare NEPA compliance documents as needed (including EIA/EIS requirements). 2. Prepare general and site-specific water requirements data. 3. Prepare siting guidelines and requirements for MHD facilities.

4. ENVIRONMENTAL ACTION PLAN

4.1 Introduction

The major purpose of the MHD-EDP is to make environmental activities a part of the developing MHD technology program. The immediate establishment of a detailed environmental research program is essential to maximize the chances of the availability of appropriate environmental data for informed decisions on environmental standards, control technologies, and other mitigating measures.

The environmental assessment and research program should focus on the technology. It must be keyed to the development of the technology, and it should provide environmental information to be used as the technology proceeds toward commercialization. MHD technology development can be divided into the following phases: supporting science and technology; component test and integration; engineering testing; and commercial demonstration. Much technological research work has been and is being done, but research in the environmental area has been initiated only recently. The environmental research program also has certain developmental stages which include characterization, monitoring, effects, control technology, and assessments.

Environmental research, associated with the MHD technology, must be adapted to the differences in the systems which have been discussed throughout Sections 2 and 3. Consequently, environmental work conducted on the CDIF will not necessarily provide data which will accurately reflect conditions existing in the ETF system or commercial processes.

Environmental considerations change in response to modifications made to the MHD technology system. MHD technology will be in a rapid evolutionary phase for many years, and environmental research efforts must be attuned to new developments. Failure to identify these technological changes will result in an inappropriate ranking of priorities. The consequences of misdirected research efforts could result in lengthy and costly delays in commercialization of otherwise acceptable hardware. By identifying and investigating environmental issues during the entire MHD development process, the chances for commercial success of MHD will be greatly enhanced in terms of its operating in an environmentally acceptable manner.

The environmental action plan for MHD described in this section has been developed from the issues discussed in Section 3.2 and the research requirements listed in Section 3.3. Together, these encompass the range of needed activities which will assure that the technologies can be developed in an environmentally acceptable manner. All of the identified research requirements, however, are not appropriate for all technologies at each stage of development, because the required data may not yet be available and because certain research areas are of more immediate priority.

4.2 Priorities for Determining Future Research

Of all the environmental research activities which could be undertaken in response to the environmental issues arising from technology development, specific projects are scheduled and funded each fiscal year on the basis of several factors, which interact to determine priorities for environmental research. The priority environmental research areas will be determined during the Fiscal Year 1978 based on the following criteria:

- schedule for commercialization;
- severity of impact;
- regulatory concerns;
- degree of current knowledge;
- public concern;
- cost-effectiveness; and
- budget limits.

Whenever it is estimated that the time required to resolve an environmental issue through RD&D is greater than or equal to the time before the technology is available to the public (commercialization time) then that issue is given high priority. For example, health effects studies generally require at least several years; therefore, immediate initiation of these projects is highly desirable.

In determining research priorities, the severity of environmental impacts should also be considered, including the segment of the environment affected, the nature of the potential impact, the extent (geographical distribution) of the impact, the impact time frame, and the degree of reversibility of the impact. This last criterion is especially significant. If the impact is irreversible, its characterization and potential for prevention or mitigation will rank high in the research program.

The degree of compliance required by existing as well as more stringent future Federal, State, or local regulations must also be given high priority. When regulations or standards exist, research is directed primarily toward producing cost-effective control technologies to meet current limits, but also toward determining the potential for meeting more stringent levels of control.

Technologies whose environmental impacts have been well characterized generally require less environmental research than the less understood technologies. For example, since the fundamental kinetics of NO_x formation and degradation have been well characterized and modeled in the study of conventional technologies and in laboratory work under conditions similar to those encountered in MHD systems, resources should be spent on characterizing the emissions and mechanisms for which less information currently exists, such as the effects of strong electromagnetic fields or the size distribution and chemical composition of MHD particulate emissions.

Public environmental comment may require that specific potential effects be investigated in response to public apprehension or to clarify a controversial issue. High priority will be given to such comment, and if necessary, research will be conducted as appropriate.

Many diverse technologies have similar environmental problems, such as control of fine particulates and NO_x emissions. Researching the problems of a particular technology may resolve similar problems associated with other technologies. Research applicable to more than one technology should be viewed as cost-effective and ranked accordingly.

Finally, budget limitations play an important role in determining which of the many identified research needs which ideally should be carried out will be funded in any given year. Because limited funds are made available to ERDA, it is impossible for all potential projects to be funded immediately. In order to use the available funds in the most effective way, those projects considered to be of the highest priority are selected for actual implementation.

4.3 Ongoing and Completed Research

When determining future research needs, it is necessary to know what work is ongoing or has been completed in order to avoid duplication and to aid scheduling of future research. Some of the current and completed environmental research projects relating to MHD are included in a separate attachment and can be used to identify general areas where future work is needed. A detailed literature search should be conducted on each subject area. However, such indepth study would be too voluminous to include in this effort. Attachment A does include both generic studies on the effects of emissions which are common to coal combustion technologies and studies which are specific to MHD (categories 5 and 6). Those projects specific to MHD technologies are summarized at the end of Attachment A. The Federal Inventory number (when applicable), title, monitoring agency, author or performing organization, and completion date for each project are listed. This information was obtained from the following sources:

- Inventory of Federal Energy-Related Environment and Safety Research (FY 1976);
- Smithsonian Science Information Exchange (March, 1977);
- Summaries of projects sponsored by the Division of Environmental and Socioeconomic Programs (ERDA), 1977;
- Division of Fossil Energy Research Contract Fact Sheets, (ERDA), Revised as of March 31, 1977;
- Bibliography compiled by Exxon Research and Engineering Company for their report, Environmental Assessment of Advanced Energy Conversion Technologies;
- The Electric Power Research Institute's Publications and Research and Development Projects lists (1977);
- Matray, P., "The Bioenvironmental Impact of Trace Element Emissions from a Magnetohydrodynamics (MHD) Facility: A Literature Review and Recommendations," MERDI In-House Document (September, 1976).
- Energy Research Information System, Old West Regional Commission and USDA Forest Service, Surface Environment and Mining, (1975-76); and
- Fiscal Year 1976 Health and Environmental Effects Research Program Abstracts, Office of Energy Minerals and Industry, Office of Research and

Development, U.S. Environmental Protection Agency, EPA 600/7-77-04, (January, 1977).

Major environmental research related to MHD is being carried out by ERDA through the Assistant Administrator for Fossil Energy and the Assistant Administrator for Environment and Safety. Efforts relating to the overall MHD system, seed recovery and the environmental aspects of the system (primarily SO_x, NO_x, and CO emissions and control) are being conducted by ERDA's Pittsburgh Energy Research Center (PERC). Much of ERDA's present environmental work specifically related to MHD is in conjunction with the MHD CDIF. Studies being conducted include: 1) trace element analysis; 2) socioeconomic impact of CDIF construction on the Butte, Montana area; and 3) baseline monitoring and biological monitoring for the CDIF. Table 4-1 is a partial list of organizations participating in the ERDA MHD program.

Much of ERDA's environmental research, which is related but not specific to MHD, concerns air pollution and has focused on such areas as gaseous and particulate pollutants, formation of toxic compounds, trace elements in the biosphere, and health aspects of fossil fuels. ERDA also is funding research on the environmental transport and fate and the ecological and health effects of coal combustion products. Guidelines for designing and implementing environmental monitoring programs for ERDA Fossil Energy programs are being developed.

EPA is concerned primarily with setting emission and effluent standards and evaluating environmental controls for new technologies. It has developed an extensive array of studies on sampling, monitoring, and characterization techniques, as well as air, water, and solid waste impacts of coal combustion (e.g., effects of fly ash, coal leachate, long-term exposure to coal combustion emissions). Concerning environmental control, EPA has studied the effects of combustion and other process modifications in controlling NO_x emissions, the effect of fuel sulfur on NO_x formation, and the economics of control processes.

The National Institute of Environmental Health Sciences (NIEHS), the National Cancer Institute (NCI), EPA, and ERDA are performing the bulk of the health studies, covering the spectrum of health effects (e.g., carcinogenicity, mutagenicity, teratogenicity, and cardiovascular, neurological, and reproductive disturbances) of such pollutants as NO_x, SO_x, CO, particulates, hydrocarbons, sulfates, trace metals, thermal effluents, photochemical oxidants, and fluorocarbons. In addition ERDA is currently conducting studies on the health effects of magnetic fields.

The Electric Power Research Institute (EPRI) contributes most actively in the private sector to environmental research. EPRI has funded research on the emissions and impacts of thermal discharges, SO_x, NO_x, and fine particulates. EPRI has also funded studies of NO_x control technologies for MHD.

Completed and ongoing research which is of particular importance to the development of an environmentally acceptable MHD technology is discussed briefly below.

4.3.1 Characterization, Measurement, and Monitoring

A number of research projects have addressed the problems of physical and chemical characterization of particulates from conventional coal-fired power plants, which are similar to particulates expected from MHD facilities, as well as from coal-fired MHD test units. Studies indicate that fine particles in the 0.1-1.0 μ range are difficult to collect in commercially available sampling devices.[16/] Techniques used to measure particle size and morphological properties include the light microscope, scanning electron microscope, X-ray analysis, and optical measurement of mean particle size in the exhaust of a coal-fired MHD generator.[26, 27/] Methods of chemical analysis of particulates include scanning electron microscopy, X-ray analysis, Auger spectroscopy, and the use of ion microprobe analyses.[26/]

Chemical analyses of fly ash indicate that fly ash composition is influenced strongly by the chemical composition of the coal used. Trace elements are differentially absorbed into or adsorbed onto fly ash particles and bottom ash as a function of particle size and the elements' volatility. The more volatile elements are enriched preferentially in fly ash as compared to bottom ash, and some elements (particularly the toxic elements) increase in concentration with decreasing particle size.[16/] Studies on the effects of high temperatures and magnetic fields on seed recovery, particulate formation and size distribution indicate that MHD processes may result in a greater proportion of fine particle emissions and vast differences in other emissions as well, compared to those from conventional coal-fired power plants.[8/] Several mass balance analyses have been performed on coal-fired power plants,[11-15/] and will be useful for comparison with a similar analysis focusing on trace elements currently underway for MHD (funded by ERDA under MERDI Task S).

Modeling studies have been directed primarily toward modeling the formation and decomposition of NO_x under a variety of combustion, stochiometric oxygen, air-

TABLE 4-1
SELECTED MHD PARTICIPANTS

Argonne National Laboratory (ANL)
Arnold Engineering and Development Center (AEDC)
AVCO Everett Research Laboratory
FluiDyne
General Electric Company
Gilbert Associates Inc.
Magnetic Corporation of America
Massachusetts Institute of Technology (MIT)
Mississippi State University
Modern Electric Power Products and Services Company (MEPPSCO)
Montana Energy and MHD Research and Development Institute (MEMRDI)
National Aeronautics and Space Administration (NASA) Lewis Research Center
National Bureau of Standards (NBS)
National Magnet Laboratory (NML)
R. M. Parsons Company (RMPCO)
Pacific Northwest Laboratory
Pittsburgh Energy Research Center (PERC)
Rand Corporation
Stanford University
STD Research Corporation
TRW Energy Systems
University of Tennessee Space Institute (UTSI)
Westinghouse Electric Corporation

Source: Jackson, W.D., "MHD Electrical Power Generation: Prospects and Issues," AIAA Paper No. 76-309, AIAA 9th Fluid and Plasma Dynamics Conference, San Diego, California, July 14-16, 1976.

to-fuel ratio, and gas cooling rate conditions.[28/] As mentioned earlier, work is currently underway to develop a model(s) which will simulate emissions from open-cycle, coal-fired MHD power plants.

Ambient baseline monitoring is being conducted (funded by ERDA under MERDI Task Q) at the MHD CDIF in Butte, Montana and currently includes analysis of air quality, meteorology/climatology, and water quality. Air quality data include total suspended and settleable particulates and their chemical analysis (including trace elements), ambient NO_x and SO_2, flourides, sulfates, nitrates, and precipitation washout samples and their chemical composition. Baseline water quality monitoring is being conducted for both groundwater and surface waters near the CDIF. Samples are analyzed for normally expected minerals and trace elements.

4.3.2 Pollutant Pathways, Transport, and Fate

Several analyses of large power plants have been undertaken to determine downwind concentrations of pollutants using existing mathematical dispersion models.[29–32/] Plume rise and associated downwind concentrations for other industrial sources are considered similar to that of power plants. The major factors which could result in different concentrations are photochemical alteration of effluent constituents, depositional depletion of particulates, and coagulation. Mountainous terrain effects on diffusion have also been investigated, but none of the studies have produced a model which will predict accurately plume dispersion and pollutant concentrations.[33-36/] In the event photochemical, depositional, and coagulation effects data do not become available or are inadequate to model MHD facilities, independent research efforts should be initiated to define the effects of the early MHD plants so that the results may be used in assessing the impact of the larger plants of the future.

A few studies of leaching of solid waste have been completed. However, little is known about the total amounts of water-leachable elements in different coal ash and the migration of such elements through soils.

4.3.3 Environmental Control Technology

NO_x control for MHD has been primarily concerned with minimizing the formation of NO_x by controlled combustion techniques and reduction of NO_x by holding exhaust gases at temperatures where the chemical kinetics favor the decomposition of NO_x. Experimental and modeling work in NO_x control through two-stage combustion and other combustion modifications, have been conducted by PERC,[4] AVCO Everett Research Laboratory,[37] and Stanford University.[38] These studies indicate that these methods should be adequate to meet the needs of MHD facilities. In addition, if gas residence times in the radiant boiler and high temperature air preheater sections are controlled properly, these emissions should be reduced even further. Research will be needed to verify the adequacy of these control techniques in advanced MHD facilities.

Research directed at removing NO_x at the end of the system and converting it to a saleable product has not been as extensive.[39] Results conflict as to whether or not recovery of fixed nitrogen products is economically feasible. More research in this area may be warranted.

Experimental results indicate that the use of potassium carbonate seed in open-cycle MHD systems will provide a satisfactory means of controlling SO_2 emissions to well below acceptable levels. Research should continue to ensure that SO_2 control will be both adequate and economical.

Current studies at the University of Tennessee Space Institute include evaluating the effectiveness of baghouses and wet scrubbers for collecting the submicron particles formed in the MHD test train. Study of particulate formation and control at other existing support technology facilities could greatly benefit the selection of control equipment for larger MHD facilities.

4.3.4 Occupational Health and Safety

With the exception of the safety considerations reports on the Montana CDIF by Gilbert/Commonwealth Engineers/Consultants,[21, 22] little direct information in published form exists on occupational health and safety aspects of open-cycle MHD operations. Environmental analyses and safety guidelines have been developed for the University of Tennesee Space Institute (UTSI) MHD facility in Tullhoma, Tennessee; however, the resultant document is not yet published. A comprehensive research program in this general area is being supported by ERDA with major efforts at the Lawrence Berkley Laboratory and Pacific Northwest Laboratory.

4.3.5 Health Effects

Adverse health effects have been reported from magnetic fields resulting from magnetic separators (used in coal preparation to separate out pyrite and tramp metals) and high intensity magnetic fields encountered at the Stanford Linear Accelerator[19/] and at the Soviet MHD facility.[20/] However, there is no clear-cut information regarding total duration of exposure or dose/response relationships.

Although considerable research efforts have been expended on the introduction of metal ion pollutants via the atmosphere, most of the effort has concentrated on lead and mercury to some extent, while little predictive information is available yet for trace elements such as Sb, As, Cd, Cr, Ni, Cu, and Mn. It is questionable whether the vapor phase is significantly involved in the emission and transport of trace elements other than mercury. There is some evidence that Zn, Cd, Sb, Se, and Pb[40/] as metals or volatile metal chelates would be transported significantly through a vapor phase. A number of transition metals form volatile carbonyl complexes such as nickel tetracarbonyl and thus, can be transported readily in the vapor phase.

Investigations into the toxicology of trace elements associated with fly ash particles are complicated by several factors. First, an elemental analysis of the fly ash particle does not give the chemical nature (compound form) of the trace element in question. The chemical form of the element has profound importance on the trace element's solubility, biological availability, and toxicological potential. Second, the usual procedure for investigating the toxicity of a trace element is to introduce into test animals graded doses of a soluble form of the trace element in question. However, fly ash consists of insoluble oxides of a whole spectrum of trace elements which are essentially inert when tested in bioassay.

Research on toxicological effects of metals has focused primarily on acute effects of a single element and its compounds. Observed toxic effects of heavy metals include: kidney damage and respiratory problems from cadmium and mercury; behavioral, central nervous system, teratogenic and embryotoxic effects of certain nickel compounds; antihemopoetic, neurotoxic and nephorotoxic effects from lead; and Parkinson-like symptoms from manganese.

Considerable progress has been made recently in the development of short-term screening methodologies, which, in a few days can differentiate carcinogenic organic compounds. The onset of chemically induced cancer requires about 20 to 30 years in humans or several years in laboratory rats. The Ames test measures background vs. chemically-induced mutations in bacteria. The test is also conducted using human tissue cells, and similar mutagen testing systems are being developed for higher organisms.

Unlike organic compounds, the carcinogenicity and teratogenicity of a large number of inorganic compounds, with the exception of chromic oxides and certain platinum complexes, cannot be verified with the mutagen screening techniques now available.

While the systemic effects of the majority of the trace elements have been documented, the carcinogenicity (with the exception of As, Ni, Cr, U, Ra), teratogenicity, and mutagenicity of the trace elements remain largely unveiled. The synergistic or antagonistic effects of combinations of trace elements should also be investigated.

4.3.6 Ecological Processes and Effects

A tremendous amount of research has been conducted on the ecological effects of construction and operation of conventional coal-fired power plants which should be similar to the effects from MHD facilities. The bioenvironmental impacts of trace elements are currently under investigation at the Colstrip Montana generating facility.[41/] Similar research at MHD facilities may be helpful in determining whether MHD has less bioenvironmental impact than conventional coal-fired facilities.

Infrared photography has been used successfully in aerial detection of vegetation damage caused by air pollution. Infrared slides have been obtained for the CDIF by MERDI for use in establishing baseline vegetation characteristics. An analysis of grassland communities near the CDIF site was also performed and a baseline biological surveillance program is currently underway.

4.3.7 Integrated Assessments

The programmatic assessment of ERDA's MHD program is included in the Environmental Impact Assessment for ERDA's Coal Program. This programmatic assessment will be updated periodically as more information becomes available.

Environmental, physical, and socioeconomic effects resulting from construction and operation of the CDIF have been addressed in the CDIF comprehensive site survey[42/] and evaluated in the environmental assessment[43/]. It was determined from this assessment that an environmental impact statement was not required. In addition, an assessment of the environmental, health, safety, and socioeconomic impacts and consequences of the developed MHD technology has been initiated at Montana State University. An ETF siting study is currently being conducted.[44/] This four phase study is evaluating social, environmental, economic, managerial, and institutional constraints as well as physical constraints.

ERDA is currently funding a study to monitor the socioeconomic impact of the CDIF during the pre-construction, construction, and post-construction phases. Although social impact assessment has been included in the Environmental Impact Assessments for two recent energy developments in Montana,[45, 46/] there was no apparent criteria on how this information was evaluated in terms of other constraints, nor was the research found to be entirely adequate for analysis of the MHD technology. Another deficiency in socioeconomic evaluation is in the area of community impacts from the termination of an energy related industry. However, the social impact of the termination of two government ABM sites has been investigated,[47/] and may provide a basis for impact analysis at MHD facilities.

4.4 Future Environmental Research and Assessment Activities

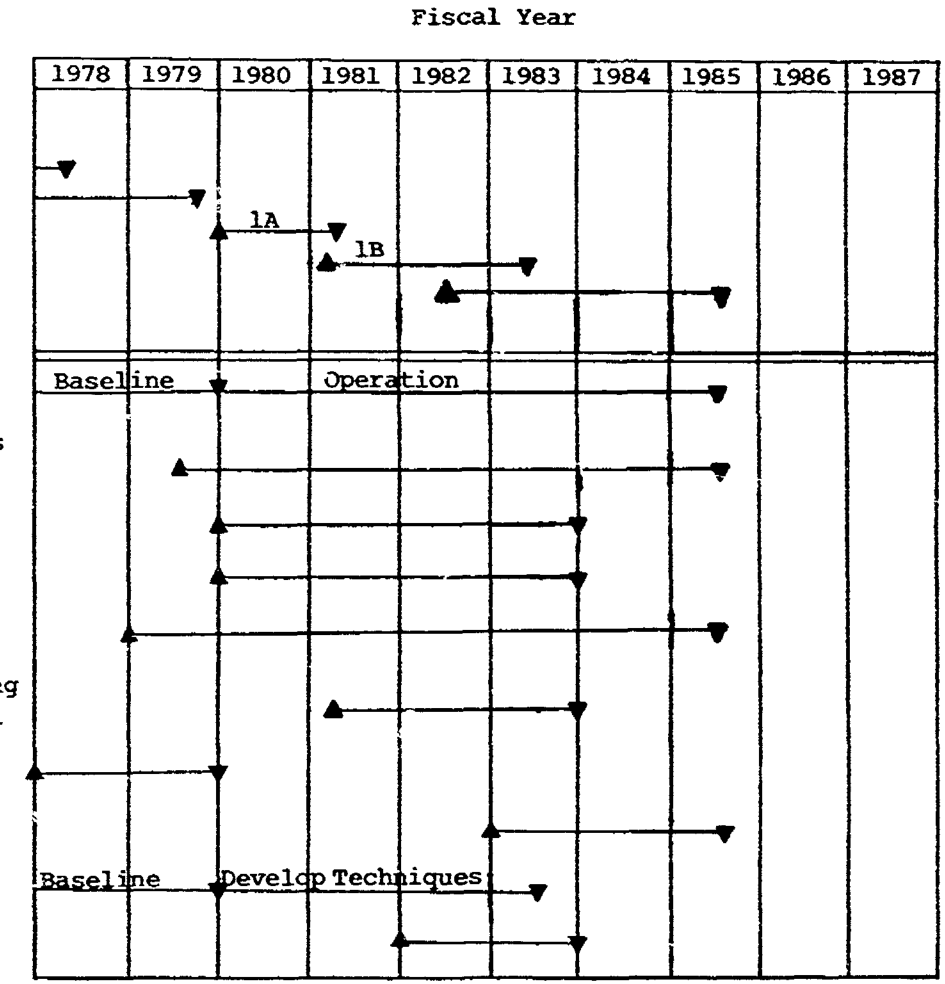
Based upon the environmental, health, and safety issues and research needs identified in Section 3, and the review of ongoing and completed research reviewed above and in Attachment A, and in accordance with the priorities scheme presented in Section 4.2, it is possible to develop a future environmental research plan to be implemented in concert with the MHD technology development program. The proposed plan presented in this section includes a discussion and scheduling of those projects considered to be of high priority. These attempt to address the issues pertinent to MHD. It should be realized, however, that there are many projects, other than those presented here, which would further the development of MHD as an environmentally acceptable technology.

In brief, the plan for future research encompasses general research, such as improved sampling and control techniques for fine particulates, and specific research, such as monitoring and characterization of air emissions at specific facilities.

Monitoring and characterization are of primary importance in determining which pollutants are produced from MHD facilities and which ones present potential environmental problems. These data aid in the modification or development of the environmental control systems needed to control those effluent species determined to be of greatest concern. Monitoring data also are very useful in identifying which pollutants from MHD are of greatest concern with respect to effects on humans and ecosystems. This in turn helps to define the areas of needed future research on health effects. Finally, based upon the baseline and operating ambient and effluent monitoring data, control technology evaluation and development, and effects research, assessments can be made concerning the environmental, health, and safety impacts of MHD facilities and the developed industry. Figures 4-1, 4-2, and 4-3 summarize the schedule of the work plan presented below.

FIGURE 4-1

ENVIRONMENTAL ACTION PLAN FOR THE MHD CDIF



CDIF Technology Development
- Detailed Design
- Construction
- Testing - Train 1A
  - Train 1B
  - Downstream Components

Baseline and Operating Ambient Monitoring Programs for MHD Facilities

Characterize and Monitor Air Emissions and Water Effluents During Operation

Assessment of Particulate Control Technologies

Assessment of Nitrogen Oxides Emissions

Design and Implementation of an Occupational Health and Safety Monitoring Program at MHD Facilities

Analysis of the Chemical and Physical Stability of MHD Slag and Fly Ash and the Implications of Treatment and Disposal

Development of a Water Conservation Plan for the MHD CDIF

Determination of Transport and Fate of Trace Elements in Solid Waste Leachate

Assessment of Ecological Impacts of MHD Emissions

Analysis of Alternative Means of Solid Waste Management

Legend ▲= Begin

▼= Complete

Note: A detailed description of each of these projects is presented in the text below.

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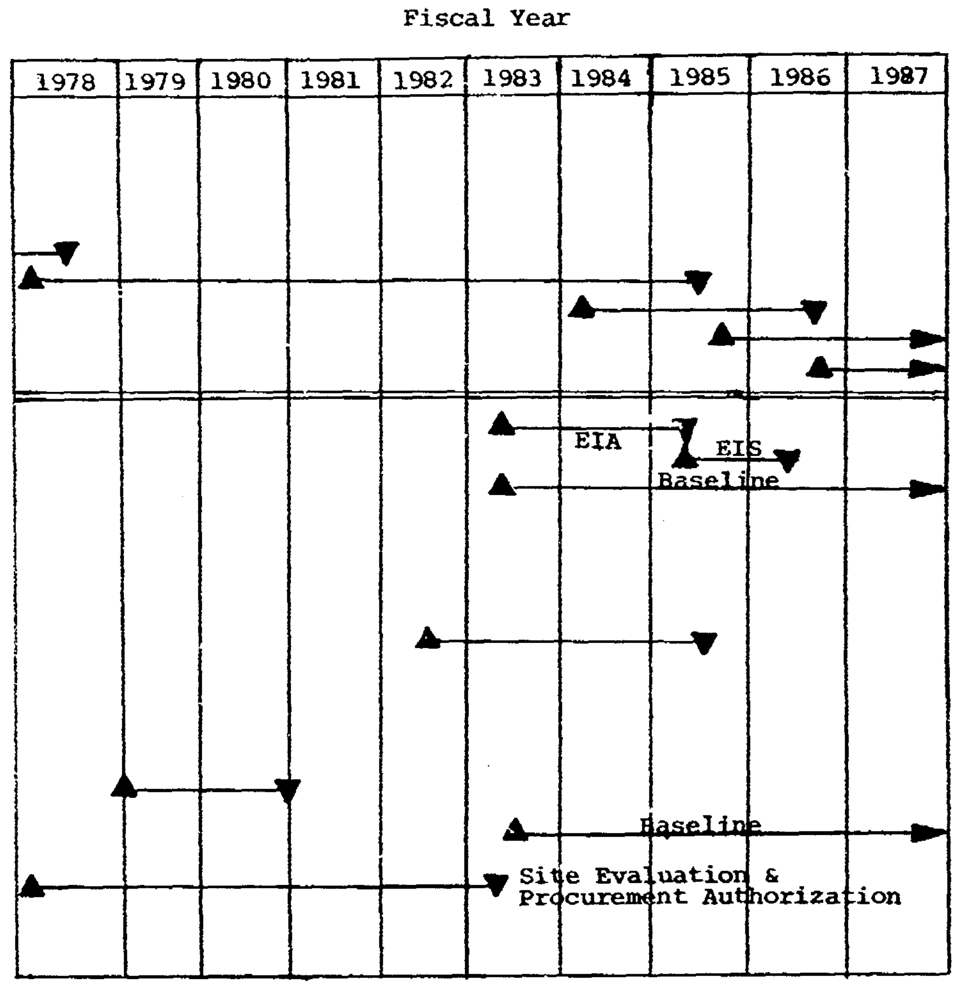
FIGURE 4-2

ENVIRONMENTAL ACTION PLAN FOR THE MHD ETF



ETF Technology Development

- Conceptual Design
- System Engineering Studies
- Preliminary Design (Title I)
- Detailed Design (Title II)
- Construction

Preparation of EIA and EIS, if necessary, for the MHD ETF

Baseline and Operating Ambient Monitoring Programs for MHD Facilities

Characterize and Monitor Air Emissions and Water Effluents During Operation

Development of Economic and Environmentally Acceptable MHD Seed Recovery Subsystems

Design and Implementation of an Occupational Health and Safety Monitoring Program at MHD Facilities

Development of a Water Conservation Plan for the MHD ETF

Assessment of Ecological Impacts of MHD Emissions

Expansion of the ETF Siting Study

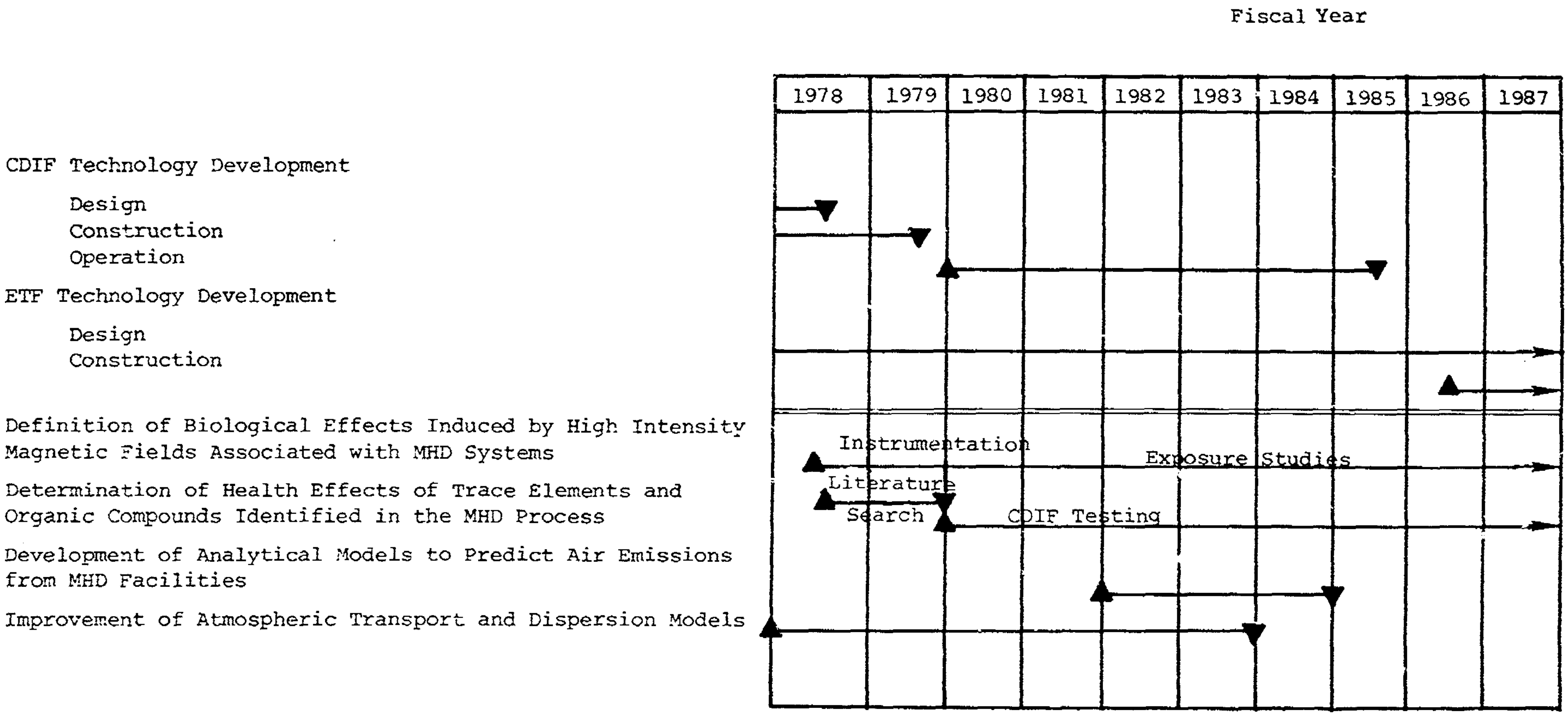
Legend ▲ = Begin

▼ = Complete

Note: A detailed description of these projects is presented in the text below.

FIGURE 4-3

ENVIRONMENTAL ACTION PLAN FOR GENERAL MHD RESEARCH



Legend ▲ = Begin

▼ = Complete

Note: A detailed description of these projects is presented in the text below.

PREPARATION OF EIA AND, IF NECESSARY, EIS FOR THE MHD ETF.
(In Response to R&D Requirements IX.A.1)

Objective: To comply with NEPA and ERDA guidelines for NEPA compliance relative to the MHD program by preparing an EIA and, if necessary, an EIS on major projects.

Significance: NEPA requires Federal agencies to consider the potential environmental effects of their proposed actions at the earliest possible time and to integrate environmental considerations into the decision-making process at all stages of technology development. Preparation of an EIA and EIS, if necessary, for the ETF will fulfill ERDA's legal obligations under the National Environmental Policy Act (NEPA), and thereby avoid project delays which would result from any criticisms or law suits brought against ERDA on this subject.

Suggested Research: During the detailed design phase and after selection of the site, preparation of the EIA will begin in parallel to the water availability assessment, if necessary, and baseline monitoring program. Basic data on the range of environmental and socioeconomic impacts expected from the ETF will be collected. A site visit and evaluation of available ambient monitoring data will be included. If upon review of the EIA, preparation of an EIS is recommended, the EIA will be expanded into an EIS.

The EIA and EIS will include assessment of environmental impacts of the ETF on the following areas: air, surface water, groundwater, land use, ecosystems, and the socioeconomic environment (e.g., employment, population, economics, health and safety, aesthetics, and historical and recreational areas). Impacts on the quality and quantity of resources will be included, as well as mitigating measures, unavoidable impacts, short-term and long-term impacts, irreversible and irretrievable impacts, and identification of alternatives to the potential project. Environmental problems associated with fine particle emissions, potassium seed material, high temperature creation of toxic compounds, and health effects of human exposure to magnetic fields should be addressed. The social impact of terminating a test facility with a design life of 15 years should be determined and mitigating measures identified.

The EIA will be used to determine whether or not the project will result in a significant impact on the environment, and whether an EIS should be prepared. The EIA and EIS should be completed in time for the project evaluation at the end of the detailed design phase and before the decision to construct is made.

Recommended Schedule of Activities: Initiate ETF environmental assessments - FY 1983.

Final EIA - FY 1985
Final EIS, if necessary - FY 1986

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CHARACTERIZE AND MONITOR AIR EMISSIONS AND WATER EFFLUENTS FROM MHD FACILITIES

(In Response to R&D Requirements I.A.1, 2, 3 & 6/I.B.3, 4, 5/II.A.2/ III.A.1,2/IX.A.2)

Objective: To insure that specific ERDA facilities will not adversely affect air and water quality and to obtain emission and effluent data which can be scaled up to evaluate impacts of the larger MHD facilities.

Significance: Characterization and quantification of emissions and effluents at specific MHD facilities, when coupled with baseline ambient air and water quality monitoring, will provide a basis for assessing whether MHD systems will be significant contributors to ambient pollutant levels. Emissions and effluent data from the CDIF will be useful in preparing the EIA for the ETF and also will provide a basis for modifying ETF control system designs if this proves necessary. Data from the ETF and more advanced MHD facilities will be scaled up to evaluate impacts from commercial plants. Without adequate emissions and effluent data, subsequent EPA regulatory actions regarding MHD emissions could impede CDIF operation or delay ETF construction until the emission and effluent control potential of MHD facilities has been adequately addressed.

Suggested Research: Design and implement a comprehensive program to monitor and characterize all ducted and fugitive gaseous and particulate emissions and water effluents to identify and quantify pollutant species, including thermal discharges, released to the environment by MHD facilities. Include monitoring of solid waste leachate and/or runoff from solid waste disposal sites. Start up, load changes, shutdown and maintenance operating modes will be considered in addition to design conditions. Analyze for criteria pollutants, thermal discharges, trace elements, fine particulates, radioactive emissions, and highly toxic or carcinogenic compounds. Perform chemical analyses on effluents and various size fractions of particulates for potassium seed compounds, sulfates, trace metals, and other potentially harmful substances. Perform multi-element mass balance studies of air, water or solid waste effluents at selected MHD facilities and compare with similar studies done at conventional coal-fired power plants. Establish the relationship between specific operating parameters and the relative concentration of toxic molecules in particle emissions. Monitoring data obtained at the CDIF will also be used in a computer model currently being developed to forecast trace element and sub-micron particle emissions from the MHD ETF, and may provide a basis of knowledge for the ETF EIA.

Recommended Schedule of Activities: Initiate design of emissions and effluent monitoring systems for the

CDIF - FY 1979
ETF - FY 1987

Initiate monitoring and analysis program for the

Supporting technology centers - FY 1978
CDIF - FY 1980

BASELINE AND OPERATING AMBIENT MONITORING PROGRAMS FOR MHD FACILITIES

(In Response to R&D Requirements I.B.2, 3, &6/II.A.1 & 3/V.A.1/V.B.1)

Objective: To establish a data base against which the effects on the environment of MHD facility construction and operation can be compared and evaluated.

Significance: Through the comparison and analysis of baseline ambient air quality, water quality, and ecological monitoring data with these same types of monitoring data obtained during construction and operation of MHD facilities, adverse environmental effects are identified, if they exist. This provides corrective feedback for control technology modifications and contributes to the verification of the environmental acceptability of the MHD technology. Baseline monitoring data are very helpful in preparing the site-specific EIA/EIS for proposed facilities.

Suggested Research: Design and implement programs for baseline and operational monitoring of ambient air quality and surface and groundwater quality at MHD facilities. Include data collection for criteria pollutants, trace elements, and all other compounds which potentially could result from operations at MHD facilities (in particular potassium seed compounds). Emphasis will be primarily on fine particulates, NO_x, trace elements and sulfates. Meteorological data on wind velocity, direction, stability, etc., will also be obtained if data are not available from existing nearby weather stations. Ecological monitoring will include terrestrial and aquatic fauna and flora and will concentrate on sensitive indicators of habitat quality and those species most likely to suffer from MHD plant siting, construction and operation. Assess the response of economically important species to MHD potential pollutants such as fine particles and trace elements.

Baseline and operational ecological monitoring should include such aspects as: a reference collection of soil, plant, and animal samples; soil, vegetation and animal analyses for SO_2, NO_x, trace elements, and other regulated or potential pollutants; ecological community structure near the site prior to facility operation; use of infrared photographs of the site before operation to establish the extent of vegetational damage, if any. Monitoring at the CDIF site will focus on developing techniques which will be used to determine health effects at the ETF.

Ambient baseline sampling and continuous monitoring of ambient air quality will occur prior to plant operation within a specified region (usually 1 to 3 miles from the plant site). This baseline monitoring has already begun at the CDIF site and will be continued until CDIF test operation, scheduled to begin in 1980. More extensive sampling and continuous monitoring of ambient air quality downwind of plant emissions will continue after the onset of CDIF operation. Baseline monitoring at potential ETF sites will begin in FY 1978. Upon selection of a specific site, the monitoring program will be expanded.

Recommended Schedule of Activities: Initiate baseline ambient monitoring program.

ETF - FY 1983

Complete baseline ambient monitoring program and initiate operational ambient monitoring program.

CDIF - FY 1980

ASSESSMENT OF NITROGEN OXIDES EMISSION CONTROL TECHNOLOGIES FOR MHD POWER PLANTS
(In Response to R & D Requirements VI.A.1, 2, 3, 5, 6, & 8)

Objective: To perform a quantitative and qualitative assessment of the atmospheric emissions of nitrogen oxides from MHD power systems and to analyze the effectiveness of alternative NO_x control measures.

Significance: MHD systems may result in NO_x emissions above those of conventional coal-fired boilers. This is due to typically higher combustion temperatures (4000°F-5000°F), and possibly from superconducting magnets [87] and NO_x control systems.[97] Since allowable emissions of NO_x may be decreased in the future, it is necessary for ERDA to develop data on MHD NO_x emissions and alternative techniques available for their control to insure that adequate controls will be available for the more advanced MHD facilities.

Monitoring and quantification of atmospheric NO_x emissions at MHD sites will provide a data base on actual MHD NO_x emissions in the light of potentially stricter standards. Some work in this area has already been carried out at the Stanford University, PERC, AVCO and UTSI facilities. Failure to complete this study may delay ETF operation or commercial development until the NO_x problem has been adequately addressed and control measures implemented. Further, it may result in the setting of NO_x emission limits applicable to MHD without the full benefit of technical data producible only at ERDA facilities.

Suggested Research: Emissions of nitrogen oxides at MHD facilities will be monitored and emissions data collected and recorded during the length of the facility's operation. NO_x emissions data will be modeled and compared to ambient air qulaity data derived from baseline air quality monitoring performed prior to plant operation. This will result in an assessment of MHD contributions to ambient NO_x levels. In the event that conventional control techniques (such as multi-stage combustion and modification of air-to-fuel ratios and gas cooling rates) are not found to be adequate in controlling NO_x emissions, research into alternative control measures will be conducted. Such research will be aimed at developing an environmentally acceptable (considering potentially stricter NO_x emission standards) and cost-effective control procedure. Cost/control curves will be developed for all NO_x control technologies evaluated.

Recommended Schedule of Activities: Initiate quantitative assessment of NO_x emissions and conventional control technologies

CDIF - FY 1980

Complete assessment of conventional NO_x control technologies and, if necessary, initiate assessment of alternative technologies

CDIF - FY 1984

Complete alternative NO_x control technology development

CDIF - FY 1985

ASSESSMENT OF PARTICULATE CONTROL TECHNOLOGIES FOR MHD FACILITIES

(In Response to R&D Requirements VI.A.1, 3, 4, 6 & 8)

Objectives: To analyze and evaluate the effectiveness of alternative particulate control technologies, with particular emphasis on the control of fine particulates.

Significance: EPA is currently revising the particulate standards for utility boilers downward. To ensure that future standards applicable to MHD can be met, adequate control technology must be made available. In addition, MHD power generation may result in the creation of fine particulates not effectively removed by existing particulate control technologies. These particulates will contain trace elements and sulfates formed via reaction of the seed material with the sulfur and trace elements present in the coal. The EPA views atmospheric sulfates as a potentially serious air pollution problem and is conducting further research in this area. ERDA requires adequate knowledge of the potential for and degree of MHD contribution to atmospheric sulfate and trace element levels if the environmental acceptability of the technology is to be established. Failure to complete this study may delay ETF operation until the fine particulates problem has been addressed and control measures, if necessary, are implemented. In addition, although the promulgation of emission limits for small particulates is probably several years away, ERDA should begin to identify the incidence of small particle emissions and develop the best possible and most cost effective technologies possible for their control.

Suggested Research: This project should concentrate on the development of control options for particle control. The characterization and monitoring data collected during operation of supporting technology facilities and the CDIF will be used to determine the physical and morphological characteristics and chemical composition of various size fractions of particulates from MHD facilities. The mass respirable fraction should also be determined. The effectiveness of existing control technologies for particulates will be evaluated (e.g., high energy wet scrubbers, cyclones, electrostatic precipitators and baghouses). If fine particle emissions for MHD are a problem and control with current technology is found to be inadequate, variations, improvements, and/or new technology options will be investigated and tested. Cost/control analyses will be performed for all potential technology options so as to determine the maximum level of control economically achievable.

Recommended Schedule of Activities: Initiate evaluation of particulate emissions

Supporting technology facilities FY 1980

CDIF - FY 1980

Complete control technology evaluation and, if necessary, intiate modification and/or development of new control technologies

CDIF - FY 1984

Complete particulate control technology development

CDIF - FY 1985

DESIGN AND IMPLEMENTATION OF AN OCCUPATIONAL HEALTH AND SAFETY MONITORING PROGRAM AT MHD FACILITIES
(In Response to R&D Requirements IV.A.1, 2, 3, 5, 6, 7 & 8/ IV.B.2/IV.C.1, 2, & 3)

Objective: To establish an occupational health and safety monitoring and recording program for each ERDA MHD facility to assess occupational health and safety hazards associated with MHD facilities and to provide a data base for establishing OSHA standards.

Significance: The occupational health and safety hazards associated with MHD technologies are not fully known. Of particular concern in the MHD process is the generation of high intensity magnetic fields reaching six or more Tesla, the occupational health effects of which are largely unknown. Noise, vibration and generation of fine particulate matter are also potential problems. Without an adequate data base for use in evaluating possible occupational health and safety hazards, a basis for evaluating the technology's environmental acceptability and for establishing OSHA standards will not exist. This would delay operation at the ETF and commercialization goals. This project will also provide guidance to AES by identifying areas of needed health effects research.

Suggested Research: A detailed occupational health and safety monitoring program should be developed specific to MHD facilities which includes parameters to be monitored, level, frequency, and location of monitoring stations. Monitoring of the work environment will include qualitative and quantitative monitoring of electromagnetic fields, in-plant air emissions, heat, noise, and vibration levels. Workers will be monitored by means of medical surveillance, including pre-employment and periodic physicals; and epidemiological studies of workers at the ETF will be conducted to identify potential health effects of MHD, particularly those associated with exposure to high intensity magnetic fields. A specially trained physician with experience in occupational health and industrial hygiene should be provided to establish appropriate pre-employment and subsequent periodic medical laboratory examinations and suggested research. An industrial hygienist should also be employed. Needs for protective clothing, such as gloves and respirators, or equipment (i.e., shields for superconducting magnets) will be identified, and health protection procedures for workers will be established. Hazardous components, areas of potential mechanical failure, combustion hazards and other safety hazards in MHD facilities will be identified, and methods to minimize these hazards will be developed. Monitoring programs will be more extensive at the ETF and commercial demonstration facilities as these facilities will operate for longer periods of time and provide data more representative of a commercial MHD facility.

Recommended Schedule of Activities: Design occupational health and safety monitoring program

CDIF - late FY 1978
ETF - FY 1987

Implement monitoring program and develop necessary protective measures

CDIF - FY 1979

DEFINITION OF BIOLOGICAL EFFECTS INDUCED BY HIGH-INTENSITY MAGNETIC FIELDS ASSOCIATED WITH MHD SYSTEMS
(In Response to R&D Requirements IV.B.3. & 5.)

Objective: To build a data base to be used in devising guidelines for occupational and other exposures to the high-intensity magnetic field associated with MHD systems.

Significance: Health effects of magnetic fields are ill-defined and poorly understood. A number of symptoms in humans exposed to high-intensity magnetic fields have been reported including headache, fatigue, irritability, altered appetite, altered pulse rate, lowered blood pressure, and decreased white blood cell count. Published results from several laboratories indicate that low level magnetic field intensities may cause mutagenesis and teratogenesis, as well as cell and chromosome division perturbation. However, human data are very limited and much of what is available is open to serious question. Moreover, although many studies of biomagnetic effects in animals have been reported, results have not been sufficiently reproducible or reliable to permit extrapolation to man. Given the existing high degree of uncertainty relative to health effects of magnetic fields, the possibility of worker exposure to the high-intensity fields expected to exist at MHD facilities is of major concern. Inasmuch as an adequate data base on human responses to magnetic fields will not be available for many years, early decisions concerning limits on occupational exposures will of necessity rely heavily on quantitative data obtained from carefully controlled animal experiments. At present, no formal guidelines or standards applicable to human exposure to magnetic fields are in effect in the United States.

Suggested Research: To ensure proper assessment of exposure, research on instrumentation to measure dosage from high intensity magnetic fields is vital and should include the development of: 1) an area monitor for measurement of magnetic field strength, orientation, and gradient; 2) a personal integrating monitor or dosimeter to measure exposure to workers; and 3) a theoretical framework for magnetic field dosimetry which includes effects of field strength, orientation, gradient and frequency.

Selected short-lived animals will be exposed to magnetic fields at the CDIF and possibly the U-25 under carefully controlled conditions. Both short-term and long-term exposures will be employed. Particular care will be taken to define all animal exposure parameters precisely and to eliminate physical as well as biological artifacts. The acquisition of quantitative dose-response data will be emphasized. Supporting research in simpler experimental systems will serve to identify biomagnetic response parameters of interest, develop a basis for understanding animal responses to magnetic fields, and facilitate the design and interpretation of animal experiments. Because so little is known about biomagnetic phenomena, many response parameters will need to be evaluated in exposed animals, including (1) genetic effects, (2) effects on reproduction, growth, and development, (3) effects on the nervous system and behavior, (4) effects on hematopoiesis and blood chemistry, (5) effects on cardiovascular function, (6) effects on morbidity patterns, and (7) effects on life span and mortality patterns. Range-finding studies of biomagnetic effects now in progress will be selectively expanded as scientific knowledge increases.

Prospective epidemiological strategies will be designed and completed with the exposure data collected by monitoring devices so that more meaningful safety standards can be developed as guidelines for occupational exposures to magnetic fields. Recommendations regarding limits on occupational exposures to magnetic fields will be made, and periodically reviewed as more information becomes available.

The possibility that MHD magnetic fields may affect flight patterns of birds will be assessed by a scientific panel to define possible impacts, identify uncertainties, and plan any research that may be needed.

Recommended Schedule of Activities

Initiate instrumentation research - FY 1978.

Initiate exposure research - FY 1979.

Make recommendations regarding limits on occupational exposures to magnetic fields occurring in ERDA operations - FY 1979.

DETERMINATION OF HEALTH EFFECTS OF TRACE ELEMENTS AND ORGANIC COMPOUNDS IN MHD PROCESS WASTES
(In Response to R&D Requirements I.C.1/II.B.1/III.B.1/and IV.B.4.)

Objective: To identify and quantify any process-specific health effects attributable to trace elements or organic compounds in emissions, effluents, and solid wastes produced at MHD facilities under normal operating conditions.

Significance: Trace elements, fine particulates, hydrocarbons, and other organic compounds released as by-products of coal combustion are known to represent a serious hazard to human health. In many instances, toxicity is incompletely understood, particularly with respect to possible late effects (e.g., mutagenesis) resulting from chronic, low-level exposures. Nevertheless, Federal standards limiting human exposures to a number of the above-mentioned by-products have been established. Ongoing research sponsored by Federal agencies (including ERDA) is providing additonal toxicity data that will be needed to refine and supplement existing standards. In view of the high temperatures involved in the MHD combustion process, the introduction of potassium seed material into the combustion stream, and the ionic character of the combustion plasma, the profile of MHD by-products is expected to differ both qualitatively and quantitatively from the profile seen in conventional coal-combustion processes. Such differences must be defined and their significance with respect to health effects must be determined. It is anticipated that nonunique MHD health effects can be assessed primarily on the basis of MHD by-product monitoring, existing information on coal-combustion health effects, and data produced by other fossil-fuel studies. The purpose of this work unit is to conduct both process-specific and generic assessments in the context of occupational as well as public health.

Suggested Research: Perform a literature search on the health effects of expected pollutants in process waste streams. In the operational monitoring programs MHD emissions, effluents, and solid wastes will be analyzed, characterized (where necessary), and quantified with respect to trace elements, particulates, hydrocarbons. and other organic compounds. To the extent that by-products are qualitatively similar to those characteristic of conventional coal combustion processes, health effects should be assessable without additional research. Unique by-products will be subjected to toxicological testing. In general, a multi-tier system of toxicological testing will be employed in which test materials are rapidly screened in simple, well-standardized biological systems (including the Ames bacterial system) to obtain preliminary information on mutagenic, carcinogenic, clastogenic, and teratogenic properties as well as cytotoxicity. In the case of complex mixtures (e.g., organic materials) screening is conducted in conjunction with chemical separations to evaluate the toxicity of reproducible fractions and eventually specific compounds. Substances identified as potentially hazardous are further studied in animal systems. Long-term animal studies are conducted only when warranted on the basis of preliminary evaluations of acute, subacute, and delayed responses. In the case of particulate materials, preliminary work consists of chemical and physical characterization, evaluation of cytotoxicity in vitro (rabbit alveolar macrophage test system), and screening (as described above) of inorganic and organic fractions extracted from the particulate material. Positive indications of toxicity would require long-term inhalation studies of particulates in animal systems. With the experimental approach outlined, only a limited number of long-term animal studies is anticipated.

Recommended Schedule of Activities:

Initiate literature search - FY 1978.

Initiate health effects studies using data from the CDIF and ETF
CDIF - FY 1980

DEVELOPMENT OF ECONOMIC AND ENVIRONMENTALLY ACCEPTABLE MHD SEED RECOVERY SUBSYSTEMS
(In Response to R&D Requirements III.C.3/VI.A.1, 4, 6, 7 & 8/VI.B.1)

Objective: To develop economic and environmentally acceptable seed recovery and regeneration subsystems to be used in the MHD ETF and to evaluate the potential environmental impacts of these subsystems.

Significance: For economic as well as environmental reasons, the alkali metal seed materials used in MHD power generation must be recovered and regenerated and sulfur must be removed and disposed of in the regeneration process. This will entail a series of recovery, regeneration, cleanup, and disposal steps with emission or disposal problems related solely to these subsystems. Analysis is therefore necessary to determine potential emission sources, characterize emissions, and develop mitigation measures. This project will enable the integral development of impact mitigation measures with ETF seed recovery system design modifications for purposes of mitigating environmental problems. Secondary environmental problems attributed to the seed subsystems could delay ETF construction if this project is not completed.

Suggested Research: Identify all sources of seed loss (i.e., ash, slag, fly ash, internal hold-ups, and seed recovery and regeneration plant) and determine the extent of seed loss by each under actual operating conditions. Identify mechanisms leading to significant seed loss (e.g., slag or possible fine particulate emissions), and develop and test control methods to maximize seed recovery, including process and design modification and particulate control technologies. Perform engineering and cost analyses on potential candidates for seed extraction and regeneration systems to select the most promising technologies for further research. Test and develop extraction technologies which maximize potassium extraction from spent seed and fly ash/seed material. Test and develop regeneration technologies which maximize seed recovery and minimize solid waste generation and other secondary environmental problems associated with seed regeneration systems. Scale up the most promising systems for testing at the ETF scale. Determine the potential emission and effluent sources in the seed recovery/regeneration subsystems. Characterize all potential emissions and effluents resulting from seed regeneration, subsequent cleanup measures (e.g., Claus sulfur recovery unit), and generation of the H_2 and CO synthesis gas used in seed regeneration. Assess the impacts on air and water quality of identified pollutants and identify potential health hazards. Assess the practicability of various effluent and emission control and impact integration measures. Determine the combination of recovery/regeneration systems and seed materials which offer the greatest degree of environmental acceptability and cost/effectiveness.

Recommended Schedule of Activities:

Initiate engineering and environmental assessment of seed recovery and seed regeneration systems - FY 1982.

Complete engineering and environmental assessment of seed recovery subsystems - FY 1985.

ANALYSIS OF THE CHEMICAL AND PHYSICAL STABILITY OF MHD SLAG AND FLY ASH AND THE IMPLICATIONS FOR TREATMENT AND DISPOSAL

(In Response to R&D Requirement II.A.4/III.A.1)

Objective: To analyze the physical and chemical stability of MHD generated slag and fly ash and to assure the use and/or development of environmentally acceptable methods for treatment and disposal.

Significance: MHD-generated slag and fly ash may have different characteristics than slag and fly ash usually encountered in coal-fired boilers. This is due to the very high combustion temperatures (2760°C/5000°F) and the addition of potassium seed material (potassium carbonate). Consequently, research is necessary to assess potential disposal and leachability problems resulting from MHD-generated slag and fly ash and determine appropriate environmental control measures. This analysis will result in an assessment of the environmental implications of MHD-generated slag and fly ash and identify appropriate control measures available to mitigate such problems. Failure to complete this assessment could result in significant disposal problems for CDIF and ETF-generated wastes, and delay MHD commercialization if waste disposal methods are not formulated or developed at this time.

Suggested Research: Using samples derived from the CDIF and ETF when operating under conditions representative of commercial plant conditions, the chemical composition and physical stability of MHD-generated slag and fly ash will be compared analytically with ash generated by conventional coal-fired boilers, with special emphasis on quantitative and qualitative assessment of trace elements which may be generated in MHD systems by high combustion temperatures. Conditions under which MHD solid wastes release potential contaminants will be characterized and the individual contaminant concentrations under these conditions will be determined. The rates at which various contaminants are released will be evaluated. Laboratory analyses will be conducted to simulate leaching of MHD solid residues before and after seed regeneration under a variety of conditions, including leaching by natural waters (i.e., rainwater, surface water and groundwater), leaching under mildly oxidizing and mildly reducing environments, and successive solids/leachate contacts to assess qualitatively the longterm rate of leaching of identified compounds. The following analytical information will be determined: 1) physical properties of slag and fly ash including bulk and particle density, porosity, and surface area; 2) chemical composition with emphasis on main constituents and significant trace elements; and 3) contaminant composition of leachate including pH, sulfate levels, and trace metals content. Finally, a determination will be made of whether conventional treatment and disposal methods are adequate for MHD slag and fly ash.

Recommended Schedule of Activities:

Initiate analysis of CDIF non-regenerated solid waste - FY 1981.

Complete analysis of CDIF solid wastes - FY 1984.

DEVELOPMENT OF A WATER CONSERVATION PLAN FOR MHD FACILITIES
(In Response to R&D Requirements II.C.1/VII.A.4/IX.A.2)

Objective: To develop data on water resource requirements and water supply availability for proposed MHD facilities in order to avoid hindrance of MHD technology development and facility siting due to limitations on water use.

Significance: Completion of the water conservation plan for the CDIF and ETF will provide important data on MHD water requirements, which will be useful to the Water Resources Council in preparing the water assessments mandated by Section 13 of the Federal Nonnuclear Energy R&D Act of 1974. This project will also provide information on the methods available for the reduction of MHD water usage. Lack of these data could impede ETF and commercial plant development and siting due to water availability limitations.

Suggested Research: Water conservation plans for MHD facilities will be prepared. Data will be collected on the quantitative and qualitative water requirements of MHD operations. Techniques for reducing MHD water consumption, such as recycling or cooling system modification, will be examined. In addition, methods of utilizing low quality or wastewater in MHD systems will be investigated. Recommendations will be made for the implementation of cost effective techniques capable of reducing overall MHD fresh water requirements and/or substituting lower quality water for MHD uses. The CDIF water conservation plan will support ETF design and siting analyses as well as provide a background in this area for the ETF EIA.

Recommended Schedule of Activities:

- Compile data on MHD water requirements
  - CDIF - early FY 1978
  - ETF - FY 1980
- Complete water conservation plan including recommendations for applicable water conservation techniques
  - CDIF - FY 1980
  - ETF - FY 1982

ASSESSMENT OF ECOLOGICAL IMPACTS OF MHD EMISSIONS
(In Response to R&D Requirements V.B.1.)

Objective: To outline a research plan for the determination of the ecological impacts of MHD emissions.

Significance: The most important factor in an evaluation of the ecological impact of MHD emissions is to establish how these emissions differ both qualitatively and quantitatively from pollutants produced from conventional coal combustion. Current evidence indicates that open-cycle MHD will produce significantly lower amounts of SO_2, up to ten times as much NO_x depending on the types of controls used, and an increased proportion of fine particles (adhering to these particles will be various trace elements and potassium seed material). These pollutants can have substantial effects on both terrestrial and aquatic ecosystems, and it will be necessary to measure the distribution and accumulation of these substances in both plants and animals.

Suggested Research: There are two major elements to an evaluation of the ecological impact of MHD: 1) baseline studies which determine the distribution of important pollutants and inventory the presence of biota prior to the operation of MHD facilities, and 2) research programs on the biological effects of emissions from MHD facilities after operation has begun.

Baseline monitoring studies which are and will be conducted at MHD facility sites, should establish the concentration of important pollutants in soil, vegetation, and animals. The following pollutants should be measured either because they are directly produced by MHD or because it is an important secondary reaction product of primary emissions. They include SO_2, sulfates, NO, NO_2, and fine particulate matter including seed material (potassium compounds) in the atmosphere at and downwind of the proposed sites; and the potentially toxic heavy metals listed above in soils, animals, (both terrestrial and aquatic), and vegetation native to the region. By establishing the levels of pollutants prior to operation, it will be possible to clearly establish whether increases in concentrations occur after the facility is in operation. Of equal importance is that baseline measurements also will provide convincing demonstration that no significant increases in pollutants have occurred should that be the case.

The biological effects should provide an inventory of: 1) economically important agricultural and forest crops, 2) endangered animal or plant species, 3) private, State, or Federal parks or wildlife preserves, 4) important habitats for wildlife such as marshlands, and 5) potable water supply regions. This work is being conducted in the ETF siting work presently being carried out by MERDI under Task M. MERDI is also presently conducting a preoperational baseline biological surveillance program near the CDIF site. This program is designed to establish reliable techniques which can be used at the larger ETF and CDP. Due to the size of the CDIF and short time of operation (less than 100 hours), it is improbable that measurable amounts of effluents will be deposited in the ecosystem surrounding the CDIF site. Therefore work at the CDIF should concentrate on technique, and as soon as an ETF site is chosen, a comprehensive ETF baseline program should be initiated. The emphasis of this project will bear directly upon the characterization and air and water monitoring work.

Recommended Schedule of Activities:

Initiate biological baseline data study for the
- CDIF - ongoing
- ETF - FY 1983

Operational analysis for the
CDIF - 1980

Complete development and evaluation of techniques for determining effects
CDIF - FY 1983.

DETERMINATION OF MECHANISMS OF TRANSPORT AND FATE OF TRACE ELEMENTS IN SOLID WASTE LEACHATE
(In Response to R&D Requirements III.A.3)

Objective: To determine transport mechanisms and chemical and physical actions of the trace metals, seed materials and any organometallics in the leachate as it affects groundwater supplies.

Significance: The chemical and physical composition of slag, fly ash, and effluents from MHD plants is different from the waste products of conventional coal boilers. The difference stems from the high temperatures ($\sim 2760^{o}C/5000^{o}F$) and the use of seed materials such as K_2CO_3. The leachates produced by MHD operations must be carefully studied to see what deleterious effects may result upon adsorption onto or absorption into the soil. Effects upon soil chemistry, microbiology, and vegetation must be examined. Further movement through the soils, geologic formations, and groundwater supplies must be known to avoid contamination of private or municipal wells.

Suggested Research: Based upon the data from chemical analyses performed on the slag, and ducted emissions produced at MHD facilities, and where possible, soliciting similar analytical data from other MHD facilities performing these analyses, a program will be estabished to measure the transport rates through various types of soils. Baseline and operational hydrologic (e.g., water table, stream flow, lake levels) and water quality (surface and groundwater) monitoring data collected at the MHD facility sites will be made available, and representative water and soil samples will be provided by the CDIF and ETF monitoring teams and sent for laboratory analysis. Laboratory tests will be conducted on these samples to determine the mechanisms of transport and fate and the types of chemical and microbial reactions. Special attention will be paid to sulfates, pH, trace metals, and organometallics.

Recommended Schedule of Activities:

Initiate transport test and chemical analyses for leachate
CDIF - FY 1983

Complete transport and fate analyses
CDIF - FY 1985

ANALYSIS OF ALTERNATIVE MEANS OF MHD SOLID WASTE MANAGEMENT
(In Response to R&D Requirements III.C.1 & 2/VI.C.1, 2 & 3/VII.A.3)

Objective: To develop an economic and environmentally acceptable method of disposing of MHD solid waste.

Significance: Disposal of solid wastes from MHD facilities may be similar to the fly ash disposal problem of conventional coal-fired power plants. However, there is a possibility that different disposal techniques, load requirements and beneficial use of solid wastes from MHD may be desirable due to the expected enrichment of potassium compounds and trace elements in MHD solid wastes. In addition, the higher combustion temperatures may also cause solid wastes to have a finer texture compared to those from conventional facilities. To ensure the environmental acceptability of MHD, potential waste disposal problems and beneficial uses must be identified, and adequate waste management methods developed.

Suggested Research: Based upon the results of the solid waste characterization study, in which the physical and chemical stability of MHD solid wastes are analyzed, criteria for environmentally acceptable land disposal techniques will be identified, and if necessary, modified and developed. These criteria will be based upon geological, hydrologic, climatologic and soil characteristics of proposed disposal sites. As a basis, perform a literature search of beneficial uses of solid waste from conventional coal-fired power plants. Potential uses of MHD solid wastes for construction material, road-fill, or useful by-products will also be assessed on the basis of the physical and chemical stability of MHD solid waste. Cost/effective analyses will be performed for all land disposal and by-product use options identified to determine which alternatives are the most economic and environmentally acceptable for individual MHD facilities. Secondary impacts of viable disposal techniques and beneficial uses for MHD solid waste will also be analyzed.

Recommended Schedule of Activities:

Initiate study of solid waste management alternatives
CDIF - FY 1982

Complete cost/effective analysis of solid waste management alternatives and provide recommendations
CDIF - FY 1984

DEVELOPMENT OF ANALYTICAL MODELS TO PREDICT AIR EMISSIONS FROM MHD FACILITIES
(In Response to R&D Requirements I.B.1.)

Objective: To develop an analytical model which can be used to predict air emissions from MHD facilities under varying operating conditions.

Significance: While the characterization and quantification of air emissions from a specific MHD facility will yield useful data, the information will tend to be very specific to the process conditions at the time of measurement. These data alone will have little value in predicting emissions from a commercial facility. This is particularly true of a program in its early development stage when various reaction conditions are being considered such as temperature, pressure, air-to-fuel ratio, gas composition, seed concentration and other variables. An analytical model which could assist in predicting air emissions would be a useful tool.

Suggested Research: The first step in the development of a predictive analytical model for air emissions is to obtain data from the CDIF under specified operating conditions such as temperature, pressure, air-to-fuel ratio, gas composition, type of coal used, etc. The analytical model can then be developed for the air emissions actually produced under the given operating conditions. The next step in the process is to evaluate the predictive capability of the analytical model under different MHD operating conditions, by comparison with actual emissions data. To develop a truly predictive model for air emissions the MHD system will have to be operated under a series of varying conditions, i.e., temperature, gas composition, type of coal, air-to-fuel ratio, seed concentration, etc. On this basis, through an iterative process, an analytical model can be eventually developed which would predict with reasonable accuracy air emissions from an MHD facility. As with all models, the developed analytical model is expected to be extremely sensitive to the operating conditions of the MHD system.

Recommended Schedule of Activities:
Initiate modeling effort
CDIF - FY 1982.

IMPROVEMENT OF ATMOSPHERIC TRANSPORT AND DISPERSION MODELS
(In Response to R&D Requirements I.B.7)

Objective: To develop improved atmospheric transport and dispersion models which will allow determination of both short term exposures from fugitive emissions of potentially toxic substances as well as long term doses at various distances from the MHD plant.

Significance: Because of the high temperatures (~ 2760°C/5000°F) associated with a MHD plant such as the Engineering Test Facility or the Commercial Demonstration Plant and the use of K_2CO_3 seed materials, the normal emissions due to fugitive emissions and inefficiencies in collectors may be different from that of a conventional coal-fired power plant. Existing models assume that all emissions are dispersed as gases, and do not take into account the effects of mountainous topography on dispersion. To assess the impact on vegetation, surfaces of livestock, and humans, transport and dispersion models are necessary which will take into account rates of deposition and chemical and physical interactions of the MHD emissions. With higher temperatures, particle sizes are expected to be smaller resulting in slower deposition rates and thus, transport over potentially larger distances. In selecting MHD facility sites as well as in selecting other power generation facility sites, it is essential to consider transport and dispersion characteristics since not only atmospheric stability conditions, but humidity will affect the concentration of particulate emissions.

Suggested Research: The development of models tailored to the emissions from MHD plants will of necessity depend upon the air quality data obtained from other MHD air quality and emission characterization programs. This must be a mutually dependent effort since the placement of monitors must depend on a sound model, and conversely, a sound model must be developed from good sets of baseline data. A cooperative program starting with the CDIF should be set up for the development of an improved model.

It is essential to set up a network of meteorological monitoring stations, especially at sites in irregular terrain, for several years prior to plant operation and continue for at least several years during operation to determine the effect upon the atmosphere of the MHD plant operation. This should be started with the CDIF and repeated for the ETF and CDP. The meteorological data obtained from a specially designed network coordinated with those of the air quality networks are necessary for the development of a sound transport and dispersion model to predict transport and fate in irregular terrain and particle deposition rates. These networks of air quality and meteorological stations are essential for model verification. Existing National Weather Service Stations or stations operated by industry are generally unsuitable for high caliber model development.

Recommended Schedule of Activities:

Obtain data from meterological and air quality monitoring stations and initiate the development of transport models

CDIF - FY 1978

ETF - FY 1983.

Complete transport and chemical fate models

FY 1984.

EXPANSION OF THE ETF SITING STUDY
(In Response to R&D Requirements IX.A.3)

Objective: Public Law 93-404 Section 107 requires that ERDA construct the MHD-ETF in the state of Montana. In order that the siting be environmentally acceptable several areas of the siting study require expansion.

Significance: Traditional siting studies have not included the utilization of low grade waste heat from facilities. The omission of this results in two basic effects. First, useful energy is wasted which, if used, may decrease demand and lower direct pollutant emissions. Second, this waste heat must be dissipated in some manner that potentially increases consumptive water use, fogging and thermal pollution.

Although ERDA explicitly states the need to consider social impacts equally with physical effects in determining environmental acceptability, there is no defined procedure for doing so. The siting of a facility in an area where it is not socially acceptable may greatly hinder its development.

Suggested Research: This project will be an expansion of the siting survey being conducted under MERDI Task M, funded by ERDA. A complete literature search of waste heat utilization possibilities for the ETF will be conducted. Upon receipt of ETF design criteria, those uses suitable for Montana must be analyzed in detail to determine under what specific conditions they would be environmentally, energetically and economically optimal. Siting locations which may feasibly allow for the waste heat from the ETF bottoming cycle to be utilized in existing facilities will be identified.

A methodology will be formulated to incorporate social acceptability into decision making. Such a methodology will weigh survey findings, majority votes, public hearing response, and community leadership involvement into a weighted criteria.

Recommended Schedule of Activities:

Initiate both studies - FY 1978.
Site selection - FY 1983.

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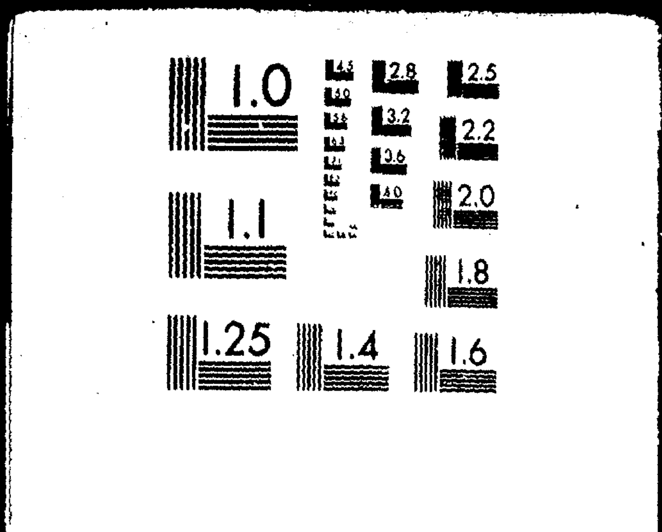

5. MANAGEMENT STRATEGY

5.1 Management of ERDA Environmental Responsibilities

Within ERDA, the Assistant Administrator for Fossil Energy (AFE) and the Assistant Administrator for Environment and Safety (AES) have major and complementary responsibilities for the environmental, health, and safety aspects of Fossil Energy programs.

The Assistant Administrator for Fossil Energy manages and directs the fossil energy research, development, demonstration, and commercial application program for the Energy Research and Development Administration concerning coal liquefaction, coal gasification, gas and oil development, oil shale, coal utilization, including combined cycle, direct combustion, and magnetohydrodynamics, and advanced technology (including materials research, combustion systems, extraction technology (excluding coal), and offshore drilling technology), and their directly related environmental, safety, and socioeconomic matters. He provides policy guidance, programmatic direction, and coordination to the ERDA organizations engaged in carrying out the foregoing functions and activities. He acts as the principal spokesperson, advisor, and assistant to the Administrator on all aspects of the foregoing fossil energy programs. In concert with appropriate staff and field offices, he coordinates fossil energy activities with others such as Congress, Federal and State agencies, industry, universities, and foreign and international organizations having an interest in these activities. He also identifies major fossil energy research, development, demonstration, and commercialization problems in ERDA programs and takes action to resolve them or recommends solutions. He establishes and implements procedures for periodic consultation with representatives of science, industry, environmental organizations, consumers, and other groups which have special expertise or interest in the areas of fossil energy research, development, and technology.[48/]

The Assistant Administrator for Environment and Safety (AES) manages and directs the environment and safety program for the Energy Research and Development Administration and acts as the principal spokesperson, advisor, and assistant to the Administrator on all aspects of biomedical, environmental, and safety research and development and the protection of health, safety, and environment with respect to development of energy technologies. He develops transportation standards and technology for ERDA operations from the standpoint of environment and safety. He

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coordinates ERDA activities required or specified under the National Environmental Policy Act (NEPA); and in concert with appropriate staff and field offices, coordinates environment and safety activities with others such as Congress, Federal and State agencies, industry, universities, foreign and international organizations having an interest in these activities. He administers health, safety, and environmental protection programs applicable to all ERDA activities, including performance of independent assessments of the health, safety, and environmental protection aspects of ERDA programs and facilities, the conduct of research and development related to ERDA-wide problems of health, safety, and environmental protection; and the overview and assessment of environmental and safety research and development, primarily control technology, performed under programs of other Assistant Administrators. He identifies major biomedical, environmental, and safety research, development, and demonstration problems in ERDA programs and takes action to resolve them or recommends solutions. He exercises overview responsibility for the environmental and safety aspects of ERDA programs and working with other Assistant Administrators, assures that for each energy source and energy conversion system being developed or improved there are early identification and full consideration of such factors as environmental degradations, effluent hazards, uncontrolled land use, resource depletion, and waste generation, and that to resolve these and related problems there is timely development of adequate plans and provision for funding. He concurs or nonconcurs in all Environmental Impact Statements and Environmental Development Plans. He initiates and performs research, development, and demonstration directed at achieving environmental protection and safety when such undertakings are not appropriate for assignment to a particular energy or energy conversion program. He establishes procedures for periodic consultation with representatives of science, industry, environmental organizations, consumers, and other groups which have special expertise or interest in the areas of biomedical, environmental, and safety research, development, and technology.[49/]

The Assistant Administrator for Fossil Energy and the Assistant Administrator for Environment and Safety shall include among program elements and activities research, development, and demonstration designed to assure that program activities under their direction are conducted with due regard for: safety, energy conservation, environmental and social consequences, and impact of water consumptive technologies on water resources; the need for environmental assessments and the preparation of Environmental Impact Statements; technologies which utilize renewable or essentially inexhaustible energy sources; and the potential of technologies for net energy production.[48, 49/]

5.2 Environmental Overview Committee (EOC)

To facilitate these activities, an Environmental Overview Committee (EOC) will be established to advise AES and AFE management personnel on matters that relate to evaluation of the Fossil Energy EDP's adequacy of the research, implementation, and associated progress. The committee will consist of a maximum of eight members from AFE-AES Divisions. This committee will be co-chaired by AES/TO and AFE/ESP committee members. Other representatives may be called upon to contribute to the EOC as necessary.

5.3 Responsibilities for EDP Updating

AES has the responsibility for ensuring the quality and timeliness of EDP's. Preparation is the joint responsibility of AES and AFE. Other program and staff Assistant Administrators are to review EDP's relative to their current planning needs.[25/]

5.4 Interaction with Other Federal Agencies

Other Federal agencies are involved in various environmental and safety aspects of MHD. ERDA will continue to cooperate with these agencies by providing information obtained through the work of AFE and AES, through interagency Memoranda of Understanding, and Interagency Agreements. Included in such cooperation is work with EPA in developing New Source Performance Standards (NSPS) and other environmental standards for MHD facilities; with Water Resources Council (WRC) to assess water requirements of these facilities and water availability; and with OSHA to set worker health and safety standards.

5.5 Public Involvement

This EDP and its annual updates will be made available for public review, and each year ERDA will consider public comments when setting priorities for environmental issues and scheduling environmental research and assessment activities. Through the EDP process, the public will be kept aware of ERDA's activities in technology development and environmental research. This mechanism will allow the public to help ERDA evaluate its progress toward the Magnetohydrodynamics Program goal: the development of environmentally acceptable and commercially viable MHD technologies.

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APPENDIX A

FEDERAL ENVIRONMENTAL LEGISLATION APPLICABLE TO MAGNETOHYDRODYNAMICS

Legislation	Applicability to Magnetohydrodynamics
• Energy Reorganization Act of 1974, PL 93-438	• ERDA is required to ensure the environmental acceptability of the energy technologies under development.
• National Environmental Policy Act of 1969 (NEPA) PL 91-190	• Environmental Impact Statements (EIS's) must be prepared for all major Federal actions significantly affecting the quality of the human environment. Environmental Impact Assessments (EIA's) usually done to determine which actions require EIS's.
• Non-nuclear Energy Research and Development Act of 1974 (Section 13) PL 93-577	• Water availability assessments are required for commercial plants, and demonstration plants which may have a significant impact on water availability. Assessments are done by Water Resources Council (WRC).
• Clean Air Act as amended PL 91-604 as amended by PL 92-157 PL 93-15 PL 93-319	• Ambient air quality standards have been set for SO_2, TSP, NO_2, CO, HC, and O_x; more are being considered. • New Source Performance Standards (NSPS) apply to coal-fired boilers and regulate SO_2, NO and particulates. Lower emission levels are being considered, as are regulations for small particulates. Stricter standards specific to MHD may be established. • Standards for hazardous air pollutants regulate mercury, beryllium, polyvinal chloride, and asbestos. • NSPS and regulations for the prevention of significant deterioration may affect plant siting. • Best Available Control Technology (BACT) may be required when locating in "clean" regions. BACT will be determined on a case-by-case basis. • Lowest achievable emission rates (LAER) may be required when locating in non-attainment regions.

Legislation	Applicability to Magnetohydrodynamics
• Federal Water Pollution Control Act Amendments of 1972 PL 92-500	• National Pollutant Discharge Elimination System (NPDES) permits are required to control wastewater discharges. • Since effluent guidelines have not been developed for most fossil energy technologies, permit requirements are determined on a case-by-case basis to meet state plans. • A "No Discharge" goal has been set for 1985.
• Resource Conservation and Recovery Act of 1976 PL 89-272	• Solid waste disposal must comply with most stringent air and water standards; monitoring is required. • New regulations will be developed in 1-2 years for a Federal hazardous waste handling permit system and state programs for non-hazardous solid wastes.
• Toxic Substances Control Act (TOSCA) PL 93-523	• Disposal of specific materials used in MHD processes may be regulated.
• Safe Drinking Water Act PL 93-523	• Wastewater discharges may require additional treatment for heavy metals or organic waste if they impact drinking water supplies.
• Noise Control Act of 1972 PL 92-574	• To protect health and welfare, ambient noise levels are recommended; they may become standards for facilities regulated by state and local governments.
• Occupational Safety and Health Act (OSHA) PL 91-596	• Health and safety regulations must be met for workers in MHD facilities.
• Coastal Zone Management Act of 1972 PL 92-583	• State coastal zone management plans developed with Federal financing assistance may affect plant siting and design.

Legislation	Applicability to Magnetohydrodynamics
• Marine Protection, Research and Sanctuaries Act of 1972 PL 92-532	• Permits are required for activities in wetland areas which may restrict MHD facility siting.
• Rivers and Harbors Act 33U.S.C. 401-413	• Permits are required for dredge and fill activities in navigable waters, which may affect MHD facility siting. • Projects must be integrated with flood control, river, and dam projects.
• National Historic Preservation Act of 1966 PL 89-665	• Federally financed, assisted, or permitted projects cannot impact important historic or cultural sites unless no alternatives exist.
• Endangered Species Act PL 93-205	• Identification of endangered aquatic and terrestrial species at a potential construction site is required, which may affect MHD facility siting.
• Fish and Wildlife Coordination Act PL 85-624	• Any project requiring modification of bodies of water must be reviewed to prevent loss or damage to fish and wildlife.
• Wildlife and Scenic Rivers Act PL 90-542	• Project must not degrade the quality of wild and scenic rivers.

NOTE: A special study was carried out for ERDA at the University of Michigan (under subcontract to Argonne National Laboratory (ANL), on regulatory aspects: "A Survey of Federal and Selected State Laws and Regulations Relevant to Coal-Fired MHD Power Plants," by Michael Sauer under the direction of Professor Wes Vivian, first draft submitted July 29, 1977, 92 pp. Final published version should be available from ANL in the near future.

ATTACHMENT A

BIBLIOGRAPHY OF ONGOING AND COMPLETED RESEARCH

Attachment to the Magnetohydrodynamics
Environmental Development Plan

Prepared for:
Energy Research and Development Administration
Washington, D.C.

September, 1977

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Attachment A

BIBLIOGRAPHY OF ONGOING AND COMPLETED RESEARCH

A. Introduction

This is a compilation of some of the current and completed environmental research projects relating to MHD and can be used to identify general areas where further work is needed. This is not intended to be a comprehensive summary of all environmental research projects applicable to MHD, but instead should indicate the types of research being conducted in various areas. Anyone interested in a particular subject area should conduct a more extensive literature search than is provided here, using this bibliography as a starting point. The information presented here was obtained from the following sources:

- Inventory of Federal Energy-related Environment and Safety Research (FY 1976);
- Smithsonian Science Information Exchange (March, 1977);
- summaries of projects sponsored by the Division of Environmental and Socioeconomic Programs (1977);
- Fossil Energy Research Update for 1977;
- bibliography compiled by Exxon Research and Engineering Company for their report, Environmental Assessment of Advanced Energy Conversion Technologies;
- the Electric Power Research Institute's Publications and Research and Development Projects lists (1977);
- Matray, P., "The Bioenvironmental Impact of Trace Element Emissions from a Magnetohydrodynamics (MHD) Facility -- A Literature Search and Recommendations," September, 1976, MERDI in-house document;
- Energy Research Information System, Old West Regional

- Commission and USDA Forest Service, Surface Environment and Mining, 1975-76; and
- Fiscal Year 1976 Health and Environmental Effects Research Program Abstracts, Office of Energy Minerals and Industry, Office of Research and Development, U.S. Environmental Protection Agency, EPA 600/7-77-04, January, 1977.

Projects listed include both generic studies on the effects of emissions which are common to coal combustion technologies and studies which are specific to MHD (categories 5 and 6). The large number of generic studies on health effects precluded the inclusion of all these projects in Attachment A; however, representative generic projects have been included in the bibliography to illustrate the nature of ongoing research in this area.[1/]

The Federal Inventory number (when applicable), title, monitoring agency, author or performing organization, and completion date for each project are listed. In addition, each project has been organized according to the following environmental research areas:

- Characterization, measurement, and monitoring;
- Environmental transport - physical and chemical processes and effects;
- Environmental control technology;
- Operational safety;
- Health effects;
- Ecological processes and effects;
- Integrated assessments; and
- Regulatory activities.

1/ See the ERDA Inventory of Federal Energy-related Environment and Safety Research for FY 1976, Volume II, Part 2, for specific studies, prepared by the Aerospace Corporation, April, 1977.

These research areas are further divided into categories according to the level of specificity of the project. The following categories are used:

- Category 1: General environmental research;
- Category 2: Energy-related research;
- Category 3: Coal research;
- Category 4: Coal utilization research;
- Category 5: Magnetohydrodynamic research; and
- Category 6: Site-specific or project-specific research.

Following the listing of project titles, brief summaries are included for those projects specific to MHD technologies (categories 5 and 6) for which information was readily available. These summaries are also organized according to research area.

B. Listing of Project Titles

CHARACTERIZATION, MEASUREMENT, AND MONITORING

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 1: GENERAL ENVIRONMENTAL RESEARCH				
070299	Investigation of NO_x-Nitrate-Sulfate Production	EPA	United Technologies Research Center	n/a
082038	Survey of Instrumentation for Environmental Monitoring	ERDA	University of California, Berkeley	n/a
086075	Trace Constitutent Analysis by Laser Excitation	ERDA	Battelle Pacific Northwest Lab.	n/a
091017	Aerosol Technology	ERDA	ERDA Health and Safety Laboratory	1976
091021	Trace Elements in the Biosphere	ERDA	ERDA Health and Safety Laboratory	0*
098069	Development of an On-Line Aerosol Size Mass Monitoring Instrument	ERDA	Los Alamos Scientific Laboratory	
013017	Air Pollution Studies	EPA	NOAA	n/a
032006	A Pocket-Sized Gas Chromatographic Analyzer for Chemical Contaminants in Air: A Feasibility Study	NIOSH	Stanford University	1977
032004	A Portable Microwave Spectrometric Analyzer for Chemical Contaminants in the Air: Design and Prototype Construction	NIOSH	University of California, Livermore	1977
070039	Perfection of Previously Developed Instrumentation for the Collection and Analysis of Carcinogenic Vapors in Ambient Atmospheres	EPA	Research Triangle Institute	n/a
070187	Application of Biological Testing Techniques of Process Samples	EPA	Stanford Research Institute	n/a
081061	Ambient Aerosol Determination	ERDA	Brookhaven National Laboratory	n/a
082010	Electronic/Diffraction Structure Analysis	ERDA	University of California, Berkeley	n/a
082014	Physical Methods of Measuring Environmental Contaminants	ERDA	University of California, Berkeley	1978
070186	Sampling and Analysis for the US/USSR Joint Sampling	EPA	York Research	n/a
070275	Sampling and Analysis Research and Development	EPA	Research Triangle Institute	n/a
085111	Development of Portable Analyzer	ERDA	Oak Ridge National Laboratory	n/a
	Air Quality Criteria for CO	NAPCA	NAPCA	1970
	Factors Influencing Plume Opacity	n/a	S. California Edison Company	1976
	Trace Element Study	TVA	In-House	n/a
	Air Quality Criteria for Particulate Matter	NAPCA	NAPCA	1969
	Air Quality Criteria for Hydrocarbons	NAPCA	NAPCA	1970

n/a - not available

*0 - ongoing

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 1: GENERAL ENVIRONMENTAL RESEARCH				
	Particle Size Analysis Using Differential Interference Contrast	n/a	Mellon Institute of Science	1976
	Submicron and Commicron Particulate Detection Using Surface Ionization	n/a	University of Pittsburgh	1975
	How to Mathematically Model Particle Size Distributors	n/a	Pollution Measurement Corporation	1976
	Electron Spectroscopy for Chemical Analysis of Airborne Particulates	n/a	Walter C. McCrone Assoc., Inc.	1976
	A New Concept Size Selective Sampling System for Monitoring Particulate Air Pollution	n/a	Donaldson Co., Inc.	1975
	Development of Fugitive Emissions Sampling Techniques	EPA	Research Corp. of New England	0*
	Thermodynamic Transport Properties of Potassium	ORNL	Oak Ridge National Laboratory	1968
	Modelling of Gas-Phase Kinetics of Fuel Nitrogen	n/a	California State University	1976
	Kinetics of NO Formation	n/a	Exxon	1976
	Measurement of Reaction Rate Constants of NO + O Gives N + O_2 and NO + H Gives N + OH	n/a	Stanford University	1976
	Liquid-Metals Handbook	AEC	Atomic Energy Commission	1952
	Mathematical Modelling of Fine Particle Collection by Electrostatic Precipitation	n/a	Gooch, J.P. and McDonald, J.R.	1972
	Rapid Instrumentation for Particle Size Analysis, A Review, Parts I, II, III	n/a	ITT Research Institute	1974
CATEGORY 2: ENERGY-RELATED RESEARCH				
081036	Atmospheric Diagnostics of Airborne Pollutants	ERDA	Brookhaven National Laboratory	n/a
082007	Characterization of Particulates on Lung and Leaf Surfaces	ERDA	University of California, Berkeley	n/a
082033	Instrumentation Technology for Energy-Related Contaminants	ERDA	University of California, Berkeley	1977
083001	Assay of Mammalian Sperm Motility	ERDA	University of California, Livermore	n/a
083019	Trace Contaminants from Fossil Fuel Power Stations	ERDA	University of California, Livermore	n/a
083030	Field Laboratory for Characterization of Gaseous and Particulate Pollutants	ERDA	University of California, Livermore	1976
083040	Multistate Atmospheric Power Production Pollution Study	ERDA	University of California, Livermore	n/a
035054	Toxicant Formation in Condenser Cooling Systems	ERDA	Oak Ridge National Laboratory	n/a
012002	Development of Standard Reference Materials, Instrumentation, and Methods Needed for Monitoring Air Quality Associated with Energy Development	EPA	National Bureau of Standards	1980
012003	Water Quality Assurance and Instrumentation	EPA	National Bureau of Standards	1980
012004	Energy Related Air Pollutant Analysis Instrumentation	EPA	National Bureau of Standards	n/a

n/a - not available

*0 - ongoing

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 2: ENERGY-RELATED RESEARCH				
013012	Cloud and Precipitation Modification Effects of Pollutants from Energy Production	EPA	National Oceanic and Atmospheric Administration (NOAA)	n/a
013014	Lidar Techniques for Measuring Particulate Pollutants from Energy Production and Their Transport and Dispersion Processes	EPA	NOAA	1980
032017	Enumeration of Energy Occupational Health Problems	Public Health Services	Western Area Occupational Health Laboratory	n/a
077038	Identification and Measurement of High Molecular Organic Compounds in Emissions from Power Plants and Oil Refineries	EPA	Southern Research Institute	n/a
070152	Particulate Sampling and Support	EPA	Southern Research Institute	n/a
086058	Environmental Pollution Analysis, Instruments, and Methods Developing	ERDA	Battelle Pacific Northwest Laboratory	n/a
087548	Characterization of Gaseous Molecular Pollutants Emitted by Energy Generation Sources	ERDA	Ames Laboratory	n/a
091023	Nonnuclear Pollutants in Surface Air (baseline)	ERDA	In-House	n/a
091024	Assessment and Control of Nonnuclear Air Contaminants	ERDA	In-House	n/a
091158	Nonnuclear Pollutants on the Earth's Surface (baseline)	ERDA	In-House	n/a
098026	Studies to Determine SO_3 and SO_4 in Power Plant Stack Emissions	EPA	Brookhaven National Laboratory	n/a
098056	Develop Instrumentation and Methods to Identify, Measure, and Analyze Energy-Related Aerosols and Particulates in Relation to Direct Effects on Health	ERDA	Lovelace Foundation for Medical Education and Research	1976
098057	Development of Improved Generation Methods and Sizing Instruments for Fine Particles in Aerosols for Characterizing Inhalation Hazards	ERDA	Lovelace Foundation for Medical Education and Research	n/a
098068	Optimized Filters and Stack Probe for Aerosol Stack Sampling	EPA	Los Alamos Scientific Laboratory	n/a
070257	Sampling and Analysis of "Reduced" and "Oxidized" Species in Process Streams	EPA	TRW, Inc.	n/a
070255	Fuel Decomposition and Flame Reactions in Conversion of Fuel Nitrogen to NO	EPA	Rockwell International Corporation	n/a
070287	Characterization of Emission and Combustion Performance of Alternate Fuels	EPA	EPA	O*
070153	Identification and Measurement of High Molecular Weight Organic Compounds in Emissions from Power Plants and Oil Refineries	EPA	Southern Research Institute	n/a
070188	Review and Develop Test Plans and Measurement Programs	EPA	Mitre Corporation	n/a
070271	The Development of Fugitive Emissions Sampling	EPA	Research Corporation of New England	n/a
	Use of a Tracer to Determine Contribution of a Power Plant to Suspended Particulate Levels	n/a	American Electric Power Service Corporation	1976
	Technical Manual for Measurement of Fugitive Emissions	EPA	Research Corporation of New England	1976
	Measurement of NO and NO_2 in Combustion Systems	n/a	University of California	1973
	Fuel-Specific Environmental Emission Coefficients for Industrial Processes	n/a	Brookhaven National Laboratory	n/a

n/a - not available

*O - ongoing

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 2: ENERGY-RELATED RESEARCH				
	Laboratory Studies and Mathematical Modeling of NO_x Formation in Combustion Processes	n/a	Exxon	n/a
	Kinetic Mechanisms Governing the Fate of Chemically-Bound Sulfur: Nitrogen in Combustion	n/a	Shell Development Company	n/a
	Rapid Continuous Determination of NO_x Concentration in Exhause Gases	n/a	University of California	1968
	Evaluation of Saltzman and Phenol Disulfonic Acid Methods for Determining NO_x in Engine Exhaust Gases	n/a	Pratt and Whitney	1969
	Air, Water, and Solid Residue Models for Conventional Combustion Sources	n/a	Monsanto Research Corporation	1976
	Modeling of Combustors: The Effects of Ambient Conditions upon Performance	n/a	Laval University	1973
	Rate-Constrained Partial Equilibrium Models for the Formation of NO_x from Organic Fuel Nitrogen	n/a	MIT	n/a
	A Study of NO_x Emission Characteristics in 2-Stage Combustion	n/a	Tokyo Gas Co., Ltd.	n/a
	Chemistry of Fuel Nitrogen Conversion to NO_x in Combustion	EPA	Rockwell International Corp.	n/a
	Basic Kinetic Studies: Modeling of NO_x Formation in Combustion Proce ses	n/a	Exxon	n/a
	NO_x Prediction from Diffusion Model	n/a	Westinghouse Electric	n/a
	The Formation and Destruction of Hydrogen Cyanide from Atmospheric and Fuel Nitrogen in Rich Atmospheric Pressure Flames	n/a	Shell Research, Ltd.	n/a
	An Experimental Correlation of Oxides of Nitrogen Emissions from Power Boilers Based on Field Data	n/a	Riley Stoker Corporation	n/a
	Biological Impact of Air Pollution on Insects	n/a	Jerry J. Bromenshenk Fort Union Coal Field Symposium	1975
	Trace Metal Variation in Soils and and Sagebrush in the Powder River Basin, Wyoming	n/a	J. J. Connor, J. R. Keith, and B. M. Anderson, Jour. Research, U.S. Geological Survey	1976
	Accumulation of Fluorides by Insects Near an Emission Source in Western Montana	n/a	J. E. Dewey, Environmental Entomology	1973
	Gas and Leachates from Landfills	n/a	EPA	1976
	Program Approval Document FY 77 Magnetohydrodynamic Program	n/a	ERDA	1976
	Residence Time of Particles in Urban Air	n/a	N. A. Esman, Atmospheric Environment	1971
	Evidence for the Accumulation of Atmospheric Lead by Insects in Areas of High Traffic Density	n/a	F. E. Giles, S. G. Middleton, and J. G. Grau, Environmental Entomology	1973
	Chemical Concentrations of Pollutant Lead Aerosols, Terrestrial Dusts and Sea Salts in Greenland and Antarctica Snow Strata	n/a	A. J. MacLean, R. L. Halstead, and B. J. Finn, Geochim Cosmochim Acta	1969
	Effect of Soil Properties and Amendments on the Availability of Zinc in Soils	n/a	A. J. MacLean, Can. J. Soil Sci.	1974

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 2: ENERGY-RELATED RESEARCH				
	Mercury in Plants and Retention of Mercury by Soils in Relation to Properties and Added Sulfur	n/a	A. J. MacLean, Can. J. Soil Sci.	1974
	Further Measurements Around Modern Power Stations--I-III	n/a	A. Martin and F. R. Barber, Atmospheric Environment	1973
	Characterization of Atmospheric Pollutants for Power Plants	n/a	D. F. S. Natusch	n/a
	Multi-element Size Characterization of Urban Aerosols	n/a	J. J. Paciga and R. E. Jervis Environmental Science and Technology	1976
	Lead in Terrestrial Arthropods: Evidence for Biological Concentration	n/a	Peter Price, B. J. Rathere, and D. A. Gentry, Environmental Entomology	1974
	Gaseous Nitrogen Compound Pollutants from Urban and Natural Sources	n/a	E. Robinson and R. C. Robbins J. Air Pollution	1970
	Atmospheric Concentrations and Sources of Trace Elements at the South Pole	n/a	W. H. Zoller, E. J. Gladney, and R. H. Duce, Science	1974
CATEGORY 3: COAL RESEARCH				
070139	Mineral Analysis of Coal	EPA	Illinois State Geological Survey	n/a
070145	Characterization of Coal and Coal Residue	EPA	Illinois State Geological Survey	n/a
093028	Collection, Chemical Analysis and Evaluation of Coal Samples from U.S. Coal Reserves	ERDA	U.S. Geological Survey	n/a
093077	Improvement of Analytical Methods for Determining Trace Elements in Coal	ERDA	PERC	n/a
	Clean Energy from Alaskan Coals	ERDA	Stanford Research Institute	1975
	Empirical Correlation of Coal Ash Viscosity With Ash Chemical Composition	n/a	Babcock and Wilcox	1976
	An Examination of the Influence of Ash on the Combustion Characteristics of Anthracites	n/a	Foster Wheeler	n/a
	Oxygen Stoichiometry in Coal and Coal Derivatives	FER	University of California at Irvine	1978
	Neutron Activation Analysis of Oxygen in Coal	MER	North Dakota State University	1977
	Chemical Structure of Coal and Coal-derived Products	FER	Argonne National Laboratory	1977
	Chemistry and Structure of Coal	FER	Oak Ridge National Laboratory	1977
CATEGORY 4: COAL UTILIZATION RESEARCH				
081025	Characterization of Plumes Emitted from Tall Stacks	ERDA	Brookhaven National Laboratory	n/a
086093	Reaction Kinetics of Combustion Processes	ERDA	Battelle Pacific Northwest Lab.	n/a
130016	Particulate Technology	TVA	TVA	n/a
096015	Lab Testing of Surface Combustion	NASA	NASA Lewis Research Center	n/a
060265	Combustion Research on Coal Nitrogen and Particulate Organic Matter	EPA	MIT	0*

n/a - not available

*0 - ongoing

CATEGORY 4: COAL UTILIZATION RESEARCH

PI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
070157	Effect of Fuel Sulfur on NO_x Formation in Combustion Processes (pilot plant)	EPA	University of Arizona	O*
	Characterization of Hazardous Materials Emitted from Coal Combustion and Conversion	NSF	University of Illinois	n/a
	Study of Coal-Associated Wastes Resulting from Mining, Processing, and Utilization of Coal	ERDA	West Virginia University	n/a
	Direct Sampling and Characterization of Gaseous Species Responsible for Fireside and Turbine Corrosion in Fossil-Fuel Fired Systems	ERDA	Midwest Research Institute	n/a
	Ash Fouling Studies Related to Combustion of Lignite and other Western Coals	ERDA	GFERC	n/a
	Energy Conversion Alternatives Study: Phase I: Final Report	NASA	Westinghouse Electric (Phase I) General Electric (Phase II)	1977
	Trace Elements in a Combustion System - Final Report	EPRI	Battelle, Columbus	1975
	Emission Assessment of Conventional Combustion Systems	n/a	Battelle, Columbus	n/a
	Reactions of Fuel Nitrogen in Rich Flame Gases	n/a	General Electric Co.	1976
	Coal-Fired Power Plant Trace Element Study	n/a	Radian Corporation	1975
	Fate of Trace Mercury in the Combustion of Coal	U.S. Bureau of Mines	U.S. Bureau of Mines	n/a
	Fundamentals of Nitric Oxide Formation in Fossil Fuel Combustion	FER	Western Michigan University	1978
	Study of Mineral Matter Distribution in Pulverized Fuel Coals with Respect to Slag Deposit Formation in Boiler Furnaces	FER	Pennsylvania State University	1979
	Surface Resource Inventory of Eastern Montana Rangelands Utilizing High Altitude Color Infrared Aerial Photography	n/a	F. T. Bateson and J. C. Elliott, Fort Union Coal Field Symposium	1975
	Significance of Particulate Emissions	n/a	J. K. Burchard, JAPCA	1974
	Trace Element Content of the Four Corners Power Plant	n/a	H. L. Cannon and B. M. Anderson, Coal Resources Work Group	1972
	Lateral and Vertical Variations in Sulfur and Trace Elements in Coal; Coalstrip Field, Montana	n/a	R. A. Chadwick, R. A. Woodriff, R. W. Stone, and C. M. Bonnett, Fort Union Coal Field Symposium	1975
	Particulates from Power Plants	n/a	R. J. Cheng, V. A. Mohnen, T. T. Shen, M. Current, and J. B. Hudson, JAPCA	1976
	Hazardous Emission Characteristics of Utility Boilers	n/a	C. Cowherd, M. Marcus, C. M. Guenther, and J. L. Spigarelli, EPA	1975
	Trace Elements in Fly Ash: Dependence of Concentration on Particle Size	n/a	R. L. Davison, D. F. Natusch, R. Wallard, and J. R. Evans, Environmental Science and Technology	1974
	A Coal-Fired Power Plant Trace Element Study: A Three-Station Comparison	n/a	EPA Region VIII, Denver, Colorado	1975
	The Bioenvironmental Impact of a Coal-Fired Power Plant	n/a	EPA	1975

n/a - not available

*O - ongoing

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 4: COAL UTILIZATION RESEARCH				
	Composition and Size Distribution of In-Stack Particulate Material at a Coal-Fired Power Plant	n/a	E. S. Gladney, J. A. Small, G. E. Gordon, and W. H. Zoller, Atmospheric Environment	1976
	Trace Element Behavior in Coal-Fired Power Plants	n/a	J. W. Kaakinen, R. M. Jorden, Lawasini and West, Environmental Science and Technology	1975
	Magnetic Demineralization of Pulverized Coal	n/a	W. M. Kester, Mining Engineering	1965
	Pathways of Thirty-Seven Trace Elements through Coal-Fired Power Plants	n/a	D. M. Klein, et al., Environmental Science and Technology	1975
	Toxic Trace Elements--Preferential Concentration in Respirable Particles	n/a	D. F. S. Natusch, J. R. Wallace, and C. A. Evans, Science	1974
	Characterization of Trace Elements in Fly Ash	n/a	D. F. S. Natusch	n/a
	Composition and Trace Element Content of Coal and Power Plant Ash	n/a	J. E. Swanson, Coal Resources Work Group	1972
	Composition and Trace Element Content of Coal, Northern Great Plains Area	n/a	V. E. Swanson, D. Huffman, and J. C. Hamilton, Mineral Resources Work Group	1974
	The Determination of Trace Elements in Coal, Fly Ash, Fuel Oil, and Gasoline. Part I: A Preliminary Comparison of Selected Analytical Techniques	n/a	D. J. VonLehmden, R. H. Jungers, and R. E. Lee, Anal. Chem.	1973
	Organic Material in the Atmosphere	n/a	E. W. Went, Proc. Nat. Accel. Sci.	1960
CATEGORY 5: MAGNETOHYDRODYNAMIC RESEARCH				
	Atmospheric Pollution Aspects of Magnetohydrodynamics Power Plants - Final Report	EPRI	Stanford University, High Temperature Gasdynamics Lab.	1975
	Advanced Energy Conversion Techniques for Utility Applications Using Coal or Coal-Derived Fuels	NSF	Westinghouse Electric Corporation	n/a
	Coal-Fired MHD Electric Power Generation	n/a	Montana State University	n/a
	Comparative Study of Advanced-Cycle Systems	n/a	EPRI	n/a
	Methods of Coal Combustion and Processing in Open Cycle MHD Systems	n/a	AVCO Everett Research Lab.	1975
	13th Symposium on Engineering Aspects of Magnetohydrodynamics	n/a	Stanford University	1973
	The Thermodynamic Data Tables for Fossil Fuel Utilization Processes (includes MHD)	ERDA	Dow Chemical Company	1979
	Thermophysical Properties of Molten Coal Slags and Alkali Seed Mixtures Relating to MHD	NSF	Battelle Memorial Institute	1976
	Composition of Fly Ash from a Coal-Fired MHD Generator with Potash Seed	BOM	MERC	1974
	Energy Technologies	Office of Coal Research	National Bureau of Standards	1975
	MHD Program	Office of Coal Research	MIT	1974

n/a - not available

CHARACTERIZATION, MEASUREMENT, AND MONITORING

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 5: MAGNETOHYDRODYNAMIC RESEARCH				
	Economically Efficient Design of an MHD Power Station Employing an Open-Cycle System	n/a	Foreign Technology Div., Wright Patterson AFB	1972
	Optical Measurements of Mean Particle Size in the Exhaust of a Coal-Fired MHD Generator	n/a	D. Holve and S. Self, University of California, San Diego and La Jolla	1976
	Urban Aerosol Toxicity: The Influence of Particle Size	n/a	D. F. S. Natusch and J. R. Wallace, Science	1974
	Investigation of Factors Influencing Potassium Seed Recovery in a Direct Coal-Fired Generator System	n/a	K. E. Tempelmeyer, L. Sher, L. Becker, M. Beaton, and J. Martin, 16th Symposium--Engineering Aspects of Magnetohydrodynamics, University of Tennessee Space Institute	1977
	Slag-seed Interactions and Particulate Formation	ERDA	University of Tennessee Space Institute	O*
	ERDA Task S: Characterization and Modelling of MHD Emissions	ERDA	MERDI	O*
	Characterization of Atmospheric Pollutants for Power Plants (includes coal-fired MHD)	n/a	D. F. S. Natvich	(in press)
	Development Program for MHD Direct Coal-Fired Power Generation Test Facilities		Quarterly Technical Progress Report University of Tennessee, Tullahoma Space Institute	1975
CATEGORY 6: SITE-SPECIFIC OR PROJECT-SPECIFIC RESEARCH				
	ERDA Task Q: Ambient Baseline Monitoring Program at the MHD CDIF	ERDA	MERDI	O*
	ERDA Task S: Biologic and Socioeconomic Monitoring Program for the MHD CDIF	ERDA	MERDI	O*

*O - ongoing

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 1: GENERAL ENVIRONMENTAL RESEARCH				
086008	Precipitation Scavenging	ERDA	Battelle Pacific Northwest Lab.	n/a
086015	Hemispheric Pollution Behavior Studies of Chemical and Radiation Substances	ERDA	Battelle Pacific Northwest Lab.	n/a
086016	Atmospheric Research - Cloud Physics, Aerosols, Pollutant Gases, Atmospheric Tracers, and Turbulence	ERDA	Battelle Pacific Northwest Lab.	n/a
087014	Instrumental Balloon Investigation of Pollutants Transport and Transformation	ERDA	Sandi Labs.	n/a
090029	Distribution and Interrelationship to Trace Elements in Biological Systems	ERDA	University of California, Los Angeles	n/a
070049	Study of the Effects of Airborne Sulfur Pollutants on Materials	EPA	Rockwell International Corp.	n/a
070051	Airborne Monitoring Study: Hyperbolic Cooling Tower Effluents and Interactions	Nat'l Envir. Res. Ctr.	Maryland Bureau of Air Quality Control	n/a
070054	Sampling and Analysis of Atmospheric Aerosols	EPA	Minnesota University	n/a
070055	Sources and Transport of Trace Metals in Urban Aersols	EPA	Florida State University	n/a
	Heat Exchange and Transport in the Environment	EPRI	Johns Hopkins University	1974
	Modeling the Gas-Phase Kinects of Fuel-Nitrogen Reactions - Final Report	EPRI	KVB Engineering Co.	1976
CATEGORY 2: ENERGY-RELATED RESEARCH				
086013	Cooling Tower Atmospheric Impact	ERDA	Battelle Pacific Northwest Lab.	1976
086022	Influences of Soils and Sediments on the Chemical Behavior, Transport and Bioavailability of Pollutants Resulting from Energy Production	ERDA	Battelle Pacific Northwest Lab.	n/a
086077	Determining the Effects of Increased Fossil Fuel Utilization in Power Production on the Chemical Nature of Precipitation in the North-east U.S.	ERDA	Battelle Pacific Northwest Lab.	n/a
001025	Plume Studies	ERDA	Brookhaven National Lab.	n/a
070040	Smog Chamber Studies of Atmospheric Chemistry of Organic and Nitrogen-Containing Emissions from Emerging Energy Technologies	EPA	Research Triangle Institute	n/a
083040	Multistate Atmospheric Power Production Pollution Study	ERDA	California University, Livermore	n/a
086028	Combined Effects of Waste Heat and Environmental Factors Acting in Concert	ERDA	Battelle Pacific Laboratory	n/a
100016	Technical and/or Policy Evaluation for Air and/or Water Environmental Impacts from Energy Generation	FEA	Environmental Research Technology, Lexington, Mass.	n/a
	Environmental Responses to Thermal Discharges from Marshall Steam Station, Lake Norman, North Carolina	EPRI	Johns Hopkins University	1974
	Environmental Responses to Thermal Discharges from the Indian River Station, Indian River, Delaware	EPRI	Johns Hopkins University	1974

n/a - not available

ENVIRONMENTAL TRANSPORT

PHYSICAL AND CHEMICAL PROCESSES AND EFFECTS

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 2: ENERGY-RELATED RESEARCH				
	Environmental Responses to Thermal Discharges from the Chesterfield Station, James River, Virginia	EPRI	Johns Hopkins University	1974
	Reactions of Nitrogen Oxides, Ozones, and Sulfur in Power Plant Plumes - Final Report, Interim Report	EPRI	University of Washington	1976
	Determination of the Feasibility of Ozone Formation in Power Plant Plumes - Volumes I-V	EPRI	Meteorology Research, Inc. and Systems Applications, Inc.	1976
	Concerning the Effect of Terrain Configuration on Smoke Dispersal	n/a	G. Fleming, Atmospheric Environment	1967
	Study of the Emissions from Major Air Pollution Sources and their Atmospheric Interactions	n/a	G. E. Gordon, et al., Progress Report, University of Maryland, Department of Chemistry	1974
	Diffusion over Coastal Mountains of Southern California	n/a	W. T. Hinds, Atmospheric Environment	1970
	A Theory of Plume Rise Compared with Field Observations	n/a	D. P. Hoult, J. A. Fay, and L. J. Forney, Journal of Air Pollution Control Association	1969
	Results of Recent TVA Investigations of Plume Rise	n/a	T. L. Montgomery, S. B. Carpenter, W. C. Colbaugh, and F. W. Thomas, Journal of Air Pollution Control Association	1972
	Effluent Dilutions over Mountainous Terrain	n/a	G. E. Start, N. R. Ricks, and C. R. Dickson, NOAA Technology Memo	1974
	Diffusion in a Canyon within Rough Mountainous Terrain	n/a	G. E. Start, C. R. Dickson, and L. L. Wendell, Journal of Applied Meteorology	1975
CATEGORY 4: COAL UTILIZATION RESEARCH				
094002	Atmospheric Particle Chemistry and Sulfur-Emission Control Studies	ERDA	Argonne National Laboratory	n/a
087759	Environmental Impact of Coal Ash on Lake Erie	ERDA	State University College, Fredonia, New York	n/a
085116	Environmental Fate of Emissions from Coal Combustion Plants	ERDA	Oak Ridge National Laboratory	n/a
086014	Aerosol and Trace Gas Transformations	ERDA	Battelle Pacific Northwest Lab.	1976
087758	The Contamination of Groundwater by Heavy Metals Through the Land Disposal of Fly Ash	ERDA	Notre Dame University	n/a
130001	Atmospheric Transformation of Emissions from Coal-Fired Power Plants: Full-Scale Field Studies	EPA	TVA, Muscle Shoals, Alabama	1981
130002	Regional Atmospheric Transport of Coal-Fired Power Plant Emissions	EPA	TVA, Muscle Shoals, Alabama	1980
	Sulfate Formation in Coal Processes	ERDA	FPC	n/a
	Fundamentals of Nitric Oxide Formation in Fossil Fuel Combustion	ERDA	Western Michigan University	n/a
	Heavy Metals: Fallout Around a Power Plant	n/a	D. H. Klein and P. Russell Environmental Science and Technology	1973
	Effects of Stack Emissions on Range Resource in Vicinity of Colstrip, Montana	n/a	F. Munshower, Montana State University	1976

n/a - not available

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 1: GENERAL ENVIRONMENTAL RESEARCH				
070210	Evaluation of Novel Fine Particulate Collection Devices	EPA	Performing Organization Southern Research Institute	n/a
070300	High Velocity Fabric Filtration	EPA	Harvard University	n/a
065028	Automated Analyses for Biochemical Indicators of Genetic Differences	ERDA	Oak Ridge National Laboratory	n/a
070140	The Synthesis of Unlabelled and Radiolabelled Compounds	EPA	Midwest Research Institute	n/a
070218	Development of Environmental Assessment and Control Technology Quality Assessment Programs	EPA	Research Triangle Institute	n/a
070221	Policy Analysis for Hazardous Waste Control	EPA	Colorado School of Mines Research	n/a
070280	Evaluation of Fundamental Combustion Phenomena	EPA	n/a	n/a
087024	Study of Physical Parameters of Transportation Accidents	ERDA	Sandia Laboratories	n/a
087026	Maintenance of a Transportation Environmental Data Bank	ERDA	Sandia Laboratories	n/a
090089	Environment and Safety Planning Support	ERDA	Aerospace Corp.	n/a
094002	Atmospheric Particle Chemistry and Sulfur Emission Control Studies	ERDA	Argonne National Laboratory	n/a
094020	Solvent Extraction Studies Using High-Molecular Weight Amines	ERDA	Texas Southern University	n/a
096014	Surface Combustion Computer Model	NASA	n/a	n/a
CATEGORY 2: ENERGY-RELATED RESEARCH				
013053	Power Plant Siting and Energy Issues in the Great Lakes Coastal Zone	NOAA	Wisconsin University	n/a
054012	Mined Area Reclamation and Related Land Use Planning	USGS	n/a	1976
054015	Energy Lands Program	USGS	n/a	n/a
054023	Arctic Environmental Studies	USGS	n/a	1982
054024	Subsurface Heat Storage	USGS	n/a	1978
055001	Substation Acoustical Study	DOI/ Bonneville Power Admin.	Bolt, Beranek and Newman, Inc.	n/a
070174	Impacts to Groundwater and Surface Water Quantity and Quality from Proposed Energy Development on the Northern Cheyenne Reservation, Montana	EPA	Northern Cheyenne Research Project	n/a
070198	Technical Support for Environmental Problem Definition and Pollutant System Studies	EPA	Radian Corporation	n/a
070201	Control Technology Development for Products and By-products	EPA	Catalytic, Inc.	n/a
070211	Technical and Engineering Support for the Industrial Environmental Research Lab - Research Triangle Park	EPA	Dow Chemical Co.	n/a
070213	Quick Reactions Engineering and Technical Services	EPA	Research Triangle Institute	n/a
070214	Support to EPA in Evaluation of Control Technologies	EPA	Dayton University	n/a
070216	Quick Reactions Engineering and Technical Services	EPA	EPA	n/a

n/a - not available

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 2: ENERGY-RELATED RESEARCH				
070217	Professional Services: Dr. Jumpei Ando - Evaluations of Japanese Pollution Control Technologies	EPA	Chuo University	n/a
070225	Air, Water and Solid Residue Prioritization Models for Conventional Combustion Systems	EPA	Monsanto Co.	n/a
070253	Investigation of Aerodynamic Phenomena in Pollution Control	EPA	United Aircraft Corp.	n/a
070272	Composition/Temperature Measurements in Flames	EPA	United Technologies Research Center	n/a
070284	Technical Support for USA/USSR Cooperative Agreement	EPA	Battelle Columbus Labs.	n/a
070287	Characterization of Emission and Combustion Performance of Alternate Fuels	EPA	EPA	n/a
070303	Program Support in Environmental Assessment and Control Technology Development for Advanced Fossil Fuels	EPA	Stanford University	n/a
120001	Western Energy-Related Overhead Monitoring	EPA	NASA	1980
	Air Pollution and Its Control in Fossil Energy Processes	ERDA	Air Pollution Technology, Inc.	1976
	An Investigation of the Potential for Utilization of Saline Groundwater in Energy-Related Processes	ERDA	Radian Corp.	1977
	New Concept for Fine Particle Control at High Temperature and Pressure	EPA	Air Pollution Technology, Inc.	n/a
	Measurement of Critical Rate Constants for Nitric Oxide Decomposition	EPRI	Stanford University, High Temperature for Dynamics Laboratory	1975
	The Influence of Design Variables on the Production of Thermal and Fuel NO_x from Residual Oil and Coal Combustion	EPA	EPA	1973
	Bags, Cages, Accessories for all Makes of Baghouses	n/a	Baghouse Accessories Co.	n/a
	Air Quality Criteria for Particulate Matter		Air Pollution Control Administration	1969
	Air Quality Criteria for Nitrogen Oxides		Air Pollution Control Administration	1971
	Control of Fine Particulate Air Pollutants: Equipment Update Report		P. Cheremisinoff and R. Young, Pollution Engineering	1976
	Fine Particle Control Technology: Conventional and Novel Devices		D. Drehmel, JAPCA	1977
	Disposal of Organochlorine Wastes by Incineration at Sea		EPA	1975
	Meteorological Program for Limiting Power Plant Stack Emissions		J. Leavitt, S. Carpenter, J. Black-ll, T. Montgomery, Journal of Air Pollution Control Association	1971
	Air Quality Criteria for Sulfur Oxides, Summary and Conclusions		National Air Pollution Control Administration	1969
	Air Quality Criteria for Particulate Matter, Summary and Conclusions		National Air Pollution Control Administration	1969
	Air Quality and Power Plant Effluents Report		L. Rancitelli, Battelle-Northwest	1975
	EPA Sets Its Sights on Nixing CPI's NO_x Emissions		L. Ricci, Chemical Engineering	1977

?I Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 3: COAL RESEARCH				
000003	Control Technology for Mine Reclamation	FDA	FDA	n/a
000006	Technologies for Controlling Effects of Mining on the Forest and Range Environment and on Users and Related Communities	USDA/ Forest Svc.	USDA/Forest Service	n/a
000007	Plant Materials Studies to Improve Technologies of Surface Mine Land Reclamation	USDA	USDA	1980
070105	Coal Mine Haul Road Sediment Control Technique	EPA	Kentucky Dept. of Natural Resources	n/a
070106	Snowy Creek-Laurel Run Watershed Demonstration Project Feasibility	EPA	West Virginia Dept. of Natural Resources	n/a
070109	Environmental Monitoring and Assessment of Coal Strip Mining and Reclamation in the Four Corners Area	EPA	Arizona University	n/a
070110	Effects of Surface Configuration in Water Pollution Control on Semi-arid Mined Lands	EPA	Montana State University	n/a
070117	Environmental Impact of Coal Transportation	EPA	PEDCO Environmental Specialists, Inc.	n/a
070124	A Cooperative Program to Evaluate Surface and Groundwater Problems Associated with Potential Strip Mine Sites	EPA	Montana State University	n/a
070125	Assessment of Fugitive Dust in Mining	EPA	PEDCO Environmental Specialists, Inc.	n/a
070126	Manual Practice for Pre-mining Site Evaluation - Eastern Surface Coal Mining	EPA	Pennsylvania State University	n/a
070127	Environmental Impact of Steep Slope Mining	EPA	West Virginia Surface Mining and Reclamation Association	n/a
070128	Environmental and Pollution Aspects of Coal Slurry Pipelines	EPA	Colorado School of Mines	n/a
070129	Water Quality Hydrology of Surface Mined Watersheds	EPA	Colorado State University	n/a
070132	Evaluation of Groundwater Pollution from Eastern Underground Coal Mines	EPA	Geraghty and Miller, Inc.	n/a
070134	Underground Stowing of Waste	EPA	Pennsylvania Dept. of Environmental Resources	n/a
070135	Modified Block Cut Utilizing Onsite Controls of Surface-mine Sedimentation	EPA	Kentucky Dept. of Environmental Resources	n/a
080049	Land Reclamation Program	EPA	Argonne National Laboratory	Annual Report 1976
084071	Assessment and Control of Environmental Contamination from Coals During Storage	ERDA	Los Alamos Scientific Laboratory	n/a
085128	Coal Mining Impacts, Development of Environmental Assessment in Appalachia	ERDA	Oak Ridge National Laboratory	n/a
130058	TVA Long Pit Strip Mining	TVA	TVA	n/a
CATEGORY 4: COAL UTILIZATION RESEARCH				
070164	Assessment of Pollution Control Technologies to Identify Data Collection Needs	EPA	n/a	n/a
070165	Field Testing: Application of Combustion Modification to Control Pollutant Emissions from Power Generation Combustion Systems	EPA	Exxon Research and Engineering Co.	n/a

n/a = not available

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CATEGORY 4: COAL UTILIZATION RESEARCH

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
070170	Field Testing: Application of Combustion Modification Technology to Industrial Combustion Equipment	EPA	AVB Engineering, Inc.	n/a
070212	Operation of IERL Test Facility	EPA	Monsanto Research Corp.	n/a
070251	Pilot Scale Evaluation of Advanced Combustion Control Technology for Fossil and Waste Fuels	EPA	Acurex Corp.	n/a
080072	Environmental Control Technology for Generation of Power from Coal	ERDA	Argonnne National Lab.	1978
130044	Develop Comparative Economics of Major Stack Gas Emissions Control Processes	EPA	TVA	n/a
070283	Emissions Control Technology for High Pressure Combustion Systems	EPA	EPA	n/a
087733	The Design and Implementation of a Demonstration Supplementary Control System	ERDA	MIT	n/a
	Control Technology Assessment	ERDA	PERC	n/a
	Combustion Research and the EPRI	EPRI	n/a	1976
	Control of Pollutants in Fossil Fuel Conversion/ Treatment Processes	n/a	Exxon	1973
070262	Low Emission Burners for Package Boilers (Modified burner design)	EPA	Ultrasystems, Inc.	n/a
	Status of Flue Gas Desulfurization and Simultaneous Removal of SO_2 and NO_x in Japan	EPA	Chuo University	1976
	Control of NO_x and SO_x Emissions	n/a	AIChE	1975
070157	Effect of Fuel Sulfur on Nitrogen Oxide Formation in Combustion Processes	EPA	Arizona University	n/a
070169	Analysis of NO_x Control in Utility Boilers	EPA	Aerospace Corporation	n/a
070223	Catalytic Reduction of Nitrogen Oxides with Ammonia; Utility Pilot Plant Operation	EPA	Environics, Inc.	n/a
070254	Environmental Assessment of Stationary Source NO_x Control Technologies	EPA	Acurex Corporation	n/a
070255	Fuel Decomposition and Flame Reactions in Conversion of Fuel Nitrogen to NO_x	EPA	Rockwell International Corp.	n/a
070263	Mechanisms and Chemistry of Fuel Nitrogen to NO_x	EPA	Rockwell International Corp.	n/a
070265	Combustion Research on Coal Nitrogen and Particulate Organic Matter	EPA	MIT	n/a
130013	Economic Study of Dry NO_x Removal Processes	EPRI	TVA	n/a
130014	NO_x Technology	TVA	TVA	n/a
130015	Control of NO_x Formation in Wall, Coal-Fired Utility Boilers	EPA	TVA	n/a
	Reduction of NO_x through Staged Combustion in Combined Cycle Supplemental Boilers - Final Report - Volumes 1 and 2	EPRI	KVB, Inc.	1975
	Homogenous Gas Phase Decomposition of Oxides of Nitrogen - Final Report	EPRI	KVB, Inc.	1976
	Effectiveness of Gas Recirculation and Staged Combustion in Reducing NO_x on a 560-MW Coal-Fired Boiler - Final Report	EPRI	KVB, Inc.	1976

n/a - not available

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CATEGORY 4: COAL UTILIZATION RESEARCH

070244	Fabric Filter Analysis	EPA	n/a	n/a
070245	Baghouses as Emission Control Devices for a Solid Waste Incineration/Boiler: A Pilot Plant Study	EPA	Nashville Thermal Transfer Corp.	n/a
070301	Operating Procedures for Fine Particulate Control Equipment	EPA	PEDCO Environmental Specialists, Inc.	n/a
093033	Electrostatic Precipitation of High-resistivity Fly Ash in Stack Gases	ERDA	GFERC	n/a
130016	Particulate Technology	TVA	n/a	n/a
070205	Fabric Filtration Measurements and Modeling Program	EPA	GCA Corp.	n/a
070281	Fabric Filtration Research	EPA	EPA	n/a
	Survey Information on Fine Particle Control	EPRI	Southern Research Institute	1975
	Electrostatic Precipitators: Gas Conditioning	n/a	Bitz Labs.	n/a
	Baghouse Filtration of Air Pollutants	n/a	Pollution Engineering	1974
	Control Techniques for Particulate Air Pollution	n/a	NAPCA	1969
	The Production and Treatment of Gaseous Pollutants in an Electrostatic Precipitator	n/a	Texas A&M University	n/a
	Concept of Effective Residence Time Applied to Cyclone Type Particle Collectors	n/a	Corning Glass Co.	1976
	Shallow Multistage Fluidized Beds for Particle Collection	n/a	University of Idaho	n/a
	High Gradient Magnetic Particulate Collection	EPA	EPA	1976
	Filtration of Submicron Particles by Fixed and Fluidized Granular	n/a	University of Puerto Rico and University of Cincinnati	1976
	Primary Fine Particle Control Technology	EPA	n/a	n/a
	Fine Particle Scrubber Performance Tests	n/a	APT Inc.	n/a
093027	Improvement of Analytical Methods for Determining Trace Elements in Coal	ERDA	PERC	n/a
130024	Trace Element Study	TVA	TVA	n/a
070162	Power Plant Cooling Tower Blowdown Recycle by Verticle Tube Evaporation with Interface Enhancement; Mobile Plant Construction and Fluid Testing	EPA	California University	n/a
070224	Bromine Chlorine, An Alternative to Chlorine for Fouling Control in Condensor Cooling Systems	EPA	Martin Marietta Corp.	n/a
070235	Optimizing Design Specifications for Larger Dry Cooling Systems	EPA	PFR Engineering Systems, Inc.	n/a
070236	Advanced Waste Heat Control - Waste Heat and Water Utilization	EPA	Lockheed Electronics, Inc.	n/a
070239	Wastewater Renovation - Recycle for a Novel Power Plant Cooling Cycle Utilizing Irrigation Drainage with Interface-Enhanced Cooperation	EPA	California University	n/a
070240	Mobile Bed Flux Force/Condensation Scrubbers	EPA	Air Pollution Technology, Inc.	n/a
130027	Alleviation of Power Plant Condenser and Raw Water System Fouling by Corbicula	TVA	n/a	n/a
130029	Study of Methods to Prevent Saturation of Closed-loop Ash Pond Systems	TVA	n/a	n/a
130030	Protection of Aquatic Life at Power Plant Cooling Water Intakes	TVA	n/a	n/a

n/a - not available

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CATEGORY 4: COAL UTILIZATION RESEARCH				
	Nitrogen Oxides Reduction	EPRI	Foster Wheeler	1976
	Control of NO_x Formation in Tangentially Coal-Fired Steam Generators	EPRI	Combustion Engineering	1976
	Aqueous Scrubbing of NO_x from Stack Gases	n/a	Exxon	n/a
	NO_x Abatement for Stationary Sources in Japan	n/a	PEDCO Environmental Specialists, Inc.	1976
	Energy Cost of NO_x Control	n/a	FLUOR	1976
	Development of the Aqueous Processes for Removing NO_x from Flue Gas	EPA	Exxon	1972
	Premixed Combustion in a Baffle Combustor - The Effect of Steam Injection on NO_x Emissions	n/a	Laval University	1974
	Assessment of Catalysts for Control of NO_x from Power Plants	EPA	TRW Systems	1975
	Design Criteria for Stationary Source Catalytic Combustors	n/a	Acrotherm/Acurex Corp.	1976
	Catalytic Oxidation of Fuels for NO_x Control	EPA	Acurex Corp.	1976
	Process Removes NO_x Efficiently	n/a	Sumitome Chein Co., Ltd.	1974
	Catalytic Combustion and the Fuel-Nitrogen Problem	n/a	University of California	n/a
	NO_x Control for Stationary Combustion Sources	n/a	MIT	1976
	A Study of Low NO_x Combustion	n/a	Tokyo Gas Co., Ltd.	1974
070254	Environmental Assessment of Stationary Source NO_x Control Technologies	EPA	Acurex Corp.	O*
	Reduction of NO_x by EGR in a Compact Combustor	n/a	Battelle, Columbus	1973
	NO_x Emissions Reduction from Staged Combustion	n/a	Battelle, Columbus	1972
	NO_x Emissions at Low Excess-air Levels Pulverized - Coal Combustor	n/a	U.S. Bureau of Mines	1970
	NO_x Control Review	EPA	n/a	1976
	NO_x Considerations in Alternate Fuel Combustion	EPA	n/a	1975
070146	The Effects of High Temperature and Pressure on Particle Collection Mechanisms	EPA	Air Pollution Technology, Inc.	n/a
070147	New Concept for Fine Particle Control at High Temperature and Pressure	EPA	Air Pollution Technology, Inc.	n/a
070154	Electrostatic Precipitators for Control of Fine Particles	EPA	Southern Research Institute	n/a
070206	Demonstration of High-Efficiency Throughput Baghouse	EPA	EPA	n/a
070207	Nonwoven Fabrics as Filters for the Removal of Particulate Matter in Respirable Dust Range	EPA	Textile Research Institute	n/a
070208	Evaluation of Novel Devices	EPA	Meteorology Research, Inc.	n/a
070209	Fine Particulate Control with U.W. Electrostatic Scrubber	EPA	Washington University	n/a
070210	Evaluation of Novel Fine Particulate Collection Devices	EPA	Southern Research Institute	n/a
070241	Electrostatic Effects in Fabric Filtration	EPA	Carnegie-Melon University	n/a
070242	Design, Fabricate, and Install a Pilot-Scale Electrostatic Precipitator	EPA	Acurex Corp.	n/a
070243	Design and Construction of a Versatile Fabric Filter Test Unit	EPA	n/a	n/a

n/a - not available

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FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 4: COAL UTILIZATION RESEARCH				
130035	Membrane Processes for Refurbishing Power Plant Water Supply	TVA	n/a	n/a
130040	Characterization of Effluents from Coal-Fired Utility Boilers	EPA	TVA	n/a
070166	Dewatering Principles and Equipment Design Studies	EPA	Auburn University	n/a
130035	Fly Ash Characterization and Disposal	EPA	TVA	n/a
093035	An Investigation of the Mechanisms of Fly Ash Formation in Coal-Fired Utility Boilers	ERDA	New Hampshire University	n/a
130045	By-Product Marketing	EPA	TVA	n/a
130031	Heat Dissipation Technology	TVA	n/a	n/a
130032	Thermal Effects from Steam-Electric Generating Facilities	TVA	n/a	n/a
130039'	Study of Methods to Reduce Chlorine Discharges	TVA	TVA	n/a
130041	Advanced Waste Heat Control	EPA	TVA	1979
	Selecting and Installing Synthetic Pond Linings	n/a	Van Scoyoc and Wiskeg	n/a
	Alternatives for Disposal of Flue Gas Cleaning Wastes	EPA	Aerospace Corp.	1976
	Sludge Disposal from SO_2 and Particulate Removal Processes	TVA	TVA	n/a
	Pollutant Control Through Staged Combustion of Pulverized Coal	FER	University of Arizona	1978
	Control Techniques for Beryllium Air Pollutants	EPA	n/a	n/a
	Reduction of Sulfur from Steam Coal by Magnetic Methods		W. Kester, J. Leonard and E. Wilson Mining Congress Journal	1967
	Size Distribution of Fine Particulate Emissions from a Coal-Fired Power Plant		E. Schmidt, J. Gieseke and J. Allen Atmospheric Environment	1976
	Thermomagnetic Method of Concentrating and Desulfurizing Coal		A. Yorovsky and I. Nemesnikov, Koksi Khimiia	1958
CATEGORY 5: MAGNETOHYDRODYNAMIC RESEARCH				
	Effect of Nitric Oxide Control on MHD - Steam Power Plant Economics and Performance	Dept. of Interior	Stanford University, High Temperature Gasdynamics Lab.	1974
	Magnetohydrodynamic Power Generation	ERDA	PERC	1975
	A Preliminary Environmental Assessment for an MHD Energy System	n/a	Lockheed Missiles and Space Co.	1975
	Studies of Gaseous Core Reactor - MHD Power Plant Concepts	n/a	Georgia Institute of Technology	1973
	Radiation Transport for MHD Pollution Control	n/a	AVCO Everett Research Lab., Inc.	1975
	Coal-Fired MHD for Central Station Power Generation Power Generation	n/a	Jackson, W.D. and R. V. Shanklin, III; Oklahoma State University	1973

n/a - not available

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 5: MAGNETOHYDRODYNAMIC RESEARCH				
	Recovery and Utilization of Dilute Nitric Oxide from an MHD Generator - Task H-IV	ERDA	MERDI	1976
	Prediction of NO Concentrations in MHD Power Plants by Axi-Symmetric Two-Dimension Analyses	n/a	Mori, Y., et al Tokyo Institute of Technology	1975
	Kinetic Study of Oxides of Nitrogen in MHD Power Plants	n/a	Mori, Y., et al Tokyo Institute of Technology	1972
	Reduction of NO_x Concentrations in MHD Steam Power Plant System	n/a	Mori, Y., et al Tokyo Institute of Technology	1973
	Atmospheric Pollution Aspects of MHD Power Plants	Edison Elect. Inst.	Stanford University School of Engineering	1974
	Development and Design of High Temperature Air Preheaters and Techniques for Emission Control of Nitrogen Oxides for Open Cycle MHD Power Systems	n/a	AVCO Everett Reserach Lab.	1975
	Engineering Aspects of Magnetohydrodynamics	n/a	Argonne National Laboratory	1972
	MHD Power Generation - SO_2 Removal, Seed Regeneration and Preheating	Bureau of Mines	n/a	1974
	MHD Power Generation Development Program	EPRI	AVCO Everett Research Lab.	1975
	MHD Generator Development	Bureau of Mines	AVCO Everett Research Lab., Inc. Office of Coal Research	1974
	Coal Combustion Aspects of MHD Power Generation	Bureau of Mines	PERC	1974
	Three-Stage Combustor for MHD Power Generation	Bureau of Mines	n/a	1974
	Air Pollution Aspects of MHD Power Generation	Bureau of Mines	PERC	1973
	Production of a Clean Working Fluid for Coal Burning, Open-Cycle MHD Power Generation	Bureau of Mines	PERC	1972
	Environmental Aspects of MHD Power Generation	Bureau of Mines	PERC	1971
	High-Temperature Combustion of Coal Seeded with Potassium Carbonate in the MHD Generation of Electric Power	n/a	PERC	1970
	Decomposition of NO on Alumina Surfaces under Reducing Conditions for Emission Control of NO in MHD Power Plants		Tokyo Institute of Technology	1975
	Economic and Energy Considerations in MHD Seed Regeneration		P. Bergman, D. Gyorke and D. Bienstock 16th Symposium--Engineering Aspects of Magnetohydrodynamics	1977
	Open-cycle Coal Burning MHD Power Plants for Commercial Service		J. Cuttings, R. Schnyder, R. Lawit, B. Headman, and P. Zygielbaum, Proceedings of the 16th Symposium on Engineering Aspects of MHD	1977
	MHD Power Generation--Economic and Environmental Implications		F. Hals and W. Jackson, Proceedings of the Tenth Symposium on Engineering Aspects of MHD	1969
	Control Techniques for Nitrogen Oxides in MHD Power Plants		F. Hals and P. Lewis, Proceedings of the 12th Symposium on Engineering Aspects of MHD	1972

n/a - not available

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 5: MAGNETOHYDRODYNAMIC RESEARCH				
	Development and Design of High-Temperature Air Preheaters and Techniques for Emission Control of Nitrogen Oxides for Open-Cycle MHD Power Systems		F. Hals, R. Gannon, B. Kivel, F. Becker and H. Steinle, Sixth International Conference on MHD Electrical Power Generation	1975
	Status of the Reference Dual-Cycle MHD-Steam Power Plant		W. Jackson, K. Lawit, R. Stoudt, M. Klett, J. Cuttings and C. Maxwell, Proceedings of the 16th Symposium on Engineering Aspects of MHD	1977
	Prospects for More Effective Utilization of Fuel through MHD		V. Ovcharenko, Natural Resources Forum	1976
	NO Concentrations in MHD Steam Power Plant Systems		J. Pepper, R. Eustis and C. Kruger, Proceedings of the 12th Symposium on Engineering Aspects of MHD	1972
CATEGORY 6: SITE-SPECIFIC OR PROJECT-SPECIFIC RESEARCH				
	Direct Coal-Fired MHD Power Generation System	ERDA	University of Tennessee Space Inst.	1975

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FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 1: GENERAL ENVIRONMENTAL RESEARCH				
09088	Environment and Safety Planning Support	ERDA	Aerospace Corporation	n/a
083052	Criteria for Seismic Design of ERDA Facilities	ERDA	California University, Livermore	n/a
150140	Distribution of T·rnadoes	Nuclear Regulatory Comm.	Chicago University, Dept. of Geophysical Sciences	n/a
150141	Waterspout Measurements	Nuclear Regulatory Comm.	Colorado State University, Dept. of Atmospheric Science	n/a
150143	Engineering Analysis of Near-ground Windfields in Tornadoes	Nuclear Regulatory Comm.	Texas Tech. University	n/a
150144	U.S. Tornado Statistics	Nuclear Regulatory Comm.	NOAA, Kansas City, MO	n/a
150145	Lidar Velocity Measurements	Nuclear Regulatory Comm.	NOAA, Boulder, CO	n/a
150146	Tornado Characteristics	Nuclear Regulatory Comm.	NOAA, Norman, OK	n/a
150148	Modeling Tornado Dynamics	Nuclear Regulatory Comm.	Aeronautical Research Associates of Princeton, Inc.	n/a
087020	Vulnerability of Tornado Resistant Structures to Wind Generated Missiles	EPRI	Sandia Labs.	n/a
	Industrial Hygiene Workshop	ERDA	Booz, Allen, and Hamilton	1977
CATEGORY 2: ENERGY-RELATED RESEARCH				
033117	Auditory Effects of Long Exposure to Low Levels of Noise	NIEHS	Medical University of South Carolina, Charleston	n/a
085157	Information Center for Energy Safety	ERDA	Oak Ridge National Laboratory	n/a
089532	Alkali Metal Protective Suit	ERDA	Westinghouse Hanford Company	1976
032005	Recirculation of Exhaust Air	EPA	NIOSH	n/a
084061	Respirator Research and Development	ERDA	Los Alamos Scientific Laboratory	1976
CATEGORY 4: COAL UTILIZATION RESEARCH				
032010	Direct Reading Personnel Gas and Vapor Monitors	EPA	NIOSH, Division of Laboratory and Criteria Development (Cincinnati)	n/a
083054	Atmospheric Release Advisory Capability	ERDA	California University, Livermore (Lawrence Livermore Lab.)	1981
084062	Aerosol Sampling and Characterization for Hazard Evaluation	ERDA	Los Alamos Scientific Lab.	n/a
	Safety Program Planning for CCU Programs	ERDA	MITRE Corp.	1977
	Fire and Explosion Hazards in Fluidized-Bed Thermal Coal Dryers	n/a	H. A. Schrecengost and M. S. Childers, U. S. Bureau of Mines	1965

n/a - not available

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 5: MAGNETOHYDRODYNAMIC RESEARCH				
094041	Fusion Magnet Safety Studies, Superconducting	ERDA	Brookhaven National Lab.	1980
CATEGORY 6: SITE-SPECIFIC OR PROJECT-SPECIFIC RESEARCH				
093042	Safety Considerations Report: Montana Component Development and Integration Facility	ERDA	Gilbert Commonwealth Companies	1976
	Environmental Analysis and Safety Guidelines for the UTSI MHD Facility	ERDA	University of Tennessee Space Institute at Tullahoma, Tennessee	n/a

n/a - not available

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 1: GENERAL ENVIRONMENTAL RESEARCH				
080006	Detection and Characterization of Damages in Physiological, Cellular and Molecular Systems	ERDA	Argonne National Laboratory	n/a
082036	Probabilistic and Statistical Studies of Disease Effects of Pollutants	ERDA	University of California, Berkeley	n/a
033001	Analysis of Mechanisms of Experimental Emphysema (Nitrogen Compounds)	NIEHS	St. Luke's Hospital, Cleveland, Ohio	n/a
032012	Relationship of Metabolism, Fate, and Toxicity of Particulates and Organic Compounds			
034021	Molecular Processes Involved in the Carcinogenic Action of Polycylic Aromatic Hydrocarbons	Nat. Cancer Inst.	University of California, Dept. of Zoology	n/a
CATEGORY 2: ENERGY-RELATED RESEARCH				
030067	Combined Impulse - Continuous Noise: Auditory Effect	NI[illegible]	State University of New York (Upstate Medical Center)	n/a
033117	Auditory Effects of Long Exposure to Low Levels of Noise	NIEHS	Medical University of South Carolina, Charleston	n/a
096004	Scientific Research to Investigate the Biological Effects of High Voltage Electric Fields	ERDA	Battelle Pacific Northwest Lab.	n/a
051009	Survey to Determine the Extent and Location of Unallocated Water in the 11 Western States	Fish & Wild-life Svc.	Fish and Wildlife Service	n/a
094042	Environmental Effects (magnetic fields)	ERDA	Battelle Pacific Northwest Lab.	n/a
096005	Transmission Line Audible Noise Measurements (including those of electromagnetic fields)	ERDA	National Bureau of Standards	n/a
033002	Quantitative Genetic Study of Environmental Mutagens (fossil fuel combustion)	NIEHS	Louisiana State University, Dept. of Zoology and Physiology	n/a
098099	Use of the Mouse Specific-Locus Method to Quantify the Gene Mutation Hazard from Mutagens Associated with Nonnuclear Energy Technology	ERDA	Oak Ridge National Laboratory	n/a
098[illegible]97	In-Vivo Screening for Gene Mutations in Mouse Germ Cells and Somatic Cells	ERDA	Oak Ridge National Laboratory	n/a
032013	Mortality Study of TVA High-Risk Workers (NO_2)	Public Health Svc.	Appalachian Lab. for Occupational Respiratory Disease, Morgantown, Virginia	n/a
085102	Bioengineering Research	ERDA	Oak Ridge National Laboratory	n/a
087009	Biomedical Effects of Explosions	ERDA	Lovelace Foundation for Medical Education and Research (Albuquerque, New Mexico)	n/a
130012	Effects of High Intensity Electric Fields	TVA	Tennessee Valley Authority	n/a
	Trace Metals in Urban Aerosols - Final Report	EPRI	New York University	1975
	Interactive Effects of Sulfuric Acid and Nitrogen Dioxide in Cynomolgus Monkeys - Final Report	EPRI	Hazleton Labs., Inc.	1975
	Effects of Sulfur Oxides on the Lung: An Analytic Base - Final Report	EPRI	Science Applications	1975
	Biological Effects of High Voltage Electric Fields - Final Report	EPRI	ITT Research Institute	1975
	Health Effects of Nitrogen Oxides - Quarterly Report	EPRI	Science Applications	1976

n/a - not available

HEALTH EFFECTS

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 2: ENERGY-RELATED RESEARCH				
	Effects of Oxidant Air Pollutants	n/a	W. W. Heck, Journal of Occupational Medicine	1968
	NCI Lists Carcinogens Which May Be Linked to Occupations	n/a	Gershon W. Fishbein, Occupational Health and Safety Letter	1977
	Advanced Modern Toxicology	n/a	F. W. Sunderman	(in press)
	Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields	n/a	Haurado, Saunces, and Battocletti, Report at Marquette University and the Medical College of Wisconsin	1974
	Health Effects of Electricity Production	EPRI	EPRI-presented speech at the College of Physicians of Philadelphia Bicentennial Lectures - World Health in Human Perspective	1976
	Determination of the Effects of Material from Alternate Energy Sources on Upper EPA Respiratory Tract Clearance Mechanisms	EPA	Ball State University (Indiana)	n/a
	Health Aspects of Fossil Fuels	ERDA	ERDA	n/a
	Integrated Approach to Potential Occupational Health Problems Associated with Fossil Energy Development	ERDA	Greenfield, Attaway, Tyler	1977
	Effects of Inhaling Sulfur Dioxide, Sulfuric Acid, and Fly Ash	EPRI	Hazleton Labs., Inc.	1975
	Biologic and Clinical Effects of Low-Frequency Magnetic and Electric Fields	n/a	Haurado, Saunces, and Battocletti Marquette University and the Medical College of Wisconsin	1974
CATEGORY 4: COAL UTILIZATION RESEARCH				
070076	Comparative Toxicological Assessment of Fly Ash from Western and Eastern Coal	EPA	EPA, Health Effects Research Lab. (Cincinnati)	n/a
070085	Study Specific Causes of Morbidity and Mortality in Populations with Long-Term Exposure to Emissions from Coal Combustion	EPA	n/a	n/a
098053	Effect of Acid Sulfate Particles and H_2SO_4 Mists on the Anti-Bacterial, Anti-Viral, and Particle Clearance Mechanisms of Lung	ERDA	Lovelace Foundation for Medical Education and Research	n/a
098120	Genetic Effects from Electric Fields at the Chromosomal Level of Drosophila	ERDA	Battelle Pacific Northwest Lab.	n/a
098117	Toxicity of CO, NO_x, SO_x, and Fly Ash	ERDA	Battelle Pacific Northwest Lab.	n/a
	Steam Turbine Noise - A Status Report	n/a	Heyman, F.J., Bannister, R.L. and Niskode, P.M.	n/a
	Noise Dose and Hearing Loss in a Coal-Burning Power Plant	n/a	Broderson, A.B., Edwards, R.G., and Green, W.W.	1975
098096	Mutagenicity Assays of Fractioned Coal Conversion Products (includes combustion)	ERDA	Oak Ridge National Laboratory	n/a
098098	Chemical Introduction of Chromosomal Alterations in Mouse Germ Cells by Coal Conversion Products (includes combustion)	ERDA	Oak Ridge National Laboratory	n/a
	Hazardous Chemicals from Coal Conversion Processes	n/a	D. W. Koppenaal and S. E. Manahan Environmental Science and Technology	1976
	Coal Preparation	n/a	J. W. Leonard and T. S. Spicer, The American Institute of Mining, Metallurgical, and Petroleum Engineers, Inc.	1968

n/a - not available

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 5: MAGNETOHYDRODYNAMIC RESEARCH				
	Tin-Steam MHD Power System, Volumes I and II, Progress Reports (Noise)	Defense Advanced Research Projects Agency	Argonne National Laboratory	1975

ECOLOGICAL PROCESSES AND EFFECTS

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 1: GENERAL ENVIRONMENTAL RESEARCH				
087552	Resistance of Plants to Environmental Stress	ERDA	Michigan State University	n/a
033183	Fate of Heavy Metals and Heavy Metal Complexes in Soils and Plants	NIEHS	Battelle Pacific Northwest Lab.	n/a
CATEGORY 2: ENERGY-RELATED RESEARCH				
081065	Effects of Acid Rain on Terrestrial Ecosystems	ERDA	Brookhaven National Laboratory	n/a
083020	Trace Elements in Major Food Chains	ERDA	University of California, Livermore	n/a
085056	Environmental Effects of Cooling Tower Drift	ERDA	Oak Ridge National Laboratory	1976
070003	Toxic Effects on the Aquatic Biota from Coal and Oil Shale	EPA	Colorado State University	n/a
080017	Land and Fresh Water Environmental Sciences, Impact of Fossil Fuel Utilization on Terrestrial Ecosystems	ERDA	Argonne National Laboratory	Annual Reports
086024	Effects of Behavior of Fossil Fuel Effluents in Freshwater Ecosystems	ERDA	Battelle Pacific Northwest Lab.	1980
090027	Effects of Nonnuclear Pollutants on Arid Environments	ERDA	University of California, Los Angeles	1977
098160	Trace Metal Cycling and Effects on Terrestrial Ecosystems in S.E. United States	ERDA	DuPont de Nemours (E.I.) and Co.	n/a
130005	Characterize and Quantify the Transfer, Fate, and Effects of SO_x, NO_x, and Acid Precipitation in the Terrestrial Ecosystem Representative of the Tennessee Valley Region	EPA	TVA, Muscle Shoals, Alabama	1980
130007	Fate and Effects of Atmospheric Emissions from Cooling Systems on Terrestrial Habitats	EPA	TVA, Muscle Shoals, Alabama	1980
111015	Behavior of H_2S in the Atmosphere and its Effects on Vegetation	NSF	University of California, Riverside (Statewide Air Pollution Research Ctr.)	n/a
	Regional Climatic Effects of Power Plant Heat Rejection	n/a	Cornell University	1976
	Computer Simulation of Atmospheric Effects of Waste Heat	n/a	Stanford Research Institute	n/a
	Hydrocarbon Concentration in Food Chains	NOAA	Louisiana State University	n/a
	Simulation of Spray Canal Cooling for Power Plants - Performance and Environmental Effects	n/a	Detroit Edison	n/a
	Cooling Water Discharge Research Project -- Final Report	EPRI	Ecological Analysis, Inc./Johns Hopkins University	1976
	The Effect of Stack Emissions on the Range Resource in the Vicinity of Colstrip, Montana	n/a	F. Munshower, D. W. Sindolar, and D. R. Neuman, Montana State University	1975
CATEGORY 3: COAL RESEARCH				
070001	Bioassays Using Periphyton Communities with Emphasis on the Effects of Coal Leachate	EPA	University of Minnesota	n/a
070010	Static Coal Storage Biological and Chemical Effects on the Aquatic Environment	EPA	Wisconsin University	n/a

n/a - not available

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 4: COAL UTILIZATION RESEARCH				
085119	Ecological Effects of Coal Combustion, Response of Vegetation to SO_2, Ozone, and Acid Precipitation	ERDA	Oak Ridge National Laboratory	n/a
085156	Workshop on Effects of Trace Contaminants from Coal Combustion Systems	ERDA	Oak Ridge National Laboratory	1976
070007	Ecological Effects of Fossil Fuel Power Plants on a Grassland Ecosystem in Colstrip, MT	EPA	National Environmental Research Center	n/a
070008	The Impact of Coal-Fired Power Plants on the Environment	EPA	Wisconsin University	n/a
070009	Organic Leaching and Particulate Dispersion from Coal	EPA	Minnesota University	n/a
098114	Power Plant Heat and Chemical Effluent Effects on Selected Marine and Estuarine Communities	ERDA	Battelle Pacific N.W. Labs.	1978
085117	Biogeochemical Cycling in Aquatic Ecosystems of Trace Elements in Coal	ERDA	Oak Ridge National Laboratory	n/a
098060	Ecological Fate and Effects of Trace Contaminants from Coal Combustion and Processing	ERDA	Los Alamos Scientific Lab.	n/a
098112	The Immediate Effects of Effluents from Coal Utilization on the Behavior and Physiology of Freshwater Biota	ERDA	Battelle Pacific N.W. Labs.	1976
130003	Filtered and Filtered/Unfiltered Exposure Chamber Studies of Effects of Coal-Fired Power Plant Emissions on Crop and Forest Species	EPA	TVA, Muscle Shoals, Alabama	n/a
130004	Determine Dose-Response Kinetics for Effects of Atmospheric Emissions from Coal-Fired Power Plants on Soybeans and Other Crop and Forest Species	EPA	TVA, Muscle Shoals, Alabama	n/a

n/a - not available

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 1: GENERAL ENVIRONMENTAL RESEARCH				
	Effects of Gaseous Pollutants on Materials	EPA	n/a	1976
	Systems Analysis of the Effects of Air Pollution on Materials	n/a	Midwest Research Institute	1970
	A Survey Economic Assessment of the Effects of Air Pollution on Elastomers	n/a	Battelle	1970
	A Survey on Electrical Components	n/a	ITT Electro - Physics Laboratories	1971
	Economic Impact of Air Pollutants on Plants in the US	n/a	Stanford Research Institute	1971
	Economic Measurement of Environmental Damage	OECD	n/a	1976
	Industry Costs for Stack Monitoring	n/a	University of Texas	1976
CATEGORY 2: ENERGY-RELATED RESEARCH				
080022	Social Costs of Energy Supply Systems	ERDA	Argonne National Laboratory	n/a
089104	Graduate Training in Energy Related Problems in Health and Environmental Biology	ERDA	Tennessee University, Oak Ridge	n/a
	Environmental Aspects of Fossil Demonstration Plants	ERDA	Energy and Environmental Analysis, Inc.	1976
	Assistance in Assessing Water Resource Applications of ERDA	ERDA	Energy and Environmental Analysis, Inc.	1977
	Environmental Guidelines for Fossil Energy Pilot, Demonstration and Commercial Facilities	ERDA	PERC	1979
	Socioeconomic Impact Study	ERDA	National Governors Conference	1977
	Socioeconomics Data T Book - Task I	ERDA	Oak Ridge National Laboratory	1977
	Socioeconomic Impact Methodology	ERDA	Murphy - Williams	1977
	Environmental Evaluation Requirements for the FE Program	ERDA	MITRE	1976
	Investigation of Secondary Impacts of Western Energy Development	ERDA	CEQ (Denver Research Institute)	1977
	Development and Application of a Methodology for the Socioeconomic Impacts of Demonstration Plants	ERDA	Proposal Under Review	1979
	Environmental and Conservation Support Services to Fossil Energy Office of Plannings and Analysis	ERDA	PERC	1979
	Investigation of the Potential for Utilization of Saline Groundwater in Energy - Related Processes	ERDA	Radian Corp.	1977
	Effects of Power Plant Emissions or Materials	EPRI	Research Corp. of New England	1975
	Inventory of Environmental and Safety Projects in Fossil Energy	ERDA	TRW	1976
	Conference on Local Technology and Advanced Systems - - the University's Role	NSF	State University School of Engineerings	n/a
	Construction Worker Profile: User's Guide to the Data	n/a	J. Chalmers and J. Glazner Mountain West Research, Inc.	1975
	OCS Oil and Gas--Environmental Assessment	n/a	Council on Environmental Quality	1974

n/a - not available

INTEGRATED ASSESSMENTS

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 2: ENERGY-RELATED RESEARCH				
	Effects of Coal Development in the Northern Great Plains--A Review of Major Issues and Consequences at Different Rates of Development	n/a	Northern Great Plains Resource Program	1975
	The Social and Economic Impact of a Camp Gruber Energy Center	n/a	J. R. Young and K. E. Yandon, Battelle Pacific Northwest Lab.	1975
	Development and Application of Methodology for the Socioeconomic Impacts of Demonstration Plants	ERDA	n/a	1979
	A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future	n/a	Energy Research and Development Administation	1976
	Exploring Energy Choices	n/a	Ford Foundation	1974
	Methodologies for Power Plant Siting	USGS	E. Graf-Webster, S. Haus, S. Lubore J. Pfeffer, and J. Watson MITRE Corporation	1975
	Second Draft of a Social Impact Assessment Primer	n/a	R. L. Gold, University of Montana	1976
	A Procedure for Evaluating Environmental Impact	n/a	L. B. Leopold, F. E. Clarke, B. Hanshaw, and J. Balsley	1971
	Power Facility Siting in the State of Illinois	n/a	D. R. McFarlane, B. M. Hoglund, P. A. Roberts, and J. J. Yates, State of Illinois Institute for Environmental Quality	1975
	Final Report of the Fort Union Regional Task Force on Social and Economic Impact	n/a	National Science Foundation	1976
CATEGORY 3: COAL RESEARCH				
	Coal Research, Development and Demonstration Environmental Analysis	ERDA	Mothe	1977
	Coal RD&D Impact Statement	ERDA	MITRE	1977
CATEGORY 4: COAL UTILIZATION RESEARCH				
085156	Workshop on Effects of Trace Contaminants from Coal Combustion Systems	ERDA	Oak Ridge National Laboratory	1976
	Factors Influencing an Area's Ability to Absorb a Large-scale Commercial Coal Processing Complex - A Case Study of the Ft. Union Lignite	ERDA	Denver Research Institute	1975
	Benefit - Cost Evaluation of the ERDA FE Combustions Advanced Power Development Program	n/a	Mitre Corp.	1976
	Draft Environmental Impact Statement on Colstrip Electric Generation Units 3 & 4, 500 Kilovolt Transmission Lines and Associate Facilities	n/a	Energy Planning Division, Montana State Department of Natural Resources and Conservation	1974
	Final Environmental Impact Statement: Proposed Plan of Mining and Reclamation, East Decker and North Extension Mines, Decker Coal Company, Big Horn County, Montana	n/a	USGS, Department of the Interior, and Montana Department of State Lands	1977

n/a = not available

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 5: MAGNETOHYDRODYNAMIC RESEARCH				
070136	Development Status and Environmental Hazards of Several Advanced Energy Systems (includes MHO)	EPA	Lockheed Missiles and Space Co.	n/a
070168	Environmental Assessment of Advanced Energy Conversion Technologies (includes MHD)	EPA	EXXON Research & Engineering Co.	n/a
	An Overall Program for the Development of Open Cycle MHD Power Generation	EPRI	EPRI	1975
	Energy Technologies (includes MHD)	DOI	Bureau of Standards	1976
	Third U. S. - U. S. S. R.' Colloquim on Magnetohydrodynamics Electric Power Generation	ERDA	Moscow, U.S.S.R.	1976
	Magnetohydrodynamics Power Generation and Theory: A Bibliography	n/a	NTIS	n/a
	Environment and Conservation in Energy Research and Development	n/a	Council on Environmental Quality	1976
	MHD for Central Station Power Generation: A Plan for Action	n/a	Office of Science and Technology, Executive Office of the President	1969
	Selection of Tentative MHD-ETF Candidate Site Areas	n/a	The Montana Energy and MHD Research and Development Institute, Inc.	1977
CATEGORY 6: SITE-SPECIFIC OR PROJECT-SPECIFIC RESEARCH				
	A Reference Summary of Current MHD Test Facilities and Their Capabilities	ERDA	Gilbert/Commonwealth Associates	1976

n/a - not available

FI Number	Title	Monitoring Agency	Author or Performing Organization	Completion Date
CATEGORY 2: ENERGY-RELATED RESEARCH				
	Electric Utilities, Clean Air Act Amendments, and Sulfates	FEA	FEA	n/a
	Impacts of Clean Air Act Amendments on Fossil Energy Projects	ERDA	MITRE	1976
	Guidelines and Methodologies for Environmental Reports	ERDA	MITRE	1977
	Data Analysis and Support Services for Preparation of Environmental Impact Statements	ERDA	MITRE	1977
	Industrial Siting Legislation and Protection of the Environment		J. Speck, Rocky Mountain Center on Environment	1973
CATEGORY 3: COAL RESEARCH				
	Permit Integration to Improve Coal Production and the Regulatory Process	ERDA	HERC	1976
	Coal RD&D Program Draft Environmental Impact Statement	ERDA	MITRE	1977
CATEGORY 6: SITE-SPECIFIC OR PROJECT-SPECIFIC RESEARCH				
093043	Environmental Assessment: Montana MHD Component Development and Integration Facility	ERDA	Gilbert Associates, Inc.	1976
	Environmental Analysis of Proposed UTSI MHD Project - Tullahoma, Tennessee	DOI	Office of Coal Research	1974
	FY 1976 Annual Report -- Task H and Selection of Tentative MHD ETF Candidate Site Areas -- Second Draft Interim Report	ERDA	MERDI	1977
093041	Magnetohydrodynamics Systems Environmental Impact Study	ERDA	MERDI	1976

n/a - not available

C. Specific Project Summaries

CATEGORY 5: SPECIFIC PROJECT SUMMARIES

CHARACTERIZATION, MEASUREMENT, AND MONITORING

FI Number	Title	Author or Performing Organization
	Advanced Energy Conversion Techniques for Utility Applications Using Coal or Coal-derived Fuels This study is part of the Energy Conversion Alternatives Study (ECAS). Research has been conducted on MHD performance requirements, economics, environmental intrusions, and natural resources.	NSF/Westinghouse Electric Corp., Pittsburgh, PA.
	Comparative Study of Advanced-cycle Systems EPRI is supporting a program to develop a comparison methodology and perform a detailed evaluation and comparison of open and closed-cycle MHD systems, gas turbines, advanced steam systems, metal vapor turbines, fuel cells, and thermionics. Coal, gasified coal, oil, LMFBR, and HTGR are considered as fuels.	EPRI
	MHD Program MIT faculty developed a model in support of the Office of Coal Research's MHD development program. Included in this model were characteristics of coal combustion and gasification, the generator, the air preheater, seed recovery and gas cleaning systems, the steam generating plant, and auxiliary plant components. MIT also conducted extensive materials research.	MIT, Graduate School, monitored by the Office of Coal Research, 1974
	13th Symposium on the Engineering Aspects of Magnetohydrodynamics Papers presented at this symposium are collected in this volume. Studies on pollution aspects cover general air pollution problems, NO_x decomposition modeling, and NO_x reduction.	Stanford University, 1973
	Thermodynamic Data Tables for Fossil Fuel Utilization Processes This project will develop thermodynamic data for chemical compounds and species of interest to coal conversion and utilization processes. Potassium silicates and aluminosilicates will be studied specific to MHD, as well as cesium sulfides and silicates and gaseous CO_2, NO, SO_2, PO, and PO_2. Tables will also be prepared for water, C_2H_6, H_2S, C_1-C_2 acids, alcohols, mercaptans, and argon.	ERDA/MER, Dow Chemical Company, Midland, MI., 1979

CATEGORY 5: SPECIFIC PROJECT SUMMARIES

CHARACTERIZATION, MEASUREMENT, AND MONITORING

PI Number	Title	Author or Performing Organization
	Development Program for MHD Direct Coal-fired Power Generation Test Facilities. Quarterly Technical Progress Report, July-September, 1975. This report discusses progress made in the measurement and analysis of the interaction between slag and seed material. System requirements for very fine particulate potassium sulfate fume recovery were characterized.	University of Tennessee, Tullahoma Space Institute
	Characterization of Atmospheric Pollutants for Power Plants (including coal-fired MHD) This publication discusses the physical and morphological properties of fly ash composition produced in coal combustion and, in particular, MHD power generation. Natusch believes that large numbers of fine particles will be created in MHD power generation, while none of the larger, hollow spheres (a classification of fly ash 20 - 60 μm in diameter) will be produced.	Natusch, D. F. S. (in press) (including coal-fired MHD)
	Optical Measurements of Mean Particle Size in the Exhaust of a Coal-Fired MHD Generator This project is developing techniques to measure the mean particle size in the exhaust of a coal-fired MHD generator. Work is directed at determining slag deposition rates and how particle size effects deposition. Many sampling techniques cannot be used with MHD due to the high temperatures involved; the above approach (slag deposition rates/particle size) may prove a practical alternative.	Holve, D. and S. Self, presented at fall meeting of Western States Section of the Combustion Institute, University of California, San Diego, and LaJolla, California
	Investigation of Factors Influencing Potassium Seed Recovery in a Direct Coal-Fired Generator System This project studied the effects of high temperatures and magnetic fields on seed recovery and particulate formation and size distribution in MHD systems. (Studies of this sort suggest the vast differences that may exist between emissions from coal-fired and MHD plants.)	Tempelmeyer, et al, 16th Symposium--Engineering Aspects of Magnetohydrodynamics, Pittsburgh, Pennsylvania
	Slag-seed Interactions and Particulate Formation UTSI is investigating potassium seed management, including characterizing slag-seed interactions and related particulate formation. Baghouses and wet scrubbers are being studied for their effectiveness to collect the submicron size particulates formed in the MHD test train.	University of Tennessee Space Institute (UTSI) (Ongoing)
	ERDA Task S: Characterization and Modelling of MHD Emissions The Environmental Trace Substances Research Center at the University of Missouri is conducting a mass balance study and characterizing influents and effluents of an operating MHD plant for MERDI, funded by ERDA Task S. One or two process development units will be selected, and subsequent work (if funding continues) will provide particle size distribution curves, establish whether partitioning takes place, and analyze aspects of fine particle layering as the gas stream cools. The study will focus on trace element characterization.	MERDI (Ongoing)

CHARACTERIZATION, MEASUREMENT, AND MONITORING

FI Number | Title | Author or Performing Organization

ERDA Task S: Characterization and Modelling of MHD Emissions — MERDI

(Continued)

MERDI is also involved in producing a model or models to simulate emissions from open-cycle, coal-fired MHD power plants under actual operating conditions. This work includes: 1) identification of existing models, 2) identification of necessary modeling capability, 3) identification of data required, 4) cooperative development of models and data base, and 5) model testing.

Atmospheric Pollution Aspects of Magnetohydrodynamic Power Plants — Stanford University, High Temperature Gasdynamics Laboratory (1975)

This paper summarizes research on the economics and nitric oxide emissions of MHD power generation. Both system studies and laboratory measurements were conducted. The study concluded MHD can be competitive with conventional power plants and that NO_x emissions may be controlled by two-stage combustion. The laboratory studies measured NO decomposition rates in different temperature ranges.

Economically Efficient Design of an MHD Power Station Employing an Open-cycle System — Foreign Technology Division, Wright-Patterson Air Force Base, OH

This paper addresses the kinetics of nitrogen oxide formation in MHD generators.

Methods of Coal Combustion and Processing in Open Cycle MHD Power Systems — AVCO Everett Research Laboratory, Everett, MA.

This project studied different coal combustion techniques for MHD systems. Direct combustion, conversion to a cleaner fuel prior to combustion, and single and multi-stage combustion were analyzed for their efficiency in MHD systems.

Coal-fired MHD Electric Power Generation — Montana State University

This paper was presented at an AICHE meeting and discusses the history, operating principles, efficiency, capacity, and fuel and water requirements for MHD electricity generation.

Thermophysical Properties of Molten Coal Slags and Alkali Seed Mixtures Relating to MHD — NSF/Battelle Memorial Institute, Richland, WA, 1976

This study's objectives were to measure the molten and vapor properties of slag and seed and to model and design coal-fired MHD generators. Thermal diffusivity, viscosity, electrical conductivity, and surface tension of the molten slags were measured as functions of temperature, composition, and seed concentration.

Energy Technologies (1974-1975) E. Plante; W. Capps; C. McDaniel; H. Frederiske; T. Negas — DOI, National Bureau of Standards

This project was established to provide data for the design, construction, and operation of MHD systems. It focused on determining the physical and chemical behavior of components, process contaminants, and their reaction products as a function of the pressures and temperatures specific to MHD operation.

CHARACTERIZATION, MEASUREMENT, AND MONITORING

FI Number	Title	Author or Performing Organization
	ERDA TASK Q: Ambient Baseline Monitoring Program at the MHD COIF	MERDI (Ongoing)

A total ambient environmental monitoring program for the MHD COIF in Butte, Montana, has been designed and is currently being implemented. Air and water quality and meterology/climatology are being monitored. Implementation of the program will adhere to guidelines suggested by the Office of Research and Monitoring of the U.S. Environmental Protection Agency and would guarantee acceptance under an air and water assurance program. Baseline data will be monitored during CDIF operation, and these data will be used to predict the environmental impacts of future coal-fired MHD facilities. Ambient noise levels and a VHF frequency survey are planned. Baseline air quality data currently being monitored include the following:

- Total suspended and settleable particulate concentrations and chemical analysis of the particulates collected including trace elements;
- Short-term ambient NO_x and SO_2 concentrations;
- Long-term static sampling for fluorides, sulfates, and nitrates; and
- Precipitation washout samples and chemical analyses of the collected material.

Ambient air quality monitoring for particle size determination and chemical analysis of each separate fraction are among additional sampling techniques planned for this program. Ambient monitoring of CO and hydrocarbon levels in the COIF vicinity also is planned. Data are being obtained from a permanently located meteorology/air quality station within a quarter of a mile of the MHD-COIF currently under construction. These data are being used to define airflow characteristics of the CDIF site and to compare these characteristics with air flow data obtained at the Butte airport. Two other sites are being examined for the placement of mobile air quality/meteorology units. Wind and temperature on a 40m tower will be measured so that dispersion patterns and atmospheric thermal stratification can be characterized. The height and duration of the nocturnal temperature inversion in Butte is being measured by an acoustic radar unit. In addition vertical temperature profiles obtained by aircraft soundings over Butte are being compared to the acoustic radar data to establish the validity of the radar to determine temperature inversion height. Water quality studies include establishment of baseline data for both groundwater and surface waters in the vicinity of the CDIF. Normally expected minerals as well as trace elements are being analyzed for their presence in both surface water and groundwater.

CHARACTERIZATION, MEASUREMENT, AND MONITORING

FI Number	Title	Author or Performing Organization
	ERDA Task S: Biological and Socioeconomic Monitoring Program for the MHD CDIF	MERDI (Ongoing)

Infrared color slides obtained during the summer of 1976 were used to provide realistic vegetative baseline records. The structure of various grassland communities at sites near the CDIF location was analyzed in order to classify the grassland communities at sites near the CDIF location and thus provides baseline vegetational data. A surveillance program has been initiated near the CDIF location. Terrestrial and aquatic life indigenous to the CDIF area will be monitored for its reaction to CDIF emissions and effluents. Various sampling sites will be selected, sampling schedules recommended, and sampling and analytic techniques described. Although CDIF effluents are expected to be minimal, the approaches used there will be helpful later when establishing an ecological effects program at the ETF. A study is also being conducted to monitor the socioeconomic impact of the DCIF on a depressed community during the preconstruction, construction, and post-construction phases. The size and characteristics of the work force will be estimated as well as migration rates, per-capita income, land ownership and taxes, physical infrastructure, CDIF direct impact on economic stimulation, employment and land use, and indirect CDIF impacts on secondary income and employment.

ENVIRONMENTAL CONTROL TECHNOLOGY

FI Number	Title	Author or Performing Organization
	MHD Generator Development These system design studies assess the economic, technical, and environmental feasibility of MHD generators. Superconducting magnets were studied and one magnet design was completed. Seed recovery and the corrosive effects of seed material on metal heat exchanger surfaces were investigated. Air pollution controls were discussed.	AVCO Corporation, Everett Research Laboratory, Everett, MA., 1974
	Studies of Gaseous Core Reactor - MHD Power Plant Concepts This study demonstrates the feasibility of using a gaseous core reactor with MHD conversion. Using this reactor, the system produces more economical electric power with fewer environmental impacts than any nuclear power system currently envisioned. Overall thermal efficiencies of more than 70 percent are expected.	Georgia Institute of Technology, School of Nuclear Engineering, 1973
	Three-stage Combustor for MHD Power Generation This project studied the use of three-stage combustion in MHD power generation for its potential to produce an ash-free, electrically conductive coal combustion gas. The system would reduce the amount of ash rejected with the exit gases, minimizing pollutant problems caused by such rejection.	DOI, Bureau of Mines, 1974
	MHD Power Generation - SO_2 Removal, Seed Regeneration, Preheating In this study, almost complete SO_x removal was accomplished and 99 percent of the seed material was regenerated. The technical and economic aspects of MHD power generation were considered and it was projected that an annual savings of over $300 million in the cost of fossil fuels for electricity generation could be achieved.	DOI, Bureau of Mines, 1974
	Environmental Aspects of MHD Power Generation This study focuses on reductions achievable in air and thermal pollution by employing MHD to generate electricity. Practically all SO_x was removed by the seed addition. Nitric oxide formation approximated theoretical expectations. Fly ash was extracted with water, and 75 percent of the seed was recovered. Materials were tested and proved resistant at different temperatures.	Intersociety Energy Conversion Conference, Boston, 1971/Sponsored by PERC, Bienstock, D., et al
	Engineering Aspects of Magnetohydrodynamics This is a compilation of papers presented at the 12th Symposium on Engineering Aspects of Magnetohydrodynamics in Argonne, Illinois on March 27, 1972. Papers covered such topics as computer modeling of NO decomposition, NO_x control by two-stage combustion, and preliminary design of a three-stage coal-fired MHD pilot plant. Two-stage combustion is shown to be an effective technique in controlling NO_x emissions from the MHD effluent stack to below current EPA NSPS. The air preheater also appears to have a significant effect on the rate of NO decomposition.	Argonne National Laboratory, 1972

ENVIRONMENTAL CONTROL TECHNOLOGY

PI Number	Title	Author or Performing Organization
	Prospects for More Effective Utilization of Fuel through MHD This article discusses the feasibility of the MHD process. It emphasizes that the ability of MHD to meet pollution control requirements will be a major factor in establishing its practicability.	Ovcharenko, Valeriy A., Natural Resources Forum, 1, United Nations, N.Y., 1976
	NO Concentrations in MHD Steam Power Plant Systems This paper discusses the possibility of reducing NO_x emissions by controlling the gas residence time in the high temperature air heater.	Pepper, J. W., R. M. Eustis, and C. H. Kruger, Proceedings of the 12th Symposium on Engineering Aspects of MHD, Argonne Nationa Laboratory, Argonne, Illinois, 1972
	Open-cycle Coal Burning MHD Power Plants for Commercial Service Basing their conclusions on an STD Research Corporation Report prepared for EPRI, Cuttings et al have concluded that the economics of NO_x recovery in MHD systems are not practical (using the Mitsui Wet Process described).	Cuttings, J. L., R. P. Schnyder, R. L. Lawit, B. Headman, and P. S. Zygielbaum, Proceedings of the 16th Symposium of Engineerin Aspects of MHD, University of Pittsburgh, 1977
	Recovery and Utilization of Dilute Nitric Oxide from an MHD Generator, Task H-IV This project evaluated the economics of NO_x recovery and researched the processing steps necessary to remove NO_x from the gas stream and convert it to a saleable product. Solid and liquid absorption and adsorption techniques for NO_x removal and concentration were studied, and methods to convert the concentrated NO_x into nitric acid, ammonium nitrate, and other fixed nitrogen salts were investigated.	MERDI, 1976
	Economic and Energy Considerations in MHD Seed Regeneration Bergman has analyzed the efficiency penalties for controlling SO_2 emissions from an MHD power plant. He predicts that approximately 0.4 of an efficiency point must be sacrificed to achieve zero SO_2 emissions from a 2000 MW_t MHD power plant operating at 50 percent efficiency and burning 3 Wt percent sulfur coal.	Bergman, P. D., D. Gyorke, and D. Bienstock, 16th Symposium--Engineering Aspects of Magnetohydrodynamics, Pittsburgh, Pennsylvania, 1977
	Status of the Reference Dual-Cycle MHD-Steam Power Plant This project studies SO_2 control options applicable to MHD--coal cleanup, seed regeneration, and flue gas scrubbings. Seed regeneration appears most cost-effective for low sulfur coals; flue gas scrubbings for higher sulfur coal. Coal cleaning reduces the combustible material in the coal, although the reduced ash content and higher heating value of the washed coal may improve its combustion performance. A conceptual commercial plant has been designed and will employ an ESP and a baghouse, dry collections systems that will reduce water vapor	Jackson, W. D., R. L. Lawit, R. A. Stoudt, M. G. Klett, J. C. Cutting, and C. D. Maxwell, Proceedings of the 16th Symposium of Engineering Aspects of MHD, University of Pittsburgh, 1977

ENVIRONMENTAL CONTROL TECHNOLOGY

FI Number	Title	Author or Performing Organization
	Status of the Reference Dual-Cycle MHD-Steam Power Plant (cont'd)	
	releases from MHD coolin_ towers. This report also estimates the size of the coal particle for MHD combustion. Secondary air admitted downstream from the high temperature gas tends to complete combustion primarily of CO and unidentified aromatic hydrocarbons. Work by Jackson also indicates that combustion products may leak at the superheater unless special materials and cleaning devices are used.	
	MHD Power Generation--Economic and Environmental Implications	Hals, F. and W. D. Jackson, Proceedings of the 10th Symposium on Engineering Aspects of MHD, MIT, Cambridge, Massachusetts, 1969
	This study discusses two routes of NO_x control: minimizing the nitrogen oxides in the effluent, or maximizing the NO_x in the effluent so that recovery of fixed nitrogen becomes economically attractive. Preliminary results indicate that fixed nitrogen removal is economically feasible.	
	Control Techniques for Nitrogen Oxides in MHD Power Plants	Hals, F. and P. F. Lewis, Proceedings of the 12th Symposium on Engineering Aspects of MHD, Argonne, Illinois, 1972
	This study looked at the possibility of using two-stage combustion in a fuel-rich atmosphere to reduce NO_x emissions in MHD gases. The results indicate that the procedure will reduce NO_x emissions to levels well below current EPA emission levels.	
	Air Pollution Aspects of MHD Power Generation	BOM/PERC, D. Bienstock, 1973
	This report examines the air pollution potential of MHD systems, focusing on SO_x and NO_x emissions and seed recovery. It concludes that coal-fired MHD will eliminate nearly all SO_2 emissions for approximately one-fifth the cost required in conventional coal-fired power plants. Seed makeup costs are low even if as much as 5 percent of the seed is not recovered. Two-stage combustion can reduce NO_x emissions to levels below EPA regulations.	
	Atmospheric Pollution Aspects of MHD Power Plants	Stanford University, School of Engineering, 1974
	This research program modeled an MHD power plant and determined the influence of process variations on NO_x emissions. Gas phase reaction rates were measured for their influence on NO_x formation and decomposition, and the influences of surfaces on NO_x decomposition were determined.	
	Magnetohydrodynamic Power Generation	ERDA/PERC, Bienstock, D., et al., 1975
	This [illegible] studied the use of three-stage combustion to produce a low ash, high-temperature gas suitable for open-cycle MHD power generation. It also researched economically feasible seed regeneration methods and developed models to support the technical and economic development of MHD.	

ENVIRONMENTAL CONTROL TECHNOLOGY

FI Number	Title	Author or Performing Organization
	Effect of Nitric Oxide Control on MHD-Steam Power Plant Economics and Performance This study was designed to minimize the total generation cost of electric power from a combined MHD-steam power plant while keeping NO_x emissions below a required level. Nitric oxide decomposition was modeled, and losses were estimated from various points within the system. The report concluded that if the problems currently encountered by open-cycle MHD are resolved (e.g., materials lifetime, superconducting magnet performance, seed recovery, channel enthalpy extraction, high temperature air preheater performance), the combined MHD-steam power plant would offer an efficient, low atmospheric pollution alternative to conventional coal-fired steam power plants at competitive costs.	DOI/Stanford University, High Temperature Gasdynamics Laboratory, 1974
	MHD Power Generation Development Program This report summarizes the progress of MHD development performed by AVCO Everett Research Laboratory in collaboration with the Office of Coal Research during 1974. Particular attention focused on NO_x levels found in MHD plant effluent. Two-stage combustion or afterburning was shown to be an effective NO_x control technique. Catalytic NO_x decomposition and the radiation cooling and kinetics of exhaust gas were studied. It was shown that NO_x levels could be reduced to a fraction of the EPA standard in a furnace of reasonable size.	EPRI/AVCO Everett Research Laboratory, 1975
	High-temperature Combustion of Coal Seeded with Potassium Carbonate in the MHD Generation of Electric Power This project achieved practically complete SO_2 removal from the stack gas of a coal-fired MHD unit; nitrates in the fly ash were less than 1.7 percent of the total fixed nitrogen. Using water to extract the fly ash, a 75 percent potassium seed recovery was obtained. Materials stability at high operating temperatures was analyzed.	DOI, Bureau of Mines, 1970
	Development and Design of High Temperature Air Preheaters and Techniques for Emission Control of Nitrogen Oxides for Open-cycle MHD Power Systems Using coal as the primary fuel, this project applied the MHD concept to commercial power generation. Auxiliary power plant components were developed. Particular attention was paid to developing a high temperature air preheater that could control nitrogen oxide emissions to desirable levels.	AVCO Everett Research Laboratory, Everett, MA., 1975
	Kinetic Study of Oxides of Nitrogen in MHD Power Plants This paper describes the kinetic behavior of nitrogen oxides in an MHD-steam combined power plant. Plant conditions required to reduce NO_x emissions to a low level and the kinetics of nitrogen reduction also are discussed. Process points (e.g., gas phase and surface reactions, gas and heat exchanger temperature variations, and position of secondary air introduction) are studied to see how they affect NO formation and decomposition.	12th Symposium on Engineering Aspects of Magnetohydrodynamics, Argonne National Laboratory, Mori, Y., et al, Tokyo Institute of Technology, 1972

CATEGORY 6: SPECIFIC PROJECT SUMMARIES

ENVIRONMENTAL CONTROL TECHNOLOGY

FI Number	Title	Author or Performing Organization
	Direct Coal-fired MHD Power Generation System The Energy Conversion Division within the Space Institute is firing coal directly to fuel MHD power generation. Areas within the system where the gas can be cleaned before causing pollutive and erosive problems are being studied. The Division is optimistic about the results, indicating that mechanical gas clean-up at the end of the generator may be feasible.	University of Tennessee, Tullahoma Space Institute, 1975

CATEGORY 5: SPECIFIC PROJECT SUMMARIES

OPERATIONAL SAFETY

FI Number	Title	Author or Performing Organization
094041	Fusion Magnet Safety Studies, Superconducting This study will analyze different superconducting magnet designs from a safety viewpoint. Potential safety problems will be identified, accident analysis codes developed, and safety criteria formulated. Safety analysis procedures for superconducting magnets will be developed.	ERDA/Brookhaven National Laboratory, to be completed in 1980.

CATEGORY 6: SPECIFIC PROJECT SUMMARIES

OPERATIONAL SAFETY

FI Number	Title	Author or Performing Organization
093042	Safety Considerations Report: Montana Component Development and Integration Facility This project identified safety considerations for the Montana Component Development and Integration Facility (CDIF) so that design and operating procedures could be devised to minimize risks to personnel and facilities. Areas of potential risk of high pressure explosions, pressurized pipe whipping, dust explosions, projectiles, electric shock, and fires were identified and safety precautionary measures were recommended.	ERDA/Gilbert Commonwealth Co., 1976
	Environmental Analysis and Safety Guidelines for the UTSI MHD Facility This report is not yet available, but contains the environmental analyses and safety guidelines developed for the MHD facility at the University of Tennessee Space Institute.	University of Tennessee Space Institute at Tullahoma, Tennessee

HEALTH EFFECTS

FE Number	Title	Author or Performing Organization
	Tin-steam MHD Power System, Vols. I and II Progress Reports, Feb.-Aug. 1975 The tin-steam MHD power system is being studied conceptually, with emphasis on design criteria. The system is expected to be compatible with light water reactors and may reduce noise levels, since the few rotating parts are small and will move at low speeds.	Argonne National Laboratory

INTEGRATED ASSESSMENTS

FI Number	Title	Author or Performing Organization
070168	Environmental Assessment of Advanced Energy Conversion Technologies Over a three-year period, open and closed-cycle MHD systems will be studied with other advanced energy conversion technologies to identify their potential environmental impacts. Models will be developed to estimate effluents, pollutants, and waste energy. The cost-effectiveness of pollution control technologies will be assessed specific to each energy cycle, and field and laboratory tests will be performed to project environmental impacts. Data from these tests will be input into the models developed earlier. Fuels, combustion processes, thermodynamics and kinetics of each cycle, pollutant formation and treatment, and other related factors will be analyzed. Information from all work will be used to identify research needs to ensure the technology's environmental acceptability; anticipated funding will be considered when determining needed research. At present, progress reports are available.	EPA/Exxon Research and Engineering Co.
	Energy Technologies (1975-1976), E. Plante; W. Capps; C. McDaniel; H. Frederikse; and T. Negas This project managed energy activities within the Bureau of Standards' Inorganic Materials Division. As such it coordinated work with other agencies, particularly ERDA, and, specific to MHD, helped prepare and submit research proposals. This project also has established a national MHD materials plan with ERDA and EPRI.	DOI/Dept. of Commerce, Nat. Bureau of Standards, 1976
	Third U.S.-U.S.S.R. Colloquium on Magnetohydrodynamic Electric Power Generation Papers of U.S. and U.S.S.R. authors are presented in this volume and cover the engineering-technical aspects of MHD plant design and construction, research on the generator channel, superconducting magnet systems, and refractory materials, and diagnostic studies on working fluid characteristics. The Colloquia is a result of an Understanding of Cooperation in the field of open-cycle MHD reached between U.S. and U.S.S.R. representatives in 1972 and formalized by the U.S.-U.S.S.R. Joint Committee for Scientific and Technical Cooperation in 1973.	Moscow, U.S.S.R., Sponsored by ERDA/FE, 1976
070136	Development Status and Anticipated Environmental Hazards of Several Candidate Advanced Energy Sources This report discusses the operating principles of open and closed-cycle and liquid metal MHD systems, their efficiency and size limitations, and the history of the technology. Solid, gaseous, and particulate wastes are estimated. The report indicates that thermal discharges and fuel intake potentially are reduced when compared with conventional power plants because of the system's increased efficiency. It concludes that current emission control for MHD should be adequate to meet all standards. The report identifies organizations supporting MHD research; other advanced energy technologies are also discussed.	Lockheed Missiles and Space Co., Huntsville, AL.

CATEGORY 5: SPECIFIC PROJECT SUMMARIES

INTEGRATED ASSESSMENTS

FI Number	Title	Author or Performing Organization
	Environment and Conservation in Energy Research and Development	Council on Environmental Quality, 1976

This report is a programmatic EIS covering the environmental impacts of coal technology options. It describes the developmental stages of environmental research (characterization, effects, control technology, assessments). Characterization is the most important stage, for effects and mitigating research cannot be determined until the pollutants have been identified.

CATEGORY 6: SPECIFIC PROJECT SUMMARIES

INTEGRATED ASSESSMENTS

FI Number	Title	Author or Performing Organization
	A Reference Summary of Current MHD Test Facilities and Their Capabilities	Compiled for ERDA/MHD by Gilbert/Commonwealth, Reading, Pa., 1976

This document outlines current work on MHD at the Tennessee Space Institute, Arnold Engineering High Temperature Laboratory Development Center, Waltz Mill facility, AVCO-AERL MHD facility, Stanford University, and Fluidyne Engineering Corporation.

REGULATORY ACTIVITIES

FI Number	Title	Author or Performing Organization
093043	Environmental Assessment: Montana MHD Component Development and Integration Facility	ERDA/Gilbert Associates, Reading, Pa., 1976

This Environmental Assessment identified Butte, Montana, as the preferred Component Development and Integration Facility (CDIF) site and specified the impacts of constructing the site in accordance with the National Environmental Policy Act (NEPA) guidelines. The proposed test facility was not expected to produce significant environmental impacts.

FI Number	Title	Author or Performing Organization
093041	Magnetohydrodynamics Systems Environmental Impact Study	ERDA/MERDI, 1976

This study assessed the potential effects of a 4000-MW, coal-fired, MHD-steam power plant on several sites within the State of Montana. Existing data were used to isolate potential plant sites. Physical, biological, social, cultural, and licensability constraints were considered, and pollutant control methods were recommended. A final draft of the impact study was completed in 1976.

FI Number	Title	Author or Performing Organization
	Environmental Analysis of Proposed UTSI MHD Project - Tullahoma, Tennessee	Office of Coal Research, DOI, 1974

This study analyzes the site-specific impacts of the proposed direct coal-fired MHD test facility in Tullahoma, Tennessee. Potential environmental impacts associated with the project are analyzed. The new facility will be operating less than two percent of the time over a three-year period and will employ efficient pollution control measures. The report concludes that the project will not produce significant environmental effects.

FI Number	Title	Author or Performing Organization
	FY 76 Annual Report -- Task H	MERDI, 1977

An EIA of alternative ETF sites was initiated in FY 1977. Impact assessment methodology is being finalized, and baseline environmental data are being collected. Upon completion of the EIA, the DEIS will be prepared and presented to Federal agencies and the public for review.

ERDA Subtask M

Under subtask M, MERDI is conducting the ETF site study within Montana, evaluating social, environmental, economic, managerial, institutional, and physical constraints. They highlight that few utility transmission grids are capable of receiving the MHD power output; water availability is limited; and communities are small and rural, thus maximizing potential socioeconomic impacts.

Preliminary findings are reported in Selection of Tentative MHD-ETF Candidate Site Areas -- Second Draft Interim Report

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