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DOE/PC/90542--T2

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CLEAN COAL TECHNOLOGY III (CCT III)

10 MW DEMONSTRATION OF GAS SUSPENSION ABSORPTION

DOE Cooperative Agreement
DE-FC22-90PC90542

AirPol Job Number
RD-43

TECHNICAL PROGRESS REPORT

THIRD QUARTER, FY 1991 (4/01/91 - 6/30/91)

Cleared by Office of Patent Counsel
Chicago Operations Office
U.S. Department of Energy

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LEGAL NOTICE

EXECUTIVE SUMMARY

The 10 MW Demonstration of Gas Suspension Absorption program is designed to demonstrate the performance of the Gas Suspension Absorption System in treating the flue gas from a boiler burning high sulfur coal.

The demonstration project is divided into three major phases:

Phase I	-	Engineering and Design
Phase II	-	Procurement and Construction
Phase III	-	Operation and Testing

The project was previously on hold pending the re-definition of the overall project schedule. During the current reporting period, a revised schedule was established and approved by DOE. Phase I engineering and design work was resumed as of May 1, 1991, and following progress was made:

Task I - Project and Contract Management

Resumed discussion on Subcontract Agreement with TVA and reached preliminary agreement on general issues.

AirPol completed a cost impact study as effected by the proposed delay and concluded that the cost impact would be insignificant.

A new project schedule was made to reflect the one year delay of the plant operation date.

Task II - Process and Technology Design

Established GSA process design basis and started compiling the GSA process calculation program.

Task III - Environmental Analysis

Work on Environmental Monitoring Plan does not start pending finalization of the TVA subcontract.

Task IV - Engineering Design

Finalized general arrangement drawings and the general approach on instrumentation and control design.

ACKNOWLEDGEMENT

The planning, execution, and reporting of this project were a combined effort of many people and organizations. We wish to acknowledge the following for their outstanding effort.

U.S. Department of Energy: Sharon K. Marchant, Karen Troy

Tennessee Valley Authority: Dr. Chao Ming Huang, Thomas A. Burnett, Bruce A. Gold.

FLS miljo: Jorgen Bigum, Jorn Touborg

AirPol Inc.: Willard L. Goss, Shyam K. Nadkarni, Bindu Mistry, Stuart L. Turgel, Paul Sisler, Chuck S. Marchese.

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INTRODUCTION

The Clean Coal Technology Demonstration Program (CCT Program) is a government and industry co-funded technology development effort to demonstrate a new generation of innovative coal utilization processes in a series of full-scale, "showcase" facilities built across the country. These demonstrations will be on a scale large enough to generate all the data, from design, construction, and operation, for technical/economic evaluation and future commercialization of the process.

The goal of the program is to furnish the U.S. Energy marketplace with a number of advanced, more efficient, and environmentally responsive coal-using technologies. These technologies will reduce and/or eliminate the economic and environmental impediments that limit the full consideration of coal as a viable future energy resource.

To achieve this goal, a multiphased effort consisting of five separate solicitations is administered by the U.S. Department of Energy. Projects selected through these solicitations will demonstrate technology options with the potential to meet the needs of energy markets and respond to relevant environmental considerations.

The third solicitation (CCT-III), issued in 1989, targeted those technologies capable of achieving significant reductions in the emission of SO_2 and/or NO_x from existing facilities to minimize environmental impacts, such as transboundary and interstate pollution, and/or provide for future energy needs in an environmentally acceptable manner.

In response to the third solicitation, AirPol Inc. submitted a proposal for the design, installation and testing of the Gas Suspension Absorption system at TVA's Shawnee Test Facility. On July 25, 1990, a Cooperative Agreement was signed by AirPol for the project entitled "10 MW Demonstration of Gas Suspension Absorption". The project was approved by congress in October of 1990, and the Cooperative Agreement of the project was awarded by DOE on October 11, 1990.

This low-cost retrofit project will demonstrate the Gas Suspension Absorption which is expected to remove more than 90% of the SO_2 from coal-fired flue gas, while achieving a high utilization of reagent lime. The host site facility will be the Shawnee Test Facility (STF), located at the Tennessee Valley Authority's Shawnee Fossil Plant in West Paducah, Kentucky.

Over the past 15 years the Shawnee Test Facility has served as a testground for flue gas desulfurization (FGD) systems. At the present time a semi-dry process employing 10 MW capacity spray dryer is being tested at the facility. Upon completion of the current spray dryer test, the GSA system will be tested for a period of eleven (11) months.

The Gas Suspension Absorber was initially developed as a calciner for limestone used for cement production. It has been used successfully to clean the gases from commercial waste to energy plants in Denmark where it has also captured chloride emissions. The GSA system brings coal combustion gases into contact with a suspended mixture of solids, including sulfur-absorbing lime. After the lime absorbs the sulfur pollutants, the solids are separated from the gases in a cyclone device and recirculated back into the system where they capture additional sulfur pollutant. The cleaned flue gases are sent through a dust collector before being released into the atmosphere. The key to the system's superior economic performance with high sulfur coals is the recirculation of solids. Typically, a solid particle will pass through the system about one hundred times before leaving the system. Another advantage of the GSA system is that a single spray nozzle is used to inject fresh lime slurry.

The GSA system is expected to be the answer to the need of the U.S. industry for an effective, economic and space efficient solution to the SO_2 pollution problem.

PROJECT DESCRIPTION

This project will be the first North American demonstration of the Gas Suspension Absorption (GSA) system in its application for flue gas desulfurization. The purpose of this project is to demonstrate the high sulfur dioxide (SO_2) removal efficiency as well as the cost effectiveness of the GSA system. GSA is a novel concept for flue gas desulfurization developed by F. L. Smidth miljo (FLS miljo). The GSA system is distinguished in the European market by its low capital cost, high SO_2 removal efficiency and low operating cost.

A 10 MW GSA demonstration system shall be installed and tested at the Tennessee Valley Authority (TVA) Shawnee Fossil Plant at West Paducah, Kentucky. The new GSA system will replace the existing Spray Dryer that was installed previously as a test unit. The experience gained in designing, manufacturing and constructing the GSA equipments through executing this project will be used for future commercialization of the GSA system. Results of the operation and experimental testing will be used to further improve the GSA design and operation.

The specific technical objectives of the GSA demonstration project are to:

- o Effectively demonstrate SO_2 removal in excess of 90% using high sulfur U.S. coal.
- o Optimize recycle and design parameters to increase efficiencies of lime reagent utilization and SO_2 removal.
- o Compare removal efficiency and cost with existing Spray Dryer/Electrostatic Precipitator technology.

In order to accomplish these objectives, the demonstration project is divided into phases and tasks as shown in the Work Breakdown Structure (WBS) below:

Phase I - Engineering and Design

Task I	-	Project and Contract Management
Task II	-	Process and Technology Design
Task III	-	Environmental Analysis
Task IV	-	Engineering Design

Phase II - Procurement and Construction

Task I	-	Project and Contract Management
Task II	-	Procurement and Furnish Material
Task III	-	Construction and Commissioning

Phase III	-	Operation and Testing		
		Task I	-	Project Management
		Task II	-	Start-up and Training
		Task III	-	Experimental Testing and Reporting

According to the revised project schedule the design phase will be complete in December of 1991, the construction phase will be complete by the end of September of 1992, and the testing phase will end in September of 1993.

PROJECT STATUS

A. Task I - Project and Contract Management

Project Management - AirPol continued to provide overall project management by interfacing with DOE on all aspects of the project, and coordinating the site-related activities with TVA.

AirPol has submitted project reports as specified in the Federal Assistance Reporting Checklist as attached to the Cooperative Agreement. A computerized spread sheet has been used to track the cost and progress of the project.

Schedule Update - In a letter dated February 28, 1991 TVA informed AirPol of a one year delay in the subject project, which will postpone the projected startup of the GSA pilot plant until October 1, 1992. Per DOE request, AirPol conducted an assessment of the impacts of this delay and concluded that the said delay would only result in insignificant consequences which is, in AirPol's assessment, negligible. In AirPol's April 26, 1991 letter to DOE, the impact of the delay was summarized in the following three respects:

a. Impact on project schedule - the delayed schedule indicates an overall delay of a year as compared to the original schedule.

Tabulated below is a comparison of the existing schedule in the Cooperative Agreement and the delayed schedule based on TVA proposed delay.

Description	Original Sched.	Delayed Sched.
Phase I Tasks		
Proj./Contr. Mgt.	08/01/90-01/31/91	11/01/90-12/31/91
Process Design	08/01/90-09/01/90	11/01/90-12/31/91
Environ. Analysis	08/01/90-10/19/90	11/01/90-12/31/91
Engr. Design	08/01/90-01/31/91	11/01/90-12/31/91
Phase II Tasks		
Proj./Contr. Mgt.	02/01/91-09/30/91	01/01/92-09/30/92
Proc./Furn. Matl.	02/01/91-05/17/91	01/01/92-04/30/92
Constr./Comm.	04/05/91-09/30/91	05/01/92-09/30/92

Phase III Tasks

Project Mgt.	10/01/91-09/30/92	10/01/92-09/30/93
Start-up/Training	10/01/91-10/14/91	10/01/92-10/14/92
Testing/Reporting	10/15/91-09/30/92	10/15/92-09/30/93

b. Cost Impacts - In response to the delay of this project, AirPol has taken steps to reassign personnel that were originally assigned to this project onto other projects. By virtue of the flexibility in manpower allocation, no idle hours have resulted from the delay. It is concluded that the delay will not result in any increase of manhour expenditures.

Based on AirPol's record of material purchased during the past year, we see a clear trend of decline in price. This decline in price is attributable to the general recession in the country as well as the low activity level experienced by the air pollution industry in general. It is expected that this condition will prevail in the immediate future and that the cost impact to the subject project due to material price increase will be minimal.

A review of the construction cost estimate indicates that the delay will result in a cost increase of 2% of AirPol's original estimate. It is expected that this increase will be offset by the savings accrued from the more economical design of the support structure and the access system which will reduce the erection cost.

c. Impact to Commercialization - It is AirPol's assessment that this one year delay will not result in any significant impact to AirPol's commercialization of the GSA technology.

The above conclusion was arrived based on the fact that AirPol's commercialization effort is already in progress and will not be affected by the change of testing schedule; and that the one year delay will not upset the timing for securing the market generated by the Clean Air Act.

In summary, AirPol concludes that the impact on this project due to the proposed delay is insignificant, and the project can be successfully completed and the GSA technology successfully commercialized.

In accordance with the proposed schedule, all active work on this project was to be resumed as of May 1, 1991.

In a letter to AirPol dated June 6, 1991, DOE indicated their acceptance to the revised one year extended schedule, and required that two conditions be met:

a. A written concurrence from TVA that the subcontract would be consummated with TVA no later than October 31,1991.

b. TVA to confirm with EPA concurrence that the Clean Coal Technology (CCT) project would not be further delayed.

TVA Subcontract - In a letter to AirPol dated June 25, 1991, TVA reasserted their commitment to the completion of the demonstration project, and confirmed that the subject project would not be delayed further.

On June 27, 1991 Will Goss, AirPol President, met with TVA Manager of Generation Projects, Dr. Chao Ming Huang and discussed following issues related to the Subcontract Agreement:

a. TVA's plan for meeting the time table for Subcontract Agreement prescribed by DOE.
b. Cost negotiation.
c. Defining battery limits.

Pursuant to the meeting, TVA Contract Department commenced the preparation of the Draft Subcontract Agreement.

B. Task II - Process and Technology Design

Basis for process design - The initial effort was made to ascertain the information obtained from TVA is consistent. Based on the coal analysis, boiler combustion conditions, and flue gas composition information provided by TVA, AirPol Process Department conducted the combustion calculation and reached the process design basis for the GSA installation. The data input from TVA and the result of AirPol calculation is contained in Attachment 1.

C. Task III - Environmental Analysis

It was determined that the work related to Environmental Monitoring Plan would best be performed by TVA. However, the work cannot be started until a TVA subcontract is in place.

D. Task IV - Engineering Design

General arrangement - Preliminary general arrangement drawings were completed and sent to TVA and FLS miljo for comments.

Three cost saving features were incorporated in the arrangement:

a. Utilizing the existing stair tower serving the existing spray dryer for access to the GSA tower.
b. In lieu of enclosing the entire GSA facility, enclose only the area frequented by

service personnel, that is, the feeder box areas, and the injection lance area.

c. Build the support structure to support the cyclone and cantilever the reactor vessel on the side.

The above improvements not only allow the GSA to fit into the tight space at the TVA plant site, but also proves to be an efficient design for future retrofit installations.

Instrumentation and Control - It was determined by AirPol that the type of control presently used by FLS miljo on their existing installations is not suitable for this project or future commercialization due to following reasons:

a. The control has been designed for incinerator application which requires more complicated calculation process for both Hcl and SO_2 removal as compared to a boiler application for SO_2 removal only.

b. The control was designed with customized features not deemed competitive for the U.S. market.

AirPol's general concept for building the GSA control for the subject project and for future commercialization has been finalized as follows:

a. There are three basic control loops:

- Slurry feed rate to be controlled by SO_2 loading.
- Water injection rate to be controlled by cyclone outlet temperature.
- Lime reinjection rate to be controlled by gas flow entering the reactor.

As these three control loops will function independently in controlling the GSA operation, three separate controls will be used in lieu of a Programmable Logic Control (PLC).

b. The control for slurry injection rate will be a "Feed Backward System" (as compared to a "Feed forward and Feed backward System" currently used by FLS miljo), in which the lime injection rate is adjusted in accordance with the outlet SO_2 content. However, during the testing period, when tests will be run at various Stoichiometric Ratio, the slurry injection rate will be manually set according to calculated values. The consideration of a "Feed backward System" versus a "Feed Forward System" is favored by the fact that outlet SO_2 monitor is usually already present on existing plants and the expenditure of installing additional SO_2 monitoring system can be saved.

c. Due to the fact that all operating parameters during a given test must be held constant, the control of slurry rate and lime re-injection rate will be manual during the test period. However, all controls will be set in automatic mode during the demonstration run.

A Process and Instrumentation Diagram based on the above concept has been prepared and is shown in Attachment 2. The P&ID Drawing was released to FLS miljo for their comment.

Equipment Design - Detailed design of GSA reactor and cyclone is being prepared using basic dimension information provided by FLS miljo. the final design of these equipment will represent a combination of dimension design based on FLS miljo operating experience and structural design based on site condition and U.S. design codes.

Effort has been made in identifying qualified vendor for the manufacturing of recycle lime feeder box.

Due to the experience factor involved in the manufacturing of the injection lance, it has been decided that the injection lance for the subject project will be purchased from FLS miljo.

PLAN FOR NEXT QUARTER

A. Task I - Project and Contract Management

Project Management - Continue monitoring project cost and produce reports according to the Federal Assistance Reporting Checklist.

Continue monitoring the progress of the project and update the project schedule accordingly.

Finalize Subcontract Agreement with TVA and Technology Transfer Agreement with FLS miljo.

B. Task II - Process and Technology Design

Process Engineering Design - AirPol Process Department to start compiling the GSA process calculation program and conduct process calculation for the subject project.

C. Task III - Environmental Analysis

Environmental Monitoring Plan - An Environmental Monitoring Plan (EMP) will be prepared to describe the collection and dissemination of significant technology, project, and site-specific environmental data.

D. Task IV - Engineering Design

General Arrangement - AirPol Engineering Department will finalize general arrangement drawings by incorporating comments from TVA and FLS miljo.

Equipment Design - Complete and check fabrication drawings for GSA reactor and cyclone.

Instrumentation and Control - Finalize P&ID drawing by incorporating FLS miljo comments.

Design of Auxiliary Equipment - Start layout design of the support structure, platform and stairs and ductwork.

Attachment 1

GSA Process Design Basis

D.O.E.-Clean Coal Technology III
10 MW Demonstration of GSA-rev 1

JOB #: RD 43
Date: 28-May-91
Rev: 27-Jun-91

Mass distribution of flue gas to GSA - High sulfur coal

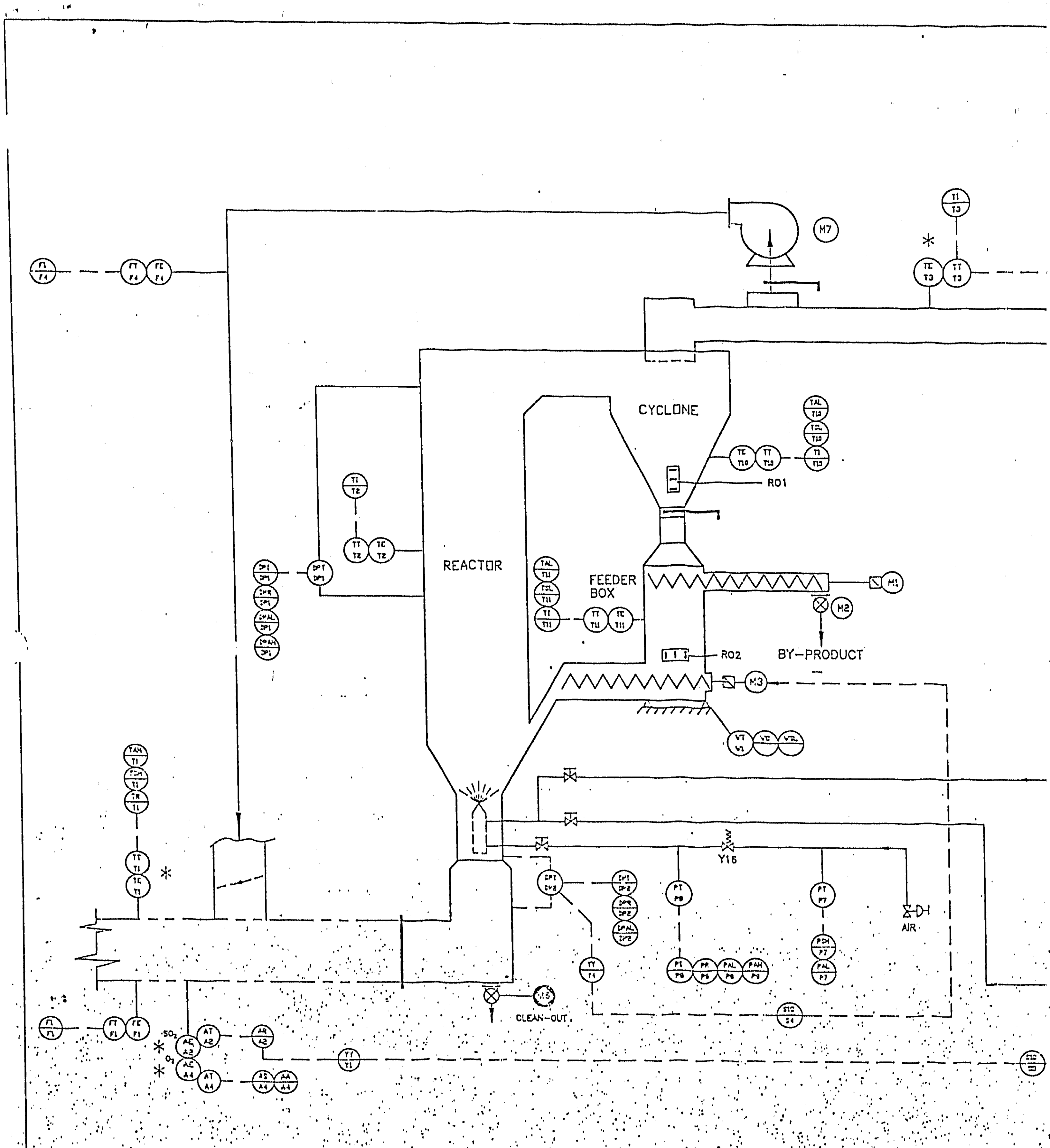
Temp	320	Deg F	
Press	13.865	Psia	-18 in wg
Flow to GSA	35300	acfm	
SCFM	21001.180		
DSCFM	19392.959		
Total flow from boiler	653958.350	acfm	
Reduction ratio	0.054		

Comp	m wt	lb/h	mol/h	vol % w	ACFM
O2	31.999	7396.273	-462.282	6.586	2325.002
CO2	44.010	16922.860	384.523	10.957	3867.846
N2	28.013	73238.997	2.728	74.500	26298.413
H2O	18.015	4841.326	268.739	7.658	2703.192
SO2	64.063	562.441	8.780	0.250	88.311
HCl	36.461	1.481	0.041	0.001	0.408
SO3	80.063	7.100	0.089	0.003	0.892
NOx	30.006	47.536	1.584	0.045	15.935
Air-O2	28.967		693.422		
N2			2611.736		
Partic.		651.916			
Total		103669.930	3509.360	100.000	35300.000

Dust 3.922 gr/DSCF

Attachment 2

Process and Instrumentation Diagram



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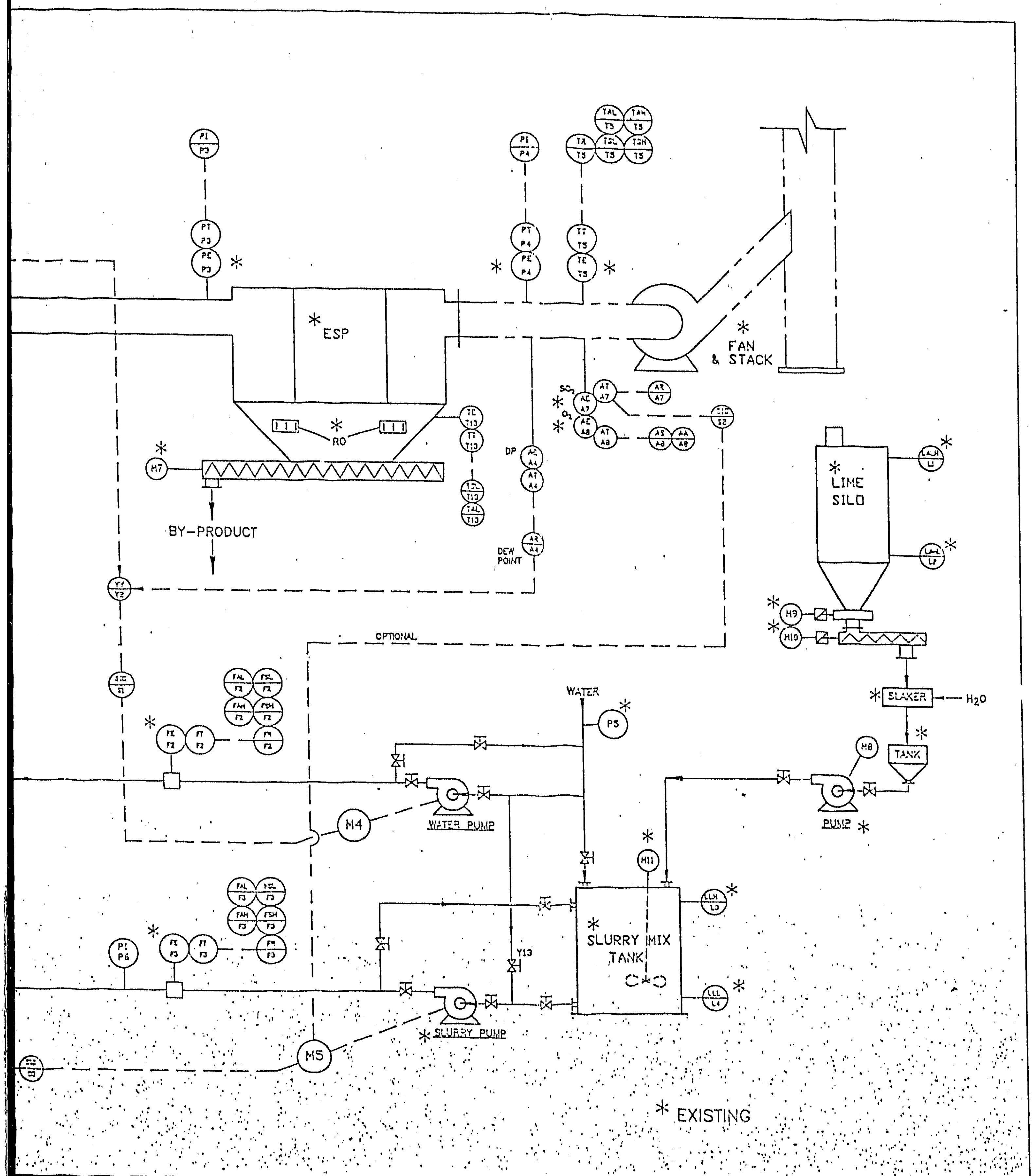

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DOE/TVA

10 MW DEMONSTRATION OF CSA

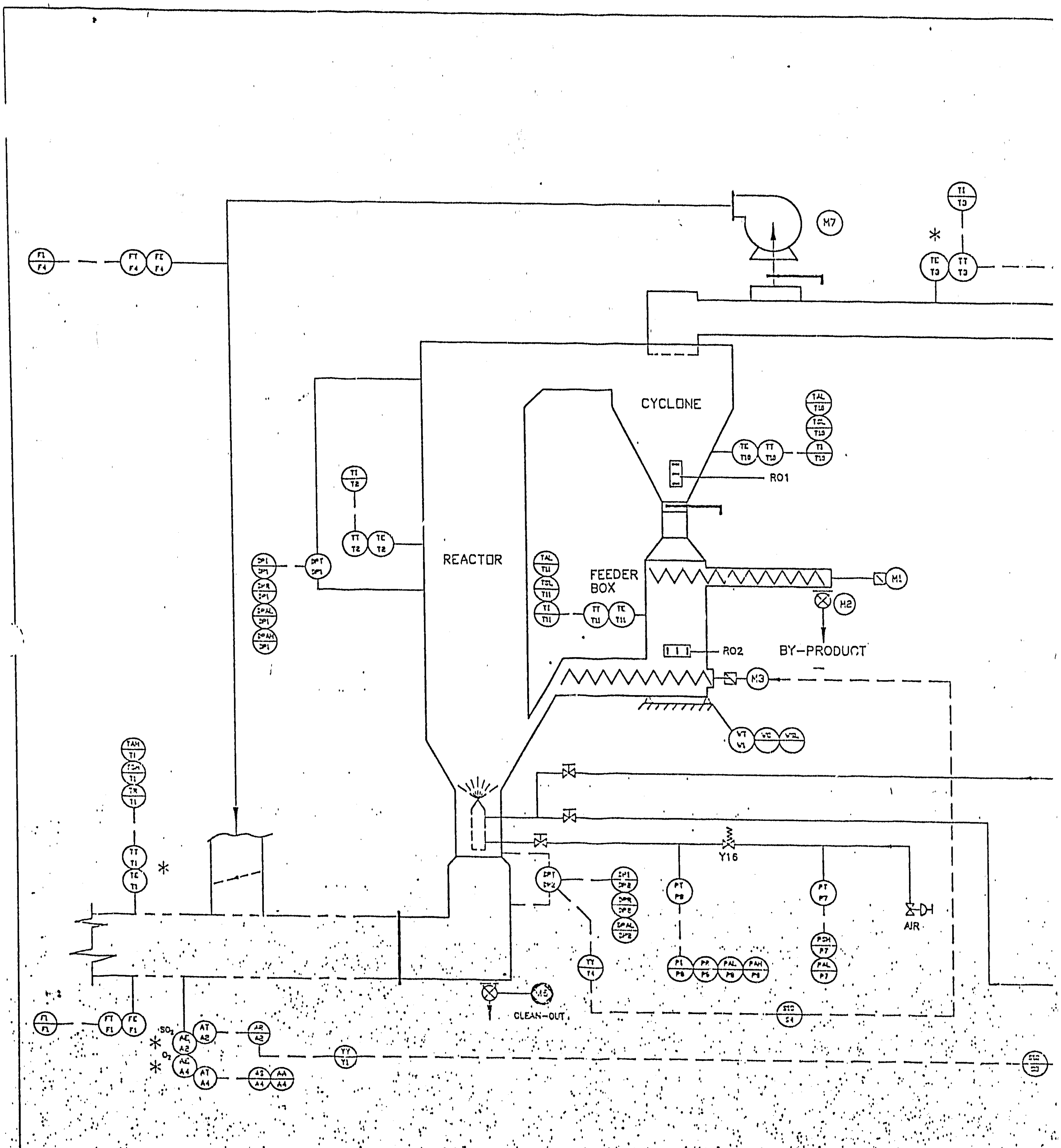
MG2196-2

SCALE NONE | DATE 3/22/91
DRAWN BY CT

AirPol Inc.

TITLE: PROCESS & INSTRUMENTATION DIAGRAM FOR GSA SYSTEM

RD-43 | D1-1 | REV NO. P



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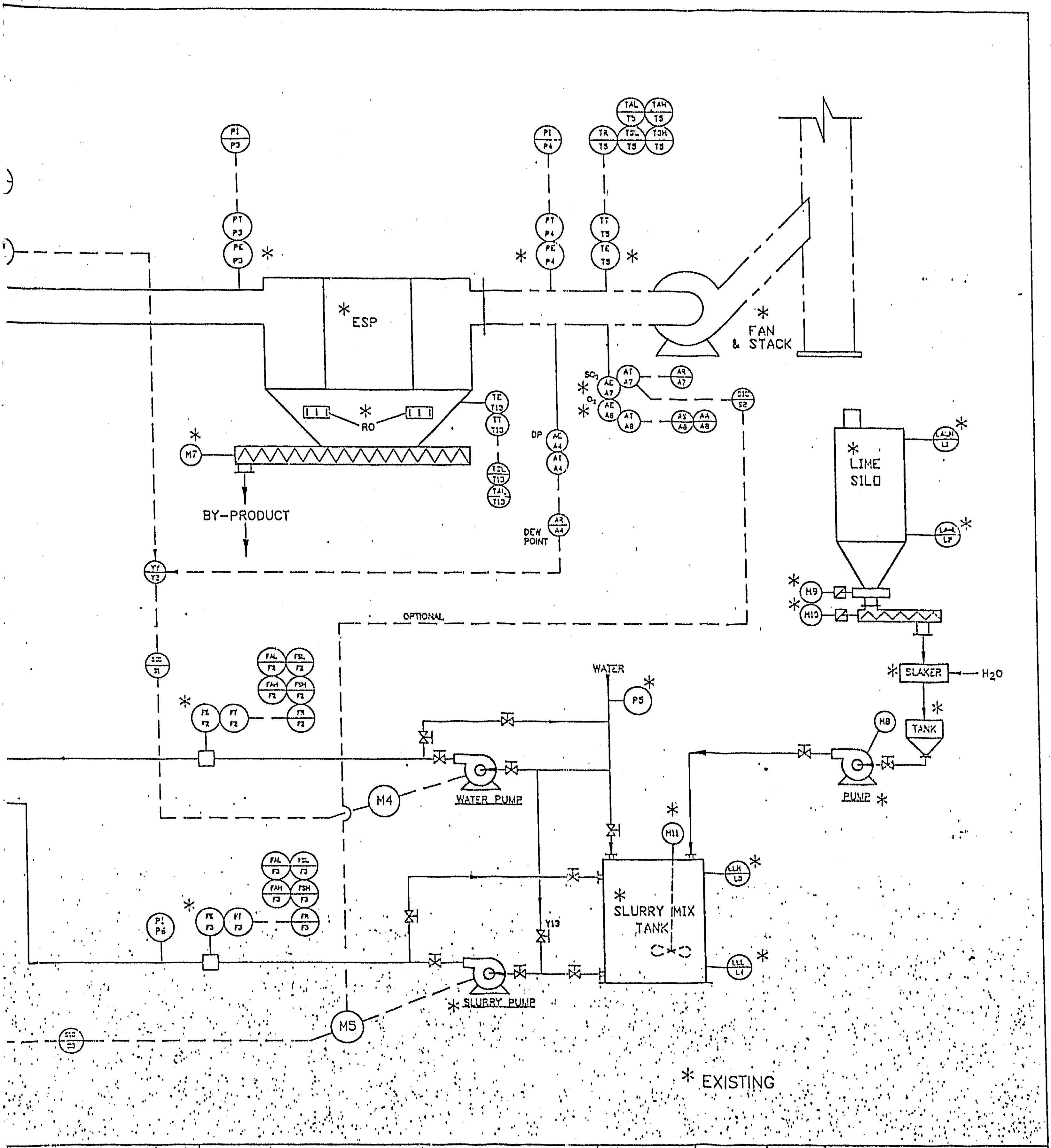

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DOE/TVA

10 MW DEMONSTRATION OF GSA

SCALE: NONE

DRAWN BY: CT

DATE: 3/22/91

AirPol Inc.

Air Pollution and Energy Recovery Systems

TITLE: PROCESS & INSTRUMENTATION DIAGRAM FOR GSA SYSTEM

MG2196-2

RD-43

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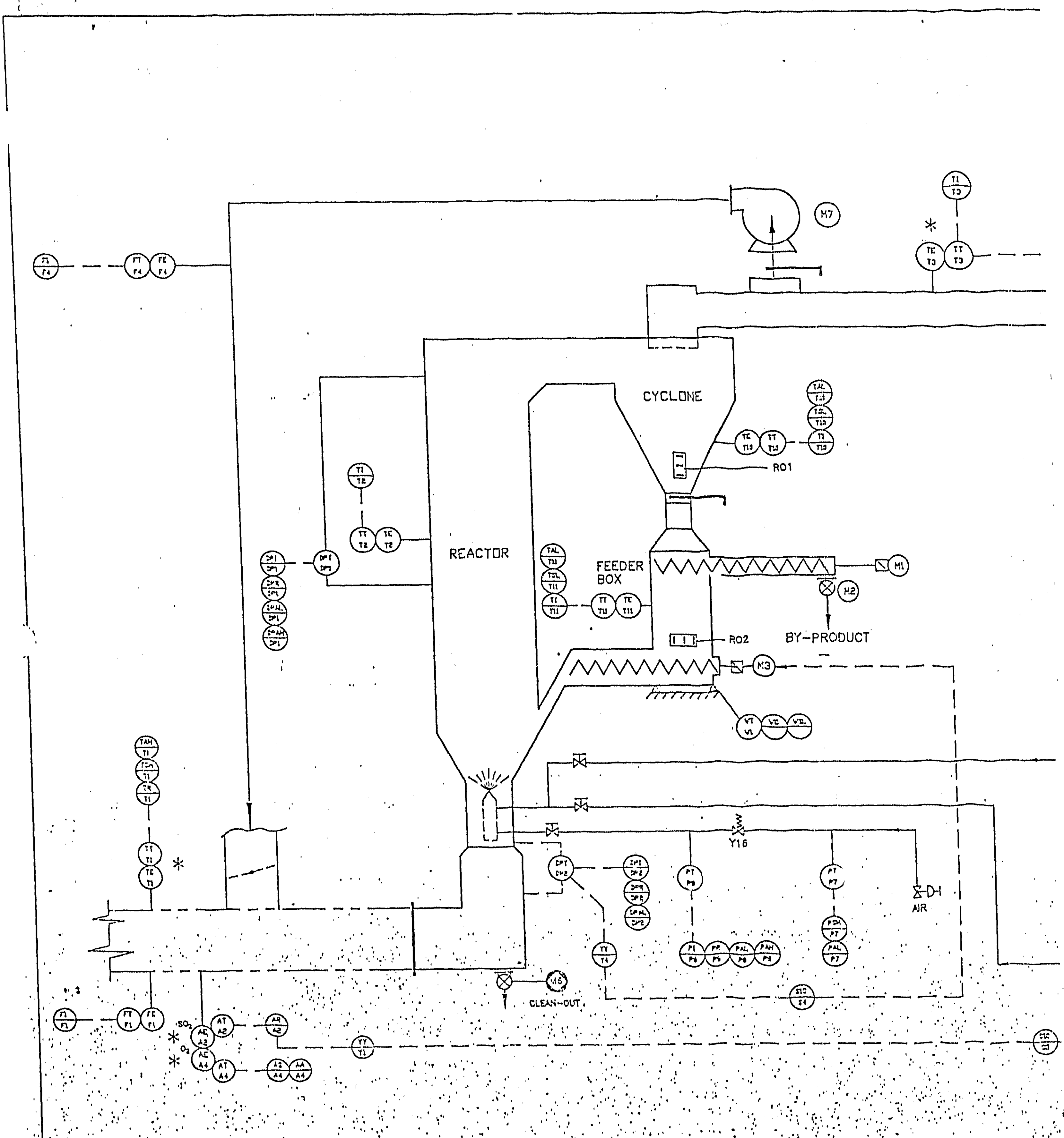
REV. NO. P



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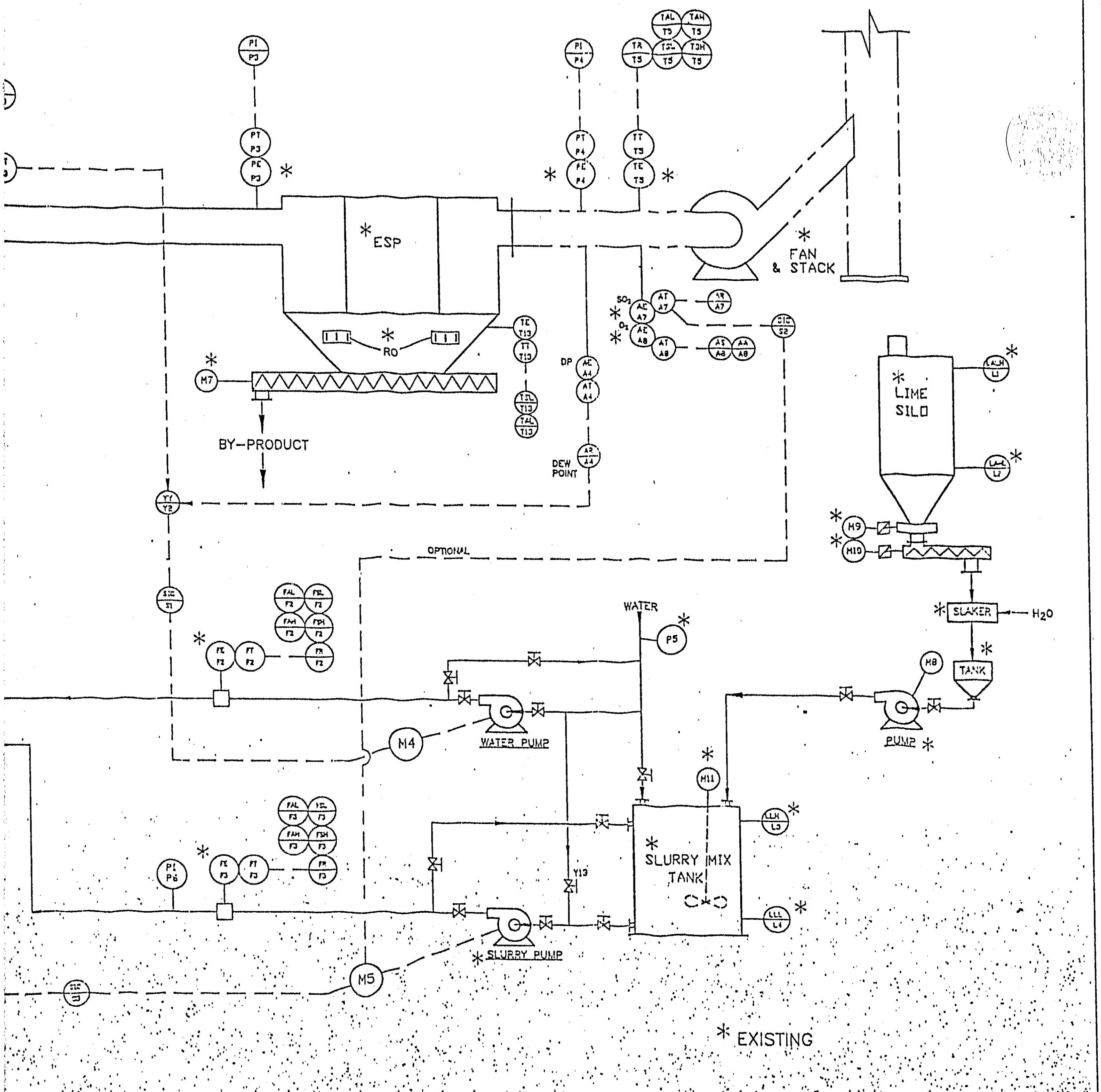

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DOE/TVA

10 MW DEMONSTRATION OF GSA

SCALE: NONE — DRAWN BY: CT — DATE: 3/22/91

AirPol Inc.

TITLE: PROCESS & INSTRUMENTATION DIAGRAM FOR GSA SYSTEM

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