**TECHNICAL SUPPORT PLAN
FOR TASK IX**

**INDUSTRIAL LOW-Btu FUEL GAS
DEMONSTRATION-PLANT PROGRAM**

MASTER

Submitted by

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MEMPHIS INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROJECT

TECHNICAL SUPPORT PLAN OF TASK IX
(Deliverable #45)

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INTRODUCTION

One area of the Industrial Fuel Gas Demonstration-Plant Program requiring major technical support is the design of the gasifier section of the demonstration plant. Under Task IX - Technical Support, the Institute of Gas Technology (IGT) has the primary responsibility for providing the necessary technical support. Efforts under this task are divided into the following areas:

1. Design Data for Demonstration-Plant Coal
2. Ash-Agglomerating Gasifier (AAG) Pilot-Plant Operations
3. Scale-Up Studies for Gasifier Mechanical Configuration
4. Gasifier System Modeling
5. Distribution and Utilization Characteristics of Fuel Gas Output

TECHNICAL SUPPORT PLAN FOR TASK IX

Plans for achieving the objectives of each of the above areas are outlined below.

1. Design Data for Demonstration Plant Coal

The exact type of coal to be used in the demonstration plant will not be known until the end of Phase I when the agreement for the purchase of coal is finalized. Therefore, for immediate pilot-plant test operations, a coal (Western Kentucky No. 9) that is similar to the expected candidate coal and that meets the contract specifications has been selected. Analysis of this coal is shown in Table 1. The AAG pilot plant will be operated on this coal

Table 1. COAL FOR AAG PILOT-PLANT TESTS

(Type — Western Kentucky No. 9;
Quantity Bought — 1000 Tons)

Proximate Analysis (as received), wt%

Moisture	7.2
Volatile Matter	34.4
Fixed Carbon	42.8
Ash	<u>15.6</u>
TOTAL	100.0

Ultimate Analysis, wt%

C	66.5
H	4.72
O	5.93
N	1.36
S	4.65
Ash	<u>16.84</u>
TOTAL	100.0

Higher Heating Value, Btu/lb	12,109
Free-Swelling Index	5-1/2 to 6-1/2

at atmospheric pressure for two months. Based on these test results, results from past experience with other coal feeds, and a computerized gasifier model, a process design for the demonstration plant will be estimated.

After modifications, the AAG pilot plant will be operated at pressure on the same coal. Based on results obtained from these latter tests, the estimated gasifier process design will be confirmed for the demonstration-plant process and mechanical design package. Additional tests may be

necessary if the final candidate coal selected for purchase has different characteristics than the coal tested in the AAG pilot plant.

2. AAG Pilot-Plant Operations

Regular Plan

The AAG pilot plant as outlined in a previous report (Plan for Interfacing Schedule and Test Work for Pilot Plant, January 1978) is available for use under this program for a period of six months.

During the six-month period, the AAG will be operated on the Western Kentucky coal specified above. One thousand tons of coal crushed to below 1/2 inch has been purchased from Island Creek Coal Company and delivered to IGT. The schedule for operation of the AAG pilot plant is shown in Figure 1.

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Figure 1. SCHEDULE FOR ASH-AGGLOMERATING GASIFIER PILOT-PLANT OPERATION

During the first two months of the program, tests will be run on Western Kentucky coal at atmospheric pressure. In general, these tests will confirm high carbon gasification efficiency, dust recycle, and predicted product gas composition with a coal similar to that to be used in the demonstration plant. Further, smooth and steady-state operation will form one base-point for later scale-up of the pilot-plant results to the pressure level of the demonstration plant. These tests will also establish the feasibility of feeding the caking Kentucky coal to the gasifier without pretreatment.

Engineering and equipment ordering for modifying the AAG for operation at about 3 atmospheres have been started during the first month. Some long-lead items have a delivery period of about three months. However, after the first two months of operation, the pilot plant will be shut down, and actual modification and additions to the unit will begin. The major anticipated modifications to the unit will be in the coal feed system, liquid oxygen vaporization unit, lockhopper valves, internal cyclone, and control valves. A new raw product wet gas scrubber is planned to be added to remove coal dust and impurities from the gas before it is incinerated. It is estimated that it will take about two months before the unit is pressure-tested and ready for operation.

Next, the pilot plant will be operated with the Kentucky coal at pressure for about two months. These tests will confirm the process design variables used in the demonstration plant design. In addition steady-state operation of the gasifier will establish the predicted product gas composition, heat, and material balance around the system and firm up the oxygen and steam requirement for gasification. Pressurized operation will indicate the effects of pressure on high carbon conversion, dust recycle, and further pressure scale-up to the level of the demonstration-plant operating pressure.

During the pilot-plant operations, procedures for start-up and shut-down (both scheduled and emergency) will be established. In addition, the gasifier turndown capability and its effects on the product gas quality will be investigated. Information bearing on the design of other sections of the plant such as gas cooling, purification, and waste-water treatment will be generated. Equipment reliability testing and identification of critical components will also be carried on during pilot-plant operation in cooperation with other Department of Energy (DOE) programs.

The above planned schedule for the operation of the AAG pilot plant will provide all process design information for the demonstration-plant design within the overall schedule for completion of Phase I by May 1979.

Contingency Plan

As originally proposed, the U-GAS[®] gasification system included a pretreatment step that destroyed the caking tendency of Western Kentucky coal, thereby feeding a pretreated char to the fluidized-bed of the gasifier. However, the AAG pilot-plant operation plan discussed above is based on feeding the Western Kentucky coal directly into the fluidized-bed of the gasifier.

This mode of operation is recommended based on recent success at the pilot plant in feeding Illinois No. 6 coal into the bed without any caking problems. Although the Illinois No. 6 coal used in the tests has a Free Swelling Index (FSI) of 3-1/2 to 4-1/2 as compared to the Western Kentucky coal's FSI of 5-1/2 to 6-1/2, there is every indication that it should be possible to feed the Western Kentucky coal directly into the gasifier. However, if caking problems are encountered, a contingency plan and schedule for including a pretreatment step in the gasification system have been developed. The contingency plan schedule is shown in Figure 2.

CONTINGENCY PLAN	1978												1979				
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M
1. OPERATION WITH PRETREATED COAL*																	
2. UNIT MODIFICATIONS FOR PRESSURE OPERATIONS																	
3. PRESSURE OPERATION WITH PRETREATED COAL*																	
4. ENGINEERING FOR INTEGRATED PRETREATER																	
5. EQUIPMENT PROCUREMENT FOR INTEGRATED PRETREATER																	
6. INSTALLATION OF INTEGRATED PRETREATER																	
7. OPERATION WITH INTEGRATED PRETREATER																	

*COAL TO BE PRETREATED USING THE HYGAS® PILOT-PLANT PRETREATMENT REACTOR.

Figure 2. CONTINGENCY PLAN SCHEDULE FOR THE ASH-AGGLOMERATING GASIFIER FOR PILOT-PLANT OPERATION

According to this plan, the HYGAS® pilot-plant pretreatment reactor will be used to prepare pretreated coal for tests in the AAG pilot plant. The schedule for both atmospheric-pressure and pressurized operation will be the same as that for the regular plan except that the contingency plan schedule will be extended by one month. Therefore, the basic process design data for the demonstration-plant design will still be available without affecting the overall program schedule but will be obtained from two separate sources — the HYGAS pretreatment reactor and the AAG pilot plant.

Integrated operation of a pretreater-gasifier with the pretreater effluent mixing with the product gases will still remain to be demonstrated, however. Operation of two interconnected fluidized-beds at about the same pressure is a common practice in the petroleum industry and would provide a basis for the mechanical design of the pretreater-gasifier. The main goal of demonstrating integrated operation is to ascertain the fate of the gases and tars generated during pretreatment as they pass through the gasifier. The objective is to introduce the effluent in such a manner as to destroy the tar and oils and utilize a simplified design for product-gas cooling and quenching.

During the December monthly meeting, DOE has selected, from the options available to demonstrate integrated gasification systems, the one that requires adding a pretreatment reactor to be integrated with the existing pilot-plant gasifier. As shown in Figure 2, engineering has begun on this task, and preliminary results indicate that this is a viable option. Engineering, procurement, and installation (which starts after completion of the tests at pressure) are estimated to last about 10 months; integrated operation will be demonstrated by the end of the year. Operation of an existing 10-inch-diameter pretreater is also planned during the ten-month period to reinforce the pretreatment design data obtained from the HYGAS pretreater operation and to fully characterize gases and liquids expected to be present in the pretreater effluent.

3. Scale-Up Studies for Gasifier Mechanical Configuration

The mechanical design of the bottom grid section of the gasifier requires careful consideration of diameter and pressure when scaling-up. In addition, the gasifier must be designed to introduce coal, steam, and oxygen into a fluidized-bed environment in such a fashion as to produce a fuel gas of satisfactory HHV and at the same time form agglomerates or highly ashed materials that can be discharged via the unique mechanism embodied in the venturi discharge nozzles. Satisfactory fluidization of the coal in the gasifier must be maintained at all times. Sufficient turbulence and mixing in the bed must be established so that each one of several discharge nozzles will operate efficiently. The introduction of additional fluidizing gas at points on the grid other than through the discharge nozzles must be arranged to avoid the accumulation of material on the grid surface that may be conducive to clinker formation.

So that a satisfactory arrangement from the point of view of the several necessary conditions and others may be employed in the demonstration-plant gasifier, a cold model is proposed here to test and verify that the several conditions shall be met.

It is proposed, then, to construct a mock-up of the demonstration-plant gasifier with dimensions as large as practical and as similar in shape and method of operation as possible. The use of the term "cold" in "cold model" is to imply the absence of deliberate heating of solids or gases to approximate the temperature in the commercial gasifier, but the actual temperature of operation is to be governed by the particular circumstances pertaining to a detailed design.

Specifically, it is proposed to investigate the following features of the gasifier system of the type proposed for the demonstration plant:

- Quantitative discharge rates of agglomerate or high-ash materials at conditions approximating those anticipated in the demonstration plant.
- The arrangement design of multiple-venturi grids and the resultant behavior of systems fluidized by such grids over a range of gas and solids characteristics (such as particle size and density and gas velocities and pressure) appropriate to the demonstration-plant concept. The above behavior should include the uniformity of discharge between multiple discharge ports and the absence of "dead zones" of bed particles or agglomerates at any critical point of the system.

Such modifications and testing as dictated by the work in progress or any other source of information that promises to improve the final design or operation will be carried out as required.

The apparatus proposed for the work will be constructed at the IGT pilot-plant facility in Chicago. The apparatus will have means for introducing a solid feed to a vessel capable of withstanding internal pressures up to 90 psia. There will be means to introduce the fluidizing gases at these pressures. The apparatus will be constructed so as to provide ready access to, and modification of, the grid area.

Instrumentation will be provided to enable the measurement of gas velocities at several places, pressure differences within the apparatus that are related to fluidized-bed densities, and any other information required to accurately determine the condition of the system. Instrumentation of an unusual type will be employed to measure solids movement and bubble sizes within the bed.

Direct visual measurements and observation will be provided for. The system will also have such additional instrumentation and control apparatus or peripheral equipment as required for safe operation.

4. Gasifier System Modeling

A comprehensive kinetic and mathematical model is available to predict the expected product gas composition, oxygen and steam requirements, and the size of the gasifier with a given coal feed to the gasifier. This model is based upon several hundred laboratory determinations and numerous bench-scale tests. The model confirms the operating experience to date in the AAG pilot plant and will be continually updated as test results from that facility become available.

The above steady-state model will be used to generate an overall gasifier system model to —

- Predict the effects of transients and perturbations in operating variables upon steady-state operations
- Assess plant behavior during start-up, shutdown, and turndown
- Help in the preparation of operating procedures for the demonstration plant
- Anticipate plant behavior on alternate coal feedstocks.

5. Distribution and Utilization Characteristics of Fuel Gas Output

A major objective under this task is to determine which Memphis Light, Gas and Water Division (MLGW) customers can satisfactorily utilize the product gas from the demonstration plant. The following procedure is proposed for gathering and analyzing data on the technical feasibility of using the product gas by MLGW customers.

The initial step will be to identify potential customers based on current natural gas service data. A preliminary list of customers has been prepared based on proximity to the gasifier site and initial inquiries. This list will serve as a basis for an initial screening of customer usage, technical feasibility, and overall serviceability. This list may be expanded to include industries in the northern sections of the Memphis distribution area.

Identification of the specific types of gas-using equipment employed by each MLGW customer can best be done with a combination of questionnaires and personal company contact. The questionnaire will alert customers as to the type of information required and provide them time to gather together such information when necessary. A follow-up contact will ensure that the information is received in a timely manner. The questionnaire essentially will request information on the types of processes in use, the number of each process in use, the type of fuels that can be used, and the type and quantity of product produced by each process. The questionnaire will be sent out together with a letter explaining its purpose and a request for the necessary information. This will be done at least one week prior to a personal interview with each company.

Responses to the questionnaire and interviews will be reviewed as they become available. The review will consist of three functions: First, it will help determine whether the information is sufficiently complete or if additional follow-up is needed; secondly, it will be used to compile a list of the energy-using processes in use by the respondents; and lastly, based on the customers' seasonal energy-use profiles, seasonal "system load-profiles" will be developed.

Based on the information developed, it will be possible to estimate the types of customers that may not be able to use the product gas from the demonstration plant. In addition, combustion systems and burner types for which data are not available for utilization of fuel gas output without significant efficiency loss will be identified. The plan, schedule, and cost to obtain the required experimental data will be prepared and submitted for approval.

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