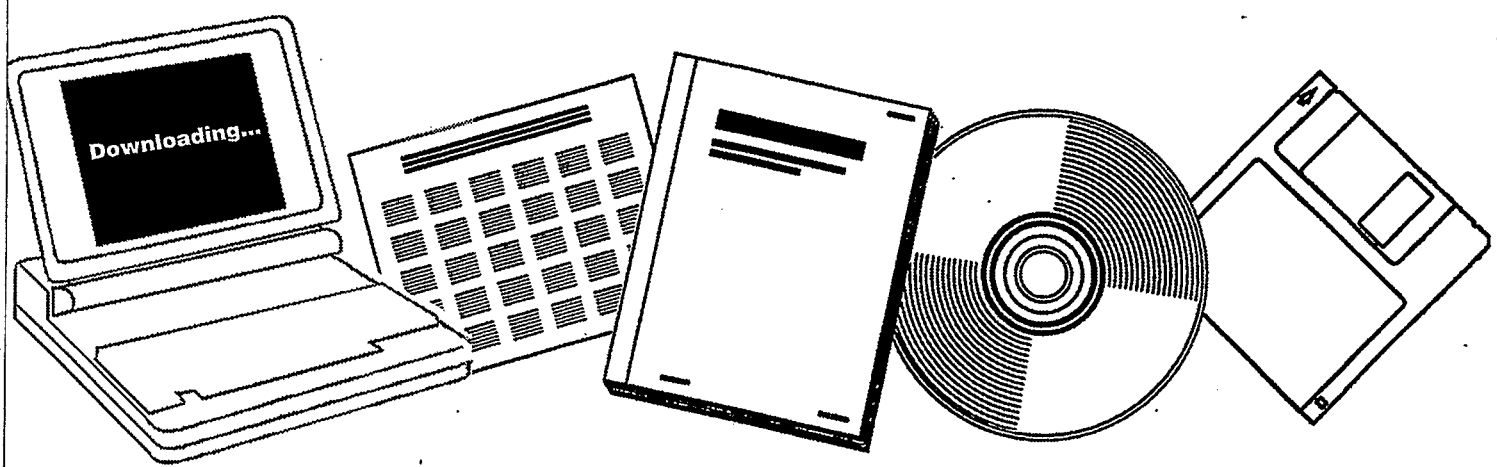
DEVELOPMENT OF IGT HYDROGASIFICATION PROCESS. MONTHLY PROGRESS REPORTS, JANUARY--DECEMBER 1968

INSTITUTE OF GAS TECHNOLOGY, CHICAGO, ILL

1968



One Source. One Search. One Solution.

NTIS

Providing Permanent, Easy Access to U.S. Government Information

National Technical Information Service is the nation's largest repository and disseminator of government-initiated scientific, technical, engineering, and related business information. The NTIS collection includes almost 3,000,000 information products in a variety of formats: electronic download, online access, CD-ROM, magnetic tape, diskette, multimedia, microfiche and paper.

Search the NTIS Database from 1990 forward

NTIS has upgraded its bibliographic database system and has made all entries since 1990 searchable on **www.ntis.gov.** You now have access to information on more than 600,000 government research information products from this web site.

Link to Full Text Documents at Government Web Sites

Because many Government agencies have their most recent reports available on their own web site, we have added links directly to these reports. When available, you will see a link on the right side of the bibliographic screen.

Download Publications (1997 - Present)

NTIS can now provides the full text of reports as downloadable PDF files. This means that when an agency stops maintaining a report on the web, NTIS will offer a downloadable version. There is a nominal fee for each download for most publications.

For more information visit our website:

www.ntis.gov

U.S. DEPARTMENT OF COMMERCE
Technology Administration
National Technical Information Service
Springfield, VA 22161

FE--381-T-5

DEVELOPMENT OF IGT HYDROGASIFICATION PROCESS

Monthly Progress Reports for the
Period January - December 1968

Institute of Gas Technology
IIT Center
Chicago, Illinois 60616

Prepared for

Office of Coal Research
U. S. Department of the Interior

OCR Contract No. 14-01-0001-381*

*This contract evolved into OCR Contract No. 14-32-0001-1221 in 1972

FE--381-T-5

CONTENTS

IGT-MPR--1/68

DEVELOPMENT OF IGT HYDROGASIFICATION PROCESS

Progress Report – January 1968
to
Office of Coal Research
Contract No. 14-01-0001-381(1)

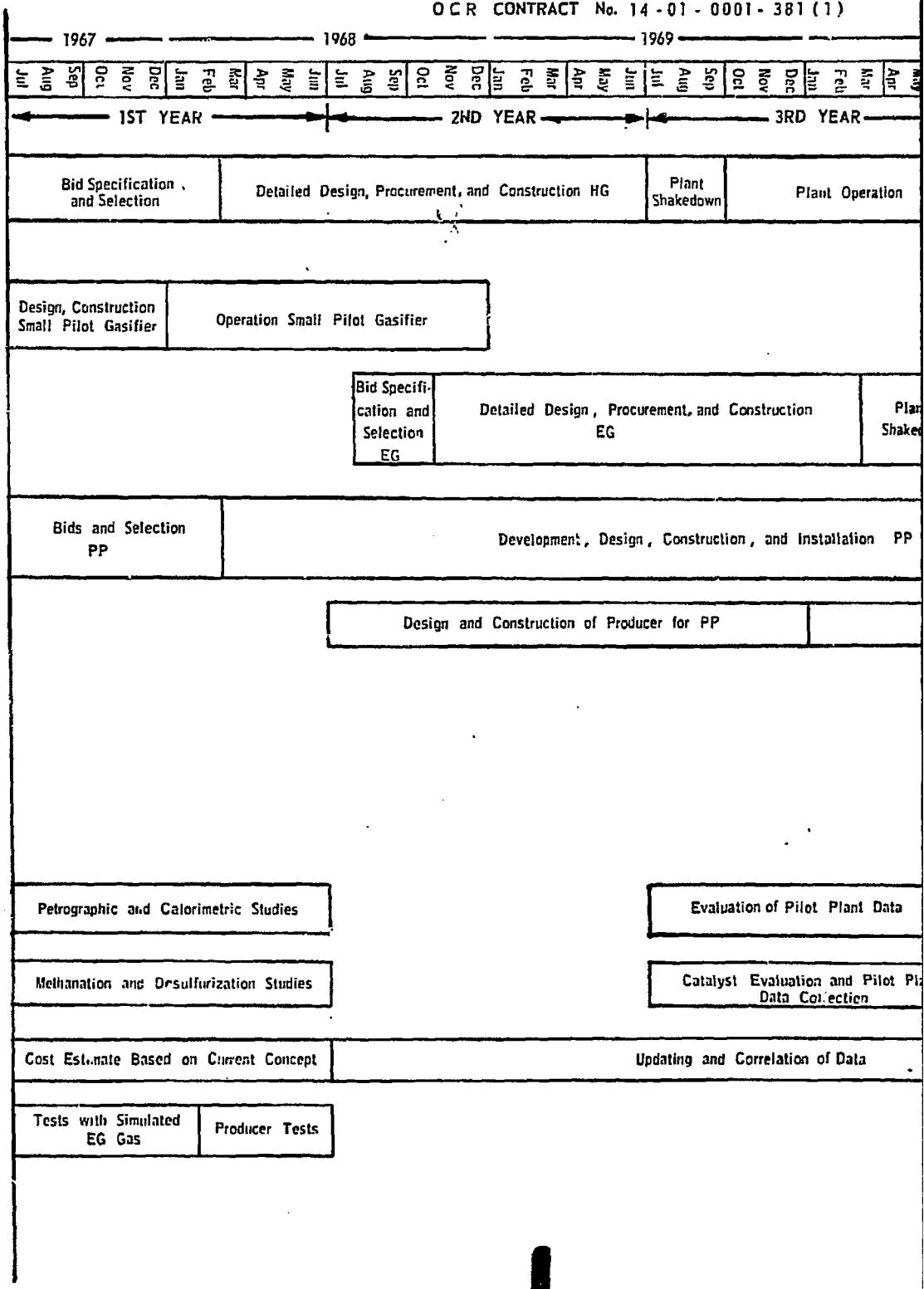
Hydrogasification

We conducted one hydrogasification test this month in the balanced-pressure pilot unit (Run HT-193). A lightly pretreated Pittsburgh seam bituminous coal from the Ireland mine was hydrogasified in a fluidized bed with a mixture of synthesis gas and steam. This test was an extension of earlier studies of the hydrogasification behavior of bituminous coals with synthesis gas instead of hydrogen. The objective of this test was to increase carbon conversion to methane over that obtained in the earlier tests. To get this increased conversion, we added the coal in a 7-ft bed instead of a 3.5-ft bed for increased coal residence. To reduce heat losses and to allow for higher average coal bed temperatures, we adjusted the bottom of the coal bed to 62 inches above the furnace bottom, in contrast to that of an earlier 7-ft bed test with synthesis gas (Run HT-168B) in which the bottom of the bed was only 31 inches above the furnace bottom. Run HT-193 lasted 4 hours, and was terminated after 2 hours of steady-state operation when the feed gas supply was used up. Preliminary results indicate an improvement in carbon conversion compared to Run HT-168B. Total carbon gasification increased from 20.8 to 28.4%, while the hydrocarbon yield per pound of coal increased from 3.67 to 4.08 SCF. Some of this increase was due to a somewhat higher hydrogen-to-coal ratio of Run HT-193.

Coal feed for Run HT-193 was prepared by pretreatment with air in the pilot plant fluidized-bed coal pretreater at the standard pretreatment conditions (Run FP-127). Synthesis gas, as for earlier tests, was premixed and stored at pressure.

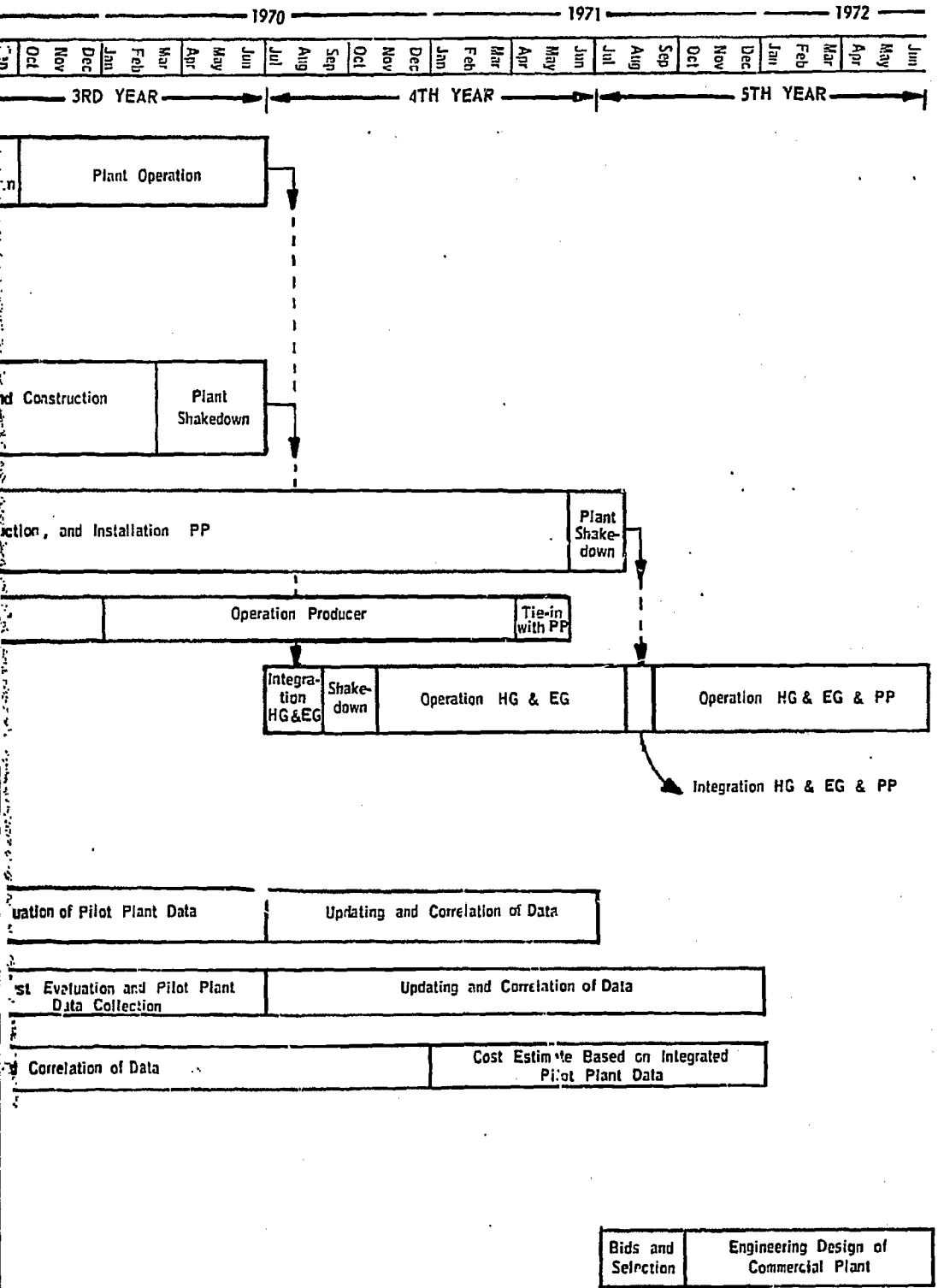
PILOT PLANT PROGRAM OF IGT HYDRO

OCR CONTRACT No. 14-01-0001-381(1)



OF IGT HYDROGASIFICATION PROCESS

0001-381(1) AGA: IU-4-1



2

D-1071369

Methanation

Upon measuring the methanation rate in the range of 5-20 atm, we found that the rate increases with increasing pressure. The reaction rate is close to first-order dependence on CO partial pressure. The rate of CO_2 formation is lowered by increases in pressure. We are now checking higher pressure ranges.

Engineering Economics Studies

The study of the plant for 500 billion Btu/day pipeline gas from lignite is continuing. The present material balance is based on calculated hydrogasifier effluent by reacting North Dakota lignite with synthesis gas. We are making contacts with vendors on the solids handling and drying equipment. We are also contacting suppliers of silica gel, molecular sieves, and activated carbon for removal of light oil (benzene) left in the gas after condensation and absorption. The concentration must be reduced to a subzero hydrocarbon dew point.

We will await tests on Montana lignite before finalizing the material and energy balances.

Electrothermal Test Unit

Assembly of the electrothermal test reactor system is now well under way. We have placed the order for a 500-kw motor generator set to supply the d-c power for the unit. This set will be delivered in 45 days. We are now requesting bids from contractors for hookup of the power supply for the 500-hp driver. Adequate power at voltage is available at our transformer bank.

We plan to investigate char-water slurry letdown using the 40-hp mud pump which will ultimately be used in the char removal system associated with the electrothermal test unit.

Pilot Plant

Bids were received from five companies for the design, procurement, and construction of the hydrogasifier portion of the pilot plant. Bids were received from —

Bechtel Corporation
Procor, Incorporated
Blaw-Knox Company
Catalytic Construction Company
Ralph M. Parsons Company

A bid is expected from J. F. Pritchard & Company by February 15. We plan to have a recommendation to OCR by the end of February.

Power Package

Negotiations were started with Avco Corporation to decide on the MHD unit specifications. We plan to send a draft of the proposed purchase order to your offices in February.

During the month, no inventions were made in the course of the work.

Approved Jack Huebler Signed Frank Schora

Jack Huebler, Research Director Frank Schora, Associate Director

IGT-MPR--2/68

DEVELOPMENT OF IGT HYDROGASIFICATION PROCESS

Progress Report – February 1968
to
Office of Coal Research
Contract No. 14-01-0001-381(1)

Hydrogasification

We conducted two hydrogasification tests this month in the balanced-pressure pilot unit (Runs HT-194 and HT-195). Both of these tests were an extension of a series of earlier studies on the use of synthesis gas in the place of hydrogen for the hydrogasification of bituminous coals and lignite. The objective of the tests was to define the operating conditions leading to increased carbon conversion to methane above that obtained in the earlier runs.

In Run HT-194, we reacted a lightly pretreated Pittsburgh seam bituminous coal with a synthesis gas-steam feed gas containing 30 mole percent steam. By operating with a steam concentration below the normally used 50 mole percent, it was easier to maintain the desired coal bed temperature of 1700°F that is necessary for converting a substantial portion of the bed carbon. To further promote carbon conversion, we increased the coal residence time by reacting the coal in a 7-ft bed instead of the normally used 3-1/2-ft bed. The test lasted 3 hours, with 45 minutes of this at steady state. The steady-state period was cut short when our liquid drain line became plugged with ammonium carbonate crystals. The results of this test show that 21% of the carbon in the coal was gasified, a conversion level below that of the earlier tests.

In Run HT-195, we reacted a dried North Dakota lignite from the Glenharold mine with a synthesis gas-steam feed gas containing 50 mole percent steam. The synthesis gas-to-lignite ratio was held at about 8 SCF/lb of lignite. This is one-half the synthesis gas-to-lignite ratio of a previous synthesis gas-lignite test. Because of the relatively high reactivity of lignite, we expected that carbon conversions could be maintained at acceptable levels, even with

the reduced synthesis gas-to-lignite ratio. The entire test lasted 4-3/4 hours; of this, 2 hours was at steady-state conditions. Preliminary indications, based on the weight of residue recovered, are that the conversion level was similar to that obtained at the higher feed gas-to-lignite ratio.

Electrothermal Reactor

Construction of the electrothermal reactor test facility is continuing. Delivery of the motor generator power supply and the steam generator-superheater is scheduled for the first part of March. The liner and insulation are now being installed in the reactor. The fabrication of the feed system is complete and will be installed after receipt of the steam generator-superheater because installation of these units requires access through the space to be occupied by the feed system.

Producer Gas Generator

We are now formulating a concept that we believe will be the best approach for generating producer gas for the conversion of char to a hot combustible gas to be used as feed to the MHD combustor. We plan to run a series of tests in the hydrogasifier reactor to establish the reactor size and to ensure the feasibility of our approach. These runs are planned after the present series of hydrogasification runs with synthesis gas.

Methanation

We have made a series of runs over the pressure range of 5-70 atm with 10% CO, 30% H_2, and 60% He feed and with 1/8-in. Harshaw Ni-0104 catalyst. The methanation reaction rate appears to depend upon some fractional power of the total pressure at 575°F. A similar result was found earlier with Girdler G-65 catalyst. This dependence of the rate on pressure definitely rules out product desorption and probably reactant adsorption as rate-determining processes. We are getting data now on smaller particles to check the above pressure-rate functionality and to check the pore diffusion influence.

Engineering Economics Studies

As requested by George Staber of OCR, an analysis and comparison was made between the Bureau of Mines'method of calculating the price of gas and the "A.G.A. Accounting Procedure" used by IGT. Numbers used were derived from the Bureau's economic analysis sent to us. This analysis was for a plant to make 250 million CF/day of high-Btu gas from the Kellogg gasification process. Based on the same input data, the Bureau's method calculates a gas price of about 5¢/million Btu higher than ours. Its procedure uses a 6.5% return and a 50% Federal income tax rate, while ours uses a 7% return and a 48% income tax rate. At the same values for these two factors, the IGT price will be 6¢/million Btu lower. The major reason for the difference is that the factors added to installed equipment costs (total construction or "bare" cost) are larger in the Bureau's method than in the A.G.A. procedure. The Bureau's factors for engineering overhead and administration, contingency, and fee add a total of 27.1% to the base cost, compared to a total of 13.1% by our method. The larger capital investment figure also results in higher investment-dependent operating costs. A separate memorandum has been written on this subject.

An initial estimate received from Link-Belt, Ltd., to dry 4.1 million lb/hr of lignite feed for a 500 million Btu/day pipeline gas plant from 35 to 5% water content indicates about $14 million will be needed for 17 fluidized-bed dryers, excluding the costs for foundations, electrical connection to plant, and feed-discharge conveyors. We will investigate other sources to see if the cost can be reduced by using larger units or combining the grinding and drying steps. Link-Belt has had problems with lignite and may be overconservative. We are holding up completion of the flow sheet until the results of our present series of hydrogasifier runs are available.

Power Generation

The purchase order in draft form has been submitted to Avco Corp. for comments. After receiving comments, this order will

be completed and submitted to OCR for approval.

Pilot Plant

Meetings were held with all organizations submitting proposals on the detailed design and construction of the pilot plant. Our letter recommending an engineering-construction firm and a request to proceed will be submitted to OCR in March after we have evaluated the various organizations.

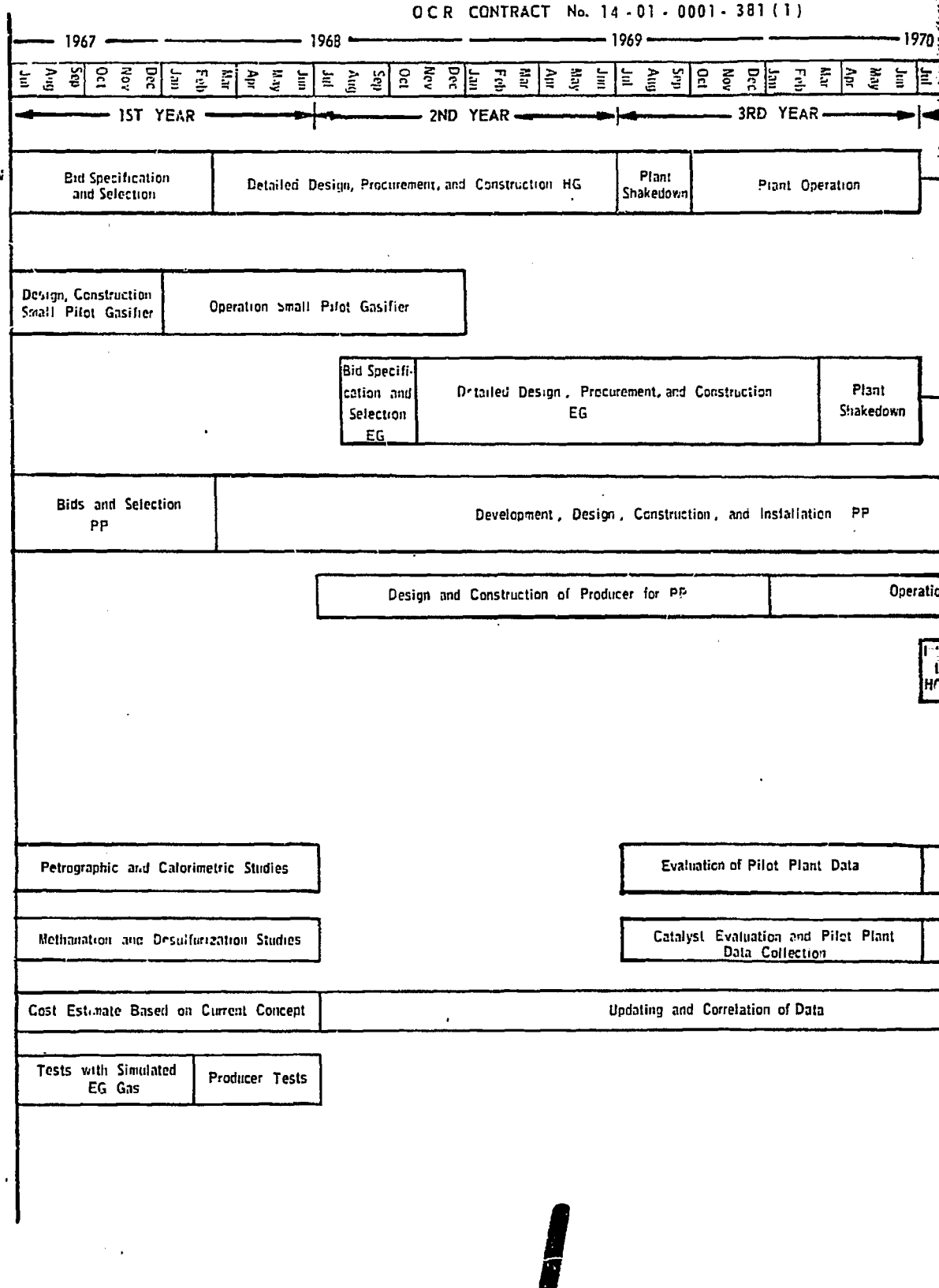
During the month, no new inventions were made in the course of this work.

Signed _____

Frank Schora, Associate Director

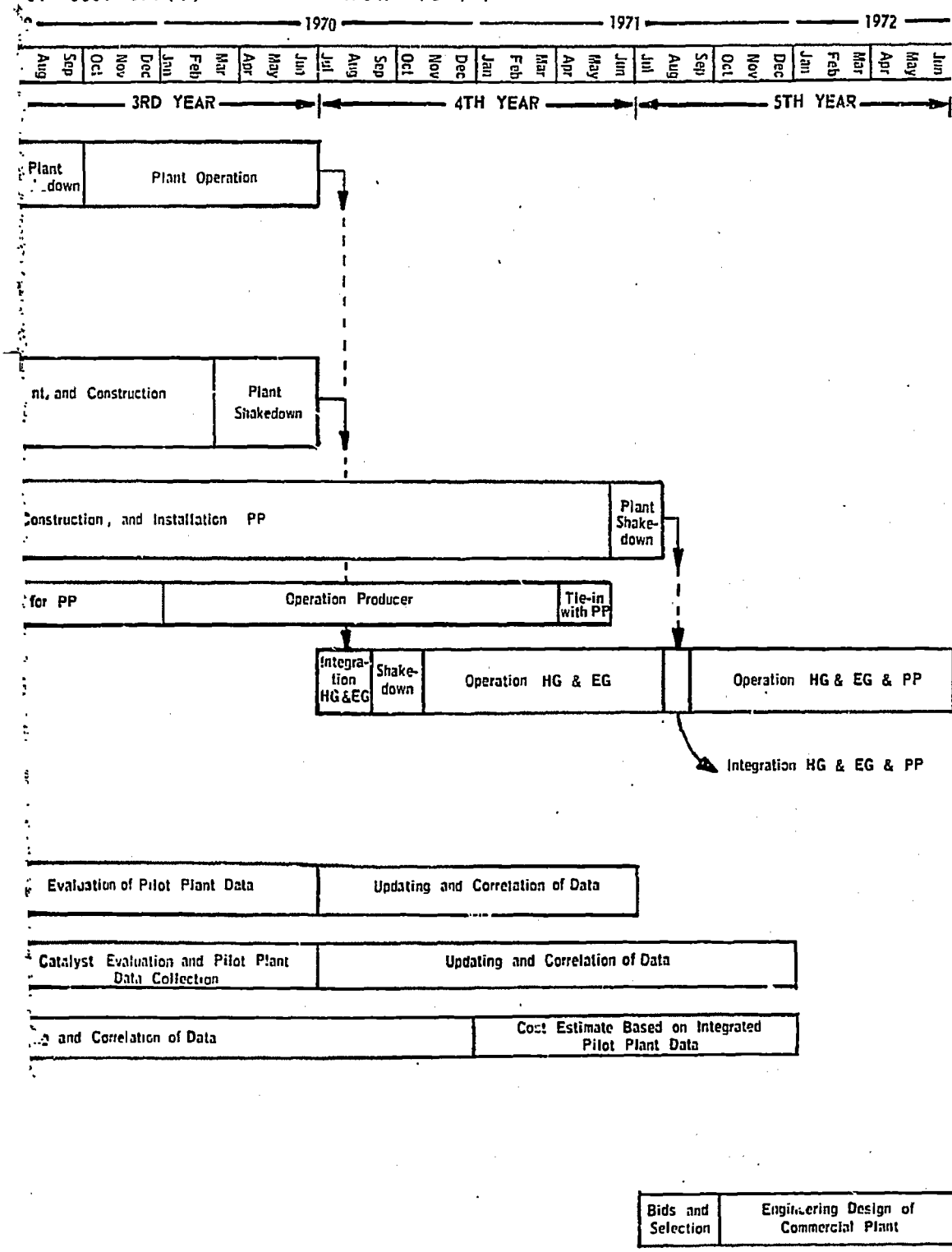
PILOT PLANT PROGRAM OF IGT HYDROGASI

OCR CONTRACT No. 14-01-0001-381(1)



AM OF IGT HYDROGASIFICATION PROCESS

CI - 0001 - 381 (1) AGA : IU-4-1



2

D-1071369

IGT-mPR--3/68

DEVELOPMENT OF IGT HYDROGASIFICATION PROCESS

Progress Report – March 1968
to #42

Office of Coal Research
Contract No. 14-01-0001-381(1)

Hydrogasification

We conducted two hydrogasification tests this month in the balanced-pressure pilot unit (Runs HT-196 and HT-197). In these tests we continued the study of the hydrogasification of a North Dakota lignite with a mixture of synthesis gas and steam. The objective of these tests was to establish the effect of the synthesis gas/lignite ratio on the gasification of carbon in the lignite, and on the relative yields of carbon oxides and methane in the product gas.

In both tests a North Dakota lignite from the Glenharold mine, dried to a 5% moisture content, was reacted with a synthesis gas-steam mixture containing 50 mole percent steam. The synthesis gas composition was similar to that used in previous tests. We reacted the lignite in a 3-1/2-ft fluidized bed at a temperature of 1700°F and a reactor pressure of 1000 psig. Each of the tests lasted 4-1/4 hours, with over 2 hours of this time at steady state.

Lignite fed at a rate of 34 lb/hr reacted with synthesis gas fed at a rate of 13 SCF/lb in Run HT-196. With this gas/lignite ratio, about 45% of the carbon in the lignite was gasified. This resulted in a net carbon oxides yield of 4.2 SCF/lb of lignite, and a methane yield of 4.4 SCF/lb of lignite.

In Run HT-197 we operated with a synthesis gas/lignite ratio of 7.5 SCF/lb as we fed lignite to the reactor at 47 lb/hr. At these conditions, we gasified 44% of the carbon in the lignite, resulting in a net carbon oxides yield of 4.2 SCF/lb of lignite, and a methane yield of 4.2 SCF/lb of lignite. The results of these two tests show that reducing the synthesis gas/lignite ratio from 13 to 7.5 SCF/lb had little effect on either the total carbon gasified or the methane yield. One reason for this is the relatively high reactivity of lignite to hydrogasification.

Methanation

Results of runs on various catalyst particle sizes indicate that the methanation rate becomes independent of particle size for particles smaller than about 30 mesh. This particle size correlation is approximate and must be checked further. We also have some evidence that for the 1/8-in., 1/4-in., and larger pellets, the rate might be inversely proportional to particle size. This behavior is expected for larger particles, but we don't yet have enough data to tell at what particle size the transition to particle size dependence occurs.

Economics

The flow sheet conditions for the economic study on the 500 million SCF/day hydrogasification plant have been frozen. This study is proceeding, and equipment sizing is now under way.

Electrothermal Reactor

Essentially all equipment has been received, and the 300-kw heater system is now being assembled. The hookup between our main transformer bank and the motor generator set is being made by an outside contractor.

Pilot Plant

We are completing our reviews with Avco on the purchase order for the MHD unit. We are awaiting authorization to start negotiations with Procon for the detailed design, procurement, and construction of the pilot plant.

Schedule and Funding

A revised time schedule (in five copies) is attached and shows our phasing of the various segments of the program. A revised estimate of our total program cost through 1972 is presented in Tables 1 through 5.

During the month no new inventions were made in the course of this work.

Table 1. ESTIMATED SCHEDULE OF EXPENDITURES

Fiscal Year 1968	$ 723,000
Fiscal Year 1969	6,585,000
Fiscal Year 1970	6,019,000
Fiscal Year 1971	2,550,000
Fiscal Year 1972	1,964,000
TOTAL	$17,841,000

Table 2. BUDGET ESTIMATE BY SECTION AS OF MARCH 1968

Hydrogasification Section	
Capital	$5,777,000
Staff	1,300,000
Materials	934,000
Section Total	$8,011,000
Electrothermal Gasification Section	
Capital	$ 870,000
Staff	1,030,000
Materials	367,000
Section Total	$2,267,000
Advanced Power Package Section	
Producer	
Capital	$ 476,000
Staff	379,000
Materials	65,000
Section Subtotal	$ 920,000
MHD System	
Capital	$4,685,000
Staff	369,000
Materials	158,000
Section Total	$6,132,000
Support Studies Section	
Subcontract	$ 312,000
Staff	959,000
Materials	160,000
Section Total	$1,431,000
PROJECT TOTAL	$17,841,000

Table 3. BREAKDOWN OF ESTIMATED NONEXPENDABLE MATERIALS, EQUIPMENT, AND SUBCONTRACTS

Hydrogasification Pilot Plant	$ 5,555,000
Electrothermal Gasification	
300-kw unit	90,000
2000-kw pilot unit	746,000
Advanced Power Package	
MHD System	4,505,000
Producer and MHD Bldg.	458,000
Engineering Design of Commercial Plant	300,000
Subtotal	$11,654,000
Contractor's Fee	466,000
Total	$12,120,000

Table 4. BUDGET ESTIMATE BREAKDOWN BY OCR COST CATEGORIES

Direct Costs	
Salaries	$ 1,725,000
Other Direct Costs	
Materials, Supplies, Travel	1,510,000
Nonexpendable Materials, Equipment, Subcontract	11,654,000
Indirect Costs	
Overhead 125% of Salaries	2,157,000
Subtotal	$17,156,000
Contractor's Fee	686,000
Total	$17,841,000

Table 5. COMPARISON OF BREAKDOWN WITH BUDGET ESTIMATE OF MARCH, 1967

Total Budget Estimate

3-68 (4% Fee)	$17,841,000
3-67 (Adjusted to 4% Fee)	$13,608,000
Increase	$ 4,233,000

Increase Attributable to:

	Capital	Staff and Material
Advanced Power Package		
MHD System	$ 1,565,000	$ 154,000
Producer and MHL Blwr.	476,000	633,000
Upgrading, Electrothermal Gasification, and Support Studies	763,000	642,000*
Subtotal	$ 2,804,000	$ 1,429,000
TOTAL	$ 4,233,000	

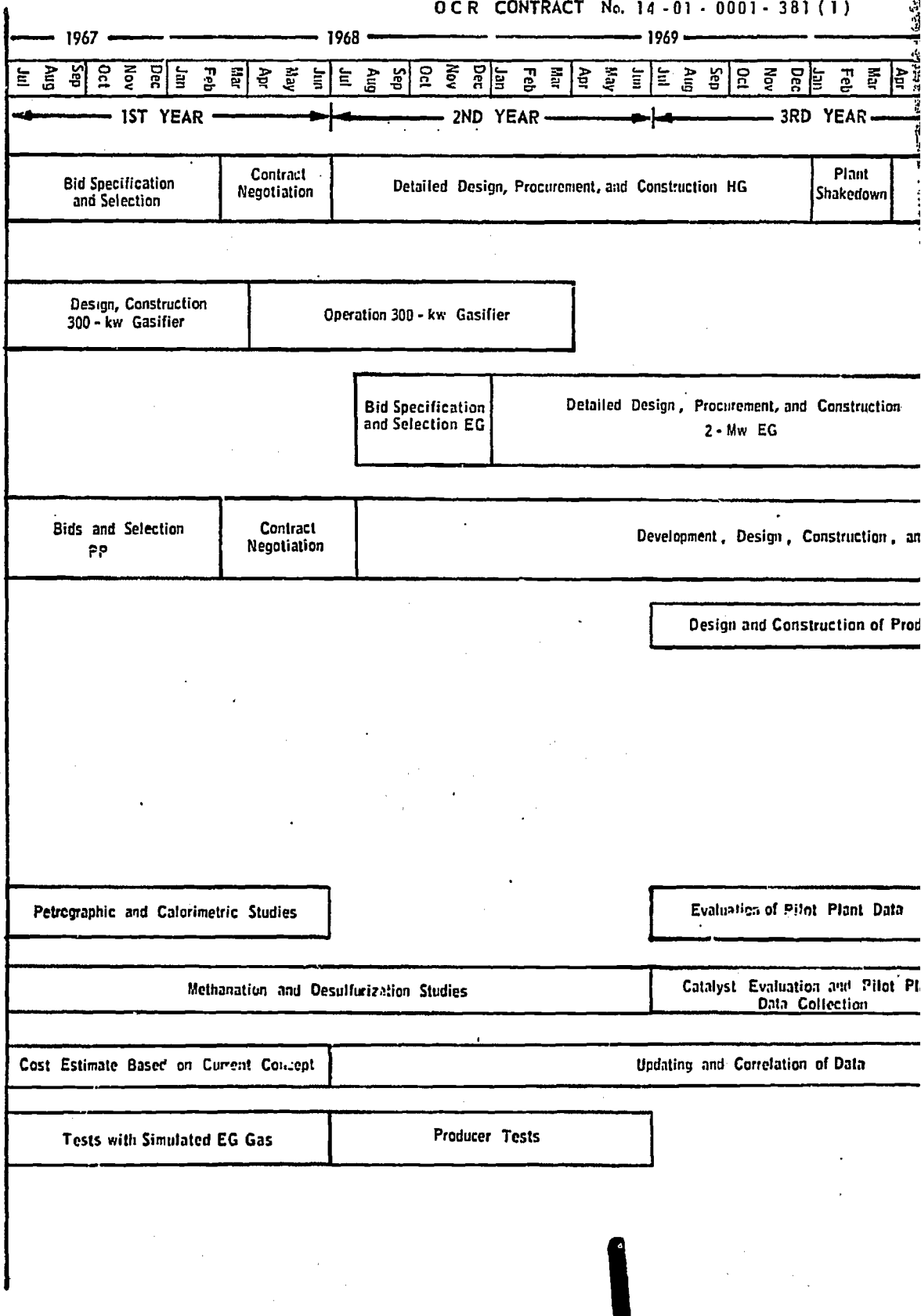
* Due partly to program delay and cost escalation.

Approved Jack Huebler
Jack Huebler, Research Director

Signed Frank Schora
Frank Schora, Associate Director

PILOT PLANT PROGRAM OF IGT HYDR

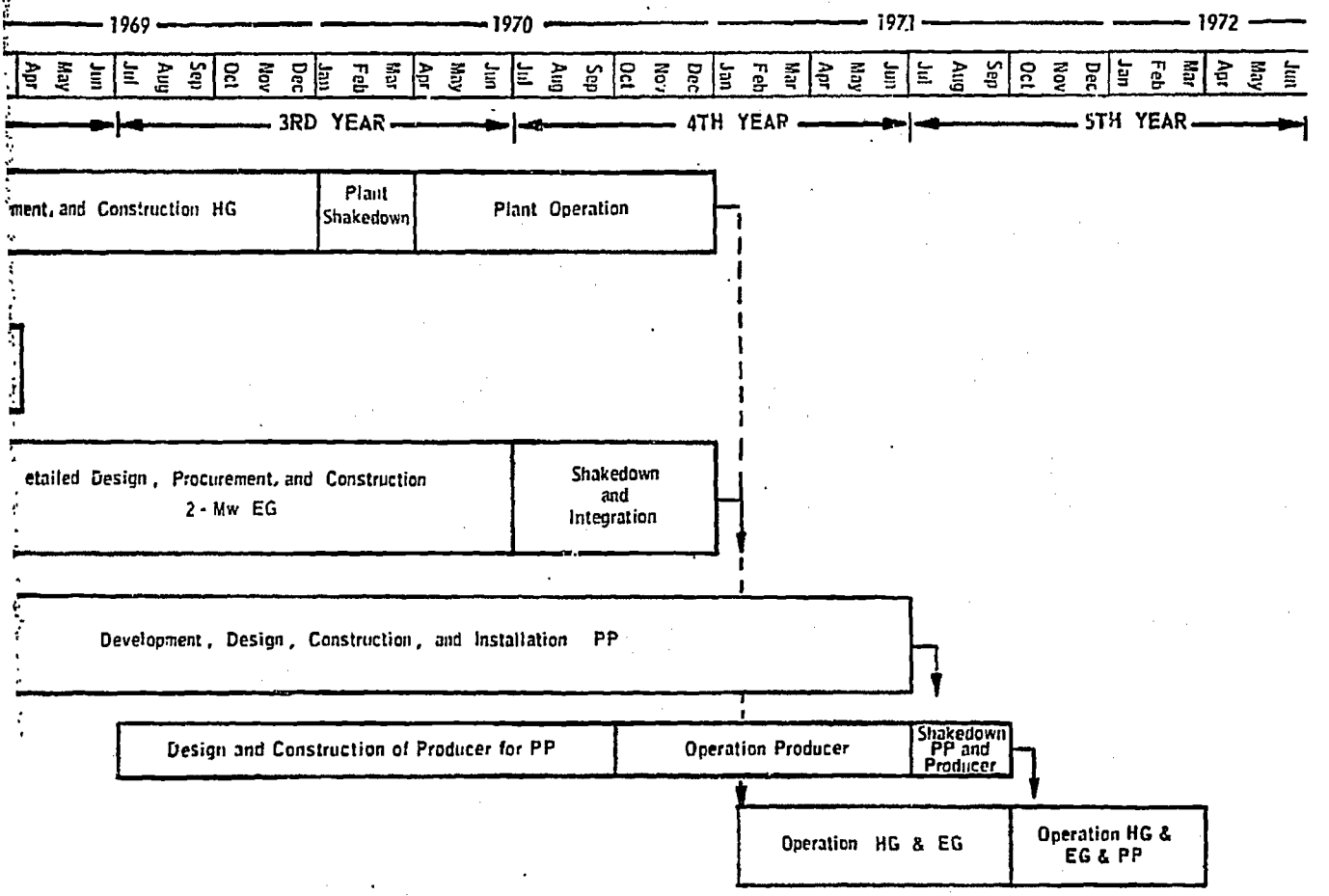
OCR CONTRACT No. 14-01-0001-381(1)



BLANK PAGE

PROGRAM OF IGT HYDROGASIFICATION PROCESS

CT No. 14-01-0001-381(1) AGA: IU-4-1



2

D-48555

IGT-MPR--4/68

DEVELOPMENT OF IGT HYDROGASIFICATION PROCESS

Progress Report — April 1968
to
Office of Coal Research
Contract No. 14-01-0001-381(1)

Hydrogasification

This month we conducted four hydrogasification tests in the balanced-pressure pilot unit (Runs HT-198, HT-199, HT-200, and HT-201). The purpose of these tests was to provide additional information on the reactions in the high- and low-temperature zones of a hydrogasification reactor when a bituminous coal is gasified with a mixture of synthesis gas and steam. In these tests, we first simulated the low-temperature zone by reacting a lightly pretreated Pittsburgh seam bituminous coal from the Ireland mine with a gas mixture representative of the off-gas leaving the high-temperature zone of the lower part of the coal bed. We then simulated the high-temperature zone by reacting the partially gasified residue from the low-temperature zone simulation with a synthesis gas-steam feed gas mixture.

Experimental data from these tests will be used in some fundamental studies of the kinetics and equilibrium of the relatively complex coal-synthesis gas-steam reaction system A better understanding of this reaction system will serve to identify operating conditions for optimum methane production, when hydrogasifying with a synthesis feed gas.

In the first three of the above tests we simulated the low-temperature zone by reacting the bituminous coal at 1300°F in a 3-1/2-ft bed with a gas-steam mixture containing 30 mole percent steam. The dry gas composition of this feed mixture, on a mole basis, was 21% carbon monoxide, 17% carbon dioxide, 38% hydrogen, and 24% methane. Coal was fed at a rate of 42 lb/hr. The gas rate was set so that the ratio of carbon monoxide and hydrogen to coal was 10 SCF/lb.

In Run HT-198, the lightly pretreated bituminous coal, although free-flowing for the most part, agglomerated just enough in the reactor after 1-1/2 hours of operation to cause a shutdown before steady-state operation was reached.

The Ireland mine bituminous coal was given additional pretreatment after which it was used as the feed for Run HT-199. This run was shut down after 1 hour when the coal feed tube plugged and the feed screw jammed. A low nitrogen purge flow through the coal feed tube was responsible for plugging the tube.

Run HT-200 was a successful simulation of the low-temperature reaction zone. The run lasted 5-1/2 hours, with 3-1/4 hours at steady state. Based on the weight of the residue recovered, we converted 32% of the carbon in the coal, while producing a product gas containing 36 mole percent methane on a nitrogen-free basis.

In Run HT-201 we successfully simulated the high-temperature zone when we reacted the residue coal of Run HT-200 in a 7-ft fludized bed with a mixture of synthesis gas and steam. The steam concentration in the mixture was 53 mole percent. The composition of the synthesis gas was 42% carbon monoxide, 5% carbon dioxide, and 53% hydrogen. We operated the run for 2-1/4 hours at a steady state before shutting it down. Preliminary data indicated a coal conversion of about 20 weight percent.

Methanation

We have received a new sample of a methanation catalyst from Catalyst and Chemicals, Inc. We had previously found that the samples this company sent us were of poor activity. A check of this sample, CCI-C13-4 nickel-alumina, showed that its activity lay between the activities of Harshaw Ni-0104-T and Girdler G65. The CCI-C13-4 became active at about 600°F compared with about 550°F for Harshaw and 650°F for Girdler.

Economics

Present plans indicate that the economic analysis of a 500 million SCF/day pipeline gas plant will be completed by the end of June, with submission of the report by the end of July. The schedule of work for preparing this estimate is shown in Figure 1.

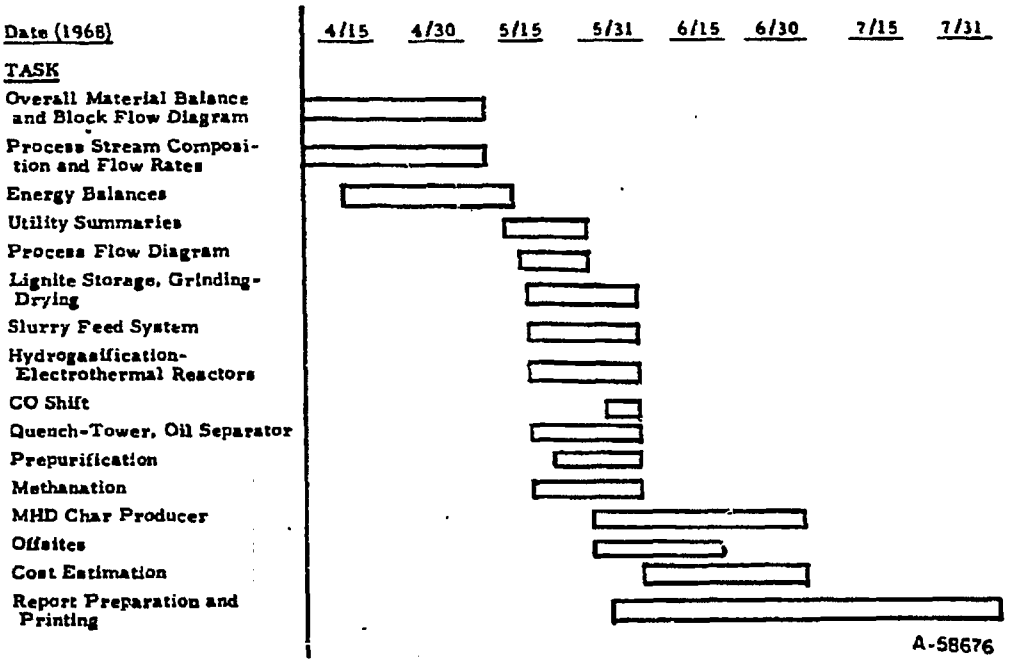


Figure 1. TIME SCHEDULE OF ECONOMIC ANALYSIS

Electrothermal Reactor

The 2,00-volt 3-phase power supply has been installed from the power house to the pilot plant. Connections to the magnetic starter and controls are now in progress.

The lower reactor section, the char discharge screw housing, the controls; and the char receiver have been installed on the 300-kw test unit. Work has begun on the quench system and feed hopper assemblies.

Piping and electrical connections for the steam generator and superheater are complete, with start-up and shakedown of

the system to begin next month.

Electrode materials to be tested that have been received are 316, 17-4PH, and 44FSE stainless steels; molybdenum; silicon carbide; and carbon – all as rods of 1-1/2 inch diameter.

Petrography

An informal cooperative program on petrographic analysis is being carried out with the Penn State coal research laboratory. Reflectance determinations were found to agree well. Work is continuing on maceral analysis. A paper on our petrographic work is being prepared for presentation at the September 1968 meeting of the Division of Fuel Chemistry of the American Chemical Society.

Pilot Plant

Our evaluation and results of preliminary negotiations with the responsive engineering-construction firms for the detailed design, procurement, and construction of the pilot plant have been submitted to OCR. We are now awaiting authorization to negotiate with the selected contractor.

During the month no new inventions were made in the course of the work.

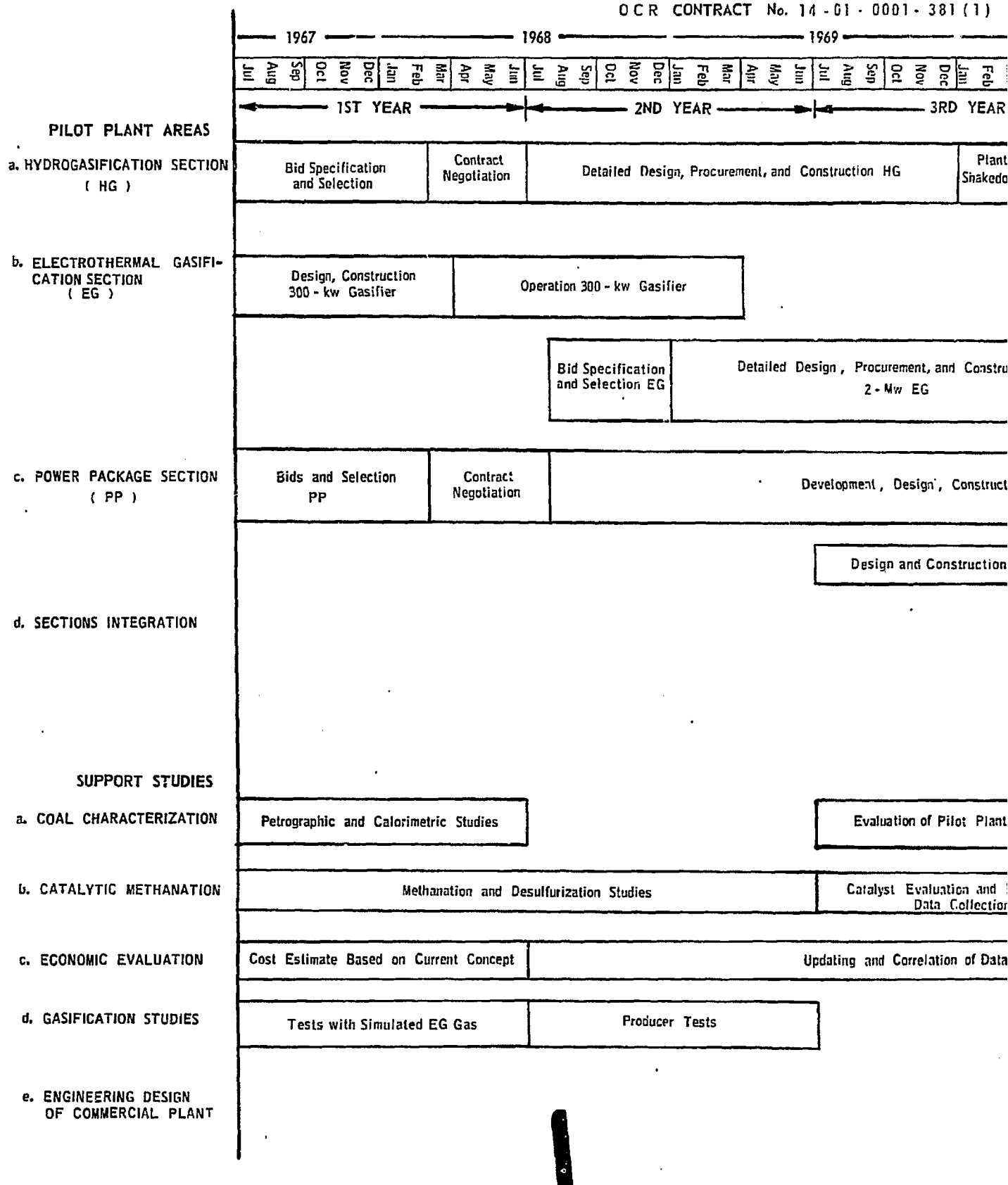
Approved Jack Huebler Signed Frank Schora

Jack Huebler, Research Director

Frank Schora, Associate Director

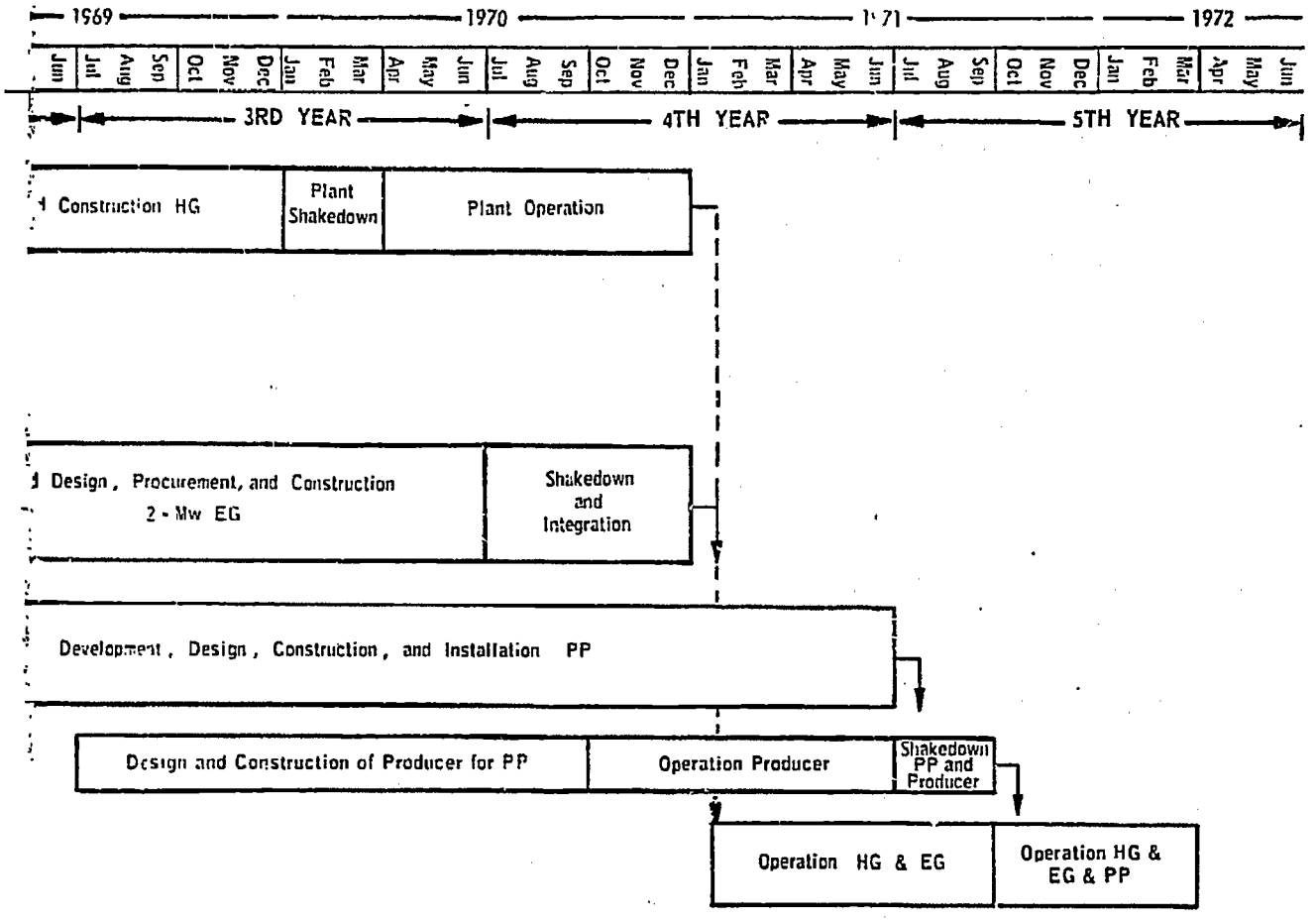
PILOT PLANT PROGRAM OF IGT H

OCR CONTRACT No. 14-01-0001-381(1)



OGRAM OF IGT HYDROGASIFICATION PROCESS

. 14-01-0001-381(1) AGA: IU-4-1



2

IGT-MPR--5/68

DEVELOPMENT OF IGT HYDROGASIFICATION PROCESS
Progress Report -- May 1968
to
Office of Coal Research
Contract No. 14-01-0001-381 (1)

Hydrogasification

We conducted four hydrogasification tests this month in the balanced-pressure pilot unit (Runs HT-202, HT-203, HT-204, and HT-205). In these tests we hydrogasified a lightly pretreated Pittsburgh seam bituminous coal from the Ireland mine with a mixture of synthesis gas and steam. The objective of these tests was to define the operating correlations leading to an increase in carbon conversion to methane above that obtained in tests to date.

Synthesis gas, with a nominal composition of 54% hydrogen, 41% carbon monoxide, and 5% carbon dioxide, was reacted with the coal in a 3-1/2-ft fluidized bed at a nominal temperature of 1700°F. The feed ratio was 8 SCF carbon monoxide plus hydrogen per pound of coal. Steam concentrations in the feed gas were 30 mole percent in Runs HT-202, HT-204, and HT-205, and 60 mole percent in Run HT-203. The lower steam concentration would tend to keep the coal bed temperature high, which would promote the steam-carbon reaction. On the other hand, the higher steam concentration would increase the extent of the water-gas shift reaction, which would maintain the hydrogen concentration at an adequate level for reaction with carbon.

We attained only partial operational success in these tests because of difficulties in feeding the coal through the upper preheat section of the reactor. The coal feed contained about 25% fines or less than 80 mesh size compared to the normal 10-15%. The suspension of this high concentration of fines at the top of the reactor and their devolatilizing in an atmosphere of low hydrogen concentration was the apparent cause of the feeding problems. In individual tests we experienced certain minor or

major equipment difficulties that, at the time of the tests, appeared to contribute to the coal feeding problem.

Run HT-203 was the most successful of the four tests. We fed coal at a rate of 42 lb/hr for nearly 3 hr and attained a steady-state operating period of 1/4 hr before shutting down after the coal feed tube plugged. In this test we had a small leak within the reactor at the base of the synthesis gas-steam feed tube that affected the contacting of the coal and gas. Tentative results indicate a carbon gasification of 25%.

Runs HT-202 and HT-204 were conducted at similiar coal, gas, and steam rates. The coal feed rates were a nominal 72 lb/hr, and the gas feed rates, a nominal 720 SCF/hr. Each of these tests lasted about 2 hr with only a brief steady-state period of 15 min before shutdown was caused by a plug in the coal feed tube. In Run HT-202 there was inadequate heat input to the upper portion of the reactor (62 in.) because furnace heating zones No. 2 and 3 shorted out.

In Run HT-205 the feed ratios were similiar to those of Runs HT-202 and HT-204, but the throughput rates were reduced. The coal feed rate was a nominal 53 lb/hr, and the gas feed rate a nominal 530 SCF/hr. We expected to have less difficulties with coal plugs at the lower feed rates. However, the coal feed tube still plugged and we had to be shut down after 2-1/4 hr of operation with 15 min of steady-state operation.

Before using the remainder of this batch of Pittsburgh seam coal for hydrogasification tests, we will screen out the fines below 80 mesh and control the fraction of fines in subsequent coal batches to less than 10%.

Methanation

We continued work on the development of a model for the methanation kinetics on −40+60 mesh particles at 575°F and various pressures. We are also continuing the development of a computer model of the methanation reactor that will include heat and mass transfer effects.

Economics

Work is proceeding on all phases of the pipeline-gas-from-lignite estimate. The flow scheme was revised to include a quench tower and hot carbonate scrubbing prior to the CO shift step. A second carbonate scrubber and benzene removal follow this step. This arrangement reduces shift catalyst requirements to one-fourth the originally estimated requirement.

The designs for the hydrogasification system, quench tower, first carbonate unit, CO shift, and lignite-drying systems have been worked out. Preliminary plant steam and utility balances have been completed for submission to Avco Corp. The plant will require about 710,000 kW, of which 620,000 is for the electrogasifier. At a 55% conversion of spent electrogasifier char to power, a total of 1,240,000 kW can be generated, leaving 530,000 kW for export.

Vendors have been contacted concerning feed slurry pumps, scrubbing liquid pumps, lignite crushers, and benezene recovery.

Electrothermal Gasification

The electrical system to the MG set which will power the 300 kW electrothermal gasification test unit was completed and the MG set was aligned and started. Work is being finished on the char feed system and system piping is in progress. We expect to initiate shakedown of the system in the latter part of June.

Pilot Plant

We are now in the process of negotiating contract terms with three organizations, Blaw-Knox, Procon, and Ralph M. Parsons, as requested by OCR. The contract draft previously submitted to OCR is being used as the basis for these negotiations. We plan to again submit our recommendations in the latter part of June.

During the month no inventions were made in the course of the work.

Approved Jack Huebler Signed Frank C. Schora

Jack Huebler, Research Director Frank Schora, Associate Director

PILOT PLANT PROGRAM OF IGT HYD...

OCR CONTRACT No. 14-01-0001-381(1)

1967 — 1968 — 1969

Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr

1ST YEAR — 2ND YEAR — 3RD YEAR

PILOT PLANT AREAS

a. HYDROGASIFICATION SECTION (HG)
- Bid Specification and Selection
- Contract Negotiation
- Detailed Design, Procurement, and Construction Hy...
- Plant Shutdown

b. ELECTROTHERMAL GASIFICATION SECTION (EG)
- Design, Construction 300-kw Gasifier
- Operation 300-kw Gasifier
- Bid Specification and Selection EG
- Detailed Design, Procurement, and Construction 2-Mw Ex...

c. POWER PACKAGE SECTION (PP)
- Bids and Selection PP
- Contract Negotiation
- Development, Design, Construction, ...
- Design and Construction of Pro...

d. SECTIONS INTEGRATION

SUPPORT STUDIES

a. COAL CHARACTERIZATION
- Petrographic and Calorimetric Studies
- Evaluation of Pilot Plant Data

b. CATALYTIC METHANATION
- Methanation and Desulfurization Studies
- Catalyst Evaluation and Pilot P... Data Collection

c. ECONOMIC EVALUATION
- Cost Estimate Based on Current Concept
- Updating and Correlation of Data

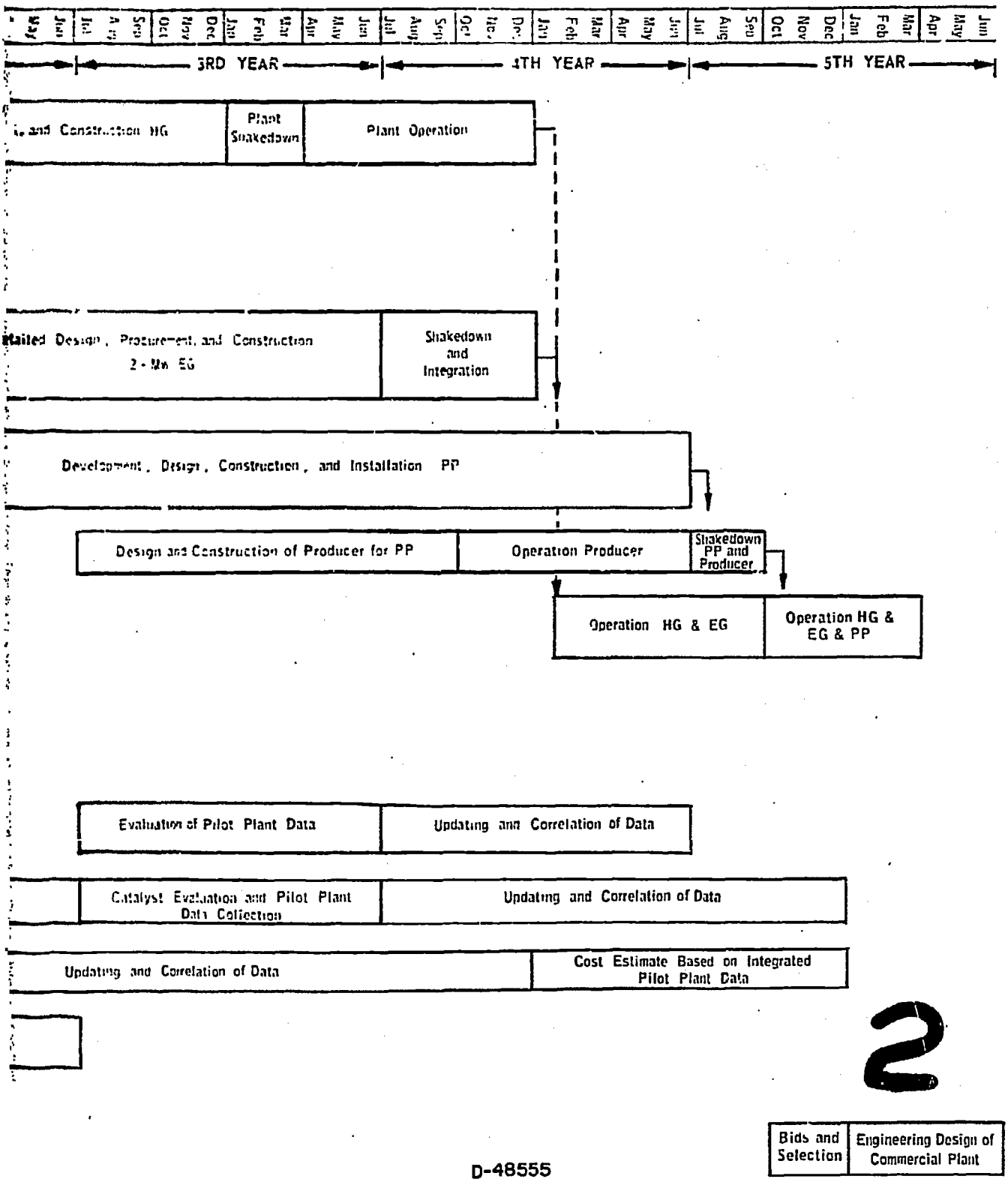
d. GASIFICATION STUDIES
- Tests with Simulated EG Gas
- Producer Tests

e. ENGINEERING DESIGN OF COMMERCIAL PLANT

BLANK PAGE

PROGRAM OF IGT HYDROGASIFICATION PROCESS

No. 14-21-0001-381(1) AGA: IU-4-1



D-48555

IGT-MPR-6/68

DEVELOPMENT OF IGT HYDROGASIFICATION PROCESS
Progress Report – June 1968
to
Office of Coal Research
Contract No. 14-01-0001-381 (1)

Hydrogasification

We conducted two hydrogasification tests this month in the balanced-pressure pilot unit (Runs HT-206 and HT-207). These tests continued our study of the hydrogasification of pretreated Pittsburgh seam bituminous coal from the Ireland mine with a mixture of synthesis gas and steam. The objective of these tests was to define the operating conditions for increased carbon conversion to methane, and to provide additional information on the hydrogasification reactions in the high-temperature zone of the reactor.

In Run HT-206 we reacted lightly pretreated Ireland mine coal in a 3-1/2-ft fluidized bed with a synthesis gas-steam mixture containing 30 mole percent steam. The synthesis gas composition was similar to that used in previous tests, namely, 54% hydrogen, 41% carbon monoxide, and 5% carbon dioxide. The temperature of the coal bed was controlled to a nominal 1700°F, while the temperature above the bed was 1200°-1300°F. Before using the pretreated coal we rescreened it to remove –80 mesh particles. In previous tests, this same batch of coal, which contained up to 25% of –80 mesh fines, did not handle too well in the reactor because fines suspended in the upper part of the reactor interfered with coal feeding. The coal used in Run HT-206, with its –80 mesh fraction reduced to about 10%, was fed and discharged from the reactor without difficulty. There were no other operational problems in this test, which lasted 4-1/2 hr with over 3 hr at steady-state conditions. Preliminary results indicate a carbon conversion of about 15%. The relatively low steam concentration of 30% appears to be responsible for the low carbon conversion.

The high-temperature zone of a two-temperature hydrogasification process was simulated in Run HT-207 to provide data for kinetic and equilibrium studies of the hydrogasification reactions at

1700°F. Partially hydrogasified Ireland mine bituminous coal was reacted in a 7-ft fluidized bed with a synthesis gas-steam mixture containing 53 mole percent steam. The synthesis gas, whose composition was similar to that used in Run HT-206, was fed at a rate of 366 SCF/hr for reaction with the partially hydrogasified coal fed at 24 lb/hr. A steady-state operating period of 3-1/4 hr was obtained in this test, which lasted 5 hr. A tentative carbon gasification of 18% of the carbon in the partially hydrogasified char is indicated.

Two coal pretreatment operations (Runs PP-131 and PP-132) were conducted in the pilot plant coal pretreatment unit. Approximately 1400 lb of Pittsburgh seam bituminous coal from the Ireland mine was pretreated to provide a feed material for the pilot plant hydrogasification unit. The coal was pretreated with air at a temperature of 750°-800°F.

Methanation

Runs were made with CO-H_2 mixtures without a helium diluent in an effort to determine the rate dependence of the methanation reaction on carbon monoxide. As the mole percentage of CO was increased from 1 to 7% at 40-atm total pressure, the rate increased and then decreased. This effect, which we observed before in some runs with mixed feeds, indicates that at high CO concentrations the adsorbed CO begins to inhibit the reaction rate. The rate would be close to first order at low CO concentrations, which is what we observed, and then would change to roughly negative first order at higher CO concentrations.

One other important effect was noticed in these runs. With H_2 as a diluent, the rates averaged about four times as high as when He was used as the diluent. Apparently, the hydrogen concentration accelerates the reaction.

Coal Characterization

Informal cooperative test programs on petrographic analysis with the Penn State Coal Research Laboratory and the Homer Research Laboratory of Bethlehem Steel Corporation were completed. Results

show that our maceral analyses now agree satisfactorily with those of other laboratories.

A paper on our petrographic work was completed for presentation at the September 1968 meeting of the ACS Division of Fuel Chemistry.

Electrothermal Test Unit

The high-pressure electrothermal test reactor is now essentially complete, and some prerun tests are under way. Initial electrical heating tests will be undertaken using nitrogen as the fluidizing gas as soon as completion of deck welding allows access to the unit.

Pilot Plant

Negotiation sessions were held with Blaw-Knox, Procon, and Ralph M. Parsons to establish their ratings after formal negotiations with these firms. Results of these negotiations did not alter our original rating of Procon, first; Ralph M. Parsons, second; and Blaw-Knox, third. Based on a meeting held in Washington on June 28 the subcontract form for the detailed design, procurement, and construction of the pilot plant is being completed for final negotiation and execution with Procon upon authorization by OCR.

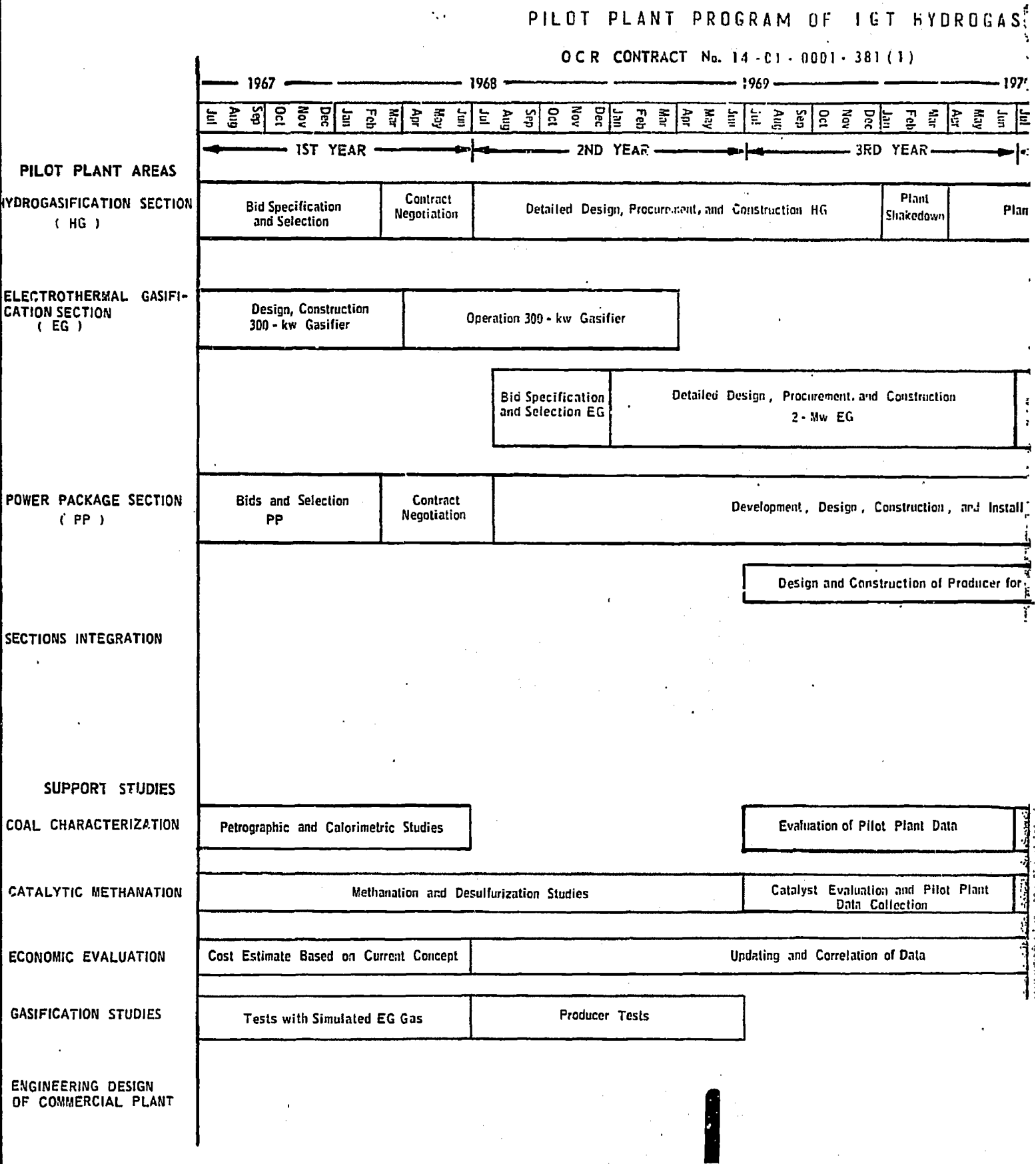
During the month no new inventions were made in the course of the work. There may be a 1-2 week delay in finalizing our economic study, which is due in the first part of July, because of a delay at Avco on MHD cost estimates. Also, we have been slightly delayed on a stress analysis of the hydrogasifier reactor vessel.

Approved Jack Huebler Signed Frank C. Schora

Jack Huebler, Research Director Frank C. Schora, Associate Director

PILOT PLANT PROGRAM OF IGT HYDROGAS

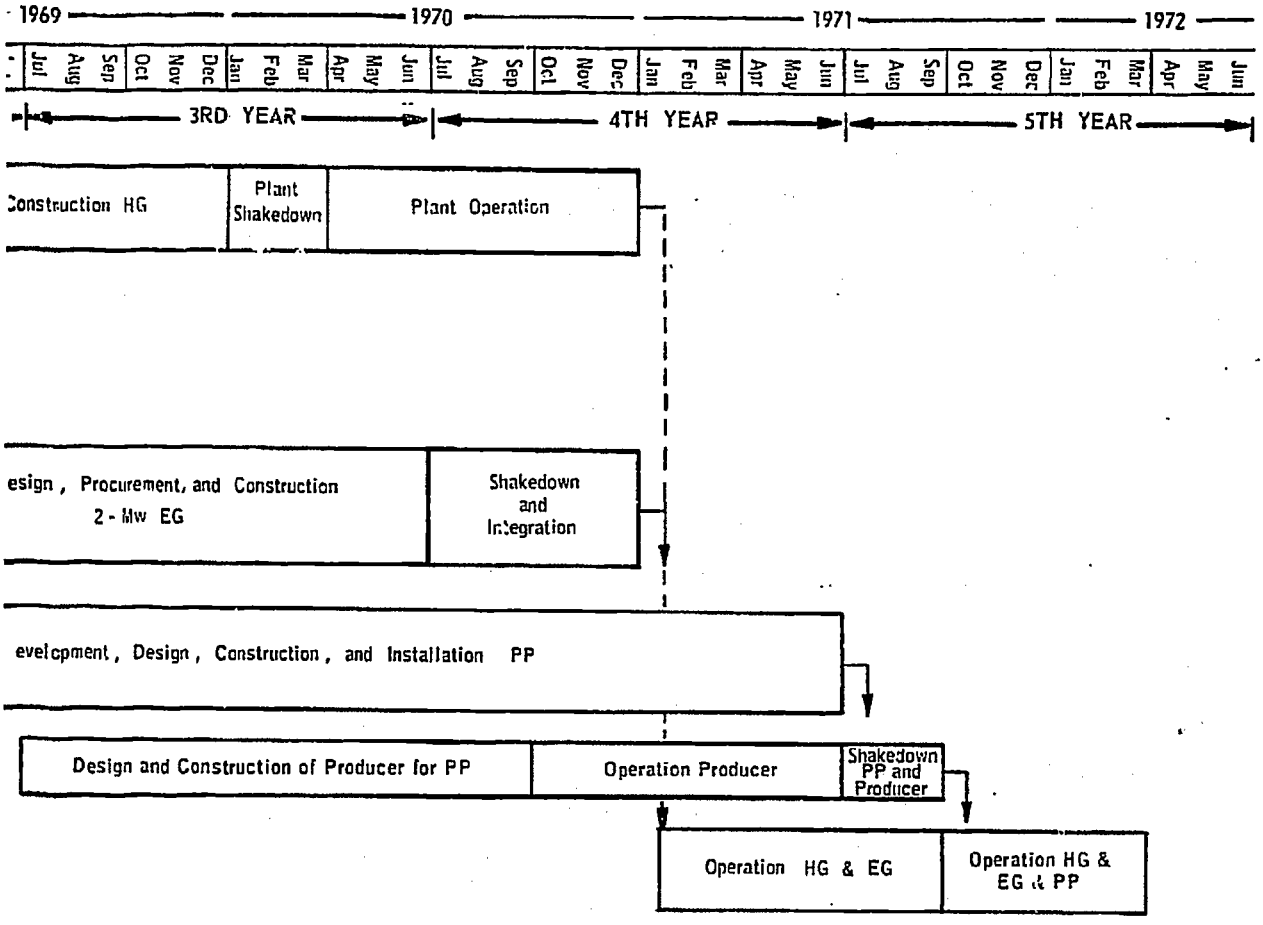
OCR CONTRACT No. 14-01-0001-381(1)



BLANK PAGE

GRAM OF IGT HYDROGASIFICATION PROCESS

:4-01-0001-381(1) AGA: IU-4-1



Evaluation of Pilot Plant Data | Updating and Correlation of Data

Catalyst Evaluation and Pilot Plant Data Collection | Updating and Correlation of Data

Updating and Correlation of Data | Cost Estimate Based on Integrated Pilot Plant Data

Bids and Selection | Engineering Design of Commercial Plant

2

IGT-MPR--7/68

DEVELOPMENT OF IGT HYDROGASIFICATION PROCESS
Progress Report — July 1968
to
Office of Coal Research
Contract No. 14-01-0001-381(1)

Hydrogasification

We conducted two hydrogasification tests this month in the balanced-pressure pilot unit (Runs HT-208 and HT-209) in a continuation of the study of bituminous coal hydrogasification with mixtures of synthesis gas and steam. The objective of these tests was to define the operating conditions necessary to increase the conversion of carbon to methane. Lightly pretreated Pittsburgh seam bituminous coal from the Ireland mine was the feed in both tests.

In Run HT-208 we investigated the effects of a 60 mole percent steam concentration and a synthesis gas/coal ratio of 10 SCF/lb on the hydrogasification of the bituminous coal. The coal was fed at a rate of 42 lb/hr and reacted in a 3-1/2-ft fluidized bed with 425 SCF/hr of synthesis gas and 30 lb/hr of steam. Temperatures in the coal bed were controlled at 1700°F, and temperatures above the bed were controlled at 1300°F. Three hours of steady-state operation were obtained in this test, which lasted 4-3/4 hr. Results show that more than 28% of the carbon in the coal was gasified and that over 16% of the steam fed was reacted.

In Run HT-209, we studied the effects of a 50 mole percent steam concentration and a feed gas/coal ratio of 15 SCF/lb on carbon conversion. Hydrogasification with the increased gas/coal ratio would be expected to lead to increased carbon gasification. Except for the feed rates, the operating conditions were similar to those of Run HT-208. Coal was fed at 35 lb/hr, synthesis gas at 530 SCF/hr, and steam at 25 lb/hr. The test lasted 4-1/4 hr with 3-1/4 hr of this at steady-state conditions. Preliminary results indicate that the carbon gasification was similar to that of Run HT-208.

Methanation

We are continuing runs with CO/H_2 mixtures and CO/H_2 mixtures diluted with helium in an effort to find the reaction orders with respect to both CO and H_2. Present studies with 1/4-in. pellets of Ni-0104T definitely indicate a CO order slightly under 1 for less than 5% CO. Increasing amounts of helium were added to the feed gas which caused the hydrogen partial pressure to vary. The rate without helium was about the same as that with a H_2/He ratio of 4 in the feed at the same CO partial pressure in the product. When the H_2/He ratio dropped to 1.5, the rate dropped also. Apparently the rate equation is such that at high hydrogen partial pressures the reaction rate is not very hydrogen-sensitive. We are making more runs with various hydrogen partial pressures this month.

Electrothermal Reactor

Initial shakedown of the steam generation and superheater sections of the test reactor system was conducted. A safety system was fabricated and installed to detect potential breakdown of the electrical insulation which isolates the center electrode from the shell as it passes through the high-pressure vessel. The remaining deck work was completed, and the hydraulic system for driving the screw feeders was installed.

Process Economics

The investment and operating cost estimate for the MHD portion of the 500 million SCF/day plant was received from Avco. Some adjustments in the process stream conditions were necessary to integrate this facility with the electrothermal gasifier and the hydrogasification reactors. The report is now in preparation and should be completed in August.

Pilot Plant

A review of the plant layout and piping and instrument diagrams has been intiated. Plot plans are now being studied. We plan to complete the hydrogasifier reactor design and place an order

for that unit at an early date. As requested, we will include a sulfur recovery unit to recover sulfur from the H_2S-CO_2 stream leaving the scrubbing system regenerator. A work schedule will be submitted by Procon in mid-August with its first report and invoice.

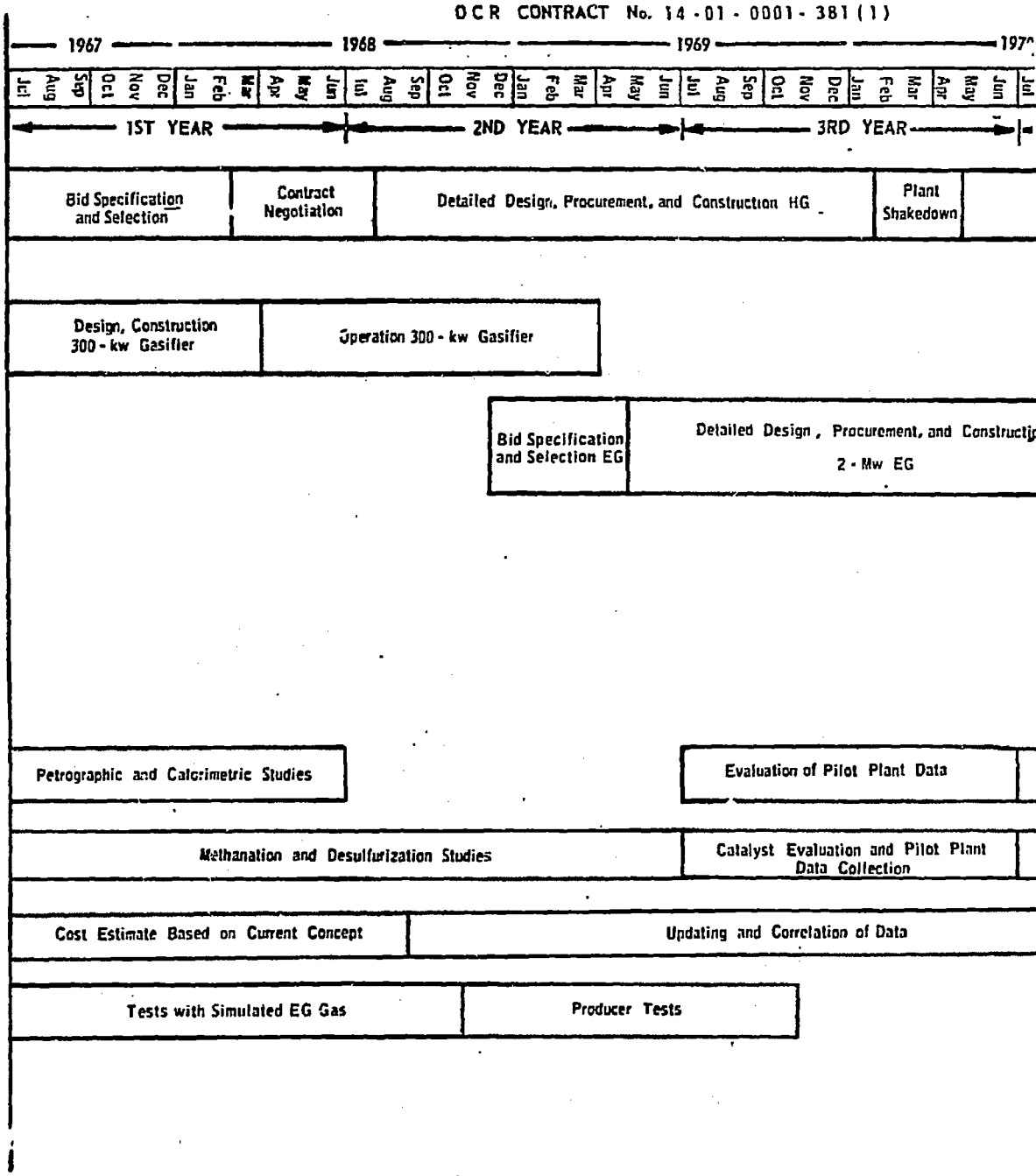
During the month no new inventions were made in the course of the work.

Approved _____ Signed _____

Frank J. Nelson, Associate Director Bernard S. Lee, Manager

PILOT PLANT PROGRAM OF IGT HYDROGAS

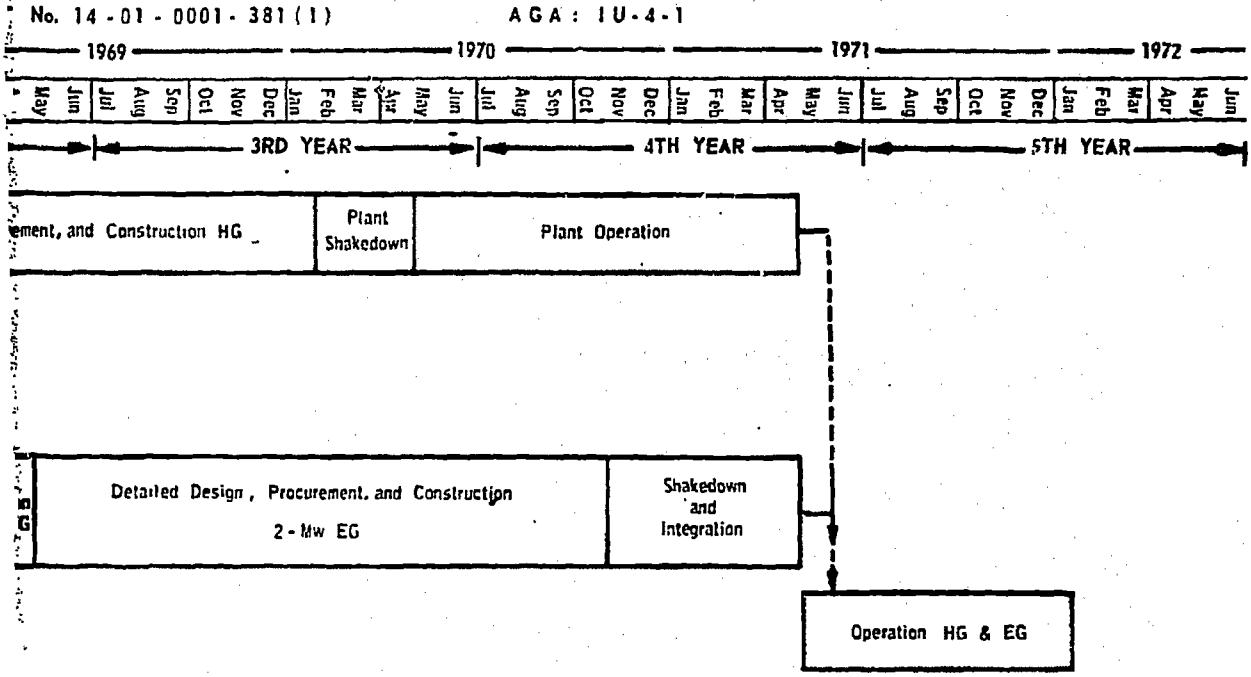
OCR CONTRACT No. 14-01-0001-381(1)

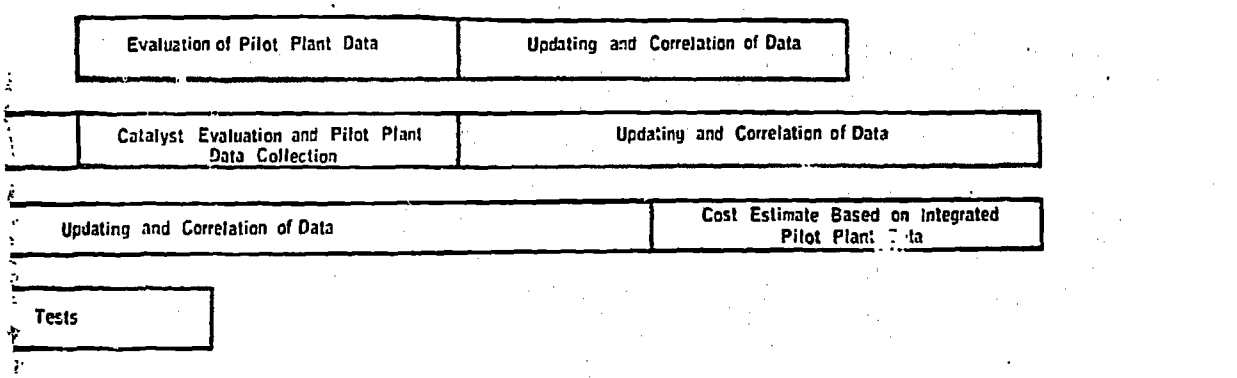


BLANK PAGE

PROGRAM OF IGT HYDROGASIFICATION PROCESS

No. 14-01-0001-381(1) AGA: IU-4-1





E-881094

2

IGT-MPR--8/68

DEVELOPMENT OF IGT HYDROGASIFICATION PROCESS

Progress Report – August 1968

to

Office of Coal Research

Contract No. 14-01-0001-381 (1)

Hydrogasification

We conducted three coal pretreatment operations (Runs FP-133, FP-134, and FP-135) in the pilot plant fluidized-bed coal pretreatment unit. Approximately 1200 lb of Pittsburgh seam bituminous coal from the Ireland mine was lightly pretreated to provide a feed material for the pilot plant hydrogasification unit. The coal was pretreated with air at 750°-800°F.

Methanation

We continued runs to determine the dependence of methanation rate on hydrogen. At constant temperature, pressure, and a CO concentration of 4%, the hydrogen reaction order is about 3/4 at hydrogen concentrations below 20%. At higher hydrogen concentrations the hydrogen order approaches zero.

An apparent activation energy of about 6 kcal was determined from runs at constant CO concentration (1.5%), constant pressure, and at temperatures between 575° and 750°F. This activation energy, found for 1/4-in. pellets, is very low and indicates pore diffusion influence.

In our next set of runs all component partial pressures will be varied independently and the data will be fit to candidate rate equations inspired by the results of the CO- and H_2-order determinations.

Engineering Economics

The economic evaluation for a 500 billion Btu/day pipeline gas plant based on North Dakota lignite was completed. This is a detailed study of plant equipment and operating costs, presented in a fashion similar to the

state-of-the-art design. Total investment is $235,193,000. Of this amount, 33% is for hydrogasification-electrogasification quench, 37% for the MHD-steam-power system, 9.7% for lignite feed preparation, 12.8% for upgrading of hydrogasifier effluent, and 7.5% for other offsites and working capital.

With lignite at 8¢/10^6 Btu, the 20-year average price of pipeline gas is 32.9¢/10^6 Btu. A 1¢/10^6 Btu change in the lignite cost changes gas price by 1.7¢/10^6 Btu. By-product credits are worth 7.9¢/10^6 Btu.

Electrothermal Gasifier Test Reactor

Final shakedown of the components of the electrothermal gasifier test system was completed in August. A malfunctioning of the SCR circuit controlling the generator field strength was encountered; that control circuit is now being repaired. The initial runs will be made with nitrogen to establish heat-up rate and temperature control. After establishing these characteristics of the system, steam will be used as a fluidizing agent and study of the steam-char system will be initiated.

Hydrogasification Pilot Plant

Progress Report No. 1 by Procon is attached. This report includes a bar chart of the work to be done to establish the Guaranteed Maximum Price and a schedule of the construction work to be done this year.

During the month no new inventions were made in the course of the work.

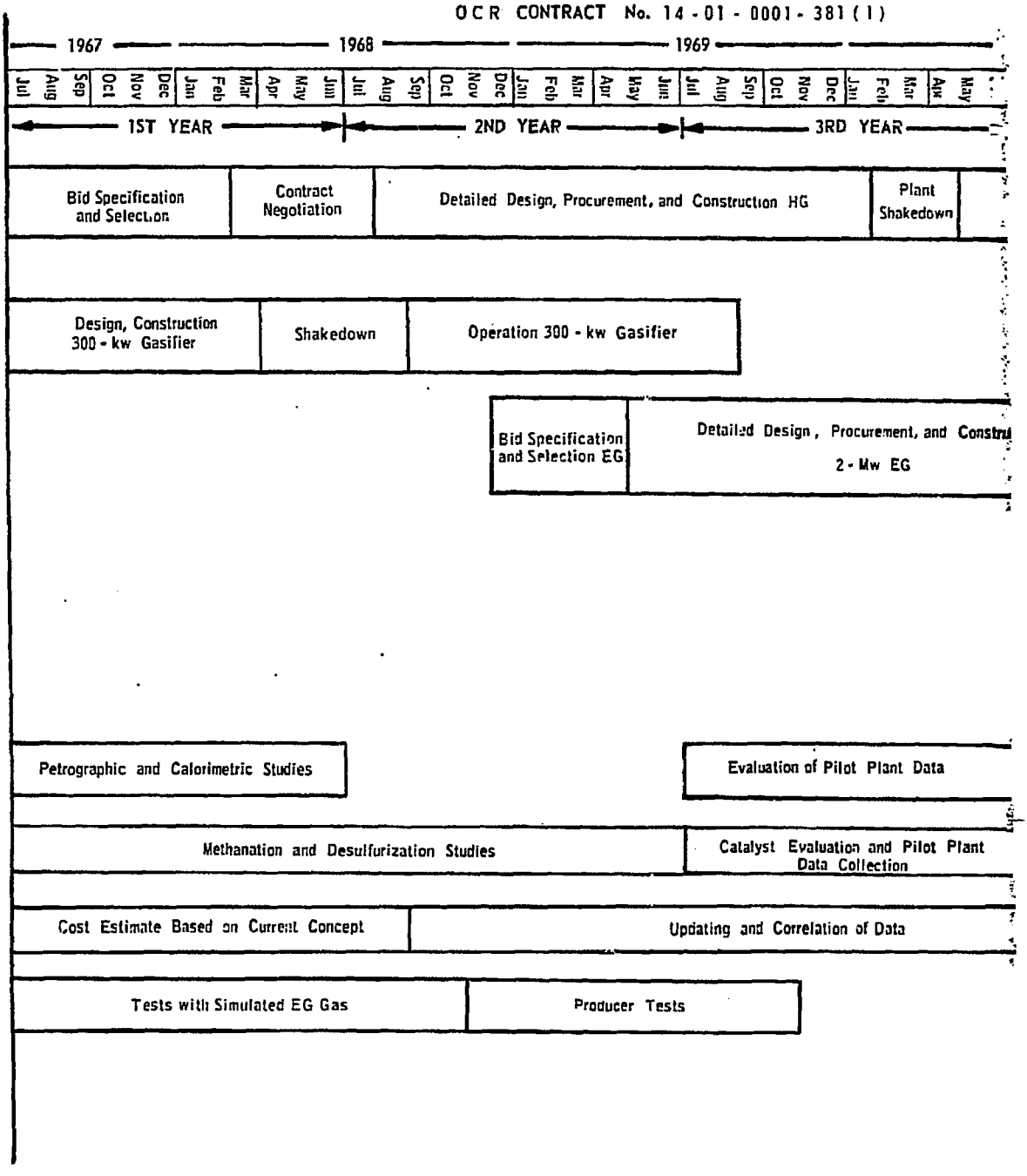
Approved Jack Huebler Signed

Jack Huebler, Research Director

Frank C. Schora, Associate Director

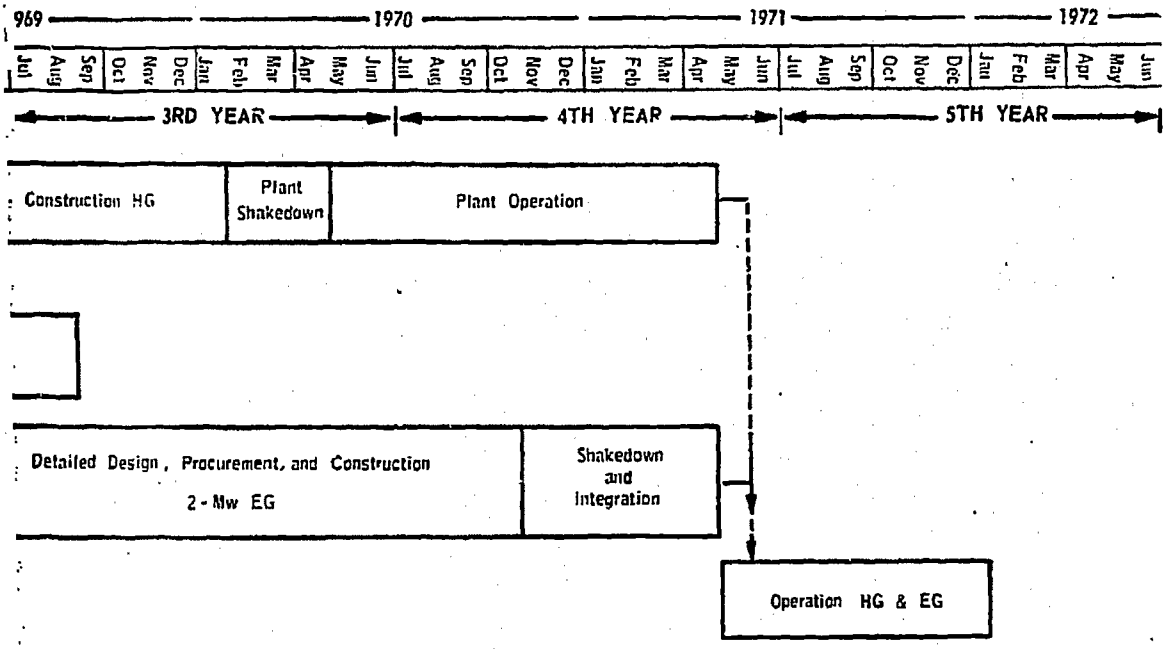
PILOT PLANT PROGRAM OF IGT HYDROG

OCR CONTRACT No. 14-01-0001-381 (1)



RAM OF IGT HYDROGASIFICATION PROCESS

-01-0001-381(1) AGA: IU-4-1



E-881094

2

PROGRESS REPORT

PROJECT:	Institute of Gas Technology Chicago, Illinois Coal Hydrogasification Pilot Plant Procon Job No. W-1784
REPORT NO.:	1
DATE:	August 15, 1968
PROCON PROJECT MANAGER	T. A. Taylor

Distribution:

Institute of Gas Technology	Procon Incorporated	
Mr. F. C. Schora - 10	Mr. M. D. Gilchrist)	
	Mr. J. C. Reed)	
	Mr. A. G. Petkus)	(1)
	Mr. W. R. Fredrick)	
	Mr. W. J. Taylor)	
	Mr. G. A. Speir)	
	Mr. W. H. Grosse	(1)
	Mr. P. N. Sicuro	(1)
	Mr. R. P. Cousins	(1)
	Mr. G. J. Landsberg	(1)
	Mr. T. A. Taylor	(1)
	Field	(1)

PROGRESS REPORT NO. 1

COAL HYDROGASIFICATION PILOT PLANT

FOR

INSTITUTE OF GAS TECHNOLOGY

CHICAGO, ILLINOIS

W-1784

TABLE OF CONTENTS

W-1784

Coal Hydrogasification Pilot Plant

I. SUMMARY

A. DEVELOPMENT OF THE GUARANTEED MAXIMUM PRICE - W-1784 X-1.

Piping and Instrument Diagrams for the Coal Handling and Pretreating, Reaction, Gas Purification and Methanation Sections will be ready for review with IGT during the week of August 19, 1968.

A preliminary general arrangement drawing has been prepared. Work on the several area plot plans has been initiated.

A flow diagram and detailed plot plan has been prepared for the material handling sections. These drawings will be included in the preliminary quotation request that will be sent to vendors.

Organizational and procedural documents are being issued.

B. DESIGN ENGINEERING - W-1784.

A preliminary requisition for the Hydrogasifier Reactor, together with IGT's reactor drawing has been sent to vessel manufacturers for quotations. Discussions are underway with

refractory manufactures to determine a basis for the Reactor refractory specification.

Quotations are being solicitated from building suppliers for the Control House and Warehouse. Approval will be requested from IGT on the Control House arrangement drawing during the week of August 19, 1968.

Studies in progress for early installation of major foundations and underground services distribution.

Numerous vendors have contacted PROCON with reference to the design and supply of various items of equipment and phases of the project.

II. BAR CHART SCHEDULE

The following schedules outline the work to be done in establishing the Guaranteed Maximum Price.

The breakdown of work is by sections of the pilot plant and further by equipment classification.

These bar charts reflect only "early start" and "late finish" dates for the work to be done.

Also included is a schedule of the construction work to be done this year.

SCHEDULE AND STATUS OF ENGINEERING
PROCUREMENT AND CONSTRUCTION

PRATT & WHITNEY

Sheet 1 Rev. 0
Date 8-15-68
By
Job No. W-1784

PO-PLACE PURCHASE ORDER

E – Engineering & Drafting
P – Procurement of Materials
C – Field Construction Work

CONSTRUCTION ACTIVITY THIS YEAR

TIME IN MONTHS FROM STARTING DATE OF: 7-15-68

	DESCRIPTION OF WORK		COMPLETE (%)
01	PLOT PLAN	E E E	PRELIM → INTERIM
		E P C	
	SUBGRADE FOUNDATIONS	E P C	
	PIPING	E P C	
	ELECTRICAL	E P C	
10	BUILDINGS	E P C	PARTIAL
12	ELECTRICAL DISTRIBUTION	E P C	PRELIM
		E P C	
		E P C	
		E P C	
		E P C	
*		E P C	PLOT PLAN SUFFICIENTLY DEFINED FOR CONSTRUCTION OUTLINED ABOVE
		E P C	
		E P C	

REVIEW ESTIMATE

SCHEDULE AND STATUS OF ENGINEERING
PROCUREMENT AND CONSTRUCTION

Sheet 2 Rev. 0
Date 8-15-68
By
Job No. W-1786

PO - PLACE PURCHASE ORDER

E - ~~Engineering & Drafting~~ WRITE REQ. / DWG.
P - ~~Procurement of Materials~~ OBTAIN QUOTES & REVIEW BIDS
C - ~~Field Construction Work~~ ESTIMATE

GENERAL - 10

TIME IN MONTHS FROM STARTING DATE OF: 7-15-63

	DESCRIPTION OF WORK		COMPLETE (%)
01	PLOT PLAN	E E E	PRELIM → INTERIM
03	STEEL STRUCTURES	E P C	
10	BUILDINGS	E P C	PARTIAL →
11	PIPING DISTRIBUTION	E P C	
12	ELECTRICAL DISTRIBUTION	E P C	PARTIAL →
13	CONTROL BOARD	E P C	
18	FIRE PROTECTION	E P C	PARTIAL →
20	SITE IMPROVEMENT	E P C	
25	COMMUNICATION	E P C	PARTIAL →
29	PAVING & FINAL GRADING	E P C	
		E P C	
		E P C	
		E P C	
		E P C	

REVIEW ESTIMATE

SCHEDULE AND STATUS OF ENGINEERING
PROCUREMENT AND CONSTRUCTION

BECHTEL

Sheet 3 Rev. 0
Date 3-15-68
By
Job No. W-1764

PO - PLACE PURCHASE ORDER

E - ~~Engineering & Drafting~~ WRITE REQ. / DWG.
P - ~~Procurement of Materials~~ OBTAIN QUOTES & REVIEW BIDS
C - ~~Field Construction Work~~ ESTIMATE

COAL HANDLING - 1 & PRETREATING - 2

TIME IN MONTHS FROM STARTING DATE OF: 7-15-68

	DESCRIPTION OF WORK		COMPLETE
00	P & ID	E E E	
05	HEATERS	E P C	
06	VESSELS	E P C	
07	EXCHANGERS	E P C	
08	PUMPS	E P C	
09	COMPRESSORS	E P C	
13	INSTRU-MENTATION	E P C	
17	MATERIAL HANDLING EQUIPMENT	E P C	
31	HOPPERS	E P C	
		E P C	
		E P C	
		E P C	
		E P C	
		E P C	

PRELIM
FINAL
PO
REVIEW ESTIMATE

SCHEDULE AND STATUS OF ENGINEERING
PROCUREMENT AND CONSTRUCTION

Date 8-15-68
By
Job No. W-1784

PO-PLACE PURCHASE ORDER

E - ~~Engineering & Drafting~~ WRITE REQ./DWG.
P - ~~Procurement of Materials~~ OBTAIN QUOTES & REVIEW BIDS
C - ~~Field Construction Work~~ ESTIMATE

REACTION SECTION - 3

	DESCRIPTION OF WORK		TIME IN MONTHS FROM STARTING DATE OF: 7-15-68 — COMPLETE (%)
00	P & ID	E E E	PRELIM — FINAL
05	HEATERS	E P C	PO
06	VESSELS	E P C	
06	REACTOR 3-C-2	E P C	PRELIM / PRELIM — PO
07	EXCHANGERS	E P C	
08	PUMPS	E P C	PO
13	INSTRU-MENTATION	E P C	
13	REACTOR VALVES	E P C	PRELIM — PRELIM — FINAL — PO
32	MIXER	E P C	
		E P C	
		E P C	
		E P C	
		E P C	
		E P C	

REVIEW ESTIMATE

SCHEDULE AND STATUS OF ENGINEERING
PROCUREMENT AND CONSTRUCTION

Sheet 5 Rev. C
Date 8-15-68
By
Job No. W-1784

PO-PLACE PURCHASE ORDER

E - ~~Engineering & Drafting~~ WRITE REQ./DWG.
P - ~~Procurement of Materials~~ OBTAIN QUOTES & REVIEW BIDS
C - ~~Field Construction Work~~ ESTIMATE

GAS PURIFICATION - 4

	DESCRIPTION OF WORK		TIME IN MONTHS FROM STARTING DATE OF: 7-15-68	COMPLETE
100	P & ID	E E E	PRELIM FINAL	
06	VESSELS	E P C	PO	
07	EXCHANGERS	E P C		
08	PUMPS	E P C		
13	INSTRU-MENTATION	E P C		
32	MIXER	E P C		
28	PROCESS FILTER	E P C		
24	CHEMICALS & CATALYST	E P C		
		E P C		
		E P C		
		E P C		
		E P C		
		E P C		
		E P C		

REVIEW ESTIMATE

PROCUREMENT AND CONSTRUCTION

Date 8-15-68
By
Job No. W-1756

PO-PLACE PURCHASE ORDER

E - Engineering & Drafting WRITE REQ./DWG.
P - Procurement of Materials OBTAIN QUOTES & REVIEW BIDS
C - Field Construction Work ESTIMATE

METHANATION SECTION - 5

	DESCRIPTION OF WORK		TIME IN MONTHS FROM STARTING DATE OF: 7-15-68 — COMPLETE
00	P & ID	E E E	PRELIM. FINAL
05	HEATERS	E P C	PO
06	VESSELS	E P C	PO
07	EXCHANGERS	E C	
		E P C	
09	COMPRESSORS	E P C	PO
13	INSTRU-MENTATION	E P C	
24	CHEMICALS & CATALYST	E P C	
		E P C	
		E P C	
		E P C	
		E P C	
		E P C	
		E P C	

REVIEW ESTIMATE

SCHEDULE AND STATUS OF ENGINEERING
PROCUREMENT AND CONSTRUCTION

Sheet 7 Rev. 0
Date 8-15-68
By
Job No. W-1734

PO- PLACE PURCHASE ORDER

E - ~~Engineering & Drafting~~ WRITE REQ. / DWG.
P - ~~Procurement of Materials~~ OBTAIN QUOTES & REVIEW BIDS
C - ~~Field Construction Work~~ ESTIMATE

BLOWDOWN & DISPOSAL - 6

TIME IN MONTHS FROM STARTING DATE OF: 7-15-68

	DESCRIPTION OF WORK		COMPLETE (%)
00	P & ID	E E E	
06	VESSELS	E P C	
07	EXCHANGERS	E C	
03	PUMPS	E P C	
13	INSTRU-MENTATION	E P C	
17	MATERIAL HANDLING EQUIPMENT	E P C	
22	INCINERATOR	E C	
	ENGINEERED PACKAGED SYSTEMS	E P C	
		E P C	
		E P C	
		E P C	
		E P C	
		E P C	

PRELIM
FINAL
FINAL
PO
PO
PO
REVIEW ESTIMATE

PROCUREMENT AND CONSTRUCTION

Date 8-15-68
By
Job No. W-1784

PO-PLACE PURCHASE ORDER

E – Engineering & Drafting WRITE REQ./DWG.
P – Procurement of Materials OBTAIN QUOTES & REVIEW BIDS
C – Field Construction Work ESTIMATE

UTILITY PLANT - 7

TIME IN MONTHS FROM STARTING DATE OF: 7-15-68

	DESCRIPTION OF WORK		COMPLETE (%)
00	UTILITY FLOW DIAGRAM	E E E	
05	HEATERS	E P C	
06	VESSELS	E P C	
08	PUMPS	E P C	
13	INSTRU-MENTATION	E P C	
27	TANKS	E P C	
09	COMPRESSORS	E P C	
22	INSTRUMENT AIR PACKAGE	E P C	
22	COOLING WATER TREATMENT	E P C	
22	H_2 PLANT	E P C	
00	BOILER FLOW DIAGRAM	E P C	
22	B. W. TREATMENT	E P C	
19	BOILERS	E P C	
		E P C	

PRELIM FINAL

PO

PO

PO

PO

PRELIM FINAL

PO

REVIEW ESTIMATE

CONTRACT FINANCIAL REPORT (Dollars in thousands) (See instructions before preparation)	1 For Month Ended	2 No. of Work Days	3 Contract No.	Form Approved Budget Bureau No. 80R0178 Sheet _____ of _____
4 To:	5 From:		6 Contract Value $	7 Contract Type
			8 Funded Contract Amount $	9 Amounts Billed $
10 Program/Scope of Work	11 Signature and Title of Authorized Representative		12 Preparation Date	13 Payments Received $

14 Appropriation (or Fund Citation) and/or Reporting Category	15 Cost Incurred/Contract Earnings			16 Planning Data (For Agency use only)			
	Cum. Actual End of Prior Mo. a	Actual/ Estimated Current Month b	Cumulative Actual/ Estimated To Date c	a	b	c	d
Procon Incorporated W-1784	$ -0-	$ 1	$ 1				
W-1784 X-1	-0-	3	3				

"The undersigned certifies that the amount is due and payable to PROCON, in accordance with the terms of the contract up to the date of this Certificate and that Contractor has fully complied with the terms and conditions of the contract."

T. A. Taylor

T. A. Taylor

17 Total							

IGT-MPR--9/68

DEVELOPMENT OF IGT HYDROGASIFICATION PROCESS

Progress Report - September 1968

to

Office of Coal Research

Contract No. 14-01-0001-381 (1)

Summary

- Hydrogasification tests were made with Montana subbituminous coal without the need for pretreatment.
- The electrothermal test reactor program was started.
- Reactor temperatures up to 1800°F were attained. We used initial power inputs of 20 kW.
- The economic study for a 500 billion Btu/day hydrogasification plant was submitted to OCR for publication.
- The first phase of the work by Procon, in which the Guaranteed Maximum Price will be established, is estimated to be 20% complete.

BLANK PAGE

Hydrogasification Test Program

We conducted three hydrogasification tests this month in the balanced-pressure pilot unit (Run HT-210, HT-211, and HT-212). Run HT-210 was an extension of our study of the hydrogasification of a lightly pretreated Pittsburgh seam bituminous coal from the Ireland mine with a mixture of synthesis gas and steam. The objective of this test was to obtain data at comparatively high coal conversions for use in our basic kinetic studies of the synthesis gas-steam-coal hydrogasification system. In Runs HT-211 and HT-212 we began our studies of the hydrogasification behavior of a Montana subbituminous coal with hydrogen and steam. This coal was obtained from Montana Power Co.'s Colstrip mine. It was dried to a 3% moisture level for hydrogasification use, but otherwise was untreated.

Operating conditions of Run HT-210 were set to provide a coal residence time of close to 1 hour and a hydrogen/coal ratio of 50% of stoichiometric. The coal was fed at a nominal rate of 14 lb/hr and reacted in a 7-ft fluidized bed with 530 SCF/hr of synthesis gas (54% hydrogen, 41% carbon monoxide, and 5% carbon dioxide) and 25 lb/hr of steam. Steam concentration in the feed gas mixture was 50 mole percent. Temperature of the coal bed was 1600°-1700°F. This was a successful run of over 6 hours, with 3 hours of steady-state operation. Results showed that 42% of the carbon in the coal was gasified, and nearly 2% of the carbon was converted to liquids.

In Runs HT-211 and HT-212, the successful feeding and hydrogasification of an untreated Montana subbituminous coal was

demonstrated. The coal, after drying, reacted in a 3-1/2-ft fluidized bed with a mixture of hydrogen and steam without agglomerating. Run HT-211 was terminated after only 2 hours because of reduced power input to the reactor heaters, which was caused by a burned power supply cable. The reactor bed temperature averaged only 1125°F at the reduced heat input. In Run HT-212 the coal was fed at a nominal rate of 50 lb/hr and made to react with 530 SCF/hr of hydrogen and 25 lb/hr of steam. Coal bed temperatures were in the desired 1600°-1700°F range. This run lasted over 5 hours, about 3 hours of this time at steady state before voluntary termination. Based on the weight of the residue recovered, over 50% of the coal was converted.

Methanation Test Program

All measuring and analyzing instruments were recalibrated to improve precision so that experimental work can be carried out to determine a more exact generalized rate equation. From previous studies, we found that at constant temperature and pressure the hydrogen reaction order is about 3/4 and the CO reaction order about 1. We are now also investigating the reaction order of other components: CH_4, CO_2, and H_2O.

Economic Studies

The completed economic study of a 500 billion Btu/day hydrogasification pilot plant was submitted to OCR for publication. A supplementary study was started to determine the effects on gas price of capitalizing the mining operation with the gasification plant.

Electrothermal Gasification Test Program

Following the repair of the SCR control regulator, several tests were conducted to determine the operating characteristics of the electrothermal pilot unit. The reactor was filled with hydrogasified char and the bed was fluidized with nitrogen. A 1-1/2-in.-diam Type 440 stainless steel electrode was submersed 18 in. into the fluidized bed. To begin the heating, 100 volts was applied across the bed. The overall resistance was measured as 2.0 ohms. During the heat-up period the resistance decreased until it fluctuated between 0.75 and 1.50 ohms. The power input was varied from 2.0 to 20.0 kW, and reaction of the bed temperatures to the various power levels was observed. The bed was heated to 1800°F during the tests.

A batch test was then attempted with steam in place of nitrogen and hydrogasified char as the reactants. The unit was brought to 1800°F using nitrogen as the initial fluidizing gas. When we switched from nitrogen to steam at the reactor inlet, a resulting sudden loss in gas flow through the superheater caused the high-temperature safety interlock to trip out, which shut down that unit. The superheater could not be restarted due to an overheated solenoid on the air prepurge dampener which prevented the starting sequence from operating. Also, the steam flow control valve did not operate properly at this same time and allowed the full flow of steam from the generator to enter the reactor. The surge of gas carried solids from the bed into the make gas outlet piping and caused a plug. At this point the run was terminated.

Several changes were made prior to the next test. These included 1) placement of a bayonet-type sintered metal filter at the make gas outlet of the reactor to prevent solids carryover, and 2) rearrangement of the nitrogen line to the superheater so the changeover from nitrogen to steam could be made without an interruption of gas flow.

The next test, Run E.G.-1, was made as a batch test under the same conditions as the first batch test, with the objective of observing the operation of the system while feeding steam. The reactor was heated to 1800°F with nitrogen as the fluidizing gas. The applied d-c voltage was 100 V at a power input of 12 kW. The steam feed rate was 31 lb/hr; a nitrogen purge at the top of the unit was 75 SCF/hr. The bed temperature decreased to 1650°F in 15 minutes after the addition of steam. The voltage was increased to 120 V, which resulted in a power input of 18 kW. The bed temperature increased to 1720°F, and the system reached a steady-state operating period. After about 1/2 hour of steady operation the overall resistance of the system rapidly decreased, allowing the current flow to reach 2000 A. The power to the reactor was immediately switched off and the run was terminated.

Inspection of the unit following the test indicated that a portion of the ceramic sleeve that insulates the electrode from the reactor shell had broken and fallen into the reactor. Coal particles then filled the void, causing a low-resistance path from the electrode to the reactor wall. The 1-1/2-in.-diam electrode was melted about halfway through, and a 1-in.-diam hole about 1 in. deep was burned out of the top reactor hub. The

damage to the reactor hub will not prevent further testing to lower pressures (0-250 psig) because it occurred at a point that is 5 in. thick — where the temperature is below 500°F during operation. A replacement has been ordered for use at higher temperatures.

A product gas sample taken during the steady-state operation of Run E.G.-1 is as follows:

	%
Nitrogen	21.7
Carbon Monoxide	14.8
Carbon Dioxide	13.1
Hydrogen	48.8
Methane	1.6
Total	100.0

From the analysis and product gas flow rate, this corresponds to 23.5% conversion of the steam fed during the 1/2-hour period.

The pilot unit is now being prepared for further testing at low pressures with continuous feeding of hydrogasified char.

Hydrogasification Pilot Plant

Procon progress report No. II (included) covers the work during the last 30 days.

During the month no new inventions were made in the course of the work.

Approved Jack Huebler
Jack Huebler
Research Director

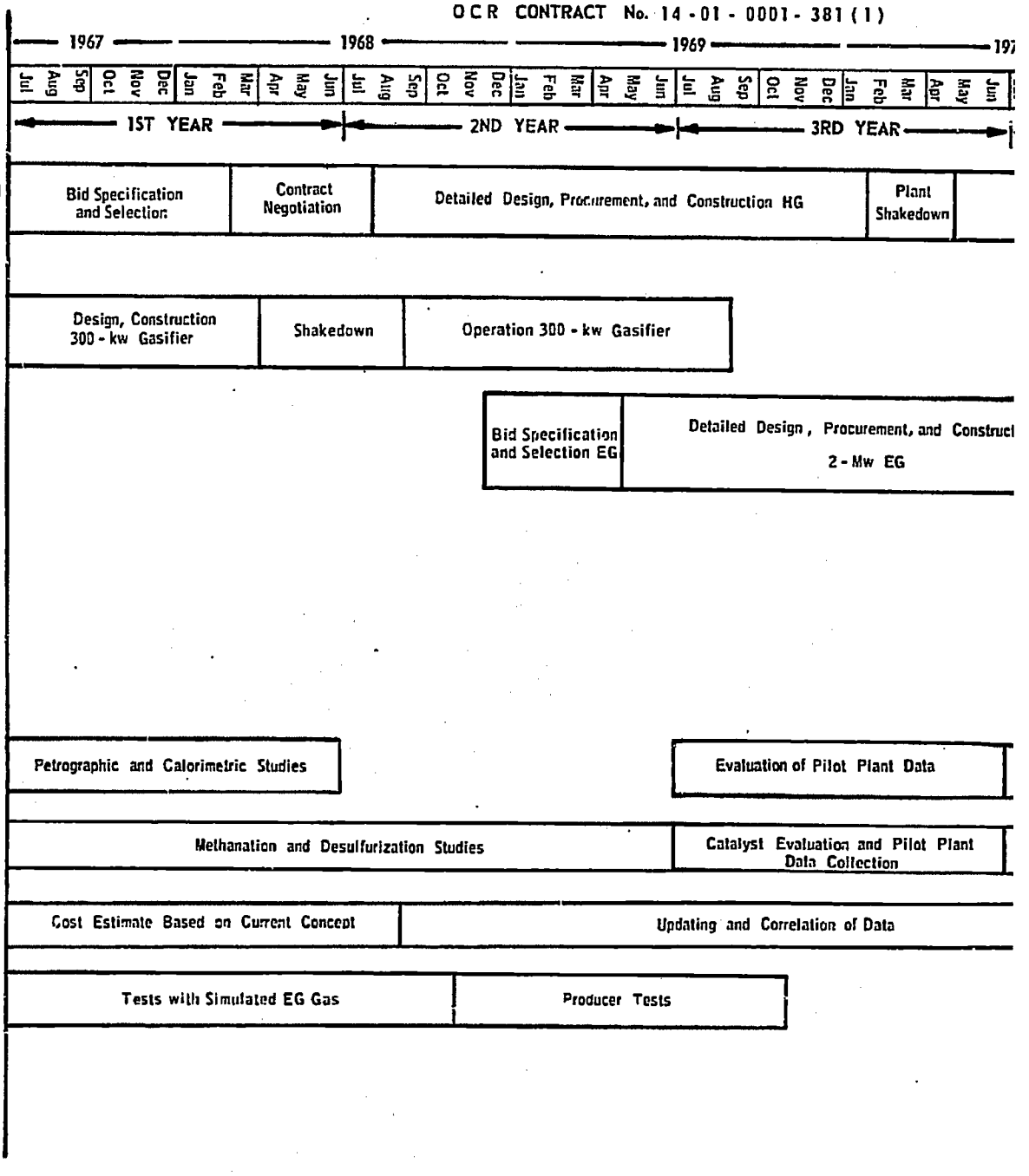
Signed Frank C. Schora
Frank C. Schora
Associate Director

Direct Salary Charges for the Month of September 1968

Name	Regular Hourly Charge	Hours Charged	Premium Hourly Charge	Hours Charged	Amount
A. Anthony	5.0511	7	6.8400	14	$131.12
T. Stanislawski			8.0100	24	192.24
M. Cerf	3.3277	136	4.6037	8	489.39
D. E. Fleming	4.2029	152	5.3766	21	751.75
W. Podlecki	4.8584	160	6.2327	29	958.09
N. Andrejczuk	3.1142	13			40.48
E. Becker	8.8088	16			140.94
W. Chalecki	4.8177	12			57.81
H. Feldkirchner	8.5817	20			171.63
S. Grom	4.1683	9			37.51
J. Huebler	16.7164	24			401.19
B. Lee	12.6486	148			1,871.99
H. Mensch	7.3892	15			110.84
D. Olson	6.2052	8			49.64
F. Schora	14.1955	100			1,419.55
E. Beer	7.1131	32			227.62
A. Lee	8.5486	120			1,025.83
T. Subramanima	6.2124	76			472.14
D. Tajbl	8.7786	64			561.83
H. Dirksen	9.5549	37			353.53
J. Arora	5.8725	50			293.63
T. Joyce	14.1955	24			340.69
L. Pimentel	3.7500	8			30.00
C. Tsaros	9.7080	76			737.81
A. Attari	7.8861	62			488.94
J. Chisholm	8.0474	8			64.38
J. Lundquist	5.2077	11			57.28
E. Maeda	4.5609	7			31.93
A. Mikulic	4.4039	63			277.45
J. Nagel	3.0812	62			191.03
N. Petrulis	3.5887	89			319.39
A. Somora	5.2767	2			10.55
D. Mason	8.7143	102			888.86
J. Budz	4.5868	78			357.77
D. Hunecke	4.9318	14			69.05
M. Manka	4.5824	12			54.99
E. Pyrcioch	7.7683	160			1,242.93
V. Kavlick	7.1727	152			1,090.25
J. Marscalek	5.2326	6			31.40
J. Meek	8.0996	136			1,101.55
R. Romero	4.1154	160			658.46
L. Toomey	3.6476	152			554.43
					$ 18,357.89

PILOT PLANT PROGRAM OF IGT HYDROGAS

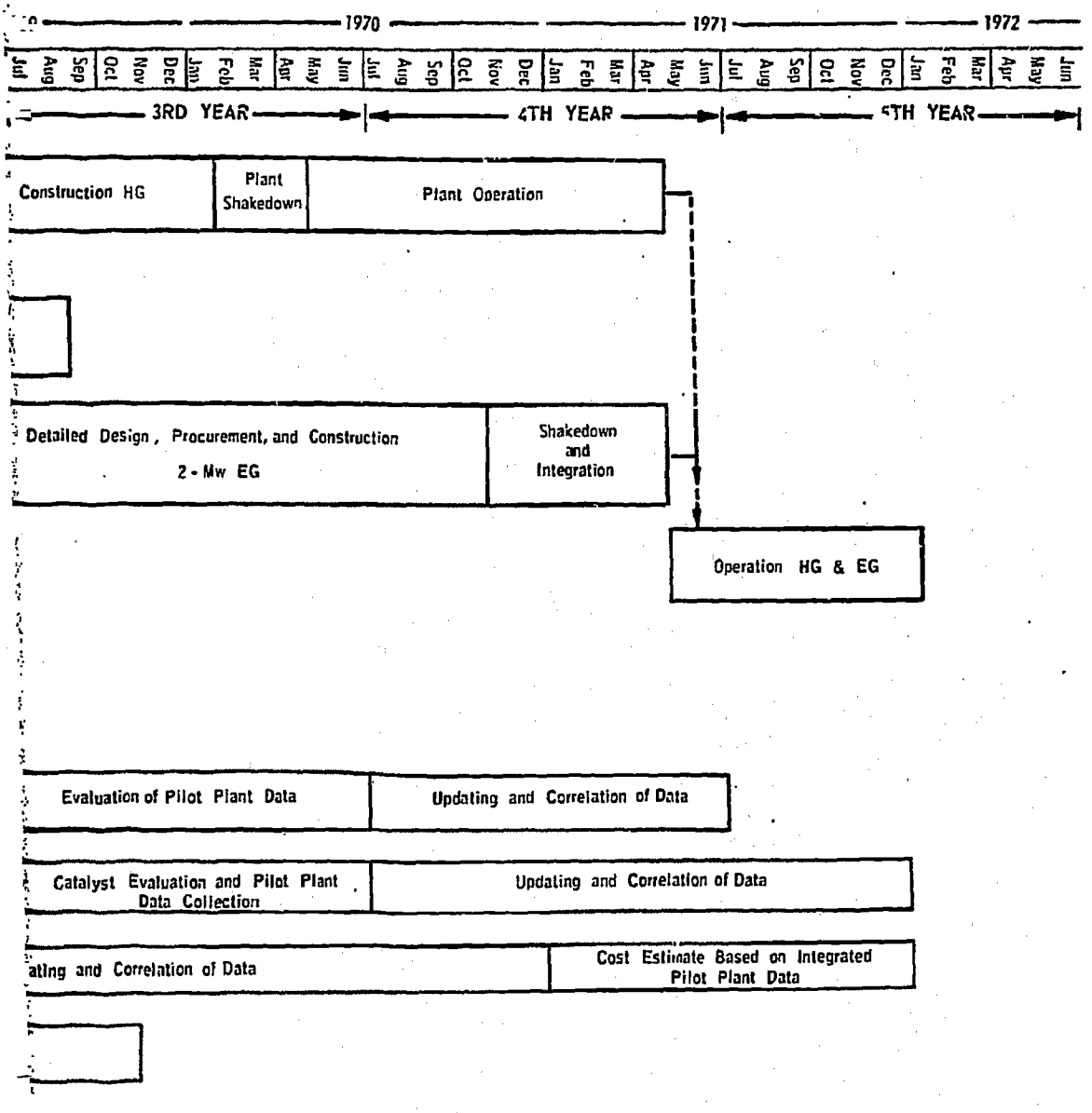
OCR CONTRACT No. 14-01-0001-381(1)



BLANK PAGE

RAM OF IGT HYDROGASIFICATION PROCESS

-01-0001-381(1) AGA: IU-4-1



E-881094

2

PROGRESS REPORT

PROJECT:	INSTITUTE OF GAS TECHNOLOGY Chicago, Illinois Coal Hydrogasification Pilot Plant Procon Job No. W-1784
REPORT NO.:	2
DATE:	September 16, 1968
PROCON PROJECT MANAGER:	T. A. Taylor

Distribution:

Institute of Gas Technology	Procon Incorporated	
Mr. F. C. Schora - 10	Mr. M. D. Gilchrist)	
	Mr. J. C. Reed)	
	Mr. A. G. Petkus)	(1)
	Mr. W. R. Fredrick)	
	Mr. W. J. Taylor)	
	Mr. G. A. Speir)	
	Mr. W. H. Grosse	(1)
	Mr. P. N. Sicuro	(1)
	Mr. R. P. Cousins	(1)
	Mr. G. J. Landsberg	(1)
	Mr. T. A. Taylor	(1)
	Field	(1)