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PIPELINE GAS FROM COAL-HYDROGENATION (IGT HYDROGASIFICATION PROCESS)

Project 9000 Monthly Status Report

For the Period April 1 through April 30, 1977

Prepared by

Institute of Gas Technology

IIT Center, 3424 S. State Street

Chicago, Illinois 60616

Date Published — May 1977

MASTER

Prepared for the

UNITED STATES ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

Under Contract No. EF-77-C-01-2434

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INSTITUTE OF GAS TECHNOLOGY · IIT CENTER · CHICAGO 60616

Project Status Report

for

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION

and

AMERICAN GAS ASSOCIATION

Report for

April 1977

ERDA Report No. FE-2434-13

Project Title Pipeline Gas From Coal – Hydrogenation (IGT Hydrogasification Process)

ERDA Contract No. EF-77-C-01-2434

I. PROJECT OBJECTIVE

The objective of this project is to continue and advance pilot plant studies (initiated under prior contract) directed at the development of a commercial process for the production of pipeline-quality gas from coal; to demonstrate the feasibility of the HYGAS® pilot plant to produce substitute natural gas using lignite, bituminous, and subbituminous coal feedstocks.

II. SUMMARY

Test 60 was conducted during April and 186 hours of self-sustained operation were achieved. The pretreater operation was satisfactory at an average temperature of 775°F. Slurry feed to the reactor was initiated at 1930 hours on March 30, and Test 60 was terminated at 1300 hours on April 8 when we were unable to fix a leak in a Grayloc flange on the reactor steam-spent char carrier line.

The test was interrupted twice, once when solids flow out of the second-stage gasifier stopped and once when mechanical problems occurred in several pumps. The reactor was in excellent condition after the run. Preliminary results for several, short, steady-state periods, selected for analysis, are presented in this report.

The light-oil recovery unit operated satisfactorily during Test 60. Installation of the new surge pot is almost complete.

The liquid-phase methanation unit was operated for 2 hours during Test 60, until a process upset caused flooding in the quench system. This, in turn, caused a carry-over of diglycolamine solution into the liquid-phase methanation unit, reducing the activity of the catalyst by two-thirds. The spent catalyst has been replaced.

III. ACHIEVEMENTS

Task 1. Pilot Plant Tests With Bituminous Coal

We made the following operating changes after Test 59 to provide more reliable feed to the reactor:

a. Tests were run on the coal mill, varying solids residence time and superficial velocity to determine optimum settings for crushed-coal size consist.

b. The pretreater feed lockhopper was modified by enlarging the gas vent line on the lower lockhopper from 1 to 3 inches and by reinstalling the lower level probe to eliminate interference from packed coal around the dead space near the base of the probe.

c. Experimental results indicated that the char-cooler fluidizing velocity should be kept at 0.45 ft/s. The increased velocity should improve heat transfer in the bed and prevent clinker formation.

Pretreater operation began at 2025 hours on March 29. Operation was interrupted briefly when the motor on the pretreater quench-water pump burned out. We resumed pretreater operation after the motor was replaced; it began providing nonagglomerating coal to the reactor at 1530 hours on March 30. The pretreater operated satisfactorily during Test 60. The modifications made before the test alleviated most of the coal-feeding problems of Test 59. Coal feed rates to the pretreater ranged from 2.5 to 3 tons/hr, and operating conditions were set at 775°F, with oxygen-to-coal ratios of 2 to 2-1/2 SCF of oxygen per pound of coal. After Test 60 was ended, the pretreater was operated at 700° and 750°F with coal feed rates of about 2 tons/hr, to find out the pretreater performance at these conditions. Table 1 summarizes the results of the tests, which show that nonagglomerating feed can be produced at pretreater temperatures of 750°F and higher. The pretreater temperature for Test 61 will, therefore, be set at a range from 750° to 775°F.

We inspected the pretreatment section after Test 60 and found a clinker on the north wall of the pretreater. The clinker was a typical hard, red, high-ash-content material. The clinker extended 8 to 10 inches from the wall and was 10 to 12 inches high.

When the char-cooler vessel was opened up, a clinker formation was found covering the entire fluidizing ring. The highest position of the formation was on the north wall. This clinker was also mostly hard, red ash. The clinkers found in both the pretreater and the char cooler could have been caused by the oversized material that escaped the ripped oversize (14 mesh) screen on the Sweco screener. The coal-feed screen analysis received after the test shows that the screen was ripped during the

Table 1. COMPARATIVE PRETREATMENT TEST RESULTS

	Test 59[c]	Test 60[d]	Special Tests[e] Period A	Special Tests[e] Period B
Temperature, °F	773	762	700	750
Bed Height, ft	10.4	11.8	4.5	5.8
Bed Density, lb/cu ft	18.1	17.2	28.6	22.4
Air, pph	3828	3265	3500	3150
Coal Feed, tons/hr	2.36	2.0	2.11	2.11
Mean Residence Time, min	109	133	78	79
IGT Boat Test Results	0	0	1	1
	0	0	4	1
	0	0	3	0
	0	0	4	1
Volatile Matter, wt %	22.8	21.6	30.0	23.7
SCF O_2/lb Coal[a] (Dry)	2.4	2.3	2.4[a]	2.2[a]
Degree of Pretreatment,[b] %	24	19	14	13

[a] 6% moisture assumed.

[b] Averaged ash, feed coal assumed to have 10.66% ash.

[c] Period from 1530 to 1830 hours (3/14/77).

[d] Period from 0030 to 0830 hours (4/1/77).

[e] Conducted at termination of Test 60.

morning of April 1. Vibration problems could have caused the failure of the screen during Test 60 as one of three springs supporting the screener motor was found to be broken. Following its repair after Test 60, the Sweco screener was tested to see if the screen would rip from normal vibration. It did not. As a safeguard, a sample will be taken from the feed to the pretreater and will be screened to check for oversize material during every shift.

We inspected the pretreater venturi scrubber and quench tower and found a buildup of tar and coal fines on the wall of the scrubber and a large accumulation at the bottom of the quench tower. The pretreater section was cleaned up and readied for Test 61.

Pressure testing of the 24-inch Grayloc closure on the start-up heater and on Manway 0 was satisfactory. The heat-up cycle was begun on March 28 at 0620 hours. Slurry feed to the reactor was initiated at 1930 hours on March 30. Smooth solids flow was established on March 31 at 2000 hours, and the external start-up heater was shut off. Coal feed had to be taken out of the gasifier at 0130 hours on April 2 when solids flow from the second-stage gasifier to the steam-oxygen gasifier was stopped. We made a continuous effort to establish solids flow. By late evening on April 2, solids transfer was reestablished, and solids feed was resumed on April 3 at 0600 hours. The solids feed rate ranged from 1 to 2 tons/hr. Mechanical problems with several pumps necessitated stopping the coal feed on April 5. The low-pressure slurry pumps supplying slurry to the high-pressure pumps, the high-pressure water pump supplying quench water to the cyclone pot and the spent char pot, the light-oil recirculating pump for oil to the slurry mixing tank, the high-pressure amine pump, the caustic injection pump for caustic wash, and the spent-char slurry recirculating pump all had mechanical problems. These pumps were fixed, and coal feed to the gasifier was resumed at 1800 hours the same day.

Test 60 was terminated at 1300 hours on April 8 when attempts to fix the leak at a Grayloc coupling in the char carrier steam line downstream of the reactor failed. Test 60 had been self-sustained since 1900 hours on March 31 for a total of 186 hours. Two hundred and seventy-eight tons of raw bituminous coal were fed to the pretreater over 102 hours. A total of 165 tons of char was fed to the gasifier.

The gas purification section was put on-stream with the gasifier and it removed CO_2 and H_2S satisfactorily. Product gas from the HYGAS reactor system was introduced to the liquid-phase methanation pilot unit at 1930 hours on April 4. Conversion was achieved for 2 hours. At 2130 hours, a process upset in the HYGAS plant allowed the diglycolamine solution to overflow through the absorber system and enter the

liquid-phase methanation pilot unit together with the product-gas stream. This terminated test operations on the liquid-phase methanation pilot unit.

A post-run inspection of the gasifier revealed that it was in excellent shape. The slurry dryer was clean except for a small amount of coal dust. The solid transfer lines were all clear, and the second-stage reactor was clean. Pieces of refractory bricks, which had fallen from Manway 3's insulating brick layer, were found in the grid area. The steam-oxygen gasifier was clean, and the steam-oxygen sparger and the stripping-steam ring were both in good condition. The reactor was cleaned and readied for Test 61.

A significant amount of coal had accumulated in all three vessels, the prequench tower, the quench tower, and the quench separator, in the quench system. This was expected after Test 60. There were indications that the quench system had flooded during the test, on April 4, when the gas purification section also flooded. The sequence of events can be traced to overfilling the reactor slurry dryer area, which caused solids overflow into the cyclone section, resulting in a malfunction of the cyclone and eventually in solids buildup in the quench system. The inability to indicate true levels in the quench separator and prequench tower because of excessive solids in the vessel and poor oil-water separation, allowed flooding of the quench tower. This precipitated filling and flooding of the absorber and, eventually, in the carry-over of diglycolamine in the purified gas to the liquid-phase methanation pilot unit.

We cleaned all the quench section vessels and cleaned and calibrated the level control instrumentation on those vessels. The entire charge of diglycolamine solution in the purification section was decanted so that the absorber, the regenerator, and the reboiler could be cleaned thoroughly for the next test.

Routine maintenance was done on the utility area. A hot spot developed on the hydrogen plant reformer stack. The hydrogen plant was shut down and the reformer furnace burner assembly removed. Scaffold was installed inside the stack to reach the hot spot-area. We found that a 2-foot by 2-foot section of refractory just below the stack dampener had spalled and fallen off. The refractory was replaced, and the hydrogen plant will be readied for Test 61.

Several, short, steady-state periods in Test 61 were selected to yield operation information for the plant. We are awaiting results from the laboratory. Preliminary information indicated that coal conversions ranged from 60% to 70%. (See Table 2.) Mechanical status of the HYGAS plant is shown in Figure 1.

Table 2. PRELIMINARY RESULTS FOR TEST 60 STEADY-STATE PERIODS FOR ENGINEERING DATA

From April 4 (1500 Hours) to April 4 (1800 Hours)

Spent-Char Samples, % ash 30.08
27.29

Pretreated Char Sample, % ash* 13.5

Coal Gasified, % 63.7, 58.4 } Avg 61.05

SOG Bed Temperature, °F 1515

From April 1 (1900 Hours) to April 1 (2200 Hours)

Spent-Char Samples, % ash 30.07
33.61

Pretreated Char Samples, % ash* 13.5

Coal Gasified, % 63.7, 69.2 } Avg 66.5

SOG Bed Temperature, °F 1640

From April 1 (0400 Hours) to April 1 (0800 Hours)

Spent-Char Sample, % ash 38.87

Pretreated Char Sample, % ash* 13.5

Coal Gasified, % 75.5

SOG Bed Temperature, °F 1575

* 13.5% ash estimated from early pretreater samples.

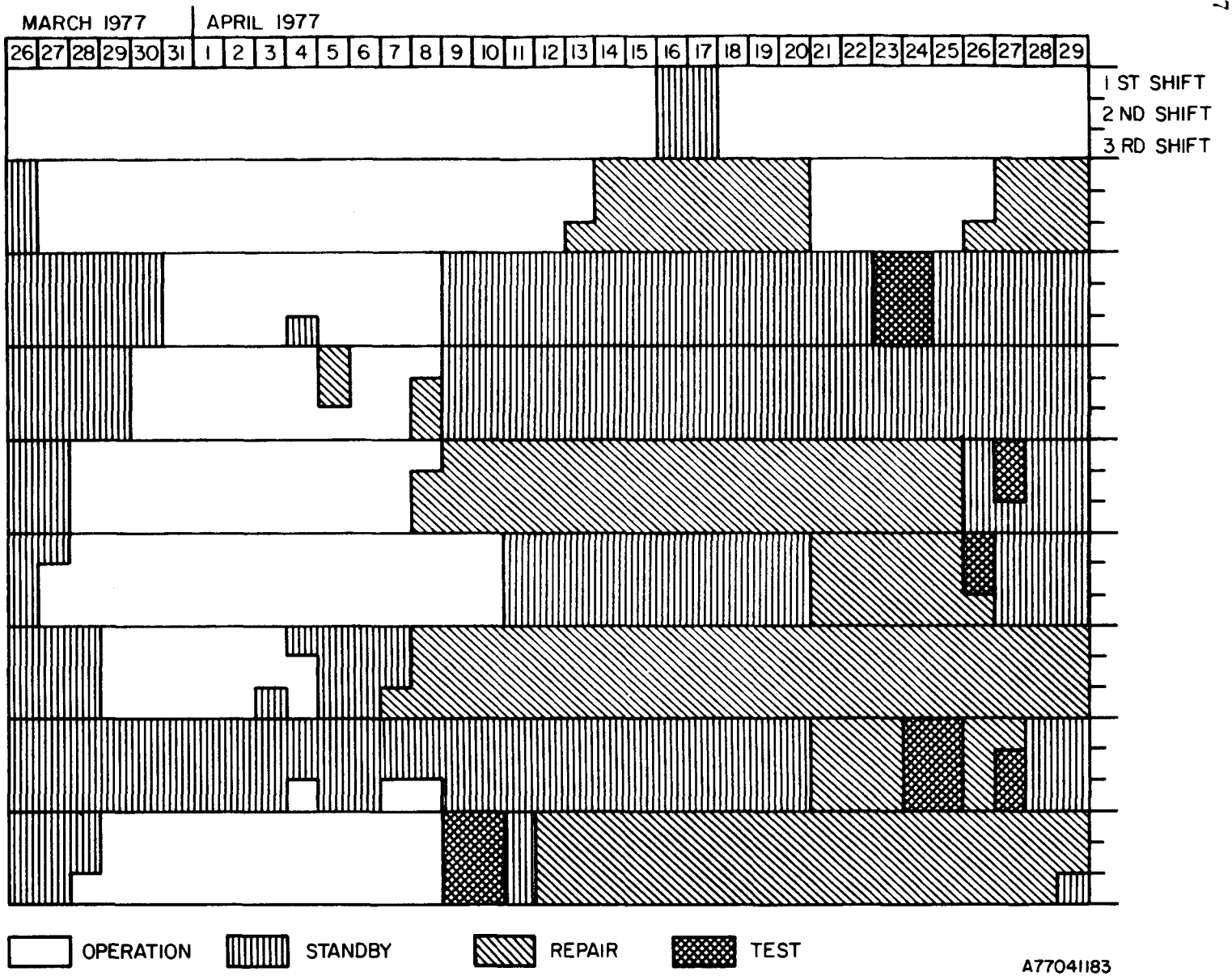

Figure 1. MECHANICAL STATUS OF THE HYGAS PLANT FOR APRIL 1977

A debriefing session on Test 60 was held on April 19. K. Rees, ERDA representatives, W. G. Bair, J. Meek, F. Lau, and R. Laurens of IGT participated in the meeting.

Task 2. Effluent Treatment and Water Reuse

The light-oil recovery unit operated satisfactorily during Test 60. We inspected the stripper vessel and found it to be fairly clean. The separator was full of coal, possibly because of excessive solids and gas carried from the cyclone slurry pot. The separator was cleaned. The new surge pot for the light-oil recovery system was nearly completed. All of the vessels and equipment have been installed, and the instrumentation is being completed.

Task 3. Methanation Test

The IGT fixed-bed catalyst methanation system is currently on standby.

The LPM pilot unit was operated by Chem Systems, Inc., during Test 60 for 2 hours on April 4. The catalyst was active. After 2 hours of operation, a process upset caused by flooding of the quench and purification systems resulted in a slug of diglycolamine solution entering the liquid-phase methanation pilot unit. The test was terminated. To determine the activity of the catalyst, Chem Systems' personnel fed a high H_2/CO ratio gas from the hydrogen plant reformer to the liquid-phase methanation pilot unit. These tests indicated that the liquid-phase methanation catalyst had lost two-thirds of its original activity. Chem Systems representatives then decided to remove the old catalyst and recharge it with a fresh batch. The Zingard sulfur-guard catalyst was also replaced with a commercial Girdler 07-2 zinc oxide sulfur-guard catalyst.

Task 4. Material Testing

Exposure for MPC corrosion and erosion test coupons was carried out during April.

Task 5. Project Review

No work was done under this task.

Task 6. Engineering Services

After reviewing the results of Test 60, we concluded that the process upset resulting in flooding of both the quench system and the gas purification system was caused by a) the high bed level in the slurry dryer area that caused excessive solids carry-over, b) inefficient operation of the cyclone, and c) improper level control in the vessels because of interference from solids in the instruments. For Test 61, the slurry

dryer bed will be controlled at about a 5-foot bed height. This will allow a 15-foot freeboard, which is sufficient to minimize fines elutriation. We will closely monitor the operation of the cyclone system to ensure that the diplegs and slurry pot are operating properly. With minimum fines elutriation from the reactor, the operation of the cyclone and slurry pot should be troublefree. The same will apply to the level control instrumentation on the quench vessels, which have been cleaned, calibrated, and put back in service.

We encountered considerable difficulties in transferring solids from the second-stage reactor to the steam-oxygen gasifier. Data from Test 60 showed that the steam-oxygen gasifier bed was kept too deep because of low bed densities with this coal. With the additional pressure drop on the refractory grid caused by refractory brick that had fallen from Manway 3 insulating bricks, the seal capacity available on Standpipe 339 was marginal. This pressure imbalance caused the stoppage of solids flow. At times there were indications also that the second-stage gasifier was filled up and might have caused problems in solids downflow from the slurry dryer bed to the lift-line gasifier. Therefore, we decided that, for Test 61, the steam-oxygen gasifier bed level will be kept at 12 feet and the second-stage gasifier bed level will not exceed 15 feet.

With this better understanding of the new coal's behavior and characteristics, operations during Test 61 should be smoother.

IV. Problems

No critical problems were encountered during April.

V. Patent Status

The work performed during April as reported herein is not considered patentable.

VI. Work Plan and Schedule

A work schedule for the HYGAS Process is presented in Figure 2.

Approved _____
Bernard S. Lee
Vice President

Signed Wilford S Bair
Wilford G. Bair
Director

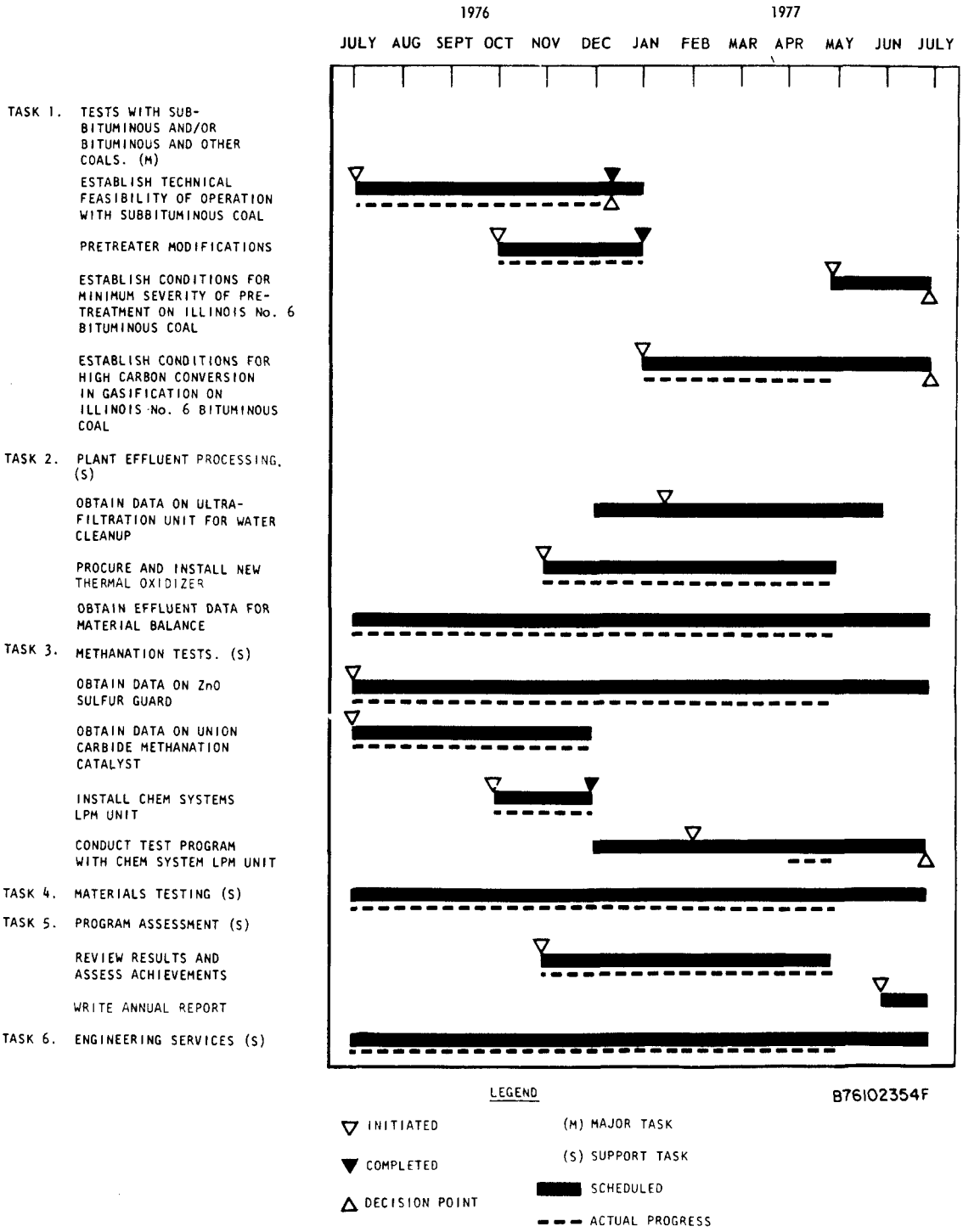

Figure 2. WORK SCHEDULE