Section 18

KILnGAS COAL GASIFICATION PROCESS: STATUS

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INTRODUCTION

This paper presents an update on the KILnGAS coal gasification demonstration program. Specifically, the paper addresses the status of the KILnGAS Commercial Module (KCM) test program, focusing on the 60-day demonstration on Illinois No. 6 coal, which was recently completed.

BACKGROUND

Conceptual feasibility of the KILnGAS process was established in the early 1970's. After subsequent engineering development and demonstration assessment programs, a decision was made to build a commercial-scale demonstration plant, called the KILnGAS Commercial Module (KCM). Design and construction of the plant was accomplished in the 1980-1983 time frame, as is shown in Figure 1. Startup

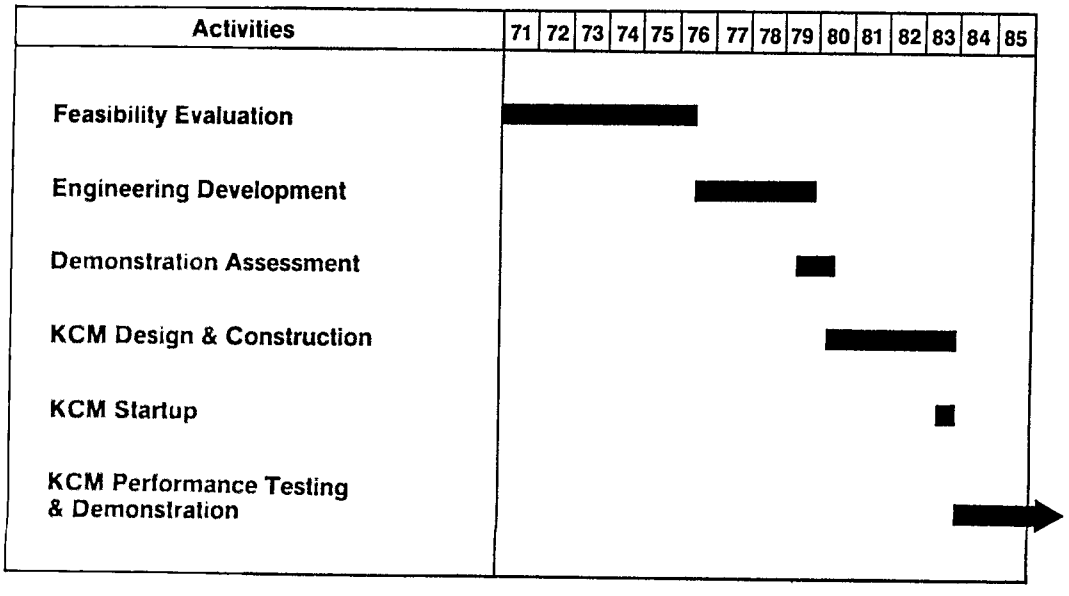

Figure 1. KILnGAS Development Time Table

was initiated in mid-'83 and performance testing began in 1984 with completion of the 60-day Illinois coal demonstration test by year end. Continued performance testing is planned for 1985 and 1986.

The primary program objectives are to demonstrate the KILnGAS process operating in a commercial environment, and to establish the technical and economic basis to proceed with large commercial plants in the 2,000 to 5,000 tons per day coal feed range.

The KILnGAS Commercial Module is located in East Alton, Illinois, adjacent to Illinois Power Company's Wood River Generating Station. The plant converts high-sulfur coal into clean gaseous fuel, which is burned in the utility's Unit No. 3 steam boiler. Referring to Figure 2, the KCM facility is to the left of the power

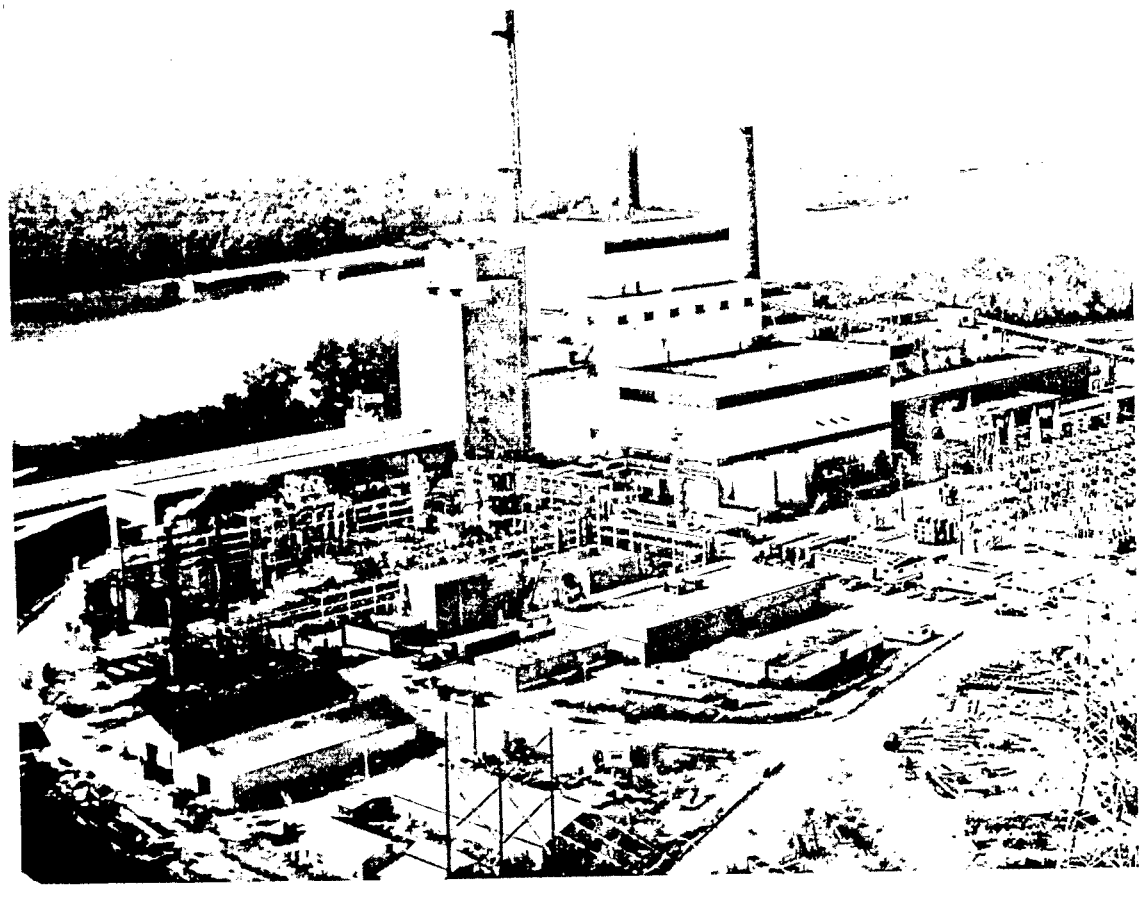

Figure 2. Aerial Photo of the KILnGAS Commercial Module

plant. The coal conveyor, which services the KCM, can be seen between the power plant and the KCM coal silo, located in the tall structure. The gasifier is located in the long lower building at the upper left. Raw product gas passes through heat recovery, cooling, scrubbing, and sulfur removal processing in the equipment located in the foreground.

The KCM is designed to process 600 tons of coal per day to supply 407 million Btu per hour of product gas to the utility boiler (50,000 KW). The reference coal, for plant design purposes, is Illinois No. 6 with an assumed Higher Heating Value (HHV) of 10,034 Btu/lb. With a design coal input of 502 x 10^6 Btu/hr and a clean gas output of 407 x 10^6 Btu/hr, a coal-to-gas conversion efficiency of approximately 81 percent is obtained. The KILnGAS process produces a low-Btu gas with an HHV of nominally 130 to 155 Btu/SCF.

Other design output quantities included are ash at 95 tons/day; hydrogen sulfide, recovered as elemental sulfur at the rate of 16.7 tons per day; and approximately 115,000 gallons of wastewater per day, which is processed in the City of Alton Municipal Treatment plant.

A summary bar chart of test segments executed in 1984 is shown in Figure 3. The first segment, Air Emissions Testing, resulted in issuance of an operating permit by the Illinois Environmental Protection Agency. The second segment verified the adequacy of modifications made to improve heat transfer in the Gas Quench and Tar

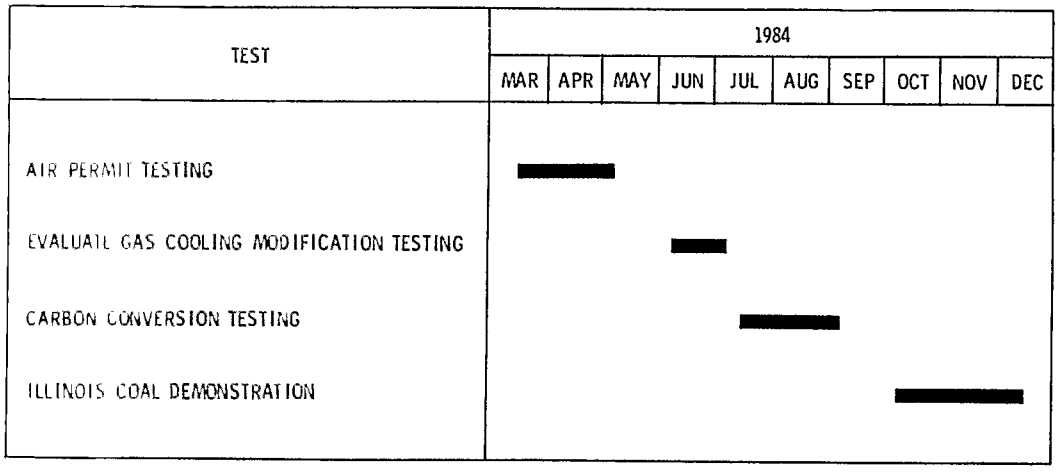

Figure 3. 1984 Test Programs

Removal System. The third series of tests was aimed at accomplishment of design level carbon conversion. The last test series involved demonstration of Illinois No. 6 coal as feedstock for the KILnGAS process. The latter is the primary focus of this paper.

60-DAY ILLINOIS COAL DEMONSTRATION

OBJECTIVES AND GOALS

A basic objective of the demonstration was to exceed a minimum operating availability of 50 percent over a 30-day period while simultaneously satisfying the four performance parameters and the five operating configuration requirements listed below. Another objective was to continue the basic technology learning experience. Specific goals were as follows:

- Achieve minimum performance of:

  --Gasifier operating pressure > 40 psig,
  --Product gas heat value of > 80 Btu/SCF,
  --Sulfur removal > 80 percent from the product gas,
  --Carbon conversion > 70 percent.*

- Maintain commercial plant configuration:

  --Tar recycle loop closed and operating,
  --Particulate loop closed and operating,
  --Biflow mode operating,
  --Stretford plant on-line,
  --Deliver product gas to Illinois Power Company for firing in the Unit #3 boiler.

*It should be noted that a relatively low carbon conversion target was established when earlier operating experience showed that ash agglomerates are produced at higher conversion levels. The ash discharge system was not designed to handle this type of discharge. Therefore, the objective was to operate at as high a conversion level as possible, consistent with the physical limitations of the ash discharge system.

- Maintain availability - keep the plant on-line while simultaneously [illegible] the test performance and configuration requirements.

  --50 percent availability over 30 days,
  --70 percent availability over best 10-day segment.

- Process a minimum of 5000 tons of coal in any contiguous 30-day test segment.

- Obtain accurate mass-energy balance data.

OPERATING RESULTS

The 60-day demonstration was started on October 17, 1984, and was concluded on December 17. The plant was initially operated in the counterflow configuration at nominally 50 percent capacity and 60 percent carbon conversion. By the end of October, the Biflow mode of operation was started and initial experience at 70 percent carbon conversion level was obtained.

Performance requirements were generally satisfied during sustained operation; however, operation was sporadic due, chiefly, to ash discharge system inadequacy. Therefore, simultaneous achievement of all performance criteria was accomplished on a limited basis. Performance trends during this run, however, were substantially improved as compared to previous test performance.

A graph of cumulative coal consumption is shown in Figure 4. Total cumulative coal consumed within a given 30-day period was 4640 tons (93 percent of the goal).

Summary conclusions are as follows:

- Performance and configuration criteria were satisfied.

  --Operating pressure was 45 psig (requirement was 40 psig minimum) for most of the test. Operation at higher pressure levels was not attempted until late in the run. Operations at 60 psig was planned for the last week of operation and achieved without difficulty.

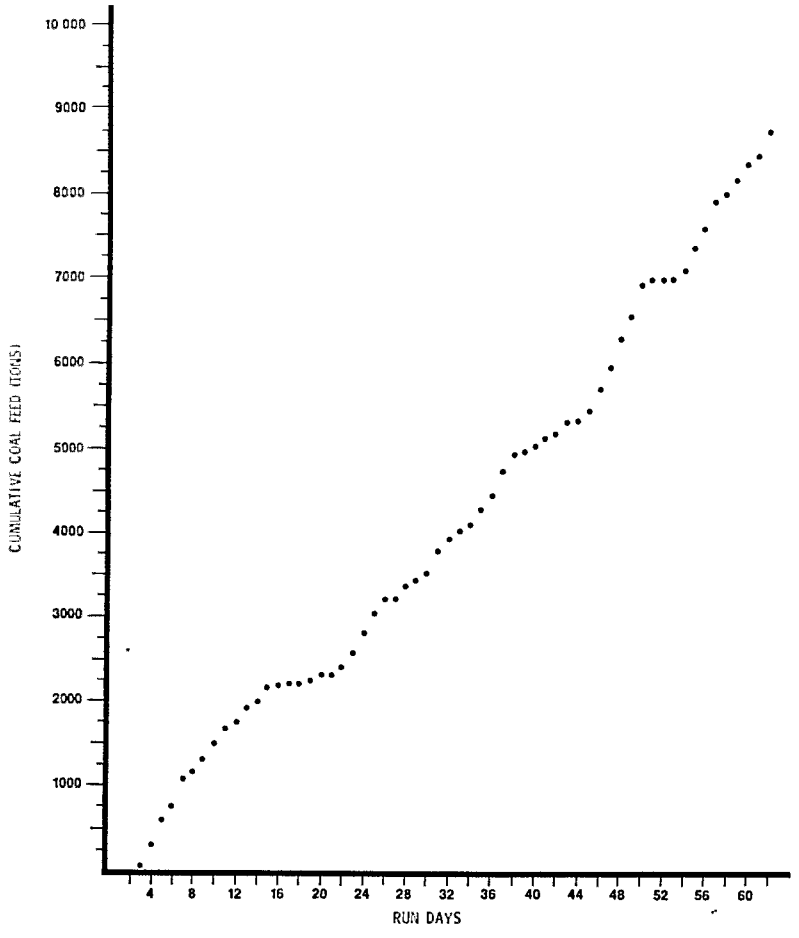

Figure 4. Cumulative Coal Consumption - 60-Day Demonstration

--The gas higher heating value averaged 127 Btu/SCF (80 Btu/SCF minimum required) over the test, and ranged from 135 to 150 Btu/SCF at various steady-state operating conditions.

--Removal of total sulfur from the product gas averaged 90 percent (80 percent minimum was the goal). Hydrogen sulfide removal exceeded 99 percent, as expected.

--Carbon conversion exceeded the 70 percent criterion for short periods, subject to ash discharge limitations.

--Recycling of tar and particulates to the gasifier for conversion to gas was accomplished on a routine basis.

--Biflow operation was satisfactory when it was used. Operation in this mode was limited, because there was insufficient thermal energy available to sustain the required minimum discharge temperature when operating at less than 50 percent load. When the Biflow Mode qualified for operation, heat recovery steam was generated at 115 percent of expected recovery levels.

--Combustion of low-Btu gas in the Illinois power boiler was satisfactory, and turndown of the boiler to light loads was better than had been expected. Twenty (20) percent was achieved as a minimum. No less than 50 percent was forecast by the boiler manufacturer.

- Process operation at high carbon conversion levels results in generation of large ash agglomerates. This type of discharge was not fully anticipated in the design of the ash-discharge system, and, therefore, presented an operational limitation. As a result, process operation was maintained at carbon conversion levels below 70 percent to achieve an operating availability of approximately 60 percent. As a result of the ash-discharge system limitations, sustained economic process operation was neither planned nor attempted. However, design level objectives (93 percent) for carbon conversion were met and exceeded for periods up to 12 hours. Therefore, achievement of economical process operation is expected to be attainable when the ash discharge system is upgraded.

- Availability and capacity objectives were not fully achieved due to the aforementioned limitation of the ash discharge system to handle ash agglomerates, and also due to limitations of the coal feed system to move wet coal fines (a common problem in the industry).

- Two long-standing issues regarding the KILnGAS technology were substantively resolved: a) the ability to process coal fines, and b) the ability to recover, recycle, and gasify tars to extinction.

OBSERVATIONS OF ILLINOIS NO. 6 COAL PERFORMANCE

Based on the observed operation of the KILnGAS Commercial Module during the 60-day Illinois Coal Demonstration run, the use of Illinois No. 6 coal as feedstock for the KILnGAS gasification process is technically feasible. The basic findings with respect to Illinois No. 6 coal performance (i.e., coal transport, gas quality, tar generation, carbon conversion, sulfur removal, combustion, and environmental considerations) are presented below.

Coal Transport

Transport (i.e., movement of coal through the gasifier) properties of Illinois No. 6 coal were shown to be satisfactory.

Illinois Coal is moderately caking. That is, upon heating, the coal softens and agglomerates. Early KILnGAS tests in the small scale (2-ft dia) pilot plant showed that the KILnGAS process was especially well suited to contend with this caking property of the coal because of the tumbling-bed action of the gasifier which breaks the agglomerations. The 60-day demonstration test further confirmed the inherent ability of the KILnGAS system to process caking coal. Nothing was observed during the test to indicate that this caking property of the coal adversely affected gasifier operation.

Operation and post-run bed inspections showed that the Illinois No. 6 coal, upon processing, tended to break into smaller pieces than expected. However, the transport and process performance of the bed remained well within design limits.

Operation also indicated that the gasifier design parameters of slope and rotational speed are adequate to transport the coal through the gasifier at rated capacity.

Gas Quality

The quality of the gas produced was shown to be satisfactory over a wide operating range.

The heating value of the gas produced from the Illinois No. 6 coal over the entire 60-day run averaged 127 Btu/SCF (while operating in the 10-60 percent gas output range). This value was averaged over all periods including those when the gasifier was being operated at abnormal conditions and at very low load, and also while undergoing transients. Typically, the gas heating value ranged from 135-150 Btu/SCF during normal, steady-state operation. This is within the expected range. The methane content of the gas was generally more than twice that expected, while the hydrogen and carbon monoxide content were less.

Tar Generation/Recovery

Tar produced when Illinois coal is gasified using the KILnGAS process must be removed from the gas before it is used as fuel, and recovered from the liquors before they are discharged as wastewater. The recovered tar and other hydrocarbon liquids are then recycled to the gasifier and completely converted to fuel gas to achieve maximum conversion efficiency from the process. The ability to recover and recycle all tars produced, gasifying them to extinction (contributing to product gas heating value), was successfully demonstrated by recycling to the gasifier via the coal feed screw.

Quench liquor from the plant, which was discharged as process wastewater after removal of tar, oils and ammonia, was routinely processed by the Alton Municipal Treatment Plant for the entire operating period with no operational upsets.

Carbon Conversion and Ash Agglomeration

Carbon makes up over 60 weight percent of the coal and accounts for more than 80 percent of the energy content. The amount of carbon converted to product gas is a measure of the coal conversion efficiency. One goal of the demonstration program was to achieve 93% carbon conversion. The potential for achieving this level of carbon conversion has been shown. KCM tests prior to the 60-day run achieved in excess of 90 percent carbon conversion on several occasions for periods of 8-12 hours. However, each of these conditions of high-carbon conversion was accompanied by the formation of agglomerated ash (slag) ranging in size from two to over 20 inches in diameter.

The gas produced during these periods showed no unfavorable affects when agglomerated ash was formed, nor did the gasifier show inability to move the agglomerated ash through and out of the gasifier into the ash locks. The main problem encountered was the limited ability of the ash locks to properly crush and discharge these agglomerates when they were received in large quantities.

The 60-Day Demonstration Run has confirmed that the process will form ash agglomerations at higher conversion rates of Illinois coal. Properly controlled, agglomerated ash may be the most desirable form of ash to produce, because the formations contain very low carbon (less than 10 percent versus the 30 percent design objective).

Sulfur Removal

Sulfur removal efficiencies were satisfactory. Sulfur from the coal is converted by the gasifier to hydrogen sulfide and small amounts of organic sulfur compounds. The product gas stream is cleaned of hydrogen sulfide by use of the Stretford process. This prevents formation of sulfur dioxide from hydrogen sulfide in the fuel gas upon combustion in the Illinois Power boiler. Elemental sulfur is the final form of sulfur produced by the Stretford System.

Hydrogen sulfide removal from the product gas was above the level necessary for compliance with Environmental Standards. Routine removal above 99+ percent was achieved when the scrubbing liquor-to-product gas ratio and chemistry was controlled to the design level.

Boiler Performance

Combustion properties and the stability of the low-Btu fuel was demonstrated to be highly satisfactory, and permitted boiler turndown to lower load levels than anticipated.

Low-Btu fuel gas (LBG) has a higher heating value (HHV) of about 15 percent that of natural gas. Supplemental firing with oil or natural gas, of the Illinois Power Company boiler was recommended by the manufacturer at boiler firing rates no less than 50 percent. This precaution was followed throughout the demonstration. However, one 5-hour period was used to test LBG, without supplemental fuel,

at approximately 20 percent boiler firing rate. Satisfactory stable combustion performance was experienced.

Environmental

Compliance with environmental regulations was demonstrated. Wastewater from the KCM was processed by the Alton Municipal Treatment Plant. Reports to the Illinois EPA, required at least three times per week, show that the treatment plant was within effluent limitations when treating the KCM process water. Efficiencies of removal of contaminants, and the contaminant levels experienced, are such that compliance can be maintained at design discharge rate for the KCM plant.

Ash from the gasifier is sluiced with water to disposal ponds. Discharge of ash via slurry water was in compliance with the ash pond NPDES permit limitations throughout the test period.

Operation of the Stretford System reduced the total sulfur content of the product gas to levels that kept boiler emissions within limits.

FUTURE PLANS

Plans for 1985 center around a Reliability, Availability, and Maintainability (RAM) testing program using Illinois coal, along with selective subsystem upgrading and modifications to improve plant performance and economics. The project (scheduled from January 1 through December 31, 1985) has two principal goals: 1) KCM operational performance improvements in 1985, and 2) application of RAM methodology in data acquisition to lay the foundation for subsequent commercial plant designs. Figure 5 graphically illustrates the six major task activities of the project. Task 1 reviews and evaluates the results of KCM operations through the end of 1984 to provide the basis for future planning. Task 2 is directed toward the preparation of plans for implementation of the RAM project. Task 3 has been established, as a contingency task, to implement design, procurement and erection of plant system modifications which may result if significant process functional changes are identified and are deemed to be necessary. Task 4 encompasses all activities directly related to plant maintenance, recommissioning and execution of the RAM - Phase I operations program. Task 5 is devoted to

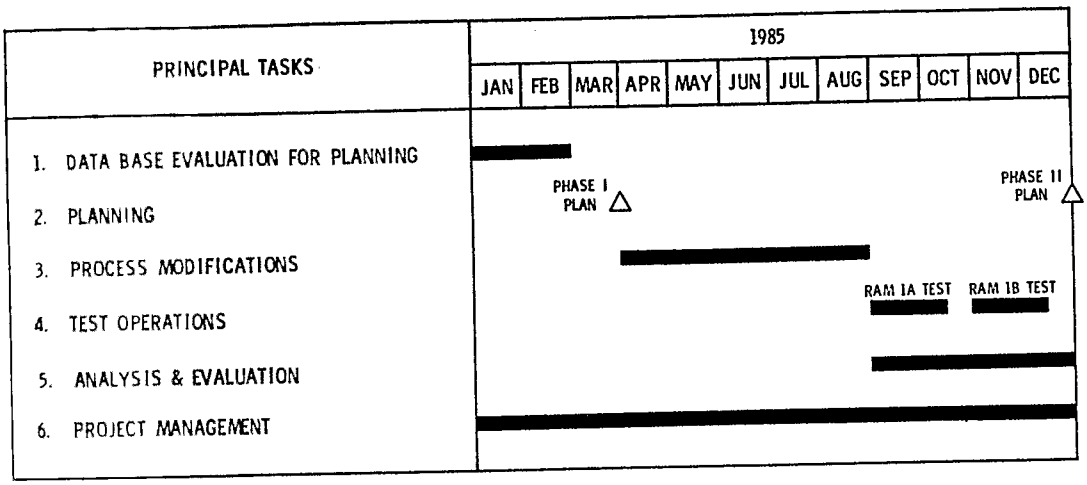

Figure 5. 1985 Program Plan

analysis and evaluation of 1985 operating results. Project management and control is the objective of Task 6.