Industrial Fuel Gas Demonstration Plant Program

MAS

OVERALL PROGRAM PLAN

FOR

TASK IX — TECHNICAL SUPPORT

VOLUME II — PILOT PLANT OPERATIONS

Prepared For
The Department of Energy
Under Contract ET-77-C-01-2582

MEMPHIS LIGHT, GAS AND WATER DIVISION
P.O. BOX 430, MEMPHIS, TENNESSEE 38145

In Association with
FOSTER WHEELER ENERGY CORPORATION
INSTITUTE OF GAS TECHNOLOGY
DELTA REFINING COMPANY

MASTER

OVERALL PROGRAM PLAN

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MEMPHIS INDUSTRIAL FUEL GAS
DEMONSTRATION PLANT PROJECT

TECHNICAL SUPPORT REPORT
(Deliverable #46)

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PREPARED FOR THE
U. S. DEPARTMENT OF ENERGY
ASSISTANT SECRETARY OF FOSSIL ENERGY

UNDER CONTRACT DE-AC02-77ET13406
(FORMERLY CONTRACT ET-77-C-01-2582)

TECHNICAL SUBCOMMITTEE RECOMMENDATIONS

This document is Volume II of a two volume program for Task IX, Technical Support. We, as members of the Technical Subcommittee, participated in the development of the Pilot Plant Test Program shown in Volume II. We find these plans to be reasonable and are focused on achieving specific milestones recognized by the Committee. We recommend DOE approval of this program.

The implementation and management of this program, including cost, is not within the scope of the Committee's activities.

9/8/78
D. Aubrecht, Chairman

9/8/78
J. Patel, ~~IGT~~

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P. Thakkar, MLGW

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SUMMARY

This document is the second of a two-volume Overall Program Plan for rescheduling Task IX (Technical Support) of the Industrial Fuel Gas Demonstration Plant Program (MLGW/DOE), Contract ET-77-C-01-2582. Volume I presents the schedule and organization for carrying out the overall plan which is divided into three major tasks: Bench Scale Tests, Cold-Flow Model Studies, and Pilot Plant Operations. This volume, Volume II, gives a more detailed presentation of the test objectives and procedures for the most important part of the plan, Pilot Plant Operations.

The objective of Volume II is to provide a systematic approach to obtain high carbon conversion under steady-state, ash agglomerating conditions with coal in the U-GAS pilot plant. This will allow the achievement of the principal goal of pilot plant operations, that is, to obtain data for the design of the U-GAS demonstration plant.

The test program for pilot plant operations has been formulated with the assistance of the Technical Subcommittee which has members from all the parties involved in the Industrial Fuel Gas Demonstration Plant Program, namely, Memphis Light, Gas and Water Division, Department of Energy, Foster Wheeler Energy Corporation, Delta Refining Company, Institute of Gas Technology, and Monsanto Research Corporation.

DISCUSSION

A pilot plant test program has been formulated with an overall objective to obtain data for the design of the demonstration plant. Since pilot plant tests to date with coal have not demonstrated ash-balanced operation with total ash agglomeration, an initial series of tests with coke and coal will be conducted. Analysis of past test data on both coke and coal has identified key variables affecting ash agglomeration. These variables are temperature, bed ash-content, bed height, particle size, and gas velocity. The objective of the coke and coal tests is to systematically obtain data on the effect of the above variables on agglomeration and establish a logical baseline for planning tests to obtain ash-balanced operation with coal. This detailed test program will confirm the operating range of the above variables for coke and establish the operating range of the above variables for coal.

Based on the results of the initial tests with coke and coal; and from the simultaneous efforts on the 2-inch-diameter bench scale unit and the cold-flow model, detailed plans for an extended period test with coal will be developed. The objective of this test will be to operate for 5 days and achieve ash-balanced operation with coal under agglomerating conditions. Data from this test will be used to develop plans for a subsequent series of tests at higher pressure to establish the design data base for the demonstration plant.

The following sections consist of specific details of the initial series of tests with coke and coal; outlines the general direction and objectives of the remainder of the test program; discusses the procedures for conducting tests, and obtaining, transferring, and reducing data; contains the details of operating procedures; and presents a cost estimate to implement the overall program plan.

PILOT PLANT TEST PROCEDURES

The procedures for planning, conducting, and monitoring pilot plant tests have been re-evaluated with greater emphasis on overall test management to assure that program objectives are attained. This section discusses procedures for formulation and implementation of test plans, pilot plant test organization and monitoring of tests.

Test Run Formulation and Implementation

The general procedure will be to formulate a detailed plan for each test run. A test run will consist of a series of set points, each set point specifying the values of controlled variables for a steady-state operating period.

Based on information from previous tests, the 2-inch-diameter bench scale tests, and the cold-flow model studies, the Operations Manager (W. A. Sandstrom) will be responsible for formulating a detailed test run plan as shown in Figure 1. Appropriate recommendations from either the Ash Chemistry Task Force or the Ash Agglomeration Task Force will be incorporated in the test plan. However, the overall test run plan will follow the general outline of the Test Plan Details section. The plan will then be reviewed and modified by the Project Manager and submitted to the Technical Subcommittee and the Executive Program Advisor for review and approval. The Technical Subcommittee Chairman will be responsible for obtaining the concurrence of the Committee and advising the Project Manager of its approval. The detailed test run plan will be finalized, documented and distributed to the plant operations, on-site monitors and the Technical Subcommittee. The approved test plan will be followed during the test run. The Shift Supervisor will be responsible for executing the approved plan and the on-site monitors will verify the test plan.

It is anticipated that changes to the test run plan may be necessary as the run proceeds. Under conditions where prompt action is required (e.g., at set point operating conditions where there are indications of ash deposition or where set point conditions lead to unstable operation), the Shift Supervisor will make appropriate decisions for any changes or termination of the test run. The on-site monitors will be informed of the decision and the action to be taken.

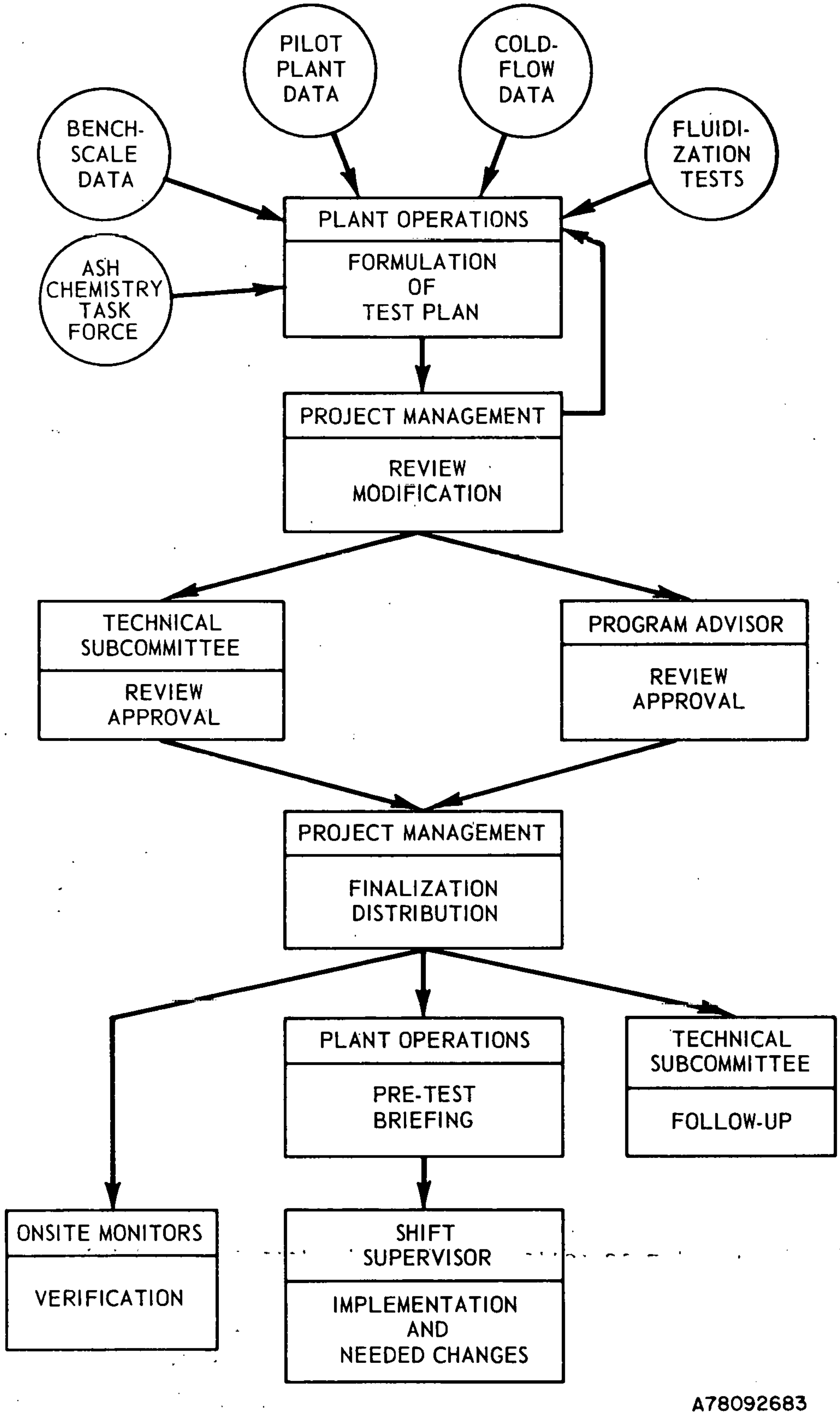

Figure 1. TEST RUN PLAN FORMULATION

Minor changes in the test plan will be similarly implemented by the Shift Supervisor in consultation with the monitors. Decisions by the Shift Supervisor on major changes to the plan or on termination of the test under normal operating conditions will be conveyed to the Project Manager. The Project Manager, or his designee, will contact the Technical Subcommittee Chairman and the Executive Program Advisor and obtain their approval before proceeding with the change.

Various set point operating conditions for a test run are based on the latest available information, both from previous tests and laboratory studies. A test run plan or any preselected condition for set point may be changed using the above outlined procedure for test run formulation.

Plant Operations Management

The pilot plant operations are under the direction of an Operations Manager who is responsible for day-to-day operation, maintenance, and upkeep of the pilot plant. He is also responsible for the work of the four subcontractors who provide services to the pilot plant (mechanical, electrical, instrumentation, and insulation). The Operations Manager, in conducting tests, is aided by an Operations Supervisor, five Shift Engineers, and eight Operators. This group also has an engineer and an assistant who are responsible for collection, assimilation, and reporting of pilot plant test data. For conducting pilot plant tests the operations organization is set up as shown in Figure 2.

To provide 24-hour coverage during a test, IGT utilizes 8-hour shifts. The shift team consists of a Shift Supervisor, a Shift Engineer, two Operators, and an Instrument Technician. Mechanical, electrical and maintenance services are provided during the day shift and are available on call during the other two shifts. The Shift Supervisor is a senior IGT person who is responsible for the overall test operations during the shift. He will assure that the approved test plan is followed, will make decisions and take appropriate action on changes or shutdowns under emergency conditions. He will also notify the Project Manager of the necessary changes, if any, to the test plan, and will carry them out after the Project Manager obtains the approval for the change. In the Project Manager's absence, the Shift Supervisor will follow the procedure outlined in the previous section to obtain approval for any changes.

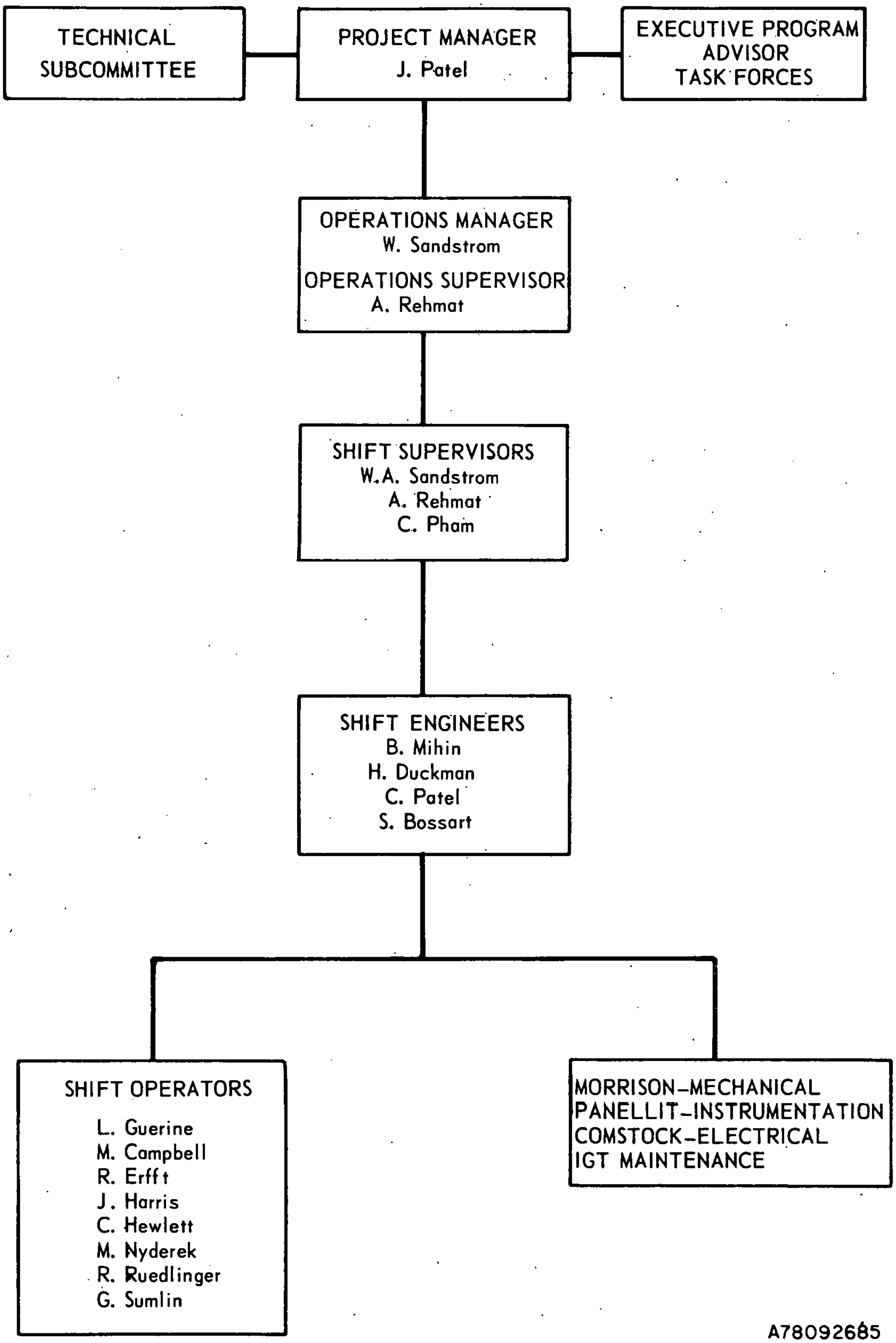

Figure 2. PIOLT PLANT TEST ORGANIZATION

The Shift Supervisor will be responsible for all communications with the on-site monitors. He will brief them on the conditions of the test, provide them test data for verification purposes, advise them of his decision and reason for suggesting a change from the approved test plan, notify them of his actions during an emergency condition, and assure that the monitors do not interfere with the normal routine of other IGT test personnel. The Project Manager will be responsible for briefing all other pertinent industrial team members, DOE personnel, and other interested parties on the status of the tests. All calls for such information will be directed to him.

The Shift Engineer will be responsible for conducting the test operations during his shift. He will assure that all necessary samples, data, and readings are gathered in a timely fashion and reduce the data at regular intervals to check test conditions. He will direct the work of the operators and the subcontracted personnel as necessary, assure that the pilot plant unit is functioning properly from both the process and the mechanical viewpoint, and will note any upsets or deviations from set conditions of the controlled variables and take necessary actions to correct them. The operators will take solids samples, dump solids and fines out of hoppers, and collect data on appropriate data sheets. They will help the Shift Engineer operate the pilot plant and also troubleshoot any operating problems. They will also be responsible for drying feed material and for upkeep of both the control room and the pilot plant surroundings. The liquid and gas samples will be collected by the pilot plant analytical group.

Test Monitoring

Both MLGW and DOE will have around-the-clock on-site monitors during each pilot plant test run. The function of the monitor will be to observe test operations in order to verify that the test plan is being followed. To accomplish this it will be necessary that the monitors have readily available test data that can be used to compare with the various set points in the test run. It will also be necessary to set up a communications procedure so that the test data and information on the status of the test run can be efficiently transferred to the monitors. The following guidelines as shown in Figure 3 will assure smooth interaction between the on-site monitors and IGT operating personnel:

1) When a test is in progress, the shift supervisor will be responsible for providing the monitors with test run data. These data will be raw unconfirmed data, that is, they will not be finalized, but will be sufficiently accurate for monitoring purposes. All other information regarding the progress of the run will be provided in pre-scheduled daily briefings by the operations manager. The operations manager will also be responsible for keeping the monitors informed of progress on the pilot plant during plant turnarounds. Information on the progress of all other project activities including the distribution of finalized test data will be the responsibility of the project manager.

2) The monitors will verify that the test plan is being followed by examining the test run data provided by shift supervisors. The monitors will prepare daily reports based on their observations of the test run and other information received during the course of the run. If any doubt exists about the data or other information they have obtained, the monitors should consult with the shift supervisor before preparing their written report. One copy of each report will be distributed to the project manager as soon as possible after preparation.

3) It may be necessary to alter the test plan because of information gained during previous test periods. In this case it will be the responsibility of the shift supervisor to consult with the monitor and inform him of these changes. For this reason the monitor should be readily available at all times, either in the U-GAS pilot plant or in his assigned office area.

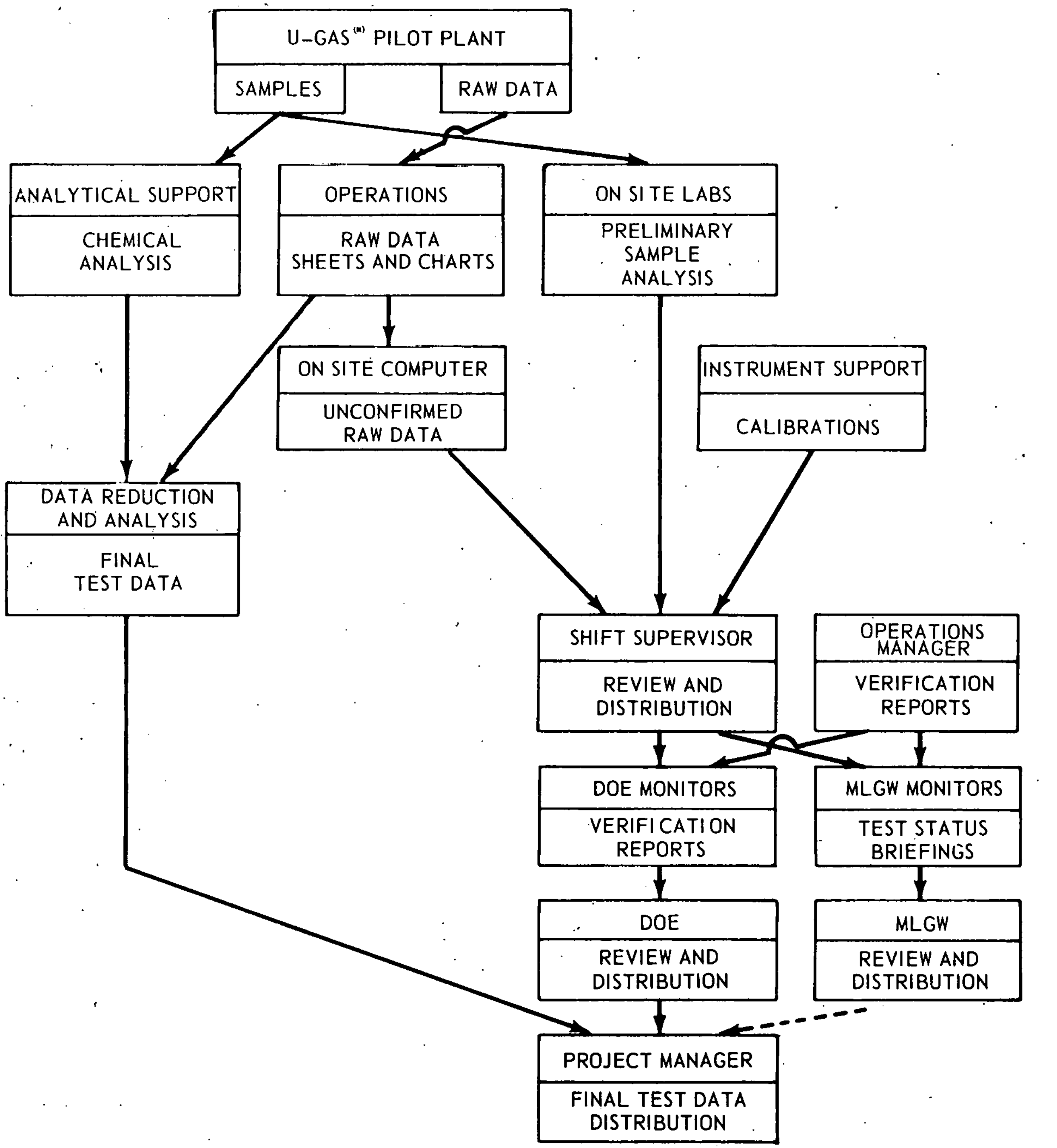

Figure 3. ACQUISITION AND DISTRIBUTION OF PILOT PLANT DATA

DETAILED TEST PLAN

The following sections contain a detailed test plan. The plan has five parts: A) Start-Up, B) Hot Shakedown, C) Tests with Coal, D) Tests at High Pressure, and E) Parametric Tests.

The Start-Up section applies to all tests and is separated from the other sections to avoid redundancy.

The reactor has undergone significant modification — a larger diameter venturi and a jet in the center of the venturi. Therefore, the first tests of the modified gasifier will use coke feed. The reason for these changes is to obtain a greater flexibility in the control of agglomerate discharge and distribution of oxygen feed. These additional runs with coke will serve to shake down the modified unit and obtain baseline data. Comparison with previous data from operations with coke feed will determine if increasing the diameter of the venturi throat from 3 inches to 4-1/2 inches affects the rate of agglomerate discharge. Data from these tests will be useful in correlating test results of the 2-inch bench-scale agglomeration unit. Finally, these tests will establish a range of operating variables with coke under ash-balanced, agglomerating conditions.

The coal tests serve the same purposes as those using coke; that is, to establish the range of operation under agglomerating conditions. In addition, carbon utilization and other data from the extended steady-state coal run will be needed in the decision regarding process feasibility.

Pressure tests with the gasifier at 60 psia using coal will provide data necessary for the design of the demonstration plant. This will be achieved by correlating test results at atmospheric pressure. In addition, higher pressure tests will serve to check the validity of IGT's mathematical model.

Parametric tests will provide data to answer any remaining questions in the design of the demonstration plant. These tests will determine gasifier turndown capability, response to feed changes, and load following capability.

This detailed test plan should determine the operating conditions necessary to achieve agglomeration under ash-balanced conditions with coal. Further support will come from tests with the cold flow model. These tests will isolate the effects of hydrodynamic factors on rate of particle discharge.

through the venturi throat. In addition, supporting tests with the 2-inch bench-scale unit will further assist in achieving ash agglomeration with coal.

A. Start-Up

This section applies to all tests. At the start of a test, the gasifier is empty at ambient temperature. U-GAS engineers have developed a sequence of steps for starting up the reactor. At the completion of these steps, the gasifier is ready to produce test data.

U-GAS pilot plant operators use a formalized list of steps, the "U-GAS Start-Up Procedure," to start all test runs. Appendix A contains the most recent version of this procedure. Upon the completion of each step, the operator writes the date, time, and initials in the appropriate box. The operator notes any difficulties and their remedy in the "Remarks" box.

B. Hot Shakedown Test

The objectives of this test, Run 127, are to carry out a hot shakedown of the U-GAS pilot plant using metallurgical coke as start-up feed material. A hot shakedown test is necessary because several modifications have been made to the pilot plant after the July test, Run 126.

Several new pieces of equipment were added: a scrubber for the product gas, a new reactor feed screw feeder, and pressure relief valves for operations at reactor vessel design pressure.

Other pieces of equipment were modified: The coal and coke screw feeder drives were revamped to provide variable feed mixtures. The venturi throat was widened to 4-1/2 inches and shortened to 2 inches. A 1-1/2 inch jet nozzle entering through the axis of the venturi throat was installed. Also, the weigh scale lockhopper feed system was significantly changed.

All equipment have been checked for operability at ambient temperature and pressure. Malfunctions and leaks have been rectified. However, only operations at or near test conditions can properly shake down the process equipment to ensure reliability during a coal test.

U-GAS engineers and technicians will carefully monitor and record the operation of all parts of the pilot plant during the hot shakedown test to confirm equipment reliability or need for further improvement.

Set Point 1

After reaching a bed temperature of approximately 1600^{o}F (Step 47 of the U-GAS start-up procedure), operators will make adjustments to the process gas flows to increase bed temperature to 1800^{o}F. Variables will be controlled within limitations called for at Set Point 1 in Table I. As the bed temperature stabilizes, the venturi annulus velocity may have to be adjusted. The proper velocity to use is that which yields a venturi discharge not exceeding 20 lbs/hr. This small discharge, essentially the coarsest fraction of the coke feed, keeps the venturi throat clear, yet allows bed ash content to build up rapidly to promote ash agglomeration and/or achieve the set point value.

As the hourly bed samples show a rising ash content, the alternate bed discharge will be activated at 30% bed ash content. By the time 35% bed ash content is recorded, the alternate bed withdrawal, determined from rough ash

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Table I

Hot Shakedown Test With Coke Operating Conditions

Set Point	Period Hrs. ± 6	Bed Temp. ± 15°F	Ash Conc. in Bed ± 5%	Superficial Velocity FPS ± 0.5	Venturi Annulus Vel. FPS ± 5	Bed Height Feet ± 0.5	Cyclone's Operating Int.	II	III
1	12	1800	35	4	40*	4	No	No	No
2	12	1850	35	4	40	4	No	No	No
2A	12	1850**	35	4	40	4	No	No	No
3	12	1900	35	4	40	4	No	No	No
4	12	1950***	35	4	40	4	No	No	No
4B	12	1950****	35	4	40	4	Yes	No	No

OTHER OPERATING CONDITIONS REQUIRED

Mode = Steam-Air-Oxygen Process Gas
Process Gas to Grid = 15% oxygen conc. max.
Process Gas to Venturi Annulus = 21% Oxygen Conc. Max.
Process Gas to Central Jet = 50% Oxygen Conc. Max.

* Or as required to control venturi discharge classification capability.

** Minimum O_2 at grid under partial aggl. mode. May be repeated at 3A or 4A.

*** Assumed temperature for balanced ash agglomeration W/O bed withdrawal. May require more set-points for ash agglomeration W/O bed withdrawal.

**** As required to sustain ash balance W/O bed withdrawal.

balance calculations, will prevent further rise in bed ash content. Two to four hours may be needed with ash samples from the bed taken hourly to confirm a stable 35% bed ash content.

To verify stabilization and obtain sufficient data for an accurate ash balance, 6 to 12 hours of operation will be required. Ash balances can be calculated from the feed bed withdrawal, venturi discharge, and dust stream ash analyses. After completion of one or two ash balances, control variables will be changed to achieve Set Point 2. Ash agglomeration may occur during Set Point 1. Onset of ash agglomeration is indicated by a rise in venturi discharge rate with no change in venturi annulus velocity. The weight fraction of agglomerates in bed and venturi discharge samples will be determined.

Set Point 2

To raise the bed temperature to 1850°F as called for in this set point, the operator will again adjust flows as described in the section "Control of Operating Variables." Additional oxygen is required to raise the bed temperature. This oxygen can be added by increasing flow through both the 938 and the 9303 streams.* However, a flow increase of oxygen to the 938 stream will increase the concentration of oxygen at 905, 906, and 9405 (see Figure 5). Since set point variable values specify no increase in the grid and venturi annulus oxygen content, the preferred method of adding oxygen is through the jet, stream 9303. Any rise in superficial velocity resulting from adding oxygen through stream 9303 can be offset by a reduction in the flow of process gas (air) through stream 9405.

As the bed temperature rises and stabilizes, an increase in the coke feed rate will be required to maintain the control variable bed level at the set point value. As with Set Point 1, hourly bed sample analyses for ash will be used to determine a rough ash balance. Alternate bed withdrawal will be adjusted to retain a 35% bed ash content. If more agglomerates form and discharge at this higher temperature, no increase in alternate bed discharge may be needed. Again, 6 to 12 hours will be required to obtain one or two successive ash balances.

Measurement of ash agglomerate content in bed and venturi discharge samples will be carried out as described in Set Point 1.

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* Flow stream numbers are referenced in Figure 4, page 33.

Set Point 2A

If the presence of ash agglomerates is detected either by visual observation of the venturi discharge material, or by an increase in the discharge rate, Set Point 2A shall be implemented. The objective of 2A is to determine if improved (a greater quantity of agglomerates) ash agglomeration results from introducing all of the oxygen at the center of the reactor. Since a comparison is needed with partial ash agglomerating conditions, this procedure (Set Point 2A) will only be implemented if partial agglomeration occurs in Set Point 2. If not, this change will be deferred until Set Point 3 or possibly Set Point 4. The procedure for making this change follows.

Based upon the computer data of stabilized conditions for Set Point 2A, a calculation will be made directing all oxygen to the central jet and venturi annulus with the total molar flow as specified in the Set Point. It may develop that to hold the stated limit of Table I, 21% O_2 at the venturi annulus and 50% at the jet, the grid oxygen concentration cannot be reduced to zero. In this case, changes will be made to achieve minimum oxygen at the grid. Care must be taken by the operator that at no time during the changes in flow should any of the above limits be broached. Oxygen flow will probably increase through the jet, stream 9303, and air flow will decrease through the jet, stream 9405. The annular venturi flow is readily changed to 100% air (or 21% oxygen) by supplying flow only through stream 906. The jet flow changes should be accompanied by a systematic adjustment to reduce flow through stream 905 and increase flow through stream 903 to maintain the same total oxygen flow.

Set Point 3

If it develops upon completing this operation to achieve Set Point 2A there is no change in agglomerate discharge rate, the conditions of Set Point 2 will be restored. However, if the change to Set Point 2A yields an improvement in the quantity of agglomerates discharge through the venturi but no ash balance without alternate bed withdrawal, preparations will be made to proceed to Set Point 3 while maintaining a low oxygen content at the grid. Since both annular and jet oxygen concentrations will probably be at maximum value, oxygen will have to be added (to raise the bed temperature) to the grid by raising stream 905 and lowering stream 903. These changes to raise the bed temperature will probably significantly increase the venturi discharge rate after a small temperature rise (10°F). Accordingly, this rise in temperature will be limited to that necessary to allow a complete elimination of the bed withdrawal stream as proven by bed ash sample analysis.

Conditions will be maintained at 1900°F for Set Point 3 if bed withdrawal is still required for a time necessary to achieve sufficient data to calculate two ash balances. Then, the same procedure used to reach Set Point 3 will be used to attain Set Point 4, namely, raising stream 905 and lowering stream 903. If in doing so each of the limits set for oxygen content (15%, 21%, and 50%) are reached, the shift supervisor shall contact the program manager for instructions as to whether any limit previously listed on Table I can be modified.

Set Point 4

If it develops that bed withdrawal is eliminated during the changes made to achieve Set Point 3 whether at 1900°F or lower, these conditions shall be held for 12 hours to record sufficient data and obtain samples. Upon achieving this goal, the final change on Table I shall be implemented. This change is 4B on Table I but it will be renumbered 3B if implemented after Set Point 3. This procedure involves activating the internal cyclone seal pot to recirculate char fines into the reactor bed. This change should be implemented by slowly raising FI 9364, the seal pot nitrogen aeration gas, while monitoring the chart traces of PDR 9301, 982, and 983. When the cyclone begins to function, PDR 9301 will rise to 0.4 psi, and PDR 982 and PDR 983 will also rise on the chart. PDR 983 should read about 0.15 psi and PDR 982, 0.4 psi. Changes to feed rate and steam/air ratios may be needed to retain the bed temperature and level. After stabilization the venturi discharge rate and bed ash level will be watched carefully (the former may fall and the latter may rise). A drop in the venturi discharge rate is not as critical (for the feed rate of coke will probably have been lowered) as a rise in bed ash content. If the latter condition develops, activate a bed withdrawal to hold ash content at the set-point condition, and then raise the bed temperature. If a larger temperature rise seems necessary to maintain an ash balance without bed withdrawal, a decision will be made whether to continue the pursuit of Set Point 3B. As Table I indicates, it may well develop that

Set Point 4 will be reached before the internal cyclone can be activated. This cyclone activation will not be used unless an ash balance is reached without alternate bed withdrawal. In any event, the same procedure just described will be used if cyclone activation occurs at 4B instead of 3B.

Assuming the above set point is attained, shakedown data for 12 hours will be recorded. Following directly upon this accomplishment, the second phase of the hot shakedown test will begin. This phase consists of determining the effect of bed height, superficial velocity, bed ash concentration and venturi annulus velocity upon the process system due to the newly altered venturi and central jet pipe.

Set Point 5

Set Point 5 (Table II) is achieved by reducing the venturi annulus gas flow and increasing the central jet flow (see "Control of Operating Variables," venturi annulus velocity). It may develop that a significant solids downflow may occur even though no other operating condition has been changed. Sufficient samples and data should be taken to substantiate the effect of this change on the classification capability of the venturi annulus. Unless there is a severe upset of the ash agglomerating process, this set point should be maintained for 6 hours, providing the venturi solids rate is not too high and is not too hot to handle in the discharge drums. Assuming the oxygen concentration is not limiting at other flow points, the venturi annulus oxygen concentration can be reduced by lowering stream 906 and adding steam through stream 9304. However, the oxygen removed would probably have to be added through stream 9303 to the central jet. The above procedure should lower the temperature of the solids discharged from the venturi.

Set Point 6

Set Point 6 is achieved by raising stream 906 and lowering stream 9405. However, this operation could result in an increased ash agglomerate concentration in the fluid bed. If evidence develops that this increase does happen, a decision will be made as to whether this concentration presents the hazard of raising the minimum fluidizing velocity. There are two direct ways of detecting this phenomenon: increased presence of ash agglomerates in the bed samples which also yield a higher ash content, and a reduced venturi discharge rate proving an unbalanced state of ash accumulation. If no problems

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Table II
Continuation of Shakedown Test with Operations at Ash Agglomerating Conditions Produced From Table 1 Coke Shakedown Data

Set Point	Period Hrs. ± 6	Bed Temp. ± 15°F†	Ash Conc. in Bed ± 5%††	Superficial Velocity FPS ± 0.5	Venturi Annulus Vel. FPS ± 5	Bed Height Feet ± 0.5	Cyclone's Operating Int.	Cyclone's Operating II	Cyclone's Operating III
5	12	1950	35*	4	30 **	4	No	No	No
6	12	1950	35	4	50 ***	4	No	No	No
7	12	1950	35	3	40 *	4	No	No	No
8	12	1950	35	4	40 *	2	No	No	No
9	12	1950	20	4	40 *	4	No	No	No
10	12	1950	45	4	40 *	4	No	No	No

OTHER OPERATING CONDITIONS REQUIRED

Mode - Steam, Air, Oxygen
Process Gas to Grid - 15% Oyxgen Conc. Max.
Process Gas to Venturi Annulus - 21% Oxygen Conc. Max.
Process Gas to Central Jet 50% Oxygen Conc. Max.

† Assumed from Table I results.
†† Assumed.

* Optimum; as required to control venturi discharge classification capability.
** 10 FPS below optimum.
*** 10 FPS above optimum.

NOTE: Decision not to include internal cyclone will be reviewed based on results of 4B.

are detectable, data and samples will be taken for 6 hours. Following this set point, conditions will be rapidly adjusted to achieve Set Point 7. This set point restores the annulus velocity found desirable during the first phase of this shakedown test.

Set Point 7

Set Point 7 will be achieved by reducing the flow through stream 9405 first, and to its minimum allowable flow (central jet velocity 50 fps), if required, to achieve the lower bed superficial velocity of 3 fps. Only then should flow through the grid (streams 905 and 903) be reduced. The operation should be watched carefully for: 1) any change in ash agglomerate size as a result of lower gasification rate and 2) any reduction in agglomerate concentration in the bed samples (both visually and by ash content). Twelve hours of shakedown data and samples will be taken.

Set Point 8

Upon restoring the superficial velocity to 4 fps, the bed height will be allowed to drop by reducing the feed rate of coke 20%. It should take 3 to 4 hours to drop the bed level to two feet. Although no hazard is envisioned by this operating mode, particular interest should be taken in the carbon oxide ratios in the product gas. Note also should be taken of the fines loss rate as the feed at this set point is entering the bed 6 inches above the top of the bed. Six to twelve hours of steady-state operations are required.

Set Point 9

Set Point 9 may not be achievable. To reduce the bed ash content below an agglomerating ash balanced state will require activation of the alternate bed withdrawal line. Based on operating conditions of Set Point 4, calculations will be made of this required bed withdrawal rate. If it is high, the bed level can be maintained by increased feed. However, increased feed will necessitate an increase in oxygen concentration at all streams not already operating at the limit. This latter development may prevent achieving Set Point 9, though data and samples will be taken at whichever reduced bed ash concentration is achievable.

Set Point 10

Set Point 10 may also be difficult. If the unit is operating in an ash balanced state without alternate bed withdrawal at 40% or less ash concentration and no operational changes are made, the ash content of the bed will not rise. Whether Set Point 10 is reached or not, steady-state data for 12 hours should be taken. Assuming gasifier operation can be continued without interruption, Table II, second part, Set Points 11 through 17, illustrates two firm and five potential set points for continued operation with coke.

Set Point 12

Set Point 12 should be achieved by reducing the oxygen concentration at the central jet so that temperatures 50°F lower than employed in Set Point 5 can be reached. Probably, alternate bed withdrawal will have to be employed to restrict bed ash content to 30%. As in Table I, at least two steady periods of ash balance should be obtained using the alternate bed withdrawal as required before going on to Set Point 13.

Set Point 13

Operations at Set Point 13 require only a small reduction in alternate bed withdrawal rate to allow the bed ash content to rise. After the bed ash content stabilizes near 40%, two complete ash balances will be taken with particular note as to whether the venturi discharge rate of Set Point 13 exceeds that of Set Point 12.

Set Points 11, 14, 15, 16, and 17

At this point, the time available for continuation of shakedown testing will be determined. If little time is left, Set Points 11, 14, 15, 16, and 17 will be cancelled. If time permits, as many as possible (in numerical order) of these set points should be conducted. The procedure is the same as that employed to achieve Set Points 5 through 10 as basically the same control variables are to be modified. The major difference is that alternate bed withdrawal will probably be needed at each of these set points. To the extent that any or all of these set points can be reached, they provide valuable data on the operation of the gasifier agglomerator after the venturi-central jet modifications made following Run 126. The reactor system will then be shut down for internal examination.

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Table II (Cont'd.)

Continuation of Coke Tests to Develop Ash Agglomerate Production Rate

Set Point	Period Hrs. ± 6	Bed Temp. ± 15°F	Ash Conc. in Bed ± 5%	Superficial Velocity FPS ± 0.5	Venturi Annulus Vel. FPS ± 5	Bed Height Feet ± 0.5	Cyclone's Operating Int.	II	III
*11	12	1900**	20	4	40 †	4	No	No	No
12	12	1900**	30	4	40 †	4	No	No	No
13	12	1900**	40	4	40 †	4	No	No	No
*14	12	1900**	40	4	30 ††	4	No	No	No
*15	12	1900**	40	4	50 †††	4	No	No	No
*16	12	1900**	40	4	40 †	2	No	No	No
*17	12	1900**	40	3	40 †	4	No	No	No

OTHER OPERATING CONDITIONS REQUIRED

Mode - Steam, Air, Oxygen
Process Gas to Grid - 15% Oxygen Conc. Max.
Process Gas to Venturi Anulus 21% Oxygen Conc. Max.
Process Gas to Central Jet 50% Oxygen Conc. Max.

* If time permits.
** 50°F lower than set points 5 to 10.

† Optimum; as required to control venturi discharge classification capability.
†† 10 FPS below optimum.
††† 10 FPS above optimum.

C. Coal Tests

Objectives of tests with coal are to establish a range of operating variables within which the gasifier can achieve stable, ash-balanced operation. Carbon utilization and other data from the extended steady-state coal test will be used in the decision regarding process feasibility.

Set Point 1

Set Point 1 will be carried out with the fluidized bed at 1825°F and 40% ash, as shown in Table III. The operator will start the test with metallurgical coke, following the standard U-GAS Start-Up Procedure through step 47. Fluidized bed temperature will be increased to 1825°F. The operator will then switch the process gas mixture to steam/oxygen. Following temperature stabilization, run-of-mine (1/4-inch X 0) Kentucky No. 9 coal will be fed into the gasifier as a blend with coke. For the first hour, approximately 20% of the feed will be coal. In the second hour, 40% of the feed will be coal. In the third hour, 60%. In the fourth hour, 80%. Five hours from the start of feeding coal, coke feed will cease altogether.

Since it is not known for certain that ash-balanced (no alternate bed withdrawal) ash agglomeration with this coal can be reached at temperatures below 1900°F, careful attention will be given to the bed ash content at all times. In addition, the presence of sinter flakes (formations of fine ash particulate) in the venturi ash discharge is cause for concern. If any are detected, a decision will be made whether to continue this set point, modify the test conditions, or go on to the next set point.

Set Point 2

Set Point 2 is readily obtained by lowering the alternate bed withdrawal rate until the bed ash content rises to 55%. Two well-substantiated ash balance periods will be obtained at this operating condition. This operating point of 55% may promote more ash sinter production than Set Point 1, but also may give strong evidence of ash agglomerate production. If agglomerates are produced, a rise in the venturi discharge rate should be apparent. If ash agglomerates demonstrate significant presence, the operator will proceed to Set Point 2A.

ASH AGGLOMERATING GASIFIER

Table III

Ash Agglomerating Gasifier Coal Test Runs

Set Point	Period Hrs. + 6	Bed Temp. ± 15°F	Ash Content in Bed, % + 5%	Superficial Velocity F/S + 0.5	Venturi Annulus, Vel. FPS + 0.5	Bed Height Ft. ± 0.5	Cyclone Int.	Cyclone Ext.
1	12	1825	40	4	40*	4	No	No
2	12	1825	55	4	40*	4	No	No
2A***	12	1825	55	4	40*	4	No	No
3	12	1825	70	4	40*	4	No	No
4	12	1825	70	4	20	4	No	No
5	12	1875	40	4	40*	4	No	No
6	12	1875	55	4	40*	4	No	No
7	12	1875	70	4	40*	4	No	No
8	12	1875	70	4	20	4	No	No
9	12	1875	55	3	40*	4	No	No
10	12	1875	55	4	40*	3	No	No
11	12	1875**	55**	4	40*	4	No	No
12	48	1875**	55**	4	40*	4	Yes	No
13	48	1875**	55**	4	40*	4	Yes	Yes

OTHER OPERATING CONDITIONS REQUIRED

Mode - Steam, Oxygen
Process Gas to Grid - 15% Oxygen Conc. Max.
Process Gas to Venturi Annulus - 21% Oxygen Conc. Max.
Process Gas to Central Jet - 50% Oxygen Conc. Max.

* Optimum; as required to control venturi discharge classification capability

** Or as results without bed withdrawal

*** Minimum O_2 at grid under partial aggl. mode. This test may be 3A, 4A, etc.

Set Point 2A

Set Point 2A is achieved in the same manner as was 2A of the hot shakedown coke test, Run 127, by increasing the annular venturi and central jet oxygen concentration to supply all the oxygen if possible. As in Run 127, the effect of this change, if any, upon ash agglomerate production rate should be readily noted. Again, 6 to 12 hours of data should be taken. If agglomerates are not seen in a relevant quantity in Set Point 2, Set Point 3 should be conducted.

Set Point 3

Set Point 3 requires operation at a high bed ash level (70%). Even more careful monitoring of the bed ash content will be required. The presence of ash flakes in the venturi discharge is even more likely. If the latter are detected, rapid changes in bed ash content must be made by fast flushing of the bed with fresh feed and increasing the alternate bed withdrawal rate while monitoring a bed temperature of at least 1800°F, so as not to evolve organics from the system. If conditions are stable and no ash flakes appear, two ash-balanced periods will be recorded before moving to Set Point 4. Again, if ash agglomerates appear in significant quantities at either Set Point 3 or Set Point 4, the "A" option should be implemented to determine if the agglomerate rate increases when all oxygen is supplied to the center of the reactor.

Set Point 4

Set Point 4 constitutes a significant change in the venturi annulus velocity. This change may result in a large solids flow from the venturi such that the alternate bed withdrawal rate may have to be reduced to maintain bed level. The change will be made by reducing the flow from stream 906 and will necessitate a flow increase to stream 9405 to maintain the superficial velocity and bed temperature. It may develop that the large solids flow from the venturi will result in a lowering of the ash content. A decision may be needed whether to raise the venturi annulus velocity to retain the 70% bed ash level. If this falling ash content problem does not occur, two steady-state ash-balanced periods will be obtained before moving on to Set Point 5.

Set Point 5

To achieve Set Point 5 it will be necessary first to reduce the bed ash content to 40% by flushing the reactor with additional feed while simultaneously removing bed material at a higher rate. This increased solids flow may temporarily require a greater total oxygen input to sustain bed temperatures. If additional oxygen is needed, none of the established limits (15% at the grid, 21% at the venturi annulus, or 50% at the jet) can be exceeded. As the 40% bed ash content is approached, oxygen will be added to the central jet to raise the bed temperature to 1875°F. Any adjustment required to maintain superficial velocity will be made by lowering stream 9405 flow. Since the operating mode is quite similar to Set Point 1, except for a 50°F higher temperature, the discharge from the venturi and bed will be closely monitored for the presence of ash flakes. If ash formations appear, solids flushing will be required to assure their removal from the reactor. Any increased flow of ash from the venturi will be noted if it occurs. If so, the "A" option will be employed so that when steady flow rates and temperatures are reached, data and samples yielding ash balances, with or without alternate bed withdrawal, shall be obtained for two periods (6 hours minimum).

Set Point 6

Set Point 6 is similar to Set Point 2 except for operation at 1875°F. Similarly, changes will be made to the alternate bed withdrawal rate to raise the ash level to 55%. The bed and venturi discharge solids will be closely observed for ash flake formations. These formations, as stated several times, if present, require operational changes to facilitate their rapid removal (flushing the bed with feed solids). If such ash formations do not appear, two steady-state ash balance periods will be obtained with the use of alternate bed withdrawal, if necessary. If there is an increase in the venturi discharge rate (more agglomerates), the use of the "A" option (maximizing oxygen to the center of the reactor) will be made to ascertain its ash agglomerating potential.

Set Point 7

Set Point 7 will be the next goal and as noted, except for a 50°F higher temperature, requires the same type of control changes as Set Point 4. Again, while watching for nonconforming ash formations in the hot solids streams, as well as an increased presence of agglomerates, two steady-state ash balance periods shall be recorded for which adequate sample documentation will be taken. If ash agglomeration improves significantly, the "A" option will be tried.

Set Point 8

Set Point 8, except for the 50°F higher bed temperature, requires the same careful observations as did Set Point 5, for it is possible that a high venturi discharge rate may preclude retaining a 70% ash concentration in the bed. If so, a modification in the 20 fps venturi annulus velocity will have to be made. Regardless, two steady-state ash balance periods shall be obtained with sufficient samples for verification.

Set Point 9

Set Point 9 allows for operation at a lower superficial velocity (3 fps). Comparisons as well as observations will be made of both the composition of the bed and venturi discharge material, for a change in ash agglomerate or ash flake presence may occur. The presence of the latter is cause for altering the set point conditions. However, an increase in agglomerate discharge from the venturi is cause for implementing the "A" option if it is not in effect. Again, data and samples for two steady-state ash balance periods shall be obtained.

Set Point 10

The effect of a lower (3 ft. versus 4 ft.) fluid bed level is investigated in Set Point 10. Data will be taken with documenting samples for two steady-state periods of ash balanced operation. Again, the "A" option, if not implemented earlier, can be used following Set Point 10 if there is an increased agglomerate presence.

Set Point 11

Beginning with Set Point 11 of this coal test run, control variables shall be adjusted to maximize ash agglomeration and minimize withdrawal. Accordingly, based upon the general trends observed in the earlier 10 set points, bed height, superficial velocity, and bed temperature shall be altered to maximize agglomerate production. If this objective is obtained, the resulting operational changes shall be documented by data from two steady-state periods of not less than 12 hours each.

Set Point 12

Upon completion of Set Point 11, the reactor's internal cyclone shall be activated. Activation is achieved as described during the coke shakedown tests by supplying nitrogen aeration gas to its reverse seal pot. Once activated, changes in reactor solids feed may be required (less fines loss). Bed withdrawal shall be activated to hold the bed ash content of Set Point 11. In addition, some oxygen will be needed to raise the bed temperature as the addition of fines to the reactor bed generally requires a higher ash agglomerating temperature. The temperature rise needed is not expected to exceed 25°F. Assuming stable conditions are achieved, data and samples should be taken for a 48-hour period to accumulate drum quantities of ash agglomerates.

Set Point 13

If Set Point 12 is achieved with steady-state data procured, the external cyclones shall be activated. The second-stage cyclone has a reverse seal pot similar to the internal cyclone. To accomplish recirculation of second-stage dust, the diverting valve shall be closed and the recirculating valve opened. After a dust leg (level) has accumulated up to the bottom of the second-stage cyclone, the aeration nitrogen will be turned on slowly until the chart traces and bed temperature indicate flow has started into the reactor. At this time, additional oxygen flow will be needed to restore the bed temperature. To the extent the capability exists, the ratio of 938 (O_2) to 904 (steam) will be increased to achieve the grid and annulus venturi oxygen limits, 15 and 21%, respectively, before adding extra oxygen to the central jet by way of 9303 flow. Probably a 10° to 15°F bed temperature rise over Set Point 12 will be required to sustain full ash agglomeration. Depending upon the amount of extra oxygen required, a feed rate change may or may not be necessary to hold the bed level. It will take 6 to 12 hours to substantiate steady-state operation. When steady-state is achieved, program requirements consistent with time allowed may suggest a 72 to 120 hour test period as discussed below.

Extended Coal Test

Based on results from the above coal test run and from simultaneous efforts on the 2-inch-diameter bench-scale unit and the cold-flow model, a logical approach to ash-balanced operation with coal will be developed and form a specific basis for an extended period test with coal. The objective of this test will be to operate for 5 days under ash-balanced, agglomerating conditions at operating variable values determined from Set Points 1 through 13.

D. Pressure Tests

The objective of these tests is to determine if reactor operation changes significantly with an increase in pressure.

After tests at atmospheric pressure have determined a test parameter "envelope" for ash-balanced gasifier operation at controllable conditions, U-GAS engineers will carry out tests at a higher pressure. IGT feels testing at only one higher pressure level, 60 psia, will suffice to extrapolate reactor behavior to the demonstration plant's design value of 90 psia. However, if 60-psia test results cannot be readily extrapolated from those at atmospheric pressure, tests at intermediate pressure, 40 psia, will be carried out.

The first 60-psia tests will serve to shake down the U-GAS reactor operating in the high pressure regime. During shakedown tests, the gasifier will use a coke feed. Following demonstration of stable gasifier operation with coke, U-GAS engineers will start feeding coal. The test will proceed with coal feed at operating variable values from the previous atmospheric pressure long-duration coal test. The test will last several days to demonstrate stable gasifier operation with coal feed at 60 psia.

If warranted, tests at 40 psia will be carried out in the same manner as those at 60 psia.

E. Parametric Tests

The objective of these tests is to determine the gasifier's turndown capability, response to changes in operating variables, and load-following characteristics. More detailed plans for these tests will be formulated after the 6 months pilot plant operations.

Turndown Tests

Turndown refers to the ability of the gasifier to produce a smaller quantity of gas with no decrease in gas quality. During turndown tests the gasifier will operate on coal. In the first test, operators will achieve stable, atmospheric gasifier operation. They will then reduce feed rates of coal and process gas in small decrements. If the bed remains well-fluidized and gas quality does not suffer, operators will proceed to the next decrement, and so on, until fluidization or gas quality finally deteriorates. At this point, operators will restore the gasifier to the original operating conditions.

In the next test, operators will achieve stable, steady-state gasifier operation at 60 psia. They will then reduce feed rates of coal and process gas in small decrements, and follow the same procedure as in the atmospheric-pressure turndown test.

Response to Changes in Operating Variables

For these tests the gasifier will operate on coal. Operators will achieve stable, steady-state gasifier operation at atmospheric pressure. They will then reduce and restore, in succession, each of the seven operating variables described in the section "Control of Operating Variables." Amount of reduction will be determined by change in outlet gas quality; for example, either an increase or decrease by 10%, or other pre-determined percentage, in heating value.

The test will then be repeated, except operators will first increase and then restore operating variables. Amount of increase will, as in the previous test, be determined by change in outlet gas quality.

Load Following Capability

For these tests the gasifier will operate on coal. Operators will achieve stable, steady-state gasifier operation at 60 psia. They will then attempt manually to alter gas output in response to an artificial load. This artificial load will be a line on a pre-prepared strip chart. The strip chart will be mounted in the product gas flow recorder. The operator will attempt to superimpose the line record of product gas flow on the artificial load line without sacrificing gas quality. Achieving and controlling this capability in the U-GAS pilot plant may require additional automatic control components.

CONTROL OF OPERATING VARIABLES

Past experience has shown that nearly all observable reactor behavior depends on seven controllable operating variables. These are:

1) fluidized bed temperature
2) superficial velocity
3) velocity through the venturi annulus
4) fluidized bed height
5) fluidized bed ash concentration
6) oxygen concentration of process gas entering the distributor
7) oxygen concentration of process gas entering the venturi annulus

All other variables such as product gas composition, feed rate, process gas overall composition, bed density, bed solids removal rate, and ash discharge rate depend upon changes made in the seven primary operating variables.

U-GAS operators achieve control of each operating variable through raising or lowering certain numbered feed streams, shown in Figure 4. The methods of changing operating variables are given in Table IV which follows. The diagrams in the table show different streams being raised or lowered depending on whether the process gas is a mixture of air and steam, air and steam and oxygen, or oxygen and steam.

To raise fluidized bed temperature, for example, assuming the process gas is a mixture of air and steam, the U-GAS operator would lower the flow in streams 903 and raise those in streams 905 and the air jet 9405. If oxygen concentration at the grid exceeds 15% from these changes, there is a danger of sinter formation. In this case, the operator would raise, instead of lower, steam flow to stream 903; and lower, instead of raise, air flow to stream 905. However, air flow through jet 9405 would have to be increased more than before.

The other variables are altered in a similar manner, as shown in Table IV.

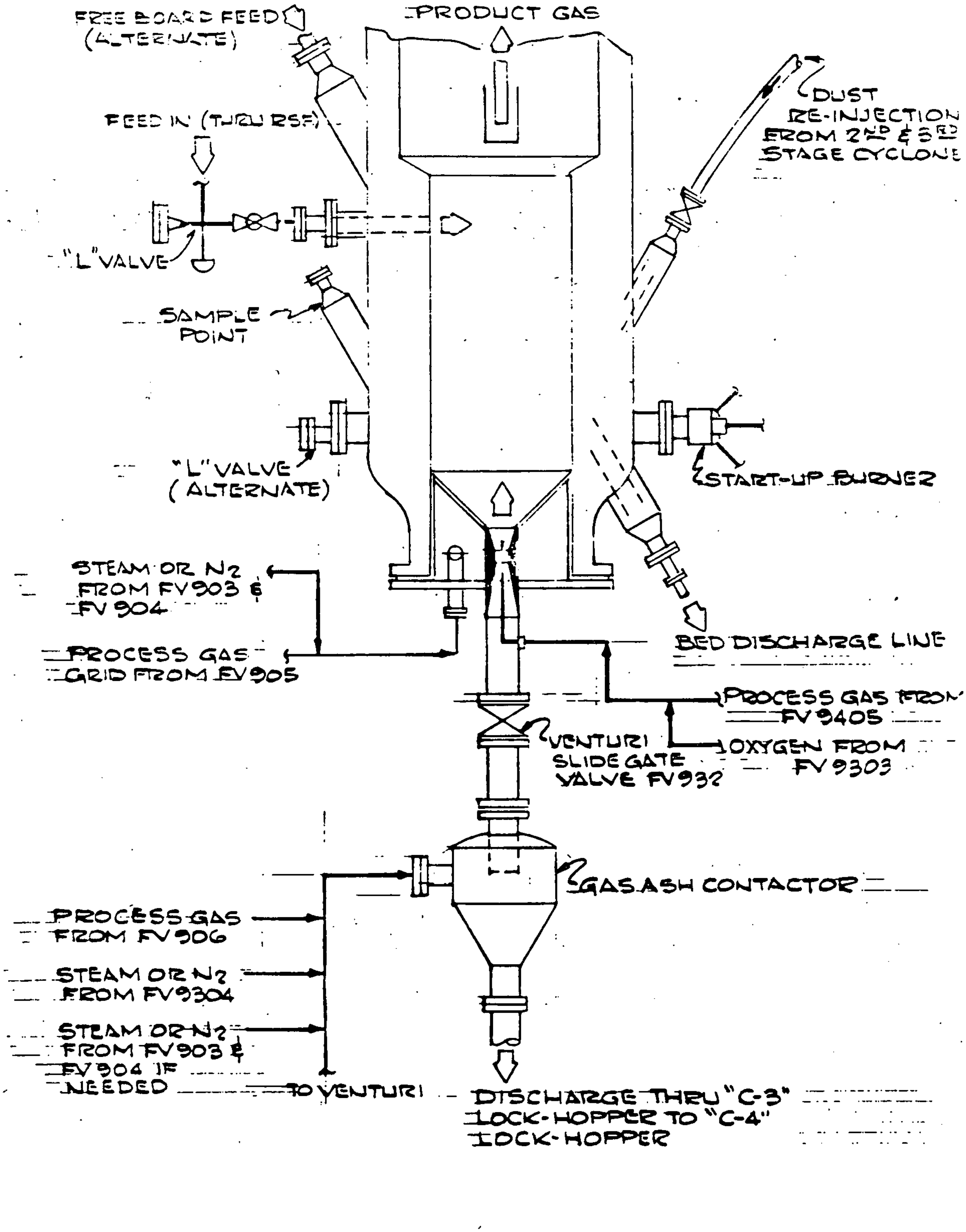

Figure 4. REACTOR CONFIGURATION

TABLE IV

FLUIDIZED BED TEMPERATURE

	Stream		Raise			Lower		
To	No.	Comp.	Air Stm	Enriched Air-Stm	Stm Oxy	Air Stm	Enriched Air-Stm	Stm Oxy
Grid	903	Steam	* ⇡ ↓	* ⇡	* ⇡	↑	↑	
Air Heater	904**	Steam			* ↓			↑
Grid	905	Air	* ⇣ ↑	* ⇣	* ⇣	↓	↓	
Ann.	906	Air		† ↓	† ⇣			
Air Heater	938**	Oxygen			↑			↓
Jet	9303	Oxygen		↑	↑		↓	↓
Ann.	9304	Steam		† ⇡	† ⇡			
Jet	9405	Air	↑	↓		↓	↑	

* Only if grid oxygen conc. will exceed 15%.

** **These streams plus air from compr. flow to air heater. Process gas from air heater flows to streams 9405, 905 and 906.** (Refer to Fig. 4)

† Only if venturi annulus oxygen conc. will exceed 21%.

Legend:

Raise ↑
Lower ↓

TABLE IV (Cont'd.)

SUPERFICIAL VELOCITY

Stream			Raise			Lower		
To	No.	Comp.	Air Stm	Enriched Air-Stm	Stm Oxy	Air Stm	Enriched Air-Stm	Stm Oxy
Grid	903	Steam	↑	↑	↑	↓	↓	↓
Air Heater	904**	Steam			↑			↓
Grid	905	Air	↑	↑	↑	↓	↓	↓
Ann.	906	Air						
Air Heater	938**	Oxygen		↑	↑		↓	↓
Jet	9303	Oxygen		↑			↓	
Ann.	9304	Steam						
Jet	9405	Air	↑	↑	↑	↓	↓	↓

** These streams plus air from compr. flow to air heater. Process gas from air heater flows to streams 9405, 905 and 906.

Legend:

Raise ↑

Lower ↓

VENTURI ANNULUS VELOCITY

To	Stream No.	Comp.	Raise Air Stm	Raise Enriched Air-Stm	Raise Stm Oxy	Lower Air Stm	Lower Enriched Air-Stm	Lower Stm Oxy
Grid	903	Steam						
Air Heater	904**	Steam						
Grid	905	Air						
Ann.	906	Air	↑	↑	↑	↓	↓	↓
Air Heater	938**	Oxygen						
Jet	9303	Oxygen						
Ann.	9304	Steam			*↑			
Jet	9405	Air	↓	↓	↓	↑	↑	↑

* Only if venturi annulus conc. will exceed 21%.

** These streams plus air from compr. flow to air heater. Process gas from air heate flows to streams 9405, 905 and 906.

Legend:

Raise ↑
Lower ↓

OXYGEN CONCENTRATION OF GRID PROCESS GAS

To	Stream No.	Comp.	Raise: Air Stm	Raise: Enriched Air-Stm	Raise: Stm Oxy	Lower: Air Stm	Lower: Enriched Air-Stm	Lower: Stm Oxy
Grid	903	Steam	↓	↓	↓	↑	↑	↑
Air Heater	904**	Steam						
Grid	905	Air	↑	↑	↑	↓	↓	↓
Ann.	906	Air						
Air Heater	938**	Oxygen						
Jet	9303	Oxygen						
Ann.	9304	Steam						
Jet	9405	Air	↓	↓	↓	↑	↑	↑

** These streams plus air from compr. flow to air heater. Process gas from air heater flows to streams 9405, 905 and 906.

Legend:

Raise ↑
Lower ↓

FLUIDIZED BED HEIGHT

Stream			Raise			Lower		
To	No.	Comp.	Air Stm	Enriched Air-Stm	Stm Oxy	Air Stm	Enriched Air-Stm	Stm Oxy
Grid	903	Steam						
Air Heater	904**	Steam						
Grid	905	Air						
Ann.	906	Air						
Air Heater	938**	Oxygen						
Jet	9303	Oxygen						
Ann.	9304	Steam						
Jet	9405	Air	↑	↑	↑	↓	↓	↓
Feed Rate			↑	↑	↑	↓	↓	↓

Note:

As new bed levels are approached, both feed rate and 9405 flow will have to be readjusted to stabilize bed height.

** These streams plus air from compr. flow to air heater. Process gas from air heater flows to streams 9405, 905 and 906.

Legend:

Raise ↑
Lower ↓

FLUIDIZED BED ASH CONCENTRATION

To	Stream No.	Comp.	Raise: Air Stm	Raise: Enriched Air-Stm	Raise: Stm Oxy	Lower: Air Stm	Lower: Enriched Air-Stm	Lower: Stm Oxy
Grid	903	Steam						
Air Heater	904**	Steam						
Grid	905	Air						
Ann.	906	Air						
Air Heater	938**	Oxygen						
Jet	9303	Oxygen						
Ann.	9304	Steam						
Jet	9405	Air	↓	↓	↓	↑	↑	↑
Bed disch. flow			↓	↓	↓	↑	↑	↑

** These streams plus air from compr. flow to air heater. Process gas from air heater flows to streams 9405, 905 and 906.

Note:

As new ash concentration is approached both bed discharge rate and 9405 flow will have to be readjusted to stabilize bed ash content.

Legend:

Raise ↑
Lower ↓

OXYGEN CONCENTRATION OF VENTURI ANNULUS PROCESS GAS

	Stream		Raise			Lower		
To	No.	Comp.	Air Stm	Enriched Air-Stm	Stm Oxy	Air Stm	Enriched Air-Stm	Stm Oxy
Grid	903	Steam		↑	↑		↓	↓
Air Heater	904**	Steam			↓			↑
Grid	905	Air		↓	↓		↑	↑
Ann.	906	Air	↑			↓		
Air Heater	938**	Oxygen		↑	↑		↓	↓
Jet	9303	Oxygen						
Ann.	9308	Steam	↓			↑		
Jet	9405	Air						

** These streams plus air from compr. flow to air heater. Process gas from air heater flows to streams 9405, 905 and 906.

Legend:

Raise ↑
Lower ↓

TEST DATA ACQUISITION AND REDUCTION

The main purpose of running the U-GAS Pilot Plant is to produce an accurate data base and to perform data analysis to determine the design conditions suitable for commercial utilization of the U-GAS process. To achieve these objectives, accuracy, care for detail, efficiency, and thorough checking and rechecking are necessary. To establish a good data base, the procedures described below must be followed carefully. However, procedures must be updated to reflect any changes made in the pilot plant system.

1. Data Acquisition

- To ensure a uniform data base, a simple procedure has been instituted regarding data acquisition.

  At the start of each run, a shift engineer will assemble a large accordian file folder with 5 cut files placed inside properly marked with the following labels:

  a) Panel & Local Data, Run # ________,
  b) Data Reduction, Run # ____________,
  c) Check Lists, Run # _______________,
  d) Analysis, Run # __________________,
  e) Charts, Run # ____________________.

  Use a marker to indicate the Run number on the pocket folder.

- A sample of Panel and Local Data sheets together with solids discharge sheets (C-4, C-7, 2nd stage fines, 3rd stage fines) are provided herein. (See Appendices B-1 through B-6.)

- On all the data sheets complete and accurate entries must be made of the Run number, the date, the names of operating personnel, etc.

- A proper markup of all the charts at the beginning of each shift is mandatory (e.g., time, date, run number). If the chart does not correspond to the clock, make the proper adjustment.

- Monitor all the charts (especially the feed chart) every few minutes to ensure their operability. If something appears to be amiss with any chart, take corrective actions immediately.

- If for some reason data are not recorded on the panel or local data sheets during the course of the run, please indicate the nature of the problem on the data sheet for that particular time interval.

- The shift engineer is responsible for making precise and appropriate entries in the log book during the course of the run. Log the exact chain of events as you perceive them and record your respective actions. (Refrain from entering such trivial remarks as "made a round of coffee tonight!") Sometimes in emergency situations, shift engineers have to take quick and thoughtful actions. At these moments, don't just spend time writing in the log book. Instead, try to bring the situation under control through analyzing and attempting to solve the problem first. Make entries afterward without drawing any undue conclusions.

- Any data acquisition changes in the pilot plant (e.g., new thermocouples, new loops, etc.) shall be incorporated by the shift engineers in the panel and local data sheets before the start of the next run.

2. Data Reduction

- To assess the actual operating conditions (flows, velocities, etc.) during the AAG test runs, it is important that the shift engineer on duty reduce the run data every 2 hours (or more frequently if necessary). A sample of input data sheet is included herein for reference. All the flow, temperature and pressure readings from the panel and local data sheets should be entered with care (always check entries against the panel and local data sheets). (See Appendix C-1.)

- A portable Data Terminal (Model 745, Texas Instrument) has been installed in the AAG Control Room. To reduce the data reduction time and computer charges, a run-only-version of the flow program (On-Line System) has been prepared. A sample of On-Line System, Input-Output is attached. Follow the sample sheet carefully and obtain an output in a reasonable amount of time (it should not take more than 5 minutes to get the output). Figure 5 shows a sample input/output.

- While still receiving the output, check the input to the computer from Input Data Sheet and make sure there are no errors in transferring the numbers. Initial the Input Data Sheet to verify that you have checked it.

- If for some reason an access to the On-Line System is not available, call 368-1895 (instead of 363-1380). If the problem still persists, inform On-Line Operations in Pittsburgh at (412) 931-7600 and explain our problem to them. If, in spite of all this, the problem still exists, don't waste time trying to run the computer. Instead, try to prepare the Input Data Sheet (you don't need a computer for this) and run it off when access to the On-Line System is available again.

- From time to time, either a change in the orifice diameter or meter range on some flow is necessary. In this event, the shift engineer should inform the Data Analysis Group of the change as quickly as possible. Under such circumstances the necessary changes in the program can be made to reflect the new conditions.

- We have a computer program for the orifice plate to determine the flow of steam, gas and liquid through a specific orifice. With a change in orifice diameter, a new coefficient must be calculated and the flow program must be updated to reflect that change. For a change in Meter Range, the data file must be updated.

- At the end of each run, the Data Terminal should be properly cleaned and returned to the office.

```
ENBEC
VC

SCHEDULED MAINTENANCE 10 PM(EDT) TO 12 PM(EDT) AUG. 1

31-JUL-78 -- CHICAGO USERS, PLEASE TYPE INFORM.

SYSTEM?..
.FOR AAG6.TMP
FILE CREATED

*I100
00100   126
00110   7/11/78
00120   0800
00130   3.8,314,71,3,1
00140   0
00150   7.3,693,20
00160   7.6,693,20
00170   0
00180   0
00190   3.8,74,78,2
00200   2.4,90,85
00210   2.6
00220   0
00230   4.85,180,20.5
00240   0
00250   2.9,90,88
00260   .64,6,683,2,1930,3
00270
*SAVE
FILE SAVED
*

SYSTEM?..
.RUN AAG6

TYPE 1 FOR FILE INPUT, TYPE 2 FOR TTY INPUT: 1


AAG RUN NUMBER  126                                   DATE: 07-11-78
                                                      TIME: 0800

OXYGEN CONCENTRATION OF FR 905,906(AND 909 WHEN APPLICABLE) FLOWS =   21.00 %
OXYGEN CONCENTRATION ABOVE VENTURI =   21.00 %
OXYGEN CONCENTRATION AT GRID =   14.32 %
```

STREAM	RANGE ("W.C.)	M. R.	TEMP (DEG F)	PRESS (PSIG)	COMPN'T	MOL WT	MASS FLOW (LB/HR)	MOLAR FLOW (LB-MOLE/HR)
FR 903	100.0	3.80	314.0	71.0	STEAM	18.00	258.4	14.36
FR 904	50.0	0.0					0.0	0.00
FR 905	15.0	7.30	693.0	20.0	MIXTR	28.90	888.8	30.76
FR 906	50.0	7.60	693.0	20.0	MIXTR	28.90	1012.1	35.02
FR 9304	100.0	0.0					0.0	0.00
FR 930	100.0	0.0					0.0	0.00
FR 9303	100.0	3.80	74.0	78.0	O2	32.00	201.8	6.31
FR 937	100.0	2.40	90.0	85.0	N2	28.00	48.1	1.72
FR 918	100.0	2.60			STEAM	18.00	534.9	29.72
FR 9330	69.2	0.0					0.0	0.00
FR 995	50.0	4.85	180.0	20.5	AIR	28.90	1960.3	67.83
FR 909	30.0	0.0					0.0	0.00
FR 9394	200.0	2.90	90.0	88.0	N2	28.00	376.5	13.45

```
OVERALL SUPERFICIAL VELOCITY (@ 1930.0 °F, 6.0 PSIG) =  4.20 FPS
GRID VELOCITY (@ 1930.0 °F, 6.0 PSIG) =  2.28 FPS
VENTURI VELOCITY (@ 682.0 °F, 6.6 PSIG, 3.0" DIA) = 113.60 FPS
PCT. DEV. OF SUM OF 995,930,904(WHEN APPLICABLE)
         AND SUM OF 905,906(WHEN APPLICABLE) =  3.03 %


STREAM  904 IS ROUTED TO AIR HEATER


CP UNITS    11

.EXIT

SYSTEM?..
.UNSAVE AAG6.TMP

FILES UNSAVED:
 AAG6.TMP
```

Figure 5. ON-LINE SYSTEM INPUT-OUTPUT

- All in all, Data Reduction every 2 hours serves two purposes:

  a) We get an accurate picture of the operating conditions of the plant which enables us to make any changes required, and

  b) As a by-product, 40-50% of the data analysis work is begun.

3. Data Analysis

- Once the data reduction is accomplished, (at every 2-hour interval) the next step in the data analysis requires preparation of a Data Summary Sheet (see Appendix C-2). This data summary sheet is in essence a running log of the entire test run. Here the raw data on gas and solids flows are reported together with analysis of reactor gas and solids (feed, bed, C-4 discharge, C-7 discharge, 2nd stage fines, 3rd stage fines). Both the reactor gas composition analysis, as determined by the Mass Spectrometer, and solids analysis (proximate, ultimate and heating value) are performed by IGT's State Street Analytical Groups. Generally, a data summary sheet with all gas and liquid flows is kept up-to-date as we proceed with the run.

- After careful evaluation of the data summary sheet, some steady-state time periods are selected for analysis. In general, these time periods reflect reasonably stable temperatures and flow rates. Samples are then selected from these time intervals and sent to State Street for the required analysis.

- On receiving these analytical results, an attempt is made to prepare material and energy balances for these steady-state periods.

  a) Manual Method

  First, worksheets of material and energy balances (see Appendices C-3 and C-4) are prepared. Then the necessary information is transferred to the Material and Energy Balance Summary Sheet (see Appendix C-5). Also an "Operating Data Summary" sheet is prepared for the particular steady-state time period (see Appendix C-6).

b. Computer Method

Recently, a computer program has been devised to prepare material and energy balances for AAG.

The following inputs are required:

time interval, ultimate analysis of feed, C-4, 2nd stage fines, 3rd stage fines, C-7, bed, feed moisture content, solids feed rates (all), gas flow rates, compositions of various streams like grid gas, venturi gas, etc., reactor gas composition (dry basis), initial and final bed height and density, temperatures of various streams, steam pressures and HHV of solids. The output is printed as in Figure 6 which follows:

Figure 6

AGS MATERIAL AND HEAT BALANCE SUMMARY

RUN NO. 122 DATE 3/30/78 TIME PERIOD 1200-1800

BASIS= 1 HR. ALL UNITS IN LBS UNLESS OTHER WISE NOTED

INPUT	C	ASH	N	S	H	O	TOTAL	BTU/HR
FEED	1168.7	340.2	20.2	89.7	82.5	148.6	1850.0	21020159.
TO VENTURI			562.7		1.7	184.2	748.6	65869.
TO GRID			2400.3		83.1	1388.0	3871.3	1099237.
TO REACTOR			70.0			0.0	70.0	-122.
PURGES			398.1				398.1	-693.
TOTAL INPUT	1168.7	340.2	3451.2	89.7	167.2	1720.8	6938.0	22184449.
WALL LOSSES	0.0	0.0	0.0	0.0	0.0	0.0	0.0	250000.
VNTRI DISCHARGE	3.1	32.7	0.0	2.1	0.0	0.0	37.9	48544.
BED DISCHARGE	35.8	119.2	0.4	6.6	0.4	0.0	162.4	498449.
2ND STAGE FINES	414.1	158.6	5.4	22.0	3.5	0.0	603.6	6600113.
3RD STAGE FINES	7.9	3.4	0.1	0.4	0.1	0.1	12.0	127064.
BED INV. CHANGE	--1.9	--5.9	--0.0	--0.4	--0.0	0.0	--8.3	--3865.
REACTOR GAS	564.6		3445.3	3.6	167.2	1658.2	5839.0	12401185.
TOTAL OUTPUT	1023.6	308.0	3451.2	34.3	167.2	1658.2	6642.6	19921488.
NET (OUT--IN)	-145.1	--32.3	0.0	--55.4	0.0	--62.6	--295.4	-2262961.
%BALANCE OUT/IN	87.6	90.5	100.0	38.2	100.0	96.4	95.7	90.

4. <u>Data Storage and Reporting</u>

Once the run is over, the shift engineer on duty must make sure that the run folder is arranged properly and readied for data analysis. The following actions must be taken to preserve the valuable run data.

- During the run, make sure there are no missing data sheets. Arrange them in proper files when you start a new sheet.
- Shift engineers are responsible for checking the entries on all the data sheets (date, run number, time, initials, etc.).
- All the charts should be properly folded and identified and then placed in the appropriate file. Folded charts should be within a 7-1/2" X 10" size range. On each folded chart a proper identification (run number, title, date, etc.) must be marked. Use paper clips and rubber bands to hold the charts together.
- Put all solids discharge data sheets with Panel and Local Data sheets.
- If quick-ash analysis results are available on several samples like bed, 2nd and 3rd stage fines, C-7, C-4, etc., arrange them in their proper categories and in chronological order (time and date) and staple them separately (each category) to avoid any mixups.
- For easy retrieval, all run folders are stored in chronological order in file cabinets in the office.
- At the end of each month, run data are reported in the Monthly Report. They include run data summary, operating data summary, mass and heat balances and the commentary on the run itself.

  In the event of late arrival of some analysis of solids, pertinent information is released as and when it becomes available.

5. <u>Weight Fraction of Agglomerates</u>

The primary purpose for investigating various operating parameters such as bed height, bed ash content, superficial velocity and bed temperatures, is to determine the rate of ash agglomeration. This rate, for the purpose of monitoring the test operation, should be determined rapidly as the test proceeds. What is wanted is the weight fraction of the agglomerates in each solids discharge stream. This determination can be accomplished by an actual physical removal and weighing of agglomerates from solids discharge samples. Another method is to take the same samples and determine by a float-sink (putting the material in a fluid to float the char and sink the ash) method, the weight fraction of agglomerates. The latter method could be excellent for accurate determinations of ash agglomerate concentrations provided that the agglomerates are consistently heavier than the char. However, this float-sink method is time-consuming and is inappropriate for control of bed ash content during the test program. Accordingly, the more suitable method during a test run is to weigh the bed samples taken hourly and physically separate the ash agglomerates by hand. IGT's experience with such samples leads to the conclusion that accuracy to within 5% can be expected. This accuracy, along with the time required, would be acceptable to yield rapidly the information needed for program changes for succeeding Set Points. The agglomerates separated would be weighed along with the bed sample weight, and the ratio would yield the percent agglomerates. If bed withdrawal is under way, the withdrawal rate would be multiplied by the agglomerate percentage in the bed sample to determine the agglomerate withdrawal rate. Upon adding this rate to that of agglomerates discharged from the venturi, the sum can be compared to the actual ash feed rate. From this information, a graph will be prepared relating bed ash content to percent of ash agglomerated.

As a back-up, the ash concentration of various particle size fractions will be determined on the same bed sample. Although the manner of illustrating agglomerate concentration by particle size has not been determined, its relationship to bed temperature may be found to be obvious, depending upon the results obtained.

NORMAL AND EMERGENCY OPERATING PROCEDURES

This section gives the major U-GAS operating procedures involved in normal operation and emergency circumstances.

Normal Operating Procedures

During normal operation, U-GAS operators follow several procedures. These procedures are for the following purposes:

- maintaining bed temperature
- switching from coke to coal feed
- maintaining bed height
- switching from steam/air to steam/oxygen gasification and vice versa
- idling the unit
- normal shutdown
- manway opening

(Appendices D-1 through D-7 show these procedures.)

Also U-GAS technicians use the following sampling procedures to collect data during normal operation:

- feed
- bed
- 2nd stage cyclone fines
- 3rd stage cyclone fines
- reactor gas
- product gas condensate
- venturi discharge
- bed discharge

(Appendices D-8 through D-15 show these solids and gas sampling procedures.)

Emergency Operating Procedures

During emergencies, U-GAS operators follow several shutdown procedures:

- high temperature in the reactor
- loss of steam
- loss of process air
- loss of power
- loss of nitrogen
- loss of feed

(Appendices E-1 through E-6 show these procedures.)

COST ESTIMATE

A summary of costs for the Pilot Plant operations is shown in Table 5 below. The costs are broken down into general categories of labor and materials and services. The usual DOE facility overhead charges and IGT's G&A costs are included. A more detailed breakdown of costs will be provided under separate cover.

Table 5. ADDITIONAL FUNDING REQUIRED FOR TASK IX — TECHNICAL SUPPORT

(Cost Estimate Summary)

Total Direct Labor	$ 255,673
Materials/Services	626,570
Total Direct Costs	$ 882,243
DOE Facility Overhead @ 17%	149,981
Total Direct and Overhead Costs	$1,032,224
General and Administrative @ 9.0%	92,900
Total Estimated Cost	$1,125,124

APPENDIX A

U-GAS Start-Up Procedure

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U-GAS START-UP PROCEDURE

STEP	DATE	TIME	INT.	ACTIONS	REMARKS (PROBLEMS AND SOLUTIONS)
1				Start the incinerator. (Refer to specific procedure.) *	
2				Start valve check list - Close bed discharge valve (FV9349), C4, C5, C6, C7 vents. Open venturi slide valve (FV932), main air supply valve (VO'-5).	
3				Open product gas inlet valve to scrubber FV915A and product gas bypass PV966. Be certain that reactor rupture disc valves VO'-243, V59'-76 are open. Check blast connections to above-mentioned valves.	
4				Turn on all recorders. Set time and date stamp on charts. Verify all recorders, controllers, indicators for zero readings. Set all controllers on zero setting and on manual operation, except: TIC 917 at 600°F on Auto operation TIC 9330 at 700°F on Auto operation PIC 901 at 20 psi on Auto operation	

* Specific operating procedures are detailed in the Procedures Manual.

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U-GAS START-UP PROCEDURE

STEP	DATE	TIME	INT.	ACTIONS	REMARKS (PROBLEMS AND SOLUTIONS)
5				Check instrument air to PDT, FT, PT, FIC, FR, etc. (both panel and local mounted) plant air to cooling rings, and nitrogen to pneumatic valves.	
6				Open slightly FV905, 906 and 9405 and set them on manual operation.	
7				Turn on all steam tracings particularly at product gas line, 2nd and 3rd stage diplegs, PV 966 vent line, feed chute to silo A and transfer screw feeder to silo B.	
8				Start scrubber (refer to specific procedure)	

U-GAS START-UP PROCEDURE

STEP	DATE	TIME	INT.	ACTIONS	REMARKS (PROBLEMS AND SOLUTIONS)
9				Open main N_2 supply to reactor. Set purges per N_2 purge list. Take one set of local and panel data. Adjust purges until all PDR's are zero and note settings. Spool piece must first be installed in nitrogen supply line to reactor. Wire blind flanges to spool piece. There should be <u>NO</u> flow through the 9361 loop or FI9349.	
10				Check all blast taps on all solid handling valves. Use radios and confirm flow on FR9314 (total nitrogen).	
11				Check FR9314. If flow does not fall below 1.0 an unmetered blast is left open. (Total purges ≈15 moles/hr.)	
12				Check N_2 purges to the reactor against FR9394. It should fall between 3.0 and 4.0. (12.5 to 16.5 moles/hr)	

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STEP	DATE	TIME	INT.	ACTIONS	REMARKS (PROBLEMS AND SOLUTIONS)
13				Open N_2 supply to 1st and 2nd quencher. Set pressure on PI 9103 and PI 9121 to 35 psi.	
14				Turn on all purges to L-valve, set at 10.0 FI 9341 FI 9345 FI 9342 FI 9346 FI 9343 FI 9347 FI 9344	
15				Turn on N_2 to 9303. Set FIC 9303 at 3.0 on automatic position. Leave manual and auto station open on 21'-6" level. (94.8 moles/hr.)	
16				Turn on start-up burner and open air valve. Adjust flow to 4" H_2O on PDI 972 and 3.0 on FI986 for cooling nozzle (on 29'-2" level). Be sure to install spool piece on the natural gas line.	

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STEP	DATE	TIME	INT.	ACTIONS	REMARKS (PROBLEMS AND SOLUTIONS)
17				Call analytical group; ask them to start gas analyzer aspiration. Make sure the block valve (V50'-76) for steam tracing and product gas sample line is open. Raise reactor pressure to 6 psi for sufficient analyzer pressure by adjusting PIC 915A. (Analyzers located in adjacent lab, Bldg. 19.)	
18				Inform Steam-Iron: AAG will use 300 #/hr of 150 psi steam in 8 hours. AAG will use 12,000 SCFH of N_2 in 4 hours. Inform HYGAS: AAG will use 10,000 SCFH of plant air and 1,000 SCFH of natural gas immediately. AAG will need a continuous supply of instrument air.	
19				Turn on compressor (refer to specific procedure). <u>Important</u>: Before turning on the compressor, clean the compressor room with air hose. Cover air inlet filter before cleaning the room and remove cover afterwards.	
20				Switch PSL 960 (process compressor failure low pressure) to off position.	

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STEP	DATE	TIME	INT.	ACTIONS	REMARKS (PROBLEMS AND SOLUTIONS)
21				Raise FIC 905 to 6.0, FIC 906 to 8.0 and FIC 9405 to 2.5 automatic mode. Maintain 20 psi at PIC 901. (9405 & 9303 to net 100 fps at center jet.) T^o = 150°F FR 905 = 37 moles/hr P = 20 psig FR 906 = 35 moles/hr FR 9405 = 6 moles/hr	
22				Mark and tare C-4 and C-7 discharge drums. Start local and panel data recording. Mark and tare 2nd and 3rd stage dust drums.	
23				Start the air heater and raise to 400°F in no less than 1 hour. (Refer to specific procedure). Increase the temperature by 100°F/hr till it reaches 800°F.	
24				Check PI 919 reading. If it exceeds 3psi, the product gas line is partially plugged. Check all PDI's readings to locate blockage and clear it.	

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STEP	DATE	TIME	INT.	ACTIONS	REMARKS (PROBLEMS AND SOLUTIONS)
25				While the air heater temperature is being raised, pressurize the system by adjusting PIC 915 until it reads 10-15 psig.	
26				Check to make sure both quenchers are drained of water and solids during the pressure test.	
27				Check for leaks at all flanges and screw thread joints which were opened before the run. Also check packings on reactor screwfeeder and L-valve. After checking, reduce PIC 915 to 2 psig.	
28				Try start-up burner. Make sure it will stay lit for 5 minutes. (Refer to procedure for igniting start-up burner). Then, turn it off. <u>Important</u>: Do not turn off the air flow and 986 purge.	
29				Turn on N_2 to 903 loop. Set PV 923 at 70 psig. Set FIC 903 to achieve 15% oxygen at grid.* Set FIC 903 on automatic mode. Notify Steam Iron of N_2 consumption. *With TR 9206-18 at 650°F and PI 905 at 20 psig 905 flow ≃26 moles/hr ∴ 903 ≃ 10 moles/hr.	

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U-GAS START-UP PROCEDURE

STEP	DATE	TIME	INT.	ACTIONS	REMARKS (PROBLEMS AND SOLUTIONS)
30				Calculate -Superficial Velocity __________FPS -Grid Velocity __________FPS -Venturi Velocity __________FPS (annular) -Center Jet Velocity __________FPS -O_2 at Grid __________%	
31				Turn on scale system. (Refer to procedure for starting scale). Switch feeding selector switch to screw feeder. Set pointer on scale to 165 lbs. Set silo selector switch to feed coke.	
32				Turn down air heater to 600°F.	
33				Check aeration at L-Valve.* Start reactor screw feeder (Automatic operation setting). Set screw feeder rate at lower limit of slow speed adjustment and test dump cycle. *FI 9341-7 =10.0	

U-GAS START-UP PROCEDURE

STEP	DATE	TIME	INT.	ACTIONS	REMARKS (PROBLEMS AND SOLUTIONS)
34				Adjust speed of reactor screw feeder for desired solids feed rate of 500 lbs/hr. Raise reactor screw speed (gradually) until desired feed rate is attained.	
35				Feed a total of 1500 lbs to the reactor.	
36				Watch for material falling through the venturi. Adjust FIC 906 if necessary to obtain a discharge rate through C-4 of 10-20 lbs/hr.	
37				Observe pen traces of PDR 913 and 912 for degree of fluidization. If in doubt, adjust FIC 903, 905 or 9405. Check velocity with computer: -Grid velocity need not exceed 0.8 FPS -Superficial velocity need not exceed 2.0 FPS	

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U-GAS START-UP PROCEDURE

STEP	DATE	TIME	INT.	ACTIONS	REMARKS (PROBLEMS AND SOLUTIONS)
38				Monitor TR 9302-3. Raise air heater to 800°F. Do not allow TR 9302-21 to exceed 1500°F.	
39				During heating of bed, calculate velocities at venturi and superficial and adjust 906 to hold 10-20 lbs/hr C-4 discharge consistently.	
40				If bed temperature TR 9206-3 does not rise at a minimum of 60°F/hr, ignite start-up burner (Refer to specific procedure.) Shut off FI 9307 and leave FI 986 A on. Set PDI 971 and PDI 972 at 4" w.c.	
41				Increase the heat input through the burner to obtain 100°F/hr rise at TR 9206-3 by raising PDI 971 and PDI 972 as needed.	

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U-GAS START-UP PROCEDURE

STEP	DATE	TIME	INT.	ACTIONS	REMARKS (PROBLEMS AND SOLUTIONS)
42				When the reactor temperature TR 9206-3 reaches 700°F; Check BFW pressure PI 9115 If it reads 200 psi, switch PSL 954 to off position. If it reads below 50 psi, use city process water and start quench pump. Open block valves upstream and downstream of TV 917 and TV 9330.	
43				When bed temperature rise reaches 300°F/hr (bed auto ignition) turn off start-up burner. Restore purge FI 9307 at start-up burner. Close all valves on air and gas supply lines downstream of pressure regulators.	
44				As the temperature in the bed attains 1500°F Switch steam to 903, 904 loops. Switch PSL 959 (low steam pressure) to off position.	
45				Run computer calculations every hour until bed temperature stabilizes so as not to exceed 4 FPS superficial velocity by adjusting 905, 903 and 9405 as needed.	

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U-GAS START-UP PROCEDURE

STEP	DATE	TIME	INT.	ACTIONS	REMARKS (PROBLEMS AND SOLUTIONS)
46				Check gas analyzer flows. These flows can be read at the adjacent lab. (Building 19). If there is no flow tell shift engineer.*	* Call Analytical Group
47				Follow specific instructions for the run by going to Test Run # _____ specific procedures.	

APPENDIX B-1

AAG PANEL INSTRUMENTS DATA SHEET	Proj. 9616	Form AAG 7-10	Rev. 8/16/78	Test Day #	Run #	Date	Page 1/8
	Shift	2300-0700		0700-1500		1500-2300	
	Engineer						
	Technicians						

TIME	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
FEED												
TI 9206 High Temp. Alarm for Feed												
ANR 975 CO_2												
ANR 977 CO												
ANR 978 O_2												
ANR 981 H_2												
PDR 982 PSI ΔP-(24.5') 1st CYC. DIPLEG												
PDR 983 (9'-10") PSI ΔP ACROSS 1ST CYC. DIPLEG												
PDR 9301 PSI ΔP ACROSS 1ST CYC.												
TI 9202 ^{o}F Start-up burner nozzle temp.												

AAG/Panel	Proj. 9616	Form AAG 7-10	Rev. 8/16/78	Test Day #	Run #	Date	Page 2/8

TIME	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
PDI 9331 PSI ΔP 2ND STAGE QUENCHER												
PI 913 PSIG RCTR. P 5" ABOVE GRID												
PI 919 PSI 1ST QUENCHER OUTLET P.												
PDI 920 ΔP ACROSS 3rd CYC.												
TIC 9330 °F 2ND QUENCHER OUTLET T.												
FR 937 ___ IN W.C. N_2 TO QUENCHERS												
FR 903 ___ IN W.C.												
STM./N_2												
G/H/V												
FR 938 ___ IN W.C. O_2 TO AIR HTR.												
FR 905 ___ IN W.C. HTD. AIR TO GRID												
FR 904 ___ IN W.C.												
STM./N_2												
G/H/V												

AAG/Panel	Proj. 9616	Form AAG 7-10	Rev. 8/16/78	Test Day #	Run #	Date	Page 3/[illegible]

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
FR 906 ____ in W. C. HTD air to venturi												
PDR 912 psi ΔP Across entire bed.												
PDR 913 psi ΔP across ______ of bed												
ANR 9383 Methane												
PR 901 psig Air P. for 995 air flow												
PDR 911 psi ΔP across grid												
PDR 910 psi ΔP across venturi												
FR 920 ____ in W.C. Prod. Gas Flow												
FR 9405 ____ in W.C Process air to center jet.												
FR 9394 ____ in W.C. Purge N_2 to reactor												
FR 995 ____ in W.C. Air to air heater												
FR 918 ____ in W.C. H_2O to 1st quencher												
FR 9330 ____ in W.C. H_2O to 2nd quencher												
TR 9206-1 °F °F Gas T. entering venturi												

AAG/PANEL	Proj. 9616	Form AAG 7-10	Rev. 8/16/78	Test Day #	Run #	Date	Page 4/8

TIME	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
TR 9206-2 °F GAS T. ENTERING GRID												
TR 9206-3 °F BED T. 11" ABOVE GRID												
TR 9206-4 °F O_2 SUPPLY T.												
TR 9206-5 °F BED T. 22" ABOVE GRID												
TR 9206-6 °F BED T. 33" ABOVE GRID												
TR 9206-7 °F Grid Temp.												
TR 9206-8 °F RCTR. T. 57" ABOVE GRID												
TR 9206-9 °F RCTR. T. 69" ABOVE GRID												
TR 9206-10 °F RCTR. T. 82" ABOVE GRID												
TR 9206-11 °F RCTR. T. 92" ABOVE GRID												
TR 9206-12 °F RCTR. T. 118" ABOVE GRID												
TR 9206-13 °F RCTR. T. 142" ABOVE GRID												

AAG/Panel	Proj. 9616	Form AAG 7-10	Rev. 8/16/78	Test Day #	Run #	Date	Page 5/8

TIME	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
TR 9206-14 °F QUENCHER H_2O (INLET) T.												
TR 9206-15 °F PROD. GAS T.												
TR 9206-16 °F GAS T. TO 1ST QUENCHER												
TR 9206-17 °F STM. T. TO AIR HTR.												
TR 9206-18 °F GAS T. AT AIR HTR. OUTLET												
TR 9206-19 °F FINES RETURN 3RD STG. CYC.												
TR 9206-20 °F L-Valve feed nozzle temp.												
TR 9206-21 °F COMB. T. OF AIR HTR.												
TR 9206-22 °F 1st Quencher outlet temp.												
TR 9206-23 °F RCTR. T. 1" ABOVE GRID												
TR 9206-24 °F FINES RETURN T.												

AAG/Panel	Proj. 9616	Form AAG 7-10	Rev. 8/16/78	Test Day #	Run #	Date	Page 6/8

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
TI-9206-25 °F Temp. in Feed Chute												
TI-9206-26 °F Scrubber Inlet Gas T.												
TI-9206-27 °F Scrubber Outlet Gas T												
TI-9206-28 °F Water T. in Scrubber Sump												
TI-9206-29 °F Exhaust Temp. of air htr												
TI-9206-30 °F Air T. at FE 995												
TR 902 °F Air Htr. Control T.												

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AAC/Panel	Proj. 9616	Form AAC 7-10	Rev. 8/16/78	Test Day #	Run #	Date	Page 7/8

TIME	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
TR 917 °F 1ST QUENCHER OUTLET T.												
PDR 941 PSI ΔP ACROSS 2ND CYC.												
PR 915 PSIG FREEBOARD PRESSURE												
FR 909 ____ IN W.C. FINES SWEEP GAS (N_2)												
FR 9361 ____ IN W.C. N_2 TO BED DISCHARGE												
FR 9303 ____ IN W.C. N_2/O_2 TO VENTURI												
N_2/O_2												
FR 9304 ____ IN W.C. STM/N_2 TO VENTURI												
STM/N_2												
PDR 9302 (35') PSI ΔP ____ 3RD CYC. DIPLEG												
PDR 9360 PSI ΔP ACROSS 3RD CYC. DIPLEG												
PDR 996 PSI ΔP 30" 2ND CYC. DIPLEG												
PDR 997 PSI ΔP ACROSS 2ND CYC. DIPLEG												
FI 9384 ____ in. W.C. N_2 to Air Heater												

AAG/Panel	Proj. 9616	Form AAG 7-10	Rev.	Test Day #	Run #	Date	Page 8/S

TIME	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
PDI 9356 PSI ΔP ACROSS L-VALVE												
PDI 9355 PSI ΔP 1' 2ND STAGE SEALPOT												
FI 9336 Prod. Gas Sample Flow												
SI 916 RPM RCTR. SCR. FDR.												
WEIGH SCALE COUNTER WI 916 Net scale setting ______ lb.												
FR 9327 ______ IN W.C. TOTAL STEAM FLOW												
*FR 9314 ______ IN W.C. Total N_2 Flow												
PI 920 Prod. Gas Line P.												
PI 986 N_2 to cool Start-up burner.												

*REPLACE CIRCULAR CHART 0900 HOURS (ALSO REPLACE INCINERATOR CHART)

APPENDIX B-2

AAG Local Instruments Data Sheet	Proj. 9616	AAG 7-19	Rev. 8/16/78	Test Day #	Run #	Date	Page 1/13
	Shift	2300-0700		0700-1500		1500-2300	
	Engineer						
	Tech.						

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
Feed												
PI 9101 0'-0" Steam Press., PSIG (con. rm)												
PI 9314 0'-0" N_2 Supply press PSIG(con.rm)												
PI 9115 0'-0" quench H_2O supply P., PSIG (con. rm.)												
FI 999 0'-0" N_2 purge to C-4 hopper												
FI 9318 0'-0" N_2 purge to B. Elevator (Bottom)												
Compressor Air Discharge 0'-0" T., ^oF (Comp. Rm.) In HG Vacuum												
Air Filter Restriction 0'-0" gauge (Comp. Rm.)												
Check warning lights 0'-0" on compressor B (Comp. Rm.)												
Check warning lighta 0'-0" on Deionizer (Comp. Rm.)												

AAG/Local	Proj. 9616	AAG 7-19		Rev. 8/16/7		Test Day#		Run #		Date		Page 2/13
Time		0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
FI 975 0'-0" Gas Flow CO_2 Anal. Cfh.													
FI 951 0'-0" Gas Flow H_2 Anal. Cfh.													
FI 979 0'-0" Gas sample bypass line Cfh.													
FI 978 0'-0" Gas Flow O_2 Anal. Cfh.													
FI 977 0'-0" Gas Flow CO Anal. Cfh.													
PI 905 0'-0" FE 905 Inlet Press., psig													
PI 906 0'-0" FE 906, Inlet Press., psig													

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AAG/Local	Proj. 9616	AAG7-19		Rev. 8/16/78		Test Day #	Run #		Date		Page 3/13	
TIME		0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
N_2 tank level (inch)	0'-0"												
O_2 tank level (inch)	0'-0"												
FI 9412 N_2 purge to product gas scrubber rupture disc	0'-0"												
PI 9131 Press. of recirculating water	0'-0" psig												
PI 9132 Press. of scrubbing water to top of scrubber	0'-0" psig												
PI 9133 Press. of scrubbing water to bottom of scrubber	0'-0" psig												
PI 9134 Press. at top of scrubber	0'-0" psig												
PI 9135 Press. at the middle of scrubber	0'-0" psig												
PI 9136 Press. at the bottom of scrubber	0'-0" psig												
FI 9371 Recirculated water to spray nozzle of the scrubber	0'-0" GPM												
FI 9372 Recirculated water to plates of the scrubber	0'-0" GPM												

AAG/Local	Proj. 9616	AAG 7-19	Rev 8/16/78	Test Day #	Run #	Date	Page 4/13

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
PI 9304 13'-10" FE 9304 inlet Press, PSIG												
PI 904 13'-10" FE 904 Inlet Press, PSIG												
FI 9354 13'-10" N_2 Purge to Purple Peeper												
PI 903 13'-10" FE 903 Inlet Press, PSIG												
PI 909 13'-10" FE 909 Inlet Press, PSIG												
FI 9316 13'-10" N_2 to silo "A" (Bottom)												
PI 938 13'-10" FE 938 oxygen Inlet Press, PSIG												
Check air heater for 13'-10" Hot spots on shell												
Check sight port for 13'-10" Material falling from venturi												

AAG/Local	Proj. 9616	AAG 7-19	Rev. 8/16/78	Test Day#	Run #	Date	Page 5/13

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
FI 991 21'-6" N_2 Purge to H.P. tap PDT 9355												
FI 9306 21'-6" Purge to 2nd stage dipleg dust return line												
FI 990 21'-6" Purge 6' above 2nd stage dust injection nozzle												
FI 929 21'-6" Purge 2' above 2nd stage dust injection nozzle												
FI 911 21'-6" N_2 purge to H.P. tap PDT 911												
FI 9334 21'-6" N_2 purge to silo "B" (bottom)												
PI 9120 21'-6" Press into venturi, psig.												
PI 9119 21'-6" Press into grid, Psig												
TI 903 21'-6" FE 903 inlet temperature ^oF												
TI 9303 21'-6" FE 9303 temperature, ^oF												
PI 9303 21'-6" FE 9303 Inlet press., psig												

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AAG/Local	Proj. 9616	AAG 7-19	Rev. 8/16/78	Test Day#	Run #	Date	Page 6/13

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
PI 923 21'-6" N_2/stm. P after PV 923, psig												
FI 910A 21'-6" High press Tap, N_2 purge to (venturi) PDT 910												
PI 9160 21'-6" Regulated main P., N_2 psig.												
check venturi 21'-6" For hot spots												
FI 9365 21'-6" N_2 purge to L-valve												
FI 9349 21'-6" N_2 purge to bed discharge line												
PI 9405 21'-6" FE 9405 Inlet Press., psig.												

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AAG/Local	Proj. 9616	AAG 7-19	Rev 8/16/78	Test Day #	Run #	Date	Page 7/13					
Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
FI 9307 29'-2" N_2 purge to gas nozzle startup burner												
FI 986 29'-2" N_2 purge to start-up burner												
FI 928 29'-2" N_2 aeration 2nd stage dipleg H.P. side (PDT 996 & 997)												
FI 9348 29'-2" N_2 purge-prod. gas sample line, upstream of filters												
PDI 972 29'-2" plant air flow to start-up burner												
PDI 971 29'-2" Gas flow to start-up burner												
Check viewport for 29'-2" bed fluidization												
FI 913-B 29'-2" Low press tap N_2 purge (PDT 913)												
FI 913-A 29'-2" N_2 purge at view port												
FI 910-B 29'-2" N_2 purge-L.P. tap PDT 9301 (1st stg. cyc.)												
FI 925 29'-2" N_2 purge (Bed sample tap)												
FI 9356 29'-2" High pressure tap purge (PDT. 9356)												
FI 9355 A 29'-2" To L-valve 1/2 ft above grid.												

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AAG/Local	Proj. 9616	AAG 7-19	Rev. 8/16/78	Test Day#	Run #	Date	Page 8/13

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
FI 9355B 29'-2" To L-valve 1/2 ft above grid.												
FI 9344A 29'-2" N_2 purge to L-valve												
FI 9344B 29'-2" N_2 purge to L-valve												
FI 920A 29'-2" N_2 purge on H.P. side of FT 920 (Pro. gas)												
FI 920B 29'-2" N_2 purge on L.P.Side of FT 920 (Pro. gas)												
PI 920 29'-2" Product Gas Press., psig												
FI 9369 29'-2" seal pot N_2 aeration for reinjection of 2nd stage cyclone fines												
FI 9369-A 29'-2" N_2 purge to seal pot in dust reinjection line, 2nd stg. cyclone												
FI 9369-B 29'-2" N_2 purge to seal pot in dust reinjection line, 2nd stg. cyclone												
FI 9391 29'-2" N_2 purge to bed sample line												
PI 913B 29'-2" P. Tap on low side of PDT 913 psig												
FI 9341 29'-2" L-valve purge #1												
FI 9342 29'-2" L-valve purge #2												
FI 9343 29'-2" L-valve purge #3												

AAG/Local	Proj. 9616	AAG 7-19	Rev. 8/16/78	Test Day #	Run #	Date	Page 9/13

TIME	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
FI 9344 29"-2" L-valve purge #4												
FI 9345 29"-2" L-valve purge #5												
FI 9346 29"-2" L-valve purge #6												
FI 9347 29"-2" L-valve purge #7												
PI 9110 29"-2" N_2 to L-valve rotameters psig												

AAG/Local	Proj. 9616	AAG 7-19	Rev 8/16/78	Test Day #	Run #	Date	Page 10/13

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
FI 9360 39'-0" Low press. Tap purge (PDT 9360)												
FI 982 39'-0" N_2 purge (mid) 1st stage dipleg H.P. side of (PDT 982&983)												
FI 9319 39'-0" N_2 purge (top) 1st stage dipleg L.P. side of (PDT 983)												
FI 983 39'-0" N_2 purge (bottom) 1st stage dipleg L.P. side of (PDT 982)												
FI 9363 39'-0" N_2 purge to flange at the top of rctr. scr. feeder												
FI 912 39'-0" Low press. tap purge (PDT 912)												
FI 931 39'-0" N_2 purge to delv. end of rctr. scr. feeder												
FI 930 39'-0" N_2 purge to receiving end of rctr. scr. feeder												
PDI 915 39'-0" ΔP 3' freeboard, psi												
FI 994 39'-0" high press. tap purge (PDT 9302)												
FI 915 B 39'-0" N_2 purge to low side of PDI 915												

AAG/Local	Proj. 9616	AAC 7-19	Rev. 8/16/78	Test Day #	Run #	Date	Page 12/13

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
FI 984 59'-0" N_2 purge to F.M. scale												
PI 9121 59'-0" Press of Quench N_2 (2nd stage) psig												
PI 9109 59'-0" Press of quench H_2O (2nd stage) psig												
PI 9330 59'-0" press of quench H_2O (2nd stage) psig												
PI 9103 59'-0" Press of quench N_2 (1st stage) psig												
PI 9102 59'-0" Press of quench H_2O (1st stage) psig												
PI 9164 59'-0" C-2 hopper press, in . w.c.												
FI 985 59'-0" N_2 purge to C-2 hopper												
TI 9381 A 59'-0" BFW Temp. to wasteheat boiler. °F												
TI 9381 B 59'-0" Steam temp. from wasteheat boiler °F												
PI 9381 A 59'-0" BFW Press. to wasteheat boiler psig												
PI 9381 B 59'-0" Steam press. from wasteheat boiler psig												
PI 9121 B 59'-0" N_2 supply press. to 2nd stage quencher psig												

APPENDIX B-5

AAG/Local	Proj. 9616	AAC 7-19	Rev 8/16/78	Test Day#	Run #	Date	Page 11/13

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
TI 937 50'-0" FE 937, Tem., °F												
PI 937 50'-0" FE 937 Press., psig												
FI 997 50'-0" Low Press. Tap purge (PDT 997)												
FI 9302 50'-0" N_2 purge (Top) 3rd stage dipleg L.P. side of (PDT 9302)												
FI 996 50'-0" Low press. Tap purge (PDT 996)												
FI9364 50'-0" N_2 purge to reverse seal pot Internal cyclone												
FI 9381 50'-0" Flow indicator to BFW to waste-heat boiler GPM												
FI 9104 50'-0" N_2 supply pressure to quenchers psig												

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AAG/Local | Proj. 9616 | AAC 7-19 | Rev 8/16/78 Test Day # | Run # | Date | Page 13/13

Time	0200	0400	0600	0800	1000	1200	1400	1600	1800	2000	2200	2400
FI 919 69'-6" High press tap purge (PDT 941) 2nd stage cyc.												
FI 941 69'-6" Low press. tap purge (PDT 941)												
FI 9331 69'-6" Low press tap purge (PDT 9331) for 2nd stg. qunh-ΔP												
FI 915 69'-6" Low press tap purge (PDT 920) for 3rd stg. cyc. ΔP												
FI 9338 69'-6" Purge to level indicator (silo A)												
FI 9339 69'-6" Purge to level indicator (silo B)												
FI 9362 69'-6" N_2 purge to silo A hopper												
FI 9340 A 69'-6" N_2 purge to reactor high press. relief valve.												
FI 9340B 69'-6" N_2 purge to reactor low press. relief valve.												

APPENDIX B-3

Run Number ______

AAG C-4 DISCHARGE SHEET

Sheet Number ______

DATE	TIME		TARE, LB	GROSS, LB	NET, LB	TOTAL, LB	DRUM NUMBER
	START	FINISH					

Form AAG 7-18 Rev. 8/1/78

APPENDIX B-4

AAG C-7 DISCHARGE SHEET

Run Number________ Sheet Number__________

DATE	TIME		TARE, LB	GROSS, LB	NET, LB	TOTAL, LB	DRUM NUMBER
	START	FINISH					

Form AAG 7-18 Rev. 8/1/78

AAG 2ND STAGE CYCLONE FINES SHEET

Run Number__________ Sheet Number__________

- Start fines rate at steam switchover.
- A fines rate must be taken every 4 hours even if drum is not filled.
- Take final rates when shutdown procedure is started.

START TIME	FINISH TIME	ELP. TIME	TARE WT.	GROSS WT.	NET WT.	RATE
DATE	DATE	MINUTES	LBS.	LBS.	LBS.	LBS/HR

Form AAG 7-17 Rev. 8/1/78

APPENDIX B-6

AAG 3RD STAGE CYCLONE FINES SHEET

Run Number__________ Sheet Number________

- Start fines rate at steam switchover.
- A fines rate must be taken every 8 hours even if drum is not filled.
- Take final rates when shutdown procedure is started.

START TIME DATE	FINISH TIME DATE	ELP. TIME MINUTES	TARE WT. LBS.	GROSS WT. LBS.	NET WT. LBS.	RATE LB/HR

Form AAG 7-17 Rev. 8/1/78

APPENDIX C-1

INPUT DATA SHEET FOR AAG6

Rev: 8/16/78

Run No. ____________________

Date ____________________

Time ____________________

Meter	MR	T, °F	P, psig		
FR-903 hm = 100" W.C.	MR ________,	________, TR-9206-17, steam TI-937, N_2	________, PI-903 psig	________, 1 for N_2 3 for steam	________ 1 to 905 2 to 906
FR-904 hm = 50" W.C.	MR ________,	________, TR-9206-17, steam TI-937, N_2	________, PI-904 psig	________, 1 for N_2 3 for steam	________ 0 to air htr 1 to 905 2 to 906
FR-905 hm = 15" W.C.	MR ________,	________, TR-9206-18	________ PI-905 psig		
FR-906 hm = 50" W.C.	MR ________,	________, TR-9206-18	________ PI-906 psig		
FR-9304 hm = 100" W.C.	MR ________,	________, TR-9206-17, steam TI-937, N_2	________, PI-9304 psig	________ 1 for N_2 3 for steam	
FR-938 hm = 100" W.C.	MR ________,	________, TR-9206-4	________ PI-938 psig		
FR-9303 hm = 100" W.C.	MR ________,	________, TI-9303	________, PI-9303 psig	________ 1 for N_2 2 for O_2	
FR 9405 hm = 100" W.C.	MR ________,	________, TR-9206-18	________, PI 9405 psig		
FR-937 hm = 100" W.C.	MR ________,	________, TI-937	________ PI 937 psig		
FR-918 hm = 100" W.C.	MR ________				
FR-9330 hm = 69.2" W.C.	MR ________				
FR-995 hm = 50" W.C.	MR ________,	________, TI-9203	________ PR-901 psig		
FR-909 hm = 30" W.C.	MR ________,	________, TR-9206-17, steam TI-937, N_2	________, PI-909 psig	________ 1 for N_2 3 for steam	
FR-9394 hm = 200" W.C.	MR ________,	________, TI-937	________, PI 9314R psig		

ΔP vent, psi ________, PDR 910 ________, PI-913, psig ________, °F, TR-9206-1 ________, °F, TR-9206-3 ________ Vent Diam., in.

NOTE: For meter differential changes from indicated values, use meter reading on chart multiplied by

$$\sqrt{\frac{\text{hm (new)}}{\text{hm (indicated on this sheet)}}}$$

, until the program is updated.

APPENDIX C-2

ASH AGGLOMERATING GASIFIER-DATA SUMMARY Rev. 4/14/78

Date:____________________ Run No.________________

Time									
TE 9206.1 Gas Temp. entering venturi, °F									
TE 9206.2 Gas Temp. entering grid, °F									
TE 9206.3 Bed Temperature, °F									
TE 9206.16 Gas Temp. entering quencher, °F									
FF 903 mols/hr _____ Flow to Grid/Heater/venturi									
FF 904 mols/hr _____ Flow to Grid/Heater/venturi									
FR 905 _____ Flow to grid, mols/hr									
FR 906 _____ Flow to venturi, mols/hr									
FF 9304 _____ to venturi, mols/hr									
FR 938 Oxygen to air heater, mols/hr									
FR 9303 Aux. _____ to reactor, mols/hr									
FR 9405 _____ Flow to center jet (reactor) mols/hr									
FR 937 Atomizing N_2, mols/hr									
FR 918 (1st stage quencher) Rate of quench water, mols/hr									
FR 9330 (2nd stage quencher) Rate of quench water, mols/hr									
FR 995 Air to air heater, mols/hr									
FR 909 Sweep gas (N_2), mols/hr									
Nitrogen purge to reactor, mols/hr									
Bed density, lbs/cu.ft.									
Bed height, ft									
Reactor gas composition (dry)%									
N_2									
CO									
CO_2									
H_2									
CH_4									
H_2S									
_____ feed rate, wet (avg), lbs/hr									
C-7 (bed) discharge rate, lbs/hr									
C-4 (ash) discharge rate, lbs/hr									
2nd stage fines removal rate, lbs/hr									
3rd stage fines removal rate, lbs/hr									
Feed Composition %C									
%Ash									
Reactor bed Composition %C									
%Ash									
Discharged bed Composition %C									
%Ash									
Ash Composition %C									
%Ash									
2nd stage fines composition, %C									
%Ash									
3rd stage fines composition %C									
%Ash									

APPENDIX C-3

Rev. 8/16/78

AAG MASS BALANCE WORKSHEET

Run No.____________ Date____________ Time Period____________

Feed Rate		#/hr
Mositure in Feed	%	#/hr
Dry Feed______#/hr	%	#/hr
Carbon		
Ash		
Hydrogen		
Sulfur		
Nitrogen		
Oxygen		
Bed Ht./Initial/Final	/	ft
Density/Initial/Final	/	$\#/ft^3$
Δ Bed Invnt.______mols/hr	%	#/hr
Carbon		
Ash		
Hydrogen		
Sulfur		
Nitrogen		
Oxygen		
C-7 Disch.______#/hr	%	#/hr
Carbon		
Ash		
Hydrogen		
Sulfur		
Nitrogen		
Oxygen		
C-4 Disch.______#/hr	%	#/hr
Carbon		
Ash		
Hydrogen		
Sulfur		
Nitrogen		
Oxygen		
2nd Stage Fines ______#/hr	%	#/hr
Carbon		
Ash		
Hydrogen		
Sulfur		
Nitrogen		
Oxygen		
3rd Stage Fines ______#/hr	%	#/hr
Carbon		
Ash		
Hydrogen		
Sulfur		
Nitrogen		
Oxygen		
Stm. to Grid FR 903		mols/hr
Stm. to Heater FR 904		mols/hr

O_2 to Heater, FR 938			mol/hr
Air to heater, FR 995			mol/hr
% O_2 to Heater			
M.W. of gas to heater			
To Grid, FR 905______mols/hr	%		mol/hr
N_2			
O_2			
Steam			
Stm. to Venturi, FR 9304			mol/hr
To venturi, FR 906______mol/hr	%		mol/hr
N_2			
O_2			
Steam			
To center jet, FR 9405____mol/hr	%		mol/hr
N_2			
O_2			
Steam			
Aux. N_2/O_2 to Rectr. FR 9303			mol/hr
Total at Grid______mol/hr	N_2	O_2	Stm
FR 903			
FR 905			
Total			
Total at venturi______mol/hr	N_2	O_2	Stm
FR 9304			
FR 906			
Total			
Total at Center Jet______mol/hr	N_2	O_2	Stm
FR 9405			
FR 9303			
Total			
Fines Reinj. gas, FR 909, N_2			mol/hr
Total N_2 purges			mol/hr
Total N_2 Input		mol/hr	
Purges, incl. 909			
N_2 at Grid			
N_2 at venturi			
N_2 at center jet			
N_2 from feed			
Subtotal			
Less N_2 in Solids discharge			
Total N_2			
Dry Reactor Gas______mol/hr	%		mol/hr
N_2			
CO			
CO_2			
H_2			
CH_4			
H_2S			
Reactor Gas Condensate	%s		mol/hr

APPENDIX C-4

Rev. 8/16/78

AAG HEAT BALANCE WORKSHEET

Basis: 77°F

Run No.__________ Date__________ Time Period__________

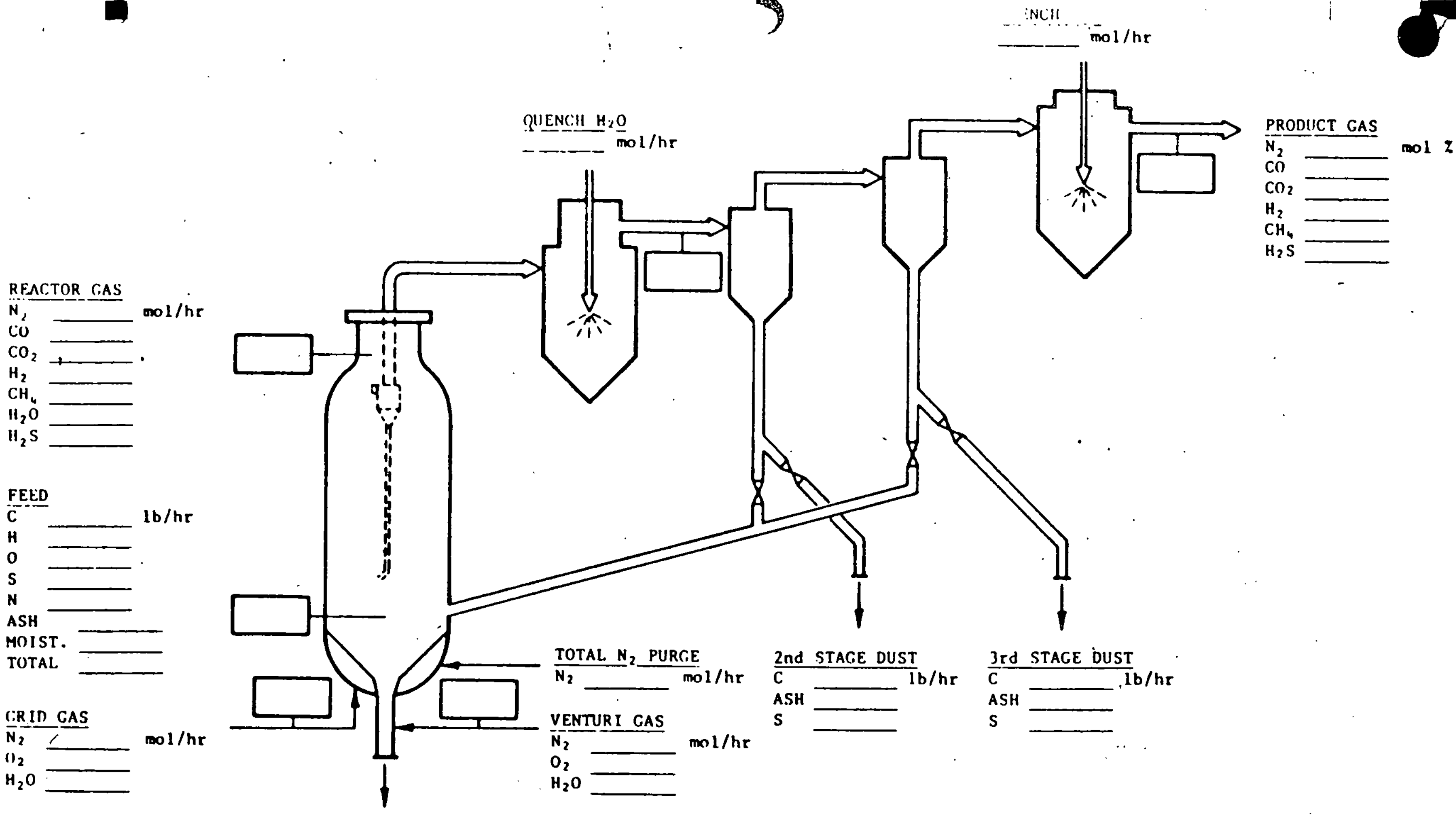
IN

Coal Feed, Dry 70°F		#/hr
Moisture 70°F		#/hr
N_2 Purge, 70°F		#/hr
FR 905, Grid Gas ____ °F		mols/hr
	N_2	
	O_2	
	Steam	
FR 903 ____ P. ____ °F,	Steam	mol/hr
FR 906, Vent. gas ____ °F		mol/hr
	N_2	
	O_2	
	Steam	
FR 9304, ____ P. ____ °F,	Steam	mol/hr
FR 9405, Center jet gas ____ °F		mols/hr
	N_2	
	O_2	
	Steam	
FR 9303 N_2/O_2 70°F		mol/hr
Coal		
Sensible Heat =		Btu/hr
Heat of comb =		Btu/hr
Mois. Enthalpy =		Btu/hr
N_2 Purge		
Purges =		Btu/hr
Grid Gas		
Sen. Heat N_2 =		Btu/hr
Sen. Heat O_2 =		Btu/hr
905 Stm. Enthalpy =		Btu/hr
903 Stm. Enthalpy =		Btu/hr
Total at Grid		Btu/hr
Venturi Gas		
Sen. Heat N_2 =		Btu/hr
Sen. Heat O_2 =		Btu/hr
906 Stm. Enthalpy =		Btu/hr
9304 Stm. Enthalpy =		Btu/hr
Total at Venturi		Btu/hr
Center Jet		
Sen. Heat N_2 =		Btu/hr
Sen. Heat O_2 =		Btu/hr
9405 Stm. Enthalpy =		Btu/hr
Total at Center Jet		Btu/hr
Total In		Btu/hr
Out - In =		Btu/hr
% Balance = (Out/In)x100		

OUT

Reactor Gas ____ °F		
N_2		mols/hr
CO		mols/hr
CO_2		mols/hr
H_2		mols/hr
CH_4		mols/hr
H_2S		mols/hr
H_2O		mols/hr
Solids		
Δ Bed Inv.	°F	#/hr
C-7 Discharge	°F	#/hr
C-4 Discharge	°F	#/hr
2nd Stage Fines	°F	#/hr
3rd Stage Fines	°F	#/hr
R. G. (Sensible Heat)		
N_2 =		Btu/hr
CO =		Btu/hr
CO_2 =		Btu/hr
H_2 =		Btu/hr
CH_4 =		Btu/hr
H_2S =		Btu/hr
R. G. (Heat of Comb.)		
CO =		Btu/hr
H_2 =		Btu/hr
CH_4 =		Btu/hr
H_2S =		Btu/hr
Total R.G.		Btu/hr
Solids (Sen. Heat)		
Δ Bed =		Btu/hr
C-7 Dis. =		Btu/hr
C-4 Dis. =		Btu/hr
2nd Stage Fines =		Btu/hr
3rd Stage Fines =		Btu/hr
Soilds (Heat of Comb.)		
Δ Bed =		Btu/hr
C-7 Dis. =		Btu/hr
C-4 Dis. =		Btu/hr
2nd Stage Fines =		Btu/hr
3rd Stage Fines =		Btu/hr
Total Solids		Btu/hr
Wall losses		Btu/hr
Total Out		Btu/hr

APPENDIX C-5



ASH
C lb/hr
S
ASH

Material and Energy Balance Summary Sheet

	ASH	CARBON	NITROGEN	OXYGEN	HYDROGEN	BTU/HR
Feed						
To Venturi						
To Grid						
To Reactor						
Purges						
TOTAL INPUT, Lb/Hr						
Wall Losses						
Venturi Discharge						
Bed Discharge						
2nd Stage Fines						
3rd Stage Fines						
Bed Inventory Change						
Reactor Gas						
TOTAL OUTPUT, lb/hr						
NET (OUTPUT-INPUT)						
% Balance, Output/Input						

APPENDIX C-6

AAG OPERATING CONDITIONS SUMMARY

Run No.________ Date__________ Time Period__________ to__________

Venturi Diameter ________ inches Feed Material __________

Cyclone Fines Collector: ________, Internal________ External________

1	Average Fluidized Bed Temperature, °F	
2	Average Reactor Pressure, psig	
3	Venturi Pressure Drop, psi	
4	Superficial Velocity, ft/sec	
5	Freeboard Velocity, ft/sec	
6	Venturi Velocity, ft/sec	
7	Grid Gas, mol/hr	
8	Grid Gas Composition: $\%N_2$	
9	$\%O_2$	
10	%Steam	
11	Venturi Gas, mol/hr	
12	Venturi Gas Composition: $\%N_2$	
13	$\%O_2$	
14	%Steam	
15	Fluidized Bed Density, lb/CF	
16	Fluidized Bed Height, ft	
17	Feed Composition, ______ #/hr, %C/%Ash	
18	Average Fluidized Bed Composition, ______ #/hr, %C/%Ash	
19	Bed Discharge Composition, ______ #/hr, %C/%Ash	
20	Venturi Discharge Composition, ______ #/hr, %C/%Ash	
21	2nd Stage Fines Composition, ______ #/hr, %C/%Ash	
22	3rd Stage Fines Composition, ______ #/hr, %C/%Ash	
23	Carbon/Oxygen (Weight Basis)	
24	Carbon/Steam (Weight Basis)	

U.S. Sieve Size, wt.%	3	6	12	20	40	70	140	270	PAN	200	230	60.8 μ	40 μ	20 μ	10 μ	5 μ
Feed																
Fluidized Bed																
Discharged Bed																
Ash																
2nd Stage Fines																
3rd Stage Fines																

Rev. 4/14/78

APPENDIX D-1

INSTITUTE OF GAS TECHNOLOGY
LOW-BTU PROGRAM

PROCEDURE
FOR MAINTAINING BED TEMPERATURE

STEP	ACTION	REMARKS
	Under steady flow during the gasification process the bed temperature rarely changes significantly. However, sharp rise of bed temperature can occur due to the following causes: (N.B. - Reactor high temperature had been set at 2000°F. At this temperature steam or N_2 will be automatically injected to reactor through 904 loop until it is reset. Therefore be certain that loop 904 to air heater is open and 904 switch is on "on" position.)	
	A. <u>Stoppage of Feed</u>:	
1.	Monitor WR 916. If it indicates that the hopper is empty, start recirculating feed to hopper.	
2.	If hopper if full check the following: - Operation of the screw feeder to weigh drum. - Operation of reactor screw feeder. - Scale cycle and operation of pneumatic valves, C_2 vent. - L-valve.	
	It is always safe to idle the unit (refer to idling procedure) while feed problem is being rectified and re-start the gasification process afterwards.	
	B. <u>Loosing Bed Height</u>:	
1.	Check bed discharge rate and C_4 discharge rate. Reduce discharge rate while monitoring bed ash content.	
2.	Increase feed rate to maintain 4 feet of bed height.	
	C. <u>Loosing Steam Pressure</u>:	
1.	Maintain 70 psig steam by adjusting PR923.	
2.	Increase steam rate through loop 903 to re-establish pre-determined temperature.	

STEP	ACTION	REMARKS
3.	While on steam/oxygen gasification reduce oxygen flow and monitor superficial velocity.	
4.	In case of total loss of steam start shut down (refer to specific procedure)	
	D. <u>Onset of Clinker Formation</u>:	
1.	If any one of the bed thermocouples suddenly shows a sharp rise in temperature this indicates the onset of clinker formation. Start idling the unit. Some times the bed height suddenly increases slightly without significant rise in temperature. This could also indicate the onset of clinker formation.	

APPENDIX D-2

INSTITUTE OF GAS TECHNOLOGY
LOW BTU PROGRAM

PROCEDURE FOR SWITCHING FROM COKE TO COAL

STEP	ACTION	REMARKS
1.	Activate silo (A) level indicator and determine the quantity of coal available.	
2.	Be certain that silo (A) hopper is full.	
3.	If in doubt, fill up hopper: - Flip flap gate to "A" position. - Turn on bucket elevator and feed transfer conveyor. - Open silo (A) discharge valve (VO'-42). This valve is used regulate the filling rate of hopper. Caution: If valve is opened too much, large quantity of coal might jam the bucket elevator causing lengthy stoppage. - 30 minutes lead time is needed prior to feeding coal to reactor. If hopper is full: - Flip flap gate to "A" position. - Turn off screw feeder from Silo (B) to weigh drum. - Switch silo selector to silo (A) position. - Turn on screw feeder from silo (A) to weigh drum (automatic position).	
4.	Watch weigh recorder (WR 916) for filling rate of C-1. If it is zero, you have a problem on hand, try to locate source and take appropriate action. While working on coal feeding problems, use coke to feed the reactor to maintain bed height by: - stop screw feeder from silo (A) to weigh drum. - Start screw feeder from silo (B) to screw feeder (Automatic position). N.B. - Coal recirculating to silo (A) hopper should be done while coal is being fed to reactor. Switching from coal back to coke after idling the unit (low reactor temperature) requires draining of C_1 & C_2, before proceeding to feed coke.	

APPENDIX D-3

Rev. 8.15.78

INSTITUTE OF GAS TECHNOLOGY
LOW BTU PROGRAM

PROCEDURE
FOR MAINTAINING BED HEIGHT

STEP	ACTION	REMARKS
	A. (To raise bed height).	
1.	Increase RPM of reactor screw feeder. Do not set this speed higher than the rate of filling C-1.	
2.	Check the rate of bed discharge and C-4 discharge. Reduce these rates if necessary to raise bed height.	
3.	Once the desired bed height is reached maintain bed by adjusting reactor screw feeder RPM.	
	B. (To Lower bed height)	
1.	Reduce speed of reactor screwfeeder to minimum RPM.	
2.	Adjust gasification media accordingly to maintain desired bed temperature and superficial velocity.	
3.	Check the rate of C_4 discharge. Increase C-4 discharge if needed. Bed discharge line can also be activated in case immediate reduction of bed level is required. N.B. Experience shows that discharge cycle set on timer (15"-open; 10'-close equals approximately 70 lbs/cycle at reactor $T^o \approx 1850^oF$, P = 10 psig, 10 mols/hr N_2 thru 9361)	
4.	Once the desired bed height is reached, maintain bed level by adjusting reactor screw feeder RPM.	

APPENDIX D-4

INSTITUTE OF GAS TECHNOLOGY
LOW BTU PROGRAM

PROCEDURE
FOR SWITCHING FROM STEAM/AIR TO STEAM/OXYGEN GASIFICATION
AND VICE VERSA

Step	Actions	Remarks
	A. Oxygen Stream	
1.	Open all block valves from oxygen tank outlet to AAG building main oxygen supply valve VO'-101.	
2.	Set oxygen pressure regulator at 70 psig.	
3.	Check FIC 938 and FR 938 for zero reading. (If needed, have Panellit zerocheck them.) Be certain that instrument air is on.	
4.	Check 938 loop. Bypass valve V13'-33 must be closed. Open V13'-84 and V13'-83.	
5.	Open oxygen main supply valve O'-101.	
	B. Steam Flow	
1.	Be certain that all block valves on 904 loop to the air heater are open. (Except 904 bypass valve V13'-49, V13'-74, V13'-45, and V13'-46).	
2.	Steam injection 904 system is on "ON" position.	
3.	Check FIC 904 and FR 904 for zero reading. Be certain that instrument air is on.	
	C. Switching from Steam/Air to Steam/Oxygen	
1.	Flip air pressure bypass switch PSL 960 to ON position.	
2.	If O_2 is used at the 9303 jet, close N_2 manual station V21'-112, V21'-113 and open vent V21'-114.	

Step	Actions	Remarks
3.	Switch FIC 904 to manual position. Open FV 904 slightly to have 10 mols/hr of steam. Set FIC 904 on "Automatic" position.	
4.	Open main vent valve (VO'-5) slightly.	
5.	Switch FIC 938 to manual position. Open FV 938 slightly to have 2 mols/hr of oxygen.	
6.	Press "Oxygen-On" button on the panel board. Green light indicates the solenoid valve is open and oxygen is flowing.	
7.	Monitor FR 904 and FR 938 for correct flow. After the steam and oxygen flows have been established, switch FIC 938 to "automatic" position.	
8.	Raise flow through 904 and 938 slowly in corresponding ratio while intermittently opening manual vent (VO'-5). To monitor the pressure of the steam/oxygen stream on PIC 901, switch 3-way diverter valves on panel board to steam/oxygen mode and to PT 901.	
9.	As the steam/oxygen flow increases, air flow decreases as indicated on FR 995. When flow 904 and 938 reach the desired set point, close main air inlet valve to heater V13'-42.	
10.	Adjust 904 and 938 flows to maintain bed temperature and velocities.	
	IMPORTANT: In emergency hit the "Oxygen Off" button on the panel board. Red light indicates oxygen is off.	
11.	Turn off compressors. (Refer to specific procedures)	
	D. Switching From Steam/Oxygen Back to Steam/Air Gasification	
1.	Turn on compressors (refer to specific procedures).	
2.	Switch 3-way diverter valves to steam/air mode and to PT 9337.	
3.	Set PIC 901 at 20 psi and on automatic operation.	
4.	Open main air inlet valve VO'-1.	
5.	Decrease flows through 904 and 938 to maintain steady flow at 905 and 906.	
6.	Check to be certain N_2 manual station to 9303 is open.	
7.	Cut off oxygen flow by hitting "Oxygen Off" switch.	
8.	Reduce FIC 904 to zero.	
9.	Once steady flow is restored, flip PSL 960 to OFF position.	

APPENDIX D-5

INSTITUTE OF GAS TECHNOLOGY
LOW BTU PROGRAM

PROCEDURE FOR IDLING THE UNIT

1. Introduce steam to air heater through FR 904 ____________
2. Introduce steam to venturi through FR 903 and FR 9304 ____________
3. Turn PSL 960 to "ON" position ____________
4. Reduce air flow to the reactor as you increase steam ____________
5. Turn off oxygen if it is being used ____________
6. Make sure N_2 is flowing through FR 9303 when O_2 is turned off ____________
7. Introduce enough steam into the reactor to sustain fluidization (about 50 moles) ____________
8. Close the 4" brass valve (V13'-42) on 13' level to isloate the compressor and to prevent steam from getting into the compressor. ____________
9. Turn off the feed ____________

APPENDIX D-6

SHUTDOWN PROCEDURE FOR

ASH AGGLOMERATING GASIFIER

Run No.__________ Date __________

Reason for Shutdown __________________________ Time __________

Action:	Initial
1. Divert N_2 to FE9303 (if O_2 is being used) by using SW9303.	______
2. Turn off O_2 valve at the panel and all valves related to O_2 flow on the O_2 pad and in the building.	______
3. Divert all dust from second and third stage cyclones to the bypass.	______
4. Divert steam flow in FE904 to the grid and FE903 to the venturi. Turn off feed.	______
5. Introduce flows in FE903 and FE904 while simultaneously reducing air flow to FE905, FE906, and FE9405 to sustain fluidization.	______
6. Turn off air heater.	
7. Close 4" brass block valve V13'-42 on 13'-10" level, as FR 905, 906 and 9405 approach zero.	______
8. Flip all pressure switches PSL959, PSL960, PSL954 and vent valve bypass to "on" position.	______
9. Turn off compressor (Joy) and its cooling water pump.	______
10. Tell analytical lab to turn off.	______
11. Close V59'-6.	______
12. Turn off FI920A, FI920B, and FI9348.	______
13. Close FV934.	______
14. Let reactor cool down to 1000°F with steam before attempting to remove the bed.	______
15. Remove the bed either through the venturi or bed discharge line.	______
16. Switch to N_2 at FE903 and 904.	
17. Turn off flow to FE903 and reduce flow to FE904 to 5000 SCFH.	______
18. Drain 1st and 2nd stage quenches of any solids or water. Make sure that they are empty. Leave them open.	______

19. When the reactor temperature drops to 800°F, close the block valves upstream of TV917 and TV9330. Close BFW bypass and valve downstream of quench pump (V21'-120 & V21'-125). ______

20. Remove spool piece from natural gas mainline and install blind flanges to prevent all flow. ______

21. When the reactor temperature as indicated by TE9206.13 drops below 600°F, start opening the manways. Follow manway opening procedure from this step onward. ______

APPENDIX D-7

Run # ___________

AAG REACTOR MANWAY OPENING PROCEDURE

Initial/Date

1. Start plant air to reactor via start-up burner when TE-9206-13 reaches 600°F. If temp rise occurs and lasts for 15 minutes, stop air flow, cool reactor to 500°F, reintroduce air flow for 15 minutes to check again for temp rise. ___________
   Comments:

2. Blast with N_2 through bypasses on FI's to all purges on internal, second, and third stage cyclone diplegs to clear pressure taps of dust. ___________
   Comments:

3. Turn off all flows to unit including main N_2. Remove spool piece and install blind flanges to block all N_2 flow to reactor system. Notify HYGAS we are no longer using N_2. ___________
   Comments.

4. Obtain signed approval from shift eng'r to open reactor. Send copy to shift supervisor.

5. Open blind flange on reactor outlet "T" by loosening all bolts, then loosening flange. When assured that any residual pressure has been relieved, remove bolts and then flange. ___________
   Comments:

6. Open upper manway. Follow Procedure of Item 5. Insert air mover. ___________
   Comments:

7. Open lower manway. Follow procedure of Item 5. ___________
   Comments:

8. Open valves below venturi to help draw cool air to reactor. ___________
   Comments:

9. Check PT's and PR's for zero reading. ___________
   Comments:

10. Check all PDT's and PDR's for zero reading. ____________
Comments:

11. Check all local gauges for zero reading. ____________
Comments:

12. Add oil to automatic valve oilers on 21', 29', 39', 50', and 59' level with DTE-24 oil. ____________
Comments:

13. If the manways are open and the reactor temperature begins to rise (bed material oxidizing), put nitrogen through 905 & 906, and post a sign at each manway that nitrogen is in the reactor. ____________

14. Before proceeding with the reactor check list, check the refractory to insure that none will fall while working in the reactor. ____________

APPENDIX D-8

Feed Sample

Once feed to the reactor has started, the feed sample is to be taken every four hours unless otherwise specified. The sample point is located on the 39' level under the reactor screw feeder directly below the C-8 hopper. The sample is trapped and isolated by use of two 3" ball valves and then discharged through a 4" pipe line to be collected in a 5-gallon pail at grade level.

The procedure is as follows: See Figure D-1.

1. Place an empty 5-gallon pail beneath the feed discharge line at grade level.

2. At the 29' level, the feed discharge line branches off into two separate lines. One line goes to grade level inside the building where the sample is collected, and the other goes to grade level outside the building. Open V29'-78 (4" knife gate valve block) and close V29'-79 (4" knife gate valve block) so the sample will be collected inside the building.

3. At the 39' level make sure V39'-51 (3" ball valve) is closed, then open V39'-52 (3" ball valve directly below screw feeder).

4. Wait several seconds for the section of 3" pipe between V39'-52 and V39'-51 to fill with feed sample, then close V39'-52 to isolate the sample from the reactor.

   CAUTION: At no time should V39'-52 and V39'-51 both be open allowing reactor pressure to escape through sample discharge line.

5. Next, open V39'-51 to discharge the sample to a 5-gallon pail.

6. When the 3" line between V39'-52 and V39'-51 is empty, close V39'-51.

7. Collect a quart sample from the 5-gallon pail. Label it "Feed Sample", "Coke", or "Coal". Mark the correct time, date, and run number. Record the sample in the running sample log.

   NOTE: After the feed stock to the reactor has been switched from coke to coal or vice versa, the next sample taken should be discarded due to possible residual feed sample in the feed discharge line directly above V39'-52. After discarding the first sample, resample and properly label the second sample.

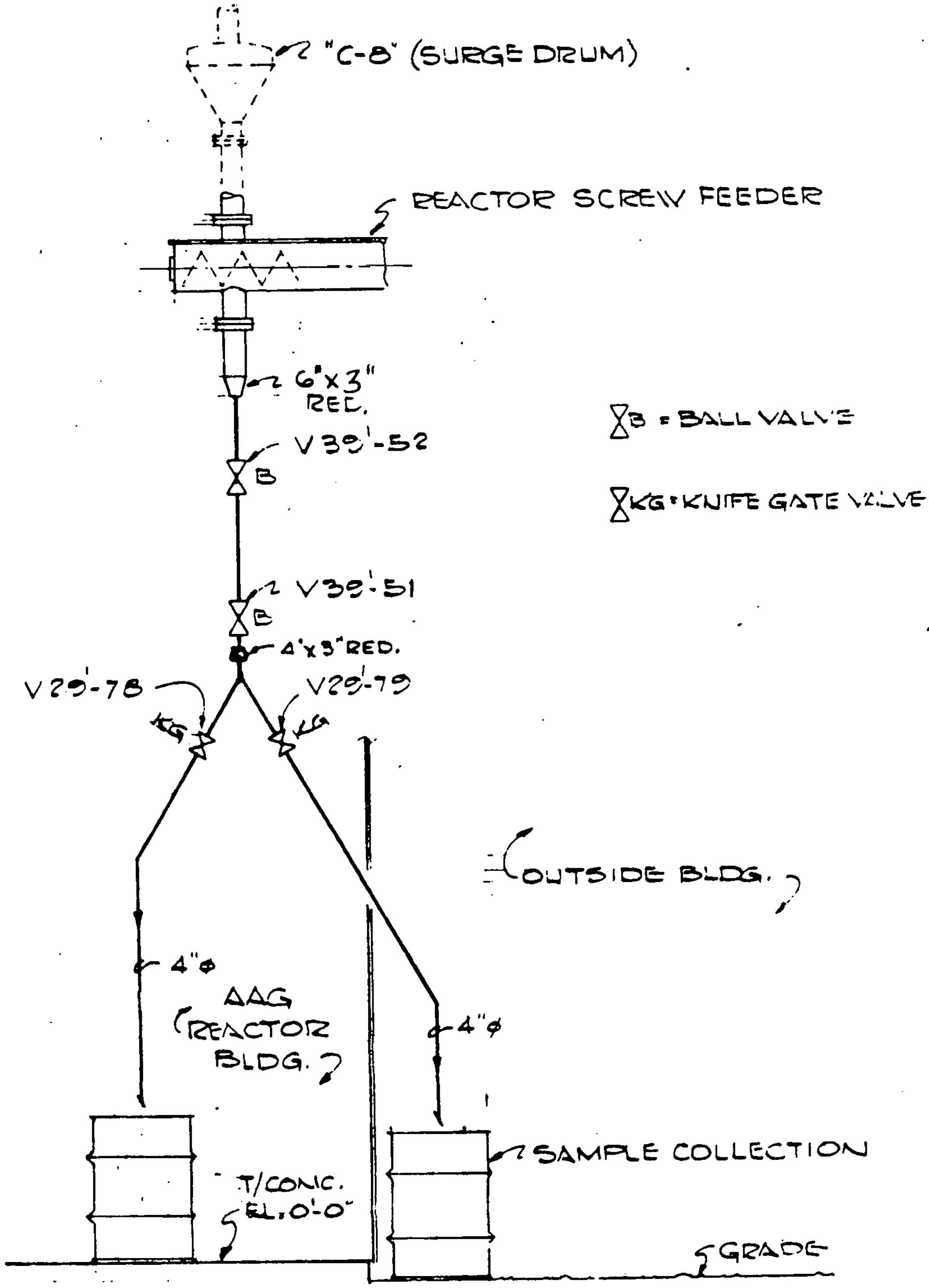


FIG D-1 FEED SAMPLE

APPENDIX D-9

Bed Sample

The bed sample tap is located on the 29' level and a sample is taken every hour, once autogenous reaction has begun. The procedure is as follows: See Figure D-2.

1. Place an empty sample pot under the outlet of the sample discharge line.
2. Place the cooling coil in the pot and establish the flow on FI 9404.
3. Close V29'-55 on the sample tap line if open.
4. Open block valve V29'-54 on the sample drain line if closed.
5. Open V29'-160, if it is closed (the valve should stay in the open position).
6. Close V29'-163 sight port block valve if open.
7. Rapidly swing open, closed V29'-55. Reactor pressure will move the sample through the 1" line to drain to the sample pot.*
8. If the sample does not move freely through the 1" line, use nitrogen from V29'-58 to aid sample flow.*
9. When 1/2 to 1 quart of sample has been collected and V29'-55 is closed, close V29'-58 if the N_2 blast is on.
10. Close V29'-160.
11. Open V29'-55.
12. After the sample has cooled, turn off the N_2 flow through FI 9404 to the sample coil. Remove the coil and place the sample in a quart jar. Label it "Bed Sample". Mark the correct date, time and run number on label. Record the sample in the running sample log.

*CAUTION: Face shield or goggles must be worn when taking sample.

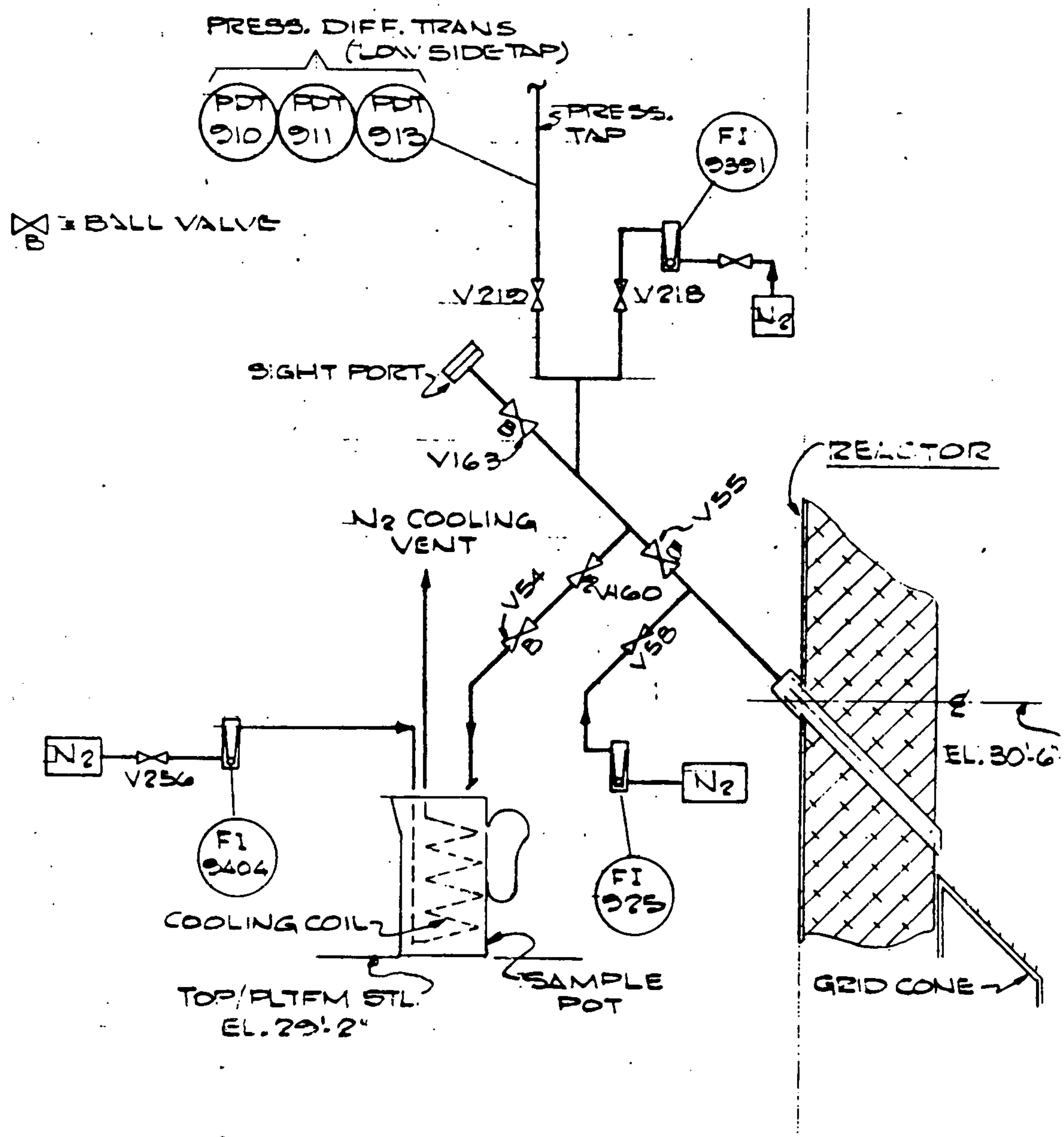


FIG. D-2 BED SAMPLE

APPENDIX D-10

2nd Stage Fines Sample

Once autogenous reaction has taken place the second stage fines sample is taken every four hours unless otherwise specified. The sample is taken at one of two points, 1) at the bottom of the C-5 hopper, grade level, when fines are not being reinjected into the reactor, and 2) directly from the cyclone dipleg line at the 39' level when fines are being reinjected.

The procedure for taking a sample when fines are being collected at grade level is as follows:

See Figure D-3.

1. Close the VO'-106, 2" ball valve on the outlet of the C-5 hopper to allow dust to collect in the hopper if the valve is not already closed.

2. While waiting for dust to collect in the hopper, screw a sample jar onto the sample cap attached to the 3/4" line out of the bottom conical section of the C-5 hopper.

3. Open VO'-100 carefully to allow sample to flow from the C-5 hopper into the quart jar. (Rapid opening and closing of valve works best to obtain a sample without plugging sample line.)

4. When the jar is half full, close VO'-100 and remove the jar and label it "2nd Stage Fines". Mark the correct time, date and run number on the label. Record the sample in the running sample log.

The procedure for taking a sample when fines are being reinjected is as follows:

See Figure D-4.

1. Connect a clean sample container to the sample line using two pipe wrenches to tighten the 1" connecting union.

2. Open V39'-94 block valve on the dust sample collecting line to the sample container.

3. Partially open the V39'-95 vent valve on the sample container to assure flow of dust into container.

4. Determine when the container is full by observing discharge from vent, then close the V39'-94 block valve on the sample line and disconnect the container from the line.

5. Label the container, "2nd Stage Fines - reinjection". Mark the correct time, date and run number on the label. Record the sample in the running sample log.

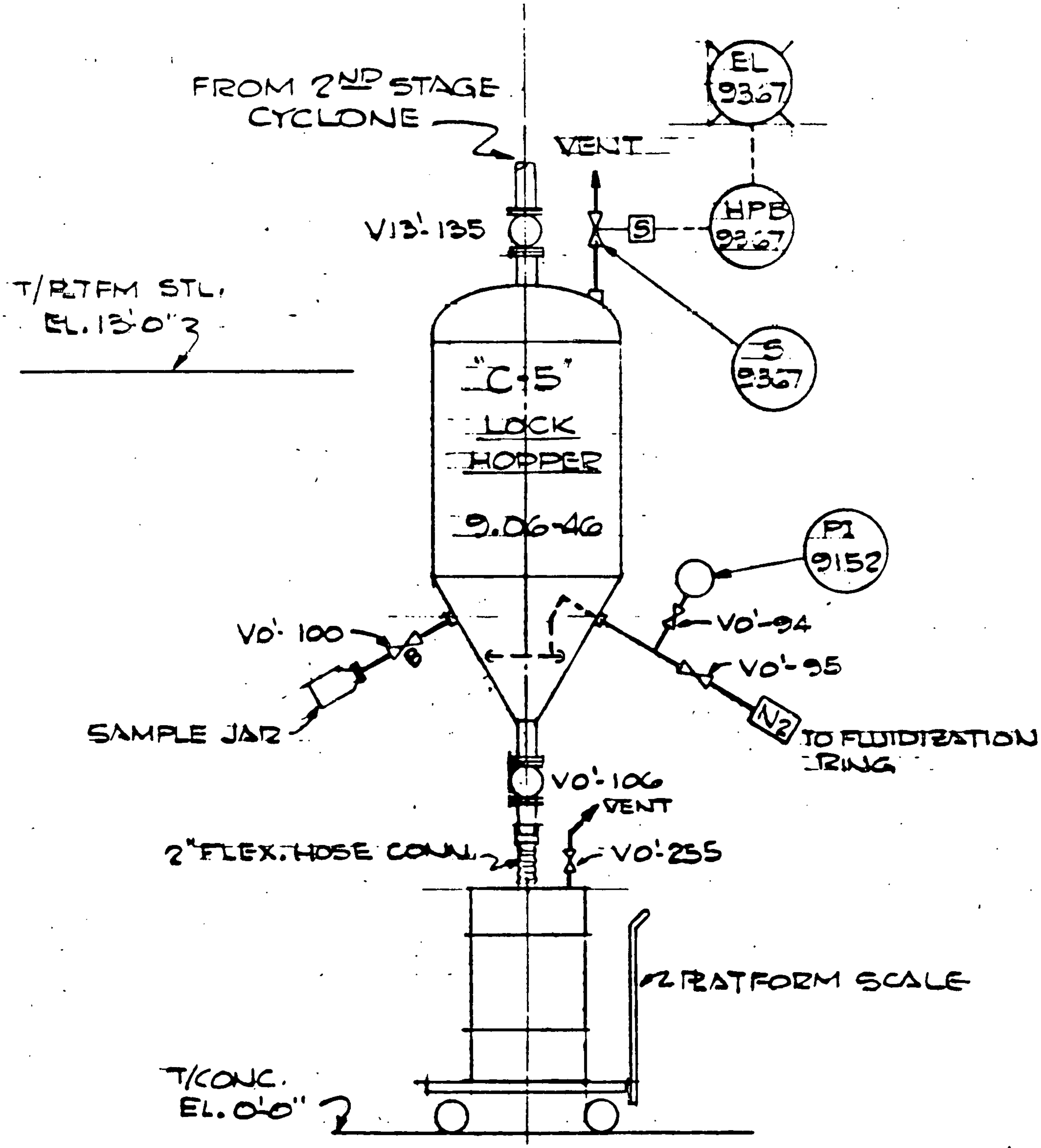


FIG. D-3 (LEVEL 0'-0")

2ND STAGE FINES DISCHARGE

(REFER DWG. AAG-322)

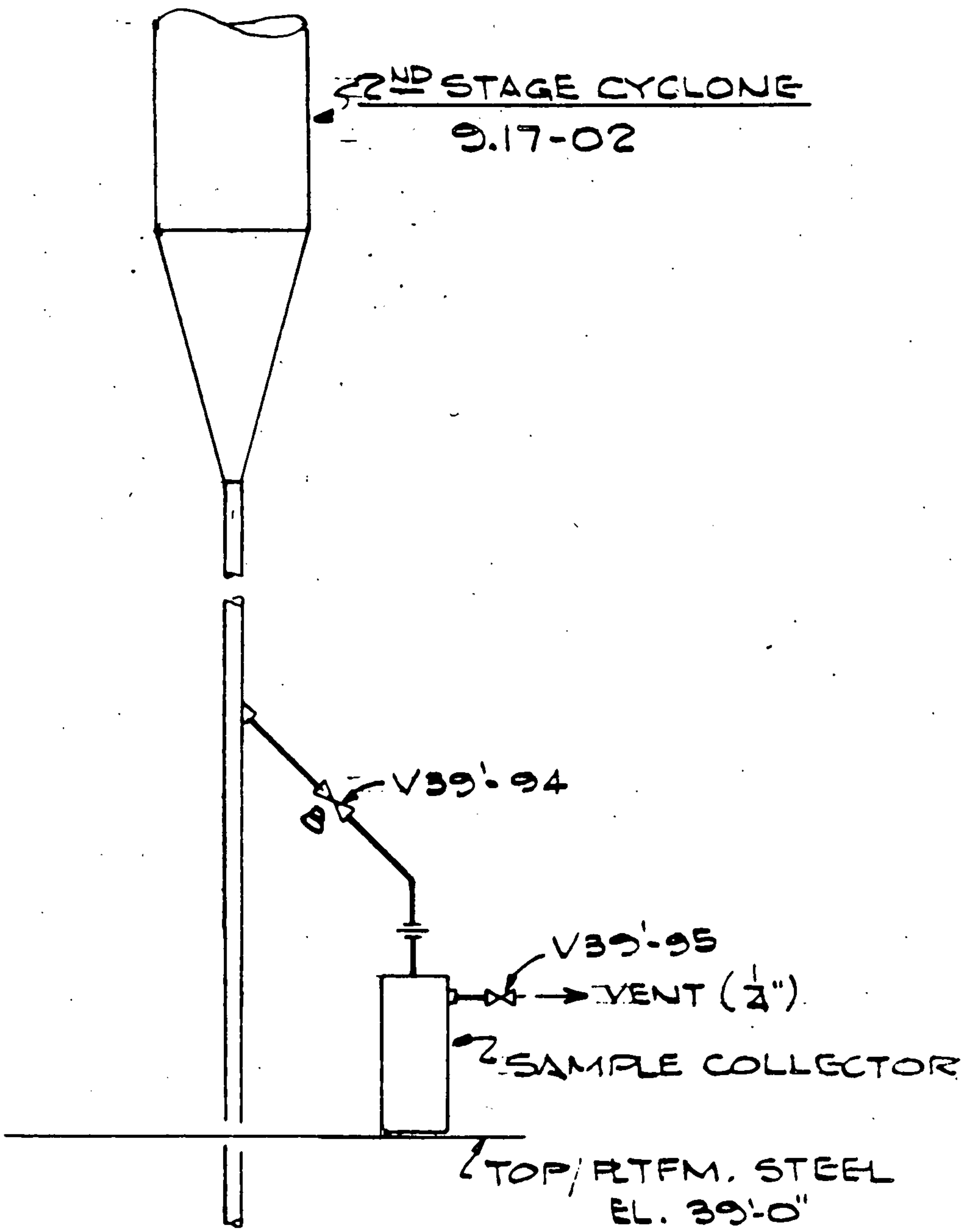


FIG. D-4 2ND STAGE FINES SAMPLE (REINJECTION MODE)

APPENDIX D-11

3rd Stage Fines Sample

The third stage fines sample is taken every four hours once autogenous operation has been achieved.

The sample is taken at one of two points: (1) at grade level at the bottom of the C-6 hopper when 3rd stage cyclone fines are being collected, and (2) at the 29' level when 3rd stage cyclone fines are being reinjected into the reactor.

The procedure for sampling when fines are being collected is as follows:

See Figure D-5.

1. Close the VO'-112, 2" ball valve (block valve) on the outlet of C-6, if it is not already closed, to collect dust in the C-6 hopper.

2. While fines are collecting in the hopper, screw the sample quart jar onto the threaded top attached to the 3/4" line out of the bottom conical section of the C-6 hopper.

3. Carefully open VO'-105 to allow sample to flow into the quart jar. (Rapid opening and closing of valve works best to obtain a sample without plugging sample line.

4. Collect 1/2 jar and then close VO'-105. Remove the jar. Label it: "3rd Stage Fines". Mark the correct time, date and run number on the sample label. Record the sample in the running sample log.

When fines are being reinjected, the procedure is as follows:

See Figure D-6.

1. Connect a clean sample container to the sampling line coming directly off the 3rd stage cyclone dipleg by means of the 3/4" pipe union provided on line.

2. Open V29'-129, block valve on the sample line out of the 3rd stage dipleg.

3. Open V29'-127, vlock valve on the sample container.

4. Partially open the V29'-126, vent valve on the sample container to assure flow of fines into the container.

5. Determine when the container is full by observing discharge from the vent, then close V29'-127 and clean the sample line with an N_2 blast from V29'-128.

6. When the sample line into the dipleg is clear, close V29'-129.

7. Close N_2 blast valve V29'-128.

8. Remove the sample container.

9. Open V29'-128 and then open V29'-129 to clean the sample line to the dipleg.

10. When the line is clear, close V29'-129.

11. Close V29'-128.

3rd Stage Fines Sample, Continued

12. Transfer the sample to a quart jar. Label it: "3rd Stage Fines". Mark the correct time, date and run number on the sample label. Record the sample in the running sample log.

13. Connect a clean sample container to the sample line.

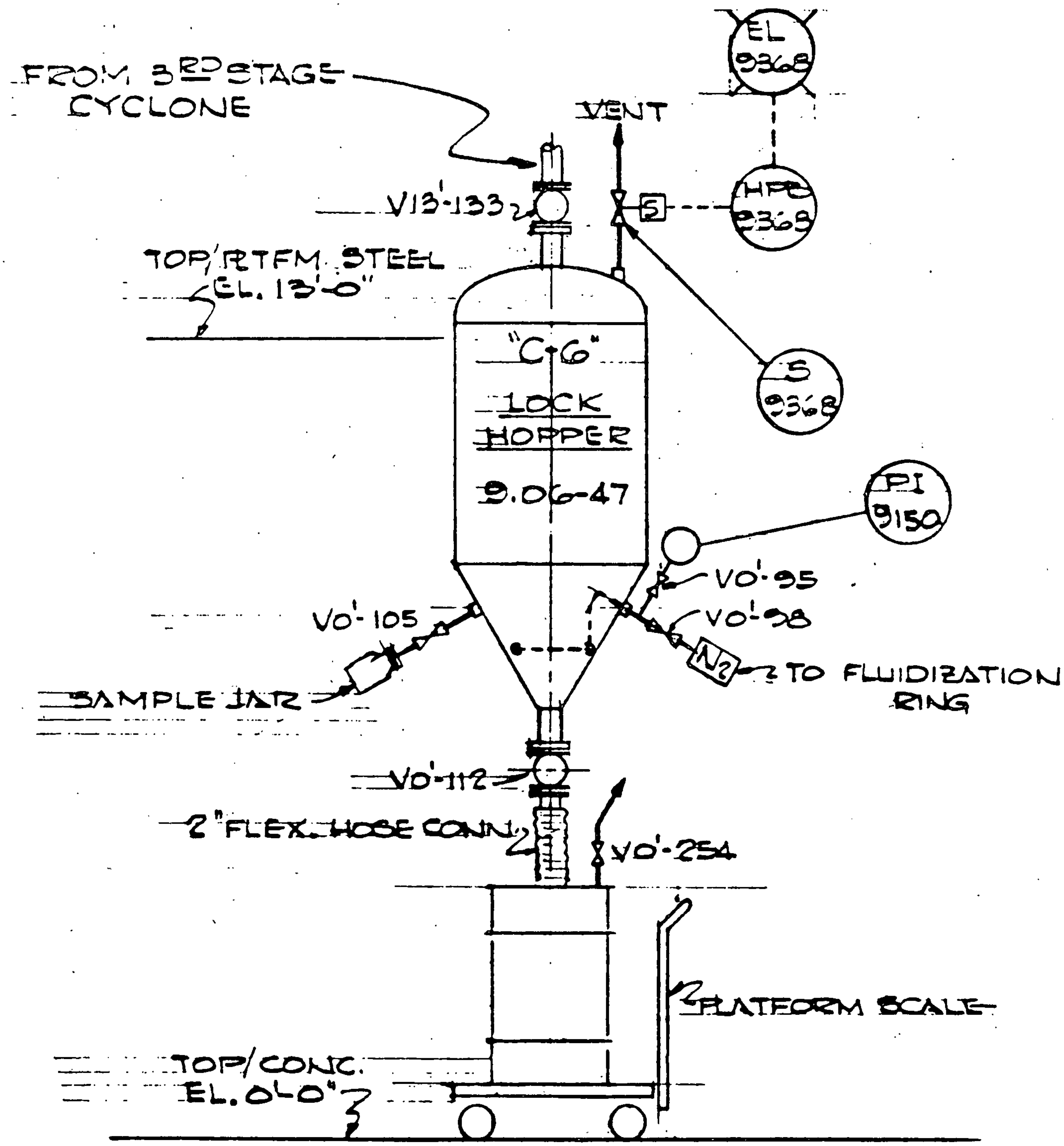


FIG. D-5 (LEVEL 0'-0')

3RD STAGE FINES REMOVAL

(REFER DWG. AAG-322)

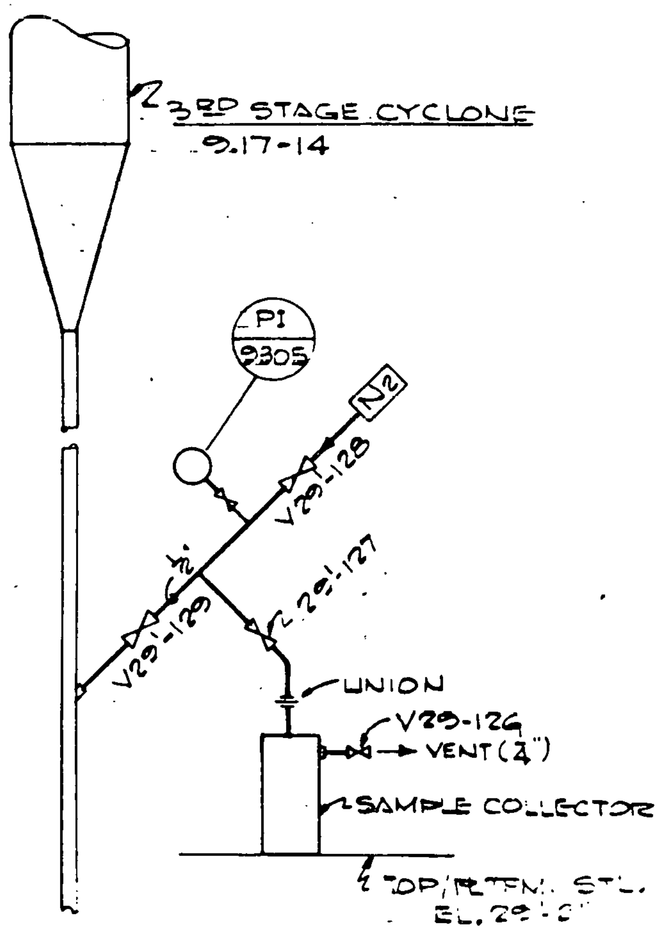


FIG. D-6. 3RD STAGE FINES SAMPLE (REINJECTION MODE)

APPENDIX D-12

Reactor Gas Sample*

The Reactor Gas is monitored continuously for O_2, CO_2, CO, H_2 and Methane, once the start-up burner has been lit. A reactor gas sample is taken every four hours once autogenous state has been reached.

The sample is taken from the reactor at the upper-most nozzle on the east side of the 39' level. See sketch of sampling system, Figure D-7.

The sampling system is operated by the analytical group only.

The analytical group is to be notified by the shift engineer as soon as feed to the reactor is started so that the sampling system and analyzer can be readied.

The analyzer outputs are monitored in the control room on the analyzer recorders. Any unusual readings should be reported to the analytical group for verification. The analyzers are calibrated daily.

* If anything appears amiss with the above equipment, notify the shift engineer immediately as reactor gas could be leaking into the AAG building.

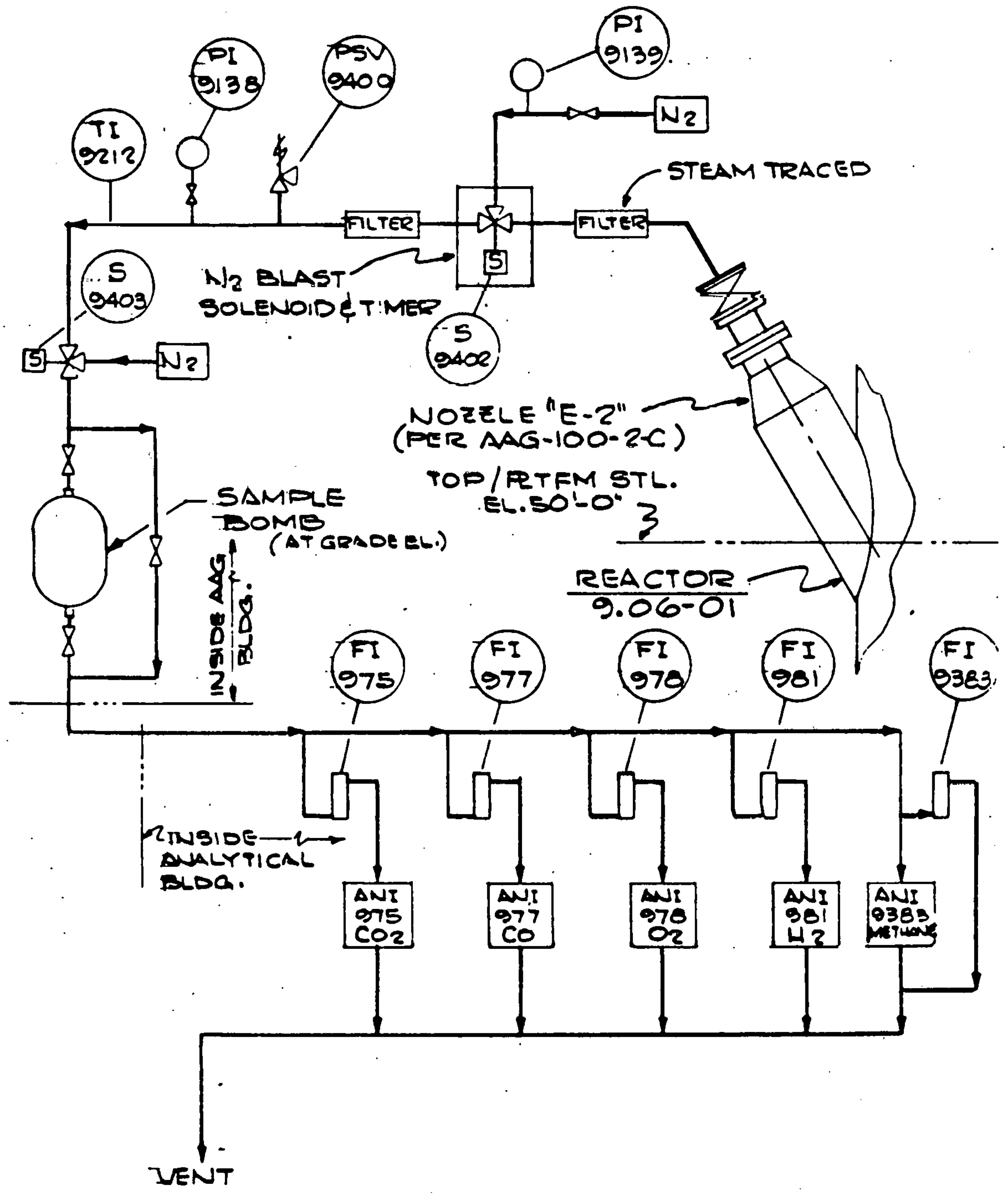


FIG. D-7 REACTOR GAS SAMPLE

APPENDIX D-13

Product Gas Condensate Sample

Once an autogenous stage has been reached, the product gas condensate is collected continuously and a sample is taken every 8 hours.

The sample is used to test for sulfur, other inorganic and organic compounds and the amount of condensate collected.

The sample is taken off the product gas line at the 21' level. See sketch of sampling system, Figure D-8.

The sampling system is operated by the analytical group only.

The analytical group is to be notified by the shift supervisor as soon as the start-up burner is lit, so that the sampling system can be readied.

No monitoring of the system by AAG personnel is necessary, but if irregularities or leaks are noticed in the sampling system, they should be reported to shift engineer so the analytical group can be notified to take corrective action.

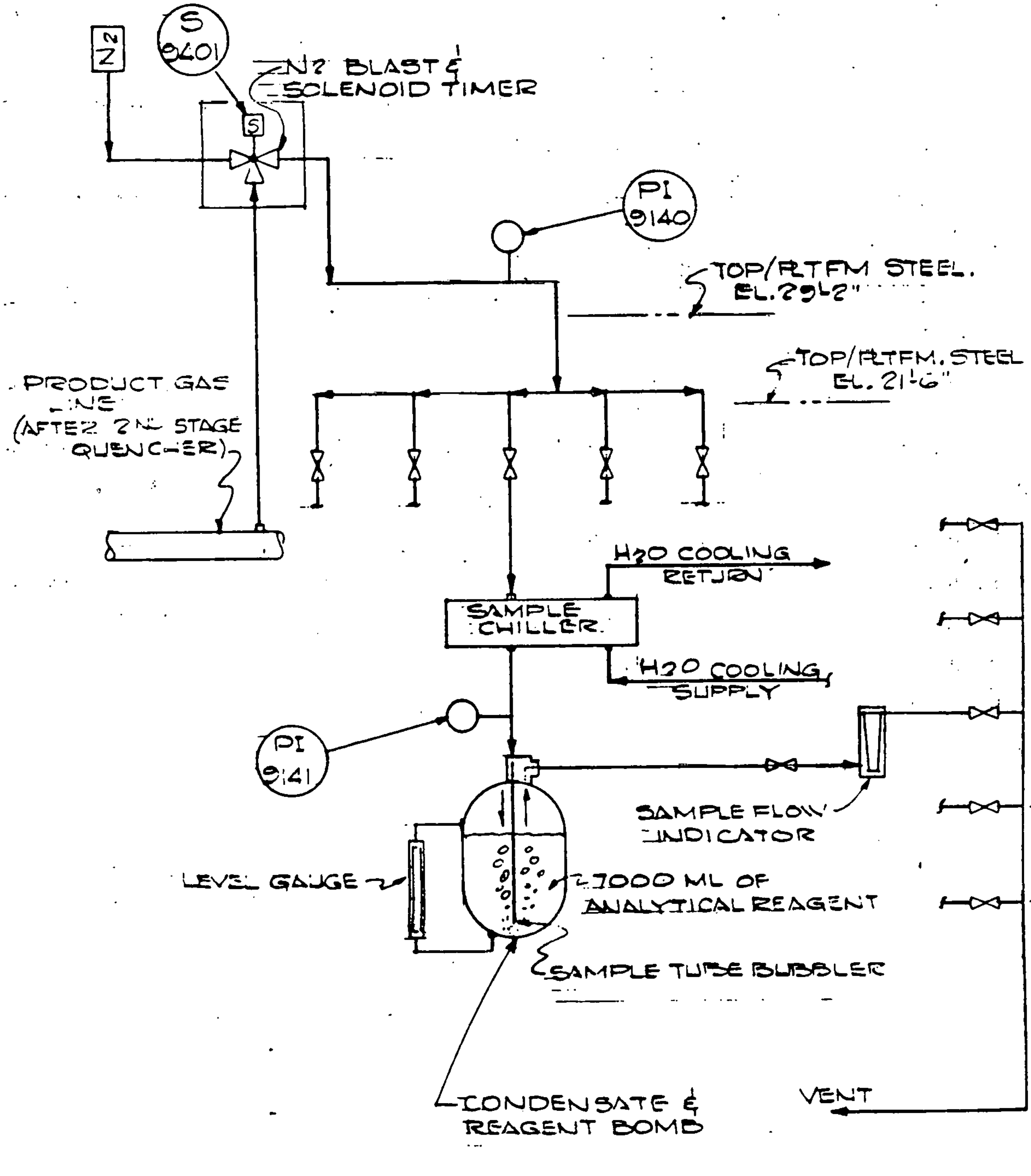


FIG. D-8. PRODUCT GAS CONDENSATE SAMPLE

APPENDIX D-14

Venturi Discharge Rate and Sample

The venturi discharge is taken every hour on the half hour starting when feed to the reactor begins. A sample of this discharge is taken every two hours unless otherwise specified. This discharge is weighed in 55 gallon drums and all weights are recorded on the C-4 discharge sheet. (The solids actually discharge from the C-4 hopper into the drum.) All C-4 drums are labeled with correct run number and drum number.

When FV999 is open and VO'-41 is closed, the C-4 discharge and sampling procedure is as follows:

See Sketch Figure D-9.

1. Set the solenoid operated nitrogen blast purge (SW 999) to FV 999 for automatic operation.

2. Close FV 999, (HPB 999)(the slide gate valve between C-3 and C-4), then the FV 999 limit switch will activate the "closed" light.

3. When the "closed" light assures that the FV 999 is fully closed, open PV 9350, the solenoid operated C-4 vent valve. The EL 9350 light will glow red.

4. When PI 908 indicates less than 2 psi in the C-4 hopper, slowly open VO'-41 (valve below the C-4 hopper) to release any residual pressure not indicated on PI 908. Use a scoop to sample the discharge as it flows from the C-4 hopper into a tared and correctly labeled drum.

5. Put the scoop with the sample on the scale top for observation while cooling.

6. Before VO'-41 is fully opened, but after the material has drained from C-4, open VO'-140 (N_2 blast to VO'-41) and adjust the purges to the bonnet and seat by using VO'-87, VO'-88 and VO'-89 to clear the valve of any residual discharge.

7. Open VO'-41 fully to assure the C-4 hopper is empty; then close VO'-41 after the C-4 hopper is certainly empty. If VO'-41 is properly closed, the N_2 flow at VO'-140 will stop. Listen for this stop.

8. Close VO'-140 (N_2 blast to VO'-41).

9. Close PV 9350. EL 9350 must stop glowing or the vent is not closed.

10. Open FV 999 (slide gate between C-3 & C-4 hoppers); an "open" light will indicate FV 999 is fully opened. PI 908 will now indicate the pressure in C-4.

11. Discharge is now complete and the weight of the C-4 drum can be logged.

12. When the sample cools, place it in a 1-quart jar and label it "C-4". Mark the correct time, date, and run number. Record the sample in the running sample log.

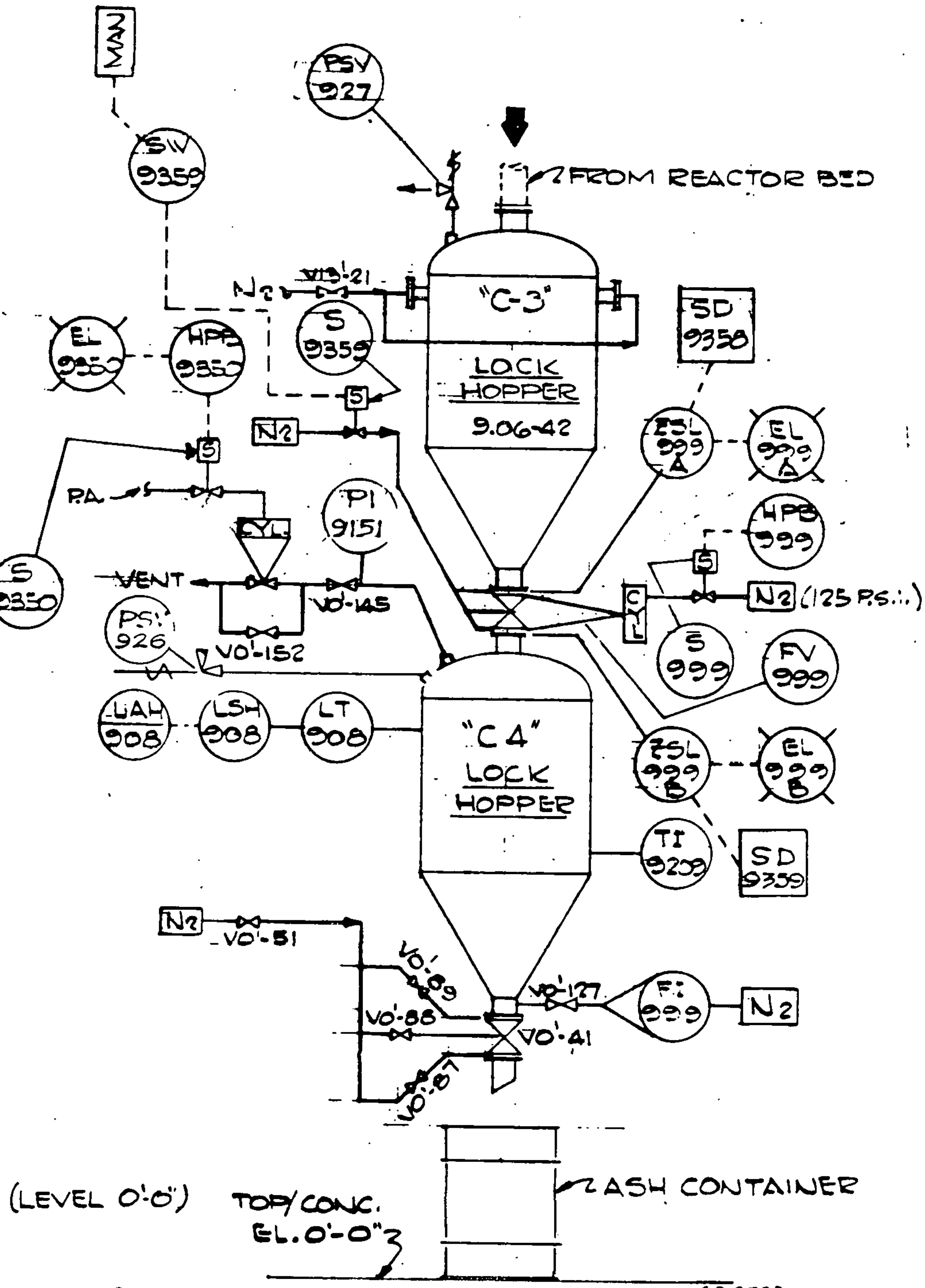


FIG. D-9. VENTURI DISCHARGE (REFER DWG. AAG-321)

APPENDIX D-15

Bed Discharge Rate and Sample

See Sketch Figure D-10

A) Turn off the bed discharge timer (TCC 9349) on the push-button panel in the Control Room and close the block valve (V21'-82) below the 3" automatic bed discharge valve FV 9349. (21'-6" level.)

B) At the ground level —

1. Open the C-7 hopper vent solenoid (S-9390). The red light must begin to glow.

2. Open the valve (VO'-48) below the C-7 hopper and wait until the material is drained into the 55-gallon drum. Use blast valve VO'-93 to clean the solids from VO'-48.

3. Close the valve below C-7 and close the C-7 vent valve.

4. Weigh the discharged material and record the weight on the C-7 discharge sheet.

5. Take a one-quart sample of the bed discharge material from every filled drum.

C) Open the block valve below the 3" automatic bed discharge valve and turn on the bed discharge timer at the push-button panel.

D) If the material is discharging from the bed:

1. PDR 912 will indicate a continuous lowering of the bed level.

2. TI 9207 will indicate a rise in temperature to 500°F or higher.

3. The bed ash content should fall to a lower level than in the previous hour.

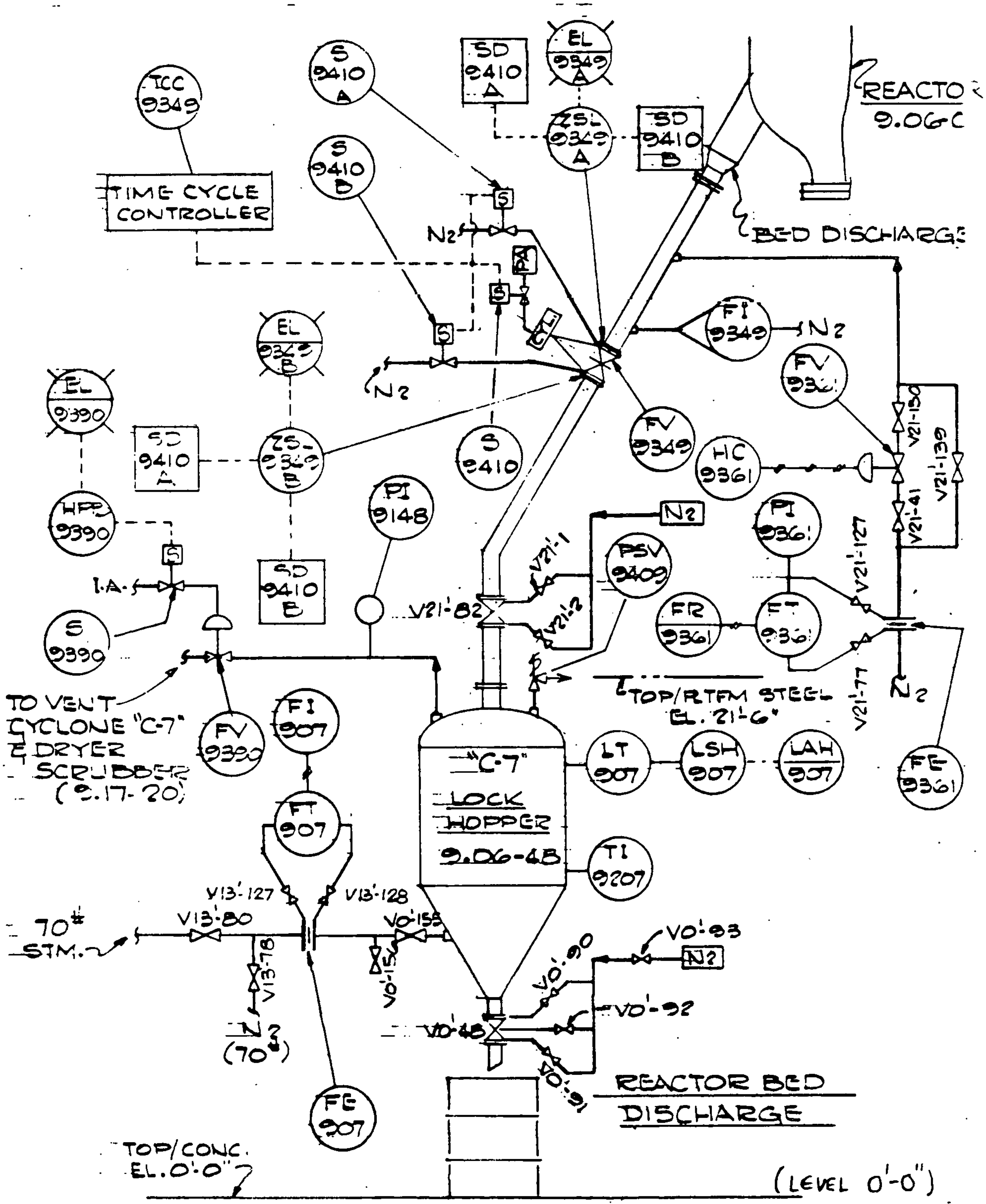


FIG. D-10. BED MATERIAL DISCHARGE SYSTEM (REFER DWG. ANG-3

APPENDIX E-1

EMERGENCY SHUTDOWN PROCEDURE IN CASE OF HIGH TEMPERATURE IN THE REACTOR

1. Examine the temperature chart (TR 9206) to determine if the bed rise is uniform throughout the bed or localized.

2. If the temperature is localized and if the formation of clinker is apparent, start shutdown procedure.

3. If the temperature rise is uniform throughout the bed, follow the idling procedure.

4. Determine ash content of the bed.

5. If ash content of the bed exceeds 30%, drop 600# of bed material and feed equivalent amount of fresh feed to lower the ash content of the bed.

6. Resume normal operations as the bed temperature approaches 1400°F uniformly.

7. During any procedure or by human error, if the bed gets defluidized and does not get refluidized either by steam or air, start shutdown procedure immediately.

APPENDIX E-2

EMERGENCY SHUTDOWN PROCEDURE IN CASE OF LOSS OF STEAM

1. In the event of loss of steam pressure, PSL 959 will shutdown the compressor and oxygen valve.

2. Introduce N_2 to the air heater through FR 904 immediately to sustain fluidization. Turn off the feed.

3. Inform HYGAS of steam shutdown.

4. Restart the unit when steam returns.

5. If during steam shutdown, bed gets defluidized due to loss of air, and if it does not refluidize after steam resumes, start shutdown procedure immediately.

APPENDIX E-3

EMERGENCY SHUTDOWN PROCEDURE IN CASE OF LOSS OF PROCESS AIR

1. In the event of loss of process air, PSL 960 will shut down air heater, close the 6-inch cylinder valve and activate N_2 blast in the venturi.

2. Implement the idling procedure.

APPENDIX E-4

EMERGENCY SHUTDOWN PROCEDURE IN CASE OF
LOSS OF POWER

1. Loss of power would shut down the compressor which in turn will activate PSL 960 to turn off air heater and close the cylinder valve.

2. If the loss of power is momentary, restart the compressor immediately, turn on the air heater and resume normal operation.

3. If the bed gets defluidized due to loss of air compressor and does not refluidize with air, start shutdown procedure immediately.

APPENDIX E-5

EMERGENCY SHUTDOWN PROCEDURE IN CASE OF
LOSS OF NITROGEN

1. Loss of nitrogen would result in the loss of all the purges, loss of flow in the 9303 loss of atomizing nitrogen in the quenchers, and probable loss of feed if L-valve is in operation.

2. Start idling procedure.

3. Inform HYGAS about N_2 pressure failure.

4. When N_2 is resumed, determine the number of plugged pressure taps, nozzles, and jets.

5. If the extent of plugging is not extensive, resume the normal run operation.

6. If many nozzles are plugged, start the shutdown procedure.

APPENDIX E-6

EMERGENCY SHUTDOWN PROCEDURE IN CASE OF LOSS OF FEED

1. Loss of feed would result in rise of the bed temperature and in possible damage to the reactor feed screw.

2. Turn off the reactor feed screw.

3. Start idling procedure.

4. Determine the cause for feed failure.

5. Rectify the feed problem.

6. Resume normal run operations.