MASTER

GASIFICATION RESEARCH ON WOOD

GROW PROJECT

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TECHNICAL REPORT

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TECHNICAL REPORT

The emphasis at the GROW facility has continued to be shared between performing safety modification and installing equipment required in the contracted task. Progress has been made in both areas and suggested start-up dates have been prepared with a probable realistic date of February 1, 1981. The areas of accomplishment will be discussed in detail in the next section.

AREAS OF EFFORT

The OSHA investigation required several documents to be prepared, they included;

- 1) safety implementation plan
- 2) total plant operating procedure
- 3) training schedule

these documents required a large amount of time and will be important as commercialization of gasification plants become a reality.

1) Implementation Plan

The implementation program has been used to perform several functions, principally the task of defining the dates for implementing the safety review and any system modifications. The program has been used to define the hazards involved in the wood gasification process and more specifically the hazards at the GROW site.

2) Total Plant Operating and Maintenance Procedures

The procedures were written to define plant operations under:

- normal operations

- maintenance operations
- emergency procedures.

The procedures include the steps to be taken to start, run, and shut down the equipment. The steps outlined will provide specific flow diagrams and necessary precautions for performing hot work on the site. The procedures include a detailed procedure for tank entry and permits to be signed for either hot work or tank entry. The procedures are extensive and every operator or worker will have to read them before working at the site.

3) Training Schedule

The training schedule has been prepared outlining the necessary training for every plant employee. Instructions will be principally provided by project staff except in the safety equipment. The safety equipment training will be provided by the equipment manufacturers.

A copy of the implementation plan and operating, maintenance, and safety procedures is attached to this report. Another question which had to be answered was an expert opinion defining the hazard level, if hazardous, of the facility. An expert has been retained and we are waiting his written report. By telephone conversation the expert suggested that the outside portion of the site is not class I, but the compressor is probably class I division II which will require special electrical fixtures.

CONTRACT MODIFICATIONS

The installations modification which have been accomplished are:

- 1) scrubber system erected
- 2) modified feed handling
- 3) caustic handling erected
- 4) demister installed
- 5) fume hood for the gas chromatograph

1) Scrubber

The scrubber columns have been erected and the system piping is being undertaken.

2) Caustic System

The three tanks for storing 10% and 20% caustic solutions are installed and the piping is nearing completion. The safety procedure for handling the caustic will be included in the procedures and the special clothing and shower system are on site.

3) Modified Feed Handling

The feed handling system has been modified to reduce the amount of equipment. The feed system of interest is from the blender to the bin. The change has eliminated the auger and now the hogged product is pneumatically conveyed to the fan. A schematic is included and the auger will be removed.

4) Demister Installed

A filter or demister has been installed in the gas production line. The demister is located downstream of the drop out drum helping to insure clean gas to the recycle compressor. The design engineer realizes that it will increase the pressure drop but the hope of a cleaner gas is believed to be worth the pressure drop.

5) Hood

A fume hood has been added in the control room to insure

that any gas lost from the chromatograph will be exhausted through the fume hood.

CONCLUSIONS

The site has had a high level of activity with a corresponding effort in preparing procedures. The staff is eager to restart the facility and to start once again producing data.

IMPLEMENTATION PLAN FOR SAFETY

GROW PROJECT

UNIVERSITY OF MISSOURI-ROLLA

INTRODUCTION

The GROW (Gasification Research on Wood) project consists of a research project on thermochemical degradation of wood particles (sawdust or hammermilled wood) on a pilot plant scale and utilizes a 100 cm (40 in.) diameter fluidized sand bed reactor at capacities of up to 1000 Kg/Hr (2200lb/hr). Supplementary facilities include wood preparation and air conveying, a wood feed bin, feed and transfer screws, an air compressor with storage and filter tanks, an electrical preheater, a propane-fired preheater, a cyclone separator removing solids from product gas, a water scrubber to cool and clean product gas, a scrubber water settling tank, a scrubber water cooler, a knockout drum, a demister to be installed in the future, a recycle compressor for recirculation, a recycle gas storage tank, a flare and stack with air blower to dispose of the gas, 2 CO₂ stripper columns to be installed in the future to remove CO₂ by caustic absorption, caustic tanks, and the necessary piping, pumps, sampling, and measurement facilities.

The unit is operated intermittently for research, development, and demonstration purposes only. Construction and maintenance work are not carried out on equipment being used but is carried out only on idle facilities, with the exception of minor adjustments or modifications to facilitate operations usually during brief shutdowns.

HAZARD CONSIDERATIONS AND DEFINITIONS

The materials involved are wood, air, steam, product gas (essentially the same as recycle gas), wood tar, char (finely divided charcoal), wastewater,

catalyst to be used in the future (K_2O), and sodium hydroxide in 50% and 10% solutions. The hazardous materials are as follows:

<u>Material</u>	<u>Hazard</u>	<u>Comment</u>
Product or recycle gas	Toxic (carbon monoxide, CO) Flammable Recycle gas under 25 psig with storage tank.	Usually smells like smoke. Low to medium Btu gas (100 to 400 Btu/ft ³). Mixture of H ₂ , CO, CO ₂ , N ₂ ; small amounts of CH ₄ , O ₂ . High percentage of H ₂ O. Not easily ignitable.
Wood Tar	Flammable if not wet with water. Might be carcinogenic.	May deposit in piping and equipment where ignition can occur if air is present.
Waste Water	Might contain carcinogenic compounds.	Dilute mixture of wood tar and char in water. Not known to be carcinogenic. Toxic at some levels to salmonella bacteria, and anaerobic bacteria sludges.
Potassium Oxide Catalyst (dry)	Alkaline-can damage eyes and skin.	To be mixed dry with feed and recovered and recycled with char.
Sodium Hydroxide To be received as 50%, to be used as 10%.	Alkaline-can damage eyes and skin.	To be used as 10% solution in CO ₂ stripping towers fed from tanks with recirculation.
Char	Combustible, smolders long periods without flame.	If removed from system hot it is likely to smolder or ignite if not thoroughly wetted.
Propane	Combustible, suffocating	Used only for heating and maintaining flare.
Steam	Under 25 psig	
Air	Under 25 psig	

OPERATING HAZARDS

Fire: The operation of the GROW reactor is in essence a controlled combustion with a deficiency of air. The reactor and the downstream equipment is designed to handle combustion products so that internal process does not appear to be a

problem. Improper operation of the scrubber and tar separation could result in high temperatures entering the recycle compressor and recycle system. If air is admitted combustion could occur in the recycle system under pressure.

External fires could result from leaks or from ruptures of pipe or equipment. Such fires would be limited to the production rate of gas, except in the case where the recycle system is in operation when the contents of the 25 psig 500 gallon storage tank could be burned almost instantaneously in case of a major rupture.

The equivalent of a flue fire could occur in any of the piping or the scrubber or knockout drum if tar deposits ignited and air was present in the system. This could damage equipment, possibly cause leaks, or could cause a fire in the recycle system.

The char separated from the gas remains hot for some time and may smolder and start combustion which could spread to other materials.

Explosion:

The potential for explosion exists, but the explosions would probably not be very likely or extremely powerful because of the low heating value of the gas, and the low pressures where explosive mixtures could accumulate. In addition the gas is not easily ignitable.

The locations where explosions seem most likely to occur would be the recycle gas storage tank and the feed bin. With improper water circulation, it is possible an explosion could occur in the scrubber but pressure would be relieved through the flare.

Chemical Exposure:

The toxic nature of the carbon monoxide could be hazardous during operation in the case of large leaks or rupture of piping or equipment. An extensive rupture would be necessary to cause a serious hazard in the majority of the plant which is of outdoor construction, and the toxic effects would probably

be minor unless a person were trapped where he could not escape the product gas. A small leak could produce a hazard from the sample lines in the control room or from the recycle lines and compressor in the compressor building.

Breaks, leaks, or spills could produce hazards to skin or eyes from the caustic solution to be used in the CO_2 stripper columns. Similar hazards could result from contact with the catalyst, potassium oxide, which is to be added to the wood feed and recovered with the char from the cyclone.

There is a possibility that some components of the wood tar could be carcinogenic and result in a hazard if exposure to the skin occurs.

Steam and compressed air also pose a potential hazard due to possibilities of ruptured pipes or equipment and burns.

MAINTENANCE HAZARDS

Confined Spaces:

Confined spaces where product gases could accumulate are a major hazard if it becomes necessary to perform maintenance inside tanks. The tanks that it is possible to enter include the feed bin, the reactor, scrubber, settling tank, and caustic tanks. Carbon monoxide in lethal quantities could be contained in all these tanks, although improper operation would be necessary to permit carbon monoxide to enter the settling tank and caustic tanks. With the exception of the caustic tank all the above tanks could contain deposits of wood tar and char. Caustic tank entry would include the hazard of contact with caustic solutions. Future operations with K_2O catalyst would allow K_2O to be present in any of the enterable tanks except the caustic tanks.

None of the enterable tanks involve power equipment except the feed bin vibrator.

Flammable Hazards:

With normal shutdown procedures there would be little chance for flammable product gas in any equipment or lines, except for the feed bin and the recycle

system. Changes from past procedures could eliminate product gas in the feed bin and recycle system.

Short shutdowns to correct problems could produce a flammable hazard if piping or equipment are being modified, but except for the recycle system and bin, quantities of flammable gas would be limited.

Work on any propane lines or burners would present a flammable hazard.

MECHANICAL AND ELECTRICAL HAZARDS

Work on pumps, hammermills, blowers, fans, screws, compressors, slide valves, electrical preheaters, and feed treatment-handling equipment present a hazard from moving parts, electrical shocks, or burns. The operation of the "Bobcat" loader constitutes a mechanical hazard.

GENERAL HAZARDS

Any work on elevated equipment involves the hazard of possible falls. Similarly there is some hazard from falling, objects, tripping, bumping equipment, or slipping.

The possibility also exists for unauthorized or inexperienced or untrained personnel to enter the facilities and be injured by improper use of equipment or facilities.

Recommended Plan for Implementing Safe Practices
on the GROW Project

As a result of the fatal accident to two GROW employees, attention has been focused on improving the safety of operating maintenance and construction procedures. A preliminary safety report has been written by a committee of employees and supervision. This report outlines desirable safety equipment, procedures, and recommended changes, but was not meant to be all-inclusive and is subject to further changes and improvements. It has not attempted to cover the management or direction of the project. The Safety Report and the NIOSH recommendations (1) are the basis for the following plan of implementation.

Entry of Confined Spaces and Rescue

After consideration of the checklist on page 5 of NIOSH recommendations (1), the following steps will be required prior to entering any confined vessel:

- 1) The vessel will be isolated with valves locked and tagged.
- 2) The vessel shall be purged with air, and any moving parts will be locked out and tagged.
- 3) An analysis or monitoring device will indicate a safe concentration of carbon monoxide, oxygen, and flammable gases.
- 4) Two safety harnesses, two ropes, block and tackle, ladder (if top entry), a respirator connected by hose to a clean air supply and a 5-minute emergency exit tank, and a second respirator for emergency rescue will be available and ready for use. Hard hats and rubber gloves will be worn.
- 5) An observer-communicator standby and a second standby person will be designated. (3 people involved)
- 6) An entry permit indicating the above preparation and plan of work will be prepared and signed by an authorized person.

Entry will be carried out only with use of all the above procedures and only with trained personnel. (See attached safety report.)

The procedures will be available for operator training on January 1, 1981, and equipment and training will be completed January 31, 1981.

Permit System

A permit will be required for entry into vessels which cover the items outlined on pages 6 and 7 of the NIOSH recommendations (1), and which will require preparation as outlined above.

A permit will also be required for any "hot work" (see page 2 of recommendations) performed on the installed equipment or piping. "Hot work" shall also include work involving opening any installed piping or equipment under operating or hot conditions. Work on equipment not yet installed or opening of the closed off char drum or the settling tank under normal operations will not be considered "hot work".

Permit forms will be prepared and available by January 1, 1981.

Medical

Medical exams will be given to the technicians, graduate research assistants, and student research assistants who will be designated for work in confined spaces. There will be at a minimum five people with current medical exams at any given time.

Procedures and Training

Operating procedures including emergency procedures will be revised, updated, and completed in writing to eliminate serious hazards of fire, explosion, toxicity, and chemical exposure during start-up, operation, shutdown, and post shutdown periods.

Maintenance or construction safety procedures involving predictable hazards will be written to reduce such hazards.

These operating and maintenance or construction procedures will be written and available for approval by December 15, 1980.

A training program has already been initiated and will include training in the operating procedures, maintenance or construction safety procedures, vessel entry and rescue, the use of respirators, fire extinguishers, monitors, and other safety equipment. Records will be kept of training sessions and attendance.

The training of existing employees on the GROW Project shall be completed prior to January 31, 1981, and new employees will be provided similar training prior to their participation in any activities at the GROW Site.

Testing and Monitoring

Analytical equipment is already in use for analyzing process gases by chromatography. A continuous analyzer for CO and oxygen is on-site and being installed. Provision will be made for more flexible sampling at various locations for these instruments. A portable CO measuring device is on-site which can also measure oxygen when different tubes are ordered. There is also a supply of indicator tags which show excessive CO concentrations.

Further monitoring equipment is being ordered for testing hazardous locations for carbon monoxide and for flammable gases. This includes one permanent unit for each building and one portable unit, both for CO monitoring. In addition a portable explosive mixture instrument is on order.

Monitoring will be carried out in both buildings in the process area, and as necessary in areas where maintenance is to be performed.

Alarms will be included with the permanent CO monitors and a button alarm will be installed for emergencies.

All monitoring and testing equipment should be ready for use by January 31, 1981.

Labeling and Posting

A fence is to be installed to prevent entry of unauthorized persons. This fence will be posted and suitable signs warning of hazards will also be installed on the fence. Warning signs will be placed on all points where hazardous materials are likely to be encountered, and vessels in particular will be labeled as to hazardous contents and as to entry requirements.

Locks and tags will be made available to prevent accidental operation during maintenance.

Such labels, posting, and tags will be installed by January 15, 1981.

Safety Equipment and Clothing

In addition to respirators, fire extinguishers, monitoring equipment, harnesses and ropes previously mentioned, further safety equipment which will be available, if not already present, will include hard hats, goggles, rubber gloves, rubber aprons, dust masks, safety belts with quick connect safety loops, and others.

The safety equipment outlined above will be available by January 31, 1981.

Work Practices

The operating and maintenance safety procedures will be established in written form as discussed under training. Such procedures will be based on elimination of fire, explosion, toxic gas exposure, and chemical contact hazards to the maximum extent practical. Specific hazards to be reduced will be the possibility of an explosive mixture occurring in the recycle system, the possibility of wood tar entering the recycle compressor, the possibility of flammable or toxic gases remaining in equipment or lines after shutdown, and the possibilities of improper operation that would result in

hazards in unexpected locations. In addition, maintenance procedures will be developed to eliminate the necessity for entering any vessel except in rare instances.

Considerations will be given to safety interlock switching to provide automatic shutdown under hazardous conditions. However, careful consideration will be required to make sure any such system does not impair operational flexibility that might be required in emergencies for safety reasons.

Plans will be made to maintain a positive air pressure from the safest direction in both buildings to prevent a buildup of toxic or flammable gases. Exhaust hoods will be considered for sampling lines and measuring instruments in the control room to prevent buildup from leaks. The compressor area of the compressor building with recycle gas piping will be considered for isolation and perhaps exhaust venting. All cylinders of hazardous gases will be kept outside of buildings with piping to the necessary instrumentation.

All known tripping and similar hazards will be corrected by November 26, 1980.

Plans for building and switching modifications will be complete by January 1, 1981, and all modifications will be complete by January 31, 1981.

REFERENCES

1. NIOSH - "Criteria for a Recommended Standard: Working in Confined Spaces". U.S. Dept. of HEW; NIOSH, Washington, D.C., Dec., 1979.

OPERATING, MAINTENANCE

AND

SAFETY PROCEDURES

GROW PROJECT

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OPERATING PROCEDURES

ACTIVITY A: Compressor start-up.

- A1. Throw the compressor switch, No. 10 on the 440 control panel in the control room to ON. Main switch should be ON.
- A2. Close compressor outlet valve V1, open Air Bleed Valve V43.
- A3. On the compressor panel, turn the Normal - No Load Switch, to No Load.
- A4. Push start button on compressor panel.
- A5. Let discharge temperature rise to 100°F, then turn Normal-No Load switch to Normal.
- A6. Gradually open air valve, V1, and close bleed valve, V43.

ACTIVITY B: Compressor shut-down.

- B1. Turn the Normal-No Load switch to No Load.
- B2. Close air valve, V1, stay away from bleed line, wear ear protection and open bleed valve, V43.
- B3. Push STOP button on compressor panel.
- B4. Throw compressor switch on 440 panel in control room to OFF.

ACTIVITY C: Filling the feed bin.

- C1. If not running, Start-Up Compressor (Activity A).
- C2. Turn feed blower switch (1) and hammermill switch (5) on 440 panel to ON. Turn on breaker switch for feed conveyor () on 220 panel.
- C3. Turn gate valve mode switch to LOAD (transfer screw, bin activator, and volumetric feeder should be OFF).
- C4. Start hammermill with switch on unit.
- C5. Start feed conveyor to hammermill with switch on conveyor.
- C6. Start feed blower with switch on blower.

- C7. Put feed duct to feed blower into hammermill outlet.
- C8. Use a dust mask if feeding dry material, and feed wood supply into hammermill feed conveyor until bin is sufficiently full.
- C9. Stop feed conveyor and hammermill and feed blower with switches on units, and on 440 and 220 panels.
- C10. If not ready to operate reactor and compressor is not needed, shut down compressor (Activity B).

ACTIVITY D: Filling the wastewater settling tank.

- D1. Wear goggles and rubber gloves.
- D2. The settling tank may be filled during operation of the system or while draining out. If not operating, the outlet valve and the settling tank drain, valves V37 and V42, should be CLOSED.
- D3. Open the city water valve to the settling tank, V44.
- D4. Allow the settling tank to fill to a level 1 inch from the top of the sight glass.
- D5. Close the city water valve, V44.

ACTIVITY E: Draining the wastewater settling tank scrubber system.

- E1. Wear goggles and rubber gloves.
- E2. Open the settling tank drain valve, V42.
- E3. Allow settling tank to drain to the desired level, then close the drain valve, V42.
- E4. If shutting down, when the system is purged, open the scrubber drain valve, V40, allow the scrubber to drain and then close the drain, V40.
- E5. If shutting the system down during freezing weather, open the fin fan cooler drain valves, V41, until flow stops then close drain valves, V41.

ACTIVITY F: Start up procedure for Reactor Burner Preheater.

- F1. Air compressor must be running (Activity A).
- F2. Turn on breaker switch No.3 on 220 panel located in the control building.
- F3. Open valve No.5 and regulate the air pressure to psi.
- F4. Open valve No.49 to supply the gas to burner.
- F5. Wait till yellow light goes off on the burner control unit in control room which indicates burner is purged.
- F6. Turn OFF/RUN/Ignition switch on the control unit to ignition.
- F7. If red light comes on, pilot has been lighted. Then turn the switch to RUN.
- F8. If red light does not come on then alarm will sound and system has to be checked and corrected before restarting.
- F9. Turn the OFF/RUN lever, located on the burner piping by the reactor, to RUN. From time to time check preheater temperature, if it goes above 1200⁰F, shut down (Activity G). When temperature is below 1200, preheater can be restarted (Activity F).

ACTIVITY G: Shut-down procedure for Reactor Burner Preheater.

- G1. Turn OFF/RUN/Ignition switch to OFF.
- G2. Turn OFF valve V49 to shut-off gas supply.
- G3. Turn OFF valve V5 to cut off the air supply.
- G4. If no longer needed turn off breaker switch 3 on 220 panel.

ACTIVITY H: Adjusting gas or air flow to electric preheater.

- H1. Gas or air or steam flow should be open to electric preheater according to desired reactor operating instructions.
- H2. Breaker switch 26 on 220 panel should be turned ON.

- H3. Compressor (Activity A) or recycle compressor (Activity K) or boiler (Activity) should be ON.
- H4. Turn gas flow power switch on control panel to ON. Indicator light should be ON.
- H5. Set digital potentiometer to appropriate setting. Check flow by the appropriate orifice pressure difference and adjust potentiometer to obtain desired orifice reading.

ACTIVITY I: Starting wood feed from bin.

- I1. Turn the 440 Transfer Screw Bin Vibrator switch (3) to ON. Breaker switch 26 on 220 panel should be ON. Breaker switch 26 on 220 panel should be ON.
- I2. On the control panel, set feed rate dial to 0.
- I3. Turn gate valve switch to RUN.
Turn transfer screw switch to ON.
Turn volumetric feeder switch to ON.
Turn bin vibrator switch to ON.
All indicator lights for above should be ON.
- I4. Adjust feed rate with dial until tachometer reading shows the desired speed.

ACTIVITY J: Shut down of wood feed.

- J1. Turn feed rate dial to 0.
- J2. Turn control panel switches as follows:
Bin vibrator OFF.
Volumetric feeder OFF.
Transfer screw OFF.
Gate Valve LOAD.
- J3. Turn OFF screw and vibrator switch (3) on 440 panel.

ACTIVITY K: Starting recycle compressor.

- K1. Make sure preceding operating instructions have been followed and all units in the system are operating satisfactorily. Check scrubber outlet temperature to be sure it is less than 300⁰F. Drain demister. Valves V23 and V20 to compressor should be open.
- K2. Turn recycle compressor load switch on control panel to OFF. Turn 440 panel recycle compressor switch to ON.
- K3. Open cooling water valve to compressor in compressor building. Check to be sure water is flowing.
- K4. Push START button on compressor switch box at compressor.
- K5. On control panel turn recycle compressor load switch ON.

ACTIVITY L: Shutting down recycle compressor.

- L1. On control panel turn recycle compressor load switch to OFF.
- L2. Push STOP button on compressor switch box at compressor and turn OFF cooling water.
- L3. Turn 440 panel recycle compressor switch OFF.

ACTIVITY M: Start up procedure for flare.

- M1. Turn on switch No.9 on 220 panel located in the control building.
- M2. Turn on breaker switch numbered 11, 12 & 13 on 220 panel and start flare fan by turning the switch mounted on the flare fan to ON.
- M3. Open valve No's V46, V47, & V48 to supply gas to flare burner.
- M4. Wait for yellow light to go off on the flare control unit inside compressor building. This indicates that system has been purged and it is OK to ignite.

- M5. Turn OFF/RUN/Ignition switch located on flare control unit to ignition. Check for red light to come on.
- M6. If red light does not come on, it means that the pilot light did not ignite. Stop, recheck, and repeat steps M4 and M5.
- M7. When red light comes on, turn OFF/RUN/Ignition switch to RUN.

ACTIVITY N: Shut-off procedure for flare.

- N1. Turn OFF/RUN/Ignition switch on flare control unit inside compressor building to OFF.
- N2. Shut off valve No's. V46, V47 & V48 to shut off gas.
- N3. Let flare fan run for awhile until stack cools off.
- N4. If no longer needed turn OFF breaker switches 9, 11, 12, 13 on the 220 panel in control room.

ACTIVITY P: Starting the electric preheater

- P1. Be sure air, gas, or steam is flowing through preheater before it is started.
- P2. Set preheater temperature control to 0.
- P3. Throw preheater switch (9) on 440 panel to ON.
- P4. Push green button on preheater panel and throw switch on panel to ON.
- P5. Adjust temperature controller (red pointer) to desired temperature. Black pointer shows exit temperature. Over-temperature setting should be at 10.

ACTIVITY Q: Shutting down electric preheater.

- Q1. Maintain air, gas, or steam flow while shutting down preheater - except for emergencies.
- Q2. Adjust outlet temperature control to 0. Throw switch on panel to OFF, if system is to be shut down.

Q3. Allow preheater outlet temperature to drop to at least 500⁰F before shutting off air, gas, or steam flow.

Q4. Throw preheater switch (9) on 440 panel to OFF.

ACTIVITY R: Starting water circulation in scrubber and cooler.

R1. If compressor is not on it should be started (Activity A).

R2. Settling tank should contain water up to about 1 inch from top of sight glass (Activity D).

R3. Throw settling tank pump switch (6) on 440 panel, scrubber pump switch (8) on 440 panel, and Fin Fan cooler switch (4) on 440 panel, to ON.

R4. Open valve V38 partially. Drain valves V42 and V40 should be closed.

R5. Start settling tank pump by switch at the pump.

R6. Slightly open valve. V37 to Fin Fan cooler.

R7. Start scrubber pump by switch at the pump. Check operation of level control system so that control valve CV39 keeps the scrubber water level below the gas inlet line at the bottom of the sight glass.

R8. If temperature is above freezing, start fan on fin fan cooler by throwing switch below cooler.

R9. Adjust flows with V37 and V38 so that scrubber temperature is between 100⁰F and 150⁰F when reactor is operating. Fan may be stopped if water is too cold.

ACTIVITY S: Stopping scrubber circulation.

S1. Close valve V37, stop settling tank pump with switch at pump. Stop scrubber pump with switch at pump. Stop fan on fin fan cooler with switch below cooler.

S2. If unit is to be down more than an hour and the water is dark colored, the tanks should be partly drained while warm (Activity E), to remove heavy tar.

S3. If stopping operations, throw 440 panel switches for settling tank pump (6), scrubber pump (8), and fin fan cooler (4) to OFF.

OPERATION FOR PHASE I RUNS

OPERATION I: Start-up operations (in the air-blown mode). This operation is designed to start-up with a relatively highly oxidized and low BTU gas.

- O-I-1. Fill the feed bin to the desired level using procedure for Activity C.
- O-I-2. Record the date, time, and purpose of the run in the log book. Sample the feed material for moisture analysis, record in the log book the type of feed and moisture content.
- O-I-3. Fill the settling tank with water using Activity D procedure.
- O-I-4. If compressor is not running, start-up compressor by Activity A procedure.
- O-I-5. Open valves V1, V2, V4, V6, CV21. Valves V3, V13, V25, V23, V31, and V19 should all be closed. Adjust the air flow to electric preheater to about 400 LB/HR using Activity H.
- O-I-6. Start-up either reactor burner preheater by Activity F or the electric preheater by Activity P or both.
- O-I-7. Allow the air temperature entering the reactor to rise to over 600⁰F. Then start scrubber water circulation by Activity R.
- O-I-8. Open the valve V28 to bin pressure control valve CV27. Make sure air pressure to bin does not go above 10 psi. Shut off if necessary. Start the wood feed by Activity I, and adjust the feed rate to about 200 LB/HR.

O-I-9. Allow reactor to heat up to about the desired run temperature.

OPERATION II: Normal operations in the air-blown mode, Phase I.

O-II-1. Set air flow, feed flow, and electric preheater to desired rates (Activities H, I and P). If it is on, shut down the reactor burner preheater (Activity G).

O-II-2. During the following operations, the EMERGENCY PROCEDURES are shut off air flow, shut off electric preheater, shut off wood feed (see Activities H, Q, and J). The emergency procedures should be carried out in case of fire, explosion, rupture of equipment, or any dangerous disruption of operations. They should also be carried out IF THE WOOD FEED is STOPPED or IF ANY TEMPERATURES ARE RAPIDLY RISING. These procedures reduce the possibility of an explosive mixture, slump the bed and reduce danger to equipment.

O-II-3. Allow at least 30 minutes for reactor to approach steady state (1 hour is preferable). During this period read and record in the log book reactor temperatures, scrubber water temperatures, air flow and feed rates, at least once each 15 minute period, according to the form of the data sheet. At least once every $\frac{1}{2}$ hour close valve above char drum (V50) and remove char to a container. Close the char drum, and open valve V50. Close the char container.

O-II-4. As steady state is approached take all the necessary samples and analyze the product gas. At the same time as the gas sample is taken record all data needed on the data sheet.

O-II-5. If steady - state is uncertain due to interruptions or other reasons repeat sampling and data taking after an additional $\frac{1}{2}$ hour operation.

O-II-6. When run is completed. Shut off electric preheater (Activity Q). Reduce wood feed to 200 LB/HR (Activity I). Reduce air to 400 LB/HR (Activity H). Run for 10 minutes with this low BTU gas production. Then shut down wood feed (Activity J).

OPERATION III: Shut-down in the air blown mode.

O-III-1. When the electric preheater has cooled down to 500⁰F, the air flow should be set to 0 flow. Close valve V28 to bin.

O-III-2. Shut-down the scrubber circulation (Activity S), and drain the settling tank and scrubber system (Activity E).

O-III-3. Shut down the compressor (Activity B).

O-III-4. Check to make sure all 440 panel and 220 panel switches not being used are OFF.

OPERATION IV: Normal operation in the recycle mode.

O-IV-E. PHASE II

Prior to step O-IV-10 and after step O-IV-14, the system will produce highly oxidized low BTU gas.

EMERGENCY PROCEDURES up to step O-IV-10 are to shut down wood feed using Activity J. After an emergency shut down of wood feed, repeat from O-IV-1 or shut down by setting preheater to 0 and going to step O-IV-15.

O-IV-1. Start up in air-blown mode, Operation I. Read the orifice $\emptyset$ 1 pressure drop, which should correspond to 400 LB/HR.

- O-IV-2. Set electric preheater temperature control to 0.
- O-IV-3. Open valves V23 and V20 to recycle compressor, and open valve V15 on recycle line.
- O-IV-4. Open valve V5 to put air in bottom of reactor. CV9 should be open.
- O-IV-5. When ready to start recycle, check scrubber for proper operation at about 150⁰F, start recycle compressor using Activity K. When compressor is running and loaded, proceed immediately to O-IV-6.
- O-IV-6. First, close valve V6 to shut off air to electrical preheater and THEN, open valve V13 to put recycle gas into electrical preheater.
- O-IV-7. Adjust air flow with valves V4, V5, and/or V30 to maintain the orifice reading in O-IV-1.
- O-IV-8. Adjust the recycle gas flow to the desired flow rate using Activity H. Use recycle orifice pressure drop to determine adjustment.
- O-IV-9. Reset electric preheater temperature to desired recycle temperature.
- O-IV-10. EMERGENCY PROCEDURES for steps O-IV-11 through O-IV-14 are shut off air, recycle compressor, preheater, and wood feed (see Activities H, L, Q, J) in case of fire, explosion, dangerous conditions or if wood feed stops. If scrubber outlet temperature or recycle compressor inlet temperature rises above 500⁰F, turn recycle compressor to NO LOAD, close valve V13, open valve V6, close valve, V5. When conditions are corrected, return to step O-IV-4. Or, to shut down, set wood feed at

200 LB/HR, air at 400 LB/HR, preheater temperature to 0, run 10 minutes, and proceed to step O-IV-15.

O-IV-11. Set all feed and flow rates and temperatures at desired values for the run. Allow 30 minutes (1 hour is better) for steady state, take samples, record data - especially recycle flow, air flow, temperatures, gas samples, and feed rates.

O-IV-12. Check and remove char every $\frac{1}{2}$ hour by closing valve V50, opening char drum, and removing char to a container. Char drum and container should then be closed. Open valve V50. Once per hour drain demister.

O-IV-13. To run other conditions, repeat steps O-IV-11 and O-IV-12.

O-IV-14. Set wood feed to 200 LB/HR. Air should flow into bottom of reactor through valve V5 at 400 LB/HR. Run for about 10 minutes. Set preheater temperature control to 0.

O-IV-15. Shut off wood feed (Activity J). Set gate valve to load.

O-IV-16. Shut down recycle compressor (Activity L). Close valve V13, open valve V6, close valve V5. Drain demister and close valves V23 and V20.

O-IV-17. Shut down in air-blown mode by Operation III.

EQUIPMENT LISTING

<u>NAME OF EQUIPMENT</u>	<u>MATERIAL HANDLED</u>	<u>NOTES</u>
1) Fid Blower	Wood Particles & Air	===== Main Gas Flow
2) Feed Cyclone	Wood Particles & Air	----- Secondary Gas Flow
3) Pneumatic Binslide Valve	Wood Particles & Air	----- Liquid & Solid Flow
4) Pressurized Bin	Wood Particles, Air or Wood Gas	
5) Volumetric Screw	Wood Particles	
6) Transfer Screw	Wood Particles	
7) Reactor Slide	Wood Particles	
8) Reactor	Wood, Air, Wood Gas, Sand	
9) Char Cyclone	Wood Gas, Char, Wood Tar	
10) Scrubber	Water, Wood Tar, Char, Wood Gas	
11) Electric Pre-heater	Air, Wood Gas, Steam	
12) Tar Separator	Wood Gas, Wood Tar	
13) Settling Tank	Water, Wood Tar, Char	
14) Fin-Fan Cooler	Water, Wood Tar, Char	
15) Recycle Surge Tank	Wood Gas	
16) Recycle Compressor	Wood Gas	
17) Reactor Burner	Propane, Air	
18) Air Filter	Air	
19) Air Surge Tank	Air	
20) Air Compressor	Air	
21) Boiler	Steam, Water	
22) Boiler Water Tank	Water	
23) Recycle Fan	Wood Gas	
24) Flare	Wood Gas, Air, Propane	
5) CO ₂ Stripper	Wood Gas, Caustic Solutions	
26) Caustic Tank	Caustic (NaOH), Solution (10%)	
27) Charcoal Beds	Charcoal, Water, Wood Tar	

ORIFICE #ORIFICE NAME

Ø 1	Air Flow Total
Ø 2	Air Or Gas To Burner (Reactor)
Ø 3	Air Or Gas To Bin
Ø 4	Gas To Compressor
Ø 5	Steam To Preheater (Perhaps should be to burner)
Ø 6	Total Recycle Gas To Reactor
Ø 7	Recycle Gas Can To Reactor
Ø 8	Recycle Gas To CO ₂ Stripper

VALVE I.D. NO.	SIZE	VALVE OPERATOR	VALVE TYPE	MFG. NAME AND MODEL	VALVE NAME/FUNCTION
V1	2"	Manual	Gate	NIBCO/SCOTT,T133	Air Compressor Discharge
V2	2"	Manual	Gate	NIBCO/SCOTT,T133	Air Inlet To Air Filter
V3	2"	Manual	Gate	NIBCO/SCOTT,T133	Air Filter By Pass
V4	2"	Manual	Gate	NIBCO/SCOTT,T133	Air Filter Discharge
V5	2"	Manual	Gate	NIBCO/SCOTT,T-637-N	Air To Bin/Reactor Burner
V6	2"	Manual	Gate	NIBCO/SCOTT,T-637-N	Air To Preheater
V7	2"	Back Flow	Check	NIBCO/SCOTT,F-918-N	Air To Bin/React.Burner Check
V8	2"	Back Flow	Check	NIBCO/SCOTT,F-918-N	Air To Preheater Check
CV9	2"		Control	Rockwell, CF-461	Air To React. Burner Control
CV10	2"		Control	Fisher, 667-ED	Air To Preheater Control
V11	2"	Manual	Gate	NIBCO/SCOTT,T-637-N	Recycle Gas To Bin/React. Burner
V12	2"	Back Flow	Check	NIBCO/SCOTT,F-918-N	Recycle Gas To Bin/React. Burner Check
V13	2"	Manual	Gate	NIBCO/SCOTT,T-637-N	Recycle Gas To Preheater
V14	2"	Back Flow	Check	NIBCO/SCOTT,F-918-N	Recycle Gas To Preheater Check
V15	2"	Manual	Gate	NIBCO/SCOTT,T-637-N	Recycle Gas To Preheater, Bin & React.
V16	2"	Manual	Ball	Smith Co.	Burner Isolation & Direct to CO ₂ Stripper
V17	2"	Manual	Ball	Smith Co.	Recycle Gas From CO ₂ Stripper To Reactor
V18	4"	Manual	Ball	Smith Co.	Recycle Gas To CO ₂ Stripper
V19	2"	Manual	Ball	Smith Co.	Recycle Gas From CO ₂ Stripper To Flare
V20	2"	Manual	Ball	Smith Co.	Or Recycle Compressor
CV21	4"		Control	Annin - 14854	Recycle Gas From CO ₂ Stripper To Flare
V22	4"	Back Flow	Check		Recycle Gas From CO ₂ Stripper To
V23			Gate		Recycle Compressor
V24	2"		Safety		Gas From Tar Separator To Flare Control
V25	2"	Manual	Gate	NIBCO/SCOTT,T-637-N	Gas From Tar Separator To Flare Check
V26	2"	Back Flow	Check	NIBCO/SCOTT,F-918-N	Gas From Tar Separator To Recycle
CV27	1"		Control	Fisher, F-657-A	Compressor
V28	2"	Back Flow	Check	NIBCO/SCOTT,F-918-N	Recycle Surge Tank Relief To Air
V29					Steam Supply To Preheater
V30					Steam Supply To Preheater Check
V31					Air Or Recycle Gas To Bin Control
V32					Air Or Recycle Gas To Bin Check
V33					Recycle Fan To Reactor
V34					Air To Reactor Jet
V35					Low Pressure Gas To CO ₂ Stripper
V36					Recycle Gas To CO ₂ Stripper
V37	3"	Manual	Gate	Lunkenheimer	Caustic Tank To CO ₂ Stripper
V38	2"	Manual	Gate	Fig. 2127	Caustic Recirculation
CV39	2"		Control	T-133,NIBCO/SCOTT	Recycle Gas From CO ₂ Stripper To Reactor
V40	3"	Manual		513 RGS	Water Inlet To Boiler
V41	2"	Manual	Gate		Water from settling tank to cooler
V42	3"	Manual	Gate		Water recirculation in settling tank
V43	3/4"	Manual	Globe		Water control to settling tank
V44	1 1/2"	Manual	Gate		from scrubber
V45	1"	Manual	Gate		Scrubber drain valve
V46	1 1/2"	Manual	Gate		Fin fan cooler drain
V47	2"	Manual	Gate		Settling tank drain
V48	2"	Manual	Gate		Air compressor bleed valve
V49	3/4"	Manual	Gate		City water supply to settling tank
V50					Recycle surge tank drain
					Propane gas to flare burner
					Propane gas to flare burner
					Propane gas to flare burner
					Propane gas to reactor burner
					Cyclone separator isolation valve

MAINTENANCE PROCEDURES

M-I ENTRY INTO CONFINED SPACES

- M-I-1. A confined space will be considered to be any tank or vessel into which a man can enter plus any building or area with restricted ventilation into which toxic or flammable gases or volatile hazardous liquids have entered.
- M-I-2. Entry into confined spaces as considered above should be undertaken only when activities are necessary which require the entry and work of an employee. If the work can be performed from outside the confined space (by poles, pipes, hoses, hooks, ropes, etc.) or alternative methods are possible (such as removing a flange and attached equipment) the work should be carried out without entry into the confined space. An entry permit form and carbon copy should be prepared for use in the following steps. If possible, a member of Safety and Risk Management Office should be consulted prior to entry and be present at entry.
- M-I-3. Prior to entry a plan of work should be outlined in writing to permit a minimum time of entry with the safest possible conditions. A flow diagram should be consulted to determine all possible inlets or sources of hazardous materials, and this should be confirmed by inspection of the actual equipment and piping. All such sources and hazardous mechanical components should be listed.
- M-I-4. All piping sources of hazardous materials listed above should be closed off by disconnection, valves, or blank

or blind flanges. All potential rotating or moving parts hazards should be shut down. All the above valves should be locked closed and tagged - DO NOT OPEN -, and all switches for motors for moving parts should be locked in the OFF position and tagged - DO NOT OPERATE. The only available keys to these locks should be in the possession of the person to enter the confined space. The appropriate spaces on the permit should be initialed.

M-I-5. The confined space should be opened to the atmosphere and air should be forced into, and as much as possible through, the confined space, either through piping or through a hose inserted into the space. All portions of the space should be ventillated to the extent possible. The air compressor can be used as a source of air for ventillation (see Activity A).

M-I-6. The exhaust gas from the confined space should be analyzed for carbon monoxide, oxygen, and flammability until the concentration of carbon monoxide is less than 100 PPM, the oxygen is between 18% and 22%, and the gas contains less than 10% of the lower flammable limit of combustibles. Such readings should be consistent over a 15 minute period. Purging with air should be continued.

M-I-7. Any content of solids or liquid should be stirred up and step M-I-6 should be repeated. The purging step on the permit should be filled in and initialed by the person testing.

M-I-8. The following equipment should be assembled for use near the point of entry, assuming only one person is to enter

for work. All the following equipment should be available at the site, with the exception as noted under respirators.

2 Safety harnesses (wrist type for top entry).

2 Ropes sufficient to reach from outside to all parts of the space.

2 Respirators connected to clean air supply (from Fire Dept., not from GROW compressor) with portable tanks for emergency exit. At least 1 respirator should be kept at the site. The 2nd respirator should be borrowed from another unit of the university until a 2nd GROW respirator is obtained.

1 Ladder, if a top entry.

1 Block and tackle with suitable attachment capability, if top entry.

3 Hard hats.

3 Sets rubber gloves.

For each additional person working inside there should be an additional harness, rope, and respirator, so that 1 set will be outside for rescue purposes. Equipment should be initialed on permit by person responsible for work.

M-I-9. The person('s) doing the work should initial permit. A standby observer and communicator should be designated and should initial permit. An alternate available standby should be designated and should initial permit. All of the above should have been trained and medically examined for vessel entry work.

M-I-10. An authorized responsible person should sign the permit.

- M-I-11. Block and tackle should be attached to a suitable support, and ladder should be inserted, if a top entry. Respirator should be put on. Safety harness should be put on. Ropes should be attached and the other end fastened on the outside. Hard hat and gloves should be put on.
- M-I-12. Only after steps 10 and 11, entry can now be made and work performed using fixed clean air supply, not portable tank. Use portable tank only in an emergency to exit, when fixed air supply is cut off or broken. All activities should be observed from outside by observer - communicator standby.
- M-I-14. In case of problems the worker should be pulled out of the confined space by ropes by the observer and/or alternate, with use of block and tackle, if necessary.
- M-I-15. Only in case of failure of the rope or harness, or jamming should the observer preferably or alternate, but not both, put on respirator, harness, rope, hard hat, gloves and enter vessel to rescue worker. Attention should be given to prevent any problems noted in first entry.
- M-I-16. On completion of entry all equipment should be checked and readied for future use. If any illness symptoms exist such as headache, a doctor should be consulted.
- M-I-17. The original of the entry permit should be kept at the site. The carbon copy should be machine copied with one copy to Safety & Risk Management and one copy to the Director.

M-II GENERAL MAINTENANCE PROCEDURES

- M-II-1. Drugs and alcohol are prohibited for all employees.
- M-II-2. All employees must be familiar with the National Safety

Council's Accident Prevention Manual for Industrial Settings (available in the control room). Hard hats will be worn in the process area (concrete pad).

- M-II-3. No horseplay of any kind is permitted in the project area.
- M-II-4. All work places must have adequate illumination.
- M-II-5. Proper housekeeping should be practiced after each job or at the end of each work day. All areas must be swept and grease spots cleaned up.
- M-II-6. Every section should be properly ventilated and if necessary exhaust fans or blowers should be used to remove any toxic or flammable vapors.
- M-II-7. Fire extinguishing apparatus for all kinds of fire (electric, solid, gaseous) should be in working condition at all times.
- M-II-8. Fire department telephone numbers are placed in prominent places for acquiring help in case of emergency.
- M-II-9. Appropriate dress should be worn by all.
- M-II-10. Attention to all possible hazards should be maintained at all times.
- M-II-11. When tools are not in use, they must be returned to their proper storage space.

M-III HOT WORK PROCEDURES

- M-III-1. Hot work will be considered to be work on installed equipment where heating is required or any work involving installed equipment while operating.
- M-III-2. Prior to beginning hot work maintenance, a flow diagram should be consulted to determine all potential hazards.

The actual equipment should be inspected to verify potential hazards. A plan of work should be outlined and hazards and procedures to be followed should be noted on a hot work permit. The hot work permit and a carbon copy should be prepared.

M-III-3. Any sources of hazardous material should be blocked off and locks and tags applied to any valves or switches. Motor switches for power equipment should be locked OFF and tagged. Necessary purging of lines should be carried out and analysis of hazardous gases made. Each of the necessary steps should be initialed when completed.

M-III-4. Equipment and tools including safety equipment should be assembled for use.

M-III-5. An authorized responsible person should review the permit and sign.

M-III-6. The work may then be carried out. If deviations from the plan are necessary a revised permit should be initialed by the responsible person. The original permit should be kept at the sight and the copy sent to the Director.

M-IV SAFETY PROCEDURES FOR REPAIR OF EQUIPMENT

M-IV-1. All equipment requiring repair should be shut down prior to repair work.

M-IV-2. Suitable signs should be posted and not removed until repairs have been completed.

M-IV-3. Equipment suspended in slings or supported by hoists or jacks for repairs should be blocked or cribbed before men are permitted to work underneath it.

M-IV-4. Before repairs on electrically powered equipment are begun, the switches for the equipment on the 440 or 220 panels should be turned OFF, and the switch or the panel door should be locked and tagged. Test the operating switch to be sure unit will not start. The key to the switch lock should be retained by the repairman. If there is more than one repairman on a circuit each should lock the main switch with his lock to which only he has the key. Switch boxes should have this provision.

M-IV-5. Equipment should be placed on an adequate foundation and properly secured.

M-V SAFETY PROCEDURES FOR MATERIALS HANDLING, MOVING AND LIFTING EQUIPMENT

M-V-1. Inspect materials for splinters, jagged edges, burrs, rough or slippery surfaces.

M-V-2. Get a firm grip on the object before lifting or moving.

M-V-3. Keep fingers away from pinch points, especially when sitting down materials.

M-V-4. When handling lumber, pipe or other long objects keep hands away from the ends to prevent them from being pinched.

M-V-5. Wipe off greasy, wet slippery or dirty objects before trying to handle them.

M-V-6. Keep hands free of oil and grease, use gloves, hand leathers or other hand protector for handling when not working around moving machinery.

M-V-7. The speed of vehicles moving material should be limited so that it will permit stopping well within the clear distance ahead. Wet or slippery floors require a slower than ordinary speed.

M-V-8. Operators should avoid making quick starts, jerky stops or quick turns at excessive speed. Operators should use extreme caution when operating on turns, ramps, grades, rough ground, or inclines. Operator should keep his feet and legs inside the guard area of his truck.

M-V-9. The operator should leave his truck unattended only after he has put the controls in neutral, shut off the power, set the brakes, remove the key or pull the connector plug and place the load-engaging means in a lowered and inoperative position. OSHA defines an "unattended truck" as one where the operator is more than 25 feet from it or cannot see it. If it is necessary to leave the truck on an incline, it should be blocked as an added precaution.

M-V-10. Avoiding pedestrians is the truck operators responsibility. When approaching pedestrians, he should sound the horn to notify them of his presence and should stop if necessary until it is safe to proceed.

M-V-11. Loads should not be raised or lowered enroute, and should be carried as low as possible, but high enough not to strike any raised or uneven surface.

M-V-12. If a load is bulky, and is obstructing the operators' view, the operator should drive the truck backward so that he can see where he is going.

M-V-13. Lift trucks have a rated capacity. Every operator should be familiar with the maximum load limits of the truck he operates and be required to observe them.

M-V-14. Operator should never under any circumstances attempt to operate a truck with an overload that removes enough weight from any wheel for it to clear the ground.

M-V-15. Personnel should not ride on the bucket or forks of a lift device.

M-VI WORK IN HIGH PLACES

M-VI-1. Wear a safety belt or harness and non-slip type of shoes.

M-VI-2. In climbing and descending ladders, move so that weight is always supported firmly on 1 foot and so that 1 hand always has a firm grasp. Be especially careful in wet weather and freezing weather.

M-VI-3. Take all necessary precautions to climb safely to the work area and move tools to the work area. If necessary raise tools with ropes.

M-VI-4. Attach safety belt or harness to a nearby solidly fastened rail, hook, pipe, etc. with a small amount of slack, by use of a previously tested rope or line.

M-VI-5. Any heavy tools to be manipulated should be tied to framework or equipment with enough rope to allow manipulation.

M-VI-6. Perform work without using safety rope as a support or to apply force. If it is necessary to use a line for suspension or support an additional line with some slack should serve as a safety line.

M-VII WELDING AND CUTTING PROCEDURES

M-VII-1. Welding and cutting is to be done in well ventilated area to minimize toxic gases in the air.

M-VII-2. Goggles, helmets, and shields that give maximum eye protection for each welding and cutting process must be worn by operators, welders, and their helpers.

M-VII-3. Flame-resistant gauntlet gloves must be used.

M-VII-4. Low-cut shoes with l00se-fitting tops must not be used because of the spark hazard.

M-VII-5. Hard hats or other protection against sharp or heavy falling objects must be used.

M-VII-6. Never change electrodes with bare hands or wet gloves, or when standing on wet floors or grounded surfaces.

M-VII-7. Never coil or loop welding cable around the body.

M-VII-8. In confined places, cover or arrange cables to prevent contact with falling sparks.

M-VII-9. If working on installed equipment see "Hot Work" procedure, M-III.

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HOT WORK PERMIT

DATE _____

LOCATION OF WORK:

TYPE OF WORK:

PLAN OF WORK:

PERSONNEL ASSIGNED: _____

ESTIMATED TIME OF PERFORMANCE FROM _____ AM TO _____ AM
PM PM

CONTENTS OF EQUIPMENT TO BE WORKED ON: _____

HAZARDS TOXIC ☐ , FLAMMABLE ☐ , CORROSIVE ☐ , HOT EQUIPMENT ☐ ,
PRESSURE ☐ , MOVING PARTS ☐ , OTHER _____.

SAFETY PRECAUTIONS: (initial when completed)

Initials

SHUTDOWN	REQUIRED	☐	_____
	NOT REQUIRED	☐	_____

COOLED DOWN	REQUIRED	☐	_____
	NOT NEEDED	☐	_____

ISOLATION PROCEDURE	REQUIRED	☐	_____
BY _____	NOT REQUIRED	☐	_____

PURGED WITH _____	REQUIRED	☐	_____
	NOT REQUIRED	☐	_____

CLEANED	REQUIRED	☐	_____
WITH _____	NOT REQUIRED	☐	_____

ANALYSIS IF REQUIRED CO O₂ FLAMMABILITY _____.

INITIALS

SAFETY EQUIPMENT REQUIRED AND ASSEMBLED

Initials

WORK APPROVED

Authorized Responsible Person

VESSEL OR CONFINED SPACE ENTRY PERMIT

REFER TO FLOW DIAGRAM TO INDICATE

EQUIPMENT, VALVES

DATE _____

PLANNING

EQUIPMENT: NAME _____ NO. _____

ENTRY TO BE AT _____

WORK REQUIRED:

PREPARATION

MATERIALS PRESENT IN SPACE: _____

A. PURGING

Space purged with air through _____ from _____^{AM}_{PM} to _____^{AM}_{PM} by _____^(initials).

Consecutive Gas Analyses From Space

					Initials Analyst
Time	_____	_____	_____	_____	
CO in ppm	_____	_____	_____	_____	
Time	_____	_____	_____	_____	
O ₂ in %	_____	_____	_____	_____	
Time	_____	_____	_____	_____	
Flammability	_____	_____	_____	_____	

B. Sources of Hazardous Materials

Potential
Hazardous
Material

How
Isolated

Initial When
Locked Out

1)	_____	_____	_____	_____
2)	_____	_____	_____	_____
3)	_____	_____	_____	_____
4)	_____	_____	_____	_____
5)	_____	_____	_____	_____
6)	_____	_____	_____	_____

	<u>Mechanical or Electrical Hazard</u>	<u>Shut Off By Switch</u>	<u>Initial When Locked Out</u>
1)	_____	_____	_____
2)	_____	_____	_____
3)	_____	_____	_____

C. EQUIPMENT AVAILABLE

- 1) 2 Safety Harnesses
(wrist type if top entry)
- 2) 2 Ropes
- 3) 2 Respirators
- 4) Ladder (if top entry)
- 5) Block & tackle (if top entry)
- 6) Hard Hats
- 7) Rubber Gloves
- 8) Tools _____

Add one for
each additional
worker inside
over one.

Check

Initials of Supervisor of
work. _____

D. PERSONNEL INVOLVED

	<u>Name</u>	<u>Trained?</u>	<u>Initials</u>
Worker(s) to enter space	_____	_____	_____
Standby observer-communicator	_____	_____	_____
Alternate Standby	_____	_____	_____
Approval to enter from _____	AM PM	to _____	AM PM.

DATE

Signature of Authorized Responsible Person _____

Notes on Entry

Time in _____

<u>Time</u>	<u>Gas Analysis</u>	<u>Comments</u>
_____	_____	_____
_____	_____	_____
_____	_____	_____

Condition of worker on completion _____

Entry completed at _____

AM
PM

Initials person who entered _____

SCHEMATIC OF OPERATION — GROW PROJECT

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