TECHNICAL WORK PLAN NO. 49-275

The following technical program addresses the major remaining engineering activities required to develop and design a versatile thermal oxidation system for Monsanto. Specifically the Process Design Phase along with possible additional test burns are discussed.

A. PHASE II - PROCESS DESIGN

This phase of work further develops and completely defines the process concepts that were identifed in the Phase I-Process Development stage through equipment specifications, piping and instrument diagrams, and design and construction standards. The product of this effort is a "Process Design Manual" that will serve as the basis for subsequent detailed design engineering.

Hydroscience will take the lead and prime process engineering responsibility for the feed tanks, waste drum feeder, primary and secondary combustion system, flue gas conditioning and cleaning, recycle scrubbing water system, and ash removal and handling. Monsanto will take the process engineering lead for the Area 1 tank farm. A joint effort will be required for the control room and material handling building. In order to complete this phase of work in the scheduled time, a cooperative Monsanto-Hydroscience team effort will be required.

The final Phase II-Process Design Manual will contain the following:

1. A definitive project scope.
2. A definitive process description and discussion.
3. Piping and instrument diagrams showing all line sizes, valves required, piping specifications, insulation, and/or tracing requirements and instrument components.
4. Pipe line lists.
5. Complete equipment specifications and lists.
6. Instrument lists with performance specifications.
7. Electrical one-line diagram.
8. Equipment layout and plot plan.
9. General criteria for various engineering disciplines (with Monsanto CED).

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10. A review of safety and health considerations.
11. Updated capital cost estimate.
12. Updated project schedule.

In order to meet an aggressive overall schedule, some or all of the following activities will have to proceed while the Phase II process engineering program is being completed:

1. Carry out test burns to (1) simulate the firing of nitro compounds in a modified secondary combustion chamber to determine the generated NO_x and CO levels, to (2) evaluate the use of a wet electrostat on a rotary kiln incinerator system for flue gas cleaning, and to (3) determine the combustion and destruction efficiencies for a Monsanto type waste profile in a rotary kiln-secondary combustion chamber system.

2. Review and Update the Phase I-Process Development Report
The updated Phase I concept will be based upon utilizing the proposed high energy venturi gas cleaning system and thermally destroying the liquid nitro compounds in a dedicated high temperature chamber that discharges into the (main) combustion chamber.

If, after the above pilot tests are completed, a wet electrostatic flue gas cleaning system is of interest or some other concept for firing the chlorinated nitro compounds must be utilized, this will constitute an addition to the process engineering scope of work contained in this work plan.

B. TEST BURNS

1. Liquid Nitrobenzene Wastes
In response to the Monsanto incinerator construction permit application, the Illinois Environmental Protection Agency (IEPA) construction permit stipulated that incineration of the nitrochlorobenzenes will have to be carried out at 2200°F and a 2-sec retention time. The proposed Resource Conservation and Recovery combustion criteria guidelines also identify these conditions for halogenated aromatic hydrocarbons. If the existing Phase I incinerator conceptual design is utilized, an additional 8 $\bar{M}$ Btu/hr of auxiliary fuel would be required in

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the secondary combustion chamber to raise the kiln flue gases to 2200°F. This added criteria impacts upon the existing NO_x data base which was determined at a lower combustion temperature (1800°F) and based on firing the liquid nitrochlorobenzenes into the primary combustion chamber (rotary kiln).

As a result, Hydroscience and Monsanto have agreed that an alternate conceptual design should be prepared and tested in light of the newly issued incineration criteria. In this alternate concept, it is planned that the liquid nitrochlorobenzene wastes be incinerated in a dedicated reducing atmosphere and high temperature (2600°F) auxiliary unit that discharges into the head end of the main secondary combustion chamber. This design minimizes or eliminates the need for auxiliary fuel oil in order to achieve a temperature of 2200°F in the secondary chamber.

The objective of the test is to determine the combustion characteristics of liquid nitrochlorobenzenes in a high temperature reducing atmosphere by measuring NO_x concentrations, combustion efficiency, destruction efficiency, and overall burner performance in terms of stability, carbon, and carbon monoxide generation. It is proposed that this test be conducted in a two stage (reducing and oxidizing) facility at a vendor's location. This facility would allow simulation of the dedicated reducing and main combustion chambers. It is estimated that approximately 5 days elapsed time would be required to carry out the test burn and sampling program. An outline of the test is included in Appendix A.

2. Full Scale Rotary Kiln System

a. Combustion and Destruction Efficiency Tests——In order to determine combustion and destruction efficiencies as defined in the proposed Resource Conservaton and Recovery Act (RCRA) on a Monsanto type waste profile, it is recommended that a test burn be conducted in a rotary kiln incineration system. Since relatively high efficiency values have been proposed (99.9% and 99.99% for combustion and destruction efficiencies), development of this data base is important for the Monsanto incineration project. This test would be performed in a full scale system with sampling for specific compounds in the vapor phase and flue gas particulates, ash, and scrubber water discharge while liquid and solid chemical wastes are being incinerated. The form and composition of the tracer compound would be identified during the program planning stage.

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It is estimated that approximately 4 to 5 days elapsed time would be required to set up and carry out the test burn and sampling program at the incinerator site. It is anticipated that Monsanto and Hydroscience would work closely together to develop sensitive analytical standards and techniques for the tracer compound.

The results of these tests will produce data and guidelines relative to the efficiencies that can be expected in the planned Monsanto incineration system. As a result of this work the project could proceed forward with an adequate data base with respect to proposed criteria.

b. Hydro-Precipitrol Wet Electrostat Pilot Test——Due to potentially large savings in energy requirements, Monsanto has requested that the above wet electrostat be considered as an alternative to the venturi scrubber for removing flue gas particulates. A joint visit to Fluid-Ionic Systems, manufacturer of the Hydro-Precipitrol, basically indicated the unit was well constructed and no significant reason was found to indicate it would not achieve the required particulate removal efficiency. Initial problems with the unit appear to have been resolved. Since there has been minimal experience with the Hydro-Precipitrol in chemical waste incineration, a pilot test is recommended to confirm particulate removal efficiencies and to evaluate, within test constraints, the stability and sensitivity of the unit to a variety of operating conditions and situations. The results of the tests will develop particulate removal efficiency performance data and offer some opportunity to judge system durability and dependability. This data base will help to formulate a decision whether to proceed with the Hydro-Precipitrol.

It is anticipated that the test can be run at the same location and as part of the combustion and destruction efficiency tests described in 2a above, thereby resulting in improved manning efficiencies. A pilot unit is available from Fluid-Ionics and would be installed on a slip stream of the main quenched flue gas. Inlet and outlet particulate concentrations will be measured during combustion of Monsanto type liquid and solid wastes, along with analysis of the flue gases and particulates.

It is estimated that approximately 5 days elapsed time would be required to carry out the test burn and sampling program. Prior to testing, the pilot unit would have to be installed and tested at the site. An outline of the proposed two-part test burn is included in Appendix A.

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ESTIMATED COSTS AND SCHEDULE

The estimated costs and time to carry out this work plan are shown below. Because it is difficult to accurately estimate the division of effort to be expended by Monsanto and Hydroscience, ranges of cost along with the most probable costs have been established. This estimate is based on the described work plan and projected level of effort and will be dependent upon the results, conclusions, and direction as the effort proceeds.

Phase II - Process Design

Engineering Services ($170,000 -- $230,000) $200,000

Elapsed Time 28 weeks

Liquid Nitrochlorobenzene Waste Test Burn

Engineering Services ($40,000 - $80,000) $60,000*

Elapsed Time 18 weeks

Full Scale Rotary Kiln System Test Burn

1. Combustion and Destruction Efficiency Tests

Engineering Services ($40,000 - $80,000) $60,000

Elapsed Time 22 weeks

2. Hydro-Precipitrol Wet Electrostat Pilot Test

Engineering Services ($25,000 - $35,000) $30,000**

Elapsed Time 22 weeks

*This does not include rental costs for vendor pilot plant equipment.

**This does not include rental costs for the pilot unit, shipping, installation, or startup costs. It is assumed that the wet electrostat pilot test is an addition to the combustion and destruction efficiency tests. The 22 week elapsed time is the total time when both tests are carried out concurrently (total elapsed time for both tests is 22 weeks). If Monsanto wishes to conduct test 2 only and not test 1, the estimated cost is $60,000 over 22 weeks elapsed time.

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APPENDIX A

PROPOSED MONSANTO THERMAL OXIDATION TEST BURNS

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PROPOSED MONSANTO THERMAL OXIDATION TEST BURNS

I. LIQUID NITROCHLOROBENZENE WASTES

Hydroscience has conceptualized a thermal oxidation system to fire waste nitrochlorobenzene wastes in a modified secondary combustion chamber. The system complies with the proposed RCRA and IEPA requirements of thermal oxidation at 2200°F and 2 sec residence time and also minimizes the need for auxiliary fuel. Hydroscience recommends that this system be evaluated by conducting a pilot test burn at an appropriate testing facility.

A. Scope

The proposed concept is a dedicated two stage (reducing and oxidizing) thermal oxidation system for liquid nitrochlorobenzene wastes in order to control NO_x generation at the proposed elevated combustion conditions. The test burn will be designed to evaluate the feasibility of this two stage system and will be conducted in vendor pilot equipment to provide design criteria for a full scale process.

B. Operating Parameters to be Examined

1. Reduction Reaction Stage
   a. Temperature
   b. Oxygen utilization (as percent of theory)
   c. Retention time
2. Oxidation Reaction Stage
   a. Temperature
   b. Excess oxygen (as percent of theory)
   c. Retention time
   d. Destruction and combustion efficiency at each condition
   e. Generation/destruction of carbonaceous particulate

C. Analytical Requirements

1. Analysis of waste feed (liquid nitrochlorobenzene)
2. Final combustion gas analysis
   a. Nitrogen oxides (on-stream analysis)
   b. Total hydrocarbons (THC)

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c. O_2

d. CO_2

e. CO

f. Free Cl_2

g. H_2O

h. Residual nitrochlorobenzene

(1) Vapor phase

(2) Retained with particulate

i. Free carbonaceous particulate

Of particular concern and interest is NO_x generation, CO, free carbonaceous particulates, combustion, and destruction efficiencies in terms of CO and residual nitrochlorobenzene concentrations.

II. ROTARY KILN SYSTEM

A. Scope

1. Utilize a full scale rotary kiln-secondary combustion thermal oxidation system to (1) determine the combustion and destruction efficiencies at 1800°F, 2000°F, and 2200°F in the secondary combustion chamber, and to (2) provide a quenched combustion gas containing typical particulates in an inlet flue gas to a pilot wet electrostatic precipitator. Evaluation of combustion and destruction efficiencies from a full scale operating system are of interest due to the proposed RCRA combustion criteria.

2. Conduct a pilot test program on a wet electrostatic precipitator to demonstrate performance and obtain design data for a full scale unit.

B. Waste Streams to be Tested

1. Use suitable local liquid wastes containing salts and other non-phosphorus ash equivalents to provide typical particulates for pilot evaluation.
2. Use Monsanto solid wastes containing organo-phosphorus compounds to provide a P_2O_5 component in the combustion gas.

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3. Add a specific organic compound to the thermal oxidation process at a controlled rate to allow the destruction efficiency of the system to be measured.

C. Operating Parameters to Be Examined

1. Thermal Oxidation Process
   a. Temperature (1800°F, 2000°F, 2200°F)
   b. Retention time (1 sec and 2 sec in secondary combustion chamber)
   c. Specific organic compound destruction efficiency at each condition.
   d. General combustion efficiency in terms of residual CO, THC at each condition.
   e. Nitrogen oxides produced at each condition.

2. Pilot Wet Electrostatic Precipitator
   a. Particulate removal efficiency versus gas velocity
   b. Gas temperature
   c. Gas quality
   d. Hydraulic loading on collecting electrodes
   e. Water purge rate and quality

D. Analytical Requirements at Each Operating Condition

1. Thermal Oxidation Combustion Gas
   a. Gas analysis
      (1) CO_2
      (2) O_2
      (3) CO
      (4) NO_x
      (5) THC
      (6) H_2O
   b. Velocity traverse procedure to determine gas flow rates in system.
   c. Specific compound sampling and analysis (vapor phase, particulates, scrubber water discharge)

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2. Pilot Wet Electrostatic Precipitator
   a. Inlet and outlet grain loading at each condition (velocity traverse included in procedure)
   b. Gas composition at each condition
      (1) O_2
      (2) CO_2
      (3) H_2O (inlet and outlet)
   c. Particulate Analysis
      (1) Phosphorus
      (2) Carbon
      (3) Non-volatile ash

Hydroscience feels that all of the above test burns are desirable activities and recommends that they be accomplished as soon as possible.

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