START-UP AND PRE-OPERATIONAL TEST EXPERIENCE

AT THE OCONEE NUCLEAR STATION RADWASTE FACILITY

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ABSTRACT

The Oconee Radwaste Facility is a $100 million facility designed to process low-level radioactive waste generated at Oconee Nuclear Station, a three unit, 860 megawatt/unit PWR. The facility is equipped with a Liquid Waste System, a Powered Resin Recovery System, a Fluidized Bed Incinerator/Dryer Volume Reduction System, and a Polymer/Cement Solidification System. The facility is also equipped with several auxiliary systems including an Equipment Cooling System, a Breathing Air System, an Instrument Air System, and an HVAC System.

This paper discusses the start-up and pre-operational testing we have conducted. The methodology of identifying and scheduling the tests, and the objectives of the tests are discussed. Significant events which occurred during the test are identified as well as the results of the test. Also briefly discussed is the mass balance and processing rate program we will be using during the facility operation to meet the requirements of 10CFR61 and other applicable regulations.

INTRODUCTION

The Oconee Radwaste Facility is a $100 million facility designed to process liquid and solid low-level radioactive waste generated at Oconee Nuclear Station, a three unit, 860 megawatt/unit PWR. The facility is equipped with a Liquid Waste System, a Powdered Recovery System, a Fluidized Bed Incinerator/Dryer Volume Reduction System, and a Polymer/Cement Solidification System. The facility is also equipped with several auxiliary systems including an Equipment Cooling System, a Breathing Air System, an Instrument Air System, and an HVAC System.

The facility is approximately 43 meters by 61 meters and three stories tall. It contains approximately 1500 instruments, which is equivalent to half the number of instruments for one unit at Oconee Nuclear Station, 75 pumps, and approximately 2000 valves. These figures are presented to give the reader some insight into the complexity of the facility.

All the radwaste processing systems including the Equipment Cooling System are operated from a centralized control room which has three separate sets of control boards; a set of vertical control boards with full mimics, a control board with a mimic display for the *Fluidized Bed* Volume Reduction System, and a set of control boards with mimic displays for the Solidification System. The vertical control board is actually six separate panels. They are the Resin Recovery Panel, the Liquid Waste Processing Panel, the Evaporator Panel, the Liquid Waste Monitoring and Release Panel, the Concentrated Waste Collection and Resin Processing Panel, and the Equipment Cooling Panel.

All of the start-up and pre-operational tests were performed by a start-up team which consisted of a team leader, five station staff personnel, five station Radwaste technicians, two General Office, two Design Engineering, and two Construction Department staff personnel, and support personnel from the station Maintenance and Instrument & Electrical groups. Figure 1 shows the start-up organization which was used during the testing.

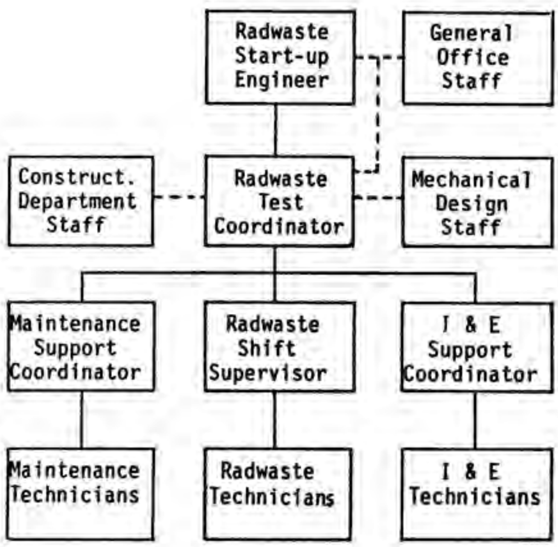

Fig. 1 Start-up Team Organization

This paper briefly discusses how we identified and scheduled the various start-up and pre-operational tests. The majority of this paper focuses upon the objectives and significant events of the major system tests that we have conducted, are currently in progress, and have planned. Also, briefly discussed is the Process/Cost Program we are developing to perform mass balance calculations in lieu of sampling to meet the requirements of 10CFR61 and other applicable regulations.

TEST IDENTIFICATION AND SCHEDULING

Identification of the required start-up testing began almost three years before the first system was completed and turned over to the Start-up Team by the Construction Department. Individuals from the Start-up team reviewed the system flow diagrams and developed test abstracts based upon their knowledge of the systems. Later, meetings were held with individuals from the Mechanical Design Engineering group to discuss the design basis and philosophy of operation for the various systems. These meetings identified other tests which would be required to demonstrate the capabilities of the systems in the facility. As information became available for the Fluidized Bed Volume Reduction System and the Solidification System, test outlines were developed and reviewed by the General Office, Design Engineering staff personnel, and the equipment vendors, Aerojet Energy Conversion Company, and Stock Equipment Company.

Once the tests were identified, the next step was to identify predecessor-successor events. This involved determining what system(s) had to be tested before another test could be performed. For example, before the Liquid Waste Processing System could be tested, the Seal Water System had to be tested and before the Seal Water System could be tested the Demineralized Water System had to be tested. As a result of this review, some tests were broken down into smaller portions. This was beneficial for several reasons; (1) it allowed us to proceed with some of the test before a complete system turned over by the Construction Department, (2) it allowed the Instrument & Electrical group to calibrate only those instruments necessary for specific test instead of whole systems at a time, and (3) it allowed us to complete the paper work for portions of systems and proceed on to other test if major problems were encountered.

A computer program, PMS-IV, developed by IBM, was used to schedule the start-up tests as well as the design and construction activities for the entire project. This program uses activity durations, predecessor/successor relationships, and resource availability/requirements to generate an optimum schedule. The start-up schedule was used to plan and coordinate test activities and project a completion date. The schedule was updated on a regular basis to reflect changes in turnover dates, start-up test completions, delays in the start of tests, and changes in resource levels. The schedule has been an effective management information tool.

TEST OBJECTIVES AND SIGNIFICANT EVENTS

Powdered Resin Recovery System

The Powdered Resin Recovery System (RR), is designed to serve as a collection and monitoring system for Secondary Condensate Polishing Demineralizer Powdex Resin used in the station. The system consists of three 113,550 liter Backwash Receiving Tanks, one 113,550 liter monitor tank, and associated pumps, filters, valves, and instruments. Powdex resin will be transferred from the station to one of the three Backwash Tanks. One tank is designated as the contaminated tank, one is designated as a tank for questionable resin, and the other is designated as the tank for noncontaminated resin. If the resin is contaminated, the excess transfer water will be decanted off, monitored and then released. the remaining resin slurry will be transferred to the Resin processing System. Noncontaminated resin will be released to the station's chemical treatment pond.

The purpose of the RR start-up test was to: (1) determine the settling time for powdex slurries, (2) determine the agitator turnover time required to achieve homogenous tank volumes, (3) test the transfer capabilities of the various pumps, (4) determine valve throttle positions for normal system operation, (5) obtain performance data for the pumps, motors and agitators, and (6) to verify the mass balance calculations relative to dry weight percent resin content in given resin slurries.

Each Backwash Receiving Tank is equipped with three sets of decant lines which exit the tanks horizontally. There was some concern that resin would migrate into the decant lines during the transfer process into the tanks. Therefore, during the start-up testing the resin accumulation in the decant lines was monitored. One of the tanks was filled with 28,900 liters of water and 17,840 cubic meters of resin (1:1, cation:anion). The agitator was then turned on and run for approximately one hour. Resin was pushed into the decant lines despite the fact that the decant line isolation valves were closed, which prevented flow in the lines. To alleviate this problem in the future, a decant line flush was added to flush the decant line back into the tanks prior to either decant or transfer operations.

Two other notable observations were the resin settling time and the dry weight percent resin content. An interface between the resin and water was observed after 15 minutes settling time and one hour of settling was sufficient to prevent resin fines carry over in the decant line. It was determined that 17,840 cubic meters of resin in 28,900 liters of water was equal to a 17% dry weight basis resin slurry. This is a significant figure because this is the optimal feed concentration for the Aerojet Fluidized Bed Incinerator.

Resin Processing System

The Resin Processing System is actually a subsystem of the Volume Reduction System and consists of an 18,925 liter Resin Batch Tank, a Resin Sluice Pump, a Resin Recirculation Pump, and associated filters, valves, and instruments. The purpose of the system is: (1) to provide a means of sluicing primary resin from the station Makeup Demineralizers, and from the in-house demineralizers in the Liquid Waste Processing System to the Resin Batch Tank, (2) to recirculate powdex resin through the Aerojet Incinerator Resin Feed Skid, and (3) to provide a method of transferring resin to the Stock Equipment Company Solidification System via the Stock Decant Tank.

The major objectives of this test were to: (1) determine the necessary pump discharge settings required to recirculate powdex resin through the Incinerator Resin Feed Pump Skid without exceeding the 1.76 kps/sq cm gauge suction pressure specified for the Resin Feed Pump by Aerojet, and (2) determine if the Resin Batch Tank, which is equipped with a floating decant arm, can be used effectively to sluice resin, recirculate resin, and transfer resin without becoming a bottleneck for resin processing. We have performed some processing rate calculations based upon expected resin quantities and they show that the tank can be used for all three uses; however verification in the field is necessary.

The Resin Recirculation Pump, which is a 360 liter/min. peristaltic hose pump, was found to be capable of recirculating a 17% dry weight basis resin slurry from the Resin Batch Tank past the Aerojet Resin Feed Skid without exceeding the specified suction pressure. The discharge pressure at the pump pulsed between .77 and 4.22 kps/sq cm but the pressure at the skid did not exceed 1.4 kps/sq cm.

Problems with the Aerojet System Test did not permit the completion of the Resin Batch Tank related tests. However, we anticipate that a spray ring may be necessary to aid in rinsing the tank after each mode of operation. Otherwise, we anticipate that it could take as much as 12 hours to rinse the tank and thereby increase the potential for bottlenecks.

Volume Reduction System

The major portion of the Volume Reduction System, VR, is the Aerojet Fluidized Bed Incinerator/Dryer System. This equipment is designed to incinerate contaminated trash, waste oil, and resin slurries, and to dry evaporator concentrates to a free-flowing anhydrous salt. The purpose of the testing was to: (1) verify the systems capability to process the various waste streams, (2) measure the mass flow rate of inputs and outputs of the system, and (3) identify any equipment which would be necessary to improve the operability and to optimize the performance of the system.

Several preliminary tests were required before the full scale system test could be performed. These tests included the Trash Shredding, Trash Transfer, and Bed Transfer Tests.

The purpose of the Trash Shredding Test was to find out if the shredder provided by Aerojet could shred simulated station trash (DAW). Several bags of simulated DAW were prepared and fed into the shredder. Table I shows the contents of a typical bag.

Table I
Typical DAW Feed Data

Contents	Weight (kg)	% Weight
Tyvek	4.5	50
Cloth Rags	2.6	30
PVC Sheeting	0.9	10
Rubber	0.5	5
Wood	0.5	5

The shredder is designed to stop reverse and restart three times when it jams or encounters an over torque condition. If the jam is not cleared after the third attempt, the shredder trips and the jam must be cleared by hand. The bags of DAW we shredded were normally handled by the shredder without exceeding the three-restart condition. However, we have decided to increase the number of allowed restarts to five so that over torque conditions, due to DAW binding between the shredder blades, can be overcome without resetting the shredder. We found that a combination of approximately 50% Tyvek and 50% rags could cause significant overloading of the shredder. However, this feed stream was not what could be called typical (if there is such a monster), because the Tyvek was fed into the shredder in sheets of material; whereas under operating circumstances the Tyvek will be feed in as disposable clothing which has been wadded up and placed in bags. This will result in a less dense feed stream to the shredder.

Next we tested the trash transfer capabilities from the Trash Storage Hoppers to the Incinerator. We did this by disconnecting the trash feed line from the trash feed nozzle and directing it to a crude but effective venturi collection device. A 208 liter drum was turned upside-down and fitted with an inlet nozzle, discharge nozzle, and a plastic bag. The venturi worked great but we had significant problems transferring trash. Once the trash was in the transport line it flowed very well. However, the augur which pulls the trash from the bottom of the hopper to the acceleration chamber above the transport line jammed. Tyvek material got wedged between the flutes of the augur and the housing which caused motor overloads. Also, trash was packed into the end of the augur housing causing blockages which would not allow trash to fall into the transport line. These problems continued into the first incinerator test and prevented the burning of satisfactory amounts of trash. The augur design will be revised so that it will be tapered slightly and a wiper finger will be added to the housing. These changes should resolve the problems we encountered. Additional testing in March 1986, will determine the effectiveness of this solution.

The Bed Transfer Test provided us the opportunity to practice our "head scratching" skills. The Fluid Bed Dryer operates with a bed material that consist of the evaporator concentrates material, and the incinerator used an Alumina/Silica bed material. The initial bed material for the Dryer can either be actual bed material from another user, or it can be sand. We decided to start up on a sodium borate bed from Commonwealth Edison's Byron Station.

The Aerojet System is designed to load the Incinerator Hopper with the Dryer bed material, transfer it to the Dryer, and then to load the incinerator bed material into the Incinerator Hopper and transfer it to the Incinerator. After we loaded the dryer bed material into the Incinerator Hopper several small problems prevented us from transferring the bed material to the Dryer. Once we resolved these minor problems and tried to transfer the bed material (2 1/2 days later) we found that the discharge of the hopper was blocked with a "brick" of bed material. Somehow moisture had been introduced to the hydroscopic bed material and it setup like concrete. We removed the plug by taking off the bottom of the Hopper and chiseling it out. The hopper bottom was reinstalled and the bed material was transferred to the Dryer. After we transferred the Dryer bed material to the Dryer the system was shutdown so we could verify the levels in the hoppers and load the Incinerator Hopper with the incinerator bed material. Everything worked fine, all the material had been transferred from the Incinerator Hopper to the Dryer and the Dryer bed dropped to the Dryer Hopper upon system shutdown. Unfortunately, moisture had accumulated in the bottom of the Dryer Hopper and the result, which we did not discover until we tried to restart the system, was another "brick". In fact, every time we had dryer bed material in the Dryer Hopper, we developed a plug at the discharge port. The formation of the plugs in the bottom of the hopper was not a problem at the prototype system in Sacramento, CA., nor do we think it was a problem at the Byron Station. We think that the moisture which caused the problem came from the Ambient Air Blower which provides all the air for the system. The air in Sacramento is considerably dryer than the 70-100% relative humidity air we have in South Carolina, and the hopper discharge valve at the Byron Station is an air tight design whereas the discharge valve on our hopper is not. Therefore, we think the uninsulated hopper bottom provides a perfect location for the ambient air, which is heated up by the blower to 135 degrees C, to condense, and since air flow is allowed up into the bottom of the hopper, sufficient moisture is introduced to the hydroscopic bed material to form "bricks". To further complicate matters, the system pressures would not allow the bed material to transfer from the Dryer Hopper to the Dryer once the plugs were removed. To overcome this problem we had to rig up a pressurization line to the Dryer Hopper so that we could get 5 kps/sq.cm. of pressure in the hopper. This additional pressure allowed the bed material to fall into the transport line.

Changes to the system will be made to allow additional pressurization of the hoppers, positive isolation of air to the hoppers unless bed material is being transferred, insulation of the hopper bottoms, and additional precautions are being taken to insure all purge air to the hoppers and their associated valves is dry.

During the actual Incinerator/Dryer Test, the trash feed and bed transfer problems continued. Three additional items of interest which occurred during the test were associated with the Secondary Condenser, the Incinerator Bed level, and the Dryer Bed level. The Secondary Condenser design includes an overflow with a seal loop and vacuum breaker. This arrangement is to prevent overfilling the Condenser sump and thereby blowing water over into the Exhaust Gas Filters. Several times during the test we found that the seal loop had blown and was providing a flow path for exhaust gas. Since the seal loop and vacuum breaker arrangement did not work adequately, we are adding level control by modulating cooling water flow to the Condenser and eliminating the seal loop. We will also add level indication which was omitted in the original design.

Another interesting occurrence was noted while running the System in the Dryer only mode. We were feeding the Dryer a 10% total dissolved solids solution of boric acid at a pH of 10.9. The system ran in this mode for approximately 40 hours during which time the bed level did not increase despite the input of approximately 1440 liters of concentrates, and a pH change in the scrub loop changed to 11.4. However, while there was no bed growth, approximately 204 kgs. of fines was collected during the same period. We did not notice bed growth in the Dryer until resins were fed to the Incinerator. The ash produced by burning resins in the Incinerator was captured by the Scrubber/Preconcentrator and fed into the Dryer along with the boric acid concentrates. Apparently, (in layman's terms), pure boric acid bed material does not like itself and refuses to grow; but once contaminates such as sulphates are introduced to the bed, its self-esteem is enhanced and it decides to grow. The other incidence concerning bed levels was observed with the Incinerator bed. For some reason, we are not sure why at this time, the Incinerator bed level decreased or at least appeared to decrease when resin slurries were introduced to the bed. Since the Incinerator bed material is inert, and this phenomenon was not observed when condensate was injected into the bed, we were extremely puzzled at this occurrence. Figure 2 is a graph which shows how the bed level changed with resin flow. We speculate that perhaps the spray pattern of resin into the bed at high flow rates causes channeling in the bed thus decreasing the differential pressure across the bed which in turn would indicate a decrease in bed level. Hopefully, further test in March 1986, will determine the validity of our assumption.

Other than the problems listed above, the system worked very well. The problems we encountered were discouraging at the time, but we learned a lot about the system and identified areas where the system can be improved. The system was shutdown on December 18, 1985, so that we could make the changes listed above plus a few others. In March 1986, the system will be restarted and tested again. At that time another full scale test will be conducted and we will collect additional mass balance data. Once this acceptance testing is complete, decontamination factor testing will be started.

Solidification System

The Solidification System is comprised of equipment provided by Stock Equipment Company and consists of a Cement Fill Station, a Cement Drumming Station, a Decant Station, a Polymer Fill Station, a Polymer Drumming Station, a remotely operated Bridge Crane, and a drum inspection Station. All this equipment with the exception of the Cement and Polymer Fill Station, and the Drum Inspection Station are operated from a control panel located in the Radwaste Control Room. Final installation and initial setup of this equipment is scheduled to be complete in February 1986; therefore, the results of functional testing is not available for this paper.

The Cement Drumming Station is designed to solidify either resin slurries or evaporator concentrates in cement. If resin slurries are to be solidified, the Decant Station is used to achieve the proper resin/ water ratio and it is also used as the final chemical adjustment tank. Testing is currently being conducted by Stock Equipment Company to determine the proper solidification chemistry necessary to comply with 10CFR61 regulations.

The Polymer Drumming Station is designed to solidify the ash and salts which are generated by the Aerojet Incinerator/Dryer System in a polymer supplied by Dow Chemical Company. The ash/salt is collected by the isolation Hopper and transferred to the Storage Hopper, both of which are provided by Stock. Material is transferred from the Storage Hopper to the Polymer Drumming Station for solidification.

Based upon feedback from Commonwealth Edison's Byron Station, we anticipate that the collection, transfer, and solidification of the ash/salt will provide the most challenge during the testing of this system. We are already in the process of adding heat tracing and ensuring that transport air is as dry as possible.

Liquid Waste Processing System

The Liquid Waste Processing System is composed of basically three major components: (1) Backflushable Filters, (2) Ion Exchange Vessels, and (3) an HPD Inc., Evaporator. These components are arranged so that liquid waste or Primary System Bleed Water can be processed through either just one of these components or through a combination of these components.

The Backflushable Filters are scheduled to be tested in February 1986. The Test will consist of loading the feedwater with a known quantity of suspended solids at a specific micron size and measuring the capture rate and run time for each filter. We will then precoat the filters with powdex resin or some other media and repeat the process. We will also be fine tuning the backflush operation to minimize the amount of water generated with each backwash.

The test associated with the Ion Exchange Vessels will consist primarily of sluicing each of the two 30 cubic foot vessels into the Resin Batch Tank. This should prove to be an interesting test since the suction piping for the sluice pump is a floating decant arm and the resins will be sluiced into the bottom of the Resin Batch Tank.

The major test of the Liquid Waste processing System was the Evaporator Test. The HPD Inc., evaporator/ crystallizer is a forced-circulation, submerged-inlet, horizontal-tube evaporator with a separate Vapor Body and Entrainment Separator.

The objectives of this functional test were to setup the proper steam flow to the evaporator, verify the proper operation of the pump out controls and establish baseline processing data. Problems with steam flow prevented the completion of this test in time to incorporate the results in this paper.

MASS BALANCE CALCULATIONS

We are in the process of developing a Radwaste Process/Cost Program which will take plant radwaste inventory data, sample analysis data, process equipment characteristics (eg., process rate, decontamination factors, operating and maintenance cost, etc), and equipment availability, and determine the most cost effective method(s) for processing the various waste streams. As part of the analysis, the Waste Trak program will also be utilized and once the operator has verified the equipment selection, feed rates, etc., the resulting mass balance information will be transferred to Waste Trak for the generation of the necessary shipping papers.

We feel that the justification for a system such as this is based upon the cost savings resulting from not having to sample waste streams such as the ash/salt produced by the VR system, and from the saving associated with effective utilization of process equipment based on feed stream characteristics.

In addition to the processing rate data we are collecting during the functional testing, we will be doing Decontamination Factor testing on the various processing streams. All this data will be used by the Process/Cost Program.

CONCLUSION

The successful completion of any task requires careful planning, scheduling, and cooperation between the involved parties. This is especially true in Pre-Operational and Start-up Testing. Hopefully this paper has been helpful in identifying the steps necessary to plan, schedule, and test radwaste equipment and has provided the reader with useful information concerning the operation and test parameters for some of the equipment we will be using.

While the majority of the formulas and data we are, and will be using are specific to Oconee Nuclear Station, some of the information may be useful to other utilities. It is difficult to determine what additional information would be most beneficial to someone else, and all of our testing was not complete at the time of the writing of this paper; therefore, we encourage any utility to contact us for specific information concerning our testing or any information contained in this paper.

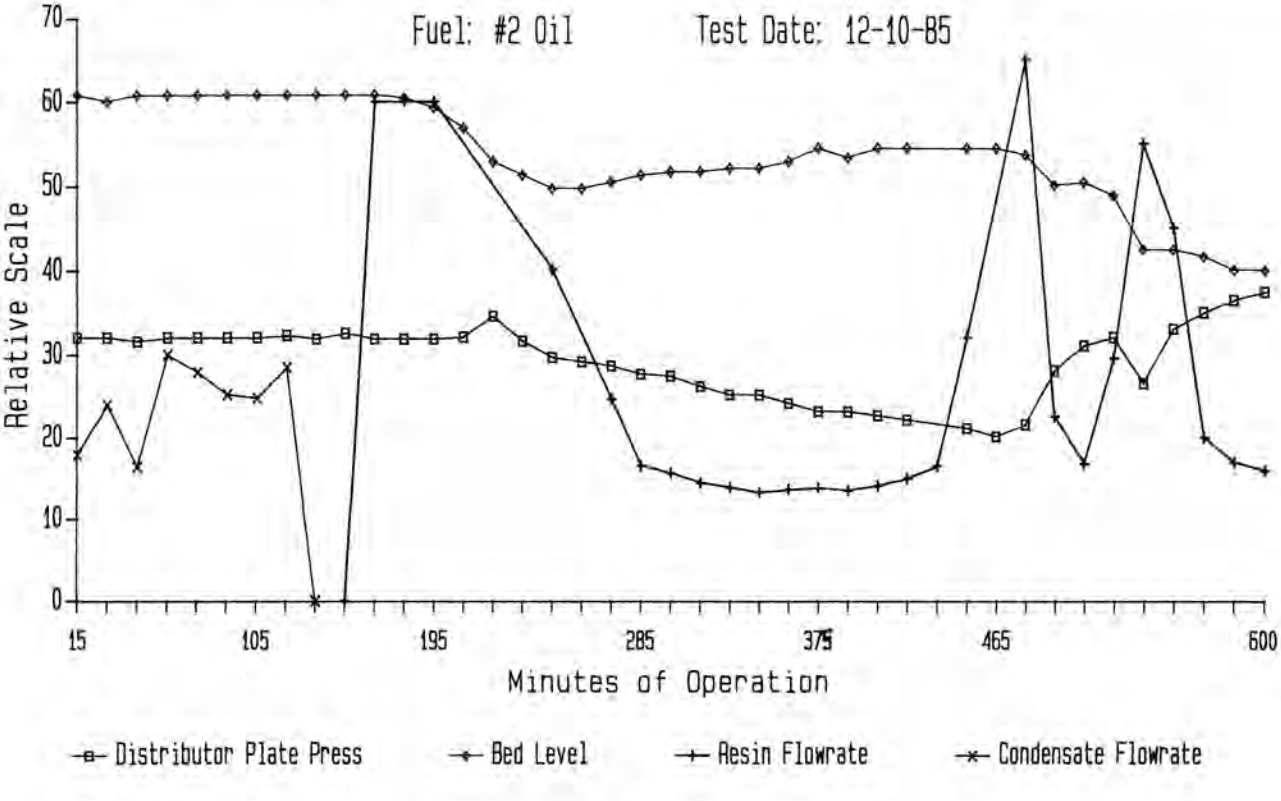

Fig. 2 Incinerator Test Data