AEROJET FLUIDIZED BED VOLUME REDUCTION SYSTEM

OPERATION AND LICENSING

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ABSTRACT

In July, 1978, the Aerojet Energy Conversion Company (AECC) (Sacramento, California) was awarded a contract by Commonwealth Edison Company (Chicago, Illinois) to deliver two fluidized bed Volume Reduction (VR) systems for processing the low-level radioactive wastes at its Byron and Braidwood Nuclear Stations. The AECC VR System for Byron is fully installed and successfully completed its Acceptance Test in September 1984. In that test three nonradioactive liquid wastes, dry wastes, and oil were processed to effect a major volume reduction of the incoming waste streams. All five waste streams were processed at rates that exceeded the specification value by at least 10%. The system processed the various waste streams for 108 hours during the Acceptance Test. The VR System also successfully passed a series of fifteen start and stop tests. As a result of the successful test operation, Commonwealth Edison Company accepted the system for operation at the Byron Station.

AECC supported the utility licensing effort by filing a Topical Report with the United States Nuclear Regulatory Commission in October, 1979. After an extensive review period concluded in November, 1984, the NRC accepted the Topical Report and its amendments as a referencing document in utility licensing applications. Meanwhile, Commonwealth Edison Company referenced this Topical Report in an Amendment to the Byron FSAR in May, 1982. After responding to plant-specific questions raised by the NRC, Commonwealth Edison Company obtained NRC approval for full-power operation of the Byron Station and to operate the AECC VR System on plant wastes on February 12, 1985. Commonwealth Edison Company also obtained a permit to operate the VR System from the state of Illinois.

The successful Acceptance Test of the AECC VR System and the NRC approval to operate the VR System on plant-generated wastes clearly demonstrates the applicability and licensability of fluidized bed volume reduction systems for processing low-level radioactive wastes.

INTRODUCTION

The Aerojet Energy Conversion Company (AECC) began research and development of a fluidized bed volume reduction system for processing a wide variety of low-level radioactive wastes in 1971. A full-scale prototype of a fluidized bed dryer for processing liquid wastes was initially operated in 1974. In 1978, a fluidized bed incinerator for processing combustible dry wastes and oil was added to the prototype facility and successfully operated the following year. This integrated full-scale fluid bed dryer/fluid bed incinerator system shares a common off-gas cleanup system for treating the exit gases from the dryer and incinerator. The full-scale system was operated for several thousand hours on a wide variety of simulated liquid waste streams, combustible dry wastes ("trash"), and oil. In July, 1978, the Aerojet Energy Conversion Company was awarded a contract based on competitive bids by Commonwealth Edison Company (Chicago, Illinois) to supply two fluidized bed Volume Reduction (VR) Systems for its Byron and Braidwood Nuclear Stations. The AECC VR System for Byron is fully installed and completed its Acceptance Test in September, 1984, processing nonradioactive liquid wastes, dry wastes, and oil, and effecting a major volume reduction of the incoming waste streams. Details of the system performance during the Acceptance Test, discussion of minor equipment problems encountered, and post-test inspection of key system components are presented below. The licensing support activity conducted by AECC consisted primarily of submitting a generic Topical Report to the U.S. NRC, which described in detail the design and operation of the system. Commonwealth Edison Company specific licensing activity consisted of filing an Amendment to the Byron Station's FSAR, referencing the Topical Report, and providing plant-specific data not contained in the generic Topical Report. Details of the successful licensing activity are also included below.

PROCESS DESCRIPTION

A simplified process flow diagram of the AECC VR System at the Byron Nuclear Station is shown in Fig. 1. The system consists of two major process vessels, the fluid bed dryer for processing liquid wastes (i.e., evaporator concentrates) and the fluid bed incinerator for processing dry active wastes and contaminated oil. These major process vessels share a common off-gas cleanup system that consists of a gas-solids separator, a primary venturi scrubber/preconcentrator, a secondary venturi scrubber/condenser, and a final filter assembly containing both HEPA filters and a charcoal adsorber. The system converts all incoming wastes to a dry salt or incinerator ash, thereby effecting a major volume reduction of the wastes that must be packaged, shipped, and buried at a shallow land burial site. The dry salt/ash produced by the system is transferred to a drumming station supplied by Stock Equipment Company where the salt/ash is immobilized in 55-gallon drums using polymer.

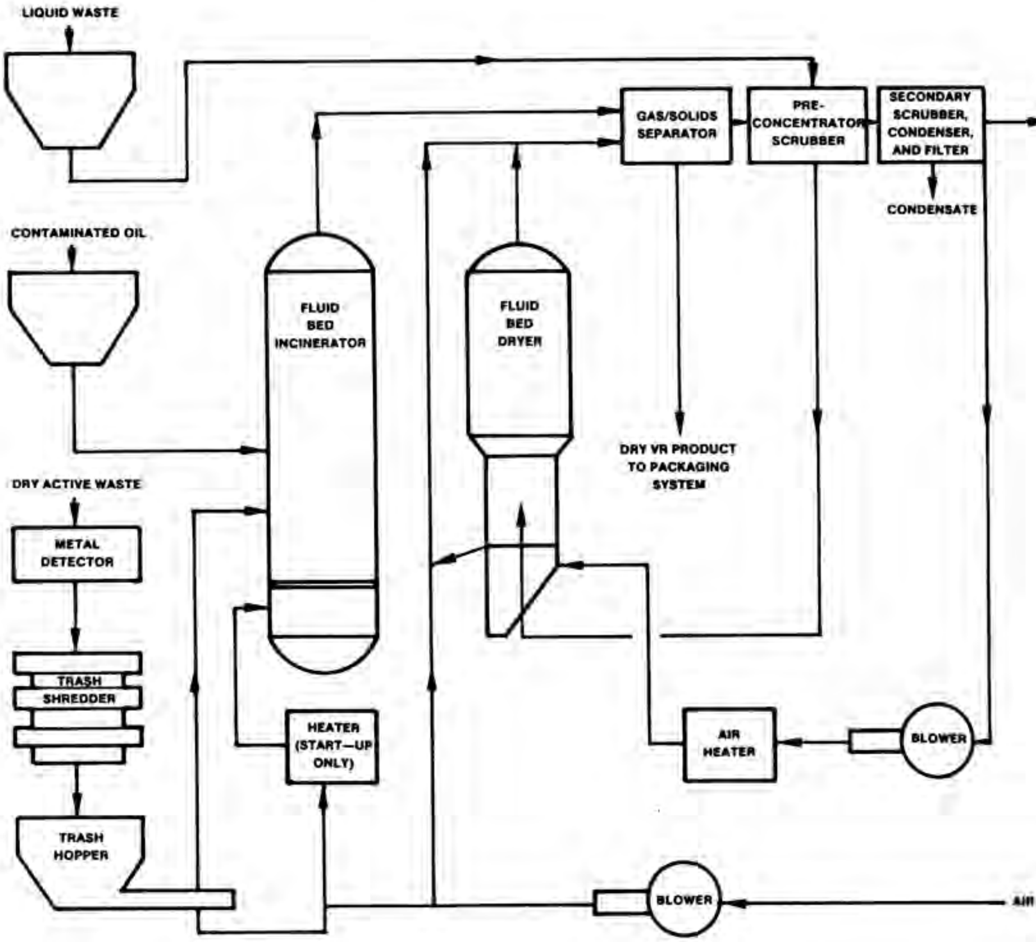

Fig. 1. Process Flow Diagram of AECC VR System at Byron Nuclear Station.

The fluid bed dryer is heated electrically via external wall heaters and an air preheater, while the fluid bed incinerator is provided with an electrical heater for preheating the air during start-up. Thereafter, the combustion of the dry active wastes and contaminated oil provides sufficient energy to maintain the desired process temperature. No auxiliary combustible fuels of any type are required or utilized in the process.

Annual waste disposal costs are reduced substantially. A typical volume reduction factor of 5-10 can be achieved on evaporator concentrates, a factor of 80 for dry active wastes, and a factor of 100 for contaminated oil. The overall plant volume reduction factor is approximately 10.

Drying of Liquid Wastes

Evaporator concentrates containing typically 7 to 25 weight % dissolved solids, after pH adjustment in the liquid waste feed tank, are pumped to the venturi scrubber/preconcentrator by the waste feed pump. The concentrates are preconcentrated there by recovering heat from the exhaust gases leaving the fluid bed dryer and fluid bed incinerator. The preconcentrated feed (25 to 28 weight % dissolved solids) is metered from the scrubber sump by the dryer feed pump to the fluid bed dryer where it is atomized with air and injected into the bed. As the liquid droplets contact the hot salt particles in the bed, the water is flash evaporated and the salt is deposited on the bed particles. Fluidizing air for the dryer is supplied by an air blower operating in a semi-closed loop circuit. The air is electrically heated by the air heater and passed upward through the dryer vessel, fluidizing the bed particles. Excess bed product is intermittently discharged from the fluidized bed, pneumatically conveyed to the gas-solids separator, and dropped to the product drumming station.

The overhead gas stream from the fluid bed dryer vessel, consisting of air, water vapor, and fine salt particles, passes through a gas/solids separator where most of the fines are removed from the gas stream and discharged to the product drumming station. The gases leaving the gas/solids separator enter the primary venturi scrubber where they are contacted with the scrubbing liquor/incoming feed mixture. The scrubber/preconcentrator performs three functions simultaneously: (1) collects the remaining particulate in the gases; (2) preconcentrates the incoming feed by recovery of the sensible heat of the gas stream; and (3) separates the gas/liquor combination into the respective process streams. The liquor stream is recirculated through the scrubber system with a portion used as concentrated feed to the fluid bed dryer.

The gas stream is then passed *through* a secondary venturi scrubber which uses condensate as the scrubbing liquor. After this second stage of scrubbing, the gas stream passes through a condenser where the water evaporated in the system is condensed. Condensate in excess of that required by the VR System is sent back to the waste evaporators for reprocessing while a portion of the gas is recycled as dryer fluidization air via the dryer blower. The remaining gaseous effluent is passed through an air heater, HEPA filter, charcoal adsorber, and a final HEPA filter before venting to the atmosphere via the auxiliary building filtered vent system.

Dried product is dropped to the Stock Equipment Company packaging system where it is packaged in 55-gallon drums using polymer binder as the immobilization agent.

When the system is to be shut down for extended periods of time or when maintenance is to be performed on the fluid bed dryer vessel, the bed material contained in the fluid bed dryer can be dropped by gravity and stored in the bed storage and transfer hopper. Prior to startup of the fluid bed dryer system, the bed material is pneumatically conveyed from the bed storage and transfer hopper to the fluid bed dryer vessel.

Incineration of DAW and Oil

Dry active wastes and contaminated oil are processed in the fluid bed incinerator. Bags of dry active wastes are passed through a metal detector to prevent large metal objects from accidentally being fed to the shredder. If large metal objects are detected, the bags are set aside either for compaction or handsorting prior to introduction into the shredder. Acceptable bags of dry waste are shredded in the three-stage shredder to nominal half-inch particles. The shredded trash is conveyed via a trash elevator to one of two trash hoppers. After a hopper is filled, locked-off, and pressurized, the shredded waste is metered out and pneumatically conveyed into the fluid bed incinerator. Contaminated oil is pumped from the oil feed tank and injected directly into the fluidized bed of the incinerator via an air atomizing nozzle. The fluidizing air, which is electrically preheated for startup, and the trash transport air are supplied by a separate air blower. The incinerator is operated with an inert bed which is controlled at a set temperature by the direct injection of condensate into the bed. The fly ash generated by the incineration process leaves the incinerator with the exhaust gas which is quenched with condensate to maintain the outlet temperature at the desired level. The exhaust is then routed to the gas-solids separator where much of the ash is removed from the gas stream and dropped to the product packaging system. The off-gas is then cleaned similar to the fluid bed dryer off-gas stream prior to discharge to the plant off-gas handling system.

ACCEPTANCE TEST

The first AECC VR System was installed and checked out at the Byron Station during 1983-84. AECC also conducted extensive training at the station in 1984. The Acceptance Test of the AECC VR System at the Byron Station was successfully performed during the period September 8-18, 1984.

Five (5) specified test feeds, consisting of three (3) liquid wastes and two (2) combustible wastes, were successfully processed in the dryer and incinerator at rates that exceeded each specification value by at least 10%. The VR System was also subjected to more than the specified ten (10) feed start and stop tests without adverse effects on the system. Those tests demonstrated the system to be installed correctly and to function properly. Some relatively minor equipment problems or deficiencies arose in the course of the test and most of them were corrected during the test. None of the minor problems or deficiencies had a significant effect on any of the primary test objectives. Inspections of key system components after the test showed the VR System to be free of any visible damage or problem that would prevent further operation.

Objectives and Requirements

The major objectives of the test were to verify that the AECC VR System was installed correctly and functioned properly under operating conditions. Successful accomplishment of those objectives was defined as meeting the following two system performance goals:

1. Processing three different specified liquid waste streams, a specified composite dry waste, and a waste oil stream at specified processing rates.

2. Satisfactory system performance during ten starts and stops of waste feed.

The compositions of the specified waste streams and the acceptable processing rates for each stream are given in Table I. System processing rates were measured while the system was operating at steady-state on each of the waste streams. System starts and stops were defined as the initiation and cessation of liquid feed to the dryer or the initiation and cessation of dry waste feed to the incinerator.

TABLE I
Waste Feed Streams

Liquid Waste Stream #1	
Composition by Weight:	20% Na_2SO_4 0.2% $(NH4)_2HPO_4$ 0.2% Undissolved Solids (1950 ppm Diatomaceous Earth and 50 ppm Fe_2O_3) In Demineralized Water
Processing Rate:	24 gph
Liquid Waste Stream #2	
Composition by Weight:	10% H_3BO_3 3% Na_2SO_4 1% Turco Plaudit 1% Turco 4306 D 1% Turco 4324 NP 500 ppm 30 wt. oil Turco Foam Go as required In Demineralized Water
Processing Rate:	15 gph
Liquid Waste Stream #3	
Composition by Weight:	10% H_3BO_3 0.2% Undissolved Solids (1950 ppm Diatomaceous Earth and 50 ppm Fe_3O_3 In Demineralized Water
Processing Rate:	25 gph

Dry Waste Stream

Composition by Weight:	50% paper and cardboard 30% cloth rags 10% plastic 5% rubber 5% chipped wood
Processing Rate:	70 lbs/hr

Waste Oil Stream

Composition by Weight:	100% waste oil or diesel #2
Processing Rate:	4 gph

The demonstration test was conducted using the specified simulated waste streams under normal system operating conditions with the following minor exceptions: (1) the VR product was collected using a temporary drum storage system, and (2) liquid waste stream components and oil were placed directly into their respective storage tanks, rather than being pumped from the plant storage tanks to the VR System tanks. The two noted exceptions to normal system operation had no impact on operation while allowing the entire VR System to be tested independent of the uncompleted product packaging system.

Schedule

Final test preparations were conducted from September 4-8, 1984, and included the following operations: (1) installation of filters and balancing of the process exhaust gas system, (2) preparation of liquid waste feeds #1 and #3 and the dry waste feed, (3) filling the caustic and oil tanks, (4) briefing of personnel involved in the test, and (5) final instrument calibrations.

The Acceptance Test was conducted from September 8-18, 1984. Startup operations were performed from September 8-13 while actual waste feed processing was conducted from September 13-18. The waste stream processing schedule is summarized in Fig. 2. Liquid waste streams #1, #2, and #3 were processed for 25.1, 61.2, and 22.7 hours, respectively, during the test. The dry waste (composite trash) and waste oil feeds were incinerated for 14.1 and 20.7 hours, respectively, in the course of the test.

Acceptance Test Plan

The Acceptance Test was comprised of five parts, each dealing with the processing of a different test feed utilizing the drying or incineration capability of the AECC VR System, as appropriate. The five test parts were as follows:

1. Processing liquid waste #1 via the dryer in a dryer-only mode of operation at a rate of at least 24 gal/hr.

2. Processing liquid waste #3 via the dryer in a dryer-only mode of operation at a rate of at least 25 gal/hr.

3. Processing liquid waste #2 via the dryer at a rate of at least 15 gal/hr in both a dryer-only and combined dryer/incinerator operating mode.

4. Processing the composite dry waste feed via the incinerator at a rate of at least 70 lb/hr while operating the dryer on liquid waste #2.

5. Processing the waste oil feed via the incinerator at a rate of at least 4 gal/hr while operating the dryer on liquid waste #2.

The sequence of the five test parts is shown by the waste stream processing schedule in Fig. 2.

In the course of processing the various waste feeds, at least ten system starts and stops were required.

Data and Sampling

The quantity of test data and stream samples taken during the test was considerably greater than recommended for routine VR System operation. The added data and samples allowed a more complete assessment of system performance by AECC personnel during the initial system test.

Detailed test data were logged by AECC personnel at approximately 4-hour intervals. Samples of the liquid waste being fed to the system, scrubber/preconcentrator samples, and condensate

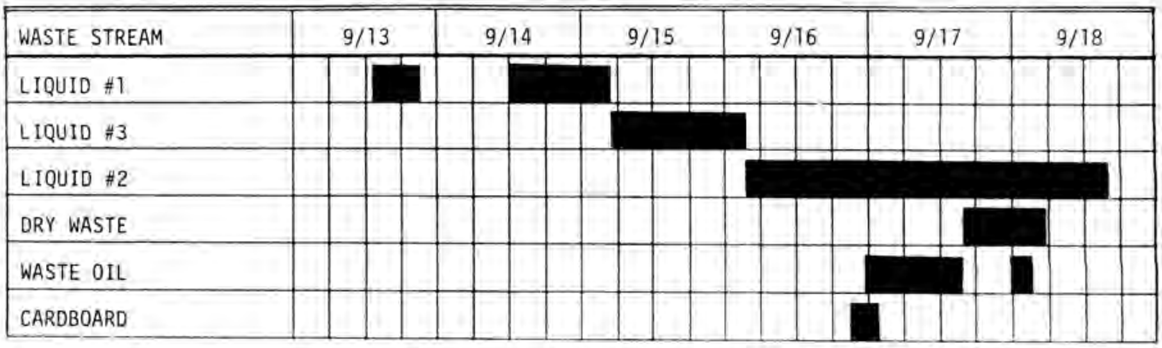

Fig. 2. Waste Stream Processing Schedule.

samples were also taken and analyzed on a similar schedule. The former samples were checked for density and pH while the condensate was checked for electrical conductivity and pH. Samples of dry product were taken from the various filled drums of product. Each of those samples was visually inspected for particle size and handling characteristics and checked for bulk density. Samples of each of the liquid waste feeds, a composite sample of condensate, and product samples were collected for such tests as the personnel of the Radchem Laboratory at the Byron Station deemed appropriate.

TECHNICAL TEST RESULTS

The technical test results of the Acceptance Test are presented in the following sections. Each of the first three deals with the processing (drying) of a different liquid waste stream. The fourth and fifth sections cover the processing (incineration) of the composite dry waste and waste oil streams. The sixth section presents results of the system start and stop tests. Typical VR System operating conditions during the test are summarized in Table II.

Processing of Liquid Waste Stream #1

Drying operations began on September 13, 1984 (see Fig. 2). Five hours later the dryer system was considered to be at steady-state. On September 15, dryer feed #1 was exhausted (low-level alarm on feed tank activated) after 25.1 hours of processing, and feed to the scrubber/preconcentrator was remotely switched to the tank which contained liquid waste feed #3. The average steady-state processing rate for liquid waste stream #1 was found to be in the range of 26.5 to 27.6 gallons per hour depending upon the method of data analysis. The capacity of the VR System for processing liquid waste #1 exceeded the required value of 24 gallons per hour by at least 10%.

Dried solid product was discharged from the dryer automatically and collected in a temporary drum storage system. As each drum became full, it was removed, weighed, sampled, and replaced by an empty drum. The average steady-state net solids production rate from liquid waste #1 was found to be in the range of 60.5 to 61.23 lb per hour depending upon the method of data analysis. These values are extremely close to the average solids input rate to the system of 61.2 lb per hour. This excellent mass balance shows that the system was operating at steady-state with essentially complete solids recovery.

TABLE II

Typical VR System Operating Conditions During the Acceptance Test

Dryer	
Bed Temperature, °F	880
Bed Depth, in. W.C.	30
Conc. Liquid Feed to the Dryer	
Rate, gal/hr	20
Specific Gravity	1.27
pH	11
Incinerator	
Bed Temperature, °F	1400
Bed Depth, in. W.C.	47
Exhaust Gas Temperature, °F	900
O_2 Conc. in the Exhaust, % vol	11
Combustible Feed Rate	
Trash, lb/hr, or	78
Waste Oil, gal/hr	5.8

The significant processing parameters and average bulk densities of the product from liquid waste #1 in its as-poured and as-vibrated conditions are listed in Table III. The product was free-flowing in its as-poured condition. The condensate produced by the VR System had a pH of 8.3 and an electrical conductivity of about 1000 micromhos.

Processing of Liquid Waste Stream #2

Processing of liquid waste feed #2 began on September 16. The system was considered to be at

TABLE III

Waste Processing Parameters and Waste Product Densities

Waste Feed Streams	Processing Time, Hours	Average Steady-State Feed Rate, Gal/Hour	Average Steady-State Net Solids Production Rate, Lbs/Hour	Average Product Bulk Density, g/cc. Pour	Tap
Liquid Waste Stream #1	25.1	26.5-27.6	60.5-61.2	1.17	1.26
Liquid Waste Stream #2	61.2	27.2-27.5	27.8	1.05	1.22
Liquid Waste Stream #3	22.7	47.8	47.6	1.11	1.22
Dry Waste Stream	14.1	77.7 lb/hr	-	-	-
Waste Oil Stream	20.7	5.8	-	-	-

steady-state approximately 10 hours into the run. Processing continued until September 18. At that time, about 1450 gallons of the feed had been processed in 61.2 hours of operation which exceeded the specification requirement by a large margin. Liquid feed #2 was processed in both the dryer-only mode of operation and the combined dryer/incinerator mode during which the incinerator was processing one or more of the following combustible feeds: composite dry waste, waste oil, or cardboard. The time periods for each of the modes of processing are shown in Fig. 2.

The average steady-state processing rate for liquid waste stream #2 was in the range of 27.2 to 27.5 gallons per hour which exceeded the required value of 15 gallons per hour by about 80%.

Dried solid product from feed #2 was discharged from the dryer automatically and collected in a temporary drum storage system as before. It should be noted that the solid product also included the ash resulting from the incineration of combustible wastes which were processed while the dryer was operating on liquid feed #2. The net steady-state solids production rate from the dryer feed and ash from incineration of the combustibles amounted to approximately 28.8 lbs per hour. The average incinerator ash production rate was about 1.0 lb per hour based on the estimated ash contents of each of the combustible wastes and quantities of each type processed during the corresponding time interval. Thus, the net solids production rate solely from waste feed #2 was about 27.8 lbs per hour. This value is very close to the average steady-state solids input rate of 27.9 to 28.1 lb per hour from waste feed #2. The excellent mass balance again indicates that the system was operating at steady-state with essentially complete solids recovery.

The significant processing parameters and average bulk densities of the product from drying liquid waste #2 and the incineration of combustible wastes in its as-poured and as-vibrated conditions are listed in Table III. The product was free-flowing in its as-poured condition. The condensate produced by the VR System had average pH and electrical conductivity values of 7.8 and 1800 micromhos, respectively.

Processing of Liquid Waste Stream #3

Processing of liquid waste feed #3 began on September 15. Uninterrupted processing continued for 22.7 hours until the supply of the feed was exhausted on September 16 as indicated by a low-level alarm in the waste feed tank. Feed #3 was processed in the dryer-only mode of operation.

The average volumetric processing rate for the feed was 47.8 gallons per hour which exceeded the required value of 25 gallons per hour by about 90%. The corresponding average solids input rate was approximately 45.5 lbs per hour.

Dried solid product from feed #3 was discharged from the dryer automatically and collected in a temporary drum storage system as was done while processing feeds #1 and #2. The average total production rate for the feeding period was 53.4 lbs per hour. This production rate includes contributions from both a decrease in the in-process inventory of solids in the scrubber/preconcentrator and from the carryover of incinerator bed fines. These contributions amount to about 2.6 and 3.2 lbs per hour, respectively. Thus, the net solids production rate solely from dryer feed was about 47.6 lbs per hour. This value agrees quite well with the average solids input rate from feed #3 of 45.5 lbs per hour. The good mass balance shows that the system was operating close to a steady-state with nearly complete solids recovery.

The significant processing parameters and average bulk densities of the product from liquid waste #3 in its as-poured and as-vibrated conditions are listed in Table III. The product was free-flowing in its as-poured condition. The condensate produced by the VR System had an average pH of 8.75 and an average electrical conductivity of 201 micromhos.

Processing of the Dry Waste Stream

A total of 1062 lbs of composite trash having the composition given in Table I was shredded and transferred into trash hopper "A". The trash components except for the rubber, rags, and wood were plant-generated wastes. Metal detection and shredding operations covered a period of 3.1 hours. Approximately 1.7 hours of that time represented actual shredding time while about 1.4 hours was delay time caused by metal detection, waste rejection, and waste sorting. A portion of the composite trash was discarded when trash plugs occurred due to the incorrect rotation of the agitators in the trash hoppers. Ultimately, 865 lbs of the original 1062 lbs of shredded composite trash were utilized in the dry waste processing test.

Processing of the dry waste began on September 17 using feed from hopper "A". A low-level alarm on trash hopper "A" activated after about five hours of feeding, and feed was automatically switched to hopper "B", as called for by the system control logic and the test plan. Feed was manually switched back to the "A" hopper to allow processing the remainder of waste in that hopper. The average processing rate for the 501 lb of dry waste processed from the "A" hopper was 77.7 lb per hour. This exceeded the required rate of 70 lbs per hour by 10%.

Dry waste feed from hopper "B" was then initiated, and waste oil feed was begun about 1 hour later. The waste oil feed was terminated early on September 18, and the dry waste supply exhausted about 3 hours later. The average dry waste processing rate while feeding from hopper "B" was 47.4 lbs per hour. The waste oil feed rate during this period was not determined.

The ash product from the incineration of dry waste was intimately mixed with the dry product resulting from the simultaneous processing of liquid waste #2 and accounted for only a small fraction of the combined dryer/incinerator product, probably less than 10%. Samples of condensate collected during the time that dry waste was being incinerated and liquid waste #2 was being dried had a pH of 7.8 and an electrical conductivity of 1800 micromhos.

Processing of Waste Oil

The waste oil used in the test was lubricating oil which had passed its recommended service or shelf life but was otherwise relatively clean, i.e., free of moisture and particulates. The incineration of waste oil only began early on September 17, and continued uninterrupted for about 14.3 hours. The dryer was operated on liquid waste #2 during the waste oil incineration period. Waste oil was processed at an average steady-state rate of 5.8

gallons per hour. Thus, the capacity of the system to process waste oil exceeded the required rate of 4 gallons per hour by about 45%.

The ash product from the incineration of waste oil accounted for only a very small fraction of the combined dryer/incinerator product, probably less than 1%, collected during the waste oil processing period. Condensate produced during the period that waste oil was being incinerated and liquid waste #2 was being dried had a pH of 7.8 and an electrical conductivity of about 1800 micromhos.

System Start and Stop Tests

Ten system starts and stops were required to demonstrate satisfactory system performance in accordance with the Acceptance Test Specification. System starts and stops were defined as the initiation and cessation of liquid feed to the dryer or the initiation and cessation of dry waste feed to the incinerator.

During the system tests, dryer feed was started and stopped on eleven occasions. Five of the stoppages were planned stop and start tests, one was an intentional stop to permit changeout of a malfunctioning pH probe, and the other five stoppages were the result of proper automatic system responses to alarm conditions. Two of the five automatic feed stoppages were part of total automatic fail-safe system shutdowns which were also proper responses to severe upsets (loss of plant instrument air and loss of condensate within the VR System). No system damage resulted from any of the dryer starts and stops.

Incinerator feeds were also started and stopped on seven occasions during the system tests. Four of the feed stoppages accompanied dry waste processing, two were waste oil stoppages, and one was a stoppage of shredded cardboard. All but one of the stops were intentional operator-directed actions which did not cause any significant system upsets. On one occasion, dry waste feed to the incinerator automatically stopped and restarted in proper response to a momentary alarm indicating a low flow of trash transport air. This stoppage caused no discernible upset to the incinerator or the overall system.

Proper VR System performance during all eleven starts and stops of dryer feed and four starts and stops of dry waste feed to the incinerator clearly exceeded the test requirement of ten satisfactory starts and stops.

Equipment Problems and Deficiencies

The success of the Acceptance Test was not compromised by any major equipment problem or deficiency. Minor problems related to improper installation, incorrect or inadvertent system operation, or instrumentation and controls were encountered which caused some delay in the testing. Generally these problems were typical of those arising in the course of any initial system start-up. In addition, a few components failed or malfunctioned. The more significant of these incidents are described below.

Both waste feed recirculation pumps required replacement of "O" ring seals which were apparently damaged from a short-term loss of seal water flow. The bearings and oil seal on the scrubber/preconcentrator recirculation pump also had to be replaced. All these pumps had been delivered to the construction site about four years earlier. All the original pH probes installed in the waste feed recirculation and scrubber/preconcentrator recirculation loops had exceeded their shelf-lives and gave unreliable responses necessitating replacements. The liquid level probes in the scrubber/preconcentrator sump and in liquid waste tank "A" were apparently damaged during installation. This necessitated the temporary replacement of the sump probe with one from the AECC prototype unit and reliance on manual level measurement in the "A" waste tank to perform the test.

Post-Test Visual Inspections

At the conclusion of the test, the dryer, dryer bed hopper, incinerator, and cyclone were visually inspected. These inspections showed the VR System to be free of any visible damage or problem that would affect further operation.

TEST CONCLUSIONS

The Acceptance Test of the AECC-supplied VR System at the Byron Station was successfully completed in September 1984. All specified performance goals regarding processing rates for various test feeds and system starts and stops were exceeded as shown in Table IV.

In addition to successfully meeting the performance specification values, the VR System was demonstrated to be installed correctly and to function properly under operating conditions. Commonwealth Edison Company personnel accepted the system. The relatively minor equipment problems or deficiencies that arose in the course of the test were identified and were largely corrected during the test. Corrective actions to any problems that could not be rectified in the course of the test have also been defined and such actions requiring AECC's attention have been undertaken.

Post-test inspections of key components in the VR System were conducted and the equipment was found to be free of any visible damage.

LICENSING

The licensing activity related to the AECC VR System at the Byron Station consisted of two parts: generic considerations and plant-specific considerations. In October, 1979, AECC filed a generic Topical Report No. AECC-2-NP(P) with the United States Nuclear Regulatory Commission (NRC) that provided a detailed technical description of the VR Systems that had been delivered to the Byron, Braidwood, and Marble Hill Nuclear Stations. That Topical Report addressed the following generic topics:

- Design Bases
- Process Description
- Equipment Description
- Plant Interfaces
- Instrumentation and Control System
- Equipment General Arrangement
- Quality Assurance Program
- Compliance with Federal Regulations
- Operating Experience
- Estimated Releases from the AECC VR System

The Topical Report was reviewed by the Meteorological & Effluent Treatment Branch (METB), Radiological Assessment Branch, and Chemical Engineering Branch. Subsequently, AECC supplied two amendments to the Topical Report (Amendment 1 in October 1982 and Amendment 2 in August 1984), containing

TABLE IV

Summary of AECC VR System Performance

During Acceptance Test At Byron

Processing Rate Tests

Test Feed	Operating Time, Hours	Quantity Processed	Processing Rate	
			Performance Specification	Demonstrated Steady-State Value
Liquid Waste Stream #1	25.1	670 gal.	24 GPH	26.5-27.6 GPH
Liquid Waste Stream #2	61.2	1,660 gal.	15 GPH	27.2-27.5 GPH
Liquid Waste Stream #3	22.7	1,080 gal.	25 GPH	47.8 GPH
Dry Waste Stream	14.1	865 lbs.	70 lb/hr.	77.7 lb/hr
Waste Oil Stream	20.7	89 gal.	4 GPH	5.8 GPH

Feed Start and Stop Tests

Type of Start/Stop	No. Starts & Stops	
	Performance Specification	Demonstrated Value
Liquid Feeds to Dryer	10	11
Dry Waste to Incinerator	Total	4

responses to questions raised by the NRC as part of its review of the system. A total of 88 questions were raised by the NRC. The subjects most questioned were (1) Instrumentation and Process Control, (2) System Design, (3) Off-gas System, (4) System Decontamination, and (5) Limits on Feed to the Incinerator. Additional technical discussions with the NRC in October, 1984 clarified the remaining issues. The Topical Report was accepted by NRC as a referencing document in utility licensing applications in November, 1984.

Plant-specific licensing for the Byron Station was initiated when Commonwealth Edison Company referenced this Topical Report in an amendment to the Byron Station's FSAR in May, 1982. As a result, NRC had only to address plant specific matters dealing with the Volume Reduction System, since generic issues were reviewed and resolved during the Topical Report review. Commonwealth Edison Company received a total of 75 questions from the NRC dealing with the VR System. The subjects most questioned were (1) Instrumentation, (2) System Design or Design Changes, (3) Plant Interfaces, and (4) Limits on Feed to the Incinerator. The final issues were resolved in February, 1985, and the NRC found the AECC VR System acceptable for processing the low-level wastes generated at the Byron Station, including evaporator concentrates, dry active wastes, and oil. The Byron Station full-power license was granted by the NRC on February 12, 1985, making this the first VR System licensed in a U.S. commercial nuclear station for processing liquid wastes to a dry product and incinerating dry active wastes and contaminated oil.

Commonwealth Edison Company also obtained a permit to operate the VR System from the state of Illinois.

CONCLUSIONS

1. The AECC VR System concluded a very successful Acceptance Test at the Byron Station in September, 1984, processing three distinct liquid waste streams, dry waste, and oil. Processing rates for all waste streams easily exceeded the specification values. As a result of this test, Commonwealth Edison Company personnel accepted the system.
2. Minor equipment and process problems encountered during the test were easily corrected, and the test proceeded to its planned conclusion.
3. Post-test inspection of the major components indicated a normal condition of all surfaces.
4. The AECC VR System is fully licensed to process evaporator concentrates, dry active wastes, and oil, via drying and incineration at the Commonwealth Edison Company's Byron Station.
5. The accepted Topical Report will accelerate the licensing process for other utilities selecting this system.
6. Volume reduction systems including incinerators can be licensed for operation at commercial nuclear power stations in the U.S.