TESTING AND OPERATION OF A TRANSPORTABLE VOLUME REDUCTION UNIT

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ABSTRACT

In order to process the high volume, low specific activity liquid radwaste from the chemical cleaning of the Oconee Nuclear Station steam generators, Duke Power Company purchased a transportable volume reduction (TVR) system from Associated Technologies, Inc. Before the unit could be operated at Oconee, the system had to be functionally tested, the process optimized and simulated waste streams processed to ensure that the end product would meet burial site requirements. Although the primary objective of the unit was to process the spent cleaning solvent, the scope of the testing was expanded to include Class B and C waste levels in addition to the Class A waste from the generator cleaning. Additionally, to ensure the unit could process other waste streams if needed, waste streams of boric acid, bead and powdered resins were tested. While all testing is not yet completed, the TVR unit has proven that it can process the various waste streams, solidify them in asphalt, and produce an acceptable burial site end product.

INTRODUCTION

Shortly after the purchase of the TVR unit by Duke Power, responsibility for the start-up and testing of the unit was transferred from Duke's Design Engineering Department to the Nuclear Production Department. The Nuclear Production Department, which operates Duke's nuclear plants, had the expertise and experience to perform this testing. While the TVR unit itself is small by nuclear power plant standards, it is a unique, state-of-the-art system. The sophistication and design principles of the unit are rivaled only by the radwaste systems still in the construction phases at most power plants. Although the equipment is sophisticated, Duke has recognized for years that the key to successful operation lies in the allocation of human resources and not hardware.

After assuming responsibility for start-up and testing of the unit in mid-1984, the human resources needed to complete the project were identified. The key positions were identified as a project manager/co-ordinator, test engineer, unit operators and supervisor, staff technical support, instrument and mechanical maintenance support, and vendor engineering/operations support. Independent of the hardware and design, an inverse correlation can be made with the human resource allocation to the time and money spent on completing the project: better human resources will result in a shorter, more economical start-up. Operational problems will be encountered and the only known fact is that the unexpected will occur. People can be both proactive and reactive to these occurrences considerably better than hardware.

TESTING AND OPERATION

Once the test organization was in place, major project tasks and schedules were defined. Specific tasks and schedules were then identified and priorities assigned. The major tasks included:

I. Unit Startup and Testing

  A. Field Functional Equipment checkout
  B. Process Optimization Program
  C. Process Control Program Development
  D. Maintenance Program Development
  E. Operating Test Procedure Development
  F. Miscellaneous Field Support

II. Unit Operation

  A. Administrative Procedure Development
  B. Operating Procedure Development
  C. Periodic Test Procedure Development
  D. Operator Training Program

III. Testing Cost Control Program

During the functional testing phase, the objectives were to ensure that all equipment would operate as designed and to process simulated waste streams which the unit could encounter. To date bead resins, boric acid and the spent EPRI generic chemical cleaning solvent have been processed. All waste forms consisting of bitumen and the dry solids were found to meet the criteria of the burial sites for Class A category wastes.

While processing the boric acid solution, two significant problems occurred. The first was that while the AC-20 bitumen and boric acid product met burial requirements for Class A waste, it would not meet the minimum 50 psi compression standard for Class B and C wastes. The second problem encountered was the periodic binding and scraping of the evaporator rotor against the evaporator shell.

The type asphalt initially used in the process was an AC-20 bitumen. AC-20 is the term used by the American Petroleum Institute (API) which denotes particular ranges for such parameters as viscosity and penetration. The test used to measure compression was ASTM D 1074, "Compressive Strength of Bituminious Mixtures." Samples consisting of both 50% and 65% solids (boric acid) by weight were tested. At 10% deflection of the samples, the compressive strengths were determined to be between 1 and 2 psi. Since these results were considerably below the 50 psi standard, a different bitumen had to be chosen.

The criteria used to select an alternate bitumen were:

1. Ease of availability

2. Compatible with existing equipment

3. More viscous at room temperature

After researching various types of bitumens, an API Type 1 roofing asphalt was selected. While the Type 1 bitumen was two orders of magnitude higher in viscosity than AC-20 at 140 degrees Fahrenheit, the viscosities at operating conditions (320 degrees Fahrenheit) of the TVR bitumen feed system were similar. Since it was available locally, the Type 1 bitumen met all the criteria defined. The total compressive strength of pure bitumen was found to be about 60 psi. Since the pure bitumen should have a lower compressive strength than any mixture of solids and bitumen, additional processing of boric acid was done to compare results with the AC-20. A product with a ratio of 50/50 bitumen to solids product was found to have a total compressive strength of approximately 120 psi which is at least a factor of two higher than the standard for Class B and Class C wastes.

The second major problem encountered during the functional testing was the binding of the Luwa evaporator rotor. Periodically, after heating the evaporator to its operating temperature of 450 degrees Fahrenheit, contact between the rotor and the shell was experienced. After consulting Luwa and ATI personnel, a plan of action was defined to identify and resolve the cause of the problem.

First, instruments were installed while the evaporator was at ambient temperature. Then measurements were again taken while the evaporator was at 450 degrees Fahrenheit. These measurements provided information on the amount of thermal expansion that was present on the evaporator piping and supports. From these measurements the direction of the thermal expansion was determined. The direction of this expansion was critical since there is only about a 2 millimeter clearance between the rotor blades and evaporator shell. If the shell and rotor were not parallel, then binding would occur. The rotor used in the evaporator is approximately 15 feet in length and a standard Luwa type N-Rotor which is a closed-form rotor with four fixed blades. It was found that the binding of the rotor was not caused by thermal expansion distorting the evaporator shell.

Eliminating exterior distortion as the problem, the rotor was removed from the evaporator for inspection. Visual inspection revealed that three of the four blades had noticeable indication of rubbing slightly below the midpoint of the rotor. Some permanent distortion was also observed on these blades. A visual inspection of the evaporator shell also showed evidence of rubbing with metal to metal contact occurring. Measurements of the rotor and shell diameters were found to be within the manufacturers tolerances. The minimum clearance on the blades was about 1.75 mm.

After reviewing the data collected, the conclusion was reached that the rotor was being heated unevenly during evaporator start-up. This was caused by the evaporator bottom valve being closed which did not allow air to flow up through the evaporator. The air flow provided a more uniform heating of the rotor. In addition to opening the valve during heatup, the rotor blades were machined so that at least a 2.0 mm clearance was obtained. Although these two actions would alleviate the problem, even the slightest potential for rotor binding in a contaminated environment could not be tolerated. Therefore, a more thermally stable rotor was ordered to replace the existing one. The new rotor will be installed at the end of testing which should greatly improve the reliability of the evaporator and save personnel radiation exposure.

A major milestone in the testing was to process simulated steam generator chemical cleaning solvent. A solution of the solvent was mixed using the EPRI generic solvent formula for iron removal. The solvent consisted of ethylenediaminetetraacetic acid EDTA), a non-proprietary corrosion inhibitor and ammonium hydroxide. The pH of the solution was adjusted to 7. Hydrazine was not included in the solvent because it would not be present by the time the waste was actually processed by the TVR unit. Magnetite was then added to the solvent at a dosage of 12,000 ppm. A proprietary reagent was added to the solution to ensure that no uncomplexed EDTA would be present. The complexed - EDTA has a higher thermal stability than does free EDTA.

Once the processing began, foaming was observed to occur in the product. Some foaming had been anticipated but not to the degree which was observed. In reviewing the solution composition, it was noted that not all the magnetite had dissolved. Since no excess of the reagent had been added, it was suspected that some free EDTA still existed and that the high temperatures in the evaporator were driving off ammonia from the ammonia form of EDTA. Additional reagent was added to increase the pH of the solution from about 7.5 to 8.2. Foaming was observed to decrease dramatically. Future cleaning solvent solutions will be adjusted to a minimum of pH 9.0. Depending on results, the pH may be increased to pH 9.5.

The effect of the foaming on the project was that voids were left in the product after the bitumen cooled and solidified. While no free water was present, these voids would reduce the compressive strength of the mixture. Compressive strengths performed on samples of 40% solids and 60% bitumen ranged from 23 to 57 psi at 10% sample deformation. This compares to 60 psi in pure Type 1 bitumen.

SUMMARY

While all testing on the TVR is not completed, the previously noted situations represent some of the more significant problems which have been encountered. Although some delays in the testing schedule have occurred, testing is targeted for completion by early May, 1985. The majority of the work which remains is the processing of boric acid, bead and powdered resins to obtain the necessary samples for 10CFR61 analyses for Class B and C level wastes. While the testing and planning for future operations appears simple, over thirty Duke Power Design Engineering, Construction and Nuclear Production personnel were involved. Other interfaces also occurred with TVR unit supplier and their vendors and associated test laboratory personnel. The ultimate challenge was not to determine whether the unit would operate as designed but to assemble, organize and coordinate the personnel to achieve the end objective.