LIQUID RADWASTE MINIMIZATION EFFORTS AT DUKE POWER COMPANY

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ABSTRACT

Most liquid radwaste processing systems are designed for "average" waste processing rates. Unfortunately, waste is not generated at this average rate but at varied rates which can overload the capacity of the systems. When the waste systems are overloaded, the operation of the entire power plant can be adversely affected. Duke Power has established a liquid radwaste minimization program designed to decrease loads on nonrecyclable waste stream process systems and to provide sufficient process capacity to handle the peak input rates in each waste stream. Elements of the program include: waste source segregation, reclamation, elimination, chemical control, leak detection, and the volume reduction of process system byproducts. Examples are given for each of these program elements. A variety of techniques are used in reducing or eliminating high-solids, high-radioactivity, and high-volume sources of waste which can overload waste systems and/or produce high volumes of byproducts for disposal. The examples illustrate that a combination of operating, engineering, and administrative tools are used to achieve the minimization program objectives.

INTRODUCTION

Duke Power operates seven nuclear reactors. They are located at Oconee, McGuire, and Catawba Nuclear Stations. All are Pressurized Water Reactors (PWR's). During the first years of operation at Oconee, the loads on the liquid waste systems were found to be higher than anticipated. Reactor trips, Steam Generator tube repair outages, and simultaneous unit outages produced waste volumes at high generation rates. These peak rates exceeded liquid waste system capacity and resulted in:

a. waste backlogs;

b. inability to recieve additional waste;

c. outage delays in draining components for maintenance;

d. reactor start-up delays in allowing reactor coolant feed and bleed.

The costs in lost generating capacity, unit availability, and diversion of plant personnel to unusual plant operating conditions demonstrated first-hand the importance of waste sources control and waste system efficiency.

As a result of this experience, and with the knowledge that McGuire and Catawba might experience similar operating difficulties, a program was established to achieve better waste control. The program is based on the evaluation of waste volumes and properties as a function of plant design, operating events, and station maintenance activities. The characteristics of each waste source are evaluated against the capabilities of radwaste process components. The program recognizes that waste sources can have complex physical, radiological, and chemical properties and that this complexity is frequently compounded when waste streams become mixed and then are introduced into process equipment.

The central program philosophy is:

> Minimize the input of radioactivity and dissolved solids to nonrecyclable (waste) systems. Segregate and control waste streams as close to the source as practical. Provide sufficient process capacity to handle peak loads from each segregated waste stream.

Specific program objectives are based on waste source characteristics and on the design limitations of process equipment. The objectives apply to both station design and operation. They include:

1. Segregation of Sources
2. Reclamation of Reactor Coolant
3. Chemical Control of Sources
4. Volume Reduction of Byproducts
5. Elimination of Sources
6. Leak Detection

A variety of methods are used in attempting to meet these objectives. Applications of these methods are shown in the examples described below. One example is presented for each of the six objectives. These examples - and station operating experience - illustrate that equipment modification is only one of several important program elements. Equally important are: 1) improved operating practices, 2) station administrative controls, and 3) ongoing waste program evaluation.

SEGREGATION OF VENTILATION CONDENSATE

Duke Power is located in the Southeastern United States. This geographic region is characterized by high relative humidity during the months of June through October. Air coolers in the Auxiliary and Reactor Building Ventilation Systems can produce volumes of condensate exceeding 1000 gallons (3.8 cubic meters) per hour during peak summer days. This Ventilation Unit Condensate has been segregated at McGuire and Catawba Nuclear Stations. Operating experience has shown this segregation to be valuable in reducing volume input to Floor and Equipment Drain Process Systems.

A sketch of the system is shown in Fig. 1 below. Sources from Auxiliary and Reactor Building Ventilation Cooler Drains enter a Drain Tank and are normally pumped to the plant discharge through a radiation monitor, sampler, and flow totalizer. Upon detection of radioactivity concentrations significantly above background, discharge is terminated by the monitor. The condensate is then pumped to the waste process system.

The monthly volume of ventilation condensate produced during a typical year at McGuire is shown in Fig. 2.

During the months of June through October, large amounts of condensate are collected and discharged without the need for processing. During July, 250,000 gallons (950 cubic meters) of condensate were discharged. As Fig. 3 shows, the radioactive content of this waste is very low. Tritium is the major nuclide present in the condensate. In most cases, the concentrations of nuclides in the condensate are lower than can be achieved with plant waste process equipment.

Condensate volumes during January and February (Fig. 2) illustrate the usefulness of the system in dealing with plant upsets. In late December, 1983, steam generator feedwater valve external leakage developed. Auxiliary Building condensate production is normally very low during the months of November through March, such that the volumes in January and February show the feedwater steam leak in the Reactor Building. Had no other events occurred, the entire volume would have been discharged without processing.

In mid January, however, a small reactor coolant steam leak developed. The radioactive concentration gradually rose to the point that condensate could not be released because the feedwater steam was contaminated by the reactor coolant leak. Fig. 2 shows the volumes which required processing until the unit was shut down for refueling and repairs.

Based on these experiences, the Ventilation Unit Condensate System has been judged a valuable asset and is scheduled for modification to further improve its usefulness. Fig. 1 shows, in dotted lines, the addition of features to allow diversion of either Auxiliary or Reactor Building condensate drains to the process system prior to entry into the Condensate Drain Tank. The modification will reduce cross-contamination of sources to the tank during unusual operating conditions.

REACTOR COOLANT RECLAMATION

Reactor coolant grade liquids are high-volume liquid sources. Included are bleed liquid from chemical shim (boron concentration) changes in the reactor coolant system and drainage from the spent fuel pool and reactor coolant systems. Reactor trip recovery, reactor power change, reactor shutdown, and fuel pool maintenance drainage represent peak load challenges to liquid process systems. Annual volumes generated by McGuire are as follows:

Year	Gallons	Cubic Meters
1982	2.2 Million	8,300
1983	3.3 Million	12,500
1984	4.2 Million	15,900

These totals do not reflect peak loads. On one occasion, 750,000 gallons (2,800 cubic meters) was processed in one month.

Without recycle (reclamation) system capacity to reclaim the peak volumes of coolant-grade liquids, the only recourse is to divert these liquids to the nonrecyclable Waste System. The peak load demand on the recycle system is then superimposed on the peak load design base of the waste system. As illustrated in the introduction, operating experience has demonstrated that such concurrent peak loads do occur - especially at multi-unit sites with shared liquid waste systems.

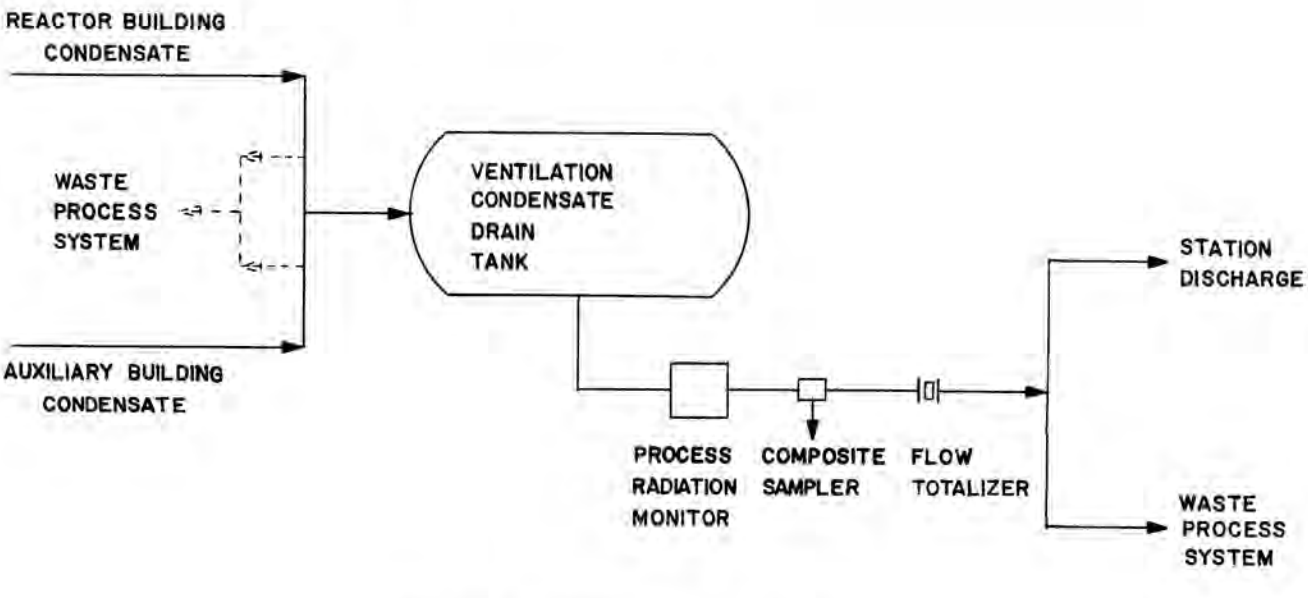

Fig. 1. Ventilation condensate system.

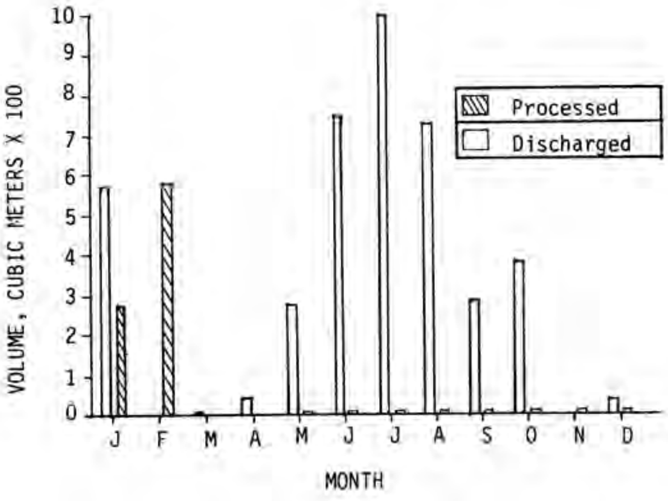

Fig. 2. Discharged/processed ventilation Condensate.

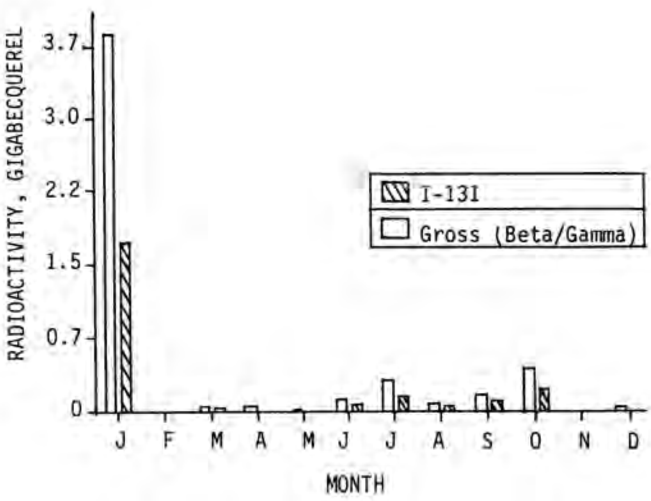

Fig. 3. Radioactivity in ventilation condensate.

To address this problem, recycle systems have been upgraded. Westinghouse evaporators were submitted to test programs. The goal was to achieve 15 gpm (3.4 cubic meters per hour), 150,000 gallon (570 cubic meters) per week process capacity, and availability greater than 90%. Deficiencies in the vent system, gas stripper, distillate and concentrate loops were found and corrected. Process monitors and automatic controls have been added to convert each evaporator from manual batch processing to automatic continuous operation. Other recycle system modifications allow continuous use of recycle demineralizers prior to evaporator feed. Radioactive cobalt and cesium concentrations are reduced to 100 times lower than reactor coolant concentrations so as to maintain average evaporator and boric acid tank contact dose below 0.2 Rad/hr (2 mGy/hr). The waste evaporator has been converted to recycle service as a peak load and backup component. This minimizes the probability of coolant liquid diversion to the waste system.

Process rates for a peak week at McGuire show the system capability as modified. Both evaporators were used during this peak week:

Feed Volume - 282,000 gallons
(1070 cubic meters)

Process Rate - 28 gpm
(6.4 cubic meters per hour)

Concentrates Reclaimed - 23,000 gallons
(87 cubic meters)

Distillate boron - 5 ppm
(Kg B per million Kg Solution)

Distillate Gross Gamma - Less than
limit of detection

High evaporator distillate quality has been achieved without using the system's polishing ion exchange components. Recycle system peak loads have not required diversion to the waste systems at McGuire and Catawba. Duke has recently provided its modification package to a neighboring utility.

SOURCE CHEMICAL CONTROL - WASTE EVAPORATOR

Oconee Nuclear Station used an evaporator to process nonrecyclable wastes. 20,000 cubic feet (567 cubic meters) of concentrates were solidified for disposal. The design restrictions for evaporator concentrates are: a) 21,000 parts per million boron (Kg boron per million Kg of concentrates), and b) 50 parts per million (ppm) chloride.

Operating data showed that the 50 ppm chloride (corrosion) maximum was reached before the evaporator concentrate reached the maximum boron concentration. Instead of averaging 21,000 ppm boron, pump-out of the concentrate occurred at 14,000 ppm boron. Reduction of chloride in the waste fed to the evaporator was targeted. Besides reducing disposal volumes by 33%, the potential cost savings were estimated at $1 million per year.

A dual appraoch was adopted to address the problem:

a. Elimiante the use of cleaners and chemicals which contained chlorides.

b. Use ion exchange resin to reduce evaporator feed chloride.

A radwaste Chemical Approval Program was established. Approval criteria were developed based on radwaste equipment compatibility. Floor drain openers and cleaning compounds used for general plant housekeeping were discovered to be the leading sources of chlorides in waste streams. Once these compounds were replaced with approved formulations, waste feed chloride levels began to decline toward the 1 ppm target maximum.

Meanwhile, the Oconee staff placed portable anion exchange vessels in service using flanged connections provided in the transfer pipe between the collection tank and the evaporator feed tank. The demineralizer beds were placed in service when collection tank analysis indicated greater than 1 ppm chloride concentrations.

The results of the programs showed that source chemical control yielded consistent concentrates production at 21,000 ppm Boron concentration, 33% reduction in annual rate of concentrates production, and less than 100 cubic feet (2.8 cubic meters) of anion resin volume.

SOURCE ELIMINATION - DECONTAMINATION

Source elimination techniques applied at Oconee Nuclear Station are outlined in the paper by H. J. Dameron given in this session. One example is the elimination of Decontamination Room chemicals from liwuid radwaste input.

The tool and equipment decontamination room had originally been equipped with heated water baths, turbulators, and ultrasonic vats. These components required the use of aggressive chemicals such as citric acid, oxalic acid, and alkaline potassium permanganate. Such chemicals provide moderate decontamination factors, but produce wastes which are incompatible with the design of the waste systems receiving them for processing. Citric and oxalic acids are corrosive agents to stainless steels. Permanganate at concentrations greater than 0.5 ppm attacks ion exchange resin and destroys its effectiveness. The plant is forced to severely restrict or completely ban such agents due to the process system damage they can cause.

As outlined in the Dameron paper, effective equipment which generates no aggressive chemical byproducts has been purchased to replace the Decontamination Room equipment at Oconee. Liquid waste byproduct technology are a major consideration in equipment selection. Similar criteria are being applied at McGuire and Catawba.

PROCESS BYPRODUCT VOLUME AND
COST REDUCTION - FILTER CARTRIDGES

Direct reduction of liquid waste system process byproducts is sometimes the most cost effective recourse. Whereas volume reduction of evaporator concentrates outlined above could be addressed close to the source, Waste Process System filters provide a contrast.

Early in McGuire operation, waste system filter cartridge replacements were required after only 1,000 to 2,000 gallons (3.8 to 7.6 cubic meters) of processing. System downtime for maintenance of cartridges reached 50%. Study of the problem revealed that filter upgrade was the only practical solution. Waste sources were surveyed to determine a reasonable design base for larger filters. Effective filtration area was increased by a factor of 30. The data shown in Table I compares the performance before and after upgrade.

Upgrade cost was approximately $40,000 installed. Payback in reduced cartridge costs and changeout labor savings was less than six months. Overall volume reduction factor for shipped cartridge volume was 3 (due to package efficiency sacrifice for larger cartridges). Service life has proved directly proportional to surface area, as predicted. System availability is approximately 90%.

The objective of filter upgrades is to sufficiently size filters so that cartridge replacement occurs based on contact dose rather than differential pressure. McGuire data has been used to specify similar upgrades at Catawba such that contact dose changeout at up to 20 R/hr (0.2 Gy/hr) - as worker exposure minimization dictates - can be expected.

SOURCE LEAK DETECTION - FLOOR DRAINS

Source leak detection can be provided by both procedural and equipment techniques. Constant monitoring of system inventory history has provided awareness of input rates to liquid waste systems at all operating plants. The ability to locate sudden large leak sources can present problems, however. Components located in shielded areas accessible only by one - to - three ton hatch plugs are one example. Components in rooms which are kept locked due to high radiation fields are another example. Determining the location of an external leak requires accessing these areas one at a time until the source is found. The effort is dose-intensive, labor-intensive, and time-consuming.

TABLE I

Filter Performance Data

	Original	Upgrade
Operating Mode:	Single Cartridge	2 Parallel
Service Life:	2000 gal (7.6 M^3)	60,000 Gallons (230 M^3)
Filter Area:	1.2 $ft.^2$ (0.1 M^2)	16 x 2 ft^2 (3.0 M^2)
Flux:	17 $gpm/ft.^2$ (12 Kg/s M^2)	0.6$gpm/ft.^2$ (0.4 Kg/s M^2)
Exhausted Contact Dose:	5 R/hr (50 mGy/hr) Design Base	0.4 Actual R/hr (4 mGy/hr)

In an effort to provide faster response to acute leakage events, a leak detector was developed. The detectors are press-fitted into floor drains and connected to alarm panel cables by plug connectors. The detectors use a float and microswitch actuator to provide alarm when input to an individual floor drain reaches rates greater than 0.1 gallons per minute (0.02 cubic meters per hour).

Detector assemblies are disposable and can be changed out in 15 seconds. The detector does not interfere with flow into the floor drain. Available flow area into the floor drain exceeds the area of the grating replaced by the detector.

Detector location is identified on each local alarm panel. The central alarm panel directs the operator to the appropriate local panel. Operating experience has demonstrated the ability to identify exact location of Auxiliary Building leaks within 5 minutes. Detector inspection and replacement are scheduled as other maintenance needs require entry to each room. The system is in operation at McGuire and is scheduled for installation at Catawba.

SUMMARY

Duke Power has established programs to reduce inputs to waste systems which produce plant effluents and which produce the highest volumes of byproducts requiring disposal. Program objectives and examples of each include:

1. Source Segregation of Ventilation Condensate.
2. Reactor Coolant Recycle by Evaporator and Recycle System Upgrade.
3. Source Chemical Control by Chemical Approval and Evaporator Feed Treatment.
4. Source elimination of Decontamination Chemicals by Equipment Upgrade.
5. Process Byproduct Volume/Cost Reduction by Waste System Filter Upgrade.
6. Source Leak Detection by Development and Installation of Floor Drain Detectors.

The application of administrative controls, refined operating practices, and equipment modifications has yielded progress toward the segregation and process capacity for station waste streams. Each program objective has contributed to reduce liquid waste byproducts, cost, and inventory backlog.