THE DEVELOPMENT AND IMPLEMENTATION OF A DRY ACTIVE WASTE (DAW) SORTING PROGRAM AT CATAWBA NUCLEAR STATION

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ABSTRACT

Duke Power Company, like other nuclear utilities, bears a burdensome radwaste disposal cost that has rapidly escalated during recent years. Dry active waste (DAW) represents approximately 85% of the total radioactive waste volume shipped to low-level disposal facilities. Sorting waste with less than detectable radioactivity from waste with detectable radioactivity provides a volume reduction (VR) technique that can save significant radwaste disposal costs and conserve dwindling burial space.

This paper presents the development and results of a project that was conducted at Catawba Nuclear Station to determine the volume reduction potential from sorting DAW. Guidelines are given so that other utilities can perform a VR potential study on a low cost basis. Based on the results of the DAW VR study, an overall DAW volume reduction program was initiated at Duke Power Company. This program includes personnel training, drumming techniques, bag tracking and equipment purchases for sorting. This program has been fully implemented at Duke Power Company since January 1, 1988 and preliminary results and savings are given.

INTRODUCTION

In 1984 as the cost for disposal of radioactive wastes escalated, Duke Power began to see a need to look closely at ways to reduce the volumes of waste being generated and sent for burial. Since DAW represents approximately 85% of the total volume shipped, emphasis was placed on potential reduction of this waste stream.

At that time, it was the Company's policy to rely on a General Employee Training (GET) Program and a color-coded drumming program to segregate clean from potentially contaminated trash in the Radiation Controlled Areas (RCAs). Materials deposited in clean (blue) receptacles were generally routed after survey to a municipal landfill and materials deposited in contaminated (yellow) drums were destined for burial at the low-level waste burial site. The company had recently made great strides in reducing DAW generation through increased housekeeping awareness and a strengthened GET program. A reduction in the volume of unnecessary materials brought into the RCA and then segregating necessary RCA trash through the drumming program accounted for most of the DAW volume reduction at the time. The DAW VR potential study, through the use of sorting techniques, was initiated in an effort to determine methods to further reduce the DAW volumes sent for burial. The decision to perform such a study was influenced by a recommended good practice in INPO OEN-9 to develop a sorting program(1).

SORTING PROJECT OUTLINE

A DAW VR potential study can be performed on a low cost basis. First, equipment must be obtained and used to produce about the same sensitivity as DAW VR equipment on the market today (approximately 5000 dpm/100 cm^2). If using friskers, care must be taken to properly integrate detection parameters (e.g. geometry, velocity, false alarm rate, etc). If friskers are used without glove boxes or other engineered respiratory controls, then alternate means should be used to address respiratory concerns.

The second step in setting up a study is to determine qualifying waste. This step involves placing manageable limits on the volume, type, and origin of the material to be surveyed in order to control the magnitude of the project that will yield estimates representative of a full scale program. For example, waste generated in a nuclear sampling lab would not qualify because of its high contamination potential. For the Catawba study, after determining from which areas the waste would be sorted, further guidelines were developed for qualification. This involved obtaining external dose rates from the bagged material. Only bags with dose rates less than or equal to 2 mR/hr. were considered for sorting.

The final aspect of preparing a DAW VR study involves determination of what to document. This would include methods for calculating mass balance and how to relate the fraction studied to the whole DAW stream for VR ratio determination. Once the VR ratio is known, then economic analysis based on cost/benefit can be presented to management for program justification.

PROJECT DESIGN

The DAW sorting project began with a literature search to determine what guidance and precedence existed for sorting trash. Contacts were made with INPO to identify utilities engaged in trash sorting within NRC Regions I and II. From this, Beaver Valley Power Station and Salem Nuclear Station were found to be the closest nuclear facilities to have active trash sorting programs with offsite release. Beaver Valley's program used manual trash survey techniques. Salem's program employed a prototype version of a mostly mechanized process that included sophisticated counting and handling devices.

Capital allocations for this project were restricted to the use of existing Station manpower and equipment resources. Based on this criteria, Beaver Valley's assistance was solicited because their successful program provided a proven format from which the test structure could be developed. Beaver Valley provided procedures, guidelines, drawings, and statistical records to assist in the project design. Guidelines for organizing the stepwise process of handling waste were adapted to Catawba's needs, further reducing project development costs.

The primary survey instrument used throughout the project was the Eberline RM-14/HP260 (frisker) with alarm setpoints (ASP) based on a modified version of the methodology presented by J. F. Sommer as the technical basis for IE Circular 81-07 (2). The modified equation for ASP methodology was used to generate a table of ASP values corresponding to 5000 dpm/100 cm^2 in fast response detection mode as a function of background. The modifications made to Sommer's equation included the use of a calculated and empirically proven 1.62% effective moving efficiency for a 100cm^2 planar source versus the 10% stationary counting efficiency Sommer used for point source detection. Other differences included our use of empirically determined RC time constant (for fast response) and source residence time. The RC time constant is equal to the measured resistance in units of ohms times the capacitance in units of farads. The RC time constant value is in units of seconds. The source residence time is based on an integrated effective detection area with respect to time for a 100cm^2 source as shown in Fig. 1. The form of the equation and the variables used are given as follows:

$$A \leq 25 + 1.625(B + S \pm K_i(t^{-.5}(B+S)^{.5}))$$

where:

λ = 0.111 min (fast response RC)

t = 3 sec (source residence time)

B = Background cpm

S = Source cpm (dpm x effective moving efficiency of 0.016 cpm/dpm)

k_i = Constant defining the probability that the source will cause a count rate as large or larger than ASP with a known background, efficiency and time.. K taken from one-tailed test curve.

25 = y intercept from Fig. 2

1.625 = slope from Fig. 2

NOTE: The term (1-e -t/λ) = 0.9888 which is approximately equal to 1, therefore this value from Sommer's equation is dropped from this modified equation.

Particular attention was needed in the guidelines for respiratory concerns. Although only bags with dose rates of less than or equal to 2 mR/hr were selected for sorting, the potential existed for intake of respirable contaminants from those being opened. Because the test could not provide for engineered respiratory controls, comprehensive air sampling was performed followed by daily analysis. In addition, daily composites were made from rejected, (greater than ASP), radioactive trash which were analyzed daily. Alarming air monitor setpoints were determined based on .25 x MPC for the limiting nuclide identified from daily analyses of air sample media or sample composites. Trash sorting personnel received weekly body burdens to further control the potential for, and to identify, any intake.

SORTING RESULTS

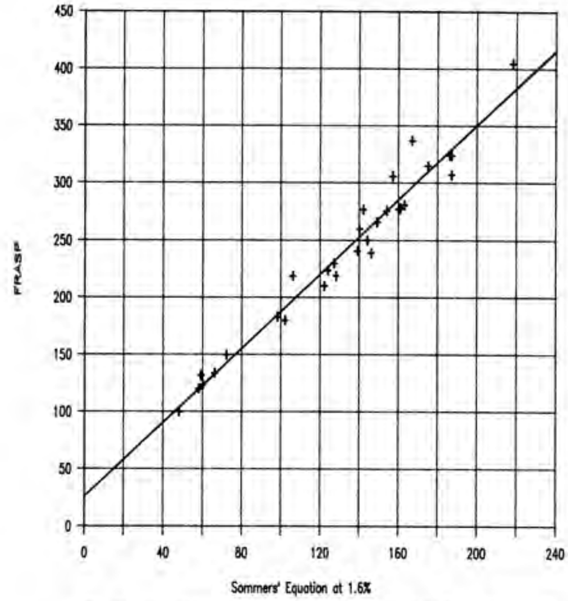
Documentation was developed to provide historical records for mass balance determination. The volume reduction ratio was calculated on worksheets by dividing "clean" trash mass by total trash mass. "Clean" trash mass included non-reclaimable items frisked without alarm. Total trash mass included the sum of "clean" trash, contaminated trash and reclaimed article mass. Reclaimable article mass included repairable Anti-Cs and respirators, tools, equipment (including metals) and wet articles.

Over 3,000 lbs. of qualifying paper or paper equivalent density trash from the DAW stream was surveyed with approximately 90% sorted out as having undetectable activity. About 10% of the station DAW did not qualify for sorting because of its origin (high contamination potential) or because the contact dose rate measured external to its container exceeded 2 mR/hr. The total trash sorting test effort yielded a volume reduction potential for qualifying waste of 89% based on a counting instrument alarm setpoint of approximately 5,000 dpm/100 cm^2 (see Table I). The volume reduction potential for the entire DAW stream was estimated to be 80%. It should be noted that very little reclaimable articles were found.

It is recognized that the stated volume reduction potential is specific to Catawba Nuclear Station for the conditions under which it was determined. Unit 1 had been operational for 2 years and Unit 2 had been critical less than a year. We expect the VR potential to decrease somewhat in the future as a function of plant maturity, housekeeping and other changing radiological parameters.

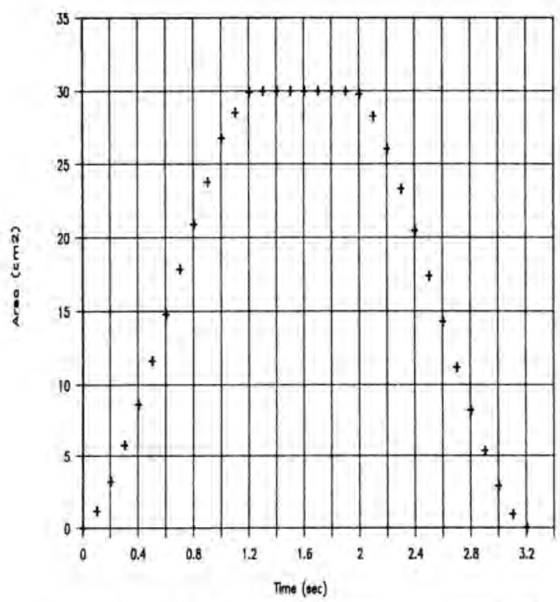
ECONOMIC ANALYSIS

Simplified economic analysis calculations were performed based on the results of the sorting study and purchase of semiautomated equipment in order to determine



The plotted points on this graph represent the data from thirty-one trial experiments. The "Y" coordinate represents the fast response alarm setpoint (FRASP) that was used during a trial, and the "X" coordinate represents the calculated alarm setpoint for that trial using Sommers' equation with a RM-14/HP-260 efficiency of 1.6%.

Fig. 1. Linear Regression Data Graph.



This graph represents the effective detection area of the HP-260 probe as it moves over a 10 x 10 cm. source at a height of 1/2" with a relative velocity of 2" per sec. between the source and the probe for a time period of 3.1 seconds.

Fig. 2. HP-260 Effective Area (moving).

TABLE I

Volume Reduction Ratio

Phase	Contaminated Mass (lbs)	Clean Mass (lbs.)	Reclaimable Articles (lbs)	%
I	138.5	856	32	83
II	108	801	8	87
III	80	1270	0	94
Total	326.5	2927	40	89

TABLE II

Benefit to Cost Ratios

VR %	PV of Costs ($)	PV of Benefits ($)	B/C Ratio
80	626,175	1,963,957	3.14
70	626,175	1,718,817	2.74
60	626,175	1,473,677	2.35
50	626,175	1,228,537	1.96
40	626,175	983,397	1.57
30	626,175	738,257	1.18
20	626,175	493,117	.79

the cost effectiveness of such a purchase. Several VR percentages were used because of the different radiological parameters at the different Nuclear Stations in the Duke System. Following are the equations and assumptions used:

Project Costs:

- Equipment, initial cost of \$500,000, lifetime of 5 years, interest rate of 12% per year.
- Operating and Maintenance cost of \$35,000 per year.

Present Value of Costs:

PV of costs = \$500,000 + (P/A, 12%, 5)(\$35,000)

= \$500,000 + (3.605)(35,000)

= \$626,175

Benefits:

- Disposal costs from a percent VR of an assumed 17,000 ft/year DAW waste generation at \$40/ft^3 can be avoided.
- Net salvage value of \$5,000 at the end of the 5th year.

Present Value of Benefits:

PV of Benefits = (P/A, 12%, 5) (17,000 ft^3) (VR)(\$40/ft^3) (P/F, 12%, 5)(\$5,000)

= (3.605)(\$680,000)(VR) + (.5674)(\$5,000)

= \$2,451,400 (VR) + \$2,837)

Benefit to Cost Ratio:

B/C = (PV of Benefits)/(PV of Costs) In this analysis, if the present value of the benefits exceeds that of the costs (B/C >1) then the project is considered economically viable. As can be seen in Table II, it appears that the decision to implement a sorting program will be economically viable as long as a VR between 20 and 30% is obtained.

DAW VR PROGRAM DEVELOPMENT

As a result of the VR Study, Duke Power Company developed an overall DAW reduction program system wide. The major components of this system are: management commitment, General Employee Training (GET), RCA trash segregation by color coded drums, bag tracking and trash segregation through the use of state-of-the-art equipment.

In the General Employee Training (GET) all station workers and vendors are taught radwaste minimization techniques. Through this training volume reduction is obtained by a reduction in the volume of unnecessary materials being brought into the RCA, proper disposal of materials that are brought into the RCA, and protection and reuse of equipment used in the RCA.

As described before, color coded drums are used to initially segregate materials used in the RCA. If used properly, this results in a very effective drum controlled volume reduction technique with an excellent cost/benefit ratio.

Bag tracking is a method of identifying where each bag of trash originates. The personnel involved in collecting the bags label each with a location and drum number. Through bag tracking, areas of high contamination can be isolated and studied. Also, if a bag from an area is discovered to have been used improperly or to contain excess contamination, it can be tracked back to where it came from. Since the drums are emptied daily, often the source of the contamination can be identified and corrected in a short period of time.

This leads us to the most important component in any radwaste minimization system, management commitment to the program. Without it, none of the administrative programs would be effective. Once the source of a problem is identified, there must be action taken to minimize its recurrence. Since radwaste minimization is a station problem, not just a Health Physics or Radwaste problem, management support is needed for reinforcement. The final component of the DAW VR Program is the trash segregation equipment. Duke Power decided to purchase state-of-the-art equipment to sort trash. It consists of a three stage process: a sorting booth which is a manual stage, a conveyor monitor for redundancy and an aggregate monitor for final QA. A shredder is also used to ensure a constant detection geometry that also produces an unrecognizable product.

CONCLUSIONS

The DAW volume reduction program has been fully implemented at all three of Duke Power Company's Nuclear Power Stations since January 1, 1988. The operating algorithms of the sorting equipment have been optimized to encompass the regulatory guidance found in: IE IN 85-92, Regulatory Guide 1.86 and system release criteria (3, 4, 5). The potentially contaminated material that qualifies for sorting is presorted by obtaining external dose rates from the bagged material. Bags that read less than or equal to 2mR/hr are sent through the sorting equipment. Bags that are from 2 to 10 mR/hr are presorted to remove articles that may be causing the higher dose rate. Bags that are greater than 10 mR/hr are sent to the compactor to be disposed of as contaminated material.

At this time the equipment is being operated to sort material into that which has detectable contamination and that which does not. The sorting table is being operated so that the MDA does not exceed 5000 dpm/100cm^2 with a 95% confidence level. This can only be done in a relatively low background area or the count times become restrictive and productivity drops off drastically. The conveyorized monitor has a comparable MDA setpoint based on the respective area of the detector. The bag monitor setpoint is based on the area of the detector and the setpoints of the other equipment to ensure that there has not been an accumulation of activity slightly below the other setpoints.

Based on the simplified economic analysis calculations, and the assumption that intermediately contaminated trash (0-5000 dpm/100cm^2) does not constitute a large share of the total trash volume, it appears that the decision to implement a sorting program will yield both substantial burial cost savings and burial space conservation. Even if intermediately contaminated, or very low-level trash represents a larger fraction of the DAW stream than assumed, then an approved de minimus or a BRC application pursuant to 10CFR 20.302 will provide the "clean" disposal option and allow the company to optimize the aforementioned benefits of a trash sorting program. Initial results from sorting of qualifying trash indicate a 65 to 70% reduction, however, only a relatively small portion of the potentially contaminated waste stream has been qualified for sorting at this time. Therefore, a corresponding VR can not be determined this early in the implementation stage of the program. In the long run, based on initial experience and current industry experience, Duke Power expects to see approximately a 40% VR without an approved BRC application that will be pursued.

It is apparent that trash sorting offers substantial benefit to the Company from both economic and environmental standpoints. Economically it provides the potential to save substantial burial costs, and, moreover, it provides the Company an opportunity to play a larger role in the industry's efforts to be environmental stewards preserving ever dwindling burial space.

REFERENCES

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5. Definitions Section, "System Health Physics Manual", Duke Power Company, Revision 4, May, 1987.