# RECYCLE OPERATIONS AS A METHODOLOGY FOR RADIOACTIVE WASTE VOLUME REDUCTION

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## ABSTRACT

The costs for packaging, transportation and burial of low level radioactive metallic waste have become so expensive that an alternate method of decontamination for volume reduction prior to disposal can now be justified. The operation of a large scale centralized recycle center for decontamination of selected low level radioactive waste has been proven to be an effective method for waste volume reduction and for retrieving valuable materials for unlimited use.

The centralized recycle center concept allows application of state-of-the-art decontamination technology resulting in a reduction in utility disposal costs and a reduction in overall net amount of material being buried. Examples of specific decontamination process activities at the centralized facility will be reviewed along with a discussion of the economic impact of decontamination for recycling and volume reduction.

Based on almost two years of operation of a centralized decontamination facility, a demonstrated capability exists. The concept has been cost effective and proves that valuable resources can be recycled.

## CURRENT DISPOSAL COSTS

The plant modification process, which includes replacement of piping, valves, pumps, heat exchangers and other large components generates large volumes of metallic low level radioactive waste. This metallic radwaste requires disposal. Until recently the most economical and probably the only viable means of disposal for this kind of material has been burial at one of the three existing commercial burial sites at Beatty, Nevada; Richland, Washington; or Barnwell, South Carolina.

There are a number of obvious costs associated with burial of metallic waste and there are some potentially hidden costs. The direct costs are for transportation and burial fees. The less obvious costs include cost of containers, labor for on site packaging and shipment preparation and arrangements to secure burial space. Disposal by burial of low level radioactive waste is not only costly but has become increasingly difficult with the added characterization and classification requirements of Title 10, Part 61 of the Code of Federal Regulations (10CFR61), and other rules regarding land disposal of waste. Also space allocation at Barnwell and political pressures at Beatty have added to the complexities associated with disposal. In addition, the formation of State Low Level Radioactive Waste Compacts is expected to increase the dollar per cubic foot burial charge even more in the years to come. For these and other reasons, the value of reducing volume, even at the expense of increased specific activity of the waste, more than justifies the consideration of additional volume reduction processes prior to disposal.

Table 1 shows a cost comparison for disposal of 2500 cubic feet of low level radioactive metallic waste at the various burial sites vs. disposal via the Quadrex HPS Recycle Center. The less obvious costs discussed earlier have not been included in this comparison and would increase the margin of difference between cost of burial and cost of recycling.

## DECONTAMINATION ACTIVITIES AT A CENTRALIZED FACILITY

Quadrex HPS Inc. owns and operates a Recycle Center in Oak Ridge, Tennessee, which is licensed by the State of Tennessee to store and process low level radioactively contaminated materials. Fig. 1 depicts the flow of radioactively contaminated metallic waste when handled through a central facility. The recycle center employs state-of-the-art as well as time proven decontamination techniques. These techniques include Quadrex HPS patented high pressure Freon®* cleaning; chemical and electro-chemical cleaning; mechanical and abrasive cleaning; and conventional cleaning methods. Fig. 2 summarizes the major decontamination processes employed at the Recycle Center.

As shown in Fig. 2, the chemical decontamination processes use various dilute and concentrated acid as well as caustic solutions to clean metals by dissolution of the radioactive surface corrosion film. The electrochemical process removes base material and thus effectively removes both fixed and smearable contamination from a variety of alloys. High pressure Freon® and mechanical decontamination processes are effective in removing surface activity from a variety of metallic and non-metallic materials. The resulting concentrated radioactive waste by-products, packaged for shipment and burial, *are five to fifteen* percent of the before-processing volume. This amounts to an average volume reduction factor for burial of seven to ten.

*Freon is a trademark patented by DuPont

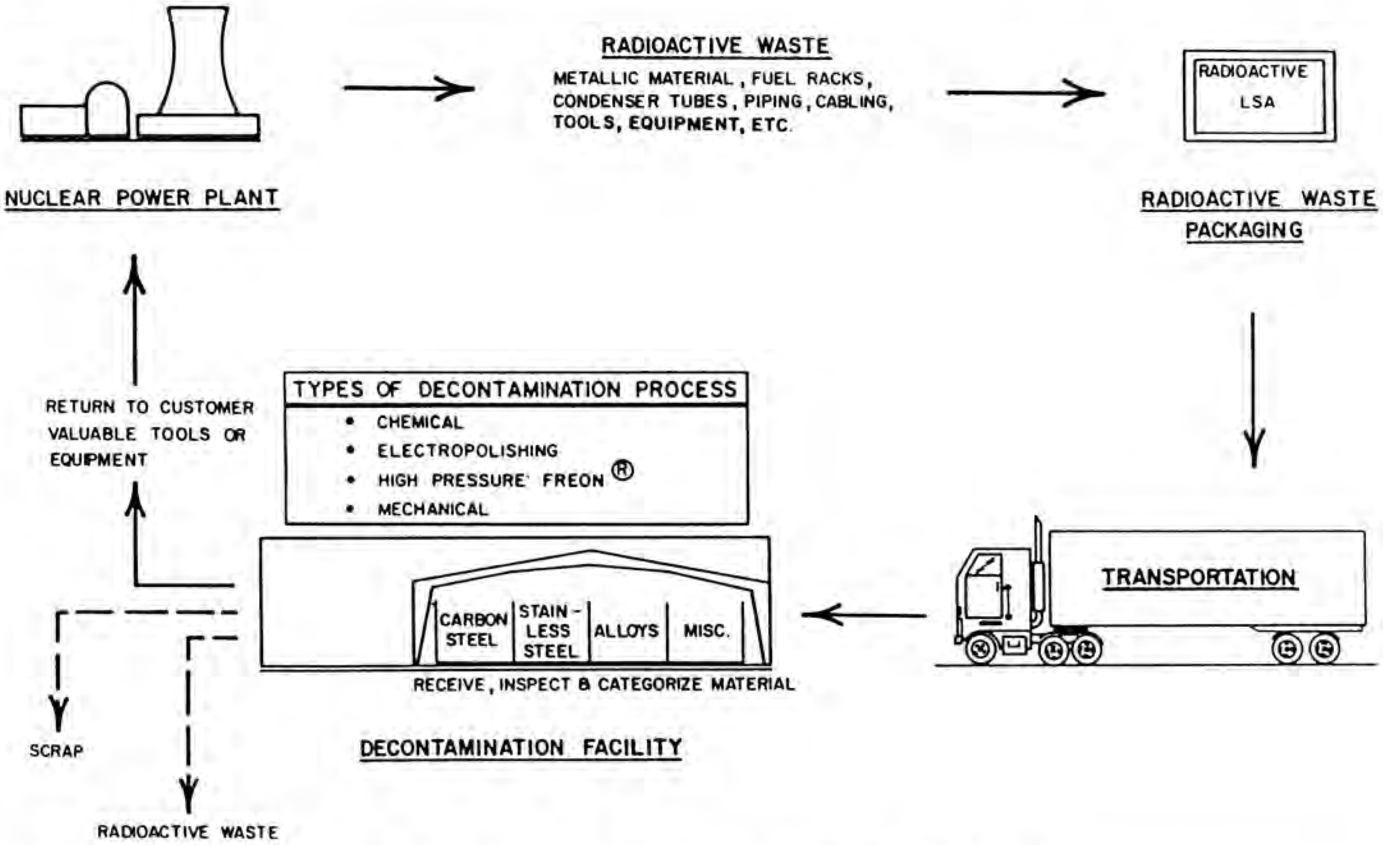


Fig. 1. Centralized decontamination and recycle facility.

# Decontamination Processes

| PROCESS | CLEANING MEDIA | MATERIAL PROCESSED |
|---|---|---|
| CHEMICAL | PHOSPHORIC ACID<br>SULFURIC ACID<br>NITRIC PLUS HYDROFLUORIC ACID<br>RINSE WATER | COPPER<br>ADMIRALTY BRASS<br>ALUMINUM<br>STAINLESS STEEL |
| ELECTROPOLISH | PHOSPHORIC ACID<br>SULFURIC ACID<br>RINSE WATER | STAINLESS STEEL<br>CARBON STEEL<br>COPPER |
| GRIT BLASTER | ABRASIVES | PAINTED, CORRODED<br>FIXED |
| "FREON" CLEANING UNITS | "FREON" 113 | SMEARABLE CONTAMINATION |
| HYDROLASER | HIGH PRESSURE WATER | NON-ELECTRICAL COMPONENTS |

Fig. 2. Decontamination Processes.

TABLE 1. BURIAL VS RECYCLE CENTER FEES

| | BARNWELL | RICHLAND | BEATTY | RECYCLE CENTER |
|---|---|---|---|---|
| Cubic foot charges | 63,725(A) | 54,400(B) | 44,625 | 50,000 |
| NIS Audit Charges | | | 8,750 | |
| Transportation | 1,200 | 5,540 | 4,910 | 1,200 |
| TOTALS: | $64,925 | $59,940 | $58,285 | $51,200 |
| | 25% higher | 17% higher | 14% higher | |

Notes/Assumptions

1) Single large container weight of 30,000 lbs. with average radiation dose of less than 50 mrem/hr.
2) Originating location is 400 miles from recycle center, and Barnwell, 2,050 miles from Beatty, and 2350 miles from Richland.
3) (A) Above includes Perpetuity Escrow Fund, South Carolina LLRW Disposal Tax, Southern Region Compact fee and Barnwell County Business License Tax.
4) (B) Above includes Perpetual Care & Maintenance, Site Closure Fund and Radwaste Surveillance Surcharge.

For certain components such as condenser tubing, recirculation piping, fuel storage racks, structural steel, heat exchangers, hand tools, scaffolding, zircalloy tubing and miscellaneous scrap items, it is cost effective to remove the surface radioactivity, volume reduce the wastes, and release the decontaminated material for reuse.

COMPONENTS AND PROCESSES

The objective of the Recycle Center is the unconditional release of material on a profitable basis, at costs lower than landfill burial. The condenser tubing processed has been of high copper content, such as 90/10 Cu-Ni and Admiralty metal 71% Cu. Recirculation piping is made of type 304 stainless and fuel storage racks are steel and aluminum. Scaffolding and scrap items are iron, steel and aluminum.

Processes for volume reduction include chemical, abrasive, Freon®, and electro-chemical, which are effective in removing fixed or smearable radioactive contaminants from surfaces.

The following are some examples of the more interesting and challenging problems encountered in volume reduction activities, and highlights of more routine processing. The sample processes are:

- Chemical cleaning - Solutions of $HF/HNO_3$ have been found very effective for cleaning aluminum and stainless steel.
- Abrasive processing (sand or glass bead blasting) have been applied to difficult decontamination situations such as finned tubed moisture separator reheaters.
- Electrochemical decontamination involves removal of surface material to depths of 1 - 3 thousandths of an inch. This process is carried out in electrolyte solutions which may contain sulfuric acid additions in concentrated phosphoric acid.

The sample tasks are:

- Recirculation Piping from BWRs: Several different sizes of contaminated stainless steel piping have been received at the Recycle Center. The wall thickness of the pipe ranged from 1/2 to 3.5 inches depending on the diameter. The diameter ranges up to 28 inches. The piping was first cut into manageable lengths and activated portions removed. The non-activated pieces were then processed in a nitric and hydrofloric acid mixture from 100 to 10,000 mr/hr to levels ranging from 5 to 100 mr/hr. Smearable contamination levels were reduced from highs of over 15 million dpm/100 $cm^2$ to less than 5000 dpm/100 $cm^2$ when measured immediately after processing. The pieces were then electropolished to reduce the contamination levels to less that 500 dpm/100 $cm^2$ and released for scrap.
- Condenser Tubing: Decontaminating condenser tubing is challenging because of the lengths and quantities involved. Very large volumes of chemicals and rinse water are required and the presence of a solid copper sulfate precipitation by-product must be accommodated to avoid retention of activity by carry-over on already-cleaned surfaces. To keep the process cost effective, very careful chemical control is required. Initial smearable contamination levels on condenser tubing have been measured as high as 10,000 to 500,000 dpm/100 $cm^2$. The process described above reduces these levels to less than 500 dpm/100 $cm^2$ enabling unrestricted release of the tubing.
- Other components: The Recycle Center has the capability to section very large items such as feedwater heaters, moisture separator reheaters, regenerative heater exchangers, let down coolers and the like.

Tubing from moisture separator reheaters (MSRs) presented special problems. First, the outside surface contains fins which increase heat transfer efficiency. These fins, approximately 1/10" high and spaced on 1/16" centers, run normal to the axis along the length of each tube (screw-thread). This type of surface was not designed with decontamination in mind. Secondly, to further complicate the decontamination process, tubes form some MSR components were covered by spots of ferrite deposits that defied removal by chemical processing. The tube material in this case was a copper alloy which required abrasive blasting to effectively decontaminate.

Rejected zircalloy tubing from nuclear fuel manufacturing processes presents another challenging problem. The tubes of varying length became contaminated internally from the loading and unloading of uranium dioxide fuel pellets. High pressure Freon® 113 is used to remove the internal surface contamination. The Freon® is continuously recycled and distilled for purification; a process which concentrates the $UO_2$ particles as solid waste, yielding a volume reduction greater than 100 to 1.

Most other contaminated materials including stainless steel and aluminum spent fuel storage racks, structural equipment, as well as miscellaneous site materials can be decontaminated using one of the chemical, electrochemical or mechanical processes previously described.

An important note on the Recycle Center operation. Although it may sound simple enough to operate a centralized decontamination facility, it is not. The assets required are capital intensive and require skilled personnel to function correctly and safely. The combination of radioactivity and chemicals in the same plant necessitates that at least one fourth of the personnel be assigned to health physics and chemistry related activities, including radwaste management, radiation protection and laboratory operations. A centralized decon facility must meet the same stringent ALARA requirements as any nuclear facility. The license requires that materials released from the Recycle Center for unrestricted reuse must contain less than 1000 dpm/100 $cm^2$ smearable contamination and less than 5000 dpm/100 $cm^2$ fixed and smearable combined. Our administrative objectives are the minimum detectable amounts (MDA) or 10% of the licensed limit.

## SUMMARY

Historically, decontamination processes have been thought of as a man-rem reduction technique. However, the spiraling costs of packaging, transporting and burying of large volumes of metallic radwaste now make the application of decontamination techniques for volume reduction cost effective. Decontamination for volume reduction at a centralized facility has been demonstrated to be cost effective and efficient, as well as a much simpler means of disposal for the generator.

The following table shows typical volumes of contaminated material processed and the associated percentage of each volume sent to burial.

| Volume Processed Cubic Feet | | % Burial |
|---|---|---|
| Misc Scrap | 28,000 | 15% |
| Aluminum Spent Fuel | 10,000 | 5% |
| Scaffolding | 2,000 | <½% |

The centralized Recycle Center concept applies state-of-the-art decontamination technologies to reduce the cost of disposal and the quantity of low level metallic waste actually buried by a factor of nearly 10 to 1. Just like the recycle of aluminum soft drink cans, this extends the useful life expectancy of burial facilities as well as conserves our natural resources and environment. Volume reduction by decontamination combined with recycling, we can economically and environmentally manage large volumes of low level metallic radwaste.