OPTIMIZATION OF PWR WASTE WATER TREATMENT: A CASE STUDY - CONSOLIDATED EDISON-INDIAN POINT II

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ABSTRACT

The Waste Policy Amendments Act of 1985 has mandated specific volume limitations for waste generators and disposal sites. This, combined with increasing cost, has caused added emphasis to be placed on waste minimization and volume reduction. Since waste streams, as well as technical specifications for water release or re-use, differ from plant to plant, this effort to minimize and reduce waste must be site specific.

Over the past several years, numerous water treatment technologies have become available and have resulted in reduced waste generation. This paper discusses the combination of various technologies Chem-Nuclear Systems, Inc. has applied to process Indian Point II's liquid waste streams, resulting in an effective waste reduction program. Included in this discussion is the station's waste reduction program history, actions and results illustrated by the change from evaporation to state-of-the-art liquid waste processing. The paper demonstrates that the Indian Point experience has direct application to other PWRs in the areas of: (1) attempting to achieve the desired results through in-plant systems, (2) evaporator availability, (3) dealing with a waste stream which fluctuates over a broad spectrum and (4) changing from total waste water recovery to discharge.

BACKGROUND

The Indian Point site, located in the northern part of Westchester County, New York on the Hudson River, is comprised of three pressurized water reactors. Consolidated Edison Company of New York (ConEd) owns Indian Point 1, which is now retired from service*, and Indian Point 2 (IP2), an 890-MWe Westinghouse unit. Indian Point 3 is owned and operated by the New York Power Authority, a public benefit corporation of the State of New York.

EVAPORATION

Until May 1981, essentially all liquid wastes were processed using evaporation followed by solidification of the concentrates. Waste was transferred from the collection tanks to the waste evaporator package through the evaporator feed filters.

Waste water was fed into the evaporator until the bottoms boron concentration reached 10,000 ppm. Bottoms were then discharged to the evaporator bottoms tanks, and a new batch feed began. The stream was then condensed using cooling water and sent to the distillate storage tanks. The distillate was discharged to the river. The evaporator bottoms were pumped to a holding cask under the control of Chem-Nuclear Systems, Inc. The bottoms were then solidified in a shipping container with cement and shipped for burial.

Significant operational problems were experienced with evaporation. River water containing chlorides ranging from 20-1,000 ppm entered the system periodically, causing localized corrosion within the evaporators and "rocking-up" of one of the units. The two units have never operated at their rated capacity of 25 gpm each. An undersized condensate return line caused backpressure to auxiliary steam entering the unit, making it difficult to operate the evaporation at the rated capacity of 25 gpm. Carryover of contaminants to the waste distillate monitor tanks created a radiation area near the tanks requiring them to be fenced off and posted. Finally, effective operation of the system through lack of chemical additions and monitoring of solids concentrations could lead to fouling of the units and pump damage.

* IP1 was removed from service in 1974; however, some of its facilities are used on a daily basis for support services for IP2 and processing of liquid radwaste from IP2.

Plant Changes

Since May 1981, all plant liquid radwaste has been processed using demineralization by Chem-Nuclear Systems, Inc. The change to demineralization eliminated essentially all of the problems associated with evaporation and provided a Volume Reduction factor of over 700:1.

Initially Chem-Nuclear responded to Con Edison's need for on-site water processing during an evaporator outage. To process the daily water needs, Chem-Nuclear set up a multibed pressurized demineralizer system incorporating disposable demineralization vessels. This initial system provided easy set up flexibility in handling a variable waste stream and still possessed the ability to process large volumes of plant waste water. The actual mobile demineralization system consists of three major components: The control skid, the disposable demineralization/filtration process vessels and individual shields.

Control skid

The technician controls the operation of the Mobile Demineralization System from the control skid. Connections between the plant piping and the process vessels use flexible hose. The control skid contains a pump, valve piping, and process instrumentation with which a variety of vessel types may be used. Dimensions are approximately 4 feet high, 4 feet wide, 5 feet long. The control skid pressure vessels and hoses are designed and tested for a working pressure of 150 psig (100 psig for containers).

Disposable Process Vessels

Carbon steel vessels are code stamped to ASME Section VIII for operating pressures up to 150 psig. Various sizes are available to meet different process requirements. The most common vessel used is 24 inches in diameter. Various heights from 51 to 72 inches are available to ensure compatibility with existing shipping casks. All carbon steel vessels are limited to an activity loading of 1 microcurie/cc for isotopes with half lives greater than 5 years.

For waste streams where the activity removed by the vessel is expected to exceed the 1 microcurie/cc limit, the Fiberglass Reinforced Plastic (FRP) vessel is recommended. The vessel is licensed as a High Integrity Container and may be loaded to 350 microcuries/cc. The vessel is 24 inches in diameter and 72 inches tall. It is designed to ASME Section VIII for operating pressures up to 150 psig.

Both types of vessels are capable of volumetric flow of up to 100 gpm. Where resin utilization and decontamination factors are critical, 50 gpm is the maximum flow rate recommended, which is equivalent to a cross sectional flow rate of 15.9 gpm/ft^2. Typically, for any ion-exchange application the cross-sectional flow rate should be limited to a source range of 10-17 gpm/ft^2 to minimize channeling. Chem-Nuclear employs a series operation, i.e., two or more vessels of the same media, to reduce the possibility of ionic breakthrough. additionally, the depth-to-diameter ratio further minimizes the impact of ionic breakthrough and maximizes media utilization.

All Chem-Nuclear pressure vessels can be loaded with any ion-exchange/filtration media available today. The specific media used depends on influent characteristics as well as the effluent quality desired.

Experience has shown that for maximum utilization of demineralization/filtration media capacity, pre-treatment is often required. This pre-treatment is usually activated carbon for gross organic removal and/or filtration to remove suspended particulate. Both of these methods are used to protect the ion-exchange resin and other process media from premature depletion due to fouling or poor kinetics.

Activated carbon is used in a disposable pressure vessel. For filtration, a stainless steel filter housing with replaceable cartridges is used. The housing is ASME code stamped for operating pressures up to 300 psig. Cartridges ar available from 0.1 micron absolute.

Individual vessels may be fitted with headers containing inlet, outlet, by-pass valves, and sample points. Use of these headers requires the by-passing and sequencing operations take place at the vessel.

Chem-Nuclear's on-site technicians operated the Mobile, Pressurized Demineralization System at Indian Point from 1981 until 1985. Numerous demineralization and filtration medias were tested and utilized during this period of time. Additionally, the standard system was designed to incorporate a remote valving skid to further reduce exposure to the operator. In April of 1985, Chem-Nuclear introduced the next evolution in mobile waste water treatment, the Chem-Nuclear Fluidized Transfer Demineralization System (FTDS). This system was designed to increase operational efficiencies while decreasing personnel exposure and disposal volumes. The key difference in the two systems is that of sluicing of medias from reusable permanent pressure vessels. In this manner disposable vessels are eliminated:

Chem-Nuclear's Fluidized Transfer Demineralization System (FTDS) consists of the following equipment:

- 7.5 HP Booster Pump (capable of flow rates up to 150 gpm)
- 5 FTDS Vessels 24" in diameter x 72" in height (10.5 ft^3 each)
- Demineralization Process Control Unit
- Resin Transfer Unit
- Effluent Mechanical Filter Housing
- Interconnecting hoses

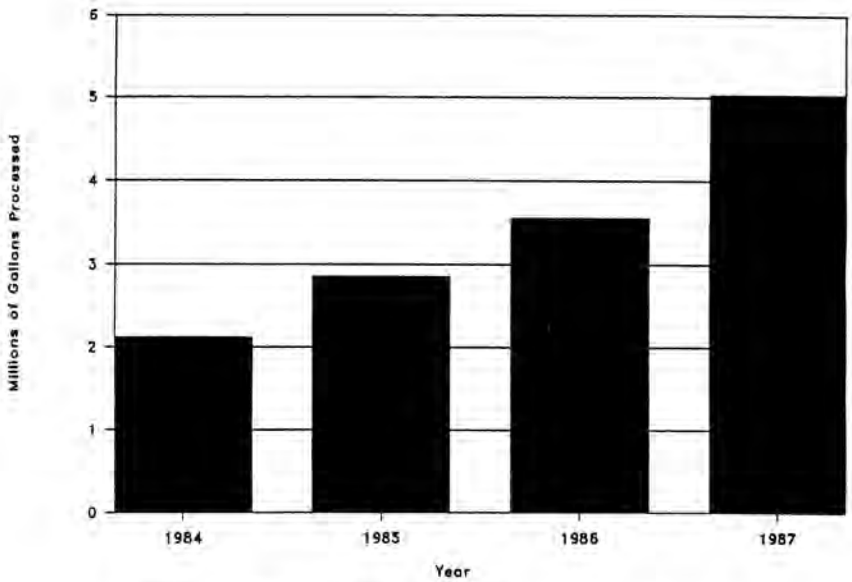


Fig. 1. Indian Point #2 Total Liquid Radwaste Processed.

FTDS Vessels

The FTDS Unit is designed to employ reusable stainless steel pressure vessels (Fig. 1) (ASME Code Stamped) capable of containing any ion-exchange media commercially available today. A down-flown approach is used. The vessel size can be adjusted to meet almost any physical constraints. Vessel dimensions generally are 24 inches in diameter by 72 inches in height. They are capable of flow rates up to 100 gpm. The cross-sectional flow rate is 16.0 gpm/ft^2. the vessels are fabricated with resin retention elements (Johnson screens) on the influent and effluent distribution headers equivalent to 60 mesh. The new fill port and spent resin out headers have isolation valves to prevent media migration.

Process Control Unit

The Process Control Unit acts as an interface between the Chem-Nuclear equipment and the plant. The design and fabrication of radwaste piping complies with applicable Federal and State regulations, i.e., REG Guide 1.143 and ANSI B31-1. Welded construction and fully ported valves are employed where possible to reduce the possibility of crud traps. All welding is performed by certified Section IX welders. All systems are hydrotested to 225 psig for an effective operating pressure rating of 150 psig.

The control unit contains the influent and effluent distribution piping, isolation and throttling valves, sample points to monitor influent and effluent of each FTDS vessel, and temperature, flow, and pressure indicators. In addition, the unit contains in-line sensors for the continuous monitoring of system influent and effluent conductivity and temperature. Individual vessels are fitted with headers containing inlet, outlet, and bypass valves.

The Demineralization Control Unit also contains instrumentation for the continuous monitoring of the system influent and effluent pH and conductivity. The control unit has the capability to monitor the influent and effluent pH and conductivity of individual vessels if required. the Demineralization Control Unit incorporates an integral sample sink is fitted with pressure gauges to measure differential pressure across major components of the system. The control unit also houses flow rate and flow totalizer instrumentation.

Resin Transfer Unit

The unit contains two manifolds, one for new resin transfers and one for spent resin transfers. These headers are designed with 45° angles, where possible, to reduce the potential for resin plugging.

Spent resin transfers can be accomplished with gas (nitrogen or air), service water, or filtered waste water.

The design and fabrication of the Transfer Unit also complies with NUREG Guide 1.143 and ANSI 31.1. All piping is hydrotested to 225 psig. Envelope dimensions are approximately (60"L x 28"W).

Effluent Mechanical Filter

Chem-Nuclear provides stainless steel filter housings utilizing disposable cartridge filters as the pre and post vessels in the process system. The first filter is for the pre-filtering of waste water prior to entering FTDS vessels. The second vessel acts as a polishing filter if colloidal and/or sub-micron particulates become a problem. Various types of cartridges with ratings from 0.1 micron absolute up to 50 micron are available depending on process requirements. The filter housings are designed to ASME Code Section VIII for operating pressures up to 300 psig and are hydrotested to 450 psig. Sampling of the vessels' influent and effluent is available.

Interconnecting Hoses

The hoses used for interconnecting the system components are pressurized continuous reinforced, non-collapsible hoses. Other system hoses are of rubber construction. All hoses are connected to the piping with quick connects.

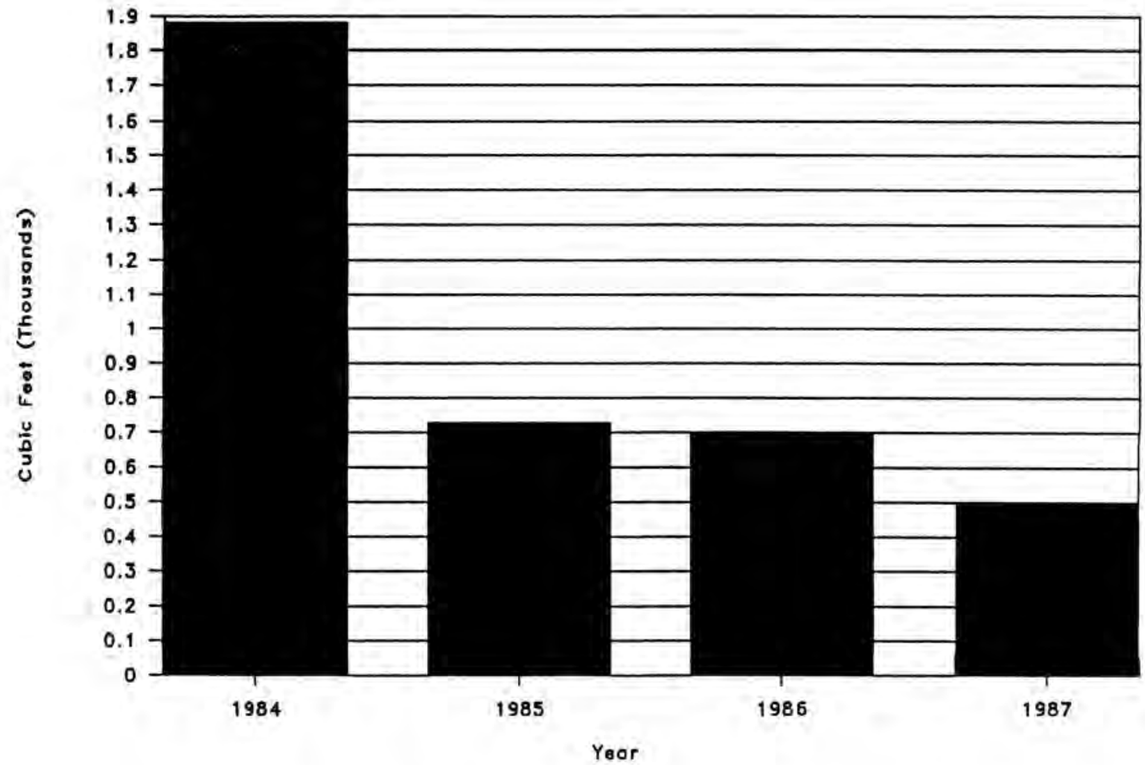
SUMMARY

In operations with the system, we have experienced significant improvements in resin and filter media throughputs while substantially reducing total radwaste generation. As shown on Table I and Figs. 1, 2, and 3, the total volume of waste water has increased due to a variety of plant operating conditions. While waste water volumes have increased, the total throughputs have increased due to:

- More predictable water qualities: Elimination of chemical regeneration of boric acid recycle beds, reduction of in-leakage of high chloride river water, desludging of five radwaste hold-up tanks, and improved area decontamination have all combined to reduce average waste water conductivity from 800 to 1000 umhos/cm to less than 100 umhos/cm.
- Improved media/filtration selection; Increased usage of medias with specific radioisotopic application to the waste stream and ongoing experimentation with new medias through column testing.

We have also experienced better throughputs by fluctuating our water processing rates.

The key benefits to this system are reduced radioactive waste volume and lowered man-Rem exposure. Final volumes of waste medias and filters are packaged in High Integrity Containers. This high efficiency packaging dramatically decreases the number of shipments and resul-



NOTE: Sluiceable Resin System Installed April 1985.

Fig. 2. Indian Point #2 Liquid Radwaste Resin and Filter Volume.

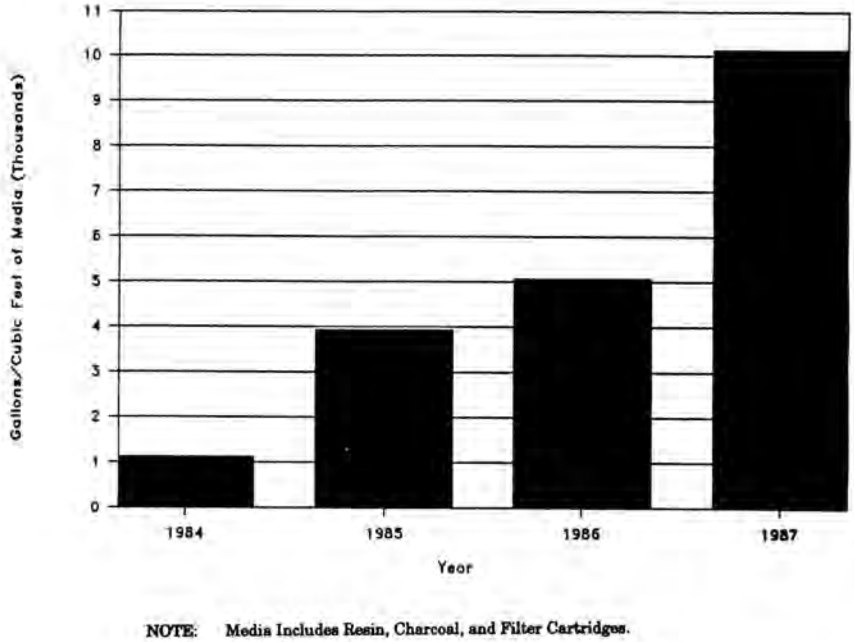


Fig. 3. Indian Point #2 Liquid Radwaste Media Throughput.

TABLE I

Total Radwaste Generation

	1984	1985	1986	1987
Total gallons	2,114,830	2,852,570	3,550,562	5,027,860
Waste media burial volume (resin & ion specific materials packaged for shipment cu. ft.)	(1,534)	(582)	(582)	(388)
Mechanical filters, burial volume when packaged cu. ft.	348	144	117	108
Gallons/cu. ft. of expended media	1,124	3,929	5,079	10,137

tant disposal volume. Additionally, this efficient packaging methodology decreases handling of radioactive materials during dewatering, sampling, labeling, loading and shipping. The result is far lower exposures to on-site and off-site personnel.

After seven years of implant processing Con Edison has reduced radioactive waste volume generation and personnel exposure through the use of flexible and efficient waste water clean-up technologies. A plant's decision to alter waste treatment techniques is a very involved and complex undertaking. Constant attention to all parameters, from plant operating conditions and plant/management philosophy to dependability and performance characteristics of the service vendor's equipment, have to be analyzed.

Consolidated Edison of New York plans to continue to maximize system efficiencies through media testing and alternate technology experimentation with its waste processing vendor.