# SURRY POWER STATION RADWASTE FACILITY: A PLANNED APPROACH TO LIQUID AND SOLID RADWASTE PROCESSING

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## ABSTRACT

Surry Power Station has been generating power since the early 1970's. Like many other "early" nuclear power plants, Surry had its share of plant problems which required unscheduled maintenance and repair. These efforts generated more radwaste than was anticipated and soon began to overload the designed radwaste treatment systems. Resulting inadequacies in the radwaste treatment system contributed further to area contamination which resulted in more radwaste.

In 1984, Virginia Power began to evaluate radwaste treatment technologies world-wide. Soon an A/E firm was contracted to study the situation at Surry and North Anna Power Stations. They were asked to evaluate current conditions, evaluate available technologies, and couple the needs and solutions into a recommended radwaste treatment approach. In early 1986, this study was completed and formed the original basis for Virginia Power's radwaste solution. In November 1986, Virginia Power selected JGC Corporation as the successful bidder for the New Radwaste Facility (NRF). Final facility specifications and the formal contract was signed in February 1987.

The Surry NRF was designed as a separate, stand alone facility utilizing proven technology. The facility has a complete HP access control system, a radiochemical laboratory, a full size decontamination facility, and a "hot" machine shop. The facility can meet the design goals of $<0.1$ Ci/yr liquid waste discharge (excluding tritium) and a solid waste volume of under 225 $m^3$/yr/unit.

## FACILITY REQUIREMENTS

The NRF requirements fall into two categories. The first is the specific processing capabilities based on anticipated waste streams. The second category (discussed here first) covers the less specific requirements that shape the overall intent, design and operation of the new facility. In brief, the intent of the NRF was to properly manage the processing of radwaste; the design was to solve problems and not create them; and the operation was to be efficient. Toward these ends, several criteria were developed for the NRF.

Separate, Stand-Alone Facility: Placement of new radwaste processing technology in the existing power station facilities was examined. Basically, there was no room. An option to remove all the old radwaste processing equipment was reviewed, but that option would have involved significant personnel dose and still would not have provided enough room. Backfitting new equipment into existing space and locations on this scale would not have allowed for properly engineered piping and equipment layouts. The concept of a separate facility transitioned into the concept of a dedicated facility. Virginia Power's review of world-wide methods and technology also showed that the separate, dedicated facility with its own trained staff outperformed facilities with mixed functions and responsibilities. Therefore, the NRF was to be a separate facility.

Proven Technology: Virginia Power was interested in processing radwaste, not processing the "bugs" out of newly designed or experimental systems. It was clearly stated from the beginning of the NRF design that only proven, commercialized equipment and methods would be accepted into the NRF facility. This was not to be an R & D effort.

Computer Based Operation: The NRF was to be designed such that it could basically run itself. A Distributed Control System (DCS) was to be designed to assist the operators in monitoring and running the radwaste processing systems. All functions of the NRF are to have manual operation capability. The DCS, however, provides a mechanism to optimize the operation of equipment, to verify valve line-ups and equipment status to help minimize any operator errors.

No Impact on Station Operations: Simply stated, no single failure in the NRF will adversely affect the operation of the power generating station which it serves. The NRF nor any of its functions are "Safety Related", but a single failure criteria was employed to ensure that there were always options to processing liquid waste from the station. Additionally, all tie-ins to the station systems were minimized and station utilities were avoided.

Other Special Concerns: Separate features required for the NRF include HP Access Control, Radiochemical Laboratory, Decontamination Equipment and a Hot Machine Shop. These functions were to integrate with and enhance, where applicable, the capabilities of the operating station in order to meet needs identified by station operations.

HP Access Control system was required to interface with station Health Physics (HP) records system. Some plant personnel would require access to both the plant and the NRF. Separate dose records would not be acceptable.

A Radiochemical Laboratory would be necessary to support the operation of the radwaste processes being performed in the NRF. Support would be needed for waste stream input characterization as well as waste form verification. The analytical capability of the lab would be greater than that in the older station and, therefore, could provide this additional analytical capability to the station as needed. This would reduce the need for off-site shipment of samples, for analysis, and reduce the turnaround time.

Decontamination Equipment would be provided to support the NRF maintenance activities. Additionally, the station requested the capability of decontaminating large quantities of outage scaffolding and large equipment up to and including a Reactor Coolant Pump motor.

Hot Machine Shop equipment was added to support both the station and the NRF. Equipment sizing and reduction was coordinated with station maintenance to optimize the NRF's support to the station during outages.

Radwaste Transfer Tie-Ins: This area is not the specific subject of this paper, but will be briefly mentioned here. The station's low level waste storage tanks and the station's laundry drain system were to be connected to the NRF by an underground transfer trench. Additionally, processed liquid waste water would be returned to the station for release at the existing release points. All liquid transfers were piped and the concrete trench functioned as a waterproof pipe chase. The trench was to be equipped with a leak detection system. The transfer trench and the tie-ins to the station systems were not within the Scope of the NRF project contract with JGC Corporation.

The sizing of equipment and tanks were based on the liquid waste and solid waste volumes determined from the 1985-1986 study of existing conditions at the Surry and North Anna Stations. The volumes were chosen on a conservative but realistic basis. Liquid volumes, for example, were improving yearly due to station clean-up and leak prevention programs. But the study values for typical liquid volumes were maintained to provide a realistic margin. The following Table I presents the processing capabilities set forth as the requirements for the NRF.

The NRF also was to have the capability to handle, not process, 22 $m^3$/yr of high activity bead resin and up to 20 high activity filters. Both of these high activity items would be processed as needed in the power station prior to storage at the NRF.

**TABLE I**

Required Processing Capabilities

| | |
|---|---|
| Liquid Waste: | 15,000 gpd |
| Laundry Waste: | 10,000 gpd |
| Dry Active Waste: | 1,415 $m^3$/yr |
| Bead Resin: | 71 $m^3$/yr |

## FACILITY GOALS

The previous section discussed a variety of facility requirements. One obvious requirement was that the facility design and operation meet the established facility goals. The facility goals, at first seemed very optimistic. They were, however, determined from what had been demonstrated as achievable objectives. The goals were not to be met solely by the NRF but by an interaction of the station's activities, waste minimization efforts and the NRF processing capabilities.

The primary processing goals are as follows:

- Liquid Waste Releases < 0.1 Ci/yr (excluding Tritium)
- Off-Site Disposal Volume < 225 $m^3$/yr/unit
- All Processed Solid Waste < Class C
- No inadvertent gaseous releases
- Chemical Discharges < 50% NPDES limits

Additionally, ALARA goals were incorporated to increase radiation protection to the NRF workers. This was to be accomplished by design of systems (e.g. Flushing capabilities, removable components, etc.) as well as by layout and shielding.

Several features of the NRF design were established by the goal/requirement that the NRF not impact the station operations. Accordingly, the NRF options are such that the shutdown of any one of the liquid waste processing systems shall not prevent the continued processing of liquid or laundry waste. Tankage for the collection of liquid waste could store up to 5 days quantity at design maximum input flows. Under extraordinary circumstance the NRF could process up to 130,000 gpd of liquid radwaste (not including laundry waste).

Storage space in the NRF was to be sufficient to hold 1 year worth of processed solid waste (DAW, resins, solidified resins and concentrates). However, due to uncertainty at the time of design, regarding low-level waste disposal compacts, provisions were to be maintained for expandable on-site storage, if possible.

## FACILITY DESIGN

Many general considerations were in play while the detailed building and equipment layouts were being determined. As mentioned earlier, ALARA principles were being employed to the fullest possible extent. Radiation zones were determined in accordance with personnel occupancy frequency and durations. Shielding was provided to maintain the desired radiation zones. Equipment and piping designs were reviewed to identify and eliminate crud traps. Curbs were placed around all areas where liquid spills were possible. Equipment and concrete coatings were specified that would be decontaminable in the event of a spill. In summary, the design attempted to eliminate the source of contamination but, if it occurred, the clean-up capability exists.

Maintenance of all equipment was evaluated. Sufficient areas were reviewed for movement or laydown. Access to each valve and instrument was considered. Mobility out of a high radiation zone to a lower zone was considered in all practical areas.

The NRF was seismically designed in accordance with Regulatory Guide 1.143. The equipment in the NRF is all classified as "non-seismic" but all below grade (ground level) structures were designed to withstand the applicable OBE criteria for the power station. The below grade structures would function to contain any liquid, resin, or slurry which may spill during a seismic event.

The physical arrangement for the NRF is given in Figs. 1 and 2. Note the block wall construction shown on Level 1F between A1 and A3. This area provides for future storage expansion, if needed. Material transport pathways were checked for clearance including incoming waste and any equipment that may be moved throughout the facility.

The final approach to ensure a proper layout of the NRF was the development of a 3-D plastic model. All items (pipe, valve, instrument, etc,) larger than 1" were modeled. The plastic NRF was walked down "visually" by JGC and Virginia Power. Many items were "fine-tuned" as a result. JGC additionally utilized a 3-D CAD model of the NRF to further ensure that the final piping design and any field changes would not compromise the ALARA, maintenance and operational provisions designed into the NRF.

As previously stated the NRF was to be as totally separate and independent from the power station as was possible. With the exceptions of the liquid waste transfer lines, necessary communications equipment and a tap into the plant fire mains, the NRF was designed completely independent of the operating power station. The NRF utilities are supplied by site but not station connected sources.

The AC power for the facility is fed from an existing offsite line and a new feed from the station switchyard. These two supplies provide for redundancy in the power supply since the NRF can operate with either one of the power sources out of service. Neither supply adds or subtracts any load to station circuits.

Potable water at Surry is all supplied from wells. A few wells on site are not connected to the station's water supply. The NRF is connected to one of these non-station wells. Any needed process or flushing water can be taken from the well systems. For high purity line flushing water, the well water is run through a demineralizer, or at the NRF operators option, clean distillate from the liquid waste evaporator could be used as a water supply. Any cooling water to the open air would utilize well water.

Water for fire protection is taken from the stations fire loop. The fire protection system is consistent with the station's fire protection requirements, however, the supply tap is taken down stream of a Safety Related isolation valve. As per fire code requirement, outside building water supply Fire Department tie-ins are available.

Instrument air, maintenance compressed air, and breathing air are all supplied by NRF compressors. Breathing air, when needed during maintenance, is regulated and filtered by connecting portable units to the compressed air supply lines in the required maintenance areas.

The NRF HVAC system is also independent of any station tie-ins. The HVAC is designed with ALARA concerns addressed in that all ventilation travels from less potentially contaminated areas to more likely (higher radiation zone) areas. It was identified early in the NRF design that HVAC systems often do not get sufficient attention during design engineering and many times end up under designed. JGC and Virginia Power specifically addressed this concern to ensure proper and adequate NRF HVAC.

## PROCESS DESIGN

Liquid waste, laundry waste, resins and solid waste were all characterized in detail and used to select processes and equipment to optimize the NRF processing capabilities. Liquid and laundry waste were characterized by a 19 month sampling program. (This program was the topic of a WM '87 joint paper by Virginia Power and B & W). DAW was characterized using several years of shipping data and procurement data. Resins were characterized by sampling results initially used to determine scaling factors for isotope inventory on shipping manifest.

Design processing volumes were previously stated in the "Facility Requirements" section. Waste average activity levels and significant characteristics are given in Tables II, III, and IV.

Liquid Waste Processing (Fig. 3): Based on discharge goals and overseas experience, Virginia Power chose a 30 gpm evaporator system to be the main element of the liquid waste system. A 60 gpm, 5 vessel demineralizer system (IX)

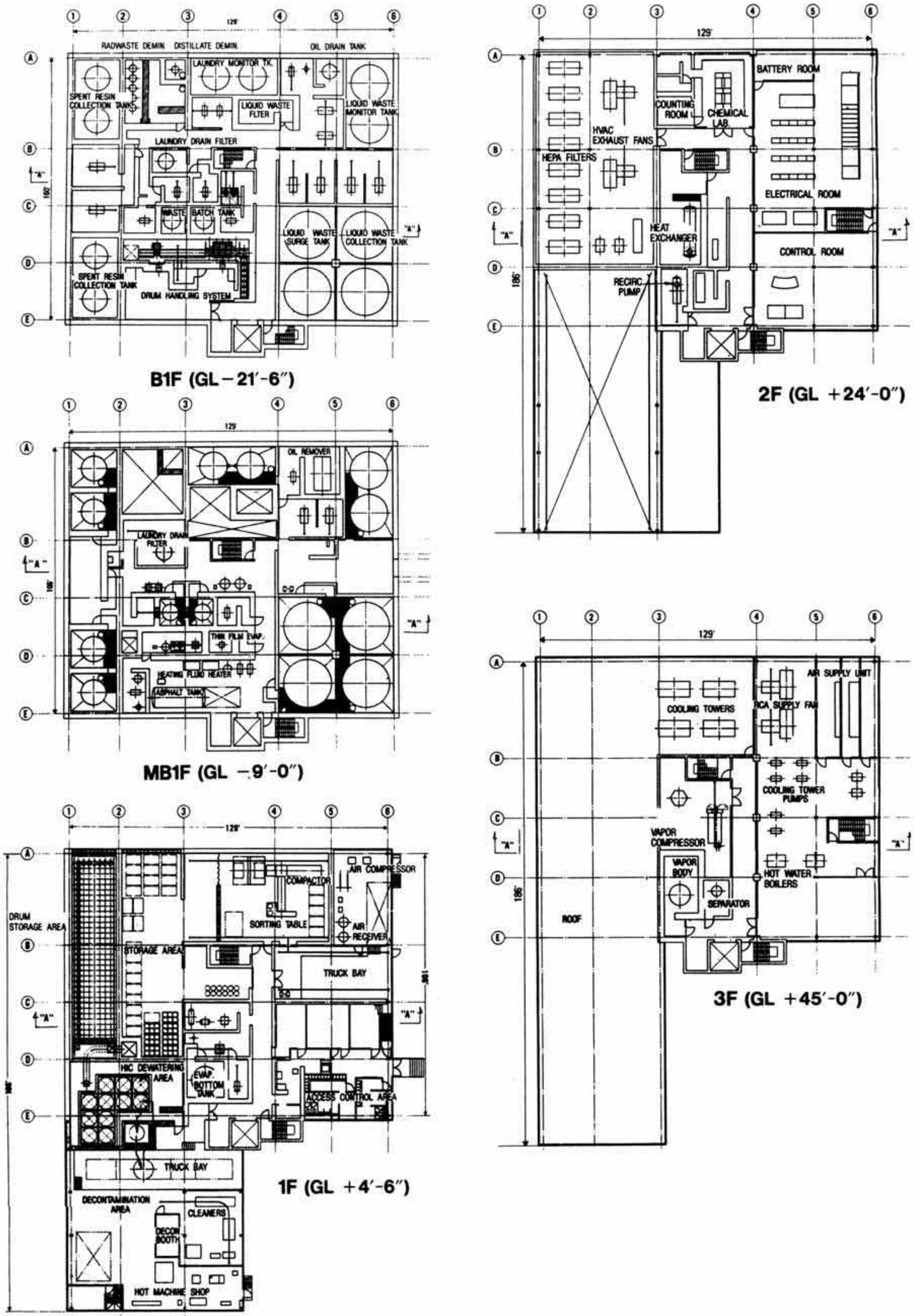


Fig. 1. General arrangement drawings-surry NRF.

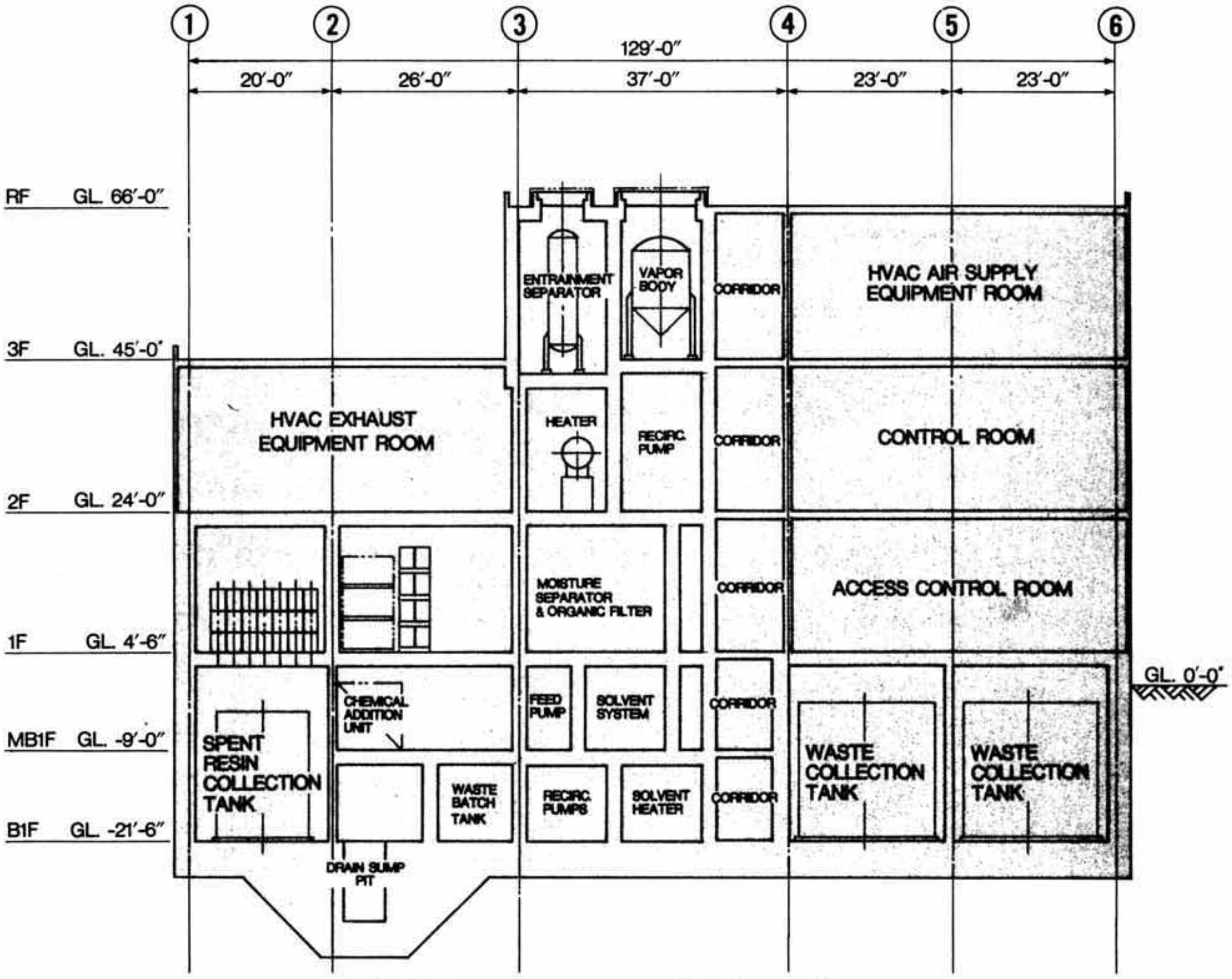


Fig. 2. General arrangement (Section A-A).

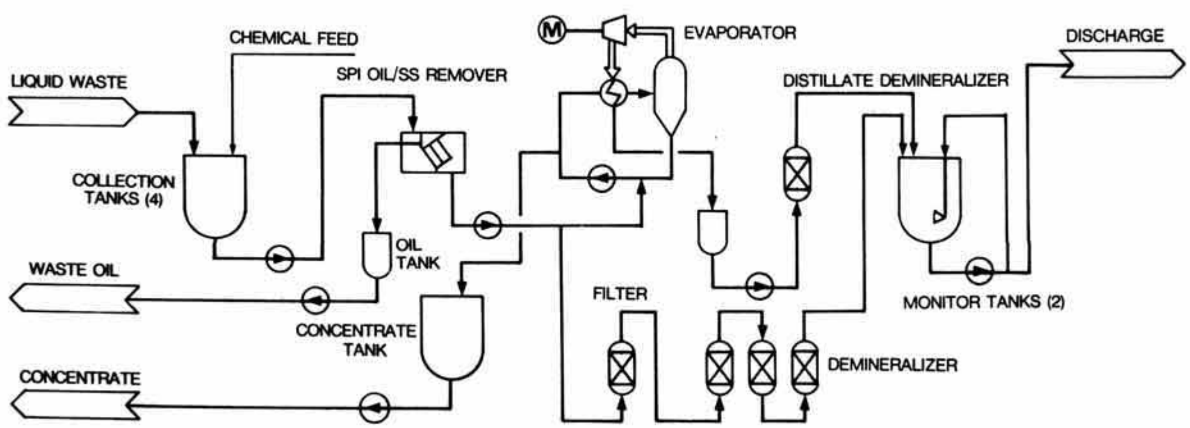


Fig. 3. Liquid waste system process flow.

provides the back-up processing method. 100,000 gallons of collection and surge tankage are available and a corrugated inclined plate oil and suspended solid separator unit precede either processing option. Decontamination Factors (DF's) for the evaporator are $10^4$ and for the IX are $10^2$. Evaporator concentrates, distillate resins, and IX resins are all sent to the NRF solidification system. Two 15,000 gallon Monitor Tanks are on the back end of the process. These tanks are mixed and sampled prior to a monitored release.

**TABLE II**

Average Activity Levels (uCi/cc)

| | |
|---|---|
| Liquid Waste | 2.6 E-2 |
| Laundry Waste | 5.0 E-5 |
| Dry Active Waste | 4.0 E-1 |
| High Level Resins | 3.7 E+2 |
| Low Level Resins | 5.1 E-1 |

**TABLE III**

Liquid Waste Characterization

| | Liquid Waste (Ave. ppm) | Laundry Waste (Ave. ppm) |
|---|---|---|
| Suspended Solids | 800 | 57 |
| Boron | 691* | 164 |
| Oil/Grease | 330 | 51 |
| Chloride | 23 | 19 |
| Sulfide | 5 | 7 |
| Calcium | 8 | 5 |

*Boron to be reduced to < 300 ppm by station

**TABLE IV**

DAW Characterization

| Material/Item | Vol.% |
|---|---|
| Plastics | 39 |
| Paper,Cloth,Wood | 24 |
| Absorbent | 9 |
| Filters | 6 |
| Rubber | 5 |
| Non-Combustibles | 7 |
| DAW Containers | 10 |

Laundry Waste Processing (Fig. 4): Currently, Virginia Power batch samples laundry waste and then discharges without additional treatment. The NRF will utilize a fiber ball (Marimo) filter to treat laundry waste. This process has a DF of 8. The back-up process is the same as current practice. In the future, laundry waste may be taken to the liquid waste evaporator system if an adequate non-foaming detergent can be found.

Solidification System (Fig. 5): Virginia Power selected a Thin-Film Evaporator Bitumen Solidification System to process liquid waste evaporator concentrates, low-level resins from the power station, and low-level resins from the NRF. The solidified product is contained in capped 55-gallon drums and yields a volume reduction (VR) of 4.5 for evaporator concentrates and 1.5 for resins. The overall VR for the system is approximately 3.3. The solidification system is designed to be remotely operated due to the potentially high dose rates of the solidified drums. The back up to solidification systems is the High Integrity Container (HIC) station for resins. The evaporator would not be used if solidification of concentrates was not available.

DAW Processing (Fig. 6): The DAW processing system is based on a High Pressure Compactor capable of densities of 800 + $kg/m^3$. Sorting of non-compactable items is integral to the DAW processing system in order to obtain desired densities. Many non-compactable items may be sent to the decontamination area to be cleaned.

Non-Processed Waste Handling: The NRF is designed to receive and store high level resins or high activity filters. High activity resins that require solidification will be solidified at the power station prior to receipt at the NRF. Filters, likewise, would be solidified in pipe cask at the station. These items would enter through the large truck bay and be remotely handled by the large overhead crane into the HIC shields in the HIC storage area. Liners of solidified resins or filters would be stored in the HIC storage shields.

## ANTICIPATED PROCESSED WASTE ACTIVITIES AND VOLUMES

JGC prepared a material balance for all waste streams identified by the input volumes and characteristics presented in this paper. The predicted results of processing using maximum volumes, design DF's and VR's and average activity values are presented in Table V. These calculations support the goals for NRF performance set at the initiation of the NRF project.

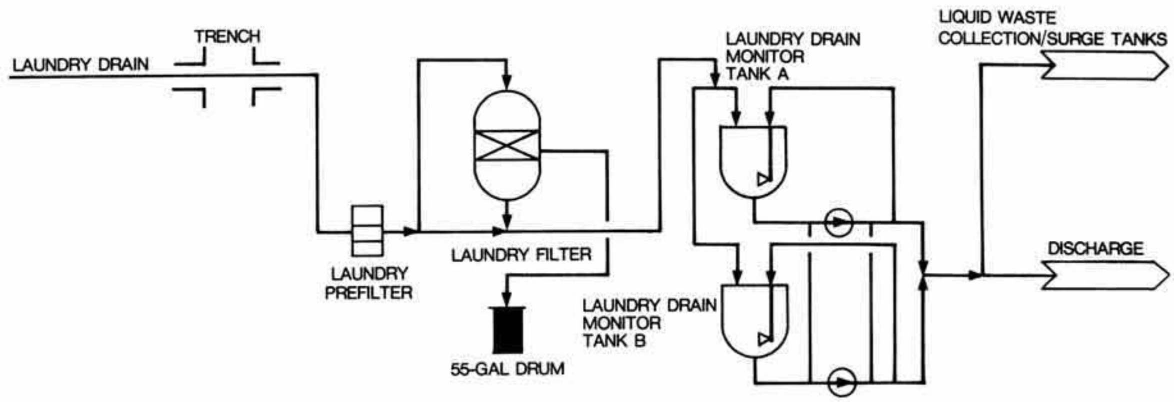


**Fig. 4. Laundry waste system process flow.**

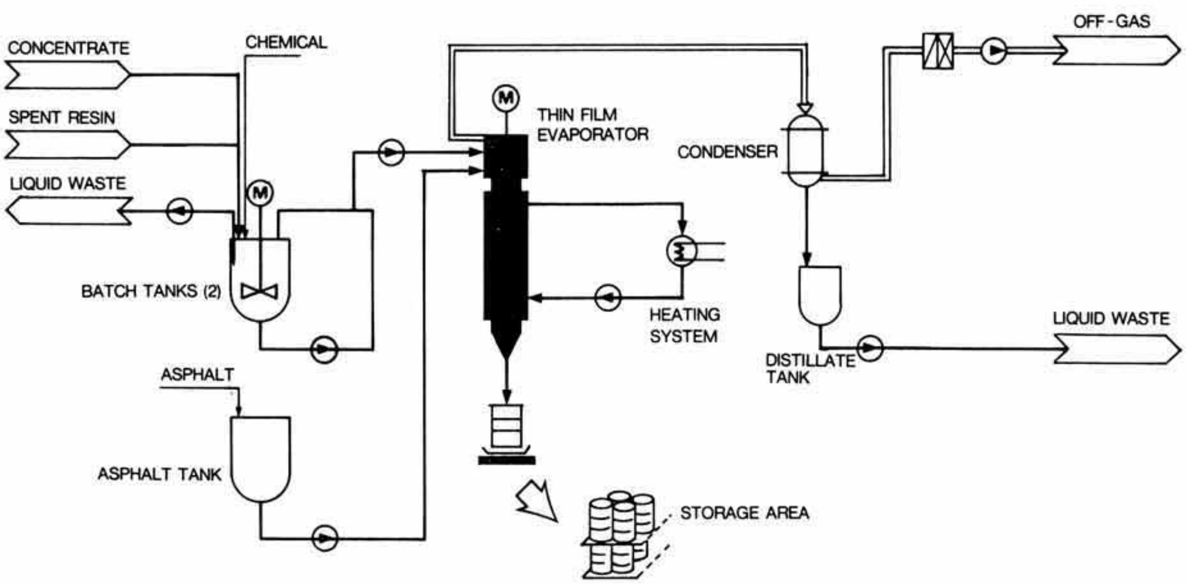


**Fig. 5. Bitumen solidification system process flow.**

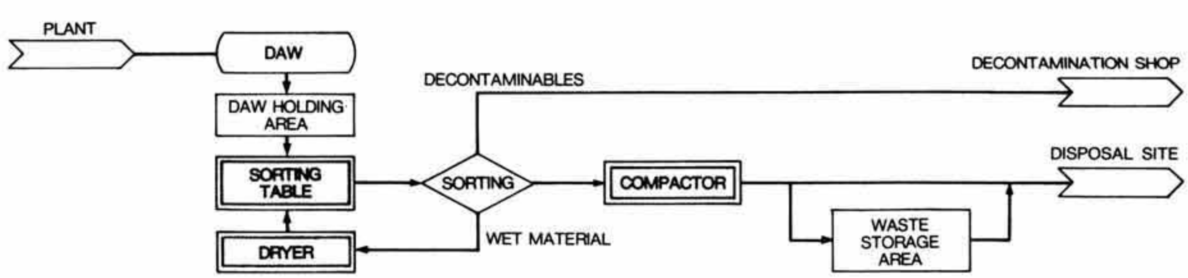


**Fig. 6. Dry active waste (DAW) system process flow.**

**TABLE V**

Predicted Processing Results (2 Unit Operation)

| | |
|---|---|
| Liquid Waste & Laundry Waste (excluding Tririum) | 0.092 Ci/yr |
| Compacted DAW | 170 $m^3$/yr |
| Solidified Drum (55-gallon) | 135 $m^3$/yr |
| High Activity Filters & Resins (Cement Solidified) | 40 $m^3$/yr |
| **Total Disposal Volume** | 345 $m^3$/yr |

## WASTE MANAGEMENT ASPECTS

Virginia Power's decision to build a radwaste facility was made in order to solve a problem, a radwaste management problem. The solution has been designed to do this by:

1. knowing the inputs
2. understanding the treatment process
3. having confidence in the treatment process
4. having control of the output as a result of all of the preceding elements.

Basically, the NRF provides a tool to manage the treatment of radwaste. Station management has the overall responsibility to control the generation and treatment of Surry's radwaste. It is obvious that the best treatment is to not generate radwaste. Information provided by the NRF can assist station management regarding the types and sources of solid and liquid radwaste. This information can be applied toward control of source minimization efforts, thus assisting in the management of radwaste.

A well planned processing facility must be available for use in order to be of benefit. The detailed evaluation of backup operations, maintenance requirements, and system reliability were all necessary design requirements so that the "radwaste solution" did not produce additional radwaste problems. In order for the NRF to have fully *planned* capabilities, a variety of unlikely, yet credible, situations were identified and incorporated into the facility design. These contingencies were worked out using station operations experience in an effort to help avoid the unexpected. The radwaste management capability at Surry will improve dramatically with the implementation of the NRF as a result of the "planned approach" to radwaste problem solving.

## PROJECT SCHEDULE

The NRF project began with the formal contract signing in February 1987. All systems were selected and general arrangements developed by November 1987. At this point, a design freeze took place as detailed engineering proceeded. JGC worked with NUS Corporation and Fluor-Daniel in developing the complex construction schedule. In July 1988, JGC and Fluor-Daniel began site mobilization and construction began in September. Detailed design of all major processing systems was completed by Fall of 1988. As detailed engineering progressed, procurement activities began. By July 1989, nearly every major procurement item had been delivered to the Surry site. Construction activities remained on schedule throughout the project and the construction phase of the NRF project was completed in October, 1990.

Starting in October 1990 through March 1991, NRF will be undergoing performance testing utilizing "cold" and "hot" waste streams. Unfortunately, this data is not available in time for this paper presentation.

The first year of operation is to be closely monitored by Virginia Power and JGC. It is anticipated that by Waste Management '92. A full performance report on the Surry NRF would be available for presentation.