RADIATION PROTECTION FEATURES OF BEAVER VALLEY UNIT 2 RADWASTE FACILITIES

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ABSTRACT

Beaver Valley Power Station - Unit 2 (BVPS-2) is an 833 MWe PWR under construction at Shippingport, PA. Although the unit was originally designed to share most of the radwaste systems of BVPS-1, several decisions in the mid to late 1970's led to the development of essentially independent systems for BVPS-2. The relatively recent commitment to new systems allowed application of several state-of-the-art processes as well as desirable radiation protection features.

Many features have been incorporated into the BVPS-2 design to increase system reliability and serviceability and to minimize personnel exposure during both operation and maintenance. These features minimize crud development and crud traps, provide separation and shielding between radioactive components, utilize remote handling equipment, allow draining and flushing of components, and prevent the spread of airborne contaminants. Many of these features have been incorporated based on experience with operation of earlier generation nuclear plants. Others were incorporated as good engineering practice, as a means of compliance with the latest or anticipated regulatory guidance and requirements, and as an effort to meet as low as reasonably achievable (ALARA) objectives.

INTRODUCTION

The management at Duquesne Light Company (DLC) is committed to maintaining occupational radiation exposure as low as reasonably achievable (ALARA). This commitment includes maintaining the annual dose to individuals working at the station ALARA and keeping the annual integrated dose to station personnel ALARA. It is an established policy within DLC to perform all reasonable actions necessary to reduce radiation exposure during work activities at the Beaver Valley Power Station. This policy is presently being implemented during the design and construction stage and will be implemented during the operation and maintenance of the plant.

Stone & Webster Engineering Corporation is the Engineer/Constructor responsible for the design and construction of BVPS-2. System design concepts and station features recognize anticipated personnel activities which would lead to exposure to substantial sources of radiation. Design features help reduce the anticipated exposure levels. Equipment specifications reflect the objectives of ALARA, including consideration of reliability, serviceability, and limitation of internal accumulation of radioactive materials.

Equipment and plant design considerations support the ALARA concept by reducing radiation levels and minimizing the need for and time spent on maintenance. These include the following design features:

- Reliable and durable equipment and components,
- Corrosion-resistant materials,
- Redundant equipment,
- Sufficient provisions for access to equipment such as ladders and platforms,
- Remote or mechanical devices that operate, repair, service, monitor, or inspect equipment,
- Draining and flushing connections to equipment and piping which contain radioactive material,
- Minimal buildup of radioactive materials in the system by continuous purification and chemistry control,
- Piping designed to minimize crud pockets where activity could accumulate,
- Isolation of radiation sources from equipment to be serviced by permanent shielding or provisions provided for temporary shielding,
- Curbs and dikes to retain potential leakage or spillage of radioactive fluids,

- Equipment arrangement and design that permits quick removal of and easy access to items to be serviced,

- Sealed valves, welded connections, and hard-pipe to valve stem leakoff connections,

- Ventilation flow from low to high radiation zones, and

- Physical barriers such as locked wire mesh doors for controlling access to high radiation zones.

The ALARA concept applies to all systems in the BVPS-2 plant. The specific ALARA features of the liquid, solid, and gaseous radwaste systems are discussed below.

LIQUID WASTE MANAGEMENT SYSTEM

The liquid waste management system (LWMS) includes two evaporators with adequate capacity to process all the anticipated liquid waste generated at BVPS-2. Two waste drain tanks accept and store all liquid waste to be processed, and allow sufficient time for sampling the liquid waste prior to processing the tank contents through the BVPS-2 evaporators or transferring it to the high level waste drain tanks in BVPS-1. As a backup, liquid waste can also be transferred to the two steam generator blowdown (SGB) hold tanks, which provide additional capacity for unanticipated transients. The normal flow path is from the waste drain tank pumps directly to the evaporators. The evaporator systems, which include the evaporators and the cleanup ion exchangers, produce a distillate suitable for reuse or discharge. Evaporator bottoms are pumped to the radioactive solid waste system.

The control of each process within the SGB and liquid waste systems is essentially automatic after the system set points have been provided by subsystem tests prior to startup.

Process flexibility is increased by allowing liquid waste of low activity, as verified by sampling, from the liquid waste drain tanks or the steam generator blowdown hold tanks to be filtered prior to discharge without evaporation and processing. The liquid discharge is monitored and automatically isolated upon evidence of high activity.

System Design Features

The following design features in the LWMS reduce equipment maintenance downtime, liquid leakage, and gaseous releases of radioactive materials to the environment. In addition, these features facilitate cleaning and improve radwaste operations:

- Conical-bottom tanks and vessels are used where there is a potential for high activity and suspended solids, thus minimizing buildup of radioactive sludge and facilitating cleaning operation.

- Components that handle potentially high activity liquids (that is, the evaporator bottoms hold tank, evaporator circulation pumps, and waste drain tanks) are located in individually shielded cubicles. Other components handling lower activity liquids are shielded, as necessary, to minimize exposure to operators and maintenance personnel. Figure 1 illustrates the individually shielded cubicles.

- Pumps that handle concentrated radioactive liquids (evaporator bottoms and hold tank pumps) have double mechanical seals. In the event of seal failure, the leakage is directed to a radioactive sump through a drain connection.

- The piping and sealed valves are designed to minimize crud pockets where activity could accumulate.

- Tanks that are expected to handle highly radioactive liquids are vented to the aerated vent system to mitigate the potential for gaseous releases into working areas.

- Alternate processing capability allows use of alternate processing paths in the event of equipment failure. System redundancy is ensured by two evaporators, two waste drain tanks and pumps, two steam generator hold tanks, two evaporator feed pumps, two test tanks and pumps, and two cleanup ion exchangers, each of which maintains system requirements while the other is isolated for maintenance.

- Controls allow system operation and monitoring from the main control room.

- The possibility and consequences of tank overflow are minimized by level indicators, level switches, alarms, and process functions.

- The evaporator bottoms portion of the liquid waste system has heat tracing and permanently-piped flushing connections, and the evaporator contains a chemical cleaning connection.

- Sample points for the evaporators are provided with a sample sink and ventilation hood, splash screen, and valves located outside the splash screen. The samples contain a recirculation path behind the shield wall at the sample sink, with reach rods for the operator.

SOLID WASTE MANAGEMENT SYSTEM

The solid waste management system (SWMS) handles solid wastes, which include spent resin from radioactive process demineralizers, condensate polishing system radioactive powdered resin sludges, and concentrated waste solutions from the BVPS-2 liquid waste evaporators. The solid waste management system consists primarily of the following subsystems: a spent resin handling system, a decanting station, a drumming station for solidification, and a cement filling station.

LEGEND

AUXILIARY BUILDING

- (4) BORIC ACID FILTER
- (5) FUEL POOL ION EXCHANGER
- (6) FUEL POOL FILTERS A & B
- (7) COOLANT RECOVERY FILTERS A & B
- (8) CESIUM DEMINERALIZERS A & B
- (9) MIXED BED DEMINERALIZERS A & B
- (10) CATION BED DEMINERALIZER
- (11) DEBORATING DEMINERALIZERS A & B
- (12) SEAL WATER FILTER
- (13) SEAL WATER INJECTION FILTERS A & B
- (14) REACTOR COOLANT FILTER
- (18) LIQUID WASTE TANKS A & B
- (19) DEGASIFIER RECIRCULATION PUMPS A & B
- (20) WASTE GAS SURGE TANK
- (21) LIQUID WASTE PUMPS A & B
- (28) PRIMARY DRAINS TRANSFER TANK
- (39) OVERHEAD GAS COMPRESSORS
- (42) CLEANUP FILTER

CONDENSATE POLISHING BUILDING

- (30) CONDENSATE BACKWASH HOLD TANK
- (31) CONDENSATE BACKWASH FEED TANK
- (37) STEAM GENERATOR BLOWDOWN/LIQUID WASTE HOLD TANKS

WASTE HANDLING BUILDING

- (38) EVAPORATOR BOTTOMS HOLD TANK

Fig. 1. Shielding Arrangement and Facilities.

The spent resin handling system contains a spent resin hold tank, a spent resin transfer booster pump and necessary piping and instrumentation. The system provides a reusable source of water to sluice resins from various radioactive ion exchangers or demineralizers to the spent resin hold tank. The resins are stored in the tank until transfer to the solidification portion of the system is deemed necessary.

The resins are then slurried to the decant tank in the decanting station where they are allowed to settle. Excess water is removed by the decant pump and pumped to the spent resin hold tank where it is reused in the sluicing process.

The resin or sludge from the decant tank (or concentrated liquids from the evaporator bottoms hold tank) is then pumped to the solidification system (drumming station) by a positive displacement metering pump and injected into containers. The metering pump also recirculates the contents of the decant tank to obtain a representative sample at the sampling station.

The containers are loaded with a measured weight of dry cement in the cement filling station. The amount of liquid radwaste (waste, resin and/or sludge) injected into a container is determined by prior analysis of the waste to assure a consistent quality waste product acceptable for shipment and burial. After the container is filled, the radwaste and cement are mixed by tumbling, allowed to solidify, sealed, and stored.

System Design Features

The following design features in the SWMS reduce equipment maintenance downtime, liquid leakage, and gaseous releases of radioactive materials to the environment. In addition, they facilitate cleaning and improve radwaste operations.

- Components which handle high activity wastes are located in individually shielded cubicles as illustrated in Fig. 1.
- The decant tank and the drumming station are located in curbed cubicles where any leakage will be retained.
- In the event of a spillage of radioactive liquid from the pumps or tanks of the solid waste system, the liquid is collected by a network of floor drains. The floor is pitched toward the floor drains. The drains are piped to the building sumps and forwarded to the radioactive LWMS for processing. The walls and floors of areas with potential for contamination have a smooth finish and are painted with an epoxy paint to facilitate decontamination.

- The drumming station prevents external contamination of the containers by use of reliable container sealing, appropriate system flushing, and instrumentation interlocks that prevent overfilling of the containers. A spray system is available in the drumming station processor to wash the process enclosure and containers.

- A swipe and decontamination area allows remote inspection, cleaning, and labeling of containers.

- Material handling of containers is provided by a remotely-operable bridge crane. The potential for spills by dropping and damaging containers is considered very small. The remotely-operated drum grab and bridge crane are specially designed to minimize such a possibility by providing redundant safety features throughout. A television camera provides the operator positive indication that each jaw of the drum grab is clamped on the drum.

- Piping containing resin slurries is designed to minimize plugging and residual contamination. Large radius bends and laterals (in place of elbows and tees) and smooth butt-welded pipe are used to ensure controlled and uniform slurry characteristics. Line velocities are kept sufficiently high to preclude resin from settling in the pipes during transfer operations.

- A shielded sample station, as shown in Fig. 2, is provided for sampling solid waste streams (evaporator bottoms, resins, and sludges). The station is provided with sample sinks and ventilation hoods, splash screens, and valves located outside the splash screens. The samples are provided with a recirculation path behind the shield wall at the sample sink, with reach rods for the operator.

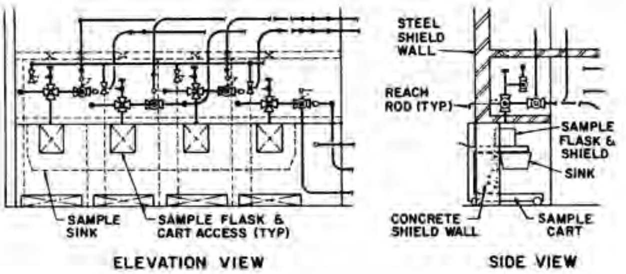

Fig. 2. Sampling Station.

- All operations are conducted in accordance with the Process Control Program (PCP). The PCP provides assurance of a consistent product acceptable for burial by establishing boundary parameters of pH, percent solids, boric acid concentration, etc, of the anticipated waste streams. The waste streams are sampled at the sampling station, analyzed, and evaluated for waste-to-cement ratios. Appropriate documentation is maintained to show that process operation was conducted in conformance to the PCP.

- The solid waste system is essentially a remotely operated system. Operations are conducted remotely or manually after the waste source has been shielded.

- The spent resin hold tank, Fig. 3, is designed to facilitate resin discharge. The tank is provided with a conical bottom equipped with resin retention screens to dewater the tank. A mechanical agitator keeps the resin suspended to enhance discharge. The agitator and motor are mounted on the top of the tank above a steel shield platform to facilitate maintenance of these items. The equipment may be removed from the tank by removing the steel shield plugs. The tank is also equipped with a spray header to wash down the tank internals.

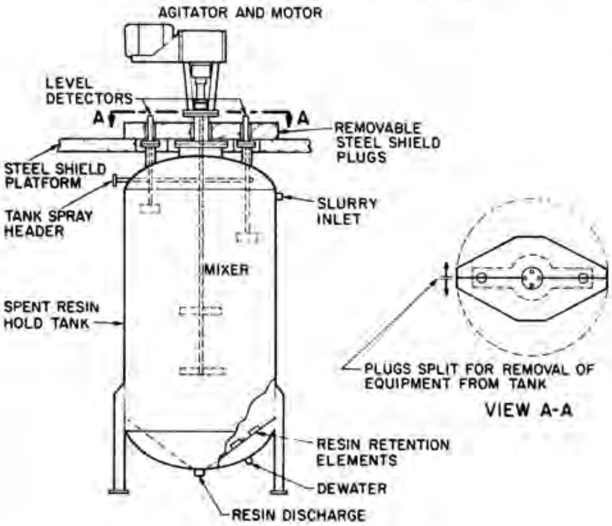

Fig. 3. Resin Hold Tank and Shield Design.

- Resin tanks and ion exchange vessels enhance resin discharge and minimize crud buildup by providing conical bottoms similar to the spent resin hold tank.

- All solidified containers are stored in the shielded waste storage area of the remotely operated onsite storage facility for low level waste.

- The system is flushed on an as-needed basis with flush water.

GASEOUS WASTE MANAGEMENT SYSTEM

The gaseous waste management system (GWMS) includes the radioactive gaseous waste disposal (GWD) system and the ventilation system. The GWD system continuously processes and monitors all waste gas streams at both BVPS-2 and BVPS-1 prior to discharge to the atmosphere. The ventilation system will service potentially contaminated areas to provide a suitable environment for personnel and equipment and to prevent the spread of radioactive contamination.

Effluent gases from the degasifiers in the boron recovery system (BRS) are dehumidified by passing through a series of two chillers (degasifier vent chiller in the BRS and the gaseous waste chiller). The gas stream is passed through and filtered by the process gas charcoal bed adsorbers and one of two redundant prefilters. The charcoal is divided evenly between two pairs of vertical tanks in series and are piped so that either pair may be bypassed. Normal flow is through the four beds in series. One of the two overhead gas compressors directs the gas stream to a gas surge tank where the gas is reduced in pressure and returned to the volume control tank. Periodically, for removal of Krypton-85, the surge tank gas is fed to the BVPS-2 gaseous waste storage tanks or the BVPS-1 charcoal delay tanks and discharged to the atmosphere after monitoring for radiation.

The gaseous effluent stream from the main condenser air ejectors of BVPS-1 and BVPS-2 is directed to the air ejector charcoal delay beds which provide sufficient delay for decay of short-lived radioactive components. Prior to entering the charcoal beds, the gas stream is dehumidified and heated. Under normal operation, the effluent gas is not contaminated and the charcoal beds will be bypassed.

Gaseous effluent from both the containment vacuum system and aerated vents of BVPS-2 is directed to BVPS-1 where it is passed through charcoal and HEPA filters, monitored for flow rate, temperature, particulate, and gaseous radioactive effluent and discharged.

The ventilation systems serving safety-related and/or potentially contaminated areas are processed, if necessary, by HEPA and charcoal filters on BVPS-2 prior to discharge. An alternate containment purge line is provided which can route containment atmosphere to the BVPS-1 process vent system.

<u>System Design Features</u>

The following design features in the GWMS reduce equipment maintenance downtime, liquid leakage, and gaseous releases of radioactive materials to the environment. In addition, these features facilitate cleaning and improve radwaste operations:

- The radioactive GWD system is operated remotely from the GWD control panel.
- Components requiring servicing are placed in individual shielded cubicles to minimize personnel exposure during maintenance.
- The radioactive GWD system is designed to meet the anticipated processing requirements of BVPS-2. Adequate capacity is provided to process gaseous wastes during periods when major processing equipment may be down for maintenance and during periods of excessive waste generation.
- Leakage from pumps is piped to floor drains.
- Automatic shutdown of the overhead gas compressors on abnormal oxygen concentration is provided to preclude the formation or buildup of explosive hydrogen/oxygen mixtures.
- Automatic isolation of the discharge stream from the gaseous waste storage tanks on high radiation levels.
- Use of hermetically-sealed valves in the GWD system.

CONCLUSIONS

All of the above features were included in BVPS-2 as an effort to meet ALARA objectives. By increasing the radwaste systems' reliability and serviceability and by minimizing personnel exposure during both operation and maintenance, the ALARA objectives can be met.