DRAFT for discussion

EPRI Guidance Document for the Implementation of 10CFR20.1406

Focus Area: Groundwater Protection

INTRODUCTION

With the nation's increased interest in the design and construction of advanced nuclear power plants, and in consideration of the challenges and high costs associated with soil and groundwater remediation, the U.S. Nuclear Regulatory Commission (NRC) has initiated rulemaking and related guidance for the implementation of 10 CFR 20.1406. This regulation states that:

> "Applicants for licenses, other than renewals, after August 20, 1997, shall describe in the application how facility design and procedures for operation will minimize, to the extent practicable, contamination of the facility and the environment, facilitate eventual decommissioning, and minimize, to the extent practicable, the generation of radioactive waste."

This guidance document is a compilation and summation of the nuclear power industry's operating experience and lessons learned as they relate to the prevention of groundwater contamination from unplanned releases of radioactive material. Its intent is to provide guidance for the design, construction and licensing of advanced nuclear plants in order to meet the requirements of 10CFR20.1406.

DISCUSSION

This guideline consists of specific plant design element recommendations, which are presented in the following categories: Spent Fuel Pool and Building, Tanks, Sub-Surface Leakage, Fluid and Steam Systems, HVAC, and General. Most of the recommendations are intended to apply to all plant types (that is, PWRs and BWRs), and provide a variety of design techniques that will help to minimize *radioactive* groundwater contamination.

For the purposes of this guide, "groundwater" is defined as any subsurface water, whether in the unsaturated or vadose zone, or in the saturated zone of the earth. Examples of groundwater include: a) any subsurface moisture or water, regardless of where it is located beneath the earth's surface; b) any water located in wells, regardless of depth, type, or whether it is potable; c) water in storm drains, unless it is confirmed that the storm drains do not leak to the ground; and d) water in sumps that communicate with subsurface water.

The term "below grade" refers to systems, structures and components (SSCs) whose elevation is below a reference ground level at that point on the site, regardless of whether the location is inside or outside of a building (e.g., a building whose lowest elevation is lower than personnel or equipment access roads).

"Underground" or "buried" SSCs refer to those that are outside of any building or other accessible structure, are surrounded by material such as soil, fill or pavement on all sides, and are generally inaccessible without excavation (e.g., a tank, with or without a concrete containment structure, that is completely covered by soil).

The term "embedded" refers to any pipe or component that is partially or fully surrounded by concrete (e.g., floor drain piping and traps).

DESIGN ELEMENT RECOMMENDATIONS

Spent Fuel Pool and Building

The Spent Fuel Pool, Spent Fuel Building, and associated fuel transfer and cask handling canals are of interest due to the large volumes of contaminated water and the high radionuclide concentrations. Small leaks are not always visible to operators, are difficult to distinguish from evaporation losses through pool level measurements, and may lead to groundwater contamination if not detected and repaired.

Item No.	Design Element Recommendations
SF-1	The structural interior surfaces of the Spent Fuel Pool, cask pit, transfer canals, and any other interconnected liquid containment cells should be designed using technology that will provide an enhanced barrier against leakage (e.g., a double barrier), effective leak detection (e.g., telltale system), and provisions for inspection of the barrier's integrity and the telltale system's operability. The above systems should be designed so as to be maintainable over the life of the plant.
SF-2	For the fabrication of the Spent Fuel Pool, cask pit, transfer canals, and any other interconnected liquid containment cells, techniques and designs should be used to minimize the potential for weld-seam failures during operation, and inspection techniques should be used to verify weld quality during fabrication and construction. This should apply to the design of both the structure and liner(s).
SF-3	Where a Spent Fuel Pool telltale system is included in the design, it should include adequately-sized drain pipes to allow access for remote integrity inspection and testing. The pipes should also be sized to minimize the potential for blockage by encrustation of precipitates, and to facilitate the removal of blockage from the pipes.
SF-4	To allow more rapid identification of leak locations, the Spent Fuel Pool telltale system (when included in the design) should allow the isolation of clearly-defined zones within that system and provide the capability of detecting and quantifying small leakage rates (i.e., several gallons per week) from each zone.

Tanks

With tanks built on or below ground, leaks may not always be visible to operators and are often difficult to detect. Such leaks may lead to groundwater contamination if not detected and repaired. The Design Elements Recommendations in this section address tank fabrication and erection, location, overflow control and protection, and leak detection capabilities.

For the purposes of this document, "tank" refers only to those that contain or potentially contain radioactive fluids.

Item No.	Design Element Recommendations
TK-1	Due to the difficulty of detecting leaks in large volume underground (buried or vaulted) tanks, their use outside of buildings should be avoided.
TK-2	Field-fabricated flat bottom tanks should be constructed with materials (e.g., the appropriate grade of stainless steel for the specific application) that will minimize corrosion. Additional, stringent NDE QC measures should be implemented to verify weld quality and integrity.
TK-3	Tank vent discharge piping should include provisions for containing and controlling tank overflow. Such provisions may include a receiving tank or indoor sump, and HI and HI-HI level alarms on the source tank.
TK-4	The capability to detect low-volume leaks (e.g., using telltale systems) should be included in the design for large volume exterior tanks (e.g., refueling water or BWR condensate storage).
TK-5	Exterior tanks should be located on or above bermed concrete pads. The berms should be capable of containing 110% of the contents of a tank. Each concrete pad should be lined or sealed with an impermeable membrane.
TK-6	Tank sampling stations should be designed to minimize the possibility of leakage of sample fluid to the ground or to the underlying pad surface.

Sub-Surface Leakage

Building walls and floors, including sumps, moats and berms, may be pathways of leakage to soil and groundwater. Design Element Recommendations in this section address building design and construction, and include such elements as concrete pour methods, seals, gaps, penetrations, the use of liners and advanced coatings, and the use of tunnels for sub-surface piping. Leakage detection and allowance for inspection are also addressed.

Item No.	Design Element Recommendations
SL-1	Structures containing primary fluid systems (e.g., Spent Fuel Pool, reactor coolant system, charging and letdown systems, radioactive waste systems, and BWR turbine building and condenser bays) should be constructed to minimize the number of gaps and joints (e.g., with a continuous concrete pour). For gaps and joints, technologically advanced seals that will not degrade over time should be provided. Leak detection and inspection capabilities should also be provided for those sealed areas.
SL-2	To minimize the seepage of water into or through walls and floors, advanced, durable material liners or durable, deep penetrating, smooth finish coatings should be applied to below grade structures within the Radiation Control Area (RCA). This applies to the interior surface up to grade level for floors and walls that form a boundary with the building exterior.
SL-3	To minimize the potential for leakage, moats and sumps should be constructed with linings, and penetrations through the lining should be welded or should be capable of being sealed using technologically advanced materials. Linings and seals should be composed of materials that minimize degradation due to environmental effects or aging. Consider using impermeable membranes, stainless steel, or HDPE materials that can be maintained and repaired.
SL-4	Sumps that are supported or surrounded by backfill should incorporate at least one dedicated sample standpipe adjacent to each sump in order to provide early detection of leakage. This does not apply to sumps, such as containment sumps, that are included in regulatory-required periodic integrated leak testing programs.
SL-5	If foundation drains are used as part of a building design, the capability for sampling the effluent should be included.
SL-6	To allow for rapid leak detection, and to take advantage of the lower installation costs during the construction phase, a method should be implemented for monitoring groundwater contamination adjacent to the Spent Fuel Building, transfer canal, and other structures that contain water with comparable levels of radioactivity.
SL-7	The design for subsurface or at-surface buildings should include provisions for the containment, control, and collection of primary water, Spent Fuel Pool water, radioactive waste processing fluid, or BWR primary steam leak condensate. Adequately-sized moats and moat drains are preferred over berms for this purpose. If a structure contains primary steam systems, ventilation systems should be evaluated to insure steam leaks will be captured in the primary ventilation exhaust and treatment system which services the structure.
SL-8	To minimize the leakage of radioactive fluids to groundwater, and the leakage of groundwater into buildings, system and structural designs should avoid the use of below-grade conduit and piping penetrations through walls that form exterior boundaries. This is particularly applicable to penetrations at or through the floor level.
SL-9	Due to the potential for undetected corrosion and leakage, system designs should avoid the use of subsurface piping for systems that contain or could possibly contain liquid radioactive materials. If the plant design includes subsurface piping that contains radioactive or potentially radioactive fluids, a system should be included that allows access for operation, inspection, and maintenance. For applications other than radioactive waste processing systems, consider the use of non-degradable materials (e.g., HDPE) or advanced coatings for the system. Trenched, double-walled, and concrete-encased piping are less desirable options. Short runs of double-

Item No.	Design Element Recommendations
	walled pipe are acceptable if used with a leak detection system. The use of single-walled piping should be avoided.

Fluid and Steam Systems

Piping, valves, and connections in radioactively contaminated fluid systems may become sources of soil and groundwater contamination. Corrosion is a concern with systems in contact with the ground, and the materials used in these systems should be carefully considered, as should the application of active corrosion protection. The types of valves used in system design, the inspectability of pipes, valves, vacuum breakers and connections, and provisions for the control of undetected leakage are also of importance.

The use of concrete in applications such as cooling water blowdown lines is of concern not only because of the potential for leakage, but also because it can create large volumes of contaminated concrete that may require disposal during decommissioning. With regard to steam systems, the control of vented steam or liquids is essential to prevent contamination of other systems and thereby soil or groundwater.

For the purposes of this document, "fluid systems" refers only to those that carry or potentially carry radioactive fluids.

Item No.	Design Element Recommendations
FS-1	Due to their greater potential for leakage, the use of check valves, flapper type valves, pressure relief valves (or similar devices), and flanged joints should be avoided for outdoor or underground applications. If a design includes any of these, provisions should be made to evaluate the potential for leakage, and to monitor for and contain potential leakage.
FS-2	To contain leakage, positive valve stem leakage containment should be included in system design.
FS-3	Where vacuum breakers are used for discharge lines, leak prevention and leak detection capability should be included in the design. If exterior vacuum breakers are used, the system should be designed to capture any leakage, provide leak detection, and be readily accessible for inspection and repair.
FS-4	To allow for positive control and to facilitate inspection and maintenance, connections between radioactive waste systems and plant monitored liquid release pathway lines should be protected from the environment and should be accessible for inspection.
FS-5	The design of the release point for main steam safety relief valves and the steam generator blowdown systems should minimize the introduction of radioactive steam or liquids into drains or supply fan intakes, and minimize the contamination of surrounding surfaces and structures.
FS-6	To prevent the uncontrolled release of radioactive liquids, the use of radioactive evaporators and boiler system rupture disks that vent directly to open spaces should be avoided. Rather, rupture disk effluent should be routed through piping to a receiving system.
FS-7	To minimize corrosion of systems that contain potentially radioactive fluids, cathodic protection of applicable metal piping should be used in exterior areas. The critical system components of the cathodic protection system should be designed to be easily accessible for inspection and maintenance.
FS-8	To prevent the introduction of potentially radioactive fluids into groundwater through an undetected and unmonitored pathway, the use of corrugated, galvanized, cast-iron, or carbon steel piping should be avoided for underground applications. The use of extruded poly materials should be considered in the design of storm drain systems.
FS-9	Any system containing radioactive liquids (e.g., cooling water blowdown lines) should not be constructed of concrete, since the concrete may absorb contamination and may crack with age, potentially causing leakage to groundwater, and also increasing concrete waste volumes at the time of decommissioning.

Item No.	Design Element Recommendations
FS-10	To enable tritium recovery, system design should consider the use of a blowdown recovery system rather than blowdown flash tank and release.

HVAC

HVAC systems may contribute to soil and groundwater contamination through the release of contaminated condensate water. In addition, water from radioactive systems may back up into the HVAC system, potentially leading to groundwater contamination.

Item No.	Design Element Recommendations
HV-1	To prevent unmonitored releases through this pathway, condensation from all coolers handling potentially contaminated air should be collected and routed to a monitored liquid effluent discharge.
HV-2	Potentially contaminated fluid systems that directly interface with HVAC systems should be designed with a drop out box that traps fluid prior to its entry into the HVAC plenum. The drop out box should be hard-piped to a sump or tank.

General

The following Design Element Recommendations relate to plant operations and hydrogeological studies.

Item No.	Design Element Recommendations
GE-1	To minimize the potential for spreading solid or liquid contamination into the environment, radioactive material handling, staging, storage, and decontamination areas should be located inside buildings or in contained areas to support refueling, maintenance, and operational activities.
GE-2	The site's subsurface hydrology will be characterized prior to construction. The hydrologic profile should be evaluated and revised as needed, following the completion of plant construction, to identify the impact construction has on the pre-construction baseline model. This should also be performed following the completion of significant construction projects over the life of the plant, and prior to the start of decommissioning (Reference 1).

REFERENCE

1. NRC Memorandum, Larry W. Camper to David B. Matthews, "List of Decommissioning Lessons-Learned in Support of the Development of a Standard Review Plan for New Reactor Licensing," October 10, 2006.