ONTARIO HYDRO'S EXPERIENCE WITH AUGERED BOREHOLE STORAGE

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ABSTRACT

Two new types of radioactive waste storage facilities have been built at Ontario Hydro's Bruce Nuclear Power Development using a soil auger construction method. The design, construction and operation of these facilities will be described.

INTRODUCTION

Ontario Hydro's nuclear waste management site lies on an exposed Lake Huron headland. Bleak winter winds whip up snow and rain off 60 miles of cold open water. Crews have to contend with drifting snow, iced-up equipment and the hazards of high winds during the six-month winter. Experience has taught us that these conditions must be taken into account when new facilities for waste storage are designed.

Direct burial has never been a practical proposition for this large utility producing 200,000 cu ft of low level radioactive wastes per year. The whole 19 acres on this property is heavy clay or till. Once exposed to poor weather, working conditions would become impossible. Open excavations would bog down mobile equipment up to the axles. Compaction and covering operations would be very difficult. In effect we would have to shut down the site for the whole winter.

The first waste emplacements on the site in 1974 were in engineered structures. They not only allowed all weather operation but also the wastes could be retrieved without undue difficulty at any time.

NON-AUGERED TILE HOLES

Ontario Hydro's first facilities for medium level waste were put into service in 1974. Medium level wastes include cartridge filters and packaged ion exchange resins. Typical contact radiation fields would be less than 100 rem/h (1 Sv/h). These wastes would normally arrive at the site in shipping flasks on trucks.

Construction

The tile holes were constructed of standard precast pipe sections, 2.4 ins ID and 12 ft deep on cast-in-place reinforced concrete base slabs. The precast concrete pipes were grouted into the base slab. Three in hot coal tar was applied to the bottom of the pipe as a sealant. The pipe was waterproofed on the outside with emulsified asphalt.

Operation

When two units of waste were stored, the contents were encased in concrete to form a monolithic structure. Richmond anchor lifting lugs provide the means of removing the entire tile hole and its contents for relocation if necessary.

The handling of wastes by the bottom unloading method was very successful and this feature has been retained for subsequent designs.

Water problems began to show on this early design almost immediately after construction. Thirty-seven of the original units were subject to ingress from the surroundings. Steel liners were fitted to correct the problem.

THE IC-2 FACILITY PLACED IN SERVICE 1985

The in-ground storage containers (IC-2) are used for placing filters, ion exchange columns and other medium level wastes from various nuclear systems into long term storage. Generally unshielded fields from these wastes range from 15 rem/h at 1 metre to about 200 rem/h at 1 metre. (Fig. 1)

Each provides about 74 ft^3 (2.1 m^3) of storage space for medium level radwaste. This is the equivalent of from four to six standard disposable ion exchange or filter vessels normally received at the site. The IC-2's are backfilled with concrete when fully loaded so that waste components are enclosed in a monolithic concrete block. Extra concrete is poured on top of the waste components to reduce facility surface dose rates to 2.5 mrem/h at 1 metre if necessary.

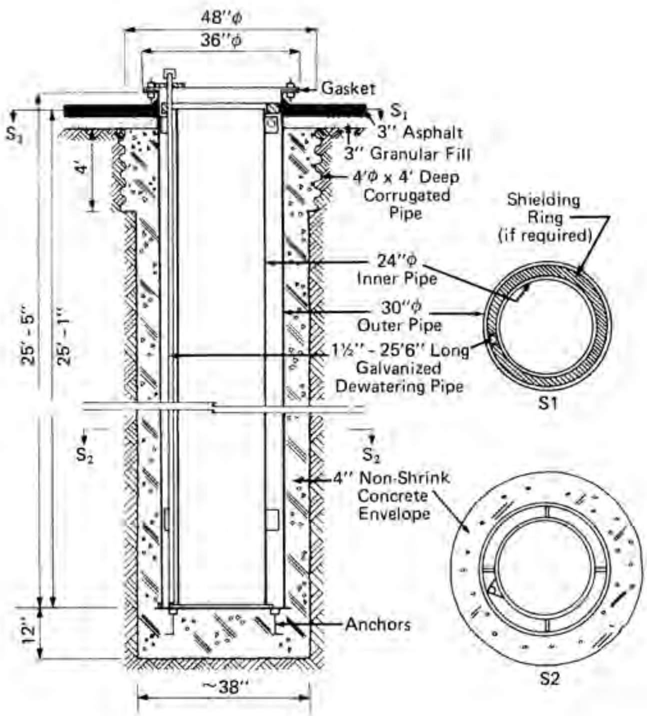

Fig. 1. IC-2 General Arrangement.

Design

Earlier designs of storage facilities for these wastes had used concrete or concrete and steel cylinders built on pads in an excavation. The "tile holes" were then backfilled to a paved working surface at ground level. The new design eliminates the need for the excavation and backfilling and hence reduces construction time down from about six months to one month.

The most successful features of the earlier tile hole designs were retained in new IC-2 design. The wastes are bottom unloaded from road casks directly into the IC-2 at ground level. Wastes can be stacked successively to fill the container using a temporary shield plug between loadings. Tile holes were about 12 feet deep and allowed stacking of two filters. The IC-2 allows four filters to be stacked in each container.

The BNPD RWOS-2 site is a till or boulder clay deposit up to 40 feet deep to the limestone bedrock. The water table is high so that hydrostatic uplift forces are a concern. The earlier tile hole design minimized uplift forces by the provision of a subsurface drainage system which lowers the water table locally. The IC-2 has no subsurface drainage system and is designed to resist uplift by a combination of skin friction and self weight. The omission of the subsurface drainage system besides lowering costs also eliminates a potential radionuclide leakage path to surface waters.

Forces exerted on the outer pipe by the grout are not critical so wall thickness was selected for primarily practical reasons. 3/8" thickness of both pipes provides adequate corrosion resistance in the groundwater conditions expected for the 50-year design life and is robust enough to withstand handling during construction.

The outer liner is constructed from seamless, single longitudinally welded or spiral welded carbon steel pipe, 30 inches O.D. A welded base plate seals the bottom end of the pipe.

The outer liner resists all compression forces expected from the surrounding soil and annulus fill.

The outer liner is provided with a welded flange to facilitate bolting of the steel cover plate. The flange/cover interface is provided with a gasket so that surface water ingress is prevented.

The bolted cover plate is provided with a pipe plug assembly to permit access to the liner interspace for dose rate measurements and checking for water infiltration.

The inner liner is constructed from seamless, spiral welded carbon steel pipe, 24 inches O.D. A seal-welded baseplate is included at the bottom end.

Eight welded steel positioning bars are provided on the exterior of the inner liner. These bars ensure that the liner is positioned near the centre of the outer liner.

The upper four positioning bars serve as lifting lugs during initial placement and eventual retrieval of the inner liner.

A pipe is attached to the exterior of the inner liner for sampling of the interspace. If water is detected, the pipe could be used for its removal.

Construction

No exploratory drilling was done to investigate the site before augering. Since the deposit is boulder clay, obstructions would be expected. In practice the boulders found were small enough that augering was not impeded. Twenty holes were completed in 17 days. One hole hit a large boulder at about 17 feet. The bore was stopped at that level and the pipes cut short rather than attempt to blast the obstruction.

The outer pipes were placed and grouted to the surrounding soil. Care had to be taken during the grouting operation not to float the outer pipes. The cavities were filled with water ballast and the rate of rise of the grout controlled.

Safety

The defense in depth philosophy of earlier designs has been retained. Groundwater can only contact the waste form upon simultaneous failure of:

(1) the waste container;
(2) the inner pipe;
(3) the outer pipe.

Surface water is prevented from entering the interspace between outer and inner pipes by:

(1) the surface drainage system;
(2) the outer pipe extension;
(3) the cover gasket.

Monitoring the interspace is made convenient by the capped sampling pipe.

Normal Operation

Present loading procedures include controlled lowering of waste components into the inner liner.

Each unit is backfilled with concrete soon after four or more standard waste components have been loaded. Site operating staff determine the required depth of concrete backfill to be added to meet Ontario Hydro's Radiation Protection Regulations. This concrete serves as a permanent seal and shielding cap for the waste components. After filling with concrete, the cover plate is installed.

After backfilling, but prior to bolting on the cover plate assembly, hand-held gamma meters are used to check the radiation fields around the opening of the IC-2. The concrete backfill slug reduces the dose rate to a maximum of 2.5 mrem/h at 3.28 ft (1 m) above the opening. However, experience has shown that in a very few cases, radiation streaming up the liner interspace may cause higher fields than anticipated. In this case, a supplementary interspace shielding ring is added around the inner liner at the surface. This carbon steel ring is slotted and positioned so that it does not interfere with access to the interspace via the cover plate pipe plug.

Abnormal Operation

The inner liner may be retrieved in the event of abnormal conditions.

Highly radioactive components removed from the stations can be stored in the IC-2 under special conditions (i.e. extra shielding, placement at bottom of IC-2, special loading procedures, etc.).

Since the liners are independent, inner liners of different shape or size can be utilized in the facility if desired.

Monitoring

Suction is applied to the sampling pipe to test for water ingress into the liner interspace. This is done annually during regular operation of the facility (after first loading). If water is found, it can be removed and tested for radionuclide content.

For a period of one year after construction, each IC-2 is sampled quarterly (weather permitting).

THE IC-12 FACILITY PLACED IN SERVICE 1986

The In-ground Container-12 (IC-12) Facility provides storage space for medium level radioactive waste. The waste consists mainly of bulk spent ion exchange resin. (Fig. 2)

Design Description

IC-12 stands for In-ground Containers having a nominal capacity to store 12 cubic metres of ion exchange resin. The IC-12 facility consists of steel and concrete lined bored holes.

The IC-12 liner is a 3/8 inch thick steel pipe with a welded steel bottom and bolted top cover plate. The liner is surrounded by about 8 inches of concrete along the sides and about 12 inches below the bottom. The inside length of the liner is about 27 feet; this is sufficient to hold 4, three cubic metre resin containers and an up to 30 inch thick concrete shield plug, leaving about 6 inches of clearance between the shield plug and the top cover.

The steel liner extends 4 to 6 inches above the ground to prevent ingress of surface water. It is covered by a steel plate bolted to the liner. A gasket seals the cover to the liner. By using a soft gasket, the number of bolts fastening the cover to the liner is minimized. The gasket prevents ingress of precipitation into the liner and allows the liner to be pressurized slightly for leak testing or to facilitate pumping out of water. There is no pressure retention requirement during normal operation.

A galvanized steel pipe runs along the outside of the steel liner for monitoring. The pipe is connected to the liner from below to allow effective drainage of water from the liner bottom. The upper part of the monitoring pipe has a threaded cap located just under the top flange of the IC-12 liner. This allows the liner to be monitored without having to remove the top cover plate.

The monitoring pipe confirms the two barriers are intact. Because the liner and waste packages are made of welded steel, no leakage is expected during the life of the facility from either ground water or from stored waste. Periodic pumping out, therefore, is not necessary.

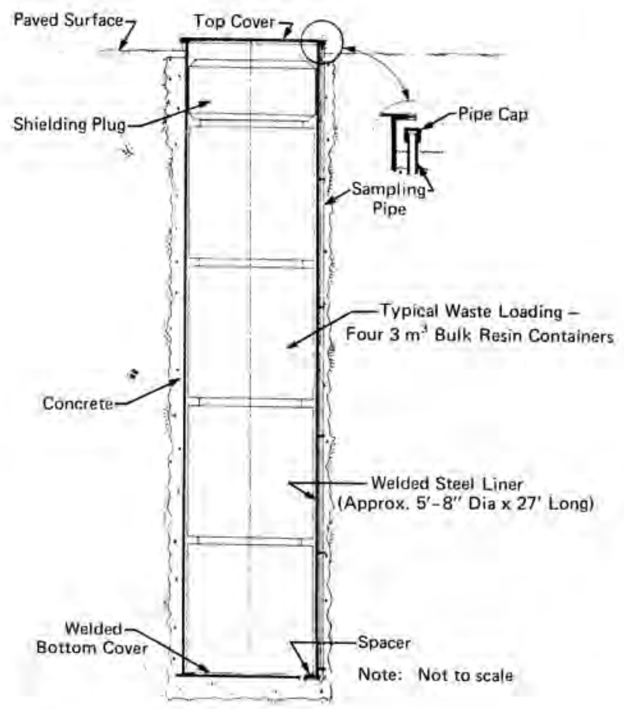

Fig. 2. IC-12 General Arrangement.

Design

The facility is designed to last at least 50 years with no maintenance. Details of how this is achieved follows:

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The outside (earth side) of the IC-12 liner is protected from corrosion by concrete and the surrounding soil conditions. The concrete and dense glacial till soil reduce the amount of water and oxygen available to corrode the steel liner. The ground water around the facility has a neutral pH and the concrete annulus further retards corrosion by creating an alkaline environment around the steel.

The inside of the IC-12 liner is protected from corrosion by a coating of coal tar epoxy. Even without the epoxy coating, there is sufficient wall thickness in the liner to prevent perforation for a least 50 years. The coating, however, is expected to last 50 years.

The design lifetime can be substantially increased if, after 50 years, the inside of liner is inspected and the epoxy coating repaired, if necessary. Restricted oxygen and moisture availability inside the liner following closure of the IC-12 minimizes corrosion. The outside of the pipe, protected by concrete is not expected to deteriorate significantly.

The 3 cubic metre bulk resin containers that will be stored in the IC-12s achieve the 50 year design life by a coating of coal tar epoxy on the outside and inside of the container. The neutral pH water inside the container combined with a restricted oxygen supply will retard corrosion on the inside wall of the container. Even without the epoxy coating, the 1/4 inch minimum thickness of the container has enough corrosion allowance to prevent failure before 50 years. Restricted oxygen and moisture after closing the IC-12 further will limit external corrosion.

The IC-12 steel liner can safely withstand the following loads:

(1) grouting pressure during construction;
(2) soil and buoyancy; forces;
(3) waste container and shield plug loads;
(4) NUPAC cask weight when placed on the IC-12 liner;
(5) vehicle loads adjacent to the IC-12s;
(6) handling loads during fabrication and construction;
(7) snow load.

Radiation Safety

During normal operation, there is no release of radionuclides from the IC-12 facility.

After loading, the maximum dose rate occurs directly above the IC-12. Shielding provided by an up to 30 inch thick concrete plug reduces the field above the IC-12 to less than 2.5 mrem/h at one metre. Based on waste receipts to date, this amount of gamma shielding is adequate.

Waste containers having unusually high dose rates can be stacked in the lower tiers of the IC-12 below less active waste to avoid having to add more shielding. Alternately, the 6 inch space between the top of the shield plug and the bottom of the cover plate can be filled with additional shielding material, if needed.

The waste stored in the IC-12 is below ground. The concrete surrounding the IC-12 liner and the soil surrounding the concrete reduces the gamma radiation field around the sides to less than 2.5 mrem/h at 1 metre.

The temporary shielding cover installed during the loading phase provides 20 inches of concrete to ensure the dose rate at one metre above the IC-12 is well below the current operating limit of 300 mrem/h at one metre. More shielding can be added, if necessary.

Waste is transferred to the IC-12s by a cask bottom unloading method. Radiation dose to operators is therefore minimized

Collimated, unshielded, radiation beams are present directly below the cask when the bottom is removed and above a partially filled IC-12 when the temporary shielding cover is removed. The unloading procedures require that operators stand away from the radiation beams to prevent possible exposure. Movement of the cask or covers is controlled by the crane operator located away from the radiation beams.

Operation

The dimensions of the IC-12s allow four NUPAC cask cavity sized containers to be loaded. The IC-12 liner diameter is slightly larger than the cask's cavity to allow for some misalignment during loading. The depth of the IC-12 allows four containers, to be stacked.

A working platform is provided to minimize the distance a cask is carried after the bottom is removed. The platform is normally placed adjacent to the IC-12 being loaded.

The IC-12 bore holes are arranged in a double row of 10 holes about 9 feet apart at the centrelines. Lifting a cask with the 140 ton capacity Grove TM 1400 hydraulic crane available at the site, over the second row of holes is within the safe loading capacity of the crane when it is spotted adjacent to the row and its stabilizing outriggers are fully extended. The distance from the centreline of the crane to the centreline of the second row of bored holes is about 30 feet. The rated lifting capacity of the crane at this distance is 106,000 pounds, which exceeds the 64,000 pound weight of a loaded cask.

Other Performance Characteristics

Surface runoff from the IC-12 Facility is directed towards the ditch draining into the existing IC-2 Facility and then to a sample station.

Retrieval of waste is possible by grappling the waste container and lifting it into a bottom unloading cask, such as the NUPAC cask, in the reverse of the loading procedure.

Another retrieval method that could be used would be to remove the 50-60 ton IC-12 complete with waste and concrete annulus from the ground. This would involve excavating of the soil around the IC-12 so the IC-12s could be lifted out and transferred elsewhere.