Canadian Nuclear Society
Waste Management, Decommissioning and Environmental Restoration
for Canada's Nuclear Activities: Current Practices and Future Needs
Ottawa, Ontario Canada May 8-11 2005

A Modular Waste Storage Yard Concept for Managing CANDU 600 MW Nuclear Generating Station Refurbishment Waste Streams

By P. Tume, C. Cottrell, T. Hiscock, J. Jamieson
Atomic Energy of Canada Limited
2251 Speakman Drive, Mississauga, ON
L5K 1B2

ABSTRACT

The waste management facility of a CANDU 600 MW Nuclear Generating Station is licensed to meet the operational requirements for the original 25 to 30 years of station life. However, these stations are now considering a Plant Life Extension through refurbishment of the reactor core and other plant systems. The refurbishment work will generate a waste stream that has a large volume and specific characteristics that typically cannot be handled and stored within the existing capacity of the waste management facility.

Atomic Energy of Canada Limited has identified the requirements for waste stream handling and storage for a CANDU 600 MW plant refurbishment. These requirements can be met through the use of either all, or part of, a Waste Storage Yard Concept that is a based on our experience on the planned refurbishment of Pt Lepreau and Gentilly 2 CANDU 600 MW power plants. This paper describes, at a high level, the waste management requirements to support the refurbishment work and describes the Waste Storage Yard Concept.

Introduction

Routine maintenance of a CANDU 600 MW plant includes activies that are similar to the work that will be performed during refurbishment of the station. Some of these activities include, Single Fuel Channel Replacement, Inspections and Feeder pipe replacement, and control system upgrades. Hence, there is a basis for understanding the characteristics of the waste stream and therefore, a basis for storing the materials. However, Large Scale Fuel Channel and Feeder Replacement (also known as Retube) and major station system upgrades occurs over a short outage duration and produces a larger than normal outage waste volume that presents unique challenges for handling and storage.

High-Level Requirements for Handling and Storage of Retube and Refurbishment Waste

To refurbish a CANDU plant, the Waste Management Facility license holder must consider if, and how, the facility license should be updated for management of the refurbishment waste stream in accordance with the Nuclear Safety and Control Act [1]. The following high-level list of requirements for the potential modifications to the waste management facility should be considered for this work:

- Refurbishment and Post-refurbishment Operational Waste Radiological Characteristics (which takes into consideration material impurity concentrations, the plant power history and chemistry, fuel defect rates and magnetite loading);
- Refurbishment and Post-refurbishment Operational Waste Thermal Characteristics (which takes into consideration the decay period allotted from the Guaranteed Shutdown state for the Refurbishment outage to the point at which the material is removed from the reactor);
- Refurbishment and Post-refurbishment Operational Waste Volume of the specific waste stream;
- The need and scope of an Environment Assessment/study [2,3] and any environmental data collection;
- The available land area s to accommodate new waste handling and storage, its geotechnical characteristics; this includes a study of siting options;
- Regulatory commitments for existing systems that could impact upon any new designs (as described in the Facility Safety analysis reports, ALARA assessments for occupational and public exposure, contact dose rates the structure and handling system);
- Safety design guides for Radiation Protection, primary waste confinement containers and secondary waste confinement structures and systems (e.g ventilation of passive filtration systems)
- Operations and decommissioning plans;
- The refurbishment project critical path/schedule constraints;
- Transportation and security requirements;
- Period of Interim storage (as this affects the facility design/service life);
- Need for the handling and storage system to manage the need for waste retrievability;
- Providing Dry conditions for waste handling and storage throughout the waste pathway;
- Management of hazards, both radiological and non-radiological, that are introduced by the site construction work and by subsequent waste transfer activities;
- Non-technical regional/public concerns (e.g., First Nations needs, archeological sensitivities);

- Quality assurance program for the facility modifications with respect to design, procurement, construction, commissioning, operations and environmental monitoring;
- Training commitments for design through to operation of the modified handling and storage systems; and
- Human factors engineering following the guidelines in CNSC regulatory guides G-276, G-278, IEEE Std. 1-23-1988, and USNRC review model NUREG-0711 [4,5,6,7].

General Design Requirements for the Waste Storage Yard

The high level requirements will typically translate into specific design support activities. In AECL's experience the following General Design Requirements must also be considered.

Quality Assurance, Code Classification and Standards

The strategic view for both spent fuel and non-fissile waste management in Canada is presented in the Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management [8]. In this context, spent fuel is handled and stored by meeting the Nuclear Safety and Control Act and the Canadian Standards Association CAN/CSA N292.2 (N292.2), which provides detailed handling and storage design requirements for Canada [9].

Design Quality Assurance

The quality assurance process for the design of spent fuel handling and storage systems is prescribed in N292.2 as CAN/CSA N286.2 (N286.2)[10]. In the absence of a standard for non-fissile waste management systems, and given that this can be considered a permanent plant modification, AECL has chosen to follow the N286.2 quality process for the design of the Waste Storage Yard.

Design Codes and Standards

In accordance with CAN/CSA-N285.0, 1995 edition, containers that hold high specific activity materials with a low pressure are classifiable under the requirements for pressure-retaining systems [11]. In this process, the Licence provides the design and operational characteristics specific to the component to be considered on a Classification Submission Form and the CNSC decides if the proposed classification either is or is not acceptable. In AECL experience, it is recommended that this process be used to obtain concurrence from the CNSC that classification is/is not applicable to the package of high specific activity materials even if the low-pressure threshold is not met.

For this scope, the CNSC has accepted that the high level waste containers are exempt from classification. This decision means that the high level retube waste container design meets all safety requirements, without unnecessary over-design that would have increased manufacturing costs by up to 200%.

In the absence of a detailed design standard for non-fissile waste management, AECL has applied the principle of "equivalent safety" for the handling and storage of the high level waste stream in the Waste Storage Yard. Consequently, the Retube Canister and Resin Structure designs incorporate the structural requirements of N292.2. The Storage Vault and the administration building designs meet the requirements of the 1995 edition of the National Building Code of Canada.

Note: At the time of production, the CNSC has indicated that a Regulatory Guide (G-320) on "Assessing Options for the Storage and Disposal of Radioactive Waste" may be issued for review in the 2005/2006 timeframe. Once issued, the Waste Storage Yard concept will be reviewed in the context of this new information.

Interfaces

As a general goal, a refurbishment project will minimize the duration of a critical path activity in order to meet the project milestones. One aspect of this work is to minimize handling of the waste by collecting the material in the same container that it will be stored. Hence, the project requires that there be a smooth transition at the handling and storage system interfaces.

For the work to date, the main interfacing requirements include

- Optimizing the tolerance-stack-up on the tooling and waste handling systems, and the handling and storage system;
- Ensuring a smooth interface transition;
- Contamination control (including interfacing with retube/refurbishment tooling);
- Occupational/Industrial and Radiological Safety of the workers and the public
- Protection of the Environment;
- Materials compatibility of the storage system (e.g., to prevent galvanic corrosion between mechanical embedments and the concrete in the storage structure); and
- The preferences of the power plant staff with respect to retrieval of the waste for disposal and maintenance of the structure.

The AECL Waste Storage Yard and its handling system, which is described below, meet the above requirements.

WASTE STORAGE YARD CONCEPT

Atomic Energy of Canada Limited has designed a Waste Storage Yard for the management of refurbishment waste that is optimized to take into account the types of waste, the waste characteristics and the form of the material. Figure 1 is a plan view of a storage yard for a typical CANDU 600 MW plant. The site layout is optimized for a common set of Canadian facility requirements. The modular nature of the layout provides the versatility to handle and store the range of materials. As an example, the Plant Owner may elect to either store decontamination resin within the station resin tanks or store both operational and decontamination resin in the Waste Storage Yard.

The Waste Storage Yard features four types of storage structures: a Retube Canister for the high (activity) level waste (e.g., fuel channel components), a Retube Vault(s) for the low and intermediate activity level waste (e.g., feeders), a Resin Storage Structure for decontamination resin and an Administration building. The Retube Vault also serves as the storage structure for the other refurbishment wastes.

The size of the Waste Storage Yard as shown is 50 x 150 m. The actual size of a specific Waste Storage Yard will need to take into consideration as a minimum:

- The owner's preference for handling the high level waste packages. The concept presented, includes a Gantry crane and crane rails for loading of the Retube Canisters and/or Resin Storage Structure and/or vaults. In certain cases the crane specification can envelope the requirements of the dry spent fuel storage area, meaning that the same crane can be used in both areas. As a result, there is a potential reduction in inspection, operations and decommissioning costs;
- Optional Interface of a transfer truck with the Retube Vaults;
- Service road to permit the transfer truck to load waste packages such that it is adjacent to a retube structure;
- Material handling de-icing system;
- Surface water collection and monitoring capability (consisting of in-ground pipes and retention tank);
- Surface water and liquid disposal;
- Paved interior to support monitoring control;
- Controlled access point through the gate and administration building;
- Radiological Zoning as defined by fence-line perimeter to meet a contact dose rate requirement of less than 10 mircoSv per hour on the fence
- Ditch (Berm) to control and minimize risk of ingress of surface water exterior to the storage yard.

Note: To date, the CNSC has amended the Point Lepreau waste management area operating license to permit the construction modifications for the refurbishment and post-refurbishment life waste stream [12]. As part of this decision, the CNSC tribunal has granted an "Authorization to Construct" to the Plant Owner by assigning a CNSC Designated Officer to regulate the work. This decision was based on an environmental screening report that has shown that there are no significant environmental effects from these facility modifications [13]. At the time of writing this paper, the regulatory decision to grant a license for the new waste management area for G2 is pending.

Storage Structures

Retube Canister

The Retube Canister is an aboveground storage structure that is based on the AECL CANSTOR® and Dry Spent Fuel Storage product line (see Figure 2). The Retube

Canister structure is a large hollow concrete cylinder that houses seven storage cylinders surrounded by air and anchored to the canister base. Each storage cylinder contains three vertically placed guide tubes, to house the high level waste containers. This design maximizes the storage capability of the canister while minimising the structure footprint. Each canister is designed for a contact dose rate of < 25 μSv/h on the structure wall .

The design of the Retube Canister facilitates monitoring through a sloped floor with drain and vent pipes located near the structure base. In keeping with the need to eventually move the waste to a disposal site, the waste containers can be retrieved through removal of the shield plug weld As with the AECL CANSTOR® and Dry Spent Fuel Storage product lines, the Retube Canister can be decommissioned by decontaminating the emptied storage cylinders, physical cutting of the storage cylinders for recycling and demolition of the concrete with standard wrecking equipment. The concrete residue can be disposed as non-radioactive material.

Retube Vault

A Retube Vault is a shown in Figure 3. The structure is built of reinforced concrete, with provision for monitoring through a through wall inspection port. The upper surface of each cover and the floor is sloped to prevent water accumulation. The structure also has a provision to interface with a precipitation collection sump. The structure is built on a lean concrete bearing pad with provision for a recessed monitoring space. This structure meets the National Building Code requirements. The design of the concrete for the storage structures will give an expected service life of 50 years.

Resin Storage Structure

A Resin Storage Structure is a shown in Figure 4. The structures are built of reinforced concrete with storage cylinders that are surrounded by concrete. Each storage cylinder will be capped with a concrete shield plug. The storage structures can be monitored in a manner similar to the Retube Canister. In addition, the Resin Storage Structure has a sampling system that is designed to ensure that by-product gases produced by resin degradation can be sampled and vented in a controlled manner. The structure is built on a lean concrete bearing pad. The nominal shielding wall thickness results in a contact dose rate on the structure wall of < 25 μSv/h. The design of the Resin Storage Structure will accommodate either operational or decontamination resin.

Administration Building

To facilitate access control, the Waste Storage Yard includes an administration building at the gated entrance. This building serves five main functions:

1. Access Control to the Zoned area;
2. Electrical Power Hook-up;
3. Land line communication capability to the facility;
4. Personnel Shelter for Inclement weather and Emergency Measures; and
5. Sampling and Personnel Monitoring Equipment Location.

This structure may be a prefabricated metal structure with nominal dimensions of 7.3 m x 7.3 m.

WASTE HANDLING INTERFACE WITH THE MODIFIED STORAGE YARD

As discussed above, the smooth transition at interface points is required for the success of the project. In this context, the refurbishment waste management system must address the handling at the reactor face, handling during transfer through the reactor and services building and over the station road, as well as loading and sealing of the structures in the Waste Storage Yard. Inside the reactor and service building, the handling system is integrated with retube processes and physical limitations of the building. For example, the high-level retube waste containers are housed in a shielded flask that interfaces with a volume reduction tool for removal of fuel channel components. The handling system design also takes into consideration space limitations and physical loads (on the platforms and cranes) to enter and leave the reactor building through the equipment air lock and transportation needs (e.g., truck capacity, road load bearing requirements).

At the Waste Storage Yard, the handling system specifically addresses the requirements for each type of container/flask to interface with the storage structure. For instance, the high level retube waste flask is designed to interface with a gated LID (Load Interface Device) that is indexed via a gantry crane to locate the flask over a specific storage tube inside the Retube Canister. For spent resin the flask/containers are loaded via commissioning-match-marks on the gantry crane to align the container with a specific storage cylinder. For feeder pipe materials, the waste is contained in an appropriately shielded, commercially available United States Department of Transportation Type A metal box that is handled through a conventional sling system.

Summary

Refurbishment of a CANDU 600 MW station includes, but is not limited to, large-scale replacement of feeder pipe and fuel channels. As such the waste management license holder (e.g., Plant Owner) must provide facilities for handling and storage of the refurbishment wastes; this typically requires construction of a new or expanded storage area to handle the both the scope of the refurbishment and post-refurbishment life waste stream. Defining the requirements early in the work minimises overall project risk.

AECL has designed a Waste Storage Yard for the management of refurbishment waste that is based on our current experience with Canadian CANDU 600 MW plants. Owing to the completeness of the requirements, the design is readily implemented in the Waste Storage facility of a typical CANDU 600MW station. The modular design of the Waste Storage Yard ensures that the Plant Owner has readily available solutions to meet both refurbishment (including retube and decontamination scope) and post-refurbishment life operational waste stream needs of the plant.

References

[1] "Nuclear Safety and Control Act, Class I Nuclear Facilities Regulations," Canada Gazette Part II, Vol. 134, No. 13 June 2000.

[2] "Environmental Management Systems - Specification with Guidance for Use," ISO 14001, International Organization for Standardization, 1996.

[3] "Canadian Environmental Assessment Act,"1992, c.37.

[4] "G-276. Regulatory Guide: Human Factors Engineering Program Plans," Canadian Nuclear Safety Commission. March 2001.

[5] "G-278. Regulatory Guide: Human Factors Verification and Validation Plan," Canadian Nuclear Safety Commission. June 2003.

[6] "IEEE Guide for the Application of Human Factors Engineering to Systems, Equipment, and Facilities for Nuclear Power Generating Stations," IEEE Std. 1-23-1988,

[7] "Human Factors Engineering Program Review Model," U.S. Nuclear Regulatory Commission, NUREG-0711, February 2004.

[8] "Canadian National Report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management," Published by the Canadian Nuclear Safety Commission," CNSC Catalogue Number INFO-0738, May 2003.

[9] "General Instruction No 1: Dry Storage of Irradiated Fuel," CAN/CSA –N292.2-96, April 1996.

[10] "General Instruction No 1: Design Quality Assurance for Nuclear Power Plants," CAN/CSA –N286.2-00, March 2000.

[11] "General Instruction No 3: General Requirements for Pressure-Retaining Systems and Components in CANDU Nuclear Power Plants," CAN/CSA –N285.0, 1995 edition, August 1998.

[12] "CNSC Record of Proceedings, Including Reasons for Decision: Application for the Amendment to the Waste Facility Operating Licenses for the Point Lepreau Solid Radioactive Waste Management Facility," January 13, 2004 (as posted on CNSC web site at http://www.nuclearsafety.gc.ca/eng/commission/pdf/NBPower-Amendment-PointLepreau03-11-26-e.pdf)

[13] "Point Lepreau Refurbishment: Environmental Assessment Experiences and the Role of the Public," C. Hickman, P. McKay, K. Duguay, E. Eagles (NBP), P. Tume (AECL), 25th Annual CNS Conference Toronto, June 6 - 9, 2004.

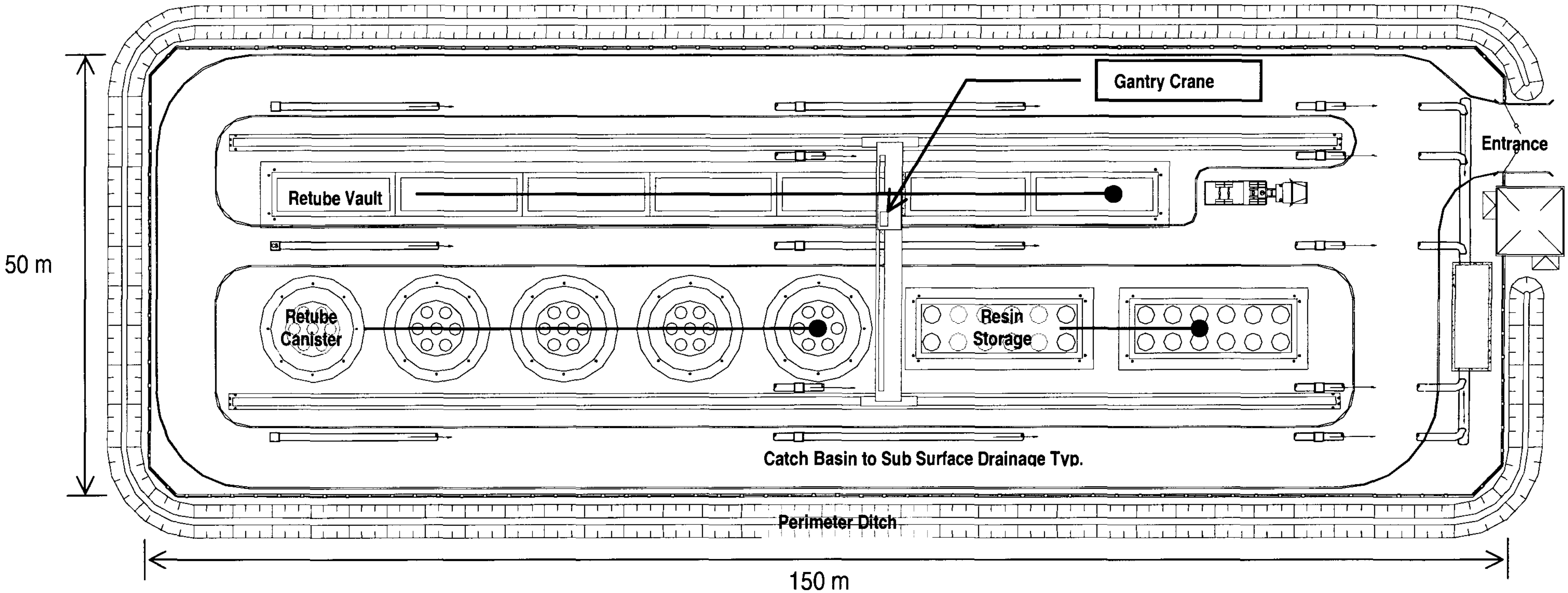

Figure 1: Typical CANDU 600 MW Waste Storage Yard for management of refurbishment waste.

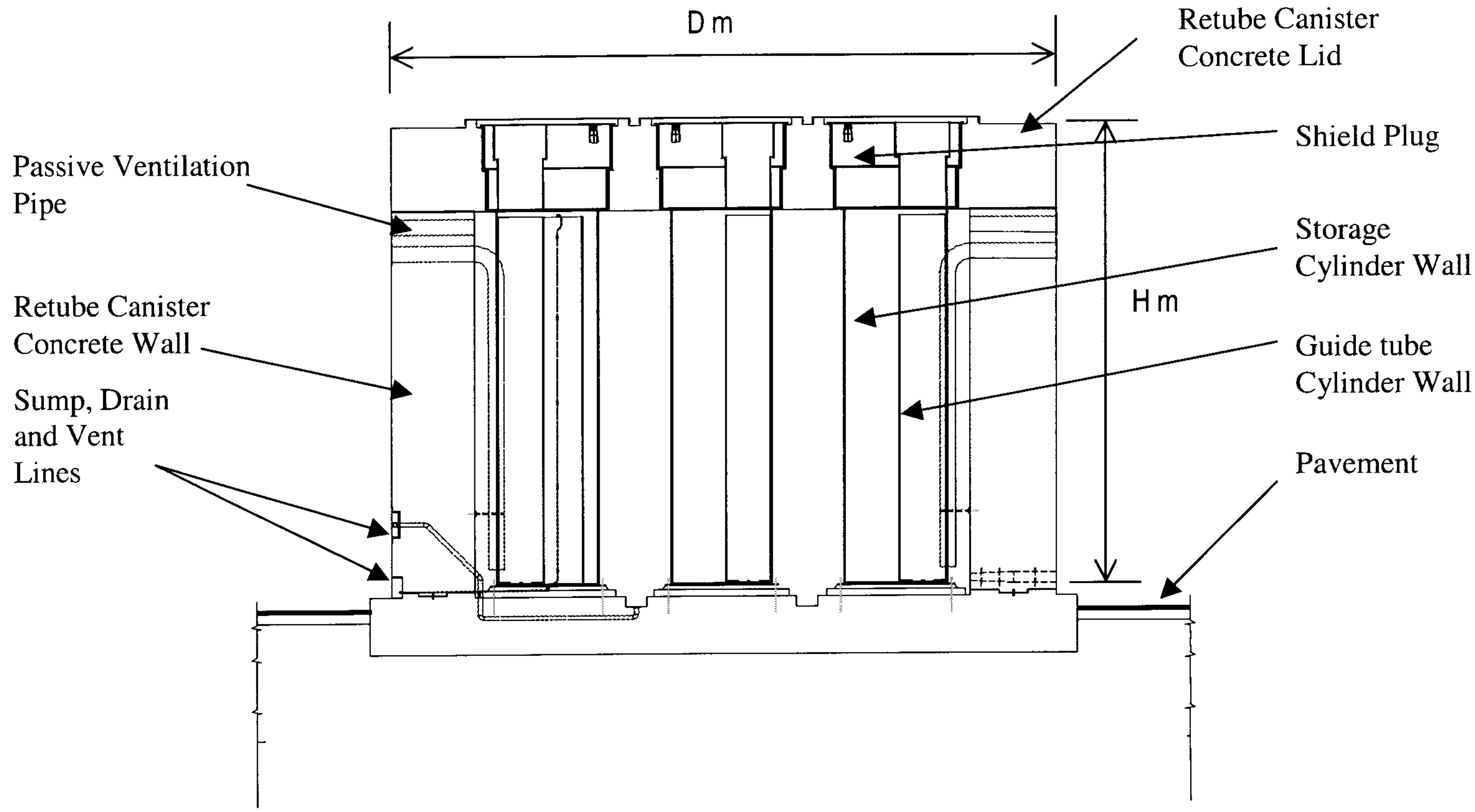

Figure 2: Sketch of Retube Canister.

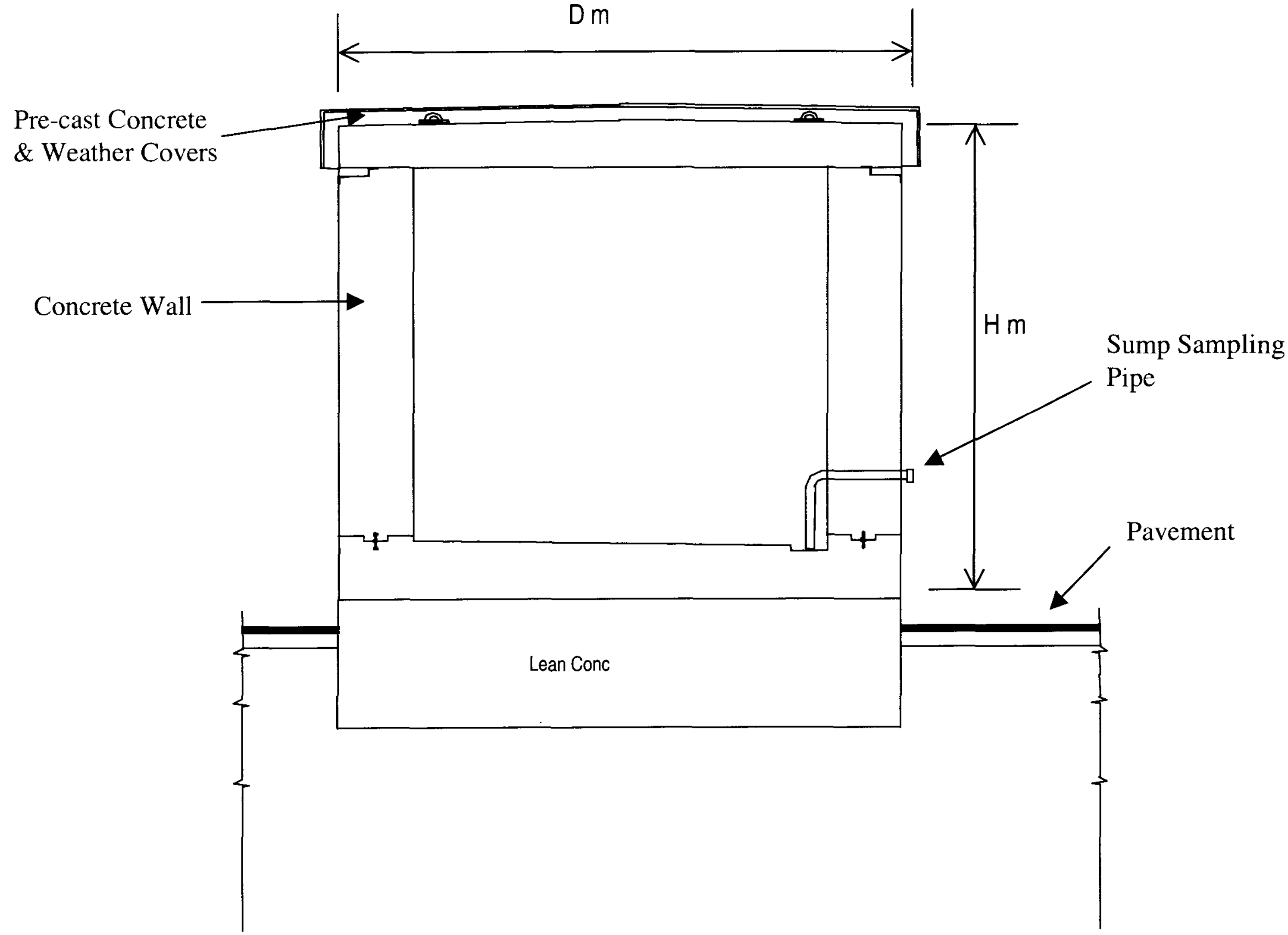

Figure 3: Sketch of Retube Vault

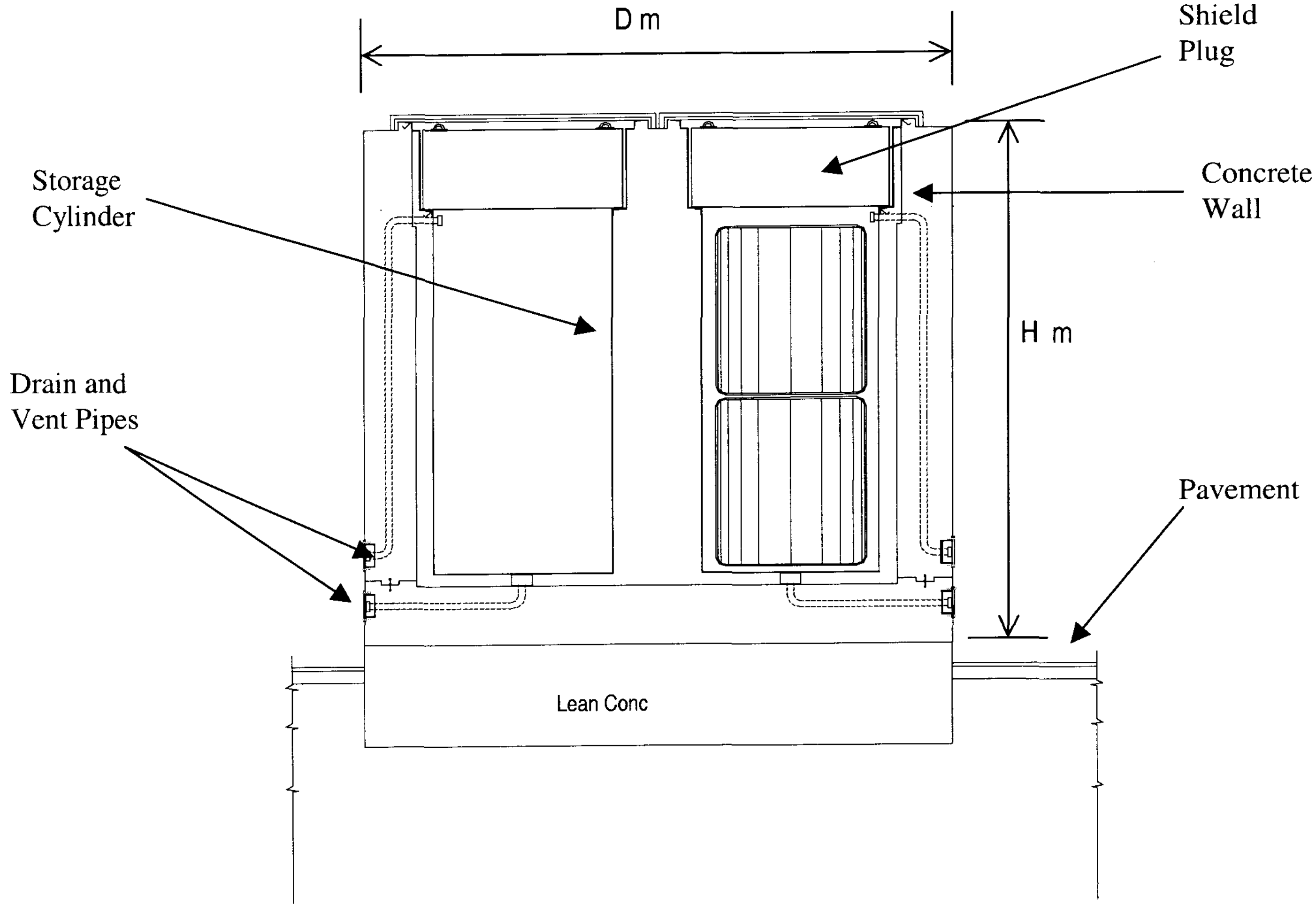

Figure 4: Sketch of Resin Storage Structure