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NWMO BACKGROUND PAPERS
6. TECHNICAL METHODS

6-7 STATUS OF STORAGE, DISPOSAL AND TRANSPORTATION CONTAINERS FOR THE MANAGEMENT OF USED NUCLEAR FUEL

EXECUTIVE SUMMARY

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BACKGROUND PAPER ON THE STATUS OF STORAGE, DISPOSAL AND TRANSPORTATION CONTAINERS FOR THE MANAGEMENT OF USED NUCLEAR FUEL

SUMMARY

The Nuclear Waste Management Organization (NWMO) is mandated to examine a range of approaches for the long-term management of Canadian used nuclear fuel. The principal approaches to be examined are 1) extended storage at reactor sites, 2) extended storage at a central site and 3) geologic disposal. This paper has been prepared at the request of NWMO to present a factual description of the current status of storage, disposal and transportation containers for the long-term management of used fuel.

Following discharge from nuclear reactors, used fuel is stored in water-filled pools to cool it and to provide shielding from its radiation. As pool storage capacity at various sites is becoming full, older and, therefore, cooler used fuel is being transferred to dry storage systems. Dry storage capacity is less expensive and provides a more easily monitored storage system for used fuel. Depending upon the type of fuel and the design of the dry storage units, the fuel must be cooled for periods of up to 10 years before it can be transferred into dry storage. Presently, the total world-wide storage capacity for used fuel is approximately 255,000 megagrams with dry storage representing 17% of this capacity. Both wet and dry storage technologies are considered to be safe and mature technologies, which can provide adequate interim storage for at least 50 years.

The concept of extended storage is one of storage in ‘perpetuity’. Wet storage is not a preferred option for extended storage because of its higher maintenance requirements, need for greater monitoring and higher overall cost. While it is feasible to increase the design life of current dry storage structures, it is nevertheless considered that over an extended storage period, used fuel would need to be periodically repackaged into new storage structures. A number of extended storage concepts have been examined for both centralized and reactor site storage. These concepts include both above ground and below ground facilities. These concepts envision storing the used fuel within dry storage containers and/or inside vaults. Extended storage at the reactor site may be a continuation of the current dry storage practice.

In general, extended storage containers must provide safe containment of the used fuel from the time of loading through handling, transportation, emplacement and during storage. Three main types of dry storage systems are currently in use: 1) concrete vaults, which are large ventilated buildings and hold 600-2000 Mg fuel, 2) concrete containers and silos, which hold 5-15 Mg fuel, and 3) metal containers, which hold 10-17 Mg fuel. For dry storage of used fuel in Canada, vaults are used at Gentilly-2, silos are used at Point Lepreau and transportable, rectangular, concrete, dry storage container (DSC)s are used at Ontario Power Generation (OPG) sites. The Pickering DSC can accommodate four fuel modules (a module is a rectangular fuel storage framework used at OPG sites which can accommodate 96 fuel bundles) weighing 10 Mg in total. OPG’s design differs significantly from container designs for light water reactor (LWR) fuel; containers for LWR fuel have a cylindrical configuration. Such a configuration is not optimal for CANDU fuel because the CANDU fuel bundles have a much shorter length.

The Canadian used fuel will eventually need to be permanently managed. Geological disposal within the stable granitic rock of the Canadian Shield, at a depth of 500-1000 m, is considered to

be generally acceptable for the permanent isolation of the used fuel. The reference Canadian used fuel container has a design life exceeding 100,000 years and has a capacity of 324 used fuel bundles. The design consists of an outer copper corrosion barrier vessel and an inner steel load-bearing vessel. The used fuel bundles are first placed within a fuel basket which is then loaded into the inner vessel. Each basket consists of an assembly of carbon steel tubings in a closed packed arrangement. The outer copper corrosion barrier is designed to collapse onto the inner steel container under repository pressure loadings and, thereafter, be supported by it. The container will be encased in bentonite clay for emplacement in disposal rooms or in boreholes. The Canadian design concept is similar in several respects to the Swedish and Finnish designs and was developed considering the present siting uncertainties for a repository.

Used fuel must be shipped to the central extended storage or disposal site in containers that shield, contain the radioactivity and dissipate the heat. The containers may be transported via road, rail and/or water. Many of the requirements for used fuel storage containers also apply to used fuel transportation containers; additional requirements also arise from a consideration of the extreme weather conditions that can be experienced in Canada. The containers must be appropriately packaged for transportation; the packaging consists of impact limiters, impact armouring and associated attachments. Packages for transporting spent fuel constitute a Type B package. Such packages are required to withstand expected accident conditions without breach of containment or an increase in radiation level that potentially could endanger the general public and those involved in rescue or clean-up operations.

Two designs exist for transporting Canadian used fuel, namely, OPG's transportable DSC and OPG's Irradiated Fuel Transportation Container (IFTC). These represent two relatively different design concepts. The IFTC, similar to the DSC, is rectangular; however, it is of stainless steel construction. It can accommodate half of the DSC's payload, i.e., two fuel modules weighing 5 Mg. While the DSC has a welded lid, is intended for single use and has a design life of 50 years, the IFTC has a bolted closure, is intended for repeat use and has a design life of 20 years. One main disadvantage of the DSC is its relatively large weight; despite this, transportation by road is considered to be feasible. The IFTC design can also accommodate non-OPG fuel storage baskets.

In contrast to the IFTC, transportation containers for enriched LWR fuel have a multi-shell cylindrical structure (lead is sandwiched between inner and outer steel shells) which also incorporates neutron shielding. Similar to the IFTC, containers for Gas Cooled Reactor fuel are also rectangular in cross-section because the fuel element has a short length. Unlike the LWR fuel transportation containers, the IFTC requires no fins for heat dissipation because CANDU fuel is much cooler; the absence of fins facilitates decontamination and makes the container cheaper to manufacture.