MAINE YANKEE: MAKING THE TRANSITION FROM AN OPERATING PLANT TO AN INDEPENDENT SPENT FUEL STORAGE INSTALLATION (ISFSI)

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ABSTRACT

The purpose of this paper is to describe the challenges faced by Maine Yankee Atomic Power Company in making the transition from an operating nuclear power plant to an Independent Spent Fuel Storage Installation (ISFSI). Maine Yankee (MY) is a 900-megawatt Combustion Engineering pressurized water reactor whose architect engineer was Stone & Webster. Maine Yankee was put into commercial operation on December 28, 1972. It is located on an 820-acre site, on the shores of the Back River in Wiscasset, Maine about 40 miles northeast of Portland, Maine. During its operating life, it generated about 1.2 billion kilowatts of power, providing 25% of Maine's electric power needs and serving additional customers in New England. Maine Yankee's lifetime capacity factor was about 67% and it employed more than 450 people. The decision was made to shutdown Maine Yankee in August of 1997, based on economic reasons. Once this decision was made planning began on how to accomplish safe and cost effective decommissioning of the plant by 2004 while being responsive to the community and employees.

INITIAL STRATEGY AND TACTICS

The accomplishment of a decommissioning project is tantamount to deconstruction, that is, construction in reverse. Many of the same skill sets in project management and implementation are common to construction project activities and are dissimilar to those found in the staff of an operating nuclear power plant. The project was initially reorganized for oversight with this project management skill set with a concurrent reduction in operating staff. The physical plant was then prepared for rapid decommissioning activities, which included physical and license spaces systems abandonment, asbestos abatement, moving the plant to a "Cold and dark" condition by eliminating and draining electrical trains and piping systems and locating all fuel into the spent fuel pool. Once the vessel was emptied of fuel, the reactor coolant system was decontaminated with a chemical process to reduce overall plant dose rates and facilitate ALARA activities for RCS system removal. Additional efforts were undertaken to recover remaining values of major components with substantial remaining useful life. A community advisory board was formed in order to insure that the community remained informed of plant activities. It was also decided to establish a "Turn key" decommissioning operations contractor (DOC). This contract was awarded to Stone & Webster in September of 1998. In May of 2000, this contract was terminated and Maine Yankee assumed the performance of the DOC subcontracts while re-bidding the DOC contracted scope. In February of 2001, Maine Yankee choose to self perform the DOC scope and to complete the project under its own management. At this writing, the project is nearly 60% complete and has included a peak decommissioning labor force of 515 workers. All large components except the reactor vessel have been removed from the site. All Greater Than Class C (GTCC) reactor internal materials have been completely segmented and are in the process of being loaded into GTCC canisters and stored inside Universal Multi-Purpose Storage Systems (UMS®) on the ISFSI. The turbine pedestal has been reduced to rubble and the turbine building was demolished on November 17, 2001.

UNIVERSAL MULTI-PURPOSE STORAGE (UMS) AND THE ISFSI

As many plant activities were underway to eliminate physical components, parallel activities were underway to prepare for the removal of all GTCC components and all spent fuel assemblies for their packaging within multi-purpose storage canisters, which could subsequently be transferred into Vertical Concrete Casks (VCC), which would be located on the ISFSI. The plant inventory of 1434 fuel assemblies as well as the volume of GTCC components requires 4 GTCC canisters and 60 canisters that can hold fuel assemblies. At its completion, this project will have 64 VCC's on the ISFSI pads.

Figure 1 shows an isometric cut-away view of the major components of the NAC Universal Multi-purpose Storage system, which is being used on this project. The primary components include the canister, which is the inner most assembly housing the fuel assemblies or GTCC materials. The VCC liner is a cylindrical component of approximately 2 1/2-inch thick carbon steel, which provides a barrier between the concrete cask and canister. The outer most component of this assembly is the VCC. This cask is about 2 1/2-feet thick and, when fully loaded and on the pad, has an approximate weight of 320,000 pounds.

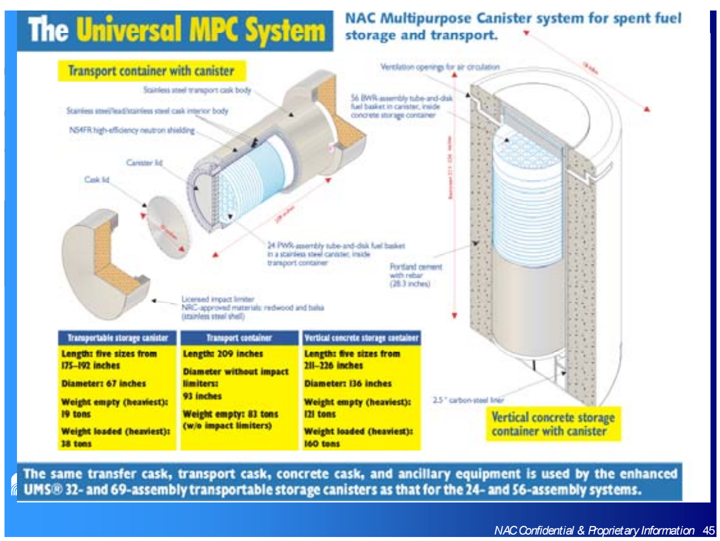


Fig. 1. NAC's Universal Multipurpose Systems (UMS©)

Figures 2, 3, and 4 below depict the sequence of activities required to load a complete canister and locate it to the ISFSI.

DESCRIPTION OF SYSTEM AND OPERATION

UMS® Components and Specifications

The UMS® is a canister-based system for the storage and transportation of spent nuclear fuel.

The principal components of the UMS® equipment are described below.

Transportable Storage Canister (TSC)

The TSC consists of a stainless steel canister, and structural and shield lids with the fuel basket structure. The canister with lids welded in place is defined as confinement for the spent fuel during storage. The basket assembly in the canister provides the structural support and primary heat transfer paths for the decay heat generated by the fuel assemblies.

Vertical Concrete Cask (VCC)

The VCC is the overpack into which the canister assembly is placed to store spent fuel. The concrete cask is a thick carbon steel inner liner surrounded by reinforced concrete with a shield plug and lid structure. The concrete cask provides the structural protection, biological shielding, and environmental barrier to protect the TSC during storage. In addition, the VCC provides a heat transfer annulus around the canister, with inlet and outlet vents to provide continuous passive cooling of the exterior of the TSC.

Universal Transport Cask (UTC)

The UTC is the shipping overpack and, with the TSC and impact limiters, is the transportation component of the UMS®. The cask is used to transport the loaded TSC off site. The cask lid, O-rings, top and bottom forging and inner shell are defined as the primary containment boundary that meets all NRC transportation requirements.

Transfer Cask (TFR)

The TFR is a biological shielding and structural overpack used for loaded TSC transfer operations at a utility site. It is used to safely move a loaded TSC between the spent fuel pool loading area and the Independent Spent Fuel Storage Installation (ISFSI). The TFR is also used to load the TSC into the concrete cask (VCC) or the transport cask (UTC) and unload the TSC from the concrete cask and load the TSC into the transport cask for off-site transport. The adapter plate facilitates the mating of the TFR with the concrete cask or transport cask.

Additional Equipment and Processes Used During Operation

During the fuel loading campaign, which takes place in the spent fuel pool-loading pit, the TFR and the TSC are filled with water. After the fuel assemblies are loaded into each fuel storage position in the basket, the shield lid is placed onto the canister, and the transfer cask is moved to the decontamination area. The water in the canister is then drained and directed to the site radwaste processing system.

Following shield lid welding and pressure testing, the cavity is drained of the remaining water. The vacuum drying system is then connected to the vent and drain ports and the canister cavity is evacuated to remove residual moisture and gases. At the completion of vacuum drying, a vacuum pressure rise test is performed to verify the absence of water and oxidizing gases in the cavity. The canister is then backfilled with helium.

Air Pads

Air pads are a safe and efficient method to move heavy loads. In the case of the UMS®, a rig set of four air pads will be positioned under the VCC. This will allow the VCC to be moved to and from the heavy-haul trailer and the storage pad. The air pad technology is designed to provide smooth and free movement of the VCC. The air-cushion technology uses a continuous, regulated airflow to create an air cushion between the air pad and the floor. The thin film of air allows the VCC to be lifted and “float” almost friction free. The rig set provides the control system to all four-air pads from the compressed air supply. The entire system is commercially available.

Lifting Jacks

Hydraulic jacks are placed underneath the VCC inlet air vents to lift the cask to allow installation and removal of the air pads. The deflated thickness of the air pads is less than 3 inches and, therefore, the cask does not have to be lifted more than 6 inches off the ground. Four hydraulic pad jacks will be provided, along with a control panel, electric hydraulic oil pump, oil reservoir tank and all hydraulic lines and fittings.

The jack will be positioned in the inlet air vents and the system lines will be properly connected. The jack will be engaged and the jacks will lift the cask. Then the air pads will be placed under or removed from underneath the cask. Lifting jacks of adequate lift capacity are readily available.

Draining and Vacuum Drying Systems

The draining and vacuum drying systems are used to drain and vacuum dry the interior of the TSC. The vacuum drying system also includes a helium test lid and a Mass Spectrometer Leak Detector (MSLD) to allow performance of the required helium leak tests.

Semiautomatic Welding System

The semiautomatic welding system consists of commercially available components with a customized fixture unit. The components include a welding machine, shield base, a remote pendant, carriage, drive motor and wire motor, remote TV cameras and video recording equipment, and the fixture unit.

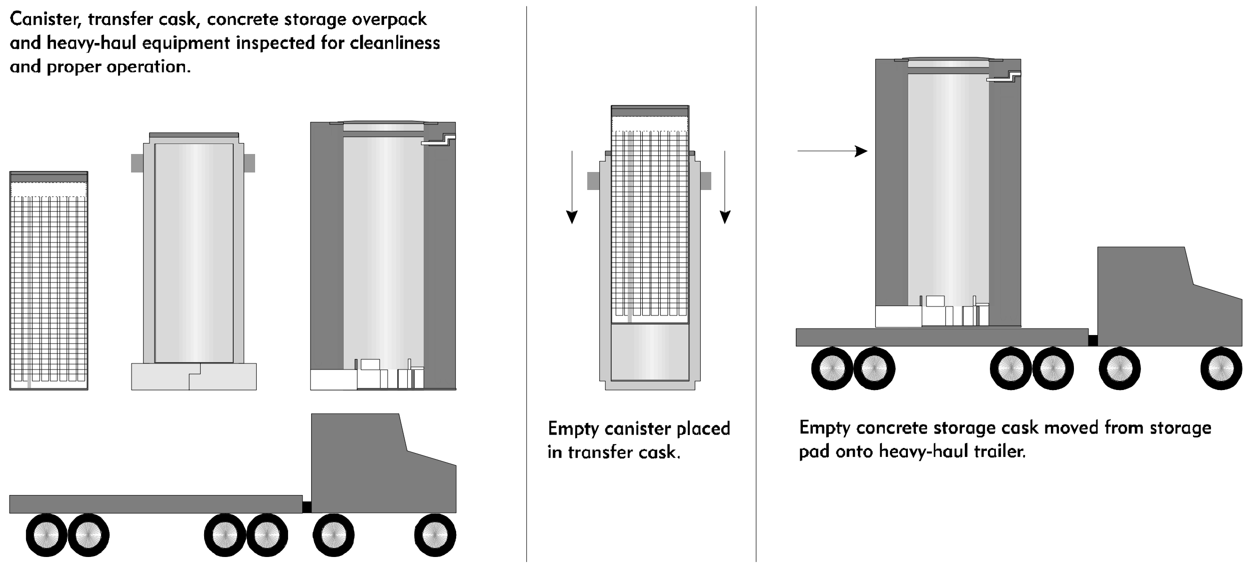
Temperature Instrumentation

The VCC has four outlet vents on the top of the cask and four inlet vents at the bottom. The outlet temperature at each outlet will be remotely monitored on a daily basis. The ambient temperature will be measured for the ISFSI site and is assumed to be the ambient temperature for all casks. The temperature elements are RTDs.

The following figures display the UMS® development and components. Table E-1 provides the key design parameters for the UMS® system.

The diagrams that follow provide an overview of the **typical** UMS® operational sequence for inspection, fuel loading, and placement in storage and transport.

EQUIPMENT INSPECTION AND PREPARATION



FUEL LOADING

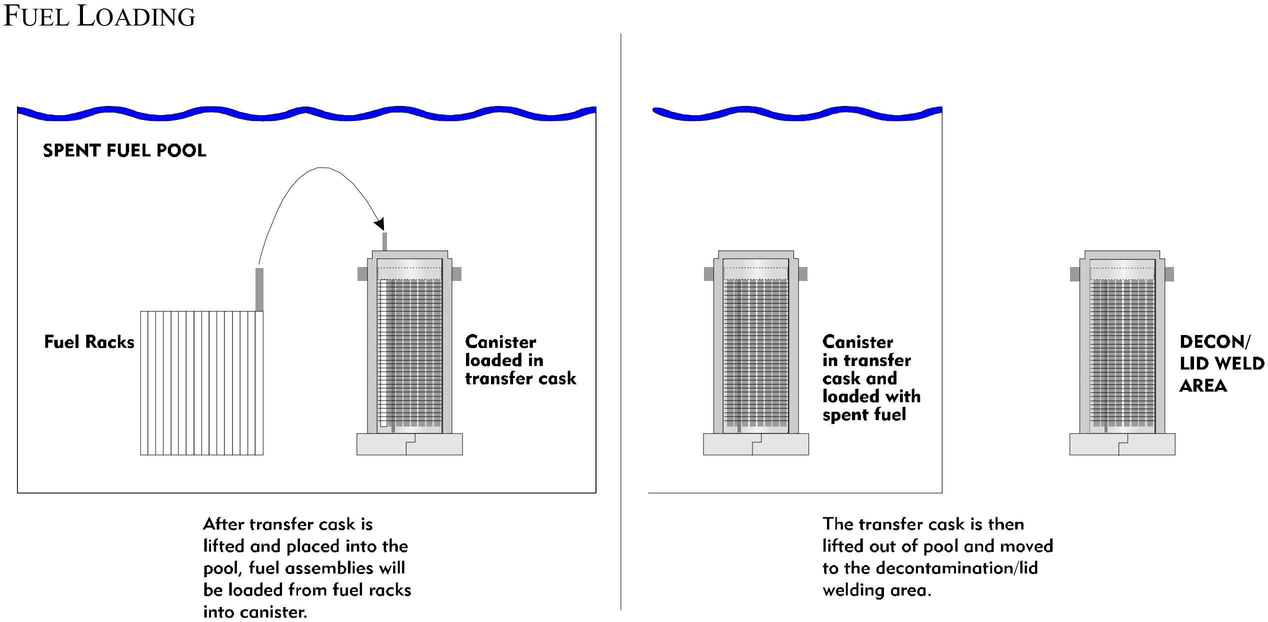


Fig. 2. UMS Operational Sequence for Fuel Loading

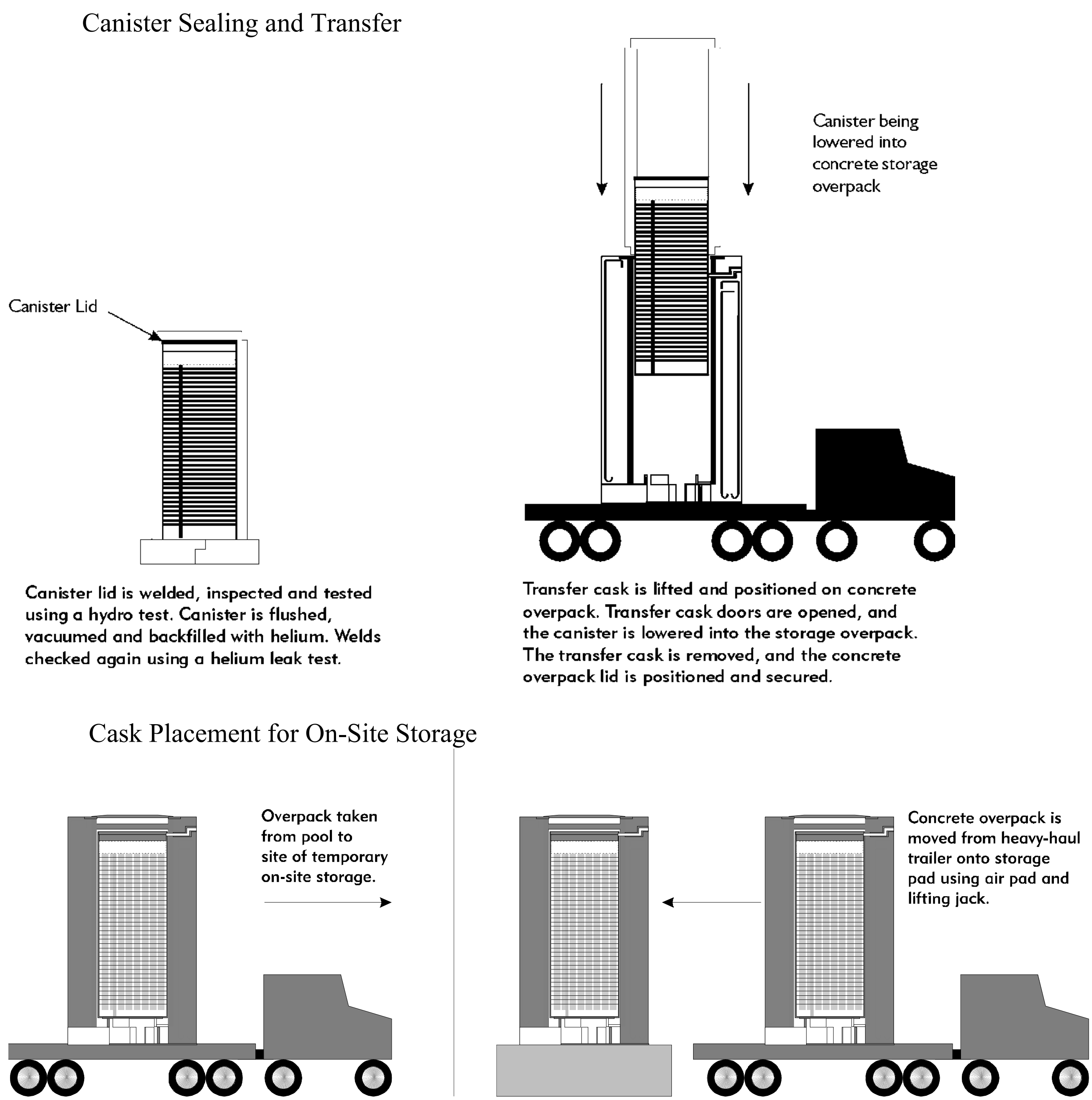


Fig. 3. UMS Operational Sequence for Canister Closure and Transfer to VCC

TRANSPORT PREPARATION AND LOADING

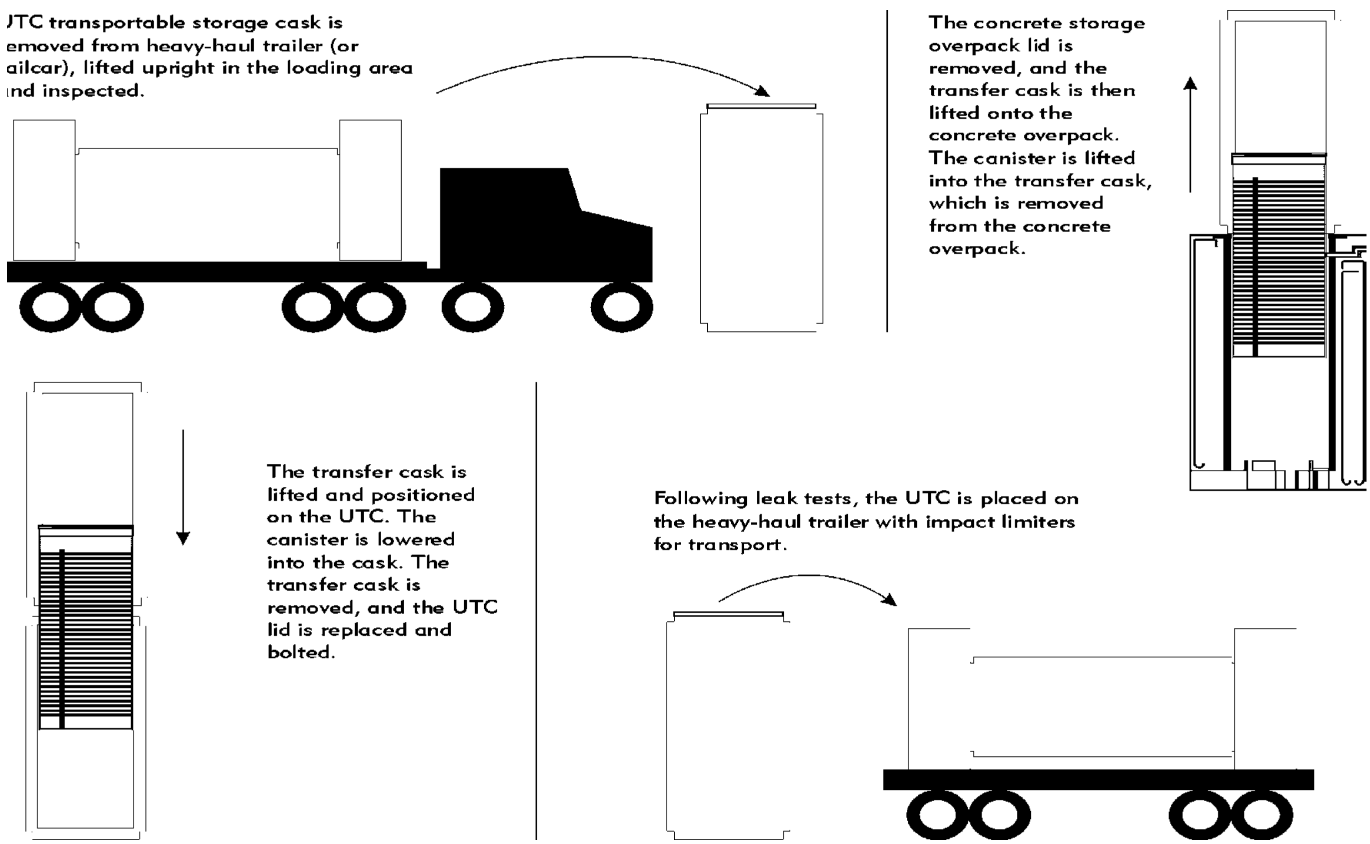


Fig. 4. UMS Operational Sequence for Transport Preparation

SAFETY OF FUEL STORED IN NAC UMS UNDER MADNESS© CONDITIONS

Following the events of September 11, 2001, there has been significant interest regarding the safety of spent nuclear fuel. We have rigorously analyzed the performance of our systems in conditions, which we have coined MADness. MADness stands for Militant Acts of Destructiveness, such as driving an airplane into one of our casks on the ISFSI. This analysis shows in summary that a Boeing 747 fuselage weighing 452,000 pounds at a density of 5.9 pounds/cubic foot, impacting on a multi-purpose storage system with a density of 162 pounds/cubic foot would result in the lighter density object flowing around the heavier density object like a fluid.

Figure 5 shows a representation of an aircraft impacting a cask, which would be roughly analogous to a plastic bag filled with goose down being thrown at a high speed against a concrete column. It is remotely possible that the column, if hit exactly perfectly could tip over and even roll. In these cases, the material in the canister shell, lids and welds do not approach ultimate material strains. This means that the canister does not fail and there is not a release of radioactivity. Once we have considered the outcome of the impact of the jet airplane, we must also evaluate the outcome of a fire. The impact of the aircraft would scatter jet fuel over a very large area, since the ISFSI is on a flat surface. As a result, there will be no pooling of the dispersed jet fuel. Aircraft fuel, which is classified as JP-5, will therefore reach a maximum temperature of around 1500°F. There are no walls or additional structures like in the World Trade Center that can reflect heat to intensify the fire temperatures around the impact location. Any resulting fire would be burned out within 30 minutes or less. The melting point of stainless steel is approximately 2500°F so that there is no potential of having any melting of the containment or confinement boundary to the fuel. Since the impact of the aircraft occurs before the fire, there are no significant mechanical loads imposed upon the multi-purpose storage system during the fire.

Scale model testing has been performed with welded stainless steel containment vessels to five times the regulatory design basis structural limits, which is far beyond any structural load worst-case scenario that could credibly be imposed by an aircraft impact. The results of these tests were no failure of any containment material or weld, no yielding of any containment material or weld and no release of contents from the containment vessel.

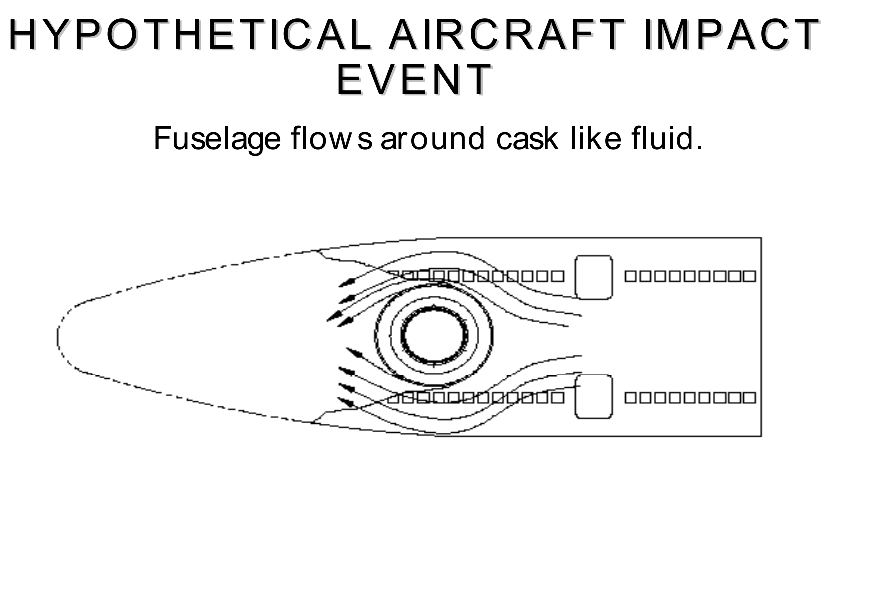


Fig. 5. Hypothetical Aircraft Impact Event

STATUS AND PATH FORWARD

As of this writing, the project is in the midst of completing Greater Than Class C (GTCC) material loading. It is expected that GTCC will conclude in late '01 or early '02, with dry run testing of fuel loading beginning immediately thereafter. Fuel loading is expected to begin in April and complete in late 2002 or early 2003.

SUMMARY

In summary, there are many challenges to be met when making the transition from an operating nuclear power plant to a facility solely dedicated to the storage and safe containment of spent nuclear fuel. This project has been challenged with some unusual situations associated with viability of selected contractors and associated commercial transitions. Like any first of a kind implementation, there are numerous unforeseen obstacles to be cleared. The events of September 11th provided additional scrutiny to these operations. In spite of these many challenges by the end of 2004, the Maine Yankee nuclear power plant will be reduced to green field status housing only 64 Vertical Concrete Casks loaded with Greater than Class C wastes and the spent fuel generated from 15 years of operations. These canisters will be anxiously awaiting the DOE to accept them at their new home, wherever and whenever that may be.