NEW FUEL BUNDLE PACKAGING

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ABSTRACT

This paper will discuss the development of a new CANDU fuel bundle container concept that is planned for implementation at Ontario Power Generation Inc. in the year 2000.

1. INTRODUCTION

In 1990, Ontario Hydro (now Ontario Power Generation Inc.), in collaboration with the two CANDU fuel bundle manufacturers GE Canada and Zircatec Precision Industries, implemented a fuel package reuse/recycle program. The objective was to reduce the amount of packaging material shipped to waste disposal facilities. Since the introduction of the program, well over 95% of the fuel packaging material has been either reused or recycled. While this program has been very successful in reducing waste, it is generally recognized that the current packaging could also be improved in terms of human factors, reducing combustible material, reuse capabilities, product integrity, component standardization, or capacity.

New fuel (N/F) bundles are currently being shipped to Bruce 5-8, Pickering B, and Darlington Nuclear Generating Stations in a package which consists of expanded Polystyrene foam (EPS) packing enclosed by a cardboard exterior mounted on a wooden pallet. About six (6) months of inventory to run the station is stored in new fuel storage areas or rooms until fuel is required. The pallets are delivered to the new fuel rooms where the bundles are subsequently loaded through the N/F transfer mechanisms and into fueling machines. When the bundles have been removed from the package the EPS and cardboard components are put back together and moved to an area for shipment back to the two bundle manufacturers.

The existing package is made mostly from combustible materials and represents a significant fire loading and fire energy source. Value of fuel is implicit, reduced risk of fire in fuel storage areas and the impact upon the station operation of a fire is most significant.

Manual unpacking and removing the EPS ladders that secure the bundles, and removing the plastic cover from the bundle has contributed to complaints from the operators regarding potential back injuries. The current method of packaging requires the operator to manually handle the fuel bundle (24 kg) 52.8 lb. to complete the fuel loading function. Operations have stressed that manual handling of fuel bundles must be significantly reduced.

These concerns have led to this new bundle container concept which eliminates the problems associated with the existing N/F packaging.

2. DESIGN REQUIREMENTS

2.1 Station Design Requirements

2.1.1 The new packaging shall be suitable for Pickering, Bruce and Darlington stations.
2.1.2 The system shall be suitable for both 19.5" standard (28 element and 37 element bundles) and 20.0" long fuel bundle.
2.1.3 Eliminate combustible packaging and wooden pallets.
2.1.4 Reduce the effort to unload bundles from packaging to the extent of no manual lifting or handling.
2.1.5 Provide a reusable container which eliminates as much scrap as possible e.g. plastic wrappers and bags, cardboard sheets and cable ties.
2.1.6 Provide a simplified container, with a minimum number of components.
2.1.7 Eliminate the handling of all cardboard and eliminate the Styrofoam packing ladders.
2.1.8 Provide more bundles per pallet to allow more new fuel to be stored in the same envelope and to reduce the number of trips through the air lock with the lift trucks
2.1.9 Provide a positive method of bar coding the bundle to help the initiative of easier input into the Nuflash program.
2.1.10 Provide a container which easily facilitates decontamination.
2.1.11 Provide a container which facilitates easy inventory and IAEA inspection purposes.

2.2 Fuel Manufacturers Design Requirements

2.2.1 Prefer a common container for all domestic shipments to Ontario Hydro or Ontario Power Generation Inc. (OPG), New Brunswick and Quebec
2.2.2 Sealable package/box to exclude debris and foreign material from contacting contents.
2.2.3 Shipping must prevent impact to contents and must not produce pellet chipping >1g UO_2 chips/element.
2.2.4 The packaging must restrain centre plane of bundles to prevent inter element spacer fretting.
2.2.5 The package must be compressed to stop bundle movement and to prevent element interlocking.
2.2.6 The package must be capable of being handled by a lift truck.
2.2.7 The package length shall be limited to 48" and the total weight to 5000 pounds.

2.2.8 The package size and configuration shall not reduce maximum transport load.
2.2.9 The package shall be designed to stack two (2) high and possibly three(3) high for long term storage.
2.2.10 The package shall be configured to allow easy loading of the box and use proper ergonomics for loading.
2.2.11 The package shall be configured to allow easy decontamination.
2.2.12 The package shall be made from a minimum number of components.
2.2.13 New style of label (transportation, GE Canada or ZPI logo or the "Radioactive" warning) which will be easily removed for the return trip back to the fuel manufacturers.

3. New Fuel Package Concept MK42

Refer to concept drawing - Figures 1, 2, and 3, on the following pages.

The new shipping package consists of a non-corrosive metal pallet or base (i.e. aluminum / galvanized steel) which is attached to the structural foam components to form the basis of the shipping container. These layers of structural foam components provide support , nesting the bundles to provide the necessary protection needed. The structural foam components are comprised of a bottom layer which is attached to the pallet or base, two separator layers, two removable side pieces for easy inspection and a top. All these pieces interlock and have lips to provide the strength and integrity to provide adequate protection against dust and foreign materials.

The shipping container accommodates a total of 42 bundles weighing approximately 2218 lb. (1008 kg.) divided into three layers of 14 bundles each. This is a 16% increase in the number of fuel bundles over the existing package which contains only 36 bundles. This was possible because the current EPS ladder contains a space which is utilized to hold a bundle, eliminating this space results in an additional two bundles per layer. The new container therefore remains approximately the same physical size as the existing package which was a limiting factor for not going to an even larger quantity of bundles.

The method of lifting or loading the shipping container is accomplished and controlled by using a lift truck or pallet lifter in the pallet which has two-way entry.

The lifting or loading of the individual fuel bundle weighing approximately 52.8 lb. (24 kg.), which is either 19.5 or 20 inches in length, is accomplished and controlled by a fuel lifting mechanism, which is attached to an air balancing hoist to lift the load. (Refer to Figure 2) The configuration is such that all "Manual Handling" of fuel bundles is eliminated while loading or unloading fuel bundles and should also eliminate the potential for complaints of back injuries associated with this activity.

This shipping container is capable of being stacked to a maximum of two (2) high when each fully loaded with 42 fuel bundles or to a maximum of four (4) high when empty of all fuel bundles.

The shipping container shall embrace the following three sustainable development principles : Reduce, Reuse and Recycle. The container has an estimated minimum design life of ten years based on the shipping container being sent full to site and returned to the fuel manufacturers empty, twice a year. The foam material is recyclable by sending damaged or broken pieces back to the packaging manufacturer for recycling.

The new configuration also allows elimination of bags and wrappers and the tie band which are presently being used to cover the individual bundle. This material currently is sent as low level waste to be disposed.

The labelling shall be peel and stick paper labels which is a new type of labelling (transportation, GE Canada or ZPI logo or the "Radioactive" warning). The "package material identity label" and the "package material label" shall be easily removed for the return trip back to the two fuel manufacturers. The new package shall have indentations in the surface to aid in consistency of placement by both fuel bundle manufacturers.

The "skin" itself of the sample material seemed adequate for attaching and removing the labels, but the package manufacturers offered to provide an additional plasticized board embedded onto the structural foam to aid in peeling off the old labels, if necessary.

4. PACKAGE SPECIFICATION MK42

Scope

This Packaging Specification describes the technical requirements for the design, manufacture, inspection and testing of the proposed New Fuel (N/F) shipping container.

Container Purpose

The purpose of the N/F shipping container is to provide adequate protection to the N/F bundles against physical damage, contamination infiltration and to retain fuel bundle integrity during shipping and storage.

Container Description

Refer to concept drawing Figure 1, 2, and 3, on the following pages.

The shipping container consists of a non corrosive metal pallet or base (i.e. aluminum / galvanized steel) and layers of structural foam components to provide support, nesting the bundles to provide the necessary protection needed. The shipping container shall embrace the following three sustainable development principles : Reduce, Reuse and Recycle. The shipping container shall <u>not</u> be considered a Type "A" package and will be used for domestic shipments only.

Regulatory Constraints

The shipping container must conform to Ontario Hydro's Fire Protection Policy & Standards Section 7.10 New Fuel Storage Areas which infers that the material be as fire resistant as economically feasible, must minimize combustible material through specification of noncombustible alternatives. Ideally, all material would have a flame spread rating of less than 25. Refer to additional Fire Requirements as outlined in section 5.

Performance Characteristics

The shipping container accommodates a total of 42 bundles weighing approximately 2218 lb. (1008 kg.) divided into three layers of 14 bundles each. The method of lifting or loading the shipping container is accomplished and controlled by using a lift truck or a pallet lifter. The lifting or loading of the individual fuel bundle weighing approximately 52.8 lb. (24 kg.) which is either 19.5 or 20 inches in length, is accomplished and controlled by a fuel lifting mechanism, which is attached to an air balancing hoist to lift the load. The configuration is such that all "Manual Handling" of fuel bundles is eliminated while loading or unloading fuel bundles. The shipping container must be capable of stacking two high when each fully loaded with 42 fuel bundles and also be capable of stacking four (4) high when empty of all fuel bundles. When stacked, the shipping container must keep its sealing integrity intact and not buckle through any of the structural foam joints.

The empty containers must stay intact without banding for the return shipments.

Description of Main Components

The metal pallet or base provides a means of attachment of the structural foam portion to form the basis of the shipping container. The pallet also distributes the total weight of the shipping container including 42 bundles for a total weight of approximately 2280 lb.(1040 kg.) and the weight of a pallet lifter approximately 400 lb.(180 kg.). The pallet distributes the entire load and the pallet lifter including the impact load of 120% of the total weight when applied. The pallet shall distribute the entire load when supported only by two opposing edges (typically when stored in storage racks). The area of the pallet shall be kept to the dimensions of concept drawing Figure 1, and provide for two way entry of lift trucks and pallet lifters. Structural foam separators shall be configured to support and to nest the fuel bundles providing circumferential squeeze in the center plane of bearing pads to prevent element interlocking during shipping. This circumferential squeeze will also minimize the fretting of inner element spacers which produces Zircaloy or Zirconium Oxide dusting. Indentations in the structural foam will be provided to place tear off adhesive markings and signage, applied by fuel manufacturers.

Inspection and Testing

One of the following two (2) functional test shall be performed to demonstrate that the shipping container design provides adequate protection against dust and foreign materials including water.

(1) This test shall be conducted using clean potable water spray for 10 minutes at 8 to 10 gpm. sprayed on all the surfaces to determine the water tightness of the shipping container. There shall be no leakage when inspected after the test.

(2) This test shall be conducted using a 10 lb. chemical fire extinguisher sprayed at the container at close range until empty. There shall be no infiltration of chemical to the interior of the container when inspected after the test.

These tests shall be done while two shipping containers, each fully loaded with 42 equivalent of fuel bundles weighing 2218 lb.(1008 kg.) are stacked on top of the other. A test report shall be prepared and the test to be witnessed by OPG Design Engineering.

Documentation

(1) Three certified copies of the Material Safety Data Sheets (MSDS) which must contain the Fire and Explosion Data to be forwarded to the OPG Design Engineering for approval prior to manufacturing. This shall be accompanied by a test piece of the material (approximately 1.0" X 4.0" X 4.0") for verification.

(2) Three certified prints of the drawings of the shipping container are to be forwarded to the OPG Design Engineering for approval prior to manufacturing. The drawings shall specify the densities of structural foam used in the various components of the shipping container.

(3) One reproducible of the approved certified print to be forwarded to the OPG Design Engineering as described in the Tendering Documents or Purchase Order.

Quality Assurance and Hazards

The manufacturer shall meet the requirements of the quality standards as specified in ISO 9001 or CSA Z299.3. The pallet shall have no sharp edges to prevent injury to personnel while at the sites or at the fuel manufacturers.

Ambient Conditions

20 to 95% Relative Humidity
-40 degree C to 50 degree C (-40 deg. F to 122 deg. F) Temperature Range

Service Life

The required service life of the shipping container is 10 years minimum, with periodic inspection and maintenance. This is based on the shipping container being sent full to site and returned to the fuel manufactures empty, twice a year.

Weight

The total weight of the shipping container shall be kept to a minimum. The Vendor to advise the OPG Design Engineering of the actual weight of shipping container.

Preparation for Shipment to Fuel Manufacturer

The N/F shipping container shall be clean and protected to prevent damage in transit to the fuel manufacturers. The N/F shipping containers may be shipped stacked to a maximum of four (4) high to the fuel bundle manufacturers. The shipping container shall be marked with the stock code or catalog identification number (supplied by the Purchaser) and the Purchaser's purchase order.

5. FIRE REQUIREMENTS FOR NEW FUEL PACKAGING

This study has been reviewed by the OHN Fire Protection Specialist from the early design stage to ensure that the combustible content and flammability of the design is as low as reasonably achievable. The purpose of this review has been to eliminate from the design materials that can readily ignite and spread fire to other fuel packages and to other parts of the plant.

To ensure the risk of fire is minimized and to minimize damage to fuel should fire occur the following design requirements shall be applied to new fuel packaging.

1. No wood or wood products shall be used.

2. No cardboard or similar combustible packaging boxes or materials shall be used.

3. No polyethylene or similar non-fire retardant plastic wrapping or sheet materials shall be used.

4. No non-fire-retardant polystyrene foam packaging to be used.

All other materials used in the fuel packaging design shall be fire retardant, self-extinguishing and meet either or both the following test standards.

1. Flame Spread Index (FSI) of 25 or less as determined by ASTM E 84 Standard Test Method for Surface Burning Characteristics of Building Materials and/or

2. US. Federal Motor Vehicle Safety Standard FMV SS 302 or 49CFR 571.302.

Suppliers shall provide documentary proof that materials supplied meet either or both of these requirements.

This will eliminate the worst of the combustibles and ensure that the foamed plastic materials are fire retardant and have self extinguishing properties such that they will not spread fire.

ACKNOWLEDGEMENTS

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REFERENCES

SPENCLEY J.W. — "Pickering ND, Bruce A ND, Bruce B ND, Darlington ND New Fuel Bundle Packaging Concept Study". GE Canada Technical Report, R97CAP1, May 1997.

FIGURE 1 MK42 SHIPPING PACKAGE

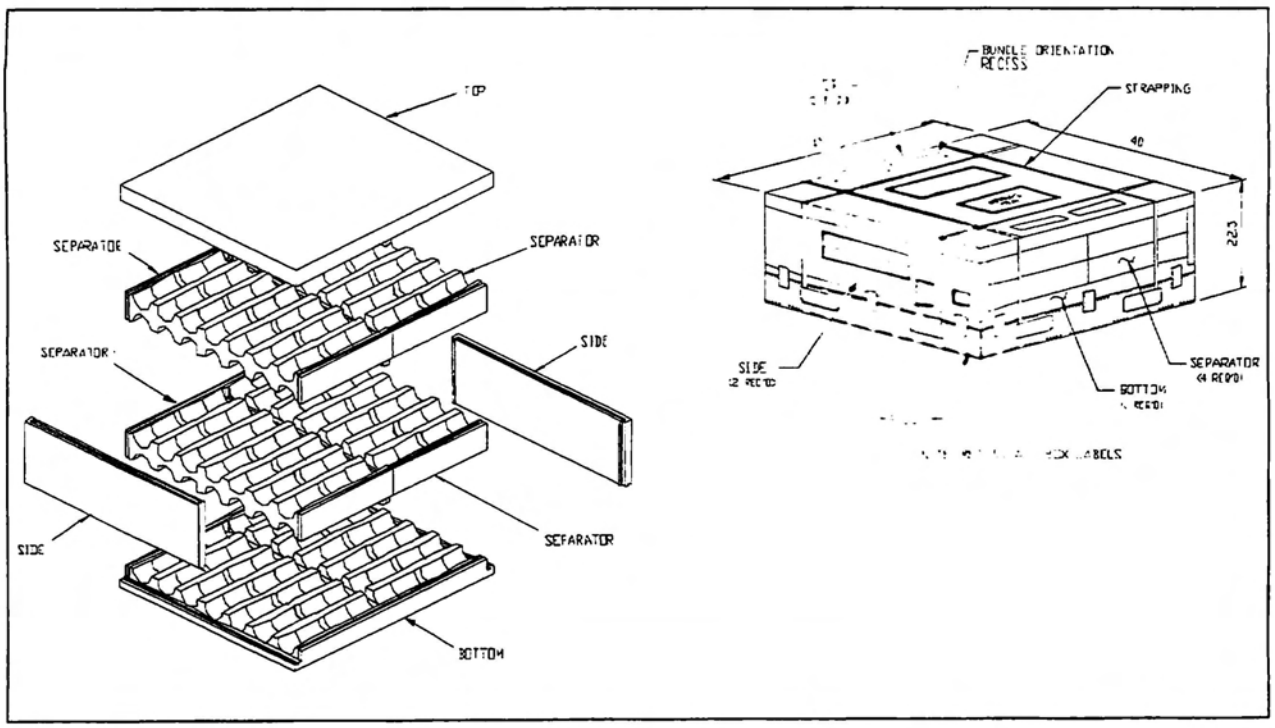

FIGURE 2 MK42 SHIPPING PACKAGE

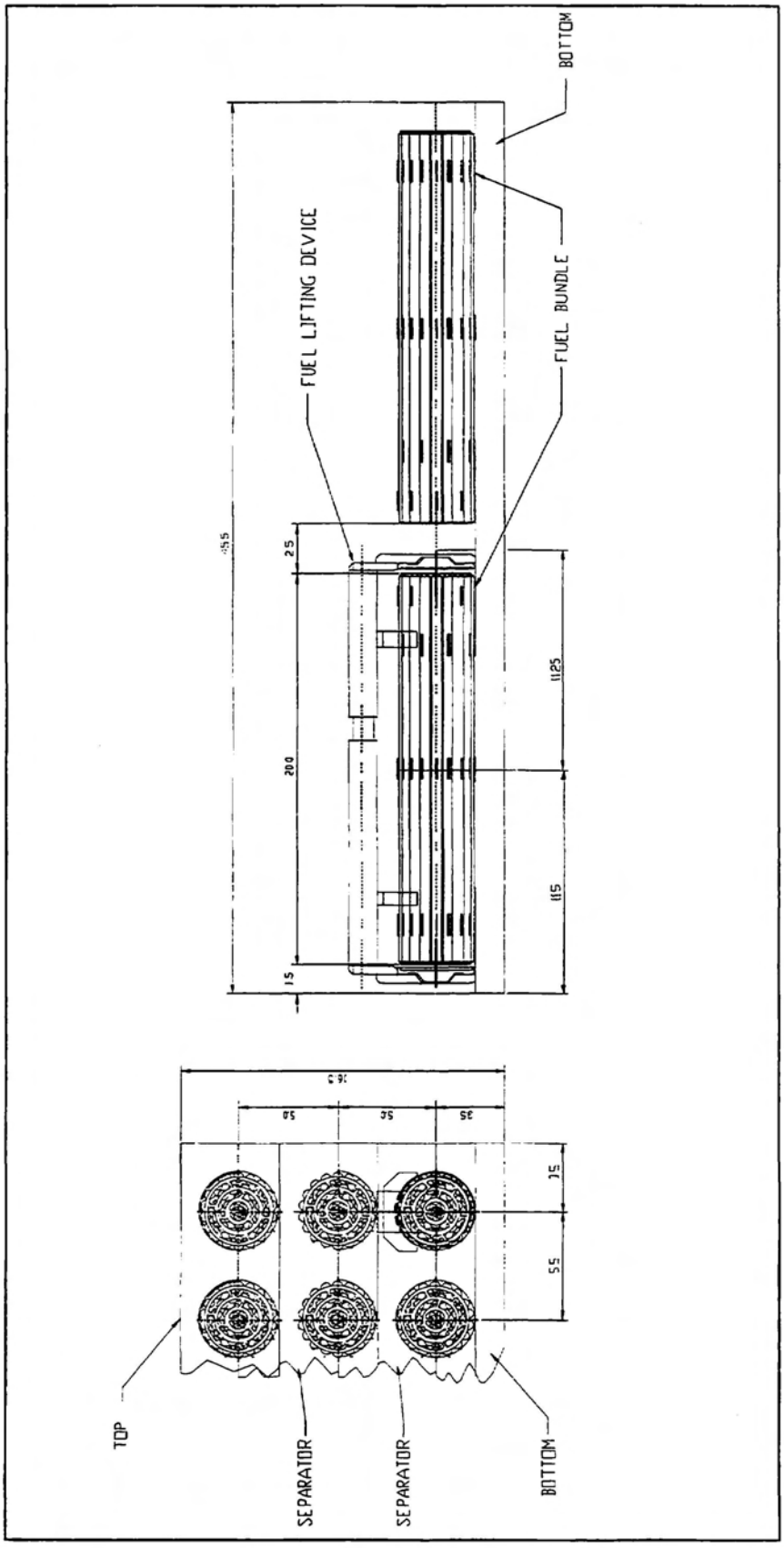

FIGURE 3 MK42 SHIPPING PACKAGE