
A Container for Storage and Disposal of Low-Level Waste

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INTRODUCTION

A unique concept for corrosion-resistant containers for storing and disposing of low-level radioactive, mixed and toxic wastes has been developed. The strength and low cost of carbon steel has been combined with the corrosion and abrasion resistance of a proprietary combination of polymers to provide an inexpensive alternative to currently available waste containers. The initial development effort has focused on a 55-gallon container, the B&W ECOSAFE-55tm. However, Babcock & Wilcox (B&W) can develop a family of ECOSAFE waste containers using this technology to accommodate user-preferred configurations and volumes. The containers will be capable of accepting a wide range of low-level radioactive (LLRW) and industrial waste forms.

Basic engineering design analyses and functional tests were performed to show compliance of the container with transportation functional requirements. These tests and analyses, along with chemical resistance tests, qualify the container for use in storing a wide range of radioactive and chemical wastes. For the container to be licensed for use as a high-integrity container in shallow land, low-level radioactive waste burial facilities, the Nuclear Regulatory Commission requires certain tests and analyses to demonstrate that container gross physical properties and identity can be maintained for 300 years.

This paper describes the container concept in generic terms and provides information on the initial, ECOSAFE-55 container design, testing and engineering analysis efforts.

WASTE CONTAINER DESCRIPTION

The container design is based on the utilization of two functional components:

- 1) A low-cost structural component and
- 2) An encapsulating component to isolate the structural component from both external environmental conditions and internal waste conditions.

The basic structural material selected for the waste container is a carbon steel (AISI 1010). This material is easily formed and welded, provides adequate strength and toughness, and is readily available at low cost.

The ECOSAFE-55 design utilizes Department of Transportation (DOT) specifications for 55-gallon drum-type containers. The design uses 16-gauge carbon steel with rolled and seamed upper and lower heads. A standard lug cover and seal are provided for closure.

The carbon steel is completely encapsulated in a proprietary combination of thermosetting and thermoplastic polymers to provide the desired corrosion and abrasion resistance. The combination of polymers was selected on the basis of manufacturers test results that demonstrated superior performance of the polymers relative to criteria established by pertinent state and federal regulations and requirements governing containers for low-level radioactive waste. The combination of polymers provides synergistic effects that are designed to prevent damage to either the carbon steel or the polymers by corrosive agents, ultraviolet exposure, radiation exposure, abrasion and temperatures of up to 300 F. The proprietary process to electrostatically apply the specially developed polymer powders is known as the Lock-Bond process and is designed to ensure complete and uniform coverage. B&W is the licensee for the polymer technology and Lock-Bond application process developed by Avancer Technologies, Inc.

TESTING

A container testing program was conducted to demonstrate compliance with DOT (49CFR173) and U. S. Nuclear Regulatory Commission (NRC) transportation (10CFR71) regulations. The DOT and NRC regulations require the following tests which, along with chemical resistance tests, qualify the container for waste transportation and storage purposes.

- * Heat test
- * Cold test
- * Reduced external pressure test
- * Increased external pressure test
- * Vibration test (transportation simulation)
- * Water spray test
- * Free drop test
- * Compression test
- * Penetration test

These tests are required to insure that the waste material contained in a package will not be released in the event that the package is subjected to a range of environmental conditions during handling, transportation, and storage.

In addition to the tests listed above, the NRC requires the following tests to assure that containers used as high-integrity containers for land disposal can maintain gross physical properties and identity for over 300 years (10CFR61).

- * Thermal cycle test
- * Gamma radiation test
- * Ultraviolet exposure test
- * Biodegradation test
- * Chemical resistance test

The testing program to date has included each of the tests listed above except the thermal cycle test which will soon be completed. Ultraviolet test results were obtained from polymer vendor data sheets, while all other tests were conducted on either prototype drums or specimens of carbon steel, encapsulated with the polymers.

The containers passed all of the transportation-related tests without loss of containment. The disposal-related tests performed, demonstrated satisfactory compliance with each of the applicable acceptance criteria.

ANALYSES

Analyses performed on the ECOSAFE-55 storage container included maximum surface temperature (due to direct sunlight exposure) and waste-generated hydrogen gas (to assure vent flow rate adequacy). These analyses were necessary to assure that temperature and internal pressure limits would not be exceeded in containers used for waste storage purposes.

Assurance is required by the NRC that containers used as high-integrity containers for disposal of low-level radioactive waste can withstand loads induced at the burial site. A stress analysis of the ECOSAFE-55 has been conducted to determine maximum burial-induced stresses. Loadings were calculated for burial depths of 55 feet (Hanford, WA and Beatty, NV burial sites) and 25 feet (Barnwell, SC burial site). Pressure distributions were considered to act hydrostatically (a conservative assumption for actual burial conditions). Soil structural rigidity was not considered to reduce burial pressure loads.

Classic analysis techniques were employed to determine container wall compressive and hoop stresses. Roark's Formulas for Stress and Strain were used to determine diaphragm stresses and deflections in the container overburden support plate and container bottom.

A finite element model was used in an ANSYS analysis for container buckling. Again, pressures were considered to act hydrostatically and no credit was taken for container contents (an empty container was used in the ANSYS model).

Detailed calculations with results have been submitted to the NRC in an ECOSAFE topical report.

ECOSAFE-55 APPLICATIONS

The combination of carbon steel as the structural component with encapsulating polymers to provide corrosion resistance has resulted in a container with the following desirable characteristics.

- * Low weight-to-volume ratio
- * Resistance to a wide range of potentially corrosive environments
- * Resistance to gamma radiation
- * Resistance to ultraviolet exposure
- * Resistance to biodegradation
- * Low cost

These attributes contribute to the utility of the waste container for a variety of waste forms including toxic and hazardous wastes, medical wastes, mixed wastes, as well as low-level radioactive wastes. Specific types of waste forms compatible with the ECOSAFE containers include:

- * Absorbed liquid wastes
- * Demineralized resins
- * Dewatered resins
- * Filter elements
- * Filtration materials
- * Solid Waste (DAW)
- * Solidified Waste (bitumen, cement, polymers)

Future development for the polymer-encapsulated containers will focus on user-specific configurations and capacities (including potential capacities of up to 195-cubic feet). Standard waste container configurations presently in use could be fabricated using the ECOSAFE carbon steel/polymeric processing to save money and ensure long-life containment of wastes.

A topical report has been submitted to the NRC that describes the carbon steel/polymeric container and the tests and analyses used to demonstrate compliance with the disposal-related regulatory codes and guides. Burial site host states have also received copies of the topical report.

The report has been reviewed by NRC contractors and the resulting questions and comments are currently being addressed. Successful review and acceptance of this report by the NRC will result in the availability and use of the ECOSAFE-55 as a high-integrity container.