

Traveller Safety Analysis Report

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8 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

8.1 ACCEPTANCE TESTS

Per the requirements of 10 CFR §71.85(c), this section discusses the inspections and acceptance tests to be performed prior to first use of the Traveller package. Complete detailed instructions are outlined within the individual plant operating procedures and quality control instructions pertinent to each specific operation.

8.1.1 Visual Inspections and Measurements

All Traveller packaging materials of construction and welds shall be examined in accordance with the requirements delineated in Table 2-2 of Section 2.

The Traveller STD and Traveller XL packages have manufacturing drawings that are controlled within a quality control process. The drawings have quality characteristics that must be inspected during the process. These characteristics were selected to ensure that safety related components are within tolerance and properly installed but also to ensure that the package will fit up properly. Source inspection and final release of the package will be performed by Westinghouse to verify the quality characteristics were inspected and that the package is acceptable. Any characteristic that is out of specification must be reported. It will then be dispositioned according to Westinghouse procedure.

8.1.2 Weld Examinations

All Traveller welds shall be examined to verify conformance with all applicable codes, and standards and noted on each drawing.

8.1.3 Structural and Pressure Tests

The Traveller packaging does not contain any structural or lifting/tiedown devices that require testing. There is also no pressure testing requirement.

8.1.4 Leak Tests

The Traveller packaging does not have any requirements for leak testing.

8.1.5 Component and Material Tests

8.1.5.1 Polyurethane Foam

The Traveller packaging utilizes a closed-cell, polyurethane foam and must be certified to meet the requirements and acceptance criteria for installation, inspection, and testing as defined in this section.

The finished foam product shall be greater than 85% closed cell polyurethane plastic foam of the self-extinguishing variety of the density specified. The closed cell configuration will ensure that the foam will not be susceptible to significant water absorption.

Traveller Safety Analysis Report**8.1.5.1.1 Density**

Rigid polyurethane foam shall have a density per the following table:

Part	Lb/ft ³
End Caps	20.0 +/- 2.0
Package body	10.0 +/- 1.0
Inner Limiter	6.0 +/- 1.0

Density shall be determined in accordance with ASTM D-1622 with the following exceptions:

- a) A minimum of one specimen per pour shall be taken, distributed regularly throughout the batch.
- b) Conditioning shall be 70°F to 80°F and 40% – 60% relative humidity for 12 hours minimum.
- c) Test conditions shall be 70°F to 80°F and 30% – 70% relative humidity.
- d) Length, width and thickness measurements shall be made with a 6-inch digital or dial caliper.
- e) Measurements shall be made and reported to the nearest 0.001 inches.
- f) Density shall be reported in pounds per cubic foot and no correction made for the (negligible) buoyant effect of air.
- g) The standard deviation of the three density determinations need not be calculated or reported.

8.1.5.1.2 Mechanical Properties

Exhibited foam compressive strength for 10% strain parallel to foam rise shall be determined in accordance with ASTM D-1621, with the exceptions noted below, and shall fall within the following range of values:

Part	Density	Min	Max
End	20.0 +/- 2.0	888 psi	1332 psi
Body	10.0 +/- 1.0	262 psi	393 psi
Inner	6.0 +/- 1.0	132 psi	198 psi

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- a) Specimen shall be right rectangular prisms 1.0+/-0.1 inches thick x 2.0+/-0.1 inches x 2.0+/-0.1 inches with the 1.0+/-0.1 inch dimension parallel to the direction of foam rise.
- b) A specimen from each batch shall be tested.
- c) Conditioning shall be 70°F to 80°F and 40% – 60% relative humidity for 12 hours minimum.
- d) Test conditions shall be 70°F to 80°F and 30% – 70% relative humidity.
- e) Length, width and thickness measurements shall be made with a 6-inch digital or dial caliper.
- f) Measurements shall be made and reported to the nearest 0.001 inches.
- g) Strain rate shall be 0.1 +/- 0.05 in/in – min.
- h) Only actual values (not averages or standard deviations) need be reported.

8.1.5.1.3 Flame Retardant Characteristics

Flame retardant characteristics shall be qualified by demonstrating compliance with the following requirements. The requirements shall be demonstrated by flame testing described in FAA Powerplant Engineering Report No. 3A. Additional certification testing to validate the flame-retardant characteristics shall also be performed in accordance with ASTM F501-93. The test described in b) below is not applicable to the 6 pcf foam.

- a) Foam shall not be capable of sustaining a flame for a period greater than five (5) minutes, following the removal of the heat source and after being exposed to temperatures up to 1,500°F. A heat source with a flame temperature of at least 1,500°F is applied until the foam is ignited. The heat source is removed after ignition of the foam and the time until self-extinguishment of the flame (absence of flame) will be monitored and compared against the 5-minute acceptance criteria.
- b) Prepare a representative sample of the foam material and test in accordance with the following:
 - 1) Cut two pieces of sheet metal (16 gauge maximum/25 gauge minimum) to a size sufficient to cover a 10 inch diameter test sample.
 - 2) Attach a thermocouple at the approximate center of one side of each piece of sheet metal.
 - 3) Prepare a representative sample of the foam material inside a 10-inch inner diameter by 6-inch long steel cylinder. Foam to fill the entire length of the cylinder and the full 10-inch diameter.

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- 4) Sandwich the sample between the two pieces of sheet metal, with the thermocouples in contact with the foam.
- 5) Expose one end of the foam sample (sheet metal) to a heat source. Apply enough heat to cause the indicated thermocouple temperature to increase from ambient temperature to 1,475°F minimum on the exposed side.
- 6) Hold the sample at a minimum of 1,475°F for a minimum period of thirty (30) minutes.

Acceptance criteria shall be as follows:

During the period that heat is applied, the thermocouple on the non-exposed end of the sample shall not exceed 180°F. The thermocouple on the back side (away from the flame) shall be isolated from the sheet metal to prevent heat from radiating from the metal instead of traversing the foam core. The thermocouple can be isolated using a piece of Nomex cloth or approved equivalent.

8.1.5.1.4 Thermal Properties

The foam shall exhibit the following thermal characteristics for the 6 pcf, 10 pcf and 20 pcf nominal density pours, minimum of three specimens per qualification:

- a) Thermal Conductivity
0.18 to 0.55 BTU-in/hr-ft²-°F
- b) Specific Heat
0.275 to 0.535 BTU/hr-°F

8.1.5.1.5 Water Absorption

The average water absorption by the foam observed by testing using ASTM D-2842, with the following exceptions, shall not be more than 5% by volume. The construction of the Traveller will further ensure that in actual operation, significantly lower water absorption rate would be observed.

- a) Length, width and thickness measurements shall be made with a digital or dial caliper.
- b) Measurements shall be made and reported to the nearest 0.001 inches.
- c) A single specimen of the qualifying material shall be molded to the density range as stated in the density chart above.
- d) The specimen shall consist of a single 3.0 inches x 6.0 inches x 6.0 inches (tolerance on dimension is 0.5 inches) block of foam.

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- e) No correction shall be made for cut or open cells in the specimen's volume calculations.

8.1.5.1.6 Chemical Composition

The chemical composition of the foam shall be as follows:

C – 50 – 70%
O – 14 – 34%
N – 4 – 12%
H – 4 – 10%
P – 0 – 2%
Si – < 1%
Cl – < 1800 PPM
Leachable Chlorides < 1 PPM
Other < 1%

The foam will be a rigid polyether polyurethane formed as reaction product of the primary chemicals: polyphenylene, polymethylene, polyisocyanate (polymeric isocyanate) and polyoxypropylene glycols (polyether polyols). These materials react to produce a rigid, polyether, polyurethane foam. The foam will not contain halogen containing flame retardant or trichloromonofluoromethane (Freon 11).

Leachable chloride testing is required when using stainless steel as the container structure because free chloride ions in contact with the container sides have been faulted as a contributor to stress corrosion cracking. Leachable chlorides will not be greater than 1 ppm when tested in accordance with GP-TM9510: Method for Sample Preparation and Determination of Leachable Chlorides in Rigid Polyurethane Foam or EPA 300.0: Determination of Inorganic Anions by Ion Chromatography.

8.1.5.2 Neutron Poison Plates

Neutron poison plates are installed along the four faces of the Clamshell to meet the requirements specified in Section 6 of this document. The Traveller packaging has two options for this material.

- a) Borated Aluminum – Boron precipitates in the form of AlB_2 and TiB_2 are contained within the matrix of 1100 series aluminum alloy.
- b) *BORAL* – a hot-rolled composite aluminum sheet consisting of a core of uniformly distributed boron carbide and aluminum particles which is enclosed within layers of pure aluminum forming a solid barrier against the environment.

The plates are used to ensure subcriticality during transportation as a neutron poison and are not relied upon for the conductivity or mechanical properties. The service conditions are not so severe as to promote significant alterations of these plates. Therefore, durability of these neutron absorbing materials is regarded to meet or exceed the service requirements of this application.

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To ensure the BORAL meets the drawing requirements, the plates will be inspected on a periodic basis not to exceed five years per Section 8.2.5. This will ensure that the BORAL maintains its durability throughout its service lifetime. The visual inspection will verify that the plates are present and in good condition. This includes inspection of the BORAL core for chipping or flaking resulting from brittleness. There are no significant loads applied to the BORAL plates, therefore no durability problems should arise during normal conditions of transport.

No processing changes are anticipated for the production of BORAL since the established process will be used to produce the packages.

8.1.5.2.1 Borated Aluminum***Boron-10 Areal Density***

The Borated Aluminum poison plate minimum ^{10}B areal density for the final thickness of 0.125 ± 0.006 " is 0.018 gm/cm^2 . Acceptance testing may be conducted using neutronics attenuation or chemical analysis to ensure an effective minimum ^{10}B areal density of 0.0163 gm/cm^2 (90% credit of Boron-10). The attenuation are of two types: luminance and transmittance:

- a) *Neutron Radiograph (luminance) testing – A non-destructive imaging technique for the internal evaluation of materials. It involves attenuation of a neutron beam by an object to be radiographed, and registration of the attenuation process (as an image) on film or video.*
- b) *Neutron Transmittance – A neutron counting testing technique performed to determine the concentration of an isotope in a material. Testing involves placement of test coupons in a calibrated neutron source beam and measuring the number of neutrons allowed to pass through the test material. Based on the number of neutron count, the areal density of the coupon can be calculated and compared to certified standards.*

Neutronics Testing Requirements

Neutron Radiograph testing shall be performed for each selected sample with a luminance test or approved equivalent to verify the uniformity of the ^{10}B distribution in the sheet at thermal neutron energies. Inspection results shall be recorded using the appropriate data recording method by the testing facility.

Neutron Transmittance testing shall be performed at thermal neutron energies per approved test method to verify the minimum required ^{10}B concentration. Test coupons are considered acceptable when the transmittance data indicates a ^{10}B areal density equal to or greater than 0.018 gm/cm^2 . Statistical data on transmissivity may be coupled with luminescence test data to demonstrate uniformity of the boron material.

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Chemical Testing Requirements

Chemical testing may be employed as an acceptable substitute to the neutronics testing to verify the minimum areal density of ^{10}B is present in the poison plate. Prior to ^{10}B verification by chemical testing, the process shall be demonstrated to be equivalent to the neutronics testing described with respect to ^{10}B uniformity and isotopic composition. Test coupons are considered acceptable when the calculated ^{10}B areal density is equal to or greater than is 0.018 gm/cm^2 .

Sampling Rates and Test Methods

The inspection levels shall be as stipulated in the supplier submitted process specification(s). Test methods, when not referenced herein, shall be reviewed by Westinghouse Columbia engineering. Sample coupons shall be randomly selected and be representative of the configuration, material, and lot being evaluated.

<i>Requirement</i>	<i>Number of Tests Per Lot</i>	<i>Test Method</i>
<i>Aluminum Alloy Composition</i>	<i>1 per Heat</i>	<i>ASTM B209 and Approved Procedure</i>
<i>Neutron Radiograph</i>	<i>100%⁽¹⁾</i>	<i>Approved Procedure</i>
<i>Neutron Transmittance for ^{10}B Areal Density</i>	<i>100%⁽¹⁾</i>	<i>Approved Procedure</i>
<i>Chemical Testing</i>	<i>100%⁽²⁾</i>	<i>Approved Procedure</i>
<p><i>Notes:</i></p> <p><i>(1) For every lot, initial sampling of coupons for neutron transmission measurements and radiograph/radioscopy shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling (50%) may be introduced based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.</i></p> <p><i>(2) For every lot, initial sampling of coupons for chemical testing shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling of the lot to 95/95 confidence sampling is acceptable based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.</i></p>		

8.1.5.2.1A BORAL
Boron-10 Areal Density

The BORAL poison plate minimum ^{10}B areal density for the final thickness of 0.125 ± 0.006 " is 0.024 gm/cm^2 . Acceptance testing may be conducted using neutronics attenuation or chemical analysis to ensure an effective minimum ^{10}B areal density of 0.018 gm/cm^2 (75% credit of Boron-10). The attenuation are of two types: luminance and transmittance:

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- a) *Neutron Radiograph (luminance) testing – A non-destructive imaging technique for the internal evaluation of materials. It involves attenuation of a neutron beam by an object to be radiographed, and registration of the attenuation process (as an image) on film or video.*
- b) *Neutron Transmittance – A neutron counting testing technique performed to determine the concentration of an isotope in a material. Testing involves placement of test coupons in a calibrated neutron source beam and measuring the number of neutrons allowed to pass through the test material. Based on the number of neutron count, the areal density of the coupon can be calculated and compared to certified standards.*

Neutronics Testing Requirements

Neutron Radiograph testing shall be performed for each selected sample with a luminance test or approved equivalent to verify the uniformity of the ^{10}B distribution in the sheet at thermal neutron energies. Inspection results shall be recorded using the appropriate data recording method by the testing facility.

Neutron Transmittance testing shall be performed at thermal neutron energies per approved test method to verify the minimum required ^{10}B concentration. Test coupons are considered acceptable when the transmittance data indicates a ^{10}B areal density equal to or greater than 0.024 gm/cm^2 . Statistical data on transmissivity may be coupled with luminescence test data to demonstrate uniformity of the boron material.

Chemical Testing Requirements

Chemical testing may be employed as an acceptable substitute to the neutronics testing to verify the minimum areal density of ^{10}B is present in the poison plate. Prior to ^{10}B verification by chemical testing, the process shall be demonstrated to be equivalent to the neutronics testing described with respect to ^{10}B uniformity and isotopic composition. Test coupons are considered acceptable when the calculated ^{10}B areal density is equal to or greater than is 0.024 gm/cm^2 .

Sampling Rates and Test Methods

The inspection levels shall be as stipulated in the supplier submitted process specification(s). Test methods, when not referenced herein, shall be reviewed by Westinghouse Columbia engineering. Sample coupons shall be randomly selected and be representative of the configuration, material, and lot being evaluated.

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<i>Requirement</i>	<i>Number of Tests Per Lot</i>	<i>Test Method</i>
<i>Aluminum Alloy Composition</i>	<i>1 per Heat</i>	<i>ASTM B209 and Approved Procedure</i>
<i>Neutron Radiograph</i>	<i>100%⁽¹⁾</i>	<i>Approved Procedure</i>
<i>Neutron Transmittance for ¹⁰B Areal Density</i>	<i>100%⁽¹⁾</i>	<i>Approved Procedure</i>
<i>Chemical Testing</i>	<i>100%⁽²⁾</i>	<i>Approved Procedure</i>
<i>Notes:</i>		
<i>(1) For every lot, initial sampling of coupons for neutron transmission measurements and radiograph/radioscopy shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling (50%) may be introduced based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.</i>		
<i>(2) For every lot, initial sampling of coupons for chemical testing shall be 100%, which shall be considered normal sampling. Rejection of a given coupon shall result in rejection of any contiguous plate(s). Reduced sampling of the lot to 95/95 confidence sampling is acceptable based upon acceptance of all coupons in the first 25% of the lot. The approved process specification shall reflect the use of reduced sampling, as applicable. A rejection during reduced inspection will require a return to 100% inspection of the lot.</i>		

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8.1.5.2.2 Mechanical Tests

The poison plates perform a neutronic function in the Traveller packages. Thus, no mechanical testing is required.

8.1.5.2.3 *Moved to Sections 8.1.5.2.1 and 8.1.5.2.1A.*

8.1.5.2.4 *Moved to Sections 8.1.5.2.1 and 8.1.5.2.1A.*

8.1.5.2.5 Visual Inspection

For all plates, the finished plate shall be free of visual surface cracks, blisters, pores, or foreign inclusions.

Borated Aluminum

Surface roughness shall not exceed 250 RMS maximum.

BORAL

Evidence of foreign material shall be cause for rejection (embedded pieces of B₄C matrix are not considered foreign material). Creases or other surface discontinuities are acceptable on the cladding of the BORAL provided the core is not exposed. If necessary, the plate shall be examined with a 5X glass to determine if a surface indication is a crease or a crack. Surface roughness shall not exceed 125 RMS roughness maximum.

8.1.5.2.6 Tests

- a) Lot Definition – A lot shall consist of all plate of the same nominal size, condition and finish that is produced from the same heat, processed in the same manner, and presented for inspection at the same time.

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- b) Heat Definition – A heat shall consist of the total molten metal output from a single heating in a batch melting process or the total metal output from essentially a single heating in a continuous melting operation and targeted at a fixed metal chemistry at the furnace spout.
- c) *Coupon (Borated aluminum) – A randomly selected sample of a lot representative of the neutron absorber used for acceptance testing of the candidate material.*
- d) *Coupon (BORAL) – A selected sample of the thinnest section of a lot of the neutron absorber used for acceptance testing of the candidate material.*

8.1.5.3 Polyethylene Sheeting

This section establishes the requirements and acceptance criteria for inspection and testing of Ultra High Molecular Weight (UHMW) Polyethylene sheeting utilized within the Traveller packaging.

8.1.5.3.1 Polyethylene Composition

The supplier shall certify that the polyethylene is Ultra High Molecular Weight (UHMW).

8.1.6 Shielding Tests

The Traveller package does not contain any biological shielding.

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8.1.7 Thermal Tests

The material properties utilized in Chapter 3, Thermal Evaluation, are consistently conservative for the Normal Conditions of Transport (NCT) thermal analysis performed. The Hypothetical Accident Condition (HAC) fire certification testing of the Traveller package (see Section 2.12.4, Certification Tests) served to verify material performance in the HAC thermal environment. As such, with the exception of the tests required for specific packaging components, as discussed in Section 8.1.4, Component Tests, specific acceptance tests for material thermal properties are not required or performed.

8.2 MAINTENANCE PROGRAM

This section describes the maintenance program used to ensure continued performance of the Traveller package.

Visual inspection for damage of all exposed surfaces will be performed before each use. Individual components will also be inspected as described in the sections below. If any defects are found during inspection, the package will be segregated and dispositioned by standard site procedure before its next use.

8.2.1 Structural and Pressure Tests

The Traveller packaging does not contain any structural or lifting/tiedown devices that require testing. There is also no pressure testing requirement.

8.2.2 Leak Tests

The Traveller packaging does not have any requirements for leak testing.

8.2.3 Component and Material Tests

8.2.3.1 Fasteners

All threaded components shall be inspected prior to each use for deformed or stripped threads. Damaged components shall be repaired or replaced prior to further use.

8.2.3.2 Braided Fiberglass Sleaving

Prior to each use, visual inspection of the braided fiberglass sleaving shall be performed for tears, damage, or deterioration. Unacceptable sleaving shall be replaced.

8.2.4 Thermal

No thermal tests are necessary to ensure continued performance of the Traveller packaging.

8.2.5 Neutronic Confirmation

On a periodic basis (not to exceed five years), packages will be inspected to verify the poison plate configuration complies with the drawing requirements. Quality Control Instructions and Mechanical Operating Procedures will define the specific inspection requirements. In accordance with established

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company procedures, a visual inspection will be conducted of the visible side of the neutron absorber plates. Personnel will visually verify that the plates are present and in good condition. These plates will be repaired or replaced if defects are found. Documentation relating to these inspections, repairs, part replacements, etc. will be produced and subsequently maintained via the existing plant records program.