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DOE EVALUATION DOCUMENT FOR DOT 7A TYPE A PACKAGING

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MOUND
Miamisburg, Ohio 45342

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DISCLAIMER

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INTRODUCTION

This document is a support document for the DOE Evaluation Document for DOT 7A Type A Packaging, MLM-3245, March 1987.

Provided herein are details concerning the performance requirements specified in 178.350 Specification 7A, General Packaging, Type A. MLM-3245 references appropriate sections in this document.

This document does not by itself meet the documentation requirements specified in 49 CFR 173.415 and has compliance value only when used in conjunction with MLM-3245.

173.24 - STANDARD REQUIREMENTS FOR ALL PACKAGES

(a) Each package used for shipping hazardous material under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY STEEL DRUMS
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 173.411, .412, .465, and/or .466 as demonstrated in MIM-3245 and this addendum.
(2) The effectiveness of the packaging will not be substantially reduced; and	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 173.411, .412, .465, and/or .466 as demonstrated in MIM-3245 and this addendum. NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY STEEL DRUMS
(c) Packaging used for the shipment of hazardous matrials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See 178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 in. high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY STEEL DRUMS
(v) Packaging which does not comply with the applicable specification listed in parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see 178.0-2 and 179.1 of this subchapter).	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Steel used shall be low-carbon commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

Gauge No.	Normal Thickness (in.)	Minimum Thickness (in.)
12	0.1046	0.0946
13	0.0897	0.0817
14	0.0747	0.0677
15	0.0673	0.0603
16	0.0598	0.0533
17	0.0538	0.0478
18	0.0478	0.0428
19	0.0418	0.0378
20	0.0359	0.0324
22	0.0299	0.0269
23	0.0269	0.0239
24	0.0239	0.0209
26	0.0179	0.0159
28	0.0149	0.0129
30	0.0120	0.0110

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY STEEL DRUMS
(3) Lumber used shall be well-seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) Packaging materials and contents shall be such that there will be no significant chemical or galvanic reaction among any of the materials in the package.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) Nails, staples, and other metallic devices shall not protrude into the interior of the outer packaging in such a manner as to be likely to cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY STEEL DRUMS
(d) Polyethylene packagings and receptacles:		
(1) Polyethylene used in packagings and receptacles must be of a type compatible with the lading and may not be permeable to an extent that a hazardous condition occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene packaging or receptacle which is used for liquid hazardous materials must be capable of withstanding without failure the procedure specified in Appendix B of this part ("Procedure for Testing Chemical Compatibility and Rate of Permeation in Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 50°C (122°F) for 28 days in accordance with Test Method 2;		

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY STEEL DRUMS
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 60°C (140°F) for 14 days in accordance with Test Method 3;		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 in. in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

173.24 - STANDARD REQUIREMENTS FOR ALL PACKAGES

(a) Each package used for shipping hazardous material under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY STEEL BOXES
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 173.411, .412, .465, and/or .466 as demonstrated in MIM-3245 and this addendum.
(2) The effectiveness of the packaging will not be substantially reduced; and	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 173.411, .412, .465, and/or .466 as demonstrated in MIM-3245 and this addendum. NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY STEEL BOXES
(c) Packaging used for the shipment of hazardous matrials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See 178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 in. high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY STEEL BOXES
(v) Packaging which does not comply with the applicable specification listed in parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see 178.0-2 and 179.1 of this subchapter).	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Steel used shall be low-carbon commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

Gauge No.	Normal Thickness (in.)	Minimum Thickness (in.)
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28	0.0149	0.0129
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	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY STEEL BOXES
(3) Lumber used shall be well-seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) Packaging materials and contents shall be such that there will be no significant chemical or galvanic reaction among any of the materials in the package.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) Nails, staples, and other metallic devices shall not protrude into the interior of the outer packaging in such a manner as to be likely to cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY STEEL BOXES
(d) Polyethylene packagings and receptacles:		
(1) Polyethylene used in packagings and receptacles must be of a type compatible with the lading and may not be permeable to an extent that a hazardous condition occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene packaging or receptacle which is used for liquid hazardous materials must be capable of withstanding without failure the procedure specified in Appendix B of this part ("Procedure for Testing Chemical Compatibility and Rate of Permeation in Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 50°C (122°F) for 28 days in accordance with Test Method 2;		

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY STEEL BOXES
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 60°C (140°F) for 14 days in accordance with Test Method 3;		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 in. in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

173.24 - STANDARD REQUIREMENTS FOR ALL PACKAGES

(a) Each package used for shipping hazardous material under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY WOODEN BOXES
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 173.411, .412, .465, and/or .466 as demonstrated in MLM-3245 and this addendum.
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(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY WOODEN BOXES
(c) Packaging used for the shipment of hazardous matrials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See 178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
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	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY WOODEN BOXES
(v) Packaging which does not comply with the applicable specification listed in parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see 178.0-2 and 179.1 of this subchapter).	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Steel used shall be low-carbon commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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30	0.0120	0.0110

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY WOODEN BOXES
(3) Lumber used shall be well-seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) Packaging materials and contents shall be such that there will be no significant chemical or galvanic reaction among any of the materials in the package.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) Nails, staples, and other metallic devices shall not protrude into the interior of the outer packaging in such a manner as to be likely to cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY WOODEN BOXES
(d) Polyethylene packagings and receptacles:		
(1) Polyethylene used in packagings and receptacles must be of a type compatible with the lading and may not be permeable to an extent that a hazardous condition occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene packaging or receptacle which is used for liquid hazardous materials must be capable of withstanding without failure the procedure specified in Appendix B of this part ("Procedure for Testing Chemical Compatibility and Rate of Permeation in Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 50°C (122°F) for 28 days in accordance with Test Method 2;		

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY WOODEN BOXES
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 60°C (140°F) for 14 days in accordance with Test Method 3;		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 in. in height. Additional text or symbols may be included in the marking. marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
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(a) Each package used for shipping hazardous material under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY FIBERBOARD CONTAINERS
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 173.411, .412, .465, and/or .466 as demonstrated in MLM-3245 and this addendum.
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(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY FIBERBOARD CONTAINERS
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(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See 178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 in. high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY FIBERBOARD CONTAINERS
(v) Packaging which does not comply with the applicable specification listed in parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see 178.0-2 and 179.1 of this subchapter).	Shipper responsibility to ensure.	Shipper responsibility to ensure.
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(7) Nails, staples, and other metallic devices shall not protrude into the interior of the outer packaging in such a manner as to be likely to cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

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(d) Polyethylene packagings and receptacles:		
(1) Polyethylene used in packagings and receptacles must be of a type compatible with the lading and may not be permeable to an extent that a hazardous condition occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene packaging or receptacle which is used for liquid hazardous materials must be capable of withstanding without failure the procedure specified in Appendix B of this part ("Procedure for Testing Chemical Compatibility and Rate of Permeation in Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 50°C (122°F) for 28 days in accordance with Test Method 2;		

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY FIBERBOARD CONTAINERS
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 60°C (140°F) for 14 days in accordance with Test Method 3;		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 in. in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

173.24 - STANDARD REQUIREMENTS FOR ALL PACKAGES

(a) Each package used for shipping hazardous material under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY UF-6 CYLINDERS
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 173.411, .412, .465, and/or .466 as demonstrated in MLM-3245 and this addendum.
(2) The effectiveness of the packaging will not be substantially reduced; and	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 173.411, .412, .465, and/or .466 as demonstrated in MLM-3245 and this addendum. NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY UF-6 CYLINDERS
(c) Packaging used for the shipment of hazardous matrials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See 178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 in. high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY UF-6 CYLINDERS
(v) Packaging which does not comply with the applicable specification listed in parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see 178.0-2 and 179.1 of this subchapter).	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Steel used shall be low-carbon commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

Gauge No.	Normal Thickness (in.)	Minimum Thickness (in.)
12	0.1046	0.0946
13	0.0897	0.0817
14	0.0747	0.0677
15	0.0673	0.0603
16	0.0598	0.0533
17	0.0538	0.0478
18	0.0478	0.0428
19	0.0418	0.0378
20	0.0359	0.0324
22	0.0299	0.0269
23	0.0269	0.0239
24	0.0239	0.0209
26	0.0179	0.0159
28	0.0149	0.0129
30	0.0120	0.0110

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY UF-6 CYLINDERS
(3) Lumber used shall be well-seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) Packaging materials and contents shall be such that there will be no significant chemical or galvanic reaction among any of the materials in the package.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) Nails, staples, and other metallic devices shall not protrude into the interior of the outer packaging in such a manner as to be likely to cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY UF-6 CYLINDERS
(d) Polyethylene packagings and receptacles:		
(1) Polyethylene used in packagings and receptacles must be of a type compatible with the lading and may not be permeable to an extent that a hazardous condition occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene packaging or receptacle which is used for liquid hazardous materials must be capable of withstanding without failure the procedure specified in Appendix B of this part ("Procedure for Testing Chemical Compatibility and Rate of Permeation in Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 50°C (122°F) for 28 days in accordance with Test Method 2;		

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY UF-6 CYLINDERS
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 60°C (140°F) for 14 days in accordance with Test Method 3;		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 in. in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

173.24 - STANDARD REQUIREMENTS FOR ALL PACKAGES

(a) Each package used for shipping hazardous material under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY LIQUIDS AND GASES
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 173.411, .412, .465, and/or .466 as demonstrated in MIM-3245 and this addendum.
(2) The effectiveness of the packaging will not be substantially reduced; and	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 173.411, .412, .465, and/or .466 as demonstrated in MIM-3245 and this addendum. NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY LIQUIDS AND GASES
(c) Packaging used for the shipment of hazardous matrials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See 178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 in. high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY LIQUIDS AND GASES
(v) Packaging which does not comply with the applicable specification listed in parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see 178.0-2 and 179.1 of this subchapter).	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Steel used shall be low-carbon commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

Gauge No.	Normal Thickness (in.)	Minimum Thickness (in.)
12	0.1046	0.0946
13	0.0897	0.0817
14	0.0747	0.0677
15	0.0673	0.0603
16	0.0598	0.0533
17	0.0538	0.0478
18	0.0478	0.0428
19	0.0418	0.0378
20	0.0359	0.0324
22	0.0299	0.0269
23	0.0269	0.0239
24	0.0239	0.0209
26	0.0179	0.0159
28	0.0149	0.0129
30	0.0120	0.0110

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY LIQUIDS AND GASES
(3) Lumber used shall be well-seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) Packaging materials and contents shall be such that there will be no significant chemical or galvanic reaction among any of the materials in the package.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) Nails, staples, and other metallic devices shall not protrude into the interior of the outer packaging in such a manner as to be likely to cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY LIQUIDS AND GASES
(d) Polyethylene packagings and receptacles:		
(1) Polyethylene used in packagings and receptacles must be of a type compatible with the lading and may not be permeable to an extent that a hazardous condition occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene packaging or receptacle which is used for liquid hazardous materials must be capable of withstanding without failure the procedure specified in Appendix B of this part ("Procedure for Testing Chemical Compatibility and Rate of Permeation in Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 50°C (122°F) for 28 days in accordance with Test Method 2;		

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY LIQUIDS AND GASES
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 60°C (140°F) for 14 days in accordance with Test Method 3;		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 in. in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

173.24 - STANDARD REQUIREMENTS FOR ALL PACKAGES

(a) Each package used for shipping hazardous material under this subchapter shall be so designed and constructed, and its contents so limited, that under conditions normally incident to transportation:

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY MISCELLANEOUS
(1) There will be no significant release of the hazardous materials to the environment;	To be considered during package design evaluation. Shipper responsibility to ensure.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 173.411, .412, .465, and/or .466 as demonstrated in MIM-3245 and this addendum.
(2) The effectiveness of the packaging will not be substantially reduced; and	To be considered during package design evaluation. Shipper responsibility to ensure. One aspect for strong consideration is effect of contents on packaging effectiveness.	All packagings met the intent of this requirement as demonstrated by meeting the more severe Type A packaging requirements of 173.411, .412, .465, and/or .466 as demonstrated in MIM- 3245 and this addendum. NOTE: Shipper responsibility to consider and evaluate, if necessary, the effect of the contents.
(3) There will be no mixture of gases or vapors in the package which could, through any credible spontaneous increase of heat or pressure or through an explosion, significantly reduce the effectiveness of the packaging.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(b) Materials for which detailed specifications for packaging are not set forth in this part must be securely packaged in strong, tight packages meeting the requirements of this section.	Does not apply.	Does not apply.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY MISCELLANEOUS
(c) Packaging used for the shipment of hazardous matrials under this subchapter shall, unless otherwise specified or exempted therein, meet all of the following design and construction criteria:		
(1) Each specification container must be marked as follows:		
(i) In an unobstructed area with letters and numerals identifying the container specification (e.g., DOT-1A, DOT-17E-304HT, DOT-23G40). See 178.0-2 of this subchapter.	Package must be marked "DOT 7A Type A." Shipper responsibility to ensure.	Shipper responsibility to ensure.
(ii) The name and address or symbol of person making the mark specified in paragraph (c)(1)(i) of this section. Symbol letters, if used, must be registered with the Director, OHMT. Duplicate symbols are not authorized.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iii) The markings must be stamped, embossed, burned, printed, or otherwise marked on the packaging to provide adequate accessibility, permanency, and contrast so as to be readily apparent and understood.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(iv) Unless otherwise specified, letters and numerals must be at least 1/2 in. high.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY MISCELLANEOUS
(v) Packaging which does not comply with the applicable specification listed in parts 178 and 179 of this subchapter must not be marked to indicate such compliance (see 178.0-2 and 179.1 of this subchapter).	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Steel used shall be low-carbon commercial quality steel. Stainless, open hearth, electric, basic oxygen, or other similar quality steels are acceptable. Steel sheets of specified gauges shall comply with the following:	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

Gauge No.	Normal Thickness (in.)	Minimum Thickness (in.)
12	0.1046	0.0946
13	0.0897	0.0817
14	0.0747	0.0677
15	0.0673	0.0603
16	0.0598	0.0533
17	0.0538	0.0478
18	0.0478	0.0428
19	0.0418	0.0378
20	0.0359	0.0324
22	0.0299	0.0269
23	0.0269	0.0239
24	0.0239	0.0209
26	0.0179	0.0159
28	0.0149	0.0129
30	0.0120	0.0110

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY MISCELLANEOUS
(3) Lumber used shall be well-seasoned, commercially dry, and free from decay, loose knots, knots that would interfere with nailing, and other defects that would materially lessen the strength.	Designer and fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Welding and brazing shall be performed in a workmanlike manner using suitable and appropriate techniques, materials, and equipment.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(5) Packaging materials and contents shall be such that there will be no significant chemical or galvanic reaction among any of the materials in the package.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(6) Closure shall be adequate to prevent inadvertent leakage of the contents under normal conditions incident to transportation. Gasketed closures shall be fitted with gaskets of efficient materials which will not be deteriorated by the contents of the container.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(7) Nails, staples, and other metallic devices shall not protrude into the interior of the outer packaging in such a manner as to be likely to cause failures.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(8) The nature and thickness of the packaging shall be such that friction during transport does not generate any heating likely to decrease the chemical stability of the contents.	Fabricator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY MISCELLANEOUS
(d) Polyethylene packagings and receptacles:		
(1) Polyethylene used in packagings and receptacles must be of a type compatible with the lading and may not be permeable to an extent that a hazardous condition occurs during transportation, handling, or refilling.	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(2) Each polyethylene packaging or receptacle which is used for liquid hazardous materials must be capable of withstanding without failure the procedure specified in Appendix B of this part ("Procedure for Testing Chemical Compatibility and Rate of Permeation in Polyethylene Packagings and Receptacles") and the maximum rate of permeation of hazardous lading through or into the polyethylene packaging or receptacles may not exceed the following rates:	Designer, tester, and evaluator to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 18°C (64°F) for 180 days in accordance with Test Method 1;		
(ii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 50°C (122°F) for 28 days in accordance with Test Method 2;		

	ACTION REQUIRED/BY WHOM	PACKAGING CATEGORY MISCELLANEOUS
(iii) 0.5 percent for materials meeting the definition of a poison according to this subchapter and 2.0 percent for other hazardous materials, when subjected to temperatures no lower than 60°C (140°F) for 14 days in accordance with Test Method 3;		
(3) Alternative procedures or rates of permeation are permitted if they yield a level of safety equivalent to or greater than that provided by paragraph (d)(2) of this section and are approved by the Director, OHMT.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(4) Each polyethylene packaging used as an outside packaging for materials meeting the definition of a poison according to this subchapter shall be permanently marked, by embossment or other durable means, with the word "POISON" in letters of at least 1/4 in. in height. Additional text or symbols may be included in the marking. The marking shall be located within six inches of the packaging's closure. The requirements of this subparagraph do not apply prior to September 1, 1985.	Shipper responsibility to ensure.	Shipper responsibility to ensure.
(e) For specification containers, compliance with the applicable specifications in Parts 178 and 179 of this subchapter shall be required in all details, except as otherwise provided in this subchapter.	Shipper responsibility to ensure.	Shipper responsibility to ensure.

173.411 - GENERAL DESIGN REQUIREMENTS

Except for a package that contains a limited quantity or excepted instrument or article under 173.421 through 173.424, each package used for shipment of radioactive materials shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL DRUMS
(a) The package can be easily handled and properly secured in or on a conveyance during transport;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry which allow conformance to paragraph (a). For example, a package 4 ft x 6 ft x 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package which would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of this requirement. In all cases, the shipper should avoid loading a top-heavy package and should be aware of the need for tie-downs for any such packages.
(b) A package with gross weight exceeding 10 kilograms (22 lb) and up to 50 kilograms (110 lb) has a means for manual handling;	This does not necessarily mean that handles are required. As in the comment on paragraph (a) above, physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are: - Large, awkard packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand; - Surfaces with sharp edges or points which make handling difficult. Designer to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of this requirement when in the 10-kg (22-lb) to 50-kg (110-lb) range.

	GUIDANCE FOR APPLICATION	PACKAGE CATEGORY STEEL DRUMS
(c) A package with a gross weight of 50 kilograms (110 lb) or more can safely be handled by mechanical means;	Thought should be given to how the the packages will be handled, and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 173.411(d). In most cases, this is for the shipper to evaluate, particularly the requirement that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of this requirement. There are many drum/barrel handling devices which have proven effective and safe for drums weighing more than 50 kg (110 lb).
(d) Each lifting attachment on the package, when used in the intended manner, with a minimum safety factor of 3, does not impose an unsafe stress on the structure of the package. In addition, the lifting attachment shall be so designed that failure under excessive load would not impair the ability of the package to meet all other requirements of this subpart. Each attachment or other feature on the outer surface of the packaging that could be used to lift the package must be removable or otherwise capable of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attaching points for other purposes (i.e., "For lifting the lid only -- not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of this requirement. The only drum with a handle is the 17C (178.115) 5-gal drum. This packaging was tested (1) at greater than 300 lb with no failure of handle, and (2) at 400 lb where the handle did fail, but only pulled free from the side coupling. Thus, the failure was in an acceptable mode. There were no other lifting devices or attachments.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL DRUMS
(e) The external surfaces, as far as practical, may be easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of this requirement.
(f) The outer layer of packaging will avoid, as far as pratical, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Spec 7A packaging. The intent is for packaging design personnel to consider this aspect. Do not design a puddle on top of a box or provide cavities to collect water which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	All the drums evaluated meet the intent of the regulation. A newly designed package should consider this requirement.
(g) Each feature that is added to the package at the time of transport and that is not part of the package will not reduce the safety of the package.	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility since the regulation addresses items added to the packaging that was already evaluated.

173.411 - GENERAL DESIGN REQUIREMENTS

Except for a package that contains a limited quantity or excepted instrument or article under 173.421 through 173.424, each package used for shipment of radioactive materials shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL BOXES
(a) The package can be easily handled and properly secured in or on a conveyance during transport;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry which allow conformance to paragraph (a). For example, a package 4 ft x 6 ft x 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package which would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All the steel boxes evaluated meet the intent of this requirement. None are intended for manual handling and all have a large, stable base.
(b) A package with gross weight exceeding 10 kilograms (22 lb) and up to 50 kilograms (110 lb) has a means for manual handling;	This does not necessarily mean that handles are required. As in the comment on paragraph (a) above, physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are: - Large, awkard packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand; - Surfaces with sharp edges or points which make handling difficult. Designer to do and shipper responsibility to ensure.	This does not apply since all the steel boxes will weigh more than 50 kg (110 lb).

	GUIDANCE FOR APPLICATION	PACKAGE CATEGORY STEEL BOXES
(c) A package with a gross weight of 50 kilograms (110 lb) or more can safely be handled by mechanical means;	Thought should be given to how the the packages will be handled, and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 173.411(d). **In most cases, this is for** the shipper to evaluate, particularly the requirement that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	These boxes are typically designed for handling with a truck or forklift. In all the steel box packagings, experience, testing, and/or design analysis have demonstrated compliance.
(d) Each lifting attachment on the package, when used in the intended manner, with a minimum safety factor of 3, does not impose an unsafe stress on the structure of the package. In addition, the lifting attachment shall be so designed that failure under excessive load would not impair the ability of the package to meet all other requirements of this subpart. Each attachment or other feature on the outer surface of the packaging that could be used to lift the package must be removable or otherwise capable of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. **The** procedures for use of the packaging should also state the intended use of any attaching points for other purposes (i.e., "For lifting the lid only -- not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	The M-4 bin and the SAND box have lifting devices which far exceed the required safety fator of 3; however, because of the strength of the lifting device, in each case the box will fail before the lifting device. This will not negatively affect the evaluation of these boxes since both are used within overpacks and the lifting devices are not used during transportation. RoGar boxes have lifting devices on the lid. These are intended only for lifting the lid and must be removed or rendered inoperable before transport. This is the shipper's responsibility.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL BOXES
(e) The external surfaces, as far as practical, may be easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. **The intent is to** promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. **Consideration should be** given to actions such as sanding or painting surfaces. Designer to do and shipper **responsibility** to ensure.	All the boxes evaluated meet the intent of this requirement.
(f) The outer layer of packaging will avoid, as far as pratical, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Spec 7A packaging. **The intent is for packaging** design personnel to consider this aspect. Do not design a puddle on top of a box or provide cavities to collect water which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	All the boxes evaluated meet the intent of the requirement
(g) Each feature that is added to the package at the time of transport and that is not part of the package will not reduce the safety of the package.	For example, a canvas cover placed over a package **for protection against the rain must not adversely** affect heat transfer **requirements.** Shipper responsibility to ensure.	This is a shipper responsibility since the regulation addresses items added to the packaging that was already evaluated.

173.411 - GENERAL DESIGN REQUIREMENTS

Except for a package that contains a limited quantity or excepted instrument or article under 173.421 through 173.424, each package used for shipment of radioactive materials shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY WOODEN BOXES
(a) The package can be easily handled and properly secured in or on a conveyance during transport;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry which allow conformance to paragraph (a). For example, a package 4 ft x 6 ft x 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package which would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All the wooden boxes evaluated meet the intent of this requirement. In all cases the shipper should avoid loading a top-heavy package and should be aware of the need for tie-downs for any such packages.
(b) A package with gross weight exceeding 10 kilograms (22 lb) and up to 50 kilograms (110 lb) has a means for manual handling;	This does not necessarily mean that handles are required. As in the comment on paragraph (a) above, physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are: - Large, awkard packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand; - Surfaces with sharp edges or points which make handling difficult. Designer to do and shipper responsibility to ensure.	All the wooden boxes evaluated meet the intent of this requirement when used in the 10-kg (22-lb) to 50-kg (110-lb) range.

	GUIDANCE FOR APPLICATION	PACKAGE CATEGORY WOODEN BOXES
(c) A package with a gross weight of 50 kilograms (110 lb) or more can safely be handled by mechanical means;	Thought should be given to how the the packages will be handled, and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 173.411(d). In most cases, this is for the shipper to evaluate, particularly the requirement that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	These boxes are typically designed for handling with a truck or forklift. For all of these packagings, experience, testing, and/or design analysis have demonstrated compliance.
(d) Each lifting attachment on the package, when used in the intended manner, with a minimum safety factor of 3, does not impose an unsafe stress on the structure of the package. In addition, the lifting attachment shall be so designed that failure under excessive load would not impair the ability of the package to meet all other requirements of this subpart. Each attachment or other feature on the outer surface of the packaging that could be used to lift the package must be removable or otherwise capable of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attaching points for other purposes (i.e., "For lifting the lid only -- not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	None of the wooden boxes have lifting attachments; this requirement does not apply.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY WOODEN BOXES
(e) The external surfaces, as far as practical, may be easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	All the boxes evaluated meet the intent of this requirement. If contamination is a significant potential problem, then sanding, painting, or similar surface preparation should be completed.
(f) The outer layer of packaging will avoid, as far as pratical, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Spec 7A packaging. The intent is for packaging design personnel to consider this aspect. Do not design a puddle on top of a box or provide cavities to collect water which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	All the boxes evaluated meet the intent of the requirement.
(g) Each feature that is added to the package at the time of transport and that is not part of the package will not reduce the safety of the package.	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility since the regulation addresses items added to the packaging that was already evaluated.

173.411 - GENERAL DESIGN REQUIREMENTS

Except for a package that contains a limited quantity or excepted instrument or article under 173.421 through 173.424, each package used for shipment of radioactive materials shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY FIBERBOARD PACKAGINGS
(a) The package can be easily handled and properly secured in or on a conveyance during transport;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry which allow conformance to paragraph (a). For example, a package 4 ft x 6 ft x 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package which would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All the fiberboard boxes and drums meet the intent of this requirement. In all cases the shipper should avoid loading a top-heavy package and should be aware of the need for tie-downs for any such packages.
(b) A package with gross weight exceeding 10 kilograms (22 lb) and up to 50 kilograms (110 lb) has a means for manual handling;	This does not necessarily mean that handles are required. As in the comment on paragraph (a) above, physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are: - Large, awkard packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand; - Surfaces with sharp edges or points which make handling difficult. Designer to do and shipper responsibility to ensure.	All fiberboard boxes and drums meet the intent of this requirement when used in the 10-kg (22-lb) to 50-kg (110-lb) range. Obviously, the Tri-wall packaging (Page D-11) is intended for weights exceeding 50 kg and will require mechanical handling equipment.

	GUIDANCE FOR APPLICATION	PACKAGE CATEGORY FIBERBOARD PACKAGINGS
(c) A package with a gross weight of 50 kilograms (110 lb) or more can safely be handled by mechanical means;	Thought should be given to how the the packages will be handled, and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One **must also ensure that, when lifted by a forklift,** the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 173.411(d). In **most** cases, this is for the shipper to evaluate, particularly the requirement that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	The boxes and drums evaluated are typically designed for handling with hand-trucks and/or forklifts when weighing in excess of 50 kg. **For all** of these packagings, experience, testing, and/or design analysis have demonstrated compliance. As in all packages, but particularly important in Tri-wall packaging, the shipper shall ensure that the content load is in the center of the box or evenly distributed along the bottom.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY FIBERBOARD PACKAGINGS
(d) Each lifting attachment on the package, when used in the intended manner, with a minimum safety factor of 3, does not impose an unsafe stress on the structure of the package. In addition, the lifting attachment shall be so designed that failure under excessive load would not impair the ability of the package to meet all other requirements of this subpart. Each attachment or other feature on the outer surface of the packaging that could be used to lift the package must be removable or otherwise capable of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attaching points for other purposes (i.e., "For lifting the lid only -- not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	None of the fiberboard packagings have lifting attachments; this requirement does not apply.
(e) The external surfaces, as far as practical, may be easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	All the packagings evaluated meet the intent of this requirement. If contamination is a significant potential problem, covering, painting, or similar surface preparation should be completed.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY FIBERBOARD PACKAGINGS
(f) The outer layer of packaging will avoid, as far as pratical, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Spec 7A packaging. The intent is for packaging design personnel to consider this aspect. Do not design a puddle on top of a box or provide cavities to collect water which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	All the packagings evaluated meet the intent of the requirement.
(g) Each feature that is added to the package at the time of transport and that is not part of the package will not reduce the safety of the package.	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility since the regulation addresses items added to the packaging that was already evaluated.

173.411 - GENERAL DESIGN REQUIREMENTS

Except for a package that contains a limited quantity or excepted instrument or article under 173.421 through 173.424, each package used for shipment of radioactive materials shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY UF-6 CYLINDERS
(a) The package can be easily handled and properly secured in or on a conveyance during transport;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry which allow conformance to paragraph (a). For example, a package 4 ft x 6 ft x 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package which would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All cylinders evaluated meet the intent of this requirement. The experience data base demonstrates the stability of these packages in transport and their ease of handling.
(b) A package with gross weight exceeding 10 kilograms (22 lb) and up to 50 kilograms (110 lb) has a means for manual handling;	This does not necessarily mean that handles are required. As in the comment on paragraph (a) above, physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are: - Large, awkard packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand; - Surfaces with sharp edges or points which make handling difficult. Designer to do and shipper responsibility to ensure.	This applies only to the 1S, 2S, and 5A cylinders. As stated above, a vast experience base demonstrates compliance.

	GUIDANCE FOR APPLICATION	PACKAGE CATEGORY UF-6 CYLINDERS
(c) A package with a gross weight of 50 kilograms (110 lb) or more can safely be handled by mechanical means;	Thought should be given to how the the packages will be handled, and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 173.411(d). In most cases, this is for the shipper to evaluate, particularly the requirement that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	For the cylinders other than 1S, 2S, and 5A, a variety of mechanical systems are provided and have been used effectively and reliably for years. See Table C-4, page C-39.
(d) Each lifting attachment on the package, when used in the intended manner, with a minimum safety factor of 3, does not impose an unsafe stress on the structure of the package. In addition, the lifting attachment shall be so designed that failure under excessive load would not impair the ability of the package to meet all other requirements of this subpart. Each attachment or other feature on the outer surface of the packaging that could be used to lift the package must be removable or otherwise capable of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attaching points for other purposes (i.e., "For lifting the lid only -- not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	All cylinders meet this requirement, as demonstrated in Table C-4, Page C-39.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY UF-6 CYLINDERS
(e) The external surfaces, as far as practical, may be easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	The metal and painted metal surfaces have demonstrated, through experience, compliance with this requirement.
(f) The outer layer of packaging will avoid, as far as pratical, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Spec 7A packaging. The intent is for packaging design personnel to consider this aspect. Do not design a puddle on top of a box or provide cavities to collect water which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	These packages meet the intent of the requirement as shown in the sketches in MIM-3245.
(g) Each feature that is added to the package at the time of transport and that is not part of the package will not reduce the safety of the package.	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	No features are added other than those described in operating procedures, and these are evaluated by the shipper.

173.411 - GENERAL DESIGN REQUIREMENTS

Except for a package that contains a limited quantity or excepted instrument or article under 173.421 through 173.424, each package used for shipment of radioactive materials shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY LIQUIDS AND GASES
(a) The package can be easily handled and properly secured in or on a conveyance during transport;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry which allow conformance to paragraph (a). For example, a package 4 ft x 6 ft x 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package which would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All packagings meet the intent of this requirement per analysis of the sketches and as demonstrated by actual experience. In all cases, the shipper should avoid loading a top-heavy package and should be aware of the need for tie-downs for any such packages.
(b) A package with gross weight exceeding 10 kilograms (22 lb) and up to 50 kilograms (110 lb) has a means for manual handling;	This does not necessarily mean that handles are required. As in the comment on paragraph (a) above, physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are: - Large, awkard packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand; - Surfaces with sharp edges or points which make handling difficult. Designer to do and shipper responsibility to ensure.	All the packagings evaluated meet the intent of this requirement when used in the 10-kg (22-kg) to 50-kg (110-lb) range.

	GUIDANCE FOR APPLICATION	PACKAGE CATEGORY LIQUIDS AND GASES
(c) A package with a gross weight of 50 kilograms (110 lb) or more can safely be handled by mechanical means;	Thought should be given to how the the packages will be handled, and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 173.411(d). **In most cases, this is for** the shipper to evaluate, particularly the requirement that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	The only two packagings **that fit these criteria are the ORNL Returnable Shielded Shipping Container** and the J. L. Sheppard Gas Cylinder No. 4 (see **Pages F-26 and F-36 of MLM-3245). Both of these** packages have outer boxes designed for routine handling with hand/mechanical devices. Experience has demonstrated packaging compliance with this requirement
(d) Each lifting attachment on the package, when used in the intended manner, with a minimum safety factor of 3, does not impose an unsafe stress on the structure of the package. In addition, the lifting attachment shall be so designed that failure under excessive load would not impair the ability of the package to meet all other requirements of this subpart. Each attachment or other feature on the outer surface of the packaging that could be used to lift the package must be removable or otherwise capable of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. **The** procedures for use of the packaging should also state the intended use of any attaching points for other **purposes** (i.e., "For lifting the lid only -- not entire packaging"). Designer, **and perhaps** tester and evaluator, to do and shipper responsibility to ensure.	The only package with a lifting attachment is ORNL's returnable plastic box (Page F-30, MLM-3245). Tests at ORNL demonstrated compliance with this requirement, and failure of the handle would not impair the ability of the packaging to meet the containment integrity requirements.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY LIQUIDS AND GASES
(e) The external surfaces, as far as practical, may be easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	The variety of surfaces meet the intent of this requirement
(f) The outer layer of packaging will avoid, as far as pratical, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Spec 7A packaging. The intent is for packaging design personnel to consider this aspect. Do not design a puddle on top of a box or provide cavities to collect water which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	These packages meet the intent of this requirement by analysis of the sketches/engineering drawings in MLM-3245.
(g) Each feature that is added to the package at the time of transport and that is not part of the package will not reduce the safety of the package.	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility since the regulation addresses items added to the packaging that was already evaluated.

173.411 - GENERAL DESIGN REQUIREMENTS

Except for a package that contains a limited quantity or excepted instrument or article under 173.421 through 173.424, each package used for shipment of radioactive materials shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY MISCELLANEOUS
(a) The package can be easily handled and properly secured in or on a conveyance during transport;	This does not necessarily mean handles are required. The intent is to maintain a package size and geometry which allow conformance to paragraph (a). For example, a package 4 ft x 6 ft x 4 ft cannot be easily handled by hand. For such a package, other handling methods would be designed. A package with sharp edges or components may not be easily handled manually. Also, package stability is required during transport. A round-shaped package, a top-heavy package, or any similar package which would not maintain its initial orientation and load position under conditions incidental to routine transportation would not meet these requirements. Tie-downs are required for the packagings mentioned in this paragraph, and exclusive use shipments or documented special provisions with the carrier are required. Designer to do and shipper responsibility to ensure.	All the packagings meet the intent of this requirement per analysis of the sketches and as demonstrated by actual experience. In all cases, the shipper should avoid loading a top-heavy package and should be aware of the need for tie-downs for any such packages.
(b) A package with gross weight exceeding 10 kilograms (22 lb) and up to 50 kilograms (110 lb) has a means for manual handling;	This does not necessarily mean that handles are required. As in the comment on paragraph (a) above, physical size, geometry, and exterior surface design should be conducive to manual handling. Excluded are: - Large, awkard packages or odd-shaped packages with no reasonable way to lift, hold, or move by hand; - Surfaces with sharp edges or points which make handling difficult. Designer to do and shipper responsibility to ensure.	Only the LLNL shielded container (see Page G-1, MLM-3245) fits this criterion and, as can be seen, it has a handle.

	GUIDANCE FOR APPLICATION	PACKAGE CATEGORY MISCELLANEOUS
(c) A package with a gross weight of 50 kilograms (110 lb) or more can safely be handled by mechanical means;	Thought should be given to how the the packages will be handled, and they should be designed accordingly. If skids are used, the balance stability of the package on the forklift must be considered. One must also ensure that, when lifted by a forklift, the bottom structure can support the weight without significant distortion or loss of containment integrity. If hooks/lifting devices are used, they must meet 173.411(d). In most cases, this is for the shipper to evaluate, particularly the requirement that failure "would not impair the ability of the package to meet all other requirements." Designer to do and shipper responsibility to ensure.	The three packages exceeding 110 lb all have means for mechanical handling, and experience has demonstrated compliance.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY MISCELLANEOUS
(d) Each lifting attachment on the package, when used in the intended manner, with a minimum safety factor of 3, does not impose an unsafe stress on the structure of the package. In addition, the lifting attachment shall be so designed that failure under excessive load would not impair the ability of the package to meet all other requirements of this subpart. Each attachment or other feature on the outer surface of the packaging that could be used to lift the package must be removable or otherwise capable of being made inoperable for transport, or shall be designed with strength equivalent to that required for lifting attachments;	A sign saying "Do Not Use As A Lifting Device," "Not A Lifting Device," etc. is not adequate to prevent the use of the unauthorized lifting devices. The procedures for use of the packaging should also state the intended use of any attaching points for other purposes (i.e., "For lifting the lid only -- not entire packaging"). Designer, and perhaps tester and evaluator, to do and shipper responsibility to ensure.	The ORNL TRU Package (see Page G-5, MLM-3245) and the FEMA Source Overpack (see Page G-9, MLM-3245) are the only two packagings with lifting devices. A structural analysis by Mound has demonstrated compliance with three times the gross weight requirement for both packages. With the ORNL TRU package, the outer metal skin will fail prior to the handle, but this would not compromise the overall ability to comply with this requirement. A similar analysis demonstrated that the handles of the FEMA package also comply with the three times the gross weight requirement, and failure of the lid handles or side handles would not reduce the ability of the packaging to comply with this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY MISCELLANEOUS
(e) The external surfaces, as far as practical, may be easily decontaminated;	Plywood, although not normally thought of as easily decontaminated, is acceptable. The intent is to promote surfaces that are relatively smooth and that minimize cracks and crevices in which surface contamination could reside. Consideration should be given to actions such as sanding or painting surfaces. Designer to do and shipper responsibility to ensure.	The external surfaces are all metal and comply with this requirement.
(f) The outer layer of packaging will avoid, as far as pratical, pockets or crevices where water might collect; and	This is not intended to eliminate 55-gal drums as Spec 7A packaging. The intent is for packaging design personnel to consider this aspect. Do not design a puddle on top of a box or provide cavities to collect water which could spill during transport or handling or could promote rusting and general deterioration of the packaging, possibly in locations difficult to detect. Designer to do and shipper responsibility to ensure.	Compliance is obvious by analysis of the sketches. The only exception is the SNL drum (see Page G-13, MLM-3245), which complies with the intent per the column on the left.
(g) Each feature that is added to the package at the time of transport and that is not part of the package will not reduce the safety of the package.	For example, a canvas cover placed over a package for protection against the rain must not adversely affect heat transfer requirements. Shipper responsibility to ensure.	This is a shipper responsibility since the regulation addresses items added to the packaging that was already evaluated.

173.412 - ADDITIONAL DESIGN REQUIREMENTS FOR TYPE A PACKAGES

In addition to meeting the general design requirements prescribed in 173.411, each Type A packaging shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL DRUMS
(a) The smallest overall external dimension of the package is not less than 10 centimeters (4 in.);	Designer to do and shipper responsibility to ensure.	As shown on the sketches and as given in the packaging description in MLM-3245, all packagings meet this requirement.
(b) The outside of the packaging incorporates a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened. In the case of packages shipped in exclusive use closed transport vehicles, the cargo compartment may be sealed instead of the individual packages;	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number and nature of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL DRUMS
(d) Containment and shielding would be maintained during transportation and storage in a temperature range of -40°C (-40°F) to +70°C (+158°F) with account taken of the possibilities of brittle fracture;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 173.461(b).] The regulations allow the assumption that the packaging is in equilibrium at 38°C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40°F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Metals used in these drums will not become excessively brittle at -40°C and all gaskets used also meet this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70°C will not result in any significant decrease in containment integrity, as show in property of materials tables.
(e) It is able to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal transportation, without any deterioration of the effectiveness of closing devices or of the integrity of the package as a whole and without loosening or unintentional release of nuts, bolts, or other securing devices even after repeated use;	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL DRUMS
(f) It includes a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by pressure that may arise within the package during normal transport. Special form, as demonstrated in accordance with 173.469, may be considered as a component of the containment system;	"Screw-type" closures can qualify. "Friction fit" normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibiity to ensure.	All packagings evaluated meet this requirement, as shown on the sketches or in the packaging descriptions.
(g) The materials of the packaging and any components or structures are physically and chemically compatible with each other and with the contents, taking into account the behavior of each under irradiation;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(h) For each component of the containment system, account is taken where applicable of radiolytic decomposition of materials and the generation of gas by chemical reaction and radiolysis;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) The containment system will retain its radioactive contents under the reduction of ambient pressure to 0.25 kilograms per square centimeter (3.5 lb/ in^2);	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioative contents must be completely retained in the containment system if the package is subjected to reduced	This analysis requires a more detailed description to provide adequate information. See Table C-1.

TABLE C-1
SUMMARY OF "REDUCED PRESSURE" TESTS
ON THE EVALUATED STEEL DRUMS

INTRODUCTION:

Paragraph 173.412(i) in effect requires a pressure differential of 0.75 atm (11.2 psi) across the surfaces of the containment system acting from the inside to the outside. In all of the steel drum packagings the containment system is defined as the drum itself. To achieve the pressure differential, the inside of the packaging was pressurized to 11.2 psig using compressed air and held for approximately 5 min. The pass/fail criteria were:

(1) No release of contents as determined by the absence of any detectable air flow or fluorscein after the test.

(2) The retention of pressure, 11.2 $\pm$ 0.3 psig. This was held for approximately 5 min.

(3) No structural distortion which would cause an increase exceeding 20% in the dose rate at the surface of the package as compared to the dose rate prior to beginning the test.

17C 55-gal drums with vent clips and with high-efficiency filters installed in the lids were tested. In this case the criteria became just containment (no release of contents) since the packaging will not hold pressure. This last statement is technically correct; however, in the instance above (vent clips and filters in lid), the pressure was raised to 11.2 psig and held for 5 min by adjusting the inward flow to equal the loss through the vent clip and/or filter. This was over-testing since there are no realistic conditions of normal transport in which a pressure differential of this magnitude could arise in a matter of seconds. In the unlikely event of such a pressure change over longer periods of time, the vent clip or filter would allow the pressures to equilibrate before differentials approaching 11.2 psi could be reached. The table below provides detailed information concerning the testing of the steel drums and the results.

TABLE C-1

Steel Drums in Order of Presentation in MIM-3245	Test Results on Standard Production Packagings Without RTV		Test Results with RTV Adhesive Sealent (Requires 24-hr Cure Before Testing)		Contents	Comments
	No. Tested	Result	No. Tested	Result		
Spec 6C 5-gal (178.88)	0		2	2 pass	Vermiculite with flour and fluorescein on top	Containers without RTV were not tested because they were not expected to pass based on previous test results.
Spec 6C 10-gal (178.99)	0		2	2 pass	Vermiculite with flour and fluorescein on top	Containers without RTV were not tested because they were not expected to pass based on previous test results.
Spec 17C 5-gal (178.115)	1	Fail	2	2 pass	Vermiculite with flour and fluorescein on top	After one failed without RTV, the next two were tested with RTV.
Spec 17C 30-gal (178.115)	None tested due to limited DOE contractor use. Evaluation based on testing/analysis of Spec 17H 30-gal packaging, a drum of less expected structural strength (i.e., 18-gauge sheet steel vs. 16-gauge sheet steel, etc.)					

TABLE C-1 (continued)

Steel Drums in Order of Presentation in MIM-3245	Test Results on Standard Production Packagings Without RIV		Test Results with RIV Adhesive Sealent (Requires 24-hr Cure Before Testing)		Contents	Comments
	No. Tested	Result	No. Tested	Result		
Spec 17C 55-gal (178.115)	5	5 pass	0		Empty	
	1	1 fail (See comments)			Flour and fluorescein	Upon inspection, a manufacturing defect in the gasket was noted. Drums from same supplier tested again and all passed.
	5	5 pass	0		Vermiculite with flour and fluorescein	
	3 LLNL Galvanized Drums	3 pass	0		Vermiculite with flour and fluorescein	
Spec 17C 55-gal (178.115) with pressure relief devices	5 Rockwell Hanford	5 pass	0		Flour and fluorescein	This test with no vent clips was to demonstrate the integrity of a standard production drum without RIV.
- Vent clip	5 Rockwell Hanford	5 pass	0		Vermiculite with flour and fluorescein	At 11.2 psig, air readily escaped, but no fluorescein was detected during or after these tests.

TABLE C-1 (continued)

Steel Drums in Order of Presentation in MIM-3245	Test Results on Standard Production Packagings Without RIV		Test Results with RIV Adhesive Sealent (Requires 24-hr Cure Before Testing)		Contents	Comments
	No. Tested	Result	No. Tested	Result		
- Filter	3 Rocky Flats	3 pass	0		Vermiculite with flour and fluorescein	The opening on the filter was covered on the inside and 11.2 psi pressure was applied to test the drums and the filter housing. As previously stated, all passed.
- Filter (same drums as above)	3 Rocky Flats	3 pass	0		Vermiculite with flour and fluorescein	At 11.2 psig, air readily escaped, but no fluorescein was detected during or after these tests.
Spec 17C 55-gal (178.115) with 90-mil HDPE liner	No tests were required since the 17C 55-gal drums had already been tested and had met this requirement.					
Spec 17H 30-gal (178.118)	5 IASL	5 fail			Empty	
	3 IASL	3 fail			Flour and fluorescein	
			3 IASL	3 pass	Flour and fluorescein	
	3 Rocky Flats	3 fail			Empty	

TABLE C-1 (continued)

Steel Drums in Order of Presentation in MIM-3245	Test Results on Standard Production Packagings Without RTV		Test Results with RTV Adhesive Sealent (Requires 24-hr Cure Before Testing)		Contents	Comments
	No. Tested	Result	No. Tested	Result		
	1 Rocky Flats	1 pass			Empty	
	3 Rocky Flats	3 fail			Vermiculite with flour and fluorescein	
Spec 17H 55-gal (178.118)	7 Mound	7 fail			Empty	Both empty and full tests were performed to demonstrate that not only were the drums leaking, but they were leaking particulates detectable with UV light.
	2 Mound	2 pass			Empty	
	5 Mound	5 fail			Vermiculite with flour and fluorescein	
			10 Mound	10 pass		
	2 Rocky Flats	2 fail			Empty	
			2 Rocky Flats	2 pass	Vermiculite with flour and fluorescein	
	2 LLNL	2 fail			Empty	
	3 LLNL	3 fail			Vermiculite with flour and fluorescein	
			2 LLNL	2 pass	Empty	

TABLE C-1 (continued)

Steel Drums in Order of Presentation in MIM-3245	Test Results on Standard Production Packagings Without RIV		Test Results with RIV Adhesive Sealent (Requires 24-hr Cure Before Testing)		Contents	Comments
	No. Tested	Result	No. Tested	Result		
Military Specification Containers						
MS-24347-1[a] 0.25-gal	3	3 pass			F/F/S/Pb[b]	
MS-24347-7 1.25-gal	3	3 pass			F/F/S/Pb	
MS-24684-1 0.25-gal	3	3 pass			F/F/S/Pb	
MS-27684-2 4-gal	2	3 pass			F/F/S/Pb	
MS-27684-3 6-gal	3	3 pass			F/F/S/Pb	
MS-27684-6 8-gal	3	3 pass			F/F/S/Pb	
MS-27684-8 12-gal	3	3 pass			F/F/S/Pb	
MS-27683-7 30-gal	3	3 pass			F/F/S/Pb	
MS-27683-13 45-gal	3	3 pass			F/F/S/Pb	
MS-27683-21 85-gal	1	1 pass	3	3 pass		The 85-gal packaging is the only one requiring RIV.
	2	2 fail				

[a]Drum assembly number.

[b]Flour, fluorescein, sand, and lead.

NOTE: Twenty-one Spec 17C 55-gal drums from three different DOE contractors were tested and demonstrated compliance with this requirement.

NOTE: Thirty-five 17H 55-gal steel drums were tested. Of the 21 tested (from three different DOE contractors) without RIV: 19 failed, 2 passed.
Of the 14 tested with RIV: 14 passed.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL DRUMS
	pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (i.e., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	
(j) Each valve through which the radioactive contents could otherwise escape is protected against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;	Designer to do and shipper responsibility to ensure.	None of these packagings have valves.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL DRUMS
(k) Any radiation shield that encloses a component of the packaging specified as part of the containment system will prevent the unintentional escape of that component from the shield;	The shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in place. The shipper must make sure that under the tests prescribed in 173.465 there will be no rearrangement of the original containment/shield orientation. Designer, tester, evaluator to do and shipper responsibility to ensure.	None of these packagings have shielding as decribed.
(l) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart.	Designer, tester, evaluator to do and shipper responsibility to ensure.	None of these packagings have tie-down attachments as described.

173.412 - ADDITIONAL DESIGN REQUIREMENTS FOR TYPE A PACKAGES

In addition to meeting the general design requirements prescribed in 173.411, each Type A packaging shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL BOXES
(a) The smallest overall external dimension of the package is not less than 10 centimeters (4 in.);	Designer to do and shipper responsibility to ensure.	As shown on the sketches and as given in the packaging description in MIM-3245, all packagings meet this requirement.
(b) The outside of the packaging incorporates a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened. In the case of packages shipped in exclusive use closed transport vehicles, the cargo compartment may be sealed instead of the individual packages;	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number and nature of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL BOXES
(d) Containment and shielding would be maintained during transportation and storage in a temperature range of -40°C (-40°F) to +70°C (+158°F) with account taken of the possibilities of brittle fracture;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 173.461(b).] The regulations allow the assumption that the packaging is in equilibrium at 38°C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40°F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Metals used in these boxes will not become excessively brittle at -40°C and all gaskets used also meet this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70°C will not result in any significant decrease in containment integrity, as show in property of materials tables.
(e) It is able to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal transportation, without any deterioration of the effectiveness of closing devices or of the integrity of the package as a whole and without loosening or unintentional release of nuts, bolts, or other securing devices even after repeated use;	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL BOXES
(f) It includes a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by pressure that may arise within the package during normal transport. Special form, as demonstrated in accordance with 173.469, may be considered as a component of the containment system;	"Screw-type" closures can qualify. "Friction fit" normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibiity to ensure.	All packagings evaluated meet this requirement, as shown on the sketches or in the packaging descriptions.
(g) The materials of the packaging and any components or structures are physically and chemically compatible with each other and with the contents, taking into account the behavior of each under irradiation;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(h) For each component of the containment system, account is taken where applicable of radiolytic decomposition of materials and the generation of gas by chemical reaction and radiolysis;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) The containment system will retain its radioactive contents under the reduction of ambient pressure to 0.25 kilograms per square centimeter (3.5 lb/ in^2);	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioative contents must be completely retained in the containment system if the package is to be subjected to reduced	This analysis requires a more detailed description to provide adequate information. See Table C-2.

TABLE C-2
STEEL BOXES

The containment system is defined as the box itself. To achieve the pressure differential, the inside of the packaging (steel box) was pressurized to 11.2 psig using compressed air, compressed nitrogen, or water, as described below. In all cases, the pressure was held for approximately 5 min. The pass/fail criteria were essentially the same as given in Table C-1, with the exception of the Capital Industry test, which used water. In this case, obviously no flour or fluorescein was used; however, the absence of a visible water leak (and retention of water pressure) was really a more sensitive test than detection of fluorescein. Note that this test applies only to the nonfiltered packagings since this differential could not reasonably be expected to be encounted in transportation with a filtered packaging.

TABLE C-2

Steel Boxes in Order of Presentation in MIM-3245	Size/Model No.	Test Methodology	Test Results	Comments
Capital Industries	S-0510-0823	Pressurized with water to 11.2 psi	Pass	No leakage of water and pressure held for 5 min.
	V-0510-0823	Vented/filtered so this test is not applicable	Pass	
	S-0450-0846	Engineering analysis by comparison to S-0510-0823 above	Pass	
	S-0730-0846	Engineering analysis by comparison to S-0730-1006 below	Pass	
	S-0240-0906	Engineering analysis by comparison to S-0510-0823 above	Pass	
	S-0480-0906	Engineering analysis by comparison to S-510-0823 above	Pass	
	S-0730-1006	Pressurized with water to 11.2 psi	Pass	No leakage of water and pressure held for 5 min.

TABLE C-2 (continued)

Steel Boxes in Order of Presentation in MLM-3245	Size/Model No.	Test Methodology	Test Results	Comments
	S-0480-1376	Engineering analysis by comparison to S-0730-1006 above	Pass	
	S-0840-1440	Pressurized with water to 11.2 psi	Pass	No leakage of water and pressure held for 5 min.
Container Products Corp.	B-96-5 S/L FD	Vented/filtered so test not applicable		
	B-96-5 S/L RA	Pressurized with air to 11.2 psi	Pass	No leakage of air and pressure held for 2 min.
	B-96-5-RA-B	Pressurized with air to 11.2 psi	Pass	No leakage of air and pressure held for 2 min.

All the remaining Container Products Corp. models are vented/filtered; therefore, this test is not applicable.

RoGar Chemical & Nuclear Services, Inc.	R-1	Engineering analysis by comparison to R-3 below.		
	R-2	Engineering analysis by comparison to R-3 below.		

TABLE C-2 (continued)

Steel Boxes in Order of Presentation in MLM-3245	Size/Model No.	Test Methodology	Test Results	Comments
	R-3	Pressurized with nitrogen to 11.2 psi	Pass	No leakage of nitrogen and pressure held for 5 minutes.
	R-4	Engineering analysis by comparison to R-3 above.		
Rocky Flats, Golden, CO	Style 1	Each style (1-4) pressurized with nitrogen to slightly above 12 psi	Pass	No leakage of nitrogen and pressure held for 5 min.
	Style 2		Pass	
	Style 3		Pass	
	Style 4		Pass	
Argonne National Laboratory - Argonne, IL	M-4 Bin	Pressurized with water to 11.5 psig	Pass	No leakage of water and pressure held for more than 5 min.
ANL-West	ANL-West steel box	Certified only for Form 3 material; thus, test not meaningful	Not Required	Box is not designed with a gasket seal intended to retain Form 1 or Form 2 contents.

	GUIDANCE FOR APPLICATION	
	pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (i.e., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	
(j) Each valve through which the radioactive contents could otherwise escape is protected against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;	Designer to do and shipper responsibility to ensure.	None of these packagings have valves.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY STEEL BOXES
(k) Any radiation shield that encloses a component of the packaging specified as part of the containment system will prevent the unintentional escape of that component from the shield;	The shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in place. The shipper must make sure that under the tests prescribed in 173.465 there will be no rearrangement of the original containment/shield orientation. Designer, tester, evaluator to do and shipper responsibility to ensure.	None of these packagings have shielding as decribed.
(l) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart.	Designer, tester, evaluator to do and shipper responsibility to ensure.	None of these packagings have tie-down attachments as described.

173.412 - ADDITIONAL DESIGN REQUIREMENTS FOR TYPE A PACKAGES

In addition to meeting the general design requirements prescribed in 173.411, each Type A packaging shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY WOODEN BOXES
(a) The smallest overall external dimension of the package is not less than 10 centimeters (4 in.);	Designer to do and shipper responsibility to ensure.	As shown on the sketches and as given in the packaging description in MIL-3245, all packagings meet this requirement.
(b) The outside of the packaging incorporates a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened. In the case of packages shipped in exclusive use closed transport vehicles, the cargo compartment may be sealed instead of the individual packages;	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number and nature of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY WOODEN BOXES
(d) Containment and shielding would be maintained during transportation and storage in a temperature range of -40°C (-40°F) to +70°C (+158°F) with account taken of the possibilities of brittle fracture;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 173.461(b).] The regulations allow the assumption that the packaging is in equilibrium at 38°C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40°F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The materials (wood, caulking, metal strips, nails, gaskets, etc.) would not become excessively brittle at -40°C and all gaskets used met this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70°C would not result in any significant decrease in integrity either, as shown in property of materials tables.
(e) It is able to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal transportation, without any deterioration of the effectiveness of closing devices or of the integrity of the package as a whole and without loosening or unintentional release of nuts, bolts, or other securing devices even after repeated use;	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY WOODEN BOXES
(f) It includes a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by pressure that may arise within the package during normal transport. Special form, as demonstrated in accordance with 173.469, may be considered as a component of the containment system;	"Screw-type" closures can qualify. "Friction fit" normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibiity to ensure.	All packagings evaluated meet this requirement, as shown on the sketches or in the packaging descriptions.
(g) The materials of the packaging and any components or structures are physically and chemically compatible with each other and with the contents, taking into account the behavior of each under irradiation;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(h) For each component of the containment system, account is taken where applicable of radiolytic decomposition of materials and the generation of gas by chemical reaction and radiolysis;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) The containment system will retain its radioactive contents under the reduction of ambient pressure to 0.25 kilograms per square centimeter (3.5 lb/ $in.^2$);	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. **The radioative contents must be** completely retained in the containment system if the package is subjected to reduced pressure. **A filtered packaging is possible** as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal	Based on the testing discussed below (see Table C-3), these packagings all meet this requirement for Form 2 and 3 materials. The containment system in each case is the wooden box itself. Obviously, the box is not expected to be air-leak tight with a significant pressure differential applied. Thirteen separate boxes were subjected to this test. The contents in all

package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (i.e., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.

cases were flour, fluorescein, and sand. In each case, the box did not hold pressure, as expected. Typically, boxes started leaking air at less than 1 psi. As the pressure increased, leak-paths increased until they began leaking all over (at the seams, around nails, etc.) at 9 psi. In each case, no sand was released, so these packagings passed for Form 2 and 3 materials (which is what they were evaluated for). In all cases, fluorescein was detected, but again, this simply means the packaging cannot be authorized for Form 1 materials. This does not present a problem since the boxes were never intended for use with Form 1 materials, and each evaluation states that Form 1 materials are "Not authorized without separate containment tested to Type A requirements with appropriate documentation."

TABLE C-3
WOODEN BOXES

This test method, raising the internal pressure to 9-11 psi and maintaining it for several minutes, is very conservative. This is because, in transport, any pressure differential encountered would be equilibrated very slowly, and the strong driving force encountered in this test would not exist.

Type of Wooden Box/ Principal User	Model/Size	Test/Analysis	Results	Comments
ANL-West	7A-217 7A-375 7A-670 7A-880 7A-995 7A-1315	These packagings are authorized only for Form 3 materials. Test results discussed in this section demonstrate that Form 3 materials would not be released.	Pass	Authorized only for Form 3 materials.
LLNL	Flush Panel 4 ft x 4 ft x 7 ft	Test data on similar packagings as discussed below demonstrate that Form 2 and 3 materials would not be released as a result of this test.	Pass	Authorized only for Form 2 and 3 materials.
MOUND Configuration A	MA-1 MA-2 MA-3	Tests data on similar packagings as discussed in this table demonstrate that Form 2 and 3 materials would not be released as a result of this test.	Pass	Authorized only for Form 2 and 3 materials.

TABLE C-3 (continued)

Type of Wooden Box/ Principal User	Model/Size	Test/Analysis	Results	Comments
MOUND Configuration B	MB-1 MB-2 MB-3 MB-4 MB-5 MB-6	Tests were conducted on MB-1, 2, 3, 4, and 5 with flour, fluorescein, and sand as contents. The package was pressurized to between 9 and 11.2 psi, and an equilibrium (escape vs. input) was achieved and held for 1-2 min. Air leaked out almost immediately. Fluorescein was detected in all cases, but in no instance was sand detected.	Pass	There was no release of Form 2 (or 3 by extrapolation) contents. Thus, these packagings are authorized for Form 2 and 3 materials.
MOUND Configuration C	MC-1 MC-2 MC-3 MC-4 MC-5	Tests data on similar packagings as discussed in this table demonstrate that Form 2 and 3 materials would not be released as a result of this test.	Pass	Authorized only for Form 2 and 3 materials.
MOUND Configuration D	MD-1 MD-2 MD-3 MD-4 MD-5 MD-6	Tests were conducted on MD-1, 2, 3, 4, 5, and 6 with flour, fluorescein, and sand as contents. The package was pressurized to between 9 and 11.2 psi, and an equilibrium (escape vs. input) was achieved and held for 1-2 min. Air leaked out almost immediately. Fluorescein was detected in all cases, but in no instance was sand detected.	Pass	There was no release of Form 2 (or 3 by extrapolation) contents. Thus, these packagings are authorized for Form 2 and 3 materials.

TABLE C-3 (continued)

Type of Wooden Box/ Principal User	Model/Size	Test/Analysis	Results	Comments
MOUND Configuration E	ME-1 ME-2 ME-3	Tests were conducted on all three models with flour, fluorescein, and sand as contents. The package was pressurized to between 9 and 11.2 psi, and an equilibrium (escape vs. input) was achieved and held for 1-2 min. Air leaked out almost immediately. Fluorescein was detected in all cases, but in no instance was sand detected.	Pass	There was no release of Form 2 (or 3 by extrapolation) contents. Thus, these packagings are authorized for Form 2 and 3 materials.

In summary, 13 of the Mound series boxes were tested and passed this test for Form 2 and 3 materials. These tests demonstrate that all of the boxes in this section would meet this requirement for Form 2 and 3 materials.

NLO Family of Boxes	G-4214 G-4245 G-4255 G-4273 G-4292	These packagings are authorized only for Form 3 materials. The test results discussed in this section demonstrate that Form 3 materials would not be released.	Pass	Authorized only for Form 3 materials.
Y-12 Series B	B-1 B-2 B-3 B-4 B-5 B-6 B-7 B-8	These packagings are authorized only for Form 3 materials. Test results discussed in this section demonstrate that Form 3 materials would not be released.	Pass	Authorized only for Form 3 materials.

TABLE C-3 (continued)

Type of Wooden Box/ Principal User	Model/Size	Test/Analysis	Results	Comments
Y-12 Picture Frames	PF-1 PF-2 PF-3 PF-4 PF-5 PF-6 PF-7 PF-8	These packagings are authorized only for Form 3 materials. Test results discussed in this section demonstrate that Form 3 materials would not be released.	Pass	Authorized only for Form 3 materials.
Rocky Flats RA Series	Configuration 1 Configuration 1	These packagings are authorized only for Form 3 materials. Test results discussed in this section demonstrate that Form 3 materials would not be released.	Pass	Authorized only for Form 3 materials.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY WOODEN BOXES
(j) Each valve through which the radioactive contents could otherwise escape is protected against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;	Designer to do and shipper responsibility to ensure.	None of these packagings have valves.
(k) Any radiation shield that encloses a component of the packaging specified as part of the containment system will prevent the unintentional escape of that component from the shield;	The shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in place. The shipper must make sure that under the tests prescribed in 173.465 there will be no rearrangement of the original containment/shield orientation. Designer, tester, evaluator to do and shipper responsibility to ensure.	None of these packagings have shielding as decribed.
(l) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart;	Designer, tester, evaluator to do and shipper responsibility to ensure.	None of these packagings have tie-down attachments as described.

173.412 - ADDITIONAL DESIGN REQUIREMENTS FOR TYPE A PACKAGES

In addition to meeting the general design requirements prescribed in 173.411, each Type A packaging shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY FIBERBOARD CONTAINERS
(a) The smallest overall external dimension of the package is not less than 10 centimeters (4 in.);	Designer to do and shipper responsibility to ensure.	As shown on the sketches and as given in the packaging description in MIM-3245, all packagings meet this requirement.
(b) The outside of the packaging incorporates a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened. In the case of packages shipped in exclusive use closed transport vehicles, the cargo compartment may be sealed instead of the individual packages;	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number and nature of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY FIBERBOARD CONTAINERS
(d) Containment and shielding would be maintained during transportation and storage in a temperature range of -40°C (-40°F) to +70°C (+158°F) with account taken of the possibilities of brittle fracture;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 173.461(b).] The regulations allow the assumption that the packaging is in equilibrium at 38°C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40°F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The materials (fiberboard, metal strips, nails, gaskets, etc.) would not become excessively brittle at -40°C and all gaskets used met this requirement. None of these packagings are authorized for liquids, so this requirement is not applicable. Temperatures of +70°C would not result in any significant decrease in integrity, as shown in property of materials tables.
(e) It is able to withstand the effects of any acceleration, vibration resonance that may arise during normal transportation, without any deterioration of the effectiveness of closing devices or of the intetgrity of the package as a whole and without loosening or unintentional release of nuts, bolts, or other securing devices even after repeated use;	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY FIBERBOARD CONTAINERS
(f) It includes a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by pressure that may arise within the package during normal transport. Special form, as demonstrated in accordance with 173.469, may be considered as a component of the containment system;	"Screw-type" closures can qualify. "Friction fit" normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibiity to ensure.	All packagings evaluated meet this requirement, as shown on the sketches or in the packaging descriptions.
(g) The materials of the packaging and any components or structures are physically and chemically compatible with each other and with the contents, taking into account the behavior of each under irradiation;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(h) For each component of the containment system, account is taken where applicable of radiolytic decomposition of materials and the generation of gas by chemical reaction and radiolysis;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) The containment system will retain its radioactive contents under the reduction of ambient pressure to 0.25 kilograms per square centimeter (3.5 lb/ $in.^2$);	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioative contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any	Except for LLNL's package, this test was not conducted on any of the fiberboard packagings since they obviously are not leak tight. With the exception of the LLNL package previously mentioned, these packagings are authorized only for Form 3 materials. Since Form 3 materials by definition have no dispersible contamina-

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY FIBERBOARD CONTAINERS
	other tests. Caution should be exercised to ensure that the contents and internal packaging components (i.e., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	tion, a movement of air from inside the package to the outside would have no adverse consequences. Thus, all these packagings authorized for only Form 3 material would meet this requirement. For the one exception, the LLNL packaging, two separate inner metal containers (No. 10 cans), were tested in a bell jar assembly and passed. The metal inner container (containment system) was immersed in a beaker of water inside a bell jar for approximately 5 min, and the pressure inside the bell jar was reduced to 3.6 psi. The water was checked for bubbles and, in both cases, none were detected. Thus, the metal inner container (No. 10 can) passed this test by itself.
(j) Each valve through which the radioactive contents could otherwise escape is protected against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;	Designer to do and shipper responsibility to ensure.	None of these packagings have valves.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY FIBERBOARD CONTAINERS
(k) Any radiation shield that encloses a component of the packaging specified as part of the containment system will prevent the unintentional escape of that component from the shield;	The shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in place. The shipper must make sure that under the tests prescribed in 173.465 there will be no rearrangement of the original containment/shield orientation. Designer, tester, evaluator to do and shipper responsibility to ensure.	None of these packagings have shielding as decribed.
(l) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart.	Designer, tester, evaluator to do and shipper responsibility to ensure.	None of these packagings have tie-down attachments as described.

173.412 - ADDITIONAL DESIGN REQUIREMENTS FOR TYPE A PACKAGES

In addition to meeting the general design requirements prescribed in 173.411, each Type A packaging shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY UF-6 CYLINDERS
(a) The smallest overall external dimension of the package is not less than 10 centimeters (4 in.);	Designer to do and shipper responsibility to ensure.	As shown on the sketches and as given in the packaging description in MIM-3245, all packagings meet this requirement.
(b) The outside of the packaging incorporates a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened. In the case of packages shipped in exclusive use closed transport vehicles, the cargo compartment may be sealed instead of the individual packages;	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number and nature of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY UF-6 CYLINDERS
(d) Containment and shielding would be maintained during transportation and storage in a temperature range of -40°C (-40°F) to +70°C (+158°F) with account taken of the possibilities of brittle fractures;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 173.461(b).] The regulations allow the assumption that the packaging is in equilibrium at 38°C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40°F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Metals used in these cylinders will not become excessively brittle at -40°C and all gaskets used also meet this requirement. None of these packagings are authorized for liquids, so freezing of contents is not a concern. Temperatures of +70°C will not result in any significant decrease in containment integrity, as show in property of materials tables.
(e) It is able to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal transportation, without any deterioration of the effectiveness of closing devices or of the integrity of the package as a whole and without loosening or unintentional release of nuts, bolts, or other securing devices even after repeated use;	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY UF-6 CYLINDERS
(f) It includes a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by pressure that may arise within the package during normal transport. Special form, as demonstrated in accordance with 173.469, may be considered as a component of the containment system;	"Screw-type" closures can qualify. "Friction fit" normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated meet this requirement, as shown on the sketches or in the packaging descriptions.
(g) The materials of the packaging and any components or structures are physically and chemically compatible with each other and with the contents, taking into account the behavior of each under irradiation;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(h) For each component of the containment system, account is taken where applicable of radiolytic decomposition of materials and the generation of gas by chemical reaction and radiolysis;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) The containment system will retain its radioactive contents under the reduction of ambient pressure to 0.25 kilograms per square centimeter (3.5 lb/ $in.^2$);	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioative contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage	All cylinders are designed to withstand pressures far in excess of 11.2 psi. The minimum service pressure for any of these cylinders is 100 psig and extends up to 200 psig for nine of the cylinders.

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	from any other tests. Caution should be exercised to ensure that the contents and internal packaging components (i.e., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	
(j) Each valve through which the radioactive contents could otherwise escape is protected against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;	Designer to do and shipper responsibility to ensure.	Each valve is protected against damage, sealed against unauthorized operation, and capped to retain any leakage.
(k) Any radiation shield that encloses a component of the packaging specified as part of the containment system will prevent the unintentional escape of that component from the shield;	The shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in	None of these packagings have shielding as decribed.

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place. The shipper must make sure that under the tests prescribed in 173.465 there will be no rearrangement of the original containment/shield orientation. Designer, tester, evaluator to do and shipper responsibility to ensure.

(1) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart.

Designer, tester, evaluator to do and shipper responsibility to ensure.

Only one configuration (48-in. cylinder) uses/incorporates tie-down attachments. Table C-4 shows the calculated safety factors and the failure mode analyses. In all cases, it was demonstrated that the lug would fail, not the cylinder. Thus, the integrity of the cylinder would not be impaired.

TABLE C-4

Cylinder	Weight (lb)	Calculated Safety Factor	Result
48X	25,530	12	Pass
48Y	32,760	10	Pass
48G	30,600	10	Pass
48H	31,190	10	Pass
48HX	31,190	10	Pass

173.412 - ADDITIONAL DESIGN REQUIREMENTS FOR TYPE A PACKAGES

In addition to meeting the general design requirements prescribed in 173.411, each Type A packaging shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY LIQUIDS AND GASES
(a) The smallest overall external dimension of the package is not less than 10 centimeters (4 in.);	Designer to do and shipper responsibility to ensure.	As shown on the sketches and as given in the packaging description in MIL-3245, all packagings meet this requirement.
(b) The outside of the packaging incorporates a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened. In the case of packages shipped in exclusive use closed transport vehicles, the cargo compartment may be sealed instead of the individual packages;	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number and nature of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY LIQUIDS AND GASES
(d) Containment and shielding would be maintained during transportation and storage in a temperature range of -40°C (-40°F) to +70°C (+158°F) with account taken of the possibilities of brittle fracture;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 173.461(b).] The regulations allow the assumption that the packaging is in equilibrium at 38°C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40°F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The materials (wood, caulking, metal strips, nails, gaskets, etc.) would not become excessively brittle at -40°C. Temperatures of +70°C would not result in any significant decrease in integrity either, as shown in property of materials tables. The shipper must ensure that, if the contents freeze, no rupture of the container will occur. In addition, the shipper must evaluate the potential for pressure buildup at elevated temperatures.
(e) It is able to withstand the effects of any acceleration, vibration resonance that may arise during normal transportation, without any deterioration of the effectiveness of closing devices or of the intetgrity of the package as a whole and without loosening or unintentional release of nuts, bolts, or other securing devices even after repeated use;	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY LIQUIDS AND GASES
(f) It includes a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by pressure that may arise within the package during normal transport. Special form, as demonstrated in accordance with 173.469, may be considered as a component of the containment system;	"Screw-type" closures can qualify. "Friction fit" normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated meet this requirement, as shown on the sketches or in the packaging descriptions.
(g) The materials of the packaging and any components or structures are physically and chemically compatible with each other and with the contents, taking into account the behavior of each under irradiation;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(h) For each component of the containment system, account is taken where applicable of radiolytic decomposition of materials and the generation of gas by chemical reaction and radiolysis;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) The containment system will retain its radioactive contents under the reduction of ambient pressure to 0.25 kilograms per square centimeter (3.5 lb/ $in.^2$);	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioative contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. Caution should be exercised to	This analysis requires a more detailed discussion to provide adequate informatiohn. See Table C-5.

TABLE C-5

Packaging/ Principal User	Model/Size	Containment System	Test/Analysis	Results
LOVELACE	MS-24347-7	Glass bottle with screw cap	Two of these glass bottles with caps screwed on by hand were inverted in a beaker of water, and a vacuum was drawn (3.6 psi). After 5 min there was no evidence of leakage (bubbles in the water). Also, the metal drum itself passed the reduced pressure test, so the tests on the bottles would not have been required.	Pass
LASL	Fiberboard box with inner lead container	Inner lead container with screw-top cap and O-ring seal	The inner lead container was inverted in a beaker of water, and a vacuum was drawn (3.6 psi). After 5 min, there was no evidence of leakage (bubbles in the water).	Pass
LLNL	3A-1800 3E-1800	Steel drum- Gas cylinders	Each of the cylinders was pressurized before being sent to Mound. The pressure was measured in each one upon receipt and averaged approximately 92 psig per cylinder. These data and the fact that the service pressure is 1800 psig demonstrated compliance with the 11.2 psi requirements.	Pass

TABLE C-5 (continued)

Packaging/ Principal User	Model/Size	Containment System	Test/Analysis	Results
ORNL	Fiberboard box for liquids and solids	Glass bottles with plastic screw-top caps: 15 mL - 6 tested 25 mL - 6 tested 50 mL - 5 tested 100 mL - 4 tested	Four to six bottles of each size were inverted in a glass beaker of water in a bell jar. The pressure was reduced (vacuum drawn) to 3.6 psig and held for 5 min. There was no leakage (bubbles in the water) in any case.	Pass
	Fiberboard box for gases	Glass ampules: 2 cc - 4 tested 5 cc - 4 tested 10 cc - 4 tested 20 cc - 4 tested	Four ampules of each size were immersed in water in a glass beaker in a bell jar. The pressure was reduced (vacuum drawn) to 3.6 psig and held for 5 min. There was no leakage (bubbles in the water) in any case.	Pass
	Fiberboard box for liquids and solids with shielding	Glass bottles with plastic screw-top caps: See above	Four to six bottles of each size were inverted in a glass beaker of water in a bell jar. The pressure was reduced (vacuum drawn) to 3.6 psig and held for 5 min. There was no leakage (bubbles in the water) in any case.	Pass
ORNL	Aluminum clad wood box (returnable)	Glass bottles with plastic screw-top caps: See above	Four to six bottles of each size were inverted in a glass beaker of water in a bell jar. The pressure was reduced (vacuum drawn) to 3.6 psig and held for 5 min. There was no leakage (bubbles in the water) in any case.	Pass

TABLE C-5 (continued)

Packaging/ Principal User	Model/Size	Containment System	Test/Analysis	Results
ORNL	Gas cylinders in returnable plastic boxes	Gas cylinders as listed on pages F-31, 32, and 36	Each of these cylinders is designed for and tested at pressures well above 11.2 psi.	Pass

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY LIQUIDS AND GASES
	ensure that the contents and internal packaging components (i.e., plastic boxes, etc.) will not effectively seal the filter during normal use. In cases where a pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	
(j) Each valve through which the radioactive contents could otherwise escape is protected against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;	Designer to do and shipper responsibility to ensure.	Two packagings in this category have valves as described below: (1) LLNL Gas Cylinders These cylinders are packaged in a 17H 30-gal steel drum, which provides the physical protection and protects against unauthorized operation. The 17H 30-gal drum also provides an enclosure to retain any leakage. More positively, each valve outlet is capped to retain any leakage. (2) ORNL Gas Cylinders Each cylinder has a threaded protective cap and is sealed against unauthorized operation. The threaded caps also retain any leakage.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY LIQUIDS AND GASES
(k) Any radiation shield that encloses a component of the packaging specified as part of the containment system will prevent the unintentional escape of that component from the shield;	The shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in place. The shipper must make sure that under the tests prescribed in 173.465 there will be no rearrangement of the original containment/shield orientation. Designer, tester, evaluator to do and shipper responsibility to ensure.	The packagings meeting this critrion are discussed below.

Only a few packages have a design fitting this criterion. These are:

Packaging	Containment System	Analysis	Results
LASL fiberboard box with inner lead shielded containers	Inner lead container (2-in. o.d.) with screw-cap and O-ring seal.	As shown in the sketch on p. F-6, the inner container is held in place by a lid with three bolts. Thus, the outer shield is securely closed. There was no rearrangement during the tests specified in 173.465.	Pass
ORNL fiberboard boxes with shielded inner containers	Glass ampule or bottle with screw cap and a sealed metal can.	As shown on pp. F-20 and 21, the packaging components are firmly held in place by the sealed metal can.	Pass
ORNL aluminum clad wood box	Glass bottle and the 2R containers.	As shown on p. F-26, the 2R container is held in place by the bolt closure lid of the stainless steel-clad lead carrier.	Pass

Packaging	Containment System	Analysis	Results
ORNL gas cylinder	The cylinder itself.	As shown on pp. F-31, 32, and 36, the lead shielding, when used, fills the void between the inner and outer wall and prevents escape.	Pass

(1) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart.	Designer, tester, evaluator to do and shipper responsibility to ensure.	None of these packagings have tie-down attachments as described.

173.412 - ADDITIONAL DESIGN REQUIREMENTS FOR TYPE A PACKAGES

In addition to meeting the general design requirements prescribed in 173.411, each Type A packaging shall be designed so that:

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY MISCELLANEOUS
(a) The smallest overall external dimension of the package is not less than 10 centimeters (4 in.);	Designer to do and shipper responsibility to ensure.	As shown on the sketches and as given in the packaging description in MIL-3245, all packagings meet this requirement.
(b) The outside of the packaging incorporates a feature, such as a seal, that is not readily breakable, and that, while intact, is evidence that the package has not been opened. In the case of packages shipped in exclusive use closed transport vehicles, the cargo compartment may be sealed instead of the individual packages;	For this requirement, the package designer may need to be skilled and creative. This is especially true for packages such as fiberboard cartons and wooden boxes. A padlock is not effective as a security seal. It is not possible with most types of padlocks to ascertain if they have been illicitly opened. One acceptable approach toward meeting this requirement is serially numbered lead-wire seals, or, in the case of fiberboard packages, a tape of sufficient adhesive strength to damage the fiberboard upon removal. Designer to do and shipper responsibility to ensure.	There are acceptable approaches to compliance for all evaluated packagings. It is the shipper's responsibility to ensure compliance with this requirement.
(c) As far as practicable, the external surfaces are free from protrusions and are designed so that they can be easily decontaminated;	The intent is to minimize the number and nature of protrusions by consideration during design and/or as a result of any modifications to the packaging. Designer to do and shipper responsibility to ensure.	All evaluated packagings meet this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY MISCELLANEOUS
(d) Containment and shielding would be maintained during transportation and storage in a temperature range of -40°C (-40°F) to +70°C (+158°F) with account taken of the possibilities of brittle fracture;	This does not mean any of the tests must necessarily be performed at the temperature extremes. [Note: 173.461(b).] The regulations allow the assumption that the packaging is in equilibrium at 38°C prior to testing. One must evaluate the packaging components with respect to behavior at the temperature extremes under conditions incidental to transportation (i.e., the jiggles, bounces, and bumps normally encountered in transportation). Gaskets and packaging components need to be evaluated to determine if they will become excessively brittle at -40°F. This may be accomplished by actual testing, referring to property of material tables, obtaining data from manufacturers, etc. The shipper must consider such things as freezing of liquid contents and evaluate the effect to ensure continued containment integrity. The shipper must also consider the buildup of pressure at elevated temperatures and ensure continued containment. Designer, tester, and evaluator to do and shipper responsibility to ensure.	The materials (wood, caulking, metal straps, nails, gaskets, etc.) would not become excessively brittle at -40°C. Temperatures at +70°C would not result in any significant decrease in containment integrity, as shown in property of material tables.
(e) It is able to withstand the effects of any acceleration, vibration, or vibration resonance that may arise during normal transportation, without any deterioration of the effectiveness of closing devices or of the integrity of the package as a whole and without loosening or unintentional release of nuts, bolts, or other securing devices even after repeated use;	Typically, one uses actual experience as a guide. If experience is not available, one normally uses a comparison to a similar packaging with an experience profile. If this isn't possible, vibration testing can be performed. The purpose of this section is to prevent the loosening of nuts, bolts, and containment devices under conditions incident to routine transportation. Designer, tester, and evaluator to do and shipper responsibility to ensure.	Experience has consistently demonstrated that these packagings or similar designs comply with this requirement. The shipper must ensure the application of quality assurance necessary to achieve this requirement.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY MISCELLANEOUS
(f) It includes a containment system securely closed by a positive fastening device that cannot be opened unintentionally or by pressure that may arise within the package during normal transport. Special form, as demonstrated in accordance with 173.469, may be considered as a component of the containment system;	"Screw-type" closures can qualify. "Friction fit" normally does not qualify. Security clips on cans could be acceptable. However, one cannot depend on friction alone. Designer, tester, and evaluator to do and shipper responsibility to ensure.	All packagings evaluated meet this requirement, as shown on the sketches or in the packaging descriptions.
(g) The materials of the packaging and any components or structures are physically and chemically compatible with each other and with the contents, taking into account the behavior of each under irradiation;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(h) For each component of the containment system, account is taken where applicable of radiolytic decomposition of materials and the generation of gas by chemical reaction and radiolysis;	Designer to do and shipper responsibility to ensure.	Shipper responsibility to ensure.
(i) The containment system will retain its radioactive contents under the reduction of ambient pressure to 0.25 kilograms per square centimeter (3.5 lb/ $in.^2$);	The containment system is defined as the components intended to retain the radioactive contents during transportation. Thus, one starts by identifying the containment system. The radioative contents must be completely retained in the containment system if the package is subjected to reduced pressure. A filtered packaging is possible as long as it can be demonstrated that the	See Table C-6.

TABLE C-6
REDUCED PRESSURE TESTS

Packaging/ Principal User	Model/Size	Containment System	Test/Analysis	Results
LLNL	Spec 55	There is only one packaging component, so this obviously is the containment system.	The cavity of this packaging was filled with a water-fluorescein solution. The package was inverted in a bell jar and subjected to a reduced pressure of 3.6 psi for 5 min. Upon completion of the test there was visible no loss of contents, and no loss was found with a black light.	Pass
ORNL	ORNL-TRU	Since the contents are restricted to Special Form [49CFR 173.403(z)], this provides the containment system.	This test has little meaning since there is no loose contamination available for dispersion or transfer. This test was not conducted, but obviously would meet the criterion, if tested, of "No Loss of Contents."	Pass
FEMA	FEMA Source Overpack	Since the contents are restricted to Special Form [49CFR 173.403(z)], this provides the containment system.	This test has little meaning since there is no loose contamination available for dispersion or transfer. This test was not conducted, but obviously would meet the criterion, if tested, of "No Loss of Contents."	Pass
LLNL	SNL Tritium Waste Package	Modified DOT 5C-304 15-gal stainless steel drum.	The inner container was subjected to a hydrostatic pressure of 80 psi for 5 min with no leakage.	Pass

	GUIDANCE FOR APPLICATION	
	filtered package will retain the contents and that the filter is not susceptible to damage from any other tests. **Caution should be** exercised to ensure that the contents and internal packaging components (i.e., plastic boxes, etc.) will not effectively seal the filter during normal use. **In cases where a** pressure differential will not build up because of the free-flow through a filter, the requirement of demonstrating the retention of contents must still be met. For a package that breathes (does not hold 11.2 psi), such as a **wooden box, one must demonstrate that, even with breathing, the contents will be retained. Otherwise, a separate inner containment capable of meeting the reduced pressure requirement is** required. Designer, tester, and evaluator to do and shipper responsibility to ensure.	
(j) Each valve through which the radioactive contents could otherwise escape is protected against damage and unauthorized operation and, except for a pressure relief device, has an enclosure to retain any leakage;	Designer to do and shipper responsibility to ensure.	The only packaging meeting this criterion is the SNL Tritium Waste Package. The 17H 30-gal drum provides the physical protection against unauthorized operation. The asphalt which surrounds the entire inner packaging and the 17H steel drum will retain any contents.

	GUIDANCE FOR APPLICATION	PACKAGING CATEGORY MISCELLANEOUS
(k) Any radiation shield that encloses a component of the packaging specified as part of the containment system will prevent the unintentional escape of that component from the shield;	The shield shall be securely closed or, by way of packaging design, ensure against escape of a containment component. One example is a package with cellotex on top of a lead shield with a press-fit lid in which closure of the cellotex holds the lid in place. The shipper must make sure that under the tests prescribed in 173.465 there will be no rearrangement of the original containment/shield orientation. Designer, tester, evaluator to do and shipper responsibility to ensure.	The only packaging meeting this criterion is the LLNL (Spec. 55) container. The packaging/shield is one piece, so it is obviously the containment system also. Since the containment system and the radiation shield are all the same, they cannot escape/ separate.
(l) Failure of any tie-down attachment on the packaging under excessive load will not impair the ability of the package to meet other requirements of this subpart.	Designer, tester, evaluator to do and shipper responsibility to ensure.	None of these packagings have tie-down attachments as described.

SUMMARY OF TYPE A PACKAGING TESTS
(49 CFR 173.465)

The purpose of this section is to provide more details concerning the Type A packaging tests that were conducted or against which the packages were analyzed for compliance. The tests involved are:

1. Water Spray
2. Free Drop
3. Compression
4. Penetration

These tests, test methods, and determination of pass/fail criteria are discussed at length in the MIM-3245 Introduction.

173.465 (a) The proposed packaging with proposed contents must be capable of withstanding the tests prescribed in this section. One prototype may be used for all tests if the requirements of Paragraph (b) of this section are complied with.

(b) Water Spray Test.

The water spray test must precede each test or test sequence prescribed in this section. The water spray test shall simulate exposure to rainfall of approximately 5 centimeters (2 in.) per hour for at least one hour. The time interval between the end of the water spray test and the beginning of the next test shall be such that the water has soaked in to the maximum extent without appreciable drying of the exterior of the specimen. In the absence of evidence to the contrary, this interval may be assumed to be two hours if the water spray is applied from four different directions simultaneously. However, no time interval may elapse if the water spray is applied from each of the four directions consecutively.

Major Points.

(1) Must precede each test
(2) 2 in./hr
(3) 1-hr duration

Comments:

This is usually a conditioning of a package, rather than a test as such. One would not expect a loss of contents or significant increase in dose rate resulting from just the water spray test. However, consideration must be given to the possibility of water leakage into the package with subsequent transport of radioactive contents out as leakage.

Designer, tester, evaluator to do and shipper responsibility to ensure.

WATER SPRAY TEST

PACKAGING CATEGORY: STEEL DRUMS

In evaluating steel drums against this requirement, one would consider such things as:

(1) The effect the water spray would have on the ability of the steel drums to meet the other Spec 7A performance requirements;

(2) The potential for inleakage of water with the subsequent potential for transport of the radioactive contents out of the packagings;

(3) Because these same packagings are air-leak tight, one would also expect them to prevent the inleakage of water under such passive conditions as a water spray (rain).

As shown in Table D-1, nine different types of steel drums (a total of 26 different packagings) were subjected to this test. In all cases, as one would expect based on materials and methods of construction, closure mechanisms, gaskets, and the painted surfaces, the water spray had no effect that could possibly be interpreted as decreasing the ability of the steel drums to meet all Spec 7A performance criteria. This is not surprising since there are years of experience demonstrating that lengthy exposures to rain have not had a negative effect on containment integrity. In addition, in each of the 26 individual tests, a careful inspection demonstrated there was no inleakage of water as a result of these tests. Because these same packagings are air-leak tight, one would also expect them to prevent the inleakage of water under such passive conditions as a water spray (rain).

As a final point of mainly academic discussion, since the steel drums are air-leak tight to begin with, in the unlikely event of an inleakage of water, it would be equally unlikely that this expected minute quantity of water would leak out. Thus, based on the test data below and after comparison of the similarity in materials and methods of construction of the untested steel drums, one can readily conclude that these steel drums meet this requirement.

WATER SPRAY TEST RESULTS FOR STEEL DRUMS

TABLE D-1

Specific Packaging	Test/Analysis Results
Spec 6C 5-gal	By comparison, this drum would meet this requirement.
Spec 6C 10-gal	By comparison, this drum would meet this requirement.
Spec 17C 5-gal	By comparison, this drum would meet this requirement.
Spec 17C 30-gal	By comparison, this drum would meet this requirement.
Spec 17C 55-gal	Three drums were subjected to this test and passed.
Spec 17C 55-gal with pressure relief device	Three lids with the "Nuc-Fil" filters were subjected to the water spray test and no water passed through the filter.
Spec 17C 55-gal w/HDPE liner	The same data shown for the 17C 55-gal drum would apply here.
Spec 17H 30-gal	Three drums were subjected to this test and passed.
Spec 17H 55-gal	Three drums were subjected to this test and passed.
MS-24347-1	By comparison, this drum would meet this requirement.
MS-24347-7	Two drums were subjected to this test and passed.
MS-27684-1	By comparison, this drum would meet this requirement.
MS-27684-2	By comparison, this drum would meet this requirement.
MS-27684-3	Three drums were subjected to this test and passed.
MS-27684-6	By comparison, this drum would meet this requirement.
MS-27684-8	Three drums were subjected to this test and passed.
MS-27683-7	Three drums were subjected to this test and passed.
MS-27683-13	By comparison, this drum would meet this requirement.
MS-24683-21	Three drums were subjected to this test and passed.

WATER SPRAY TEST

PACKAGING CATEGORY: STEEL BOXES

In evaluating steel boxes against this requirement, one would consider such things as:

(1) The effect the water spray would have on the ability of the steel boxes to meet the other Spec 7A performance requirements;

(2) The potential for inleakage of water with the subsequent potential for transport of the radioactive contents out of the packagings;

(3) Because these same packagings are air-leak tight, one would also expect them to prevent the inleakage of water under such passive conditions as a water spray (rain).

In all cases but one (the ANL-West 7A 960 steel box), as one would expect based on materials and methods of construction, closure mechanisms, gaskets, and painted surfaces, the water spray would have no effect that could be interpreted as decreasing the ability of the steel boxes to meet all Spec 7A performance criteria. This is not surprising since there are years of experience demonstrating that lengthy exposures to rain have not had a negative effect on containment integrity. Because these same packagings are air-leak tight, one would also expect them to prevent the inleakage of water under such passive conditions as a water spray (rain).

As a final point of mainly academic discussion, since the steel boxes are air-leak tight to begin with, in the unlikely event of an inleakage of water, it would be equally unlikely that this expected minute quantity of water would leak out. Thus, based on the information below and after comparison of the similarity in materials and methods of construction of the steel boxes, one can readily conclude that all the steel boxes meet this requirement (with the exception of the ANL-West 7A-960 discussed in Table D-2).

WATER SPRAY TEST RESULTS FOR STEEL BOXES

TABLE D-2

Specific Packaging	Test/Analysis Results
All - Capital Industries - Container Products Corp. - RoGar Chemical and Nuclear Services - Rocky Flat SAND Boxes - Argonne M-4 Steel Bin	All these boxes pass by analysis of materials, methods of construction, years of experience (exposure to a variety of weather conditions, including heavy rains), and air-leak or water-leak tests which have demonstrated the boxes to be leak tight. The tests referenced are the reduced pressure tests, Page C-14, of this document. The filters (for filtered boxes) have been tested and demonstrated to be water-leak resistant also.
ANL-West 7A-960	Since this package does not have a gasket, one has to assume there could be an inleakage of water, however slight. To protect against this possible exposure to water, the contents must be enclosed in plastic or equally water resistant materials, or the shipper must ensure that, if the contents were exposed to such water, there would be no transfer of radioactive materials to the liquid. See Restriction/ Specification section on Page B-28. A preferred method (since the introduction of any water into a radioactive material shipping container is highly undesirable) is to use a gasket. Thus, all of the steel boxes except the ANL-West 7A-960 meet this requirement without any restrictions or specifications, and the ANL-West 7A-960 meets this requirement when used as prescribed on Page B-28.

WATER SPRAY TEST

PACKAGING CATEGORY: WOODEN BOXES

In evaluating wooden boxes against this requirement, one would consider such things as:

(1) The effect the water spray would have on the ability of the wooden boxes to meet the other Spec 7A performance requirements;

(2) The potential for inleakage of water with the subsequent potential for transport of radioactive contents out of the packagings.

As shown in Table D-3, 14 different types of wooden boxes (a total of 24 different packagings) were subjected to this test. In all cases, as one would expect based on materials and methods of construction, closure mechanisms, and caulking/glue, the water spray had no effect that could be interpreted as decreasing the ability of the wooden boxes to meet the remaining Spec 7A performance criteria. This is not surprising since there are years of experience demonstrating that exposure to rain has not had a significant effect on containment integrity.

With respect to Item 2 above, the potential for inleakage of water, some boxes constructed of normal exterior grade plywood did allow small amounts of water to penetrate. For test purposes, the insides of the test boxes were lined with paper, and the box was subjected to the water spray test for 1 hr and allowed to sit for 2 hr. At the end of this period, the paper was inspected for spots which would indicate the presence of water.

WATER SPRAY TEST RESULTS FOR ANL AND LLNL WOODEN BOXES

TABLE D-3

Specific Packaging	Test/Analysis Results
ANL-West Family of Boxes	By comparison these boxes would meet this requirement.
LLNL Flush Panel Box	By comparison these boxes would meet this requirement.

WATER SPRAY TEST RESULTS FOR MOUND WOODEN BOXES

TABLE D-4

Configuration (Dimensions in Inches)	1st Test As Built	2nd Test RTV Used to Seal Seams on Inside	3rd Test Water Sealant Applied to Boxes[a]
Mound Configuration A 8 x 8 x 36	Pass - No indication of water	Fail[b]	Pass
Mound Configuration B 12 x 12 x 36	Pass - No indication of water	Pass	Pass
Mound Configuration C 12 x 12 x 36	Fail - Water absorbed on paper	Fail	Pass
Mound Configuration D 12 x 15 1/2 x 48	Fail - Water absorbed on paper	Fail	Pass
Mound Configuration E 21 x 21 x 22 1/2	Fail - Water absorbed on paper	Fail	Pass

[a]GEOCEL - Brushable Sealant - 1 coat

[b]Water detected on paper.

WATER SPRAY TEST RESULTS FOR WOODEN BOXES

TABLE D-5

Specific Packaging	Test/Analysis Results
NLO Family of Boxes	By comparison these boxes would meet this requirement.
Y-12 B Series	
B-1 through B-8	Each of these packagings was subjected to the water spray for 1 hr, allowed to sit for 2 hr, and then subjected to the drop test. There was no evidence of a decrease in containment integrity as a result of this test. Considering the materials and methods of construction, all of the other wooden boxes would also meet this requirement.
Y-12 Picture Frame Boxes	
PF-1 through PF-8	By comparison these boxes would meet this requirement.
Rocky Flats - RA Series of Boxes	By comparison these boxes would meet this requirement.

As shown in Table D-4, small amounts of water did appear at times on the paper, indicating an inleakage of water. The majority of the inleakage occurred at the corners and at some points in the seams; however, a few spots occurred that indicated inleakage through the walls themselves. Three possible approaches are described that are acceptable with respect to addressing this inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

(1) Securely enclose the radioactive contents within the box so that any inleaking water cannot come in contact with the radioactive material.

(2) Seal the box using GEOCEL or its equivalent. If the box is reused, it must be recoated with at least one coat to cover the seal areas before each shipment.

(3) Assure that there is no loose or removable contamination which could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: These three approaches are presented in the Restrictions/Specifications section for each of the evaluated packagings in MLM-3245. There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. The use of one of these alternatives or an equivalent allows these wooden boxes to meet this requirement.

WATER SPRAY TEST RESULTS FOR FIBERBOARD CONTAINERS

TABLE D-6

Specific Packaging	Test/Analysis Results
Fiberboard Boxes 12B-65 (p. D-2)[a]	Each of these packagings was subjected to this test prior to each of the three tests: free drop, compression, and penetration. As a result of the water spray, the addition of triple-wall support was required in many of the containers so that these packagings could withstand the compression test.
Fiberboard Box LLNL (p. D-6)	This test also demonstrated the need for water-resistant tape as required in the Restrictions/Specifications section. As one would expect, the boxes were softened considerably; however, this didn't seem to make make much difference in the drop or penetration tests.
Fiberboard Box Tri-Wall (p. D-11)	
Fiberboard Drums	Since one has to assume an inleakage of water, each shipper must address this potential inleakage of water and ensure there is no transport of radioactive materials out of the packaging by the following methods or their equivalent.

[a]Page numbers refer to MLM-3245.

Two possible approaches are described that are acceptable with respect to addressing this potential inleakage and ensuring that there is no transport of radioactive materials out of the packaging.

(1) Securely enclose the radioactive contents within the box so that any inleaking water cannot come in contact with the radioactive material.

(2) Ensure that there is no loose or removable contamination which could be entrained in any liquid and that the radioactive material is not soluble in the liquid. Thus, even if the liquids come in contact with the radioactive material, there could be no transport from the package.

NOTE: These two approaches are presented in the Restrictions/Specifications section for each of the evaluated packagings. There are obviously other possible approaches; however, if an alternative approach is chosen, the basis for the choice must be supported and documented. The use of one of these alternatives or an equivalent method allows these fiberboard packagings to meet this requirement.

WATER SPRAY TEST RESULTS FOR UF-6 CYLINDERS

TABLE D-7

Specific Packaging	Test/Analysis Results
Models 1S, 2S, 5A, 8A, 12A, 12B, 30A, 30B, 48G, 48H, 48HX, 48X, 48Y	The factors to be considered in evaluating compliance as mentioned previously were: (1) The effect the water spray would have on the ability of the UF-6 cylinders to meet the other Spec 7A performance requirements; (2) The potential for inleakage of water with the subsequent potential for transport of the radioactive contents out of the packagings. The materials and method of construction make it obvious that a water spray (rain) would not have any significant effect on the structural integrity. This is well-substantiated by years of shipping thousands of these packagings through a wide variety of weather conditions. With respect to the second aspect, inleakage of water, since these cylinders have welded seams and threaded valves which are gas-leak tight, the inleakage of water is not credible. Thus, these packagings meet this requirement.

WATER SPRAY TEST RESULTS FOR LIQUIDS AND GASES

TABLE D-8

Specific Packaging	Test/Analysis Results
Steel Drum MS 24347-7 (p. F-1)[a]	This test was not conducted on this packaging since the outer packaging component is a steel drum, and compliance is demonstrated as described on Page D-3.
LASL-12B-62 Fiberboard Box (p. F-6)	The test was conducted prior to each of the three tests: 30-ft drop, compression, and penetration. Since the packaging successfully passed these three tests, this demonstrates the lack of significant effect with respect to structural aspects. Also, since the 2-in. inner container is air-leak tight, there is no potential for inleakage of water. Thus, this packaging meets this requirement.
LLNL Steel Drums with Gas Cylinders	The compliance of the outer packaging, Spec 17H 30-gal steel drum, has already been demonstrated as described on Page D-3.
ORNL	
Liquids and Solids (p. F-15)	The water spray was performed prior to each test, and the packaging successfully met all requirements. Since there is a sealed metal inner container, there is no potential for further inleakage of water.
Disposable Container with Shielding (pp. F-20 and 21) - Liquids, Solids, or Gases	The water spray was performed prior to each test, and the packaging successfully met all requirements. Since there is a sealed metal inner container, there is no potential for further inleakage of water.

[a]Page numbers refer to MLM-3245.

TABLE D-8 (continued)

Specific Packaging	Test/Analysis Results
Wooden Box Returnable, Shielded (p. F-26)	The water spray was performed prior to each test, and the packaging successfully met all requirements. The sealed inner metal containers preclude any potential for futher inleakage.
Gas Cylinder Returnable - Hoke (p. F-30)	The water spray was performed prior to each test, and the packaging successfully met all requirements. The plastic box used as an overpack typically precludes any significant effect due to the water spray. Then, considering that the inner cylinders are gas-leak tight, there is no potential for further inleakage of water.
Gas Cylinder Returnable J. L. Shephard (p. F-36)	Considering the materials and method of construction and the fact that these cylinders are gas-leak tight, there is no potential for inleakage of water.

WATER SPRAY TEST RESULTS FOR MISCELLANEOUS PACKAGINGS

TABLE D-9

Specific Packaging	Test/Analysis Results
LLNL Spec 55 (p. G-1)	This test was not conducted since, considering the materials and methods of of construction, it is obvious that this test would not adversely affect the ability of the package to meet the additional Spec 7A requirements. In addition, since the package was demonstrated to be water-leak tight even after the 4-ft drop, there is no potential for inleakage of water.
ORNL TRU Shipping Container	This test was not conducted since, considering the materials and methods of of construction, it is obvious that this test would not adversely affect the ability of the package to meet the additional Spec 7A requirements. In addition, since the inner (source) containment has to meet the Special Form [173.412(z)] criteria, the inleakage of water would not result in a potential transport of radioactive material from the package.
FEMA Source Overpack	This test was not conducted since, considering the materials and methods of of construction, it is obvious that this test would not adversely affect the ability of the package to meet the additional Spec 7A requirements. In addition, since the inner (source) containment has to meet the Special Form [173.412(z)] criteria, the inleakage of water would not result in a potential transport of radioactive material from the package.
SNL Tritium Waste Package	The compliance of the outer packaging, Spec 17H 30-gal steel drums, has already been demonstrated and discussed on Page D-3.

FREE DROP TEST

(c) Free Drop Test.

The free-drop test consists of a fall onto the target in a manner that causes maximum damage to the safety features being tested; and

(1) For packages weighing 5,000 kilograms (11,000 lb) or less, the distance of the fall measured from the lowest point of the packaging to the upper surface of the target shall not be less than 1.2 meters (4 ft).

(2) For packages weighing more than 5,000 kilograms (11,000 lb), the distance of the fall shall not be less than the distance specified in Table II, for the applicable packaging weight.

Major Points.

(1) 4-ft drop
(2) Manner to cause maximum damage

Comments

(1) The orientation causing maximum damage may not be readily apparent. Typically, the following guidelines should be considered:

(a) Drums - side drop with bolt closure ring (BCR) at impact point;

- angle drop (approx. 45^{o} on BCR and on bottom at intersection of chime and side seam);

(b) Boxes - Top (lid) corner near features, such as lifting rings and filters, if any exist;

(c) Approximate center of gravity over impact point.

(2) A quick release device is required to ensure no change in package orientation.

Straightforward

Comments

TABLE II - FREE FALL DISTANCE FOR PACKAGING WEIGHING MORE THAN 5,000 KG

Packaging Weight (kg)	Packaging Weight (lb)	Free-Fall Distance (ft)	Free-Fall Distance (m)
> 5,000-10,000	>11,000-22,000	3	0.9
>10,000-15,000	>22,000-33,000	2	0.6
>15,000	>33,000	1	0.3

Designer, tester, and evaluator to do and shipper responsibility to ensure.

(3) For Fissile Class II packagings, the free drop specified in subparagraph (1) or (2) of this paragraph shall be preceded by a free drop from a height of 0.3 meter (1 ft) on each corner. For cylindrical packagings, the 0.3-meter (1-ft) drop shall be onto each of the quarters of each rim.

For packagings to be used for Fissile Class II shipments, further testing and evaluation per Paragraph 3 are required.

(4) For fiberboard or wood rectangular packages not exceeding 50 kilograms (110 lb) in weight, a separate specimen of the proposed packaging shall be subjected to a free drop onto each corner from a height of 0.3 meters (1 ft).

Designer, tester, evaluator to do and shipper responsibility to ensure.

(5) For fiberboard cylindrical packages weighing not more than 100 kilograms (220 lb), a separate specimen of the proposed packaging shall be subjected to a free drop onto each of the quarters of each rim from a height of 0.3 meters (1 ft).

Designer, tester, evaluator to do and shipper responsibility to ensure.

(6) The target shall have a flat, horizontal surface of such mass and rigidity that any increase in its resistance to displacement or deformation upon impact by the specimen would not significantly increase the damage of the specimen.

As a rule of thumb: An essentially nonyielding surface is one at least five times the mass of the impacting object.

Tester, evaluator to do and shipper responsibility to ensure.

FOUR-FT FREE DROP TEST RESULTS FOR STEEL DRUMS

TABLE D-10

Specific Packaging	Weight[a] (lb)	Contents	RIV/ Liner	45° Top[b] No. Tested	45° Top[b] Results	45° Bottom[c] No. Tested	45° Bottom[c] Results	Side[d,e] No. Tested	Side[d,e] Results
Spec 6C (5-gal)	80	F/F/S/Pb[f]	RIV	2	2 Pass	2	2 Pass	1	1 Pass
Spec 6C (10-gal)	160	F/F/S/Pb	RIV	2	2 Pass	2	2 Pass	1	1 Pass
Spec 17C (5-gal)	100	F/F/S/Pb	RIV	1	1 Pass	1	1 Pass	1	1 Pass
Spec 17C (30-gal)	400	(Form 1)	Tests were not done on the 17C (30-gal). This evaluation is based on testing of the 17H (30-gal) drum, which has structural integrity equal to the 17C drum.						
	500	(Form 2)	None						
Spec 17C (55-gal)	900	(Form 1) F/F/S/Pb	Liner[g]	5	5 Pass	5	5 Pass	7	7 Pass
	1,000	(Form 2) S/Pb	None	5	5 Pass	5	5 Pass	6	6 Pass

[a]This is the authorized gross weight. In each case, the actual test weights exceeded this value.

[b]Approximately a 45° angle with the package impacting on the bolt of the bolt closure ring.

[c]Approximately a 45° angle with the package impacting on the bottom chime.

[d]Oriented so that the bolt is at the point of impact.

[e]4-ft drops flat on the top and flat on the bottom were conducted on the 17H and 17C 55-gal steel drums, but were not deemed necessary for other drums because of the almost total lack of effect.

[f]Flour, fluorescein, sand, and lead, as required to achieve desired weight.

[g]4-mil polyethylene bag, not the 90-mil HDPE liner discussed later.

TABLE D-10 (continued)

Specific Packaging	Weight (lb)	Contents	RTV/ Liner	45° Top No. Tested	45° Top Results	45° Bottom No. Tested	45° Bottom Results	Side No. Tested	Side Results
Flat on Top and Bottom									
Spec 17C (55-gal)	900	F/F/S/Pb		3	3 Pass	3	3 Pass		
Spec 17C (55-gal) with Pressure Relief Device - Vent Clip	900	F/F/S/Pb	Liner	4	4 Pass	2	2 Pass	2	2 Pass
	1000	S	None	-	-	-	-	1	1 Pass
Spec 17C (55-gal) with Pressure Relief Device - Filter	900	F/F/S/Pb	None	3	3 Pass	-	-	3	3 Pass
Flat on Top									
Spec 17C (55-gal) - Filter Installed	900	F/F/S/Pb	None	3	3 Pass	-	-	-	-
Spec 17C (55-gal) with 90-mil HDPE Liners	900	F/F/S/Pb	HDPE Liner	5	5 Pass	5	5 Pass	5	5 Pass
	900	F/F/S/Pb	HDPE Liner	5	5 Pass	5	5 Pass	5	5 Pass
	900	F/F/S/Pb	HDPE Liner	2	2 Pass	2	2 Pass	3	3 Pass
Spec 17H (30-gal)	400	F/F/S/Pb	RTV	2	2 Pass	1	1 Pass	2	2 Pass
	400	F/F/S/Pb	4-mil	2	2 Pass	2	2 Pass	2	2 Pass
	400	F/F/S/Pb	None	1	1 Pass	1	1 Pass	1	1 Pass
	500	S/Pb	None	2	2 Pass	2	2 Pass	2	2 Pass

TABLE D-10 (continued)

Specific Packaging	Weight (lb)	Contents	RTV/ Liner	45° Top No. Tested	45° Top Results	45° Bottom No. Tested	45° Bottom Results	Side No. Tested	Side Results
Spec 17H (55-gal)	1,000	S/Pb	None	8	8 Pass	8	8 Pass	4	4 Pass
			Flat on Top and Bottom						
Spec 17H (55-gal)	1,000	S/Pb	None	5	5 Pass	5	5 Pass	-	-
Spec 17H (55-gal)	900	F/F/S/Pb	4-mil	5	5 Pass	5	5 Pass	-	-
	900	F/F/S/Pb	None	6	6 Fail	-	-	7	2 Pass (5 Fail)
	900	F/F/S/Pb	4-mil	8	8 Pass	2	2 Pass	11	11 Pass
	900	F/F/S/Pb	RTV	5	5 Pass	5	5 Pass	5	5 Pass
MS-24347-1 (0.25-gal)	10	F/F/S/Pb	None	2	2 Fail	-	-	3	2 Pass (1 Fail)
	10	F/F/S/Pb	4-mil	2	2 Pass	-	-	2	2 Pass
MS-24347-7 (1.25-gal)	35	F/F/S/Pb	None	1	1 Fail	-	-	1	1 Fail
		F/F/S/Pb	4-mil	3	3 Pass	-	-	3	3 Pass
MS-27684-1 (3.0-gal)	60	F/F/S/Pb	4-mil	3	3 Pass	-	-	1	1 Pass
		S/Pb	None	-	-	-	-	1	1 Pass
MS-27684-2 (4.0-gal)	110	F/F/S/Pb	None	4	4 Pass	4	4 Pass	4	4 Pass

TABLE D-10 (continued)

Specific Packaging	Weight (lb)	Contents	RTV/ Liner	45° Top No. Tested	45° Top Results	45° Bottom No. Tested	45° Bottom Results	Side No. Tested	Side Results
Flat on Top and Bottom									
MS-27684-2 (4.0-gal)		F/F/S/Pb	None	4	4 Pass	4	4 Pass	-	-
MS-27684-3 (6.0-gal)	80	F/F/S/Pb	4-mil	3	3 Pass	*	-	1	1 Pass
		S/Pb	None	-	-	*	-	1	1 Pass
MS-27684-6 (8.0-gal)	80	F/F/S/Pb	None	3	3 Pass	*	-	2	2 Pass
MS-27684-8 (12.0-gal)	200	F/F/S/Pb	4-mil	2	2 Pass	*	-	1	1 Pass
	200	S/Pb	None	1	1 Pass	*	-	1	1 Pass
MS-27683-7 (30.0-gal)	400	F/F/S/Pb	4-mil	2	2 Pass	*	-	1	1 Pass
	400	S/Pb	None	1	1 Pass	*	-	1	1 Pass
MS-27683-13 (45-gal)	500	F/F/S/Pb	4-mil Liner	3	3 Pass	*	-	2	2 Pass
		F/F/S/Pb	None	-	-	*	-	1	1 Pass
MS-27683-21 (85-gal)	800	F/F/S/Pb	RTV	2	2 Pass	*	-	2	2 Pass

*No tests were conducted since these were one-piece structures with no seals or chimes to test.

FOUR-FT FREE DROP TEST RESULTS FOR STEEL BOXES

TABLE D-11

General Comments: The primary drop orientation was inverting the box (lid down) with a corner as the point of impact. When filters were used, they were typically placed in an end, and the corner chosen for the impact point was the corner closest to the filter location.

Specific Packaging	Weight (lb)	Contents	Results	Comments
Manufacturer:				
Capital Industries				
S-0510-0823	7,000	F/F/S[a]	Pass	Angle drop on top corner. No loss of contents or significant change in package geometry. Authorized for Form 1, 2, and 3 materials.
V-0510-0823	7,000	F/F/S	Pass	Angle drop on top corner. No loss of contents or significant change in package geometry. Authorized for Form 1, 2, and 3 materials.
S-0840-1440	22,700	F/F/S	Pass	Angle drop on top corner. No loss of contents or significant change in package geometry. Authorized for Form 1, 2, and 3 materials.
S-0730-1006	10,400	F/F/S	Pass	Angle drop on top corner. No loss of contents or significant change in package geometry. Authorized for Form 1, 2, and 3 materials.

[a]Flour, fluorescein, and sand.

TABLE D-11 (continued)

Specific Packaging	Weight (lb)	Contents	Results	Comments
Manufacturer:				
Capital Industries				
S-0730-0846	8,700	Not Tested	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0730-1006 which was tested and evaluated. All materials and methods of construction were equal to or better than the evaluated packaging, and the authorized gross weight was 1,700 lb less than that for the evaluated packaging. Authorized for Form 1, 2 and 3 materials.
S-0480-0906	6,120	Not Tested	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0510-0823 which was tested and evaluated. All materials and methods of construction were equal to or better than the evaluated packaging, and the authorized gross weight was 820 lbs less than that for the evaluated packaging. Authorized for Form 1, 2 and 3 materials.
S-0450-0846	5,240	Not Tested	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0510-0823 which was tested and evaluated. All materials and methods of construction were equal to or better than the evaluated packaging, and the authorized gross weight was 1,760 lb less than that for the evaluated packaging. Authorized for Form 1, 2 and 3 materials.

TABLE D-11 (continued)

Specific Packaging	Weight (lb)	Contents	Results	Comments
Manufacturer:				
Capital Industries				
S-0240-0906	3,672	Not Tested	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0510-0823 which was tested and evaluated. All materials and methods of construction were equal to or better than the evaluated packaging, and the authorized gross weight was 3,328 lb less than that for the evaluated packaging. Authorized for Form 1, 2 and 3 mateials.
S-0480-1376	9,295	Not Tested	Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0730-1006 which was tested and evaluated. All materials and methods of construction were equal to or better than the evaluated packaging, and the authorized gross weight was 1,105 lb less than that for the evaluated packaging. Authorized for Form 1, 2 and 3 materials.
Container Products Corp. (CPC)				
B-12-44-4-S/L FD Drawing No. 01-3100-1-00 Rev. B	4,625	F/F/S	Pass	Angle drop on top corner. Authorized for Form 1, 2, and 3 materials.

TABLE D-11 (continued)

Specific Packaging	Weight (lb)	Contents	Results	Comments
Manufacturer:				
Container Products Corp. (CPC)				
B-25-4-S/L FD Drawing No. 01-2800-1-00 Rev. C	4,820	Not Tested	Pass	Evaluated by analysis and comparison to tests of B-96-5 S/L FD which has identical lid seal characteristics. In addition, this package was tested using just sand with no loss of contents. Authorized for Form 1, 2, and 3 materials.
B-52-4-S/L FD Drawing No. 04-1000-1-00 Rev. F	4,775	Not Tested	Pass	Evaluated by analysis and comparison to tests of B-96-5 S/L FD which has identical lid seal characteristics. In addition, this package was tested using just sand with no loss of contents. Authorized for Form 1, 2, and 3 materials.
B-82-6-S/L FD Drawing No. 01-2300-1-00 Rev. D	6,775	Not Tested	Pass	Evaluated by analysis and comparison to tests of B-96-5 S/L FD which has identical lid seal characteristics. In addition, this package was tested using just sand with no loss of contents. Authorized for Form 1, 2, and 3 materials.
B-87-6-S/L FD Drawing No. 04-1300-1-00 Rev. B	6,970	Not Tested	Pass	Evaluated by analysis and comparison to tests of B-96-5 S/L FD which has identical lid seal characteristics. Authorized for Form 1, 2, and 3 materials.

TABLE D-11 (continued)

Specific Packaging	Weight (lb)	Contents	Results	Comments
Manufacturer:				
Container Products Corp. (CPC)				
B-96-6-S/L FD Drawing No. 04-1200-1-00 Rev. 0	7,000	Not Tested	Pass	Evaluated by analysis and comparison to tests of B-96-8 S/L FD which has identical lid seal design. By analysis, the six side drive clips are comparable to the eight side drive clips for the B-96-8 S/L FD considering the difference of 2000 lb in authorized gross weight. Authorized for Form 1, 2, and 3 materials.
B-96-8-S/L FD Drawing No. 04-1200-2-00 Rev. 0	9,100	F/F/S	Pass	Angle drop on top corner. Authorized for Form 1, 2, and 3 materials.
B-96-5-S/L FD Drawing No. 01-2101-1-00 Rev. 0	6,050	F/F/S	Pass	Angle drop on top corner. Authorized for Form 1, 2, and 3 materials.
B-96-5-S/L RA Drawing No. 01-1901-1-00 Rev. 0	6,800	Not Tested	Pass	Identical to B-96-5-S/L FD (except for strength members added to meet reduced pressure test) which was tested and passed. Authorized for Form 1, 2, and 3 materials.
B-96-5-RA B Drawing No. 01-2201-1-01 Rev. 0	6,500	Not Tested	Pass	Identical to B-96-5-S/L FD (except there is no filter) which was tested and passed. Authorized for Form 1, 2, and 3 materials.
467-C-S/L FD Drawing No. 01-3700-1-00 Rev. C	4,000	Not Tested	Pass	Evaluated by analysis and comparison to tests of B-96-5 S/L FD which has identical lid seal characteristics. In addition, tests have been completed using just sand with no loss of contents. Authorized for Form 1, 2, and 3 materials.

TABLE D-11 (continued)

Specific Packaging	Weight (lb)	Contents	Results	Comments
Manufacturer:				
Container Products Corp. (CPC)				
B-96-5 FD B Drawing No. 01-2301-1-01 Rev. 0	6,500	F/F/S	Pass	Angle drop on top corner. Authorized for Form 1, 2, and 3 materials.
RoGar Chemical and Nuclear Services				
Model R-1	7,750	Not Tested	Pass	Evaluated by analysis and comparison (lids, lid reinforcing angle, bolt size, bolt spacing, container flange, materials of construction, etc.) to Model R-3. All materials and methods of construction were equal to or better than the test packaging, the dimensions were substantially less, and the authorized gross weight was 170 lb less than that for the test packaging.
Model R-2	7,820	Not Tested	Pass	Evaluated by analysis and comparison (lids, lid reinforcing angle, bolt size, bolt spacing, container flange, materials of construction, etc.) to Model R-3. All materials and methods of construction were equal to or better than the test packaging, the dimensions were substantially less, and the authorized gross weight was 100 lb less than that for the test packaging.

TABLE D-11 (continued)

Specific Packaging	Weight (lb)	Contents	Results	Comments
Manufacturer:				
RoGar Chemical and Nuclear Services				
Model R-3	7,920	F/F/S	Pass	This package was dropped 4 ft on a top (lid) corner. There was no loss of contents or significant change in package geometry. Authorized for Form 1, 2, and 3 materials.
Model R-4	7,920	Not Tested	Pass	Evaluated by analysis and comparison (lids, lid reinforcing angle, bolt size, bolt spacing, container flange, materials of construction, etc.) to Model R-3. All materials and methods of construction were equal to or better than the test packaging, the dimensions were substantially less, and the gross weight remained the same.
Rocky Flats SAND Box				
Style 1	7,000	Gravel and water	Pass	A number of tests were conducted at different orientations (45° on top, 45° on bottom, etc.) for each packaging. After each test, the packagings were successfully air-leak tested to 0.5 psi. The use of water and gravel was more conservative than the use of flour and fluorescein to simulate the contents. Authorized for Form 1, 2, and 3 materials.

TABLE D-11 (continued)

Specific Packaging	Weight (lb)	Contents	Results	Comments
Manufacturer:				
Rocky Flats SAND Box				
Style 2	6,000	Gravel and water	Pass	A number of tests were conducted at different orientations (45° on top, 45° on bottom, etc.) for each packaging. After each test, the packagings were successfully air-leak tested to 0.5 psi. The use of water and gravel was more conservative than the use of flour and fluorescein to simulate the contents. Authorized for Form 1, 2, and 3 materials.
Style 3	6,000	Gravel and water	Pass	A number of tests were conducted at different orientations (45° on top, 45° on bottom, etc.) for each packaging. After each test, the packagings were successfully air-leak tested to 0.5 psi. The use of water and gravel was more conservative than the use of flour and fluorescein to simulate the contents. Authorized for Form 1, 2, and 3 materials.
Style 4	6,000	Gravel and water	Pass	A number of tests were conducted at different orientations (45° on top, 45° on bottom, etc.) for each packaging. After each test, the packagings were successfully air-leak tested to 0.5 psi. The use of water and gravel was more conservative than the use of flour and fluorescein to simulate the contents. Authorized for Form 1, 2, and 3 materials.

TABLE D-11 (continued)

Specific Packaging	Weight (lb)	Contents	Results	Comments
Manufacturer:				
Argonne M-4 Bin	3,000[a]	Four 55-gal drums filled with sand, two 5-gal pails and approximately 300 lb of loose sand	Pass	Dropped on one of the bottom corners. Previous analysis had shown this orientation to be most vulnerable to damage. After the drop, the bin was filled with 24 in. of water, 18 in. above the damage area. The bin was leak tight. Authorized for Forms 1, 2, and 3 materials.
ANL-West 7A-960	960	Solid pieces of lead	Pass	Dropped on top corner of lid. There was no loss of contents and no significant pathways created by which contents could escape. Authorized only for Form 3 materials.

[a]The authorized gross weight is 3,000 lb; however, the actual gross weight for testing was 3,215 lb.

FOUR-FT FREE DROP TEST RESULTS FOR ANL AND LLNL WOODEN BOXES

TABLE D-12

Specific Packaging	Weight (lb)	Contents	Results	Comments
ANL-WEST				
7A-217 7A-375 7A-880 7A-995 7A-1315	217 375 880 995 1,315	Solid materials simulating Form 3 materials were used for all tests	Pass	Packagings were dropped on a top corner, which included the lid. In all cases, the packaging met the requirements for Form 3 materials. Authorized for only Form 3 materials.
7A-670	670	55-gal drum filled with soil placed inside the wooden box	Pass	Packaging was dropped on a top corner, which included the lid. In all cases, the packaging met the requirement for Form 3 materials. Authorized for only Form 3 materials.
LLNL				
Flush Panel	2,500	Drysorb 75% by weight; Microsel-E 25% by weight	Pass	Packaging was dropped on a top corner, which included the lid. There was no release of contents and the packaging was authorized for Form 2 and 3 materials.

FOUR-FT FREE DROP TEST RESULTS FOR WOODEN BOXES

TABLE D-13

General Comments: All drops were conducted on a top corner of the lid. There was no loss of contents and the packagings were authorized for Form 2 and 3 materials.

Specific Packaging	Weight (lb)	Contents	No. Tested	Results	Comments
Mound Wooden Boxes - Configuration A					
MA-1	40	S/Pb[a]	2	2 Pass	Authorized for only Form 2 and 3 materials.
MA-2	100	S/Pb	2	2 Pass	
MA-3	100	S/Pb	1	1 Pass	
		F/F/S/Pb[b]	1	1 Pass	
MA-4	100	S/Pb	1	1 Pass	
		F/F/S/Pb	1	1 Pass	
Mound Wooden Boxes - Configuration B					
MB-1	150	F/F/S/Pb	2	2 Pass	Authorized for only Form 2 and 3 materials.
MB-2	150	F/F/S/Pb	2	2 Pass	
MB-3	200	F/F/S/Pb	2	2 Pass	
MB-4	150	F/F/S/Pb	2	2 Pass	
MB-5	150	F/F/S/Pb	2	2 Pass	
MB-6	200	F/F/S/Pb	1	1 Pass	

[a]Sand and lead.

[b]Flour, fluorescein, sand, and lead.

TABLE D-13 (continued)

Specific Packaging	Weight (lb)	Contents	No. Tested	Results	Comments
Mound Wooden Boxes - Configuration C					
MC-1	150	F/F/S/Pb	1	1 Pass	Authorized for only Form 2 and 3 materials.
		S	1	1 Pass	
MC-2	300	F/F/S/Pb	1	1 Pass	
		S/Pb	1	1 Pass	
MC-3	250	F/F/S/Pb	1	1 Pass	
		S/Pb	1	1 Pass	
MC-4	100	F/F/S/Pb	1	1 Pass	
		S	1	1 Pass	
MC-5	150	F/F/S	1	1 Pass	
Mound Wooden Boxes - Configuration D					
MD-1	200	F/F/S/Pb	2	2 Pass	Authorized for only Form 2 and 3 materials.
MD-2	300	F/F/S/Pb	1	1 Pass	
MD-3	250	F/F/S	2	2 Pass	
MD-4	250	F/F/S	2	2 Pass	
MD-5	200	F/F/S/Pb	2	2 Pass	
MD-6	200	F/F/S/Pb	2	2 Pass	

TABLE D-13 (continued)

Specific Packaging	Weight (lb)	Contents	No. Tested	Results	Comments
Mound Wooden Boxes - Configuration E					
ME-1	150	S	1	1 Pass	Authorized for only Form 2 and 3 materials.
ME-2	150	S	2	2 Pass	
ME-3	150	F/F/S	1	1 Pass	
Y-12 B-Series Wooden Boxes					
B-1	400	S/Pb	2	2 Pass	Authorized for only Form 3 materials.
B-2	400	S/Pb	2	2 Pass	
B-3	400	S/Pb	2	2 Pass	
B-4	400	S/Pb	2	2 Pass	
B-5	400	S/Pb	2	2 Pass	
B-6	400	S/Pb	2	2 Pass	
B-7	400	S/Pb	2	2 Pass	
B-8	400	S/Pb	2	2 Pass	

TABLE D-13 (continued)

Specific Packaging	Weight (lb)	Contents	No. Tested	Results	Comments
Y-12 Picture Frame Boxes					
Picture Frame					
PF-1	500	S/Pb	1	1 Pass	Authorized for only Form 3 materials.
PF-2	750	Pb	2	2 Pass	
PF-3	1,000	Pb	2	2 Pass	
PF-4	500	Pb	2	2 Pass	
PF-5	750	S/Pb	2	2 Pass	
PF-6	1,000	Pb	2	2 Pass	
PF-7	750	Pb	2	2 Pass	
PF-8	1,000	Pb	2	2 Pass	
Rocky Flats					
RA Series					
Configuration 1	900	Solid material	1	1 Pass	Authorized for only Form 3 materials.
Configuration 2	1,250	Solid material	1	1 Pass	

FOUR-FT FREE DROP TEST RESULTS FOR NLO FAMILY OF BANDED WOODEN BOXES

TABLE D-14

General Comments: All drops were conducted on a top corner of the lid. There was no loss of contents and the packagings were authorized for Form 3 materials.

Specific Packaging	Weight (lb)	Results	Orientation	Comments
G-4214	1,805	Pass	All drops were conducted on a top corner of lid. In several instances these packagings survived drops of of 30 ft (7.5 times the prescribed distance) with no release of contents.	Authorized for only Form 3 materials.
G-4245	250	Pass		
G-4255	1,500	Pass		
G-4273	3,250	Pass		
G-4292	852	Pass		

FOUR-FT FREE DROP TEST RESULTS FOR FIBERBOARD BOXES

TABLE D-15

General Comments. All drops were conducted on a top corner of the lid. There was no loss of contents and the packagings were authorized for Form 3 materials.

Specific Packaging	Weight (lb)	Contents	No. Tested	Results	Comments
12B-65 Fiberboard Boxes					
1	65	Pb	2	2 pass	Authorized for only Form 3 materials.
2	65	Pb	3	3 pass	
3	65	Pb	1	1 pass	
4	65	S	2	2 pass	
5	65	S	2	2 pass	Authorized for only Form 3 materials.
6	65	S	1	1 pass	
7	65	S	2	2 pass	
8	65	S	2	2 pass	
9	65	S	2	2 pass	
10	65	S	2	2 pass	
11	65	S	1	1 pass	
12	65	S	2	2 pass	
13	65	S	2	2 pass	
LLNL 12B-10 with inner metal can[a]	10	Inner metal can filled with rocks	3	3 pass	Authorized for Form 1, 2, and 3 materials. Inner can was air-leak tested after each test.
Tri-Wall Fiberboard Box	350	Sand in plastic bags	2	2 pass	Authorized for only Form 3 materials.

[a]The inner metal can was removed after each test and leak checked in a bell jar under water.

FOUR-FT FREE DROP TEST RESULTS FOR 21C FIBERBOARD DRUMS

TABLE D-16

Specific Packaging	Weight (lb)	Comments	45° Top		45° Bottom		Side		Comments
			No. Tested	Results	No. Tested	Results	No. Tested	Results	
1	115	F/F/S	1	1 pass	1	1 pass	1	1 pass	Authorized for Form 3 materials only.
2	115	F/F/S/Pb	1	1 pass	1	1 pass	1	1 pass	
3	115	F/F/S	1	1 pass	1	1 pass	1	1 pass	
4	115	F/FS/Pb	1	1 pass	1	1 pass	1	1 pass	
5	115	F/F/S	1	1 pass	1	1 pass	1	1 pass	
6	115	F/F/S	1	1 pass	1	1 pass	1	1 pass	

NOTE: Even though these packagings passed the drop test without release of the floor and fluorescein, they were authorized for only Form 3 materials since their performance in the penetration test was sporadic.

FOUR-FT FREE DROP TEST RESULTS FOR UF-6 CYLINDERS

TABLE D-17

Specific Packaging	Weight (lb)	Orientation	Comments
1S	2	This category of packagings was evaluated based on numerous drop tests conducted on Models 5A, 8A, 12B, 30B, and 48X cylinders. These tests included the 4-ft drop (side and angle), the much more severe 30-ft drop (side and angle), and the 4-ft drop onto the bar (puncture test). In all of these tests, there was no loss of contents. When analyses were performed, data such as materials of construction, dimensions, authorized gross weight, and effects of testing were used to verify that the cylinders not tested meet the Spec 7A requirements.	These packagings are authorized for Form 1, 2, and 3 materials (recognizing that Forms 2 and 3 are not really appropriate).
2S	9.5		
5A	110		
8A	375		
12A	645		
12B	650		
30A	6,350		
30B	6,420		
48G	30,600		
48H	30,150		
48HX	30,150		
48X	25,530		
48Y	32,760		

THIRTY-FT FREE DROP TEST RESULTS FOR LIQUIDS AND GASES

TABLE D-18

Specific Packaging	Weight (lb)	Contents	Results/Comments
Steel Drum MS-24347-7 (p. F-1)	6	Water	Top (45°): No. Tested - 3; Results - 3 pass Flat on Top: No. Tested - 1; Results - 1 pass Bottom (45°): No. Tested - 3; Results - 3 pass Side: No. Tested - 2; Results - 2 pass Three 30-ft drops were done consecutively on the same package, then the inner containment vessel (glass bottle) was removed and inverted for 10 min to determine if there had been any loss of contents. After nine 30-ft drops, there was no evidence of leakage, and the package was evaluated as meeting all requirements.
LASL 12B-62 Fiberboard Box	62	Water	One 30-foot drop was done on this packaging. The impact point was a top corner (package was inverted). After completion of the test, the inner containment vessel (glass ampule) was removed and inverted for 10 min to determine if there had been any loss of contents. There was no loss of contents. In addition, after an additional 30-ft drop, the 2-in. diameter inner shield container with the threaded cap and O-ring seal was air-leak tested and passed. Thus, this packaging meets all requirements with any appropriate inner containment.
LLNL Steel Drums with Gas Cylinders (p. F-11) 3A 1800 3E 1800	 68 60	 Air Air	A 30-ft drop test was conducted on both configurations. After each drop test, it was determined that there had been no loss of contents (by comparison of pretest pressure to posttest pressure) from any of the seven test cylinders. Thus, there was no loss of contents and this packaging meets all requirements.

TABLE D-18 (continued)

Specific Packaging	Weight (lb)	Contents	Results/Comments
ORNL Fiberboard Box - Liquids and Solids (p. F-15)	33	Water	A 30-ft drop test was conducted on this packaging. The impact was on the bottom edge of the cardboard box. There was no evidence of loss of contents, and this packaging meets all requirements.
ORNL Fiberboard Box - Gases (p. F-20)	33	Water	A 30-ft drop test was conducted on this packaging. The impact was on the bottom edge of the cardboard box. There was no evidence of loss of contents, and this packaging meets all requirements.
ORNL Fiberboard Box - Liquids and Solids with Shielding (p. F-21)	33	Water	A 30-ft drop test was conducted on this packaging. The impact was on the bottom edge of the cardboard box. There was no evidence of loss of contents, and this packaging meets all requirements.
ORNL Wooden Box - Returnable, Shielded (p. F-26)	212	Water	Two 30-ft drops were conducted; one with the entire packaging assembly and one with just the stainless steel clad lead shield by itself (without the wooden box). The second drop indicated that this inner assembly could withstand the 30-ft drop test by itself. After both tests, the glass inner container was removed and examined. There was no loss of contents (leakage of water), and this packaging meets all requirements.
ORNL Gas Cylinder Returnable (Hoke Cylinders)			
HOH-50	9		Thirty-ft drop tests were conducted on the 1000 mL (not currently used) and 500 mL gas shipping cylinders. The test packages were dropped with the valve cover down. There was no loss of contents, and these packagings meet this requirement. These two tests subjected the packaging to maximum stress, so, after consideration of material of construction, thickness of materials, package weights, etc., the analysis demonstrated that all listed packagings meet all requirements.
HOXe-50	15		
HOKr-50	15		
HOH-150	11		
HOXe-150	35		
HOKr-150	35		
HOH-300	12		
HOKr-300	36		
HOH-500	15		
HOKr-500	50		

TABLE D-18 (continued)

Specific Packaging	Weight (lb)	Contents	Results/Comments
ORNL Gas Cylinder Returnable (J. L. Shepard)			
Cylinder 1	24		A 30-ft drop test was conducted on J. L. Shepard Model 394-500-L gas shipping cylinder. The cylinder landed on its top. Helium leak testing before and after the testing demonstrated that there was no loss of contents and this packaging meets this requirement. Since this packaging would be subject to the greatest stress, all smaller packagings also meet all requirements.
Cylinder 2	40		
Cylinder 3	60		

FOUR-FT FREE DROP TEST RESULTS FOR MISCELLANEOUS PACKAGINGS

TABLE D-19

Specific Packaging	Weight (lb)	Comments
LLNL-Old Spec 55	50	Two of these packagings were filled with a water/fluorescein solution, sealed, and dropped on a lid edge. There was no loss of contents, even with these conservative contents. Thus, this packaging meets all requirement.
ORNL TRU Shipping Container	3,700	Since this packaging is certified only for Special Form [49 CFR 173.403(z)] contents, this test has little meaning from a loss of contents standpoint. However, the test was conducted on the top edge with no significant effect on the packaging. Thus, the packaging plus the Special Form contents meet all requirements.
FEMA Source Over Pack	200	Since this packaging is authorized only for Special Form [49 CFR 173.403(z)] contents, this test has little meaning from a loss of contents standpoint. However, the test was conducted on the top edge with no significant effect on the packaging. Thus, the packaging plus the Special Form contents meet all requirements.
SNL Tritium Waste Package	200	The inner container was dropped 6 ft on a chime and 4 ft on a protected valve, and the entire package was dropped 4 ft on the top bolt closure ring, all with no loss of contents. The packaging meets all requirements.

CORNER FREE DROP TEST RESULTS FOR WOODEN BOXES

TABLE D-20

General Comments: Eight 1-ft drops were conducted (one on each corner). There was no loss of contents or other effects on containment integrity. The slight dimensional changes are shown in the last column.

Specific Packaging	Weight (lb)	Contents	No. Tested	Results	Comments
Mound Wooden Boxes - Configuration A					
MA-1	40	S/Pb	1	1 Pass	0.25-in. indent
MA-2	100	S/Pb	1	1 Pass	0.25-in. indent
MA-3	100	S/Pb	1	1 Pass	0.375-in. indent
MA-4	100	S/Pb	1	1 Pass	0.25-in. indent
Mound Wooden Boxes - Configuration B					
MB-1	150	F/F/S/Pb	1	1 Pass	0.25 in. indent
MB-2	150	F/F/S/Pb	1	1 Pass	0.375-in. indent
MB-3	200	F/F/S/Pb	1	1 Pass	0.375-in. indent
MB-4	150	F/F/S/Pb	1	1 Pass	0.375-in. indent
MB-5	150	F/F/S/Pb	1	1 Pass	0.375-in. indent
MB-6	200	F/F/S/Pb	1	1 Pass	0.375-in. indent
Mound Wooden Boxes - Configuration C					
MC-1	150	S/Pb	1	1 Pass	0.5-in. indent
MC-2	300	S	1	1 Pass	0.25-in. indent
MC-3	250	S/Pb	1	1 Pass	0.5-in. indent
MC-4	100	S/Pb	1	1 Pass	0.25-in. indent
MC-5	150	S	1	1 Pass	0.25-in. indent

TABLE D-20 (continued)

Specific Packaging	Weight (lb)	Contents	No. Tested	Results	Comments
Mound Wooden Boxes - Configuration D					
MD-1	200	F/F/S/Pb	1	1 Pass	0.25-in. indent
MD-2	200	F/F/S/Pb	1	1 Pass	0.25-in. indent
MD-3	250	F/F/S	1	1 Pass	0.25-in. indent
MD-4	250	F/F/S	1	1 Pass	0.375-in. indent
MD-5	200	F/F/S/Pb	1	1 Pass	0.25-in. indent
MD-6	200	F/F/S/Pb	1	1 Pass	0.25-in. indent
Mound Wooden Boxes - Configuration E					
ME-1	150	S	1	1 Pass	0.25-in. indent
ME-2	150	S	1	1 Pass	0.25-in. indent
ME-3	150	S	Not Tested		Pass, based on testing of similar packagings.
Y-12 Series B Wooden Boxes					
B-1	400	S/Pb	1	1 Pass	0.55-in. indent
B-2	400	S/Pb	1	1 Pass	0.25-in. indent
B-6	400	S/Pb	1	1 Pass	0.125-in. indent

CORNER FREE DROP TEST RESULTS FOR FIBERBOARD BOXES

TABLE D-21

General Comments: Eight 1-ft drops were conducted (one on each corner). There was no loss of contents or other effects on containment integrity. The slight dimensional changes are shown in the last column.

Specific Packaging	Weight (lb)	Contents	No. Tested	Results	Comments
12B-65					
1	65	Pb	2	2 pass	0.25-in. indent
2			Not Tested		Pass, based on testing of similar packagings.
3	65	S/Pb	1	1 pass	0.25-in. indent
4	65	S	2	2 pass	0.25-in. indent
5	65	Pb	2	2 pass	0.25-in. indent
6	65	S	2	2 pass	0.25 in. indent
7	65	S	2	2 pass	0.25-in. indent
8	65	S	2	2 pass	0.25-in. indent
9	65	S	1	1 pass	0.25-in. indent
10	65	S	2	2 pass	0.25-in. indent
11	65	S	2	2 pass	0.25-in. indent
12	65	S	2	2 pass	0.25-in. indent
13	65	S/Pb	2	2 pass	0.25-in. indent
LLNL 12B-10			Not Tested		Pass, based on testing of similar packagings.

CORNER FREE DROP TEST RESULTS FOR 21C FIBERBOARD DRUMS

TABLE D-22

General Comments: Eight 1-ft drops were conducted (one on each of the quarters of each rim). There was no loss of contents or other effects on containment integrity. The slight dimensional changes are shown in the last column.

Specific Packaging	Weight (lb)	Contents	No. Tested	Results	Comments
1	115	F/F/S/Pb	1	1 pass	0.25-in. indent
2	115	F/F/S/Pb	1	1 pass	0.125-in. indent
3	115	F/F/S/Pb	1	1 pass	0.25-in. indent
4	115	F/F/S/Pb	1	1 pass	0.25-in. indent
5	115	F/F/S	1	1 pass	0.25-in. indent
6	115	F/F/S	1	1 pass	0.25-in. indent

(d) Compression Test

The compression test shall last for a period of at least 24 hr and consist of a compressive load equivalent to the greater of the following:

(1) Five times the weight of the actual package; or

(2) 1300 kilograms per square meter (265 lb/ft^2) multiplied by the vertically projected area of the package. The compressive load shall be applied uniformly to two opposite sides of the packaging specimen, one of which must be the base on which the package would normally stand.

Major Points

(1) 5 times actual weight
(2) 265 lb/ft^2 times the area of package

Comments

(1) Be alert. For packages with a large top surface area, the 265 lb/ft^2 can quickly become very large.
(2) Any decreases in distances to package surfaces should be documented for use in evaluating the "No significant dose rate increase" requirement.

Tester and evaluator to do and shipper responsibility to ensure.

COMPRESSION TEST RESULTS FOR STEEL DRUMS

TABLE D-23

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
Spec 6C 5-gal	80	500	>24	1	1 Pass	No detectable effect.
Spec 6C 10-gal	160	928	>24	1	1 Pass	No detectable effect.
Spec 17C 5-gal	100	520	>24	1	1 Pass	No detectable effect.
Spec 17C 30-gal	500	Not Tested[a]				Pass, based on testing of 17H 30-gal drum.
Spec 17C 55-gal	1,000	Not Tested[b]				Pass, based on testing of 17H 55-gal drum[c].
Spec 17C 55-gal with pressure relief devices	1,000	Not Tested[c]				Pass, based on testing of 17H 55-gal drum[c].
Spec 17C 55-gal with HDPE liner	1,000	Not Tested[b]				Pass, based on testing of 17H 55-gal drum[c].
Spec 17H 30-gal	500	2,700	>24	1	1 Pass	No detectable effect.
Spec 17H 55-gal	1,000	5,100	>74	1	1 Pass	No detectable effect.

[a]The test data for the Spec 17H 30-gal drum are directly applicable since the construction specifications for these two drums (17H 30-gal and 17C 30-gal) are essentially the same.

[b]A 17C 55-gal drum filled with concrete was tested to 8,142 lb (for 24 hr) and passed.

[c]The test data for the Spec 17H 55-gal drum are directly applicable (although conservative), since the only major difference between the 17H and the 17C 55-gal drums is the thickness of the body sheet. The 17H body sheet is 18 gauge, and the 17C is 16 gauge.

TABLE D-23 (continued)

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
MS 24347-1	10	100	48	1	1 Pass	No detectable effect.
MS 24347-7	35	200	48	1	1 Pass	No detectable effect.
MS 27684-1	60	300	>24	1	1 Pass	No detectable effect.
MS-27684-2	110	Not Tested				Pass, based on comparison to test data on comparable drums.
MS-27684-3	80	401	>24	1	1 Pass	No detectable effect.
MS-27684-6	80	500	>24	1	1 Pass	No detectable effect.
MS-27684-8	200	1,000	>24	1	1 Pass	No detectable effect.
MS-27683-7	400	2,072	>24	1	1 Pass	No detectable effect.
MS-27683-13	500	2,752	>24	1	1 Pass	No detectable effect.
MS-27683-21	800	5,500	>24	1	1 Pass	No detectable effect.

COMPRESSION TEST RESULTS FOR STEEL BOXES

TABLE D-24

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
Capital Industries						
S-0510-0823	7,000	35,000	>24	1	1 Pass	No detectable effect.
V-0510-0823	7,000	35,000	>24	1	1 Pass	No detectable effect.
S-0450-0844	5,240	Not Tested	-			Pass, based on testing of Model S-0510-0823. This model passed with a load of 2500 lb/ corrogation. Model S-0450-0844 would require a test of 1871 lb/corrogation which would be expected to pass.
S-0730-0846	8,700	Not Tested	-			Pass, based on testing of Model S-0730-1006. This model passed with a load of 2167 lb/ corrgation. Model S-0730-0846 would require a test of 2175 lb/corrogation which would be expected to pass.
S-0240-0906	3,672	Not Tested	-			Pass, based on testing of Model S-0510-0823. This model passed with a load of 2500 lb/ corrogation. Model S-0240-0906 would require a test of 1353 lb/corrogation which would be expected to pass.
S-0480-0906	6,120	Not Tested	-			Pass, based on testing of Model V-0510-0823. This model passed with a load of 2500 lb/ corrogation. Model S-0480-0906 would require a test of 1913 lb/corrogation which would be expected to pass.

TABLE D-24 (continued)

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
Capital Industries						
S-0730-0906	10,400	52,000	>24	1	1 Pass	No detectable effect.
S-0840-1440	22,700	124,184	>24	1	1 Pass	No detectable effect.
S-0480-1376	-	Not Tested	-			Pass, based on testing of Model S-0730-1006. This model passed with a load of 2167 lb/ corrgation. Model S-0480-1376 would require a test of 1936 lb/corrogation which would be expected to pass.
Container Products Corp.						
B-96-5-S/L-FD	6,050	30,250	>24	1	1 Pass	No detectable effect.
B-96-5-S/L-RA	6,801	Not Tested	-			Pass, based on testing of a comparable container, B-96-5-S/L-FD, which met this requirement.
B-96-5-S/L-RA	6,500	Not Tested	-			Pass, based on testing of a comparable container, B-96-5-S/L-FD, which met this requirement.
467-C-S/L-FD TRU Waste Container	4,000	20,000	>24	1	1 Pass	No detectable effect.
B-12-44-4-S/L-FD	4,625	Not Tested	-			Pass, based on testing of a comparable container, B-25-4-S/L-FD, which met this requirement.

TABLE D-24 (continued)

Specific Packaging	Authorized Gross Weight (lb)	Comparison Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
Container Products Corp.						
B-25-4-S/L-FD	4,820	25,000	>24	1	1 Pass	No detectable effect.
B-52-4-S/L-FD	4,775	29,000	>24	1	1 Pass	No detectable effect.
B-82-6-S/L-FD	6,775	35,000	>24	1	1 Pass	No dectectable effect.
B-87-6-S/L-FD	6,970	Not Tested	-			Pass, based on testing of a comparable container, B-96-6-S/L-FD, which met this requirement.
B-96-6-S/L-FD	7,005	40,020	>24	1	1 Pass	No detectable effect.
B-96-8-S/L-FD	9,100	47,000	>24	1	1 Pass	No detectable effect.
Rocky Flats SAND Box						
Style 1	7,000	36,760	>24	2	2 Pass	No detectable effect.
Style 2	6,000	32,000	>24	3	3 Pass	No detectable effect.
Style 3	6,000	32,000	>24	1	1 Pass	No detectable effect.
Style 4	6,000	32,000	>24	2	2 Pass	No detectable effect.

TABLE D-24 (continued)

Specific Packaging	Authorized Gross Weight (lb)	Comparison Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
Argonne						
M-4 Bin	3,000	Not Tested	-			Pass, based on testing of the M-III steel bin with a compression load of 40,000 lb. The M-4 is of equal or better structural strength and would be expected to meet this requirement.
ANL-West						
Steel Box	960	4,800	>24	1	1 Pass	No detectable effect.

COMPRESSION TEST RESULTS FOR WOODEN BOXES

TABLE D-25

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
ANL-West						
7A-217	217	1,085	24	1	1 Pass	No detectable effect.
7A-375	375	4,000	24	1	1 Pass	No detectable effect.
7A-880	880	5,168	24	1	1 Pass	No detectable effect.
7A-995	995	6,308	24	1	1 Pass	No detectable effect.
7A-1315	1,315	7,000	24	1	1 Pass	No detectable effect.
7A-670	670	4,000	24	1	1 Pass	No detectable effect.
LLNL Flush Panel	2,500	25,000	>24	1	1 Pass	No detectable effect.
Mound Wooden Boxes - Configuration A						
MA-1	40	265	>24	1	1 Pass	No detectable effect.
MA-2	100	500	>24	1	1 Pass	No detectable effect.
MA-3	100	500	>24	1	1 Pass	No detectable effect.
MA-4	100	500	>24	1	1 Pass	No detectable effect.
Mound Wooden Boxes - Configuration B						
MB-1	150	Not Tested				Pass, based on shown testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-2	150	1,500	>24	1	1 Pass	No detectable effect.

TABLE D-25 (continued)

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
MB-3	200	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-4	150	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-5	150	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-6	200	1,116	>24	1	1 Pass	No detectable effect.
Mound Wooden Boxes - Configuration C						
MC-1	150	770	>24	1	1 Pass	No detectable effect.
MC-2	300	1,550	>24	1	1 Pass	No detectable effect.
MC-3	250	1,000	>24	1	1 Pass	No detectable effect.
MC-4	100	520	>24	1	1 Pass	No detectable effect.
MC-5	150	770	>24	1	1 Pass	No detectable effect.
Mound Wooden Boxes - Configuration D						
MD-1	200	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.

TABLE D-25 (continued)

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Test/Analysis Data and Results Results	Comments
MD-2	300	1,528	>24	1	1 Pass	No detectable effect.
MD-3	250	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MD-4	250	1,351	>24	1	1 Pass	No detectable effect.
MD-5	200	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MD-6	200	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
Mound Wooden Boxes - Configuration E						
ME-1	150	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
ME-2	150	755	>24	1	1 Pass	No detectable effect.
ME-3	150	755	>24	1	1 Pass	No detectable effect.

TABLE D-25 (continued)

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
NLO Family of Banded Wooden Boxes						
G-4214	1,805	10,000	>24	1	1 Pass	No detectable effect.
G-4245	250	1,000	>24	1	1 Pass	No detectable effect.
G-4255	1,500	7,500	>24	1	1 Pass	No detectable effect.
G-4273	3,250	18,000	>24	1	1 Pass	No detectable effect.
G-4292	852	4,500	>24	1	1 Pass	No detectable effect.
Y-12 Series B Wooden Boxes						
B-1	400	2,072	70	1	1 Pass	No detectable effect.
B-2	400	2,028	69	1	1 Pass	No detectable effect.
B-3	400	2,015	72	1	1 Pass	No detectable effect.
B-4	400	2,028	>24	1	1 Pass	No detectable effect.
B-5	400	2,072	>24	1	1 Pass	No detectable effect.
B-6	400	2,028	>24	1	1 Pass	No detectable effect.
B-7	400	2,072	>24	1	1 Pass	No detectable effect.
B-8	400	2,028	>24	1	1 Pass	No detectable effect.
Y-12 Picture Frame Wooden Boxes						
PF-1	500	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those
PF-2	750	3,770	>24	1	1 Pass	No detectable effect.

TABLE D-25 (continued)

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
PF-3	1,000	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
PF-4	500	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
PF-5	750	3,770	>24	1	1 Pass	No detectable effect.
PF-6	1,000	5,100	>69	1	1 Pass	No detectable effect.
PF-7	750	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
PF-8	1,000	5,100	47	1	1 Pass	No detectable effect.
Rocky Flats RA Series of Wooden Boxes						
Configuration 1	900	4,541	24	1	1 Pass	No detectable effect.
Configuration 2	1,250	6,664	24	1	1 Pass	No detectable effect.

COMPRESSION TEST RESULTS FOR FIBERBOARD PACKAGINGS

TABLE D-26

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
12B-65 Fiberboard Boxes						
1	65	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
2	65	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
3	65	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
4	65	330	>24	1	1 Pass	No detectable effect.
5	65	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
6	65	330	>24	1	1 Pass	No detectable effect.

TABLE D-26 (continued)

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
7	65	325	>24	1	1 Pass	No detectable effect.
8	65	328	>24	1	1 Pass	No detectable effect.
9	65	328	>24	1	1 Pass	No detectable effect.
10	65	325	>24	1	1 Pass	No detectable effect.
11	65	328	>24	1	1 Pass	No detectable effect.
12	65	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
13	65	Not Tested				Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
LINL 12B-10 with inner metal can	10	100	>24	1	1 Pass	No detectable effect.
Tri-Wall Fiberboard Box	350	2,510	>24	2	2 Pass	Box was compressed 0.5 in. in the middle as a result of this test.

TABLE D-26 (continued)

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
21C Fiberboard Drums						
1	115	603	>24	1	1 Pass	No detectable effect.
2	115	600	>24	1	1 Pass	No detectable effect.
3	115	601	>24	1	1 Pass	No detectable effect.
4	115	603	>24	1	1 Pass	No detectable effect.
5	115	603	>24	1	1 Pass	No detectable effect.
6	115	601	>24	1	1 Pass	No detectable effect.

COMPRESSION TEST RESULTS FOR UF-6 CYLINDERS

TABLE D-27

Packaging	Calculated No. of Packages Required for Stress Leading to Failure	Results	Comments
1S	60	Pass	Two methods of analysis were used to evaluate the containers:
2S	>100	Pass	
5A	21	Pass	(1) A linear elastic stress and buckeling analysis using the shell of revoluation program BOSOR; and
8A	15	Pass	
12A	>100	Pass	
12B	>100	Pass	(2) A linear elastic buckeling analysis and a nonlinear elastic-plastic collapses analysis using the finite element program NASTRAN.
30A	12	Pass	
30B	12	Pass	
48G	9	Pass	
48H	9	Pass	
48HX	12	Pass	
48X	12	Pass	
48Y	9	Pass	

COMPRESSION TEST RESULTS FOR LIQUIDS AND GASES

TABLE D-28

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
Steel Drum MS-24347-7 (p. F-1)[a]	10	Not Tested				Pass, see Page D-52 of this addendum for test results on this drum.
LASL 12B-62 Fiberboard Box	62	328	>24	1	1 Pass	No detectable effect.
LLNL Steel Drums with Gas Cylinders (p. F-11)		Not Tested				Pass, see Page D-51 of this addendum for test results on 17H 30-gal steel drums.
ORNL Fiberboard Box - Liquids and Solids (p. F-15)	33	165	>24	1	1 Pass	Deformation of up to 1 in. on all four sides and less than 0.5 in. on the top end button.
ORNL Fiberboard Box - Gases (p. F-20)	33	165	>24	1	1 Pass	Deformation of up to 1 in. on all four sides and less than 0.5 in. on the top end button.

[a]Page numbers refer to MIM-3245 unless otherwise stated.

TABLE D-28 (continued)

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Test/Analysis Data and Results Results	Comments
ORNL Fiberboard Box - Liquids and Solids with Shielding (p. F-21)	33	165	>24	1	1 Pass	Deformation of up to 1 in. on all four sides and less than 0.5 in. on the top end button.
ORNL Wooden Box - Returnable, Shielded (p. F-26)	212	1,040		1	1 Pass	Tests on a slightly smaller packaging at a slightly less compressive load demonstrated that this packaging would be expected to meet this requirement.
ORNL Gas Cylinder Returnable (Hoke Cylinders)	212	1,060	>24	1	1 Pass	No damage to the packaging.
HOH-50	9	Not Tested				Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOXe-50	15	Not Tested				Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOKr-50	15	Not Tested				Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOH-150	11	Not Tested				Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOXe-150	35	Not Tested				Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOKr-150	35	Not Tested				Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.

TABLE D-28 (continued)

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
HOH-300	12	Not Tested				Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOKr-300	36	Not Tested				Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOH-500	15	Not Tested				Pass, based on comparison to test data on heaviest cylinder, HOKr-500, shown below.
HOKr-500	50	285	24	1	1 Pass	No damage to the packaging. Tests were also conducted with a 1,000 mL container in which a compressive load of 580 lb was applied for 24 hr. There was no damage to the package. Since these cylinders are all identical in construction except for size and weight, the testing of the two heaviest packagings represents the worst possible cases. Thus, all of the above cylinders would pass this test.
ORNL Gas Cylinder Returnable (J. L. Shepard)						
Cylinder 1	24					Evaluated based on letter describing testing conducted by ORNL, subject "J. L. Shepard Gas Cylinder," D. M. Ferren/D. A. Edling, April 30, 1985.
Cylinder 2	40					
Cylinder 3	60					

COMPRESSION TEST RESULTS FOR MISCELLANEOUS PACKAGINGS

TABLE D-29

Specific Packaging	Authorized Gross Weight (lb)	Compression Test Weight (lb)	Test Duration (hr)	Test/Analysis Data and Results No. Tested	Results	Comments
LLNL Old Spec 55	50	300	>24	1	1 Pass	No detectable effect.
ORNL TRU Shipping Container	3,700	Not Tested				Analysis demonstrates that even 50,000 lb, a severe over-test, would not have a significant effect.
FEMA Source Over Pack	200	1,070	>24	1	1 Pass	No detectable effect.
SNL Tritium Waste Package	200	Not Tested				Pass, see Page D-51 of this document for test data on the 17H 30-gal drum.

PENETRATION TEST

(e) Penetration Test.

For the penetration test the packaging specimen shall be placed on a rigid, flat, horizontal surface that will not move while the test is being performed. The test shall consist of:

(1) A bar 3.2 centimeters (1.25 in.) in diameter with with a hemispherical end, weighing 6 kilogram (13.2 lb) being dropped with its longitudinal axis vertical, onto the center of the weakest part of the packaging specimen, so that, if it penetrates far enough, it will hit the containment system. The bar must not be deformed by the test; and

(2) The distance of the fall of the bar measured from its lower end to the upper surface of the packaging specimen shall not be less than 1 meter (3.3 ft).

Major Points.

(1) 13-lb bar
(2) 1 m (3.3 ft)
(3) Most vulnerable point

Comments

Penetration of the outer packaging(s) is not necessarily a cause for failure. The question is, "Did the test result in a loss of contents?" For outer packaging components not meeting this requirement, one could specify an inner component(s) that will or design protective devices to ensure that the bar cannot reach the primary containment system.

Tester and evaluator to do and shipper responsibility to ensure.

PENETRATION TEST RESULTS FOR STEEL DRUMS

TABLE D-30

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
Spec 6C (5-gal)	1	Lid at center	1 Pass	0.5-in. dent
	1	Side at seam	1 Pass	1-in. dent
	1	Lid near closure ring	1 Pass	0.25-in. dent
Spec 6C (10-gal)	1	Lid at center	1 Pass	0.5-in. dent
	1	Side at seam	1 Pass	0.75-in. dent
	1	Lid near closure ring	1 Pass	0.5-in. dent
Spec 17C (5-gal)	Not Tested			Pass, based on test data shown for comparable or lesser gauge steels.
Spec 17C (30-gal)	Not Tested			Pass, based on test data shown for comparable or lesser gauge steels.
Spec 17C (55-gal)	Not Tested			Pass, based on test data shown for comparable or lesser gauge steels.
Spec 17C (55-gal) with Pressure Relief Device Nuc-fil filter	3	Center of filter	3 Pass	Air flow was established after each test with flour/fluorescein as contents. There was no visible evidence of loss of contents, and no loss of contents was detected under a black light.

TABLE D-30 (continued)

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
Spec 17C (55-gal) with 90-mil HDPE Liners	Not Tested			Pass. Data shown and discussed below apply here and demonstrate compliance.
Spec 17H (30-gal)	1	Lid at center	1 Pass	0.125-in. dent
	1	Side at seam	1 Pass	0.125-in. dent
	1	Lid near closure ring	1 Pass	0.055-in. dent
Spec 17H (55-gal)	1	Lid at center	1 Pass	0.125-in. dent
	1	Side at seam	1 Pass	0.125-in. dent
	1	Lid near closure ring	1 Pass	0.055-in. dent
MS24347-1 (0.25-gal)	1	Lid at middle	1 Pass	0.75-in. dent
	1	Side at seam	1 Pass	1.25-in. dent
MS24347-7 (1.25-gal)	1	Lid at middle	1 Pass	0.5-in. dent
	1	Side at seam	1 Pass	1.25-in. dent
	1	Lid near closure ring	1 Pass	0.125-in. dent
MS27684-1 (3.0-gal)	1	Lid at middle	1 Pass	0.75-in. dent
	1	Side at seam	1 Pass	1-in. dent
MS27684-2 (4.0-gal)	Not Tested			Pass, based on test data shown for drums of lesser gauge and size.
MS27684-3 (6.0-gal)	1	Lid at middle	1 Pass	1-in. dent
	1	Side at seam	1 Pass	0.5-in. dent

TABLE D-30 (continued)

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
MS27684-6 (8.0-gal)	1	Lid at middle	1 Pass	0.125-in. dent
	1	Side at seam	1 Pass	1-in. dent
MS27684-8 (12.0-gal)	1	Lid at middle	1 Pass	1-in. dent
	1	Side at seam	1 Pass	0.562-in. dent
MS27683-7 (30.0-gal)	1	Lid at middle	1 Pass	1-in. dent
	1	Side at seam	1 Pass	0.562-in. dent
MS27683-13 (45-gal)	1	Lid at middle	1 Pass	0.125-in. dent
	1	Side at seam	1 Pass	0.125-in. dent
MS27683-21 (85-gal)	Not Tested			Pass, based on test data shown for drums of lesser gauge and size.

PENETRATION TEST RESULTS FOR STEEL BOXES

TABLE D-31

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
Capital Industries				
S-0510-0823	1	Middle top	Pass	In all cases below, including the filter test, the only effect was a minor dent. This is expected based on materials of construction and comparative testing of lesser gauge materials.
V-0510-0823	1	Center of filter	Pass	
S-0840-1440	1	Middle top	Pass	
S-0730-1006	1	Middle top	Pass	
S-0730-0846	Not Tested		Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0730-1006 which was tested and evaluated. All materials and methods of construction were equal to or better than those of the tested packaging.
S-0480-0906	Not Tested		Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0510-0823 which was tested and evaluated. All materials and methods of construction were equal to or better than those of the tested packaging.

TABLE D-31 (continued)

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
Capital Industries				
S-0450-0846	Not Tested		Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0580-0823 which was tested and evaluated. All materials and methods of construction were qual to or better than those of the tested packaging.
S-0240-0906	Not Tested		Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0580-0823 which was tested and evaluated. All materials and methods of construction were equal to or better than those of the tested packaging.
S-0480-1376	Not Tested		Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials) to packaging S-0730-1006 which was tested and evaluated. All materials and methods of construction were equal to or better than those of the tested packaging.

TABLE D-31 (continued)

Specific Packaging	Test/Analysis Results: No. Tested	Location	Results	Comments
Container Products Corp. (CPC)				
B-12-44-4-S/L FD Drawing No. 01-3100-1-00 Rev. B	Not Tested		Pass	Evaluated by analysis and comparison to packaging B-25-4-S/L FD whose top is constructed of materials of equal thickness.
B-25-4-S/L FD Drawing No. 01-2800-1-00 Rev. C	1	Top cover	Pass	Only effect was a minor dent.
B-52-4-S/L FD Drawing No. 04-1000-1-00 Rev. F	1	Top cover	Pass	Only effect was a minor dent.
B-82-6-S/L FD Drawing No. 01-2300-1-00 Rev. D	1	Top cover	Pass	Only effect was a minor dent.
B-87-6-S/L FD Drawing No. 04-1300-1-00 Rev. B	Not Tested		Pass	Evaluated by analysis and comparison to packaging B-96-6-S/L FD whose top is constructed of materials of equal thickness.
B-96-6-S/L FD Drawing No. 04-1200-1-00 Rev. O	1	Top cover	Pass	Only effect was a minor dent.
B-96-8-S/L FD Drawing No. 04-1200-2-00 Rev. O	1	Top cover	Pass	Only effect was a minor dent.

TABLE D-31 (continued)

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
Container Products Corp. (CPC)				
B-96-5-S/L FD Drawing No. 01-2101-1-00 Rev. O	1	Top	Pass	Only effect was a minor dent.
B-96-5-S/L RA Drawing No. 01-1901-1-00 Rev. O	Not Tested		Pass	Evaluated by analysis and comparison to packaging B-96-5-S/L FD whose top is constructed of materials of equal thickness.
B-96-5-RA-B Drawing No. 01-2201-1-01 Rev. O	Not Tested		Pass	Evaluated by analysis and comparison to packaging B-96-5-S/L FD whose top is constructed of materials of equal thickness.
467-C-S/L FD Drawing No. 01-3700-1-00 Rev. C	1	Top cover	Pass	Only effect was a minor dent.
RoGar Chemical and Nuclear Services				
Model R-1	Not Tested		Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials of construction) to test package (Model R-3). All materials and methods of construction were equal to or better than those of the tested packaging.

TABLE D-31 (continued)

Specific Packaging	Test/Analysis Results: No. Tested	Location	Results	Comments
RoGar Chemical and Nuclear Services				
Model R-2	Not Tested		Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials of construction) to test package (Model R-3). All materials and methods of construction were equal to or better than those of the tested packaging.
Model R-3	1	Top cover	Pass	The only effect was a minor dent.
	1	Center of filter	Pass	The only effect was a minor dent.
Model R-4	Not Tested		Pass	Evaluated by analysis and comparison (lid, lid reinforcing angle, bolt size, bolt spacing, container flange, and materials of construction) to test package (Model R-3). All materials and methods of construction were equal to or better than those of the tested packaging.
Rocky Flats SAND Box				
Style 1	1 1 1	Top Side Filter	1 Pass 1 Pass 1 Pass	Other than a minor dent, there was no damage in any instance.
Style 2	1 1 1	Top Side Filter	1 Pass 1 Pass 1 Pass	Other than a minor dent, there was no damage in any instance.

TABLE D-31 (continued)

Specific Packaging	Test/Analysis Results No. Tested	Location	Results	Comments
Rocky Flats SAND Box				
Style 3	1	Top	1 Pass	Other than a minor dent, there was no damage in any instance.
	1	Side	1 Pass	
	1	Filter	1 Pass	
Style 4	1	Top	1 Pass	Other than a minor dent, there was no damage in any instance.
	1	Side	1 Pass	
	1	Filter	1 Pass	
Argonne M-4				
Bin	1	Top	1 Pass	Other than a minor dent, there was no damage in any instance.
	1	Side	1 Pass	
ANL-West				
7A-960	1	Top	1 Pass	Other than a minor dent, there was no damage in any instance.

PENETRATION TEST RESULTS FOR WOODEN BOXES

TABLE D-32

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
ANL-West				
7A-217	1	Top	1 Pass	Only effect was a minor dent in each case.
7A-375	1	Top	1 Pass	
7A-880	1	Top	1 Pass	
7A-995	1	Top	1 Pass	
7A-1315	1	Top	1 Pass	
7A-670	1	Top	1 Pass	
LLNL				
Flush Panel	1	Top	1 Pass	Only effect was a minor dent.
Mound - Configuration A				
MA-1	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	
MA-2	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	
MA-3	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	
MA-4	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	

TABLE D-32 (continued)

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
Mound - Configuration B				
MB-1	Not Tested			Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-2	1	Bottom	1 Pass	Only effect was a minor dent in each case. The bottom was chosen because it was still wet at the time.
	1	Side	1 Pass	
MB-3	Not Tested			Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-4	Not Tested			Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-5	Not Tested			Pass, based on testing of boxes of similar materials and construction methods at weights in excess of those actually required.
MB-6	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	
Mound - Configuration C				
MC-1	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	

TABLE D-32 (continued)

Specific Packaging	Test/Analysis Results No. Tested	Location	Results	Comments
Mound - Configuration C				
MC-2	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	
MC-3	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	
MC-4	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	
MC-5	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	
Mound - Configuration D				
MD-1	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.
MD-2	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.
MD-3	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.
MD-4	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.
MD-5	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.
MD-6	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.

TABLE D-32 (continued)

Specific Packaging	Test/Analysis Results No. Tested	Location	Results	Comments
Mound - Configuration E				
ME-1	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	
ME-2	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	
ME-3	1	Top	1 Pass	Only effect was a minor dent in each case.
	1	Side	1 Pass	
NLO Family of Banded Wooden Boxes				
G-4214	1	Top	1 Pass	Only effect was a minor dent in each case.
G-4245	1	Top	1 Pass	Only effect was a minor dent in each case.
G-4255	1	Top	1 Pass	Only effect was a minor dent in each case.
G-4273	1	Top	1 Pass	Only effect was a minor dent in each case.
G-4292	1	Top	1 Pass	Only effect was a minor dent in each case.

TABLE D-32 (continued)

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
Y-12 Series B				
B-1	1	Top	1 Pass	All packages were water spray tested before testing. Only effect of the penetration test was a minor dent in each case.
	1	Side	1 Pass	
B-2	1	Top	1 Pass	All packages were water spray tested before testing. Only effect of the penetration test was a minor dent in each case.
	1	Side	1 Pass	
B-3	1	Top	1 Pass	All packages were water spray tested before testing. Only effect of the penetration test was a minor dent in each case.
	1	Side	1 Pass	
B-4	1	Top	1 Pass	All packages were water spray tested before testing. Only effect of the penetration test was a minor dent in each case.
	1	Side	1 Pass	
B-5	1	Top	1 Pass	All packages were water spray tested before testing. Only effect of the penetration test was a minor dent in each case.
	1	Side	1 Pass	
B-6	1	Top	1 Pass	All packages were water spray tested before testing. Only effect of the penetration test was a minor dent in each case.
	1	Side	1 Pass	
B-7	1	Top	1 Pass	All packages were water spray tested before testing. Only effect of the penetration test was a minor dent in each case.
	1	Side	1 Pass	
B-8	1	Top	1 Pass	All packages were water spray tested before testing. Only effect of the penetration test was a minor dent in each case.
	1	Side	1 Pass	

TABLE D-32 (continued)

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
Y-12 Picture Frame				
PF-1	1	Top center	1 Pass	Only effect was a minor dent in each case.
	1	Top edge	1 Pass	
PF-2	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.
PF-3	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.
PF-4	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.
PF-5	1	Top center	1 Pass	Only effect was a minor dent in each case.
	1	Top edge	1 Pass	
PF-6	1	Top center	1 Pass	Only effect was a minor dent in each case.
	1	Top edge	1 Pass	
PF-7	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.
PF-8	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.
Rocky Flats RA Series				
Configuration 1	1	Top	1 Pass	Only effect was a minor dent in each case.
Configuration 2	1	Top	1 Pass	

PENETRATION TEST RESULTS FOR FIBERBOARD PACKAGINGS

TABLE D-33

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
12B-65 Fiberboard Boxes				
1	1	Bottom	Pass - No Penetration	Only effect was a minor dent in each case.
	1	Top	Pass - No Penetration	
	1	Side	Pass - No Penetration	
2	1	Side	Pass - No Penetration	
3	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.
4	1	Top	Pass - Penetration	
	1	Side	Pass - Penetration	
5	1	Top	Pass - No Penetration	Only effect was a minor dent.
	1	Side	Pass - No Penetration	
6	1	Top	Pass - Penetration	
	1	Side	Pass - Penetration	
7	1	Top	Pass - No Penetration	Only effect was a minor dent.
		Side	Pass - Penetration	
8	1	Top	Pass - Penetration	
	1	Side	Pass - Penetration	
9	1	Top	Pass - No Penetration	Only effect was a minor dent.
	1	Side	Pass - No Penetration	

TABLE D-33 (continued)

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
12B-65 Fiberboard Boxes				
10	1	Top	Pass - Penetration	
	1	Side	Pass - Penetration	
11	Not Tested			Pass, based on testing of boxes of similar materials and construction methods.
12	1	Top	Pass - Penetration	
	1	Side	Pass - Penetration	
13	1	Top	Pass - No Penetration	
	1	Side	Pass - Penetration	
12B-10 with inner metal can	1	Top	Pass	Bar made 0.5-in. dent in inner can in in each case. A leak check (air) of the can in each case demonstrated continued leak tightness.
		Side	Pass	
Tri-Wall Fiberboard Box	1	Top	Pass - Penetration	
	1	Side	Pass - Penetration	

TABLE D-33 (continued)

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
21C Fiberboard Drums				
1	1	Top	Pass - No Penetration	
	1	Side	Pass - No Penetration	
2	1	Top	Pass - No Penetration	
	1	Side	Pass - No Penetration	
3	1	Top	Pass - No Penetration	
	1	Side	Pass - No Penetration	
4	1	Top	Pass - No Penetration	
	1	Side	Pass - Penetration	
5	1	Top	Pass - No Penetration	
	1	Side	Pass - Penetration	
6	1	Top	Pass - No Penetration	
	1	Side	Pass - No Penetration	

PENETRATION TEST RESULTS FOR UF-6 CYLINDERS

TABLE D-34

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
Model No.				
1S			Evaluated based on the materials and material thicknesses and by comparison to test data shown for much lesser thicknesses. This test would not have any effect (as verified by testing) on the sides of these cylinders. Testing was also conducted to demonstrate that this test, when conducted on the valve assembly/ assembly cover, would also have no effect. Thus, all these cylinders meet this requirement.	
2S				
5A				
8A				
12A				
12B				
30A				
30B				
48G				
48H				
48HX				
48X				
48Y				

PENETRATION TEST RESULTS FOR LIQUIDS AND GASES

TABLE D-35

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
Steel Drum MS-24347-7 (p. F-1)[a]				Pass, based on test data shown on page D-72.
LASL 12B-62 Fiberboard Box	1	Top	Pass - Penetration	The bar did not contact the inner container in either case.
	1	Side	Pass - Penetration	
LLNL Steel Drums with Gas Cylinders (p. F-11)				Pass, based on test data shown on Page D-72.
ORNL Fiberboard Box - Liquids and Solids (p. F-15)	1	Top (center)	1 Pass	A nonpenetrating deformation of the wet cardboard box and a 0.55-in. deep by 0.75-in. diameter indentation in the top of the inner metal can.
ORNL Fiberboard Box - Gases (p. F-20)	1	Top (center)	1 Pass	A nonpenetrating deformation of the wet cardboard box and a 0.55-in. deep by 0.75-in. diameter indentation in the top of the inner metal can.

[a]All page numbers refer to MIM-3245.

TABLE D-35 (continued)

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
ORNL Fiberboard Box - Liquids and Solids (p. F-21)	1	Top (center)	1 Pass	A nonpenetrating deformation of the wet cardboard box and a 0.55-in. deep by 0.75-in. diameter indentation in the top of the inner metal can.
ORNL Wooden Box Returnable, Shielded (p. F-26)	1	Top (center)	1 Pass	Minor, nonpenetrating dent.
ORNL Gas Cylinder Returnable (Hoke Cylinders)				
HOH-50 HOXe-50 HOKr-50 HOH-150 HOXe-150 HOKr-150 HOH-300 HOKr-300 HOH-500 HPKr-500	1	Top (center of protective valve cap)	1 Pass	This test was conducted on the HOKr 1000-mL cylinder (which is not listed), but the results can be used to evaluate the smaller packagings.
ORNL Gas Cylinder Returnable (J. L. Shepard)			Pass	Evaluated based on testing conducted by ORNL, letter dated April 30, 1985, D. M. Ferren/D. A. Edling.
Cylinder 1 Cylinder 2 Cylinder 3				

PENETRATION TEST RESULTS FOR MISCELLANEOUS PACKAGINGS

TABLE D-36

Specific Packaging	Test/Analysis Results			Comments
	No. Tested	Location	Results	
LLNL Old Spec 55	2	Lid bolts	2 Pass	No detectable effect other than a scratch.
ORNL TRU Shipping Container	1 1	Top Side	1 Pass 1 Pass	Only effect was a minor dent in each case.
FEMA Source Over Pack	1	Top	1 Pass	Only effect was a minor scratch.
SNL Tritium Waste Package				Pass, based on test data shown on Page D-72.