9.0 ACCEPTANCE TESTS AND MAINTENANCE PROGRAM

I Review Objective

In this portion of the spent fuel dry cask storage system (DCSS) review, the NRC seeks to ensure that the applicant's safety analysis report (SAR) includes the appropriate acceptance tests and maintenance programs for the system. A clear, specific listing of these commitments will help avoid ambiguities concerning design, fabrication, and operational testing requirements when the NRC staff conducts subsequent inspections.

II. Areas of Review

This chapter of the DCSS Standard Review Plan (SRP) provides guidance for use in evaluating the acceptance tests and maintenance programs outlined in the SAR. The acceptance tests demonstrate that the cask has been fabricated in accordance with the design criteria and that the initial operation of the cask complies with regulatory requirements. The maintenance program describes actions that the licensee needs to implement during the storage period to ensure that the cask continues to perform its intended functions.

As defined in Section V, "Review Procedures," a comprehensive evaluation *may* encompass the following acceptance tests and maintenance programs:

1. acceptance tests
   a. visual and nondestructive examination inspections
   b. structural/pressure tests
   c. leak tests
   d. shielding tests
   e. neutron absorber tests
   f. thermal tests
   g. cask identification
2. maintenance program
   a. inspection
   b. tests
   c. repair, replacement, and maintenance

III. REGULATORY REQUIREMENTS

Regulatory requirements applicable to this portion of the DCSS SRP govern the testing and maintenance of the cask system, resolution of issues concerning adequacy or reliability, and cask identification, as follows:

1. Testing and Maintenance

a. The SAR must describe the applicant's program for preoperational testing and initial operations. [10 CFR 72.24(p)[1]]

b. The cask design must permit maintenance as required. [10 CFR 72.236(g)]

c. Structures, systems, and components (SSCs) important to safety must be designed, fabricated, erected, tested, and maintained to quality standards commensurate with the importance to safety of the function they are intended to perform. [10 CFR 72.122(a), 10 CFR 72.122(f), 10 CFR 72.128(a)(1), and 10 CFR 72.24(c)]

d. The applicant or licensee must establish a test program to ensure that all required testing is performed to meet applicable requirements and acceptance criteria. In addition, at least 30 days before the receipt of spent fuel, the licensee must submit to the NRC a report concerning the pre-operational test acceptance criteria and test results. [10 CFR 72.162 and 10 CFR 72.82(e)]

e. The applicant or licensee must evaluate the cask and its systems important to safety, using appropriate tests or other means acceptable to the Commission, to demonstrate that they will

reasonably maintain confinement of radioactive material under normal, off-normal, and credible accident conditions. [10 CFR 72.236(l)]

f. The applicant or licensee must inspect the cask to ascertain that there are no cracks, pinholes, uncontrolled voids, or other defects that could significantly reduce confinement effectiveness. [10 CFR 72.236(j)]

g. The applicant must perform, and make provisions that permit the Commission to perform, tests that the Commission deems necessary or appropriate. [10 CFR 72.232(b)]

h. The general licensee must accurately maintain the record provided by the cask supplier showing any maintenance performed on each cask. This record must include evidence that any maintenance and testing have been conducted under an NRC-approved quality assurance (QA) program. [10 CFR 72.212(b)(8)]

i. The applicant or licensee must assure that the casks are conspicuously and durably marked with a model number, unique identification number, and the empty weight [10 CFR 72.236(k)]

2. Resolution of Issues Concerning Adequacy or Reliability

The SAR must identify all SSCs important to safety for which the applicant cannot demonstrate functional adequacy and reliability through previous acceptable evidence. For this purpose, acceptable evidence may be established in any of the following ways:

- prior use for the intended purpose
- reference to widely accepted engineering principles
- reference to performance data in related applications

In addition, the SAR should include a schedule showing how the applicant or licensee will resolve any associated safety questions before the initial receipt of spent fuel. [10 CFR 72.24(i)]

3. Cask Identification

The applicant or licensee must conspicuously and durably mark the cask with a model number, unique identification number, and empty weight. [10 CFR 72.236(k)]

IV. Acceptance Criteria

In general, the acceptance tests and maintenance programs outlined in the SAR should cite appropriate authoritative codes and standards. The staff has previously accepted the following as the regulatory basis for the design, fabrication, inspection, and testing of DCSS components:

SYSTEM/COMPONENT	ACCEPTABLE REGULATORY BASIS*
Confinement System	American Society of Mechanical Engineers (ASME), "Boiler and Pressure Vessel (B&PV) Code"[2], Section III, Subsection NB or NC "American National Standard for Radioactive Materials—Leakage Tests on Packages for Shipment" (ANSI N14.5-1987)[3]
Confinement Internals (e.g., basket)	ASME B&PV Code, Section III, Subsection NG
Metal Cask Overpack	ASME B&PV Code, Section VIII
Concrete Cask Overpack	American Concrete Institute (ACI) Standards 318[4] and 349[5], as appropriate

SYSTEM/COMPONENT	ACCEPTABLE REGULATORY BASIS*
Other Metal Structures	ASME B&PV Code, Section III, Subsection NF American Institute of Steel Construction (AISC), "Manual of Steel Construction"[6]
* The SAR should clearly identify any exceptions to the listed codes and standards.	

In addition, in applications for a dry storage independent spent fuel storage installation (ISFSI), the SAR should cite the applicable design criteria (ANSI/ANS-57.9-1984[7]) promulgated by the American National Standards Institute, American Nuclear Society, which the NRC endorsed via Regulatory Guide 3.60[8]. The SAR should clearly identify any exceptions to this standard, by stating an acceptable method of design for a dry storage ISFSI.

V. Review Procedures

The review procedures described in this section are presented in a format intended to facilitate a single, independent review. Although one or more individual(s) may be tasked with preparing the corresponding section of the safety evaluation report (SER) related to the proposed acceptance tests and maintenance program, all review team members should examine the related information presented in the SAR. Reviewers should devote special attention to those tests (or the lack of tests) that affect their functional area of review. If the descriptions included in the SAR are not sufficiently detailed to allow a complete evaluation concerning fulfillment of the acceptance criteria, reviewers should request additional information from the applicant.

In general, applicants commit to design, construct, and test the system under review to the codes and standards identified in SAR Section 2. The NRC does not generally review specific test procedures as part of the licensing process; however, the applicant is expected to describe (in the SAR) certain elements of the proposed test programs. The staff may inspect selected portions of test procedures as part of its onsite activities.

The following information provides *representative examples* of test program elements that should be subject to licensing review. If included in the SAR, each of these tests should be reviewed to ensure that the applicant has identified the purpose of the test, explained the proposed test method (including any applicable standard to which the test will be performed), defined the acceptance criteria and bases for the test, and described the actions to be taken if the acceptance criteria are not satisfied.

1. Acceptance Tests

The following guidance is presented on the basis of tests deemed acceptable by the staff in previous SAR reviews. Alternative tests and criteria may be used if the SAR provides appropriate explanation and adequate justification.

a. Visual and Nondestructive Examination Inspections

Verify the applicant’s commitment to fabricate and examine cask components in accordance with an accepted design standard such as ASME B&PV Code, Section III or VIII. These sections define the examination requirements mentioned in Section II, "Materials Specifications and Properties"; Section V, "NDE Specifications and Procedures"; and Section IX, "Qualification Standard for Welding and Brazing Procedures, Welders, Brazers, and Welding and Brazing Operators." The following guidance assumes that the ASME Code is applicable to the cask being reviewed.

The nondestructive examination (NDE) of weldments must be well-characterized on drawings, using standard NDE symbols and/or notations (see AWS A2.4[9]). Each fabricator should be required to establish and document a detailed, written weld inspection plan in accordance with an approved QA program that complies with 10 CFR Part 72, Subpart G. The inspection plan should include visual (VT), dye penetrant (PT), magnetic particle (MT), ultrasonic (UT), and radiographic (RT) examinations, as applicable. The inspection plan should identify welds to be examined, the examination sequence, type of examination, and the appropriate acceptance criteria as defined by either the ASME code, or an

alternative approach proposed and justified by the applicant. Inspection personnel should be pre-qualified, in accordance with the current revision of SNT-TC-1A[10], as specified by the ASME Code. All weld-related NDE should be performed in accordance with written and approved procedures.

Confinement boundary welds and welds for components associated with redundant sealing, must meet the requirements of ASME Code, Section III, Article NB/NC-5200, "Required Examination of Welds." This section generally requires RT for volumetric examination and either PT or MT for surface examination. The ASME-approved specifications for RT, PT, and MT are detailed in ASME Code, Section V, Articles 2, 6, and 7, respectively.

Acceptance criteria for RT should be in accordance with ASME Code, Section III, Subsection NB/NC, Article NB/NC-5320. Testers should reject unacceptable imperfections (such as a crack, a zone of incomplete fusion or penetration, elongated indications with lengths greater than specified limits, and rounded indications in excess of the limits in ASME Code, Section III, Division 1, Appendix VI). Repaired welds should be reexamined in accordance with the original examination method and associated acceptance criteria.

For confinement welds that cannot be volumetrically examined using RT, the licensee may use 100-percent UT. The ASME-approved UT specifications are detailed in ASME Code, Section V, Article 5. Acceptance criteria should be defined in accordance with NB/NC-5330, "Ultrasonic Acceptance Standards." Cracks, lack of fusion, or incomplete penetration are unacceptable, regardless of length.

The NRC has accepted multiple surface examinations of welds, combined with helium leak tests for inspecting the final redundant seal welded closures.

For confinement internals, the licensee should perform all NDE testing in accordance with ASME Code, Section III, Subsection NG.

Nonconfinement welds (which exclude welds of confinement internals) should meet the requirements of ASME Code, Section III, Subsection NF, or Section VIII, Division 1, as applicable. The required volumetric examination of welds is either RT or UT, as discussed in ASME Code, Section III, NF-5200, and Section VIII, UW-11. The appropriate specifications from ASME Code, Section V, are invoked in Article 2 for RT and in Article 5 for UT. Acceptance standards for RT are detailed in ASME Code, Section III, Subsection NF, NF-5320, "Radiographic Acceptance Standards," and for UT in NF-5330, "Ultrasonic Acceptance Standards." For Section VIII weldments, RT acceptance criteria should be in accordance with ASME Code, Section VIII, Division 1, UW-51, and the repair of unacceptable defects should be in accordance with UW-38. Repaired welds should be reexamined in accordance with the original acceptance criteria.

Nonconfinement welds that cannot be examined using RT should undergo UT in accordance with ASME Code, Section V, Article 5. Acceptance criteria should be in accordance with ASME Code, Section VIII, Division 1, UW-53 and Appendix 12, and the repair of unacceptable defects should be in accordance with UW-38. Repaired welds should be reexamined in accordance with the original examination methods and associated acceptance criteria. If applicable, the SAR should also justify the rationale for not requiring RT examination of these welds.

Nonconfinement welds for cask system components that are designed and fabricated in accordance with ASME Code, Section III, that cannot be examined using RT or UT should undergo PT or MT examination in accordance with ASME Code, Section V, Articles 6 and 7, respectively. Acceptance criteria should be in accordance with Articles NF-5350 and NF-5340, respectively. Repaired welds should be reexamined in accordance with the original acceptance criteria. If applicable, the SAR should also justify the rationale for not requiring volumetric inspection techniques (RT or UT) for these welds.

Finished surfaces of the cask should be visually examined in accordance with the ASME Code Section V, Article 9. For welds examined using VT, the acceptance criteria should be in accordance with ASME Code, Section VIII, Division 1, UW-35 and UW-36, or NF-5360, "Acceptance Standards for Visual Examination of Welds".

The licensee should use PT to detect discontinuities (such as cracks, seams, laps, laminations, and porosity) that open to the surface of nonporous metals. PT should be performed in accordance with ASME Code, Section V, Article 6. Acceptance criteria for confinement welds should be in accordance with ASME Code, Section III, Subsection NB/NC, Article NB/NC-5350. Repair procedures should be in

accordance with NB/NC-4450. Acceptance criteria for Nonconfinement welds should be in accordance with ASME Code, Section VIII, Division 1, Appendix 8, or NF-5350, "Liquid Penetrant Acceptance Standards." Repair procedures should be in accordance with ASME Code, Section VIII or NF-2500, "Examination and Repair of Material," and NF-4450, "Repair of Weld Material Defects."

Fabrication controls and specifications should be in-place and field tested to prevent post-welding operations (such as grinding) from compromising the design requirements (such as wall thickness).

b. Structural/Pressure Tests

Lifting trunnions should be fabricated and tested in accordance with ANSI N14.6[11]. Site-specific details of the spent fuel pool and lifting procedures may enable the cask to be considered a non-critical load, as defined by this standard. Generally, however, the cask is considered a critical load during its handling in the spent fuel pool. Consequently, trunnion testing should be performed at a minimum of 150 percent of the maximum service load, if redundant lifting is employed or 300 percent of the service load if non-redundant lifting applies. These load tests should be performed before filling the cask with spent fuel to ensure that the trunnions and cask are conservatively constructed and provide an adequate margin of safety when filled with spent fuel. Trunnion load testing should also be performed annually for the transfer cask and at least one year before use for the storage cask. Load testing of integral trunnions is not required once the loaded storage cask has been placed on the pad. Restrictions on cask lifting resulting from these tests should be included in Section 12 of both the SAR and the related safety evaluation report (SER) prepared by the NRC staff, and SAR Section 9 should explicitly state the testing values.

The confinement boundary (including that of the redundant seal) should be hydrostatically tested to 125 percent of the design pressure, in accordance with ASME Code, Section III, Article NB-6000. (Article NCA-2142.1, defines the design pressure as it applies to Level A Service Limits. As such, in determining the design pressure, the licensee should consider fission gas release from 1 percent of the fuel rods.) The test pressure should be maintained for a minimum of 10 minutes, after which a visual inspection should be performed to detect any leakage. All accessible welds should be inspected using PT. Any evidence of cracking or permanent deformation should constitute cause for rejection. SAR Section 9 should clearly specify the hydrostatic test pressure.

Some casks contain a neutron shielding material that may off-gas at higher temperatures. Such material is usually contained inside a thin steel shell to prevent loss of mass and provide protection from minor accidents and natural phenomenon events. Rupture disks or relief valves are generally provided to prevent catastrophic failure of this shell. The shell should be tested to 125 percent of the rupture disk burst pressure, which is usually equivalent to 125 percent of the shell design pressure. The SAR should clearly specify the burst pressure for the rupture disk, along with its coincident burst temperature and tolerance on burst pressure.

Some cask designs use ferritic steels that are subject to brittle fracture failures at low temperature. ASME Code, Section II, Part A, contains procedures for testing ferritic steel used in low temperature applications. On the basis of guidance in NUREG/CR-1815[12], Section 5.1.1, the NRC established two methods for identifying suitable materials:

- The nil ductility temperature (NDT) must be determined by either direct measurement (ASTM E-208[13]) or indirect measurement (ASTM E-604[14]), and the minimum operating temperature of the steel must be specified as 50 °F [(28 °C)] higher than the NDT.

- The NRC staff accepts ASME Charpy testing procedures for verification of the material's minimum absorbed energy. Acceptable energy absorption values and test temperatures of Charpy, V-Notch impact tests are listed in the ASME B&PV code Section II, SA-20, "Specifications for General Requirements for Steel Plates for Pressure Vessels" Table A1.15. Coordinate with the thermal review (Chapter 4 of this SRP) to ensure that the applicant selected the correct temperatures for the tests and that the SAR specifies the method of testing.

c. Leak Tests

The licensee should perform leak tests on all boundaries relevant to confinement. These include the primary confinement boundary, the boundary of the redundant seal, and (if applicable) any additional boundaries used in the pressure monitoring system. For all-welded cask confinements, the NRC staff has,

with adequate justification, considered it acceptable for licensees to omit leak testing of the second cask closure weld and the seal welds for the closure plates of the purge and vent valves. For such cases, leak testing must show that the inner closure weld meets the leakage limits.

Leakage criteria in units of std cc/s must be at least as restrictive as those specified in the principal design criteria (in SAR Section 2). The SAR should also indicate the general testing methods (e.g., pressure increase, mass spectrometer) and required sensitivities. If cask closure depends on more than one seal (e.g., lid, vent port, drain port), the leakage criteria should ensure that the total leakage is within the design requirements. Leak testing should generally be conducted in accordance with ANSI N14.5.

d. Shielding Tests

Tests of the effectiveness of both the gamma and neutron shielding may be required if, for example, the cask contains a poured lead shield or a special neutron absorbing material. In such instances, the SAR should describe any scanning or probing with an auxiliary source for the purpose of characterizing the shielding. This shield testing should be done for every cask that uses poured shielding material, in order to demonstrate proper fabrication in accordance with the design drawings. The suggested shield test applies equally to both storage and transfer casks.

In addition to the above tests, the licensee should perform dose rate measurements after the spent fuel is loaded, in order to establish that the stated design criteria have been satisfied.

e. Neutron Absorber Tests

The licensee should test fixed neutron absorbers designed to ensure subcriticality, in order to verify the minimum areal density (or other applicable specification) used in the criticality analysis in SAR Section 6. Either the material manufacture or cask fabricator should perform this verification of minimum areal density on a per lot basis.

f. Thermal Tests

Depending on the details of the cask design and the ability to determine its heat removal capability through thermal analysis, testing may be required to verify cask performance. The applicant should establish acceptance criteria on the basis of the conditions of the test (e.g., test heat loading, ambient conditions). The SAR should discuss the correlation between test performance and actual spent fuel loading conditions, in order to avoid ambiguous or unreviewed analysis after the test data are obtained.

g. Cask Identification

The vendor/licensee must mark the cask with a model number, unique identification number, and empty weight. Generally this information will appear on a data plate, which should be detailed in one of the drawings included in SAR Section 1. In addition, vendor/licensee should mark the exterior of shielding casks or other structures that may hold the confinement cask while it is in storage. This marking should provide a unique, permanent, and visible number to permit identification of the cask stored therein.

2. Maintenance Program

Storage casks are typically designed to require minimal maintenance. The SAR should address the following areas, as applicable:

a. Inspection

Usually, the cask has at least one monitoring system (e.g., pressure, temperature, dosimetry). The SAR should discuss how such systems will be used to provide information regarding possible off-normal events and what surveillance actions may be necessary to ensure that these systems function properly. Detailed procedures will be developed and implemented by the licensee at the site.

The SAR should describe routine periodic visual surface and weld inspections, which should be limited to the readily accessible surfaces (i.e., the exterior surface of the storage cask and all surfaces of empty transfer casks). In addition, the SAR should discuss inspection of lifting and rotating trunnion load-bearing surfaces.

b. Tests

The SAR should describe any periodic tests of cask components or calibration of monitoring instrumentation, as well as periodic tests to verify shielding and thermal capabilities. The SAR should also describe procedures for any applicable periodic testing of neutron poison effectiveness. As an alternative to periodic testing of neutron poison effectiveness, the licensee could perform an environmental qualification of the material.

In addition, the SAR should discuss any routine testing of support systems (e.g., vacuum drying, helium backfill, and leak testing equipment).

c. Repair, Replacement, and Maintenance

The SAR should discuss the repair and replacement of cask components, as may be required during the lifetime of the storage and transfer casks. This discussion should include methods of repair or replacement, testing procedures, and acceptance criteria. The SAR should also describe procedures for routine maintenance (such as lubrication and re-application of corrosion inhibiting materials in the event of scratches) through the expiration of the service life of the equipment. Such information is also often included in SAR Section 11, which describes actions to be taken following an off-normal event or accident condition.

VI. Evaluation Findings

Review the 10 CFR Part 72 acceptance criteria and provide a summary statement for each. These statements should be similar to the following model, as applicable:

- Section(s) _____ of the SAR describe(s) the applicant's proposed program for preoperational testing and initial operations of the [cask designation]. Section(s) _____ discuss the proposed maintenance program.

- Structures, systems, and components (SSCs) important to safety will be designed, fabricated, erected, tested, and maintained to quality standards commensurate with the importance to safety of the function they are intended to perform. Section _____ of the SAR identifies the safety importance of SSCs, and Section(s) _____ present(s) the applicable standards for their design, fabrication, and testing.

- The applicant/licensee will examine and/or test the [cask designation] to ensure that it does not exhibit any defects that could significantly reduce its confinement effectiveness. Section(s) _____ of the SAR describe(s) this inspection and testing.

- The applicant/licensee will mark the cask with a data plate indicating its model number, unique identification number, and empty weight. Drawing _____ in SAR Section _____ illustrates and/or describes this data plate.

- The staff concludes that the acceptance tests and maintenance program for the [cask designation] are in compliance with 10 CFR Part 72 and that the applicable acceptance criteria have been satisfied. The evaluation of the acceptance tests and maintenance program provides reasonable assurance that the cask will allow safe storage of spent fuel throughout its licensed or certified term. This finding is reached on the basis of a review that considered the regulation itself, appropriate regulatory guides, applicable codes and standards, and accepted practices.

VII. References

1.*U.S. Code of Federal Regulations*, Part 72, " Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste," Title 10, "Energy,"

2.American Society of Mechanical Engineers, "Boiler and Pressure Vessel Code," Sections II, III, V, VIII, and IX, 1992.

3.American National Standards Institute, Institute for Nuclear Materials Management, "American National Standard for Radioactive Materials Leakage Tests on Packages for Shipment," ANSI N14.5, January 1987.

4.American Concrete Institute, "Code Requirements for Structural Plain Concrete," ACI-318.

5.American Concrete Institute, "Code Requirements for Nuclear Safety Related Concrete Structures," ACI-349.

6.American Institute of Steel Construction, "Manual of Steel Construction."

7.American National Standards Institute, American Nuclear Society, "Design Criteria for an Independent Spent Fuel Storage Installation (Dry Storage Type)," ANSI/ANS-57.9, 1984.

8.U.S. Nuclear Regulatory Commission, "Design of an Independent Spent Fuel Storage Installation (Dry Storage)," Regulatory Guide 3.60, March 1987.

9.American Welding Society, "Standard Symbols for Welding, Brazing, and Nondestructive Examination," AWS A2.4, 1993.

10.American Society for Nondestructive Testing, "Personnel Qualification and Certification in Nondestructive Testing ," Recommended Practice No. SNT-TC-1A, December 1992.

11.American National Standards Institute, Institute for Nuclear Materials Management, "American National Standard for Radioactive Materials—Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 Kilograms) or More," ANSI N14.6, September 1986.

12.W.R. Holman and R.T. Langland, Lawrence Livermore Laboratory, "Recommendations for Protecting Against Failure by Brittle Fracture in Ferritic Steel Shipping Containers Up to Four Inches Thick," NUREG\CR-1815, August 1981.

13.American Society for Testing and Materials, "Method of Conducting Drop Weight Test to Determine Nil-Ductility Transition Temperature for Ferritc Steel ," ASTM E-208.

14.American Society for Testing and Materials, "Dynamic Tear Testing of Metallic Materials," ASTM E-604.