Spent Fuel Project Office
Interim Staff Guidance - 4, Revision 1

Issue: **Cask Closure Weld Inspections**

Discussion:

The closure weld for the outer cover plate for austenitic stainless steel designs may be inspected using either volumetric or multiple pass dye penetrant techniques subject to the following conditions:

- Dye penetrant (PT) examination may only be used in lieu of volumetric examination only on austenitic stainless steels. PT examination should be done in accordance with ASME Section V, Article 6, "Liquid Penetrant Examination."

- For either ultrasonic examination (UT) or PT examination, the minimum detectable flaw size must be demonstrated to be less than the critical flaw size. The critical flaw size should be calculated in accordance with ASME Section XI methodology; however, net section stress may be governing for austenitic stainless steels, and must not violate Section III requirements. Flaws in austenitic stainless steels are not expected to exceed the thickness of one weld bead.

- If PT examination alone is used, at a minimum, it must include the root and final layers and sufficient intermediate layers to detect critical flaws.

- The inspection of the weld must be performed by qualified personnel and shall meet the acceptance requirements of ASME B&PV Code Section III, NB-5350 for PT examination and NB-5332 for UT examination.

- If PT examination alone is used, a design stress-reduction factor of 0.8 must be applied to the weld design.

- The results of the PT examination, including all relevant indications, shall be made a permanent part of the licensee's records by video, photographic, or other means providing a retrievable record of weld integrity. Video or photographic records should be taken during the final interpretation period described in ASME Section V, Article 6, T-676.

Technical Basis:

Radiographic (RT) inspection is preferred for cask closure welds. However, RT may not be practical for field closure welds with fuel in the cask. UT is the next preferred inspection method but UT of stainless steel welds for the closure configurations may pose considerable difficulty and uncertainty. UT has only recently been demonstrated for carbon steel for the VSC-24 cask design. PT examination only identifies surface flaws but, if performed at sufficiently small weld depths, can provide reasonable assurance of weld integrity. The position recognizes both UT and multi-layered PT examination as acceptable methods; however UT is still preferred where practical.

Acceptable UT has not yet been demonstrated for austenitic stainless steels in the required configuration. At best, UT that would be developed may require considerable skill in execution and interpretation. Minimum detectable flaw sizes for UT will be relatively large (estimated 0.1 inch deep) and the technique is subject to false indications which may require grinding out weld material unnecessarily. This additional grinding may introduce additional weld integrity problems and may present ALARA issues. Although the setup for the UT would be expensive, cost could be spread over multiple containers to reduce unit cost.

PT examination only identifies surface flaws. However, the acceptance standard is no cracks or linear indications. In theory, a flaw slightly smaller than the PT examination increment size could exist, therefore, layered PT examination is necessary to assure detectable flaw sizes are less than critical flaw size. PT examination is widely used in safety critical applications such as certain reactor pressure vessel welds and, for some applications is the only practical technique. ALARA issues may arise for large welds that require multiple PT examinations.

Austenitic stainless steels do not have a nil ductility transition temperature. Thus, the weld can sustain "large" flaws without a concern for flaw growth. This allows the use of either UT or PT examination although both would have limitations on detectable flaw size and both would accept less than critical flaws.

Finally, the Nuclear Regulatory Commission (NRC) regulates to the standard of adequate protection, not absolute assurance. Although UT is the preferred technique to PT examination, in that it is a volumetric examination, PT examination is considered to be adequate for safety, specifically for austenitic stainless steels in that it can provide reasonable assurance that flaws of interest will be identified. This position does not apply to carbon steel construction.

Recommendation:

1. The ISG is specifically developed for the dry storage canister top end closure weld after the canister is loaded with spent nuclear fuel assemblies. All other dry storage canister bottom end closure welds and shell welds should be designed, fabricated, examined, and tested to the requirements of the appropriate subsections of the ASME Section III Code.

2. The top end closure welds are leak tested. No hydrostatic or pressure tests are required if a minimum margin of safety equal to or greater than 1.5 against design pressure was demonstrated by analysis.

3. The closure weld joint may be either a full thickness penetration weld or a partial penetration groove weld. For a partial penetration groove weld, the maximum clearance between the closure plate and the enclosure shell should not exceed 1/16 inch and the minimum depth of the groove shall be equal to or larger than the enclosure shell thickness. The weld strength of the closure joint is based on the nominal weld area and the design stress intensity values for the weaker of the two materials jointed. However, the minimum ultimate tensile strength of the weld metal should equal or exceed the base metal strength to preclude weld metal failure.

4. Dry storage canisters made from austenitic stainless steels Type 304, 304L, 304LN, 316, 316L, or 316LN , the top end closure weld may be examined by either the ultrasonic methods (UT) or progressive PT examination as follows:

a. If UT examined, the UT acceptance criteria are the same as those of NB-5332 for pre-service examination.

b. If PT examined, the examination should be performed progressively on the root layer, the lesser of one half of the welded joint thickness, or ½ inch intervals thereafter, and the final surface. In addition, a stress reduction factor of 0.8 shall be applied to the weld strength of the joint.

5. Dry storage canisters made from austenitic stainless steels other than Type 304 or 316 listed above, may be PT examined as in 4.b above, except that the size and number of intermediate layers to be examined should be determined by a fracture mechanics assessment of the weld considering the specific geometry, material properties, and loadings.

6. For dry storage canisters made from ferritic steels, the top end closure weld should be examined by UT.

a. Based on service temperature, material properties, and critical design stress values, determine the critical flaw size by the linear elastic fracture mechanics methodology specified in ASME Code, Section XI.

b. UT must be performed in accordance with pre-qualified procedures and methods. The UT examination methodology should demonstrate to be reasonably accurate and consistently able to detect flaw size less than the critical flaw size determined in 6.a. The UT operators are tested and certified. Welding processes, weld inspection criteria, and personnel qualifications should be verified as being in conformance with the ASME Code. The welding process and technique used should be evaluated to preclude hydrogen induced cracking.

c. Progressive surface examinations, utilizing PT or magnetic particle examination (MT), should be permitted only if unusual design and loading conditions exist. PT or MT must be performed after sufficiently small intervals to ensure the critical flaws will be detected. In addition, a stress reduction factor of 0.8 is imposed on the weld strength of the closure joint to cover imperfections or flaws potentially missed by progressive surface examinations. Because of brittle fracture concerns in ferritic steels, critical flaw sizes for ferritic steels are generally small. Therefore, PT or MT must be performed on many layers of the weld and it may become unacceptable due to ALARA concerns. The weld design should show a sufficient safety margin and should be approved by the NRC on a case-by-case basis.

The Standard Review Plans should be revised to clearly state the inspection criteria for spent fuel cask's outer cover plate closure welds.

Approved ____

E. William Brach **Date**