

1 DRAFT FOR REVIEW
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3 **Division of Spent Fuel Storage and Transportation**
4 **Interim Staff Guidance - ISG-18, Rev. 1**
5

6
7 **Issue:** The Design and Testing of Lid Welds on Austenitic Stainless Steel Canisters as
8 Confinement Boundary for Spent Fuel Storage
9

10 **Introduction:**
11

12 The purposes of this ISG are to address the design and testing of the various closure welds
13 (“lid welds”) associated with the redundant closure of all-welded austenitic stainless steel
14 canisters:
15

16 As an acceptable confinement boundary under 10 CFR Part 72.236(e) (Ref. 1) for
17 purposes of demonstrating no credible leakage of radioactive material during storage
18 and satisfying the dose limits under normal and off normal conditions in 10 CFR Parts
19 72.104(a) and 72.106(b).
20

21 This staff guidance is not a regulatory requirement. Instead, it is a specific staff approved
22 design or method which meets applicable regulatory requirements. It is provided to reduce
23 applicant burden and staff review effort. Use of this guidance by applicants is optional. Other
24 means for satisfying the appropriate regulatory requirements may be proposed for staff review.
25 However, deviation from this guidance in whole or in part may result in more lengthy staff
26 review schedules.
27

28 **Discussion:**
29

30 10 CFR 72.236(e) states: “The spent fuel storage cask (*note: also called “canister”*) must be
31 designed to provide redundant sealing of confinement systems.” For a bolted lid canister
32 design, the staff has accepted a dual seal arrangement as meeting the intent of this regulation.
33 For a welded canister design, the staff has accepted closure designs employing redundant lids
34 or covers, each with independent field welds. Thus, for either closure type, bolted or welded, a
35 potential leak path must breach two independent seals or welds, sequentially, before the
36 confinement system would be compromised.
37

38 The construction codes specify the types of non-destructive examinations (NDE) required for
39 the confinement boundary during canister fabrication and loading operations. In addition to the
40 code required NDE, a helium leakage test of the confinement boundary is considered
41 necessary to satisfy regulatory requirements. Whereas bolted lid canister designs incorporate
42 a helium monitoring system during storage, the welded closure designs must rely on weld
43 integrity to assure continued confinement effectiveness. Consequently, at least one of the
44 redundant welded closures must be helium leakage tested per the method of ANSI N 14.5 (Ref.
45 2), with one exception permitted.
46

47 When the large, multi-pass weld joining the canister shell to the structural lid of an austenitic

48 stainless steel spent fuel canister is executed and examined consistent with the guidance
49 provided in ISG-15 (Ref. 3), the staff has reasonable assurance that no flaws of significant size
50 will exist such that they could impair the structural strength or confinement capability of this
51 weld. For a spent nuclear fuel canister, such a flaw would be the result of improper fabrication
52 or welding technique, as service-induced flaws under normal and off-normal conditions of
53 storage are not credible. Any such fabrication flaw would be reasonably detectable during the
54 in-process and post-weld examination techniques described by ISG-15.

55
56 Based on evaluation, the described techniques of ISG-15 should detect any such flaw which
57 could lead to a failure or credible leakage of radioactive material. Therefore, the staff believes
58 that there is reasonable assurance that no credible leakage of radioactive material would occur
59 through the structural lid to canister shell weld of an austenitic stainless steel canister, and that
60 helium leakage testing of this specific weld is unnecessary provided the weld is executed and
61 examined in accordance with ISG-15.

62
63 Conversely, it is the staff position that other welds associated with the lid assemblies of spent
64 fuel canisters must be subject to the helium leakage test of ANSI N 14.5, in addition to the
65 ASME Code (Ref. 4) required pressure test and surface NDE in order to demonstrate
66 compliance with 10 CFR 72.236. This revision to ISG-18 expands the guidance to address all
67 welds associated with the redundant closures of a spent fuel canister and describes how each
68 individual closure weld must be considered from the overall design and testing standpoint.

69
70 Note that the criteria of ISG-15 outlined above does not supercede the flaw acceptance criteria
71 of any construction code. Instead, this criteria is used to establish the maximum allowable weld
72 deposit depth before an in-process penetrant test (PT) examination is required.

73 74 Helium Leakage Test

75
76 The helium leakage test was established to provide assurance that:

- 77
78 1. No leakage occurred after the closure welds of the cask system were executed. This
79 was viewed as necessary since no active or passive methods are employed to confirm
80 or monitor the presence of helium within an all-welded spent fuel canister over its
81 licensed lifetime. "No leakage" in this case means measured leakage rate performed
82 per ANSI N14.5, at a predetermined sensitivity that shows hypothetical doses would not
83 exceed 10 CFR Part 72 limits.
 - 84
85 2. If the weld(s) meets the criteria of ANSI N14.5, the staff has assurance that radio
86 nuclide leakage would not exceed the regulatory dose limits in 10 CFR Parts 72.104 and
87 72.106.
 - 88
89 3. No oxygen in-leakage could occur, thereby assuring the presence of the inert helium
90 atmosphere which prevents oxidation and corrosion induced degradation of the spent
91 fuel assemblies and enhances cooling of the spent fuel.
- 92

93 This revision adds discussion and staff review guidance for the:

- 94
- 95 1. Helium leakage test for closure welds.
- 96 2. Design and examination criteria to be met before any closure weld may be exempted from
- 97 the helium leakage test.
- 98 3. Criteria for helium leakage testing any closure weld which may be pressurized during the
- 99 welding process.
- 100 4. ASME Code, Section III, hydrostatic test requirement.
- 101 5. ASME Code Case N-595.
- 102 6. Criteria for limiting root pass thickness.

103

104 **Technical Review Guidance:**

105

106 General Guidance

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108 The staff should verify that the cask design under review is in compliance with the guidance of

109 this document.

- 110
- 111 1. This guidance only applies to canisters of all-welded construction, fabricated from austenitic
- 112 stainless steel, employing redundant welds for the confinement closure.
- 113
- 114 2. The welded canister (i.e., the confinement boundary) must be leakage tested in accordance
- 115 with ANSI N14.5-1997 and ISG-15, except as specified by this guidance.
- 116
- 117 3. Closure welds must conform with the guidance of ISG-15, and/or the guidance of this
- 118 instruction, as appropriate.
- 119
- 120 4. "Structures, systems, and components important to safety must be designed..... to
- 121 withstand postulated accidents." [10 CFR 72.122(b)].
- 122
- 123 5. Records documenting the lid welds shall comply with the provisions of 10 CFR Part 72.174,
- 124 "Quality Assurance Records," and ISG-15. Records storage should comply with ANSI
- 125 N45.2.9, "Requirements for Collection, Storage, and Maintenance of Quality Assurance
- 126 Records for Nuclear Power Plants" (Ref. 5).
- 127
- 128 6. Activities related to inspection, evaluation, documentation of fabrication, and lid welding
- 129 shall be performed in accordance with an NRC-approved quality assurance program as
- 130 required in 10 CFR Part 72, Subpart G, "Quality Assurance."

131

132 Specific Guidance

133

134 Helium Leakage Test - Exemption for Large, Multi-pass Welds

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136 In order for any closure weld to be exempt from the helium leakage testing to demonstrate

137 compliance with 10 CFR 72.236, the staff should verify that all of the following conditions are

138 satisfied:

- 139 1. The weld must be multi-pass, with a minimum weld depth comprised of at least 3 distinct
140 weld layers.
- 141
- 142 2. Each layer of weld may be composed of one or more adjacent weld beads.
- 143
- 144 3. The layer must be complete across the width of the weld joint.
- 145
- 146 4. If only 3 weld layers comprise the full thickness of the weld, each layer must be PT
147 examined.
- 148
- 149 5. For more than 3 weld layers, not all weld layers need be PT examined. The maximum weld
150 deposit depth allowed before a PT examination is necessary is based upon flaw-tolerance
151 calculations in accordance with ISG-15. Note: This criteria does not supercede the flaw
152 acceptance criteria of any construction code. Instead, this criteria is used to establish the
153 maximum allowable weld deposit depth before an in-process PT examination is necessary.
- 154
- 155 6. Regardless of conditions (4) or (5) above, at least 3 different weld layers must be examined,
156 e.g. the root pass, a mid-layer, and the cover pass.
- 157
- 158 7. The weld cannot have been executed under conditions where the root pass might have
159 been subjected to pressurization from the helium fill in the canister itself. When executing
160 vent and drain connection cover plate welds, it should never be assumed that the fill and
161 drain closure valves, quick-disconnects, or similar, are leak tight. It is assumed that
162 mechanical closure devices (e.g. a valve or quick-disconnect) permit helium leaks. Practical
163 experience has shown that such leaks occur and have been responsible for causing leak
164 paths through the weld. Consequently, welds potentially subjected to helium pressure (by
165 way of leakage through a mechanical closure device) during the welding process must be
166 subsequently helium leakage tested.

167 Helium Leakage-Testing of the Confinement Boundary

168 The redundant weld requirement for the confinement system closure creates two closure
169 boundaries. The staff should verify that at least one of the redundant boundaries is helium
170 leakage tested, or, some closure welds leakage tested and the remaining closure welds of the
171 same boundary designed so that the "large weld" exemption criteria of this guidance are met.
172 Only a boundary which is testable or excluded from testing, per this guidance, should be
173 considered the confinement boundary of the redundant closures. Refer to sketches A and B
174 and the following narrative for application of this criteria to two currently approved designs:
175
176

177 Leakage Testing a Single Lid With Cover Plate Design - Sketch A.

178 In sketch A, the dotted line marked (1) defines one closure boundary. Starting on the left side of
179 the sketch, the closure boundary can be traced from the canister wall, up through the large,
180 multi-pass weld joining the canister wall to the heavy section, combined shield and structural lid.
181 The boundary continues through the lid to the small weld joining the heavy lid to the vent-and-
182 drain port closure plate, and back to the heavy lid again. The remainder of the boundary (and
183 sketch) is assumed to be symmetrical with or similar to the half-sketch portion that is shown, for
184
185

186 all cases.

187

188 This boundary demonstrates confinement integrity by means of the large weld exemption
189 criteria for one weld and by helium leakage testing the small cover plate weld.

190

191 The large, canister-shell-to-lid weld is exempted from the helium leakage test. This is because
192 the canister shell to lid weld is a large, multi-pass weld meeting the flaw tolerance and other
193 guidance of ISG-15 and the appropriate portions of this guidance. Note that this weld is
194 executed prior to filling the canister with helium (excluding purging/welding gas).

195

196 Before the remaining welds of this first closure boundary are executed, the canister is drained,
197 dried, purged, and filled with helium to the design operating pressure. The helium line
198 connection is closed off and the cover plate fitted and welded into place. Since the cover plate
199 weld may have potentially been pressurized from underneath due to assumed leakage from the
200 closure valve, it must be helium leakage tested in accordance with the methods described in
201 ANSI N14.5-1997. If there are other cover plates and welds, they would also be helium leakage
202 tested.

203

204 This completes the first closure boundary. Note again that one weld was exempted from the
205 helium leakage test by the design criteria. The other weld was leakage tested. Thus, this
206 closure boundary demonstrates compliance with regulatory requirements and is consistent with
207 the staff guidance by ensuring at least one of the two redundant closure boundaries is leakage
208 tested or exempted from leakage testing by conformance with the large-weld exemption
209 guidance. This boundary thus also qualifies as the confinement boundary.

210

211 The second boundary, delineated by line 2 in diagram A, can be traced from the canister wall
212 on the left side of the sketch up through the cover plate fillet weld joining the canister wall to the
213 structural lid cover plate. The boundary continues through the cover plate to the fillet weld
214 joining the cover plate to the canister lid. The weld joining the cover plate to the canister wall
215 and lid cannot be helium leakage tested since there is no feasible means to do so. However,
216 since the first closure boundary, delineated by line 1, was tested (or exempted thru design), the
217 need to helium leakage test at least one of the closure boundaries has been satisfied. Since
218 this second boundary does not meet all the criteria for a confinement boundary, it may not be
219 designated as the confinement boundary. The first closure is thereby the confinement
220 boundary in this design, as it meets all the applicable criteria for a confinement boundary.

221

222 Leakage Testing a Dual Lid Design - Sketch B

223

224 In sketch B, the dotted line marked (1) defines one of the redundant closure boundaries. It may
225 be traced from the canister wall on the left side of the sketch. The boundary proceeds through
226 the partial penetration weld joining the canister wall to the shield lid and into the shield lid. It
227 continues through the small fillet weld joining the vent/drain port cover plate, the cover plate,
228 and back through the same fillet weld to the shield lid.

229

230 This closure boundary may satisfy the leakage test guidance by several methods, depending on
231 details of the weld design. The canister shell to shield lid weld may be designed several ways.
232 The weld may be a small seal weld which would necessitate subsequent helium leakage

233 testing. Conversely, it could be a large, multi-pass weld consistent with the guidance of ISG-15.
234 In that case, the weld would qualify for the leakage test exemption. Either way, note that this
235 weld (canister to shield lid weld) is executed prior to filling and pressurizing the canister with
236 helium (use of purge or backing gas for welding operations is not considered filling or
237 pressurizing).
238

239 Next, the canister is drained, dried, purged, and filled with helium to the design operating
240 pressure. The helium line connection is closed off. The cover plate is fitted and welded into
241 place. Since this weld may potentially be pressurized from underneath due to assumed
242 leakage through the closure valve, it must be helium leakage tested regardless of weld size
243 (thickness).
244

245 This completes the first closure boundary. Note that one weld was either tested, or, exempted
246 from the helium leakage test by the design criteria. The other weld was leakage tested. Thus,
247 this closure boundary demonstrates compliance with regulatory requirements and is consistent
248 with staff guidance by ensuring at least one of the two redundant closures is leakage tested or
249 exempted by conformance to the exemption guidance of ISG-15. This closure may therefore
250 be designated as the confinement boundary.
251

252 The secondary boundary, delineated by line 2 in sketch B, can be traced from the canister wall
253 on the left side of the sketch up through the canister wall-to-structural lid weld and into the
254 structural lid.
255

256 The weld joining the canister wall and structural lid cannot be helium leakage tested because
257 helium is not present. Note, however, that this weld complies by design with the criteria of
258 ISG-15 due to its size, structural requirements and weld examination requirements of the
259 governing construction code.
260

261 In this case the second closure also qualifies for designation as the confinement boundary
262 because the single large weld involved may be exempted from the helium leakage test per the
263 guidance of ISG-15. In this design, the designer therefore has the freedom to designate either
264 of the redundant closures as the confinement boundary. Only one of the two closures is
265 designated as the confinement boundary.
266

267 Hydrostatic Testing

268

269 Closure welds must be hydrostatically or pneumatically tested in accordance with ASME Code
270 Section III requirements to the extent practicable. The two designs discussed above meet this
271 criteria.
272

273 ASME Code Case N-595-4

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275 ASME Code Case N-595-4 (and all earlier versions) (Ref. 6) is not endorsed by the NRC staff,
276 per Regulatory Guide (RG) 1.193 (Ref. 7), and consequently is not permitted as an alternative
277 to the Code requirements.
278

279 Criteria for Limiting Root Pass Thickness

280 Cask lid welding is governed in part by the limiting flaw size analysis, per the guidance in
281 ISG-15. The method prescribed in ISG-15 controls the depth of weld deposit for the
282 intermediate passes before the required PT examination is performed. However, the root pass
283 thickness is not addressed by the guidance of ISG-15, as a single layer root pass was
284 assumed. Occasionally, multi-layer root passes are employed to smooth the weld surface to
285 avoid false positives from the PT.
286

287 A multi-layer root pass is acceptable provided the same method of limiting the weld deposit
288 depth is followed as for the intermediate weld passes. Stress analysts should note that the
289 intermediate layer critical flaw size calculation assumes a buried flaw, not a surface connected
290 flaw. For the root pass calculation, a surface connected flaw must be assumed. This will result
291 in a smaller critical flaw size, and, consequently a smaller permissible weld deposit thickness
292 before a PT exam is considered necessary, per the guidance of ISG-15.
293

294 The staff should verify that if the licensee desires to use a thicker root pass, they must limit the
295 amount of weld deposit to the ratio of the fracture toughness K values (or, J values) for the
296 different flaw types (buried K divided by surface K) multiplied by the maximum depth allowed by
297 the ISG-15 calculation method. This will limit the depth of the root pass to the critical flaw size
298 for a surface connected flaw. Thus, if a licensee desires to use a thicker weld deposit for the
299 root pass, then a limiting flaw size analysis establishes a structural basis that is consistent with
300 the intent of ISG-15.
301

302 The staff recognizes that for stainless steel, K, or even J, is not entirely correct for evaluating
303 failure in austenitic stainless steel due to the large capacity for plastic deformation. Generally
304 the result is failure due to net section stress, not fracture. However, the stress intensity ratio
305 suggested above is acceptable for this purpose.
306

307 **Regulatory Basis:**

308
309 The systems, structures, and components (SSCs) important to safety must be designed,
310 fabricated, erected, and tested to quality standards commensurate with the importance to
311 safety of the function to be performed. [10 CFR 72.122(a)].
312

313 The high-level radioactive waste.....must be packaged.....without the release of radioactive
314 materials to the environment or radiation exposures in excess of [10 CFR] part 20 limits. The
315 package must be designed to confine the high-level radioactive waste for the duration of the
316 license [10 CFR 72.122(h)(5)].
317

318 Radiation shielding and confinement features must be provided sufficient to meet the
319 requirements in parts 72.104 and 72.106 [10 CFR 72.236(d)].
320

321 The spent fuel storage cask must be designed to provide sealing of confinements systems
322 [10 CFR 72.236(e)].
323

324 The spent fuel storage cask must be inspected to ascertain that there are no cracks, pinholes,
325 uncontrolled voids, or other defects that could significantly reduce its confinement effectiveness
326 [10 CFR 72.236(j)].

327 The spent fuel storage cask and its systems important to safety must be evaluated, by
328 appropriate tests of by other means acceptable to the NRC, to demonstrate that they will
329 reasonably maintain confinement of radioactive material under normal, off-normal, and credible
330 accident conditions. [10 CFR 72.236(l)].

331
332 The independent spent fuel storage installation must be designed to provide conformance to
333 Parts 72.104 and 72.106 which define criteria for radioactive material in effluents and direct
334 radiation limits.

335
336 **Applicability:**

337
338 This guidance applied to dry cask storage system reviews conducted in accordance with
339 NUREG-1536, "Standard Review Plan for Dry Cask Storage Systems" (January 1997); and
340 NUREG-1567, "Standard Review Plan for Spent Fuel Storage Facilities" (March 2000).

341
342 **Recommendation:**

343
344 The staff recommends that the appropriate chapters of NUREG-1536 and NUREG-1567 be
345 revised to incorporate the above guidance related to the canister lid welds of austenitic
346 stainless steel canisters.

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352 **Approved** _____ **Date** _____
353 E. William Brach, Director
354 Division of Spent Fuel Storage
355 and Transportation

References

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