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Docket No. WM-45

Mr. Richard T. Haelsig, President
Nuclear Packaging, Inc.
1010 South 336th Street
Federal Way, Washington 98003

Dear Mr. Haelsig:

SUBJECT: NUPAC TOPICAL REPORT ON FL-50/EA-50 HIGH INTEGRITY CONTAINER

The Nuclear Regulatory Commission (NRC) has completed its review of the Nuclear Packaging, Inc. (NUPAC) topical report on the FL-50/EA-50 High Integrity Container (HIC) for low-level radioactive waste. The technical review included information contained in the draft topical report as well as further information that was submitted as a result of the review. The evaluation report for this review is enclosed.

We have concluded that the topical report, as supplemented by additional information that was provided in response to staff comments and questions, adequately describes the FL-50/EA-50 HIC and that, as described, the HIC meets the structural stability requirements of 10 CFR 61 for the disposal of Class B and Class C wastes. These conclusions are predicated on completion of the final revised topical report (proprietary and non-proprietary versions) to include all appropriate information that was developed during the course of the technical review and the following conditions:

1. The FL-50/EA-50 HIC shall be used in accordance with the Operating Procedure restrictions outlined in the Appendix to this TER and all additional restrictions and requirements specified by the burial site operators and governing State agencies.

2. Users of the FL-50/EA-50 HIC shall certify that all restrictions and required procedures have been adhered to and that the HICs do not contain proscribed chemicals or waste materials.

It is our understanding that NuPac will retain and provide upon request appropriate specimens of container construction material for use in possible future surveillance programs. For example, these specimens could be used as corrosion samples buried in an "archival trench" at a LLW burial site and retrieved and inspected at periodic intervals.

The enclosed evaluation report is being forwarded to the States of South Carolina and Washington for their information and use.

OFC	:WMLU	:WMEG	:WMEG	:WMEG	:	:	:
NAME	:LHigginbotham	MTokar	:TCJohnson	:JTGreeves	:	:	: :
DATE	:84/10/17	:85/10/	:85/10/	:85/10/	:	:	

If NRC criteria or regulations change such that the acceptability of the topical report is invalidated, NuPac or the applicants referencing the topical report will be expected to revise and resubmit their respective documentation or otherwise justify the continued use of the topical report without revised documentation.

Sincerely,

Original signed by
Leo B. Higginbotham

Leo B. Higginbotham, Chief
Low-Level Waste and Uranium Recovery
Projects Branch
Division of Waste Management
Office of Nuclear Material Safety
and Safeguards

Enclosure:
Evaluation Report for NuPac HIC

FC	:WMLU	:WMEG	:WMEG	:WMEG	:	:	:
NAME	:LHigginbotham	MTokar	:TCJohnson	:JTGreeves	:	:	:
DATE	:84/11/17	:85/10/	:85/10/31	:85/10/31	:	:	

United States Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Washington, D.C. 20555

STAFF EVALUATION REPORT

related to the Topical Report covering
the FL-50/EA-50 High Integrity Container
manufactured by Nuclear Packaging, Inc.

Docket No. WM-45

Prepared by: Engineering Branch
Division of Waste Management

October 1985

ABSTRACT

This Staff Evaluation Report has been prepared by the Office of Nuclear Material Safety and Safeguards of the U.S. Nuclear Regulatory Commission for the Topical Report filed by Nuclear Packaging, Inc. covering its FL-50/EA-50 High Integrity Container. The container is proposed for use as a means of containing low-level radioactive waste and meeting the structural stability requirements for waste in 10 CFR Part 61. The staff concludes that the FL-50/EA-50 high integrity container meets the structural stability requirements of Part 61 and may be used for the disposal of low-level radioactive waste that requires disposal in a stable form. Limiting conditions for use of the container may be specified by the regulating authority for a particular disposal site.

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WM-45 STAFF EVALUATION REPORT

1.0 BACKGROUND

1.1 Regulations

By Federal Register Notice dated December 27, 1982 (47 FR 57446), the United States Nuclear Regulatory Commission (NRC) amended its regulations to provide specific requirements for licensing of facilities for the land disposal of low-level radioactive waste. The majority of these requirements are now contained in Part 61 to Title 10 of the Code of Federal Regulations (10 CFR 61) entitled "Licensing Requirements for Land Disposal of Radioactive Waste" (Ref. 1). Minor modifications, mostly of a procedural nature, have been made to other parts of the Commission's regulations, such as 10 CFR 20 ("Standards for Protection Against Radiation"). These regulations are the culmination of a set of prescribed procedures for low-level radioactive waste disposal that were proposed in the Federal Register on July 24, 1981.

The effective date for the implementation of 10 CFR 20.311, which requires waste generators to meet the waste classification and waste form requirements in 10 CFR 61, was December 27, 1983. As set forth in 10 CFR 61.55, Class B and Class C waste must meet structural stability requirements that are established under 10 CFR 61.56(b). In May 1983, the NRC provided additional guidance by means of a Technical Position on Waste Form (Ref. 2) that indicated that structural stability could be provided by processing (i.e., solidification of) the waste form itself (as with large activated steel components) or by emplacing the waste in a container or structure that provides stability (that is, a high integrity container (HIC)).

1.2 Topical Report Submittals

By letter, dated November 3, 1983 (Ref. 3) Nuclear Packaging, Inc. (NuPac) requested consideration by the State of Washington for approval of a Ferralium 255 (F255) Liner System (the NuPac FL-50[1] high integrity container) for use in the disposal of Class B and C filters from Arkansas Nuclear One to Hanford, Washington at the U.S. Ecology low-level radioactive waste disposal site. At the time, Arkansas Power and Light (AP&L) was contracting with NuPac for the supply of carbon steel liners for packaging these filters for burial at Hanford. With the imminent implementation (on December 27, 1983) of the requirements for HICs as specified in 10 CFR 61, as well as site specific requirements dictated by the State of Washington, NuPac requested an early review of the request for approval of their FL-50/EA-50 HIC, as described in the topical report.

The State of Washington, in turn, requested assistance (Ref. 4) in the review

[1] During the course of this technical review, NuPac renamed the FL-50 HIC as the Enviralloy 50 (EA-50) HIC. From this point on in this Topical Report Evaluation the HIC is referred to as the FL-50/EA-50 HIC.

of the topical report through NRC's Office of State Programs. A preliminary technical review, involving primarily members of (a) the Engineering Section of NRC's Waste Management Engineering Branch, Division of Waste Management, (b) Brookhaven National Laboratory, (c) the Waste Technology Section of NRC's Waste Management Branch, Office of Research, and (d) the Transportation and Certification Branch of NRC's Division of Fuel Cycle and Material Safety, resulted in the generation of several comments (Ref. 5) on the AP&L related FL-50/EA-50 report. These comments focussed principally on the need for further information on the corrosion behavior of the Ferralium 255 alloy, because corrosion was believed to be a controlling factor in the performance of a metallic HIC.

At about the same time that the corrosion comments were being transmitted to the State of Washington for consideration, NuPac submitted (Refs. 6 and 7) a second topical report on the FL-50/EA-50 HIC. Whereas the first report had dealt with a specific application of the HIC for AP&L filter cartridge waste to be sent to Hanford, the second topical was intended to be generic, to apply to a broad spectrum of waste streams, and to allow for disposal at Barnwell, South Carolina as well as Hanford, Washington. Inasmuch as the generic report encompassed and bounded the information contained within the AP&L-related document, the review effort was consolidated, and further review activity focussed on the generic topical. A request for further information (Ref. 8) that incorporated relevant information on soil analyses by an NRC contractor (Ref. 9) and which consolidated questions on the generic report was transmitted to NuPac in October 1984.

1.3 FL-50/EA-50 HIC Description

The NuPac FL-50/EA-50 high integrity container is a simple right angle cylinder with a flat top and bottom manufactured entirely of Ferralium 255. The HIC is approximately 47 inches in diameter by 51 inches tall. The top, bottom, and sides of the container are fabricated from 3/8 inch thick material. The top head has a 24 inch diameter gasketed opening for loading. Closure of this opening is accomplished with a 3/8 inch Ferralium Alloy 255 plate held in place by eight wedge shaped retainer blocks. Four internal L-shaped vertical supports, welded to the inside surfaces of the top and bottom plates, are provided as stiffeners for the top and bottom plates. A seal is provided between the lid and top of the HIC by a silicone rubber gasket (an optional lead gasket is available for highly permeable wastes such as tritium gas). A vent system is located in the lid and allows relief of internal pressure that could result from gas generation caused by biodegradation or radiolytic decay, while preventing significant groundwater movement into or out of the container. The vented lid is not to be used with wastes that contain highly mobile or transient gases such as tritium.

Lifting of the container is accomplished using a cable sling that is provided. The sling consists of a single 3/8 inch steel cable that is attached to two lifting eyes on the container with anchor shackles.

2.0 SUMMARY OF TOPICAL REPORT

The generic topical report on the NuPac FL-50/EA-50 high integrity container is intended to demonstrate that the HIC meets (a) all the applicable stability requirements and criteria of 10 CFR 61 (using guidance provided in the May 1983 Technical Position on Waste Form), (b) 10 CFR 71 sections dealing with Type A Packaging (as the Part 71 requirements apply to HICs), (c) 49 CFR 173 Type A Packaging related areas, and (d) special testing and design conditions requested by the Agreement States.

The FL-50/EA-50 HIC was designed to be certified as a DOT Type A container that would pass all U.S. DOT and U.S. NRC transportation requirements for a Type A container. The HIC is intended to contain the following types of wastes from light water reactors: (1) dewatered bead resins, powdered resins and diatomaceous earth; (2) compressible solid waste; (3) non-compressible solid waste; (4) filter elements and cartridges; (5) solidified resins, sludges, and liquid wastes.

The material from which the FL-50/EA-50 HIC is fabricated is Ferralium 255 (F255), which is a patented ferritic-austentic, duplex stainless steel that reputedly combines high mechanical strength, hardness and ductility with excellent corrosion properties. As acknowledged in the report, "the most critical area associated with long term isolation is considered to be corrosion resistence." A major portion of the report therefore, addresses, the predicted external corrosion behavior of the F255 HIC under expected disposal site environments and an analysis of the internal corrosion of the HIC, taking dewatered bead resin as the expected worst case.

The rest of the report, as submitted, focussed on structural analyses (including results of finite-element calculations using the ANSYS computer code), analyses of closures and seals, analyses of internal gas generation and associated gasketing requirements, analyses of radiation and ultra-violet stability, prototype testing, Type A package testing, heat transfer, inspection, and quality assurance. Much of the information addressing these subjects is contained in several appendices. The final approved report will contain this technical evaluation along with additional information submitted in response to NRC review comments and questions. The additional information will be included in the revised report as a second volume.

3.0 SUMMARY OF REGULATORY EVALUATION

3.1 Major Areas of Review

The basic objective of this staff technical evaluation of the topical report was to confirm that the NuPac FL-50/EA-50 HIC meets the structural stability requirements of 10 CFR 61. The NRC's Technical Position on Waste Form (May 1983), which addresses various details including certain transportation and testing requirements that are presented in 10 CFR 71 and 49 CFR 173, provides guidance on how to satisfy Part 61. Major areas of review that are addressed in the Technical Position and which received particular attention in this review included the following:

1. Corrosion
2. Structural Analyses
3. Prototype Testing
4. Gas Generation and Internal Pressurization
5. Radiation and Ultra-violet Stability
6. Type A Packaging Requirements
7. Quality Assurance and Inspection
8. Remaining Technical Position and Other Considerations

3.2 Corrosion

3.2.1 Background

Because of its reputed high resistance to stress corrosion cracking, crevice corrosion, and chloride-induced pitting, when compared with austenitic stainless steels such as Types 304 and 316, Ferralium 255 is used in marine applications, the oil and gas (and petrochemical) industries, for pollution control equipment, and other applications where the combination of corrosion resistance and high strength are especially needed. There is little field experience, however, with F255 in long-term underground applications. Nor is there much information available in the open literature regarding the corrosion of F255 weldments and the potential for long-range pitting corrosion (for welded, as well as base, material). Concern existed regarding the potential effects of localized corrosion on the structural integrity of the FL-50/EA-50 container and the corrosion effects of various waste stream products, including sulfonated resins, organic liquids, and chlorides; though these matters were addressed indirectly in the report through an analysis that was intended to be bounding, that analysis did not provide adequate assurance that every possible corrosive chemical was accounted for.

Certain administrative procedures were to be implemented to identify and preclude incorporation of undesirable chemicals, but the procedural details were not provided. Substantive information on these matters was needed before it could be confirmed that the NuPac FL-50/EA-50 HIC meets the 300-year structural stability requirement. Accordingly, NuPac was asked (Ref. 8) for considerably more information concerning (a) the metallurgical aspects of F255 corrosion, as well as (b) waste stream or other environmentally-related effects. The following discussion of F255 corrosion addresses the review in the context of these two groups of concerns.

3.2.2 Corrosion-related Metallurgical Factors

3.2.2.1 Corrosion Performance of F255 Welds

In addressing the corrosion behavior of welded F255, NuPac (Ref. 10) cited (a) certain metallurgical characteristics of the alloy that rendered it less susceptible than other stainless steels to intergranular and pitting attack and

(b) welding procedures that would be followed to lessen the likelihood of corrosion problems with weldments. With regard to advantageous metallurgical characteristics, NuPac pointed out that the reason that austenitic stainless steels are susceptible to heat-affected-zone (HAZ) stress/corrosion cracking (SCC) is that chromium-rich carbides are formed at the grain boundaries during welding.

Low-carbon versions of the austenitic stainless steels (e.g., 316L) have been developed to lessen the HAZ problem in those alloys. Ferralium 255, however, has a typical carbon content of only 0.02%, which is even lower than the carbon content (0.03% max.) used in the low carbon version of austenitic steels such as 316L. According to NuPac, microstructural examinations of HAZs in Ferralium have failed to reveal "sensitization" (i.e., grain boundary carbide formation) as encountered in 316 SS weldments.

It was also asserted by NuPac that the Electro Slag Remelting process, which is used to produce the Ferralium F255 alloy, greatly reduces or eliminates the types of non-metallic inclusions that act as preferential sites for localized attack in acid chloride solutions. Therefore, superior performance under conditions conducive to localized corrosion would be expected. This would be true for weldments as well as parent material.

To provide assurance that the intrinsic corrosion-resistant nature of as-manufactured F255 would be preserved in welded metal, NuPac affirmed that all welding procedures utilized in the FL-50/EA-50 HIC fabrication would be developed and qualified in strict accordance with ASME Section IX requirements. Specific details regarding welding specifications, required tests, and inspections were provided in the response (Ref. 10) to NRC staff comments. Typical drawing, planning, and procurement documentation was also provided.

During the course of the review of the topical report it became apparent that there was some conflicting information in the literature regarding the recommended welding parameters (e.g., heat input and rate of cooling) for F255. As explained in NuPac's response (Ref. 10) to the staff's questions, the apparent inconsistency stemmed from differences in the wrought versus cast versions of F255. Recent work on welding parameters for F255 has been documented (Refs. 11, 12, 13) by Cabot, and NuPac will follow Cabot's recommendations in welding F255 HICs.

Intercomparative data[2] on the Ferralium 255 duplex stainless steel and 316 austenitic stainless steel were also used as supporting evidence for the

[2] Austenitic stainless steels are a class of corrosion resistant alloys for which there is a considerable body of test data and substantial experience (some of which involves underground applications). Hence, an intercomparison of the FL255 alloy (which is relatively new) with an established older alloy such as 316 stainless steel provides a measure of the relative merit of the newer material.

expected satisfactory service performance of F255 weldments. In laboratory tests involving the use of (a) potentio-dynamic polarization curves to determine pitting potential in various environments and (b) chloride pitting and crevice corrosion tests, it was shown that while there were instances where the performance of F255 and 316L SS was similar, there was no case where the performance of F255 was inferior to 316L. In 5% NaCl, 316L SS welded samples pitted in the weld, whereas no pitting was observed in F255 in the welded or unwelded state. Hence, the test results showed that F255 weldments generally were superior to 316L SS weldments. This demonstrates that F255 welds should provide even greater assurance of structural integrity and a higher safety margin regarding the required HIC design life of 300 years than would 316L stainless steel.

The performance of austenitic stainless steels in soil environments is discussed in Section 3.2.2.3 of this evaluation report. Based upon the totality of evidence regarding the performance of F255 weldments and NuPac's procedures for assuring satisfactory performance, the staff concludes that there is reasonable assurance that welding of NuPac FL-50/EA-50 F255 HICs will not impair the uniform or stress/corrosion cracking resistance of the HICs.

3.2.2.2 Pitting Corrosion Repassivation

As noted earlier, F255 corrosion test results reported in the open literature suggested that uniform and pitting corrosion rates would both be low. F255 microstructural considerations, discussed in the previous section, also suggested that F255 was quite resistant to pitting corrosion, even in the welded state. There was a concern, however, about the potential for non-passivation of corrosion pits, should corrosion pits ever be initiated. NuPac was, therefore, asked to perform cyclic voltammetry tests on F255 to assure that pitting corrosion, if initiated, would not progress to premature loss of structural integrity of the HIC.

The cyclic polarization tests, which were performed (using simulated solutions) on base metal as well as weldments of both the F255 and 316L SS, showed that there was a lack of hysteresis in all the polarization curves obtained with F255. This result, coupled with the lack of any visible pitting, confirmed the expected high resistance to pitting in F255. In contrast, significant visible pitting and significant hysteresis of welded 316L SS occurred, thereby demonstrating both the superior pitting corrosion resistance of F255 as well as the efficacy of the cyclic voltammetry test.

3.2.2.3 Field Experience with Comparative Alloys

Due to the relatively short time (less than 20 years) that duplex stainless steels such as F255 have been in existence, there is limited field experience with such alloys in soil environments. Some experience does exist, however, with other more common corrosion resistant alloys such as the 300-series austenitic stainless steels. NuPac was, therefore, asked to document such field experience (in a variety of soils with the comparative alloys) that would demonstrate reasonably satisfactory performance of the comparative alloys in those applications. That experience would serve as indirect evidence that the F255 alloy would serve adequately in the proposed application inasmuch as the F255 exhibits superior corrosion resistance to the austenitic alloys in laboratory tests.

In response, NuPac pointed out that stainless steels have not generally been used in underground applications because of cost considerations and the availability of other less expensive corrosion prevention techniques. Where stainless steel pipelines have been installed, there have been mixed results, primarily because pipelines cross a variety of soils with varying resistivities that result in the creation of "long-line currents" that, in the absence of cathodic protection, will cause corrosion. Pipelines installed a few feet below the surface of the ground also are subject to corrosion associated with bacterial decay of organic material.

While pipeline experience with austenitic stainless steels has not been totally satisfactory, NuPac contends that such experience may not be completely applicable to HIC burial because HIC's are buried deeper than normal pipelines and are more isolated electrically. On the other hand, where stainless steels have been used in small amounts for fasteners, hose clamps, couplings, and the like in underground applications, the results reportedly (Ref. 10) have been excellent.

Tests performed with 300-series stainless steels in soil environments have generally been good, although in some samples taken from the more acidic and harsher soils, some pitting corrosion has been noted. These studies indicate that the common stainless steels, while they show substantial resistance to corrosion in long-term burial applications, also have some weaknesses such as pitting. For a given thickness of metal, they thus appear to have less margin to meet the 300-year service life required for HICs.

Inasmuch as F255 has been demonstrated to have significantly higher pitting resistance than the common 300-series stainless steels, particularly when considering attack by chloride, (and taking into consideration the expected chloride concentrations, moisture content, and pH levels at the Barnwell and Hanford sites), the staff concludes that the F255 FL-50/EA-50 HICs will perform better than the 300-series stainless steels would be expected to at those sites.

3.2.2.4 Crevice Corrosion

Hypothetically, there is a potential for crevice corrosion in the area of the HIC between the container and the lid/gasket. As noted (Ref. 10) by NuPac, however, crevice corrosion testing performed with 10% ferric chloride and other solutions has shown that the temperature required for crevice corrosion is much higher than the temperatures that would be encountered at low level radioactive waste burial locations. The burial site chemical environment would, of course, be much less severe than the conditions imposed in laboratory corrosion testing. The staff, therefore, concludes that there is reasonable assurance that crevice corrosion will not be a significant problem with the NuPac FL-50/EA-50 HIC.

3.2.2.5 Effects of Localized Corrosion on Structural Integrity

In the analysis of the structural adequacy of the FL-50/EA-50 HIC (discussed in more detail in Section 4 of this staff evaluation), a wastage allowance approach is applied to account for uniform corrosion of the container. That is, it is assumed that a portion of the total 3/8 inch thickness of the F255 SS is corroded away by uniform corrosion, and the stresses developed in the HIC due to burial loads are then compared to the allowable stresses. For reasons discussed elsewhere in this Staff Evaluation, staff considers it unlikely that uniform corrosion would result in this magnitude of HIC wall thickness loss; rather, it appears more likely for the F255 container to be attacked by localized corrosion. NuPac was, therefore, asked to provide a structural analysis that would address the potential effects of localized corrosion on structural integrity.

To calculate the minimum weld thickness (the welded areas would be most susceptible to localized corrosion) required to prevent structural instability, the highest stressed element was identified, and an estimate of the allowable pitting damage was obtained by calculating the maximum allowable uniform weld reduction. That value (based on a 80,000 psi y.s. for F255) is greater than the wastage allowance for uniform corrosion of the HIC wall. The reduction in weld thickness would reduce the welds' moment carrying capability, but if a weld were pitted, the remaining non-pitted portion of the weld would still not be reduced in thickness (neglecting uniform corrosion) and would thus maintain a moment carrying capability. It would, therefore, require a gross amount of pitting to achieve a condition of structural instability.

Thus, in view of the inherent superior localized corrosion resistance of F255, and taking into account the environmental conditions expected at the Hanford and Barnwell burial sites, staff concludes there is reasonable assurance that localized external corrosion will not threaten the structural integrity of the HIC over its 300 year design life. More information on environmental factors is presented in the following subsection of this staff evaluation.

3.2.3 Environmentally-Related Corrosion Factors

3.2.3.1 General

The discussion presented in Section 3.2.2 of this Staff Evaluation centers primarily on metallurgical factors that govern the corrosion resistance of the Ferralium HIC. In Section 3.2.3 the focus is on environmental factors (internal as well as external) that were considered in assessing the 300 year corrosion performance of the HIC.

As noted earlier, a wastage allowance (i.e., thickness of material allocated for corrosion) approach was used in the FL-50/EA-50 HIC design; that is, a portion of the total 3/8 inch wall thickness is allocated for uniform corrosion. In assuring that the allowable uniform corrosion rate would not be exceeded, NuPac considered the possible external environments of the burial trench as well as the internal environment that would be provided by various waste streams.

With regard to the external environment, NuPac asserted that data on soils and their corrosive characteristics (Ref. 9) indicate that the soils in the current disposal sites are not necessarily more corrosive than other soils where austentic stainless steels have been tested and demonstrated to be highly resistant to both pitting and general attack (Ref. 14). While the possibility exists that the burial trench groundwater could, in fact, be considerably more agressive than would be encountered in native virgin soils (due to contamination from chloride or organic compound-bearing chemicals), NuPac contended that the expected soil contamination levels are well below those that would affect the F255 alloy.

Based upon comparison of the burial site soil analyses with corrosion test results and field experience with various stainless alloys, the staff would not expect the external (soil) environment to pose a threat to the structural integrity of the FL-50/EA-50 HIC. (See the following subsections for details.)

With regard to waste stream effects on the internal environment of the HIC, the situation is considerably more complicated because it is a function of many factors, including the type of waste, temperature, oxygen concentration, the history of the waste stream, and the waste stream itself. It was acknowledged by NuPac that some detrimental environments could exist. The analyses and adminstrative procedures that were developed to address the potential environmental parameters are summarized in the following subsection, 3.2.3.2.

3.2.3.2 Review Areas Concerning Environmentally Related Corrosion Factors

In the topical report, the analyses of environmentally related corrosion factors focussed primarily on two major areas: (a) soil characteristics (e.g., pH, chloride concentration, water content, organics) and (b) a "worst case" analysis of bead resin corrosion effects. A series of questions concerning these subject areas were raised by the staff. The subject matter and the responses to the Staff's questions are too lengthy and complex to cover in detail here, but the following points summarize the situation.

(1) Several pH ranges are addressed in the topical report. They deal with the pH range for soils (4.0 to 11.0), the pH range for ion exchange resins (taken as 0 to 14), the minimum pH for trench sump liquid (assumed to be 2.4) and a limiting pH of 3 on liquid bearing waste containing more than 2% free halogens. The latter is used to establish a so-called "corrosion criterion" as follows: "The liquid portion of the waste must have a pH greater than 3. If not, then the waste stream must have less than 2% by weight of ionic halogens."

    This criterion was developed by considering (a) the maximum acceptable (uniform and pitting) corrosion rate compatible with preserving structural integrity; (b) the corrosion rates associated with possible waste streams and (c) practical limitations imposed on the container by the potential waste forms.

(2) The practical application of the corrosion limitations placed on the container is provided in a section of the report that contains the responses to Staff questions that deal with a proposed container operating procedure. It is intended by NuPac that the procedure should be followed by all users of the FL-50/EA-50 HIC. Included with the operating procedure is a chemical compatibility flow diagram and check off procedure. Waste streams that would contain liquids with pH less than 3 or halides (chloride or fluoride) greater than 2% by weight would have to be neutralized, diluted or excluded from the container.

Other provisions are made for the use of a vent (to accomodate potential gas generation due to biodegradation) and short-term temperature excursions (to allow filling of the HIC with materials at greater than ambient temperature).

Users of the FL-50/EA-50 HIC will be required to certify that they have complied with all the operating procedures and that the HICs do not contain proscribed chemicals. A copy of the Operating Procedure required for FL-50/EA-50 HIC users is provided as an appendix to this evaluation report.

(3) Regarding the chemical compatibility of ion exchange resins with the HIC, a theoreotical "worst case" analysis was presented in Appendix Q of the as-submitted report. Rather than rely solely on that analysis, the NRC staff asked NuPac to (a) propose the waste streams that the FL-50/EA-50 HIC would see the products of, (b) examine the applicable test data, and (c) show by analysis that the environment that the HIC will be subjected to would not be unacceptable. In response, NuPac presented an analysis that centered around data concerning the titration of ion exchange resins and the pH of contacting water. It was shown, that even with very low pHs (simulating radiation damage effects), corrosion rates were well within the uniform corrosion limit for the HIC.

A revised Appendix Q was submitted as a theoretical backup analysis for an extreme analytical case. The results of the Appendix Q revision indicated that dewatered resins could simulate 10-20% sulfuric acid, which while it was considered excessive for 316 stainless steel, would not result in violation of the uniform corrosion limit for F255.

(4) In addition to the above points, NuPac also addressed (a) the potential need for organic solvents exclusion and pre-treatment, (b) the potential for growth of micro-organisms, (c) effects of sulfur compounds, (d) trench and organic liquid chemical corrosion resistance, (e) chloride content of soils, and (f) effects of radiation on pH. In all cases, the Ferralium container was shown, on the basis of analyses coupled with applicable

data, not to be significantly affected by the postulated plausible environmental condition.

The staff concludes, on the basis of the analyses and data presented in the FL-50/EA-50 report and responses to Staff questions that there is reasonable assurance that the FL-50/EA-50 HIC, if used within the bounds prescribed by the proposed operating procedures, will not suffer a loss of structural integrity over its 300 year design life due to corrosion effects.

Verification of acceptable performance can be provided by means of periodic surveillance of archival specimens (see Section 3.9 of this Staff Evaluation Report). It should be noted that users of the FL-50/EA-50 HIC will have to comply with all state requirements and criteria for a particular LLW burial facility. For example, South Carolina requires waste forms to be within a pH range of 4 to 11. That requirement will thus apply to any FL-50/EA-50 HICs that are buried at Barnwell, regardless of the pH <3 "corrosion criterion" proposed by NuPac.

3.3 Structural Analyses

Burial depths at the Hanford, Washington site do not exceed 45 feet, which corresponds to an external pressure of 37.5 psi on the container, while the 25 feet maximum burial depth at Barnwell, South Carolina corresponds to a container external pressure of 20.8 psi. In the original design of the FL-50/EA-50 HIC, the side walls were 1/4 inch Ferralium, and the HIC had only two internal supports. Reanalyses by NuPac, however, led to two major design changes that were related to the structural analyses of other members of NuPac's Enviralloy HIC family: (1) an increase in the HIC wall thickness to 3/8 inch, and (2) the use of four internal supports. These changes were intended to improve the structural design margin for the HICs.

In examining the February 1985 responses to NRC Staff questions, however, it was discovered that there were some areas that required further clarification and elaboration. These included, in addition to some aspects of the structural analysis, they included some aspects of the special vent design, proposed short term temperature limits for the loaded Enviralloy (F255) HICs, and the need for a clearer commitment to provide surveillance specimens. These concerns were transmitted to NuPac both orally and in writing (Ref. 15), and resulted in substantial revisions to the topical report and in responses to questions that were resubmitted (Ref. 16) in May 1985.

3.3.1 Burial Loads

One of the areas in the HIC structural analysis that required further attention was the effects of burial loads. Basically, the Staff concluded that it had not been adequately demonstrated that the HIC could withstand the predicted burial loads. Specifically, additional information was required (Ref. 15) concerning (a) the calculation of a critical buckling stress, (b) applied loads resulting from placement of the HIC in a non- vertical position in the burial trench, (c) the determination of an allowable stress intensity value, and (d) various details of the structural analysis of the internal vertical angle supports. In a telecopied response (Ref. 16(a)), which was later followed with a formal submittal (Ref. 16(b)), NuPac satisfactorily addressed the staff's concerns.

In brief, it was demonstrated that (1) the HIC did not have a stability problem due to buckling (2) there was significant margin for loading due to side burials of the HICs and (3) the stability of the internal vertical supports was adequate. While the staff did not accept NuPac's approach for deriving an allowable stress intensity for the primary membrane plus bending stress, the difference of opinion was moot inasmuch as none of the burial stresses in the container, whether in the as fabricated or "corroded" (minus the wastage allowance) state, exceeded the published yield stress of 80,000 psi for Ferralium 255.

It should be noted that NuPac analyzed the FL-50/EA-50 HIC for displacement and stresses utilizing a general purpose finite element code called ANSYS (Revision 3, Update 67L). ANSYS is a widely used and accepted finite-element analysis tool that has undergone extensive benchmarking to demonstrate its reliability for structural analysis. The assumptions used in applying the ANSYS model to analyze the behavior of the FL-50/EA-50 HIC under various loadings are described in the structural analysis section of the topical report. A discussion of the elements used and the output generated by the code are provided in various appendices of the topical report. The staff concludes, on the basis of the information provided, that there is reasonable assurance that the FL-50/EA-50 HIC is adequately designed for all conceivable burial loads.

3.3.2 Drop Test Load Analyses

In addition to the analyses of burial loads, NuPac attempted to estimate the loads that would be incurred on various components of the HIC during the drop testing of HIC prototypes. Those calculations, presented in Section 3 of the topical report, addressed such things as the load on the lid during flat-ended and corner drop tests. Several questions were raised by the staff concerning these analyses. Most of the questions dealt with the need for clarification of portions of the report text. A couple of the questions concerned the values used for the maximum payload and gross weight of the container.

In response, NuPac stated that the drop analyses were performed to provide an approximation of the conditions that would be imposed on the HIC during the drop tests and that the actual qualification of the container was based on the drop test results (see Section 3.4). Clarification of the report text was provided where needed, and certain typographical errors were corrected. With regard to the container gross weight, NuPac stated that the maximum gross weight of the FL-50/EA-50 HIC is 4200 pounds and that the user will be required to limit the HIC contents such that this gross weight is not exceeded. The 4200 pound limit meets shipping container licensing requirements.

3.3.3. Thermal Stresses

The HIC will be subjected to some thermal loads due to solar heating during transportation. Differential thermal expansion between the container and the lifting straps, for example, could occur, and a "worst case" or bounding value was calculated. A quantitative analysis of the resultant stresses in the straps or surface of the HIC, requested by the staff, showed that there was a significant safety factor, based on the difference between the maximum thermal stress and the yield stress of the material.

With regard to burial thermal loads, the relatively low burial temperature envelope at Barnwell and Hanford (68°F±18°F) would not be expected to be a factor. Mechanical strength properties of F255 decline gradually with increasing temperature (e.g., strength properties at 200°F and 400°F are reportedly 8.6% and 12.6% less, respectively, than room temperature values). Therefore, any increase in temperature of the HIC that might ensue due to soil insulating effects or the near proximity of other heat-generating wastes would not be expected to significantly affect the HIC. Likewise, temporary storage above ground in a storage facility would not be expected to be a significant factor.

3.4 Prototype Testing

3.4.1 Drop Tests

The HIC should be capable of meeting the requirements for a Type A package as specified in 49 CFR 173 and 10 CFR 71, as applicable to metallic containers (Ref. 2). With regard to drop test requirements, the applicable criteria are provided in 10 CFR 71.71. For the FL-50/EA-50 HIC, which will have a gross weight under 4250 pounds, free drop tests (with the HIC loaded to the maximum gross weight) onto an unyielding surface, from a variety of orientations (i.e., flat and corner drops) were performed. Except for a dent about 1/4 inch deep in the side wall (of a HIC with the original 1/4 inch wall) after a corner drop test, no visible damage ensued. Importantly, there was no loss of contents from the container due to cracks or rupture of the seal.

Similar results were obtained from a full series of drop tests performed from 25 feet onto compacted sand. In this series of tests, the container included a lead gasket. The lead gasket maintained a positive seal. The only visible damage that ensued from the 25 foot drop tests consisted of a denting (about 5/8 inch maximum) of the impacted side between the two end plates following a side drop. There was no loss of contents resulting from any of the 25 foot drop tests, nor did a magnetic particle test performed on the closure welds indicate any loss of structural integrity. Angles welded to the lid that serve as handles were broken at the welds after the 25 foot top down drop test, but these are non-structural components of the container and their failure did not affect container integrity.

After one drop test, which was an early test conducted on a container with a gross weight of only 3000 pounds, a crack was detected in one of the welds.

That crack was determined to be due to a weld defect, however, and was not the result of a design deficiency. NuPac has provided assurance that future inspection procedures, to be used on production containers, will preclude the presence of similar weld defects. The staff concludes, on the basis of the submitted information, that the FL-50/EA-50 HIC has satisfied the criteria for free drop tests for high integrity containers specified by NRC staff and the States.

3.4.2 Type A Package Criteria

A high integrity container for low-level radioactive waste should be capable of meeting the "normal conditions of transport" criteria for Type A packages in 49 CFR 173 and 10 CFR 71, as applicable to metallic containers (Ref. 2). Criteria used are those contained in Section 71.71(c), 10 CFR Part 71. Of the Type A package test criteria, the results of drop tests are addressed in Section 3.4.1, above. Other tests, or analyses performed in lieu of tests, are addressed in the following sections.

Penetration Test

A penetration test was performed using the criteria in 10 CFR 71.71(c)(10). In this test a vertical steel cylinder 1-1/4 inch in diameter, weighing 13 pounds, and with a hemispherical end, was dropped from a height of 40 inches onto an exposed surface of the container with no measurable effect.

Water Spray Test

Since the FL-50/EA-50 HIC is fabricated from a duplex alloy steel, the water spray test (which simulates exposure to rainfall) described in 10 CFR 71.71 (c)(6) was not performed. The staff concurs with NuPac's position that metallic stainless steel packages will undergo no measurable physical change when exposed to the equivalent of two inches of rainfall for one hour.

Vibration Testing

The test criterion for vibration normally incident to transport is contained in 10 CFR 71.71(c)(5). Inasmuch as the FL-50/EA-50 HIC is a welded metallic structure with which closure is accomplished by 8 retaining blocks that lock positively into the structure of the container, there is no credible physical way for shock and vibration normally incident to transportation to affect the integrity of the HIC. Also, inasmuch as the F255 alloy exhibits low temperature toughness characteristics similar to the commonly used ASTM A516 fine grain practice steels, vibration effects would not be expected to be a problem even at low temperatures that might be encountered during winter transport. Consequently, staff concurs in NuPac's decision not to conduct vibration testing.

Compression Testing

Criteria for compression tests are addressed in 10 CFR 71.71(c)(9). The compressive load to be applied to the HICs during these tests must be either the equivalent of five times the weight of the package or 1.85 psi multiplied by the vertically projected area of the packages, whichever is greater. As noted in Section 3.3.1 of this staff evaluation, however, the FL-50/EA-50 HIC is designed to withstand burial loads of at least 37.5 psi (corresponding to the 45 foot burial depth at Hanford). This corresponds to a projected load that is more than three times the 21,000 pound load that is obtained by multiplying the 4200 pound gross weight of the container by a factor of five. Therefore, the compression test was not conducted on the FL-50/EA-50 HIC. The staff agrees with NuPac's contention that the test is not warranted for this particular HIC.

Pressure Testing

The criterion for a "reduced external pressure" test, corresponding to an external pressure of 3.5 psia, is contained in 10 CFR 71.71(c)(3). This corresponds to a pressure differential of 11.2 psi (that is, 14.7 psia internal pressure at sea level atmosphere at time of lid closure, minus 3.5 psia). The FL-50/EA-50 HIC was pressure tested with a silicone rubber gasket, using water as the pressurization medium. Leakage past the gasket occurred at 75 psig. A separate test with a lead gasket, following a drop test, resulted in a positive seal until 20 psig pressure was achieved. The FL-50/EA-50 HIC thus was demonstrated to meet the reduced external pressure requirements. No increased external pressure tests were conducted, inasmuch as the HIC, as discussed in Section 3.3.1 of this report, was shown by analysis to be able to withstand the 37.5 psi burial loads with margin.

3.5 Gas Generation and Internal Pressurization

One of the design changes made to the FL-50/EA-50 HIC involves the incorporation of a passive vent system (to be used for non-tritium wastes) to allow relief of pressure generated by gases resulting from possible biodegradation or radiolytic decay. The concern about internal gas generation originated from experience with a few polyethelene containers that exhibited symptoms of excessive gas generation (for example, had become stuck in their transportation casks due to the swelling resulting from generation and internal pressurization). This had resulted in a request (Ref. 17) by the State of South Carolina Department of Health and Environmental Control for consideration of a passive ventilation system as a design feature that would alleviate the problem.

After due deliberation, The NRC Staff concluded that the installation of vents, in all HICs, not just polyethylene ones, would be a prudent way to address the potential symptoms of the problem with gas generation. The approach thus provides a means to minimize the effects of gas generation (e.g., over-pressurization of the HIC) on handling, personnel safety, and long-term integrity of the container. The use of vents is intended to be an interim measure, which would address the symptoms and preclude any serious effects of gas generation, while allowing a long-term solution to be arrived at via a study that would identify the specific cause of the gas generation.

Accordingly, the passive vent system that NuPac currently proposes to use in the FL-50/EA-50 HIC would be basically comprised of a permeable plug of polymeric material placed in the lid of the container in a manner that will minimize any effects on the structure of the container and the possibility of damage from exterior objects. The vent material was chosen on the basis of its radiation resistance, lack of influence on corrosion, chemical resistance and hydrophobic nature. The vent will permit the relief of internal pressure by allowing the passage of gas while still minimizing the ingress of water as recommended by the Technical Position on Waste Form (Ref. 2). Samples of the polymeric material have been tested (Ref. 16(b)) for both air and water flow at various pressures, and have demonstrated satisfactory performance. The staff concludes that there is reasonable assurance that the passive vent system coupled with the back-up capability provided by the silicone rubber gasket, will provide an adequate means to allow for the release of pressure due to gas generation resulting from biodegradation or radiolytic decay.

It should be noted that the passive vent system, though it has been designated "optional" by NuPac, is in fact mandatory because it is the current primary pressure-relieving system for all the FL-50/EA-50 HICs except those that will be used for tritium containing wastes. In the latter case the HIC will have a lead gasket with no passive vent. This lead gasket/no vent design provides reasonable assurance of the containment of the tritium gas.

3.6 Radiation and Ultra-Violet Stability

The radiation stability of proposed container materials as well as radiation degradation effects of the waste itself, should be considered in the design of the HIC. No significant changes in material design properties should result following exposure to a total accumulated dose of 10^8 Rads. (Ref. 2)

For the FL-50/EA-50 HIC, the basic material of construction, Ferralium 255, would not be expected to be affected by radiation from low-level wastes. This is so because radiation damage, in the form of swelling and embrittlement, is caused in metals by neutron radiation, but these HICs will not contain detectable levels of neutron radiation producing materials.

The only components not made out of the F255 alloy are the gasket and the vent. Neither one of these items affect the structural integrity or stability of the container. However, because the topical report contained information indicating that the silicone rubber gasket material had a 20% compression set after exposure to 1×10^7 Rads, further information was requested regarding the testing and capabilities of the gasket.

In response (Ref, 10), NuPac noted that information in the open literature (Ref. 18) indicated that a compression capability of about 10% was obtained in testing to radiation exposures of 10^8 Rads. Although this might not be considered sufficient for applications where the gasket might be subjected to impact loading (as might be encountered during transportation), we agree with NuPac's assertion that under burial conditions there is no mechanism for the gasket material to move. The staff concludes that there is reasonable assurance that the silicone rubber gasket will perform as an effective barrier. The optional lead gasket is not affected by gamma radiation at the 10^8 Rad level and is thus also acceptable from a radiation stability standpoint.

Another component of the HIC outer wall that is not constructed of metal is the passive vent. The vent is basically comprised of a permeable plug of polymeric material, which reportedly (Ref. 19) has good resistance to gamma radiation in excess of 10^8 rads. Inasmuch as the vent does not carry any significant load, any reduction in mechanical properties that might occur as a result of radiation will not affect the performance of the HIC.

In regard to the effect of radiation on the contents of HICs, NuPac indicated (Ref. 10) that only the demineralization resin media have the potential to be affected by radiation in such a manner that they may affect the container. The resin media may undergo radiolysis to produce gas within the container. The slow build-up of gas could be a potential problem (with regard to over pressurization effects) only if there were no provision for pressure relief. Inasmuch as the passive vent will permit the alleviation of the pressure, however, the radiolysis of wastes is not expected to result in over pressurization of the HIC. The potential effect of ultra-violet (UV) radiation on the silicone rubber gasket should also be insignificant, in view of the fact that most of the gasket is shielded from such radiation by the metallic lid and top of the HIC during transportation; after the HIC is buried, it will not, of course, be subject to ultra-violet rays. UV radiation effects on the vent material due to exposure during storage would be limited by covering the vent with UV opaque material (see the Operating Procedure, Section 5.5).

The staff concludes that there is reasonable assurance that the effects of radiation have been adequately considered in the design of the FL-50/EA-50 HIC.

3.7 Quality Assurance and Inspection

High integrity container should be fabricated, tested, inspected, prepared for use, filled, stored, handled, transported and disposed of in accordance with a quality assurance program (Ref. 2). Because the assurance of proper procedures for container fabrication, testing, transportation, storage and use is critical in several areas, the NRC Staff issued (Ref. 8) several questions and comments concerning this subject. NuPac's responses (Ref. 10) can be separated into two general areas: (1) those matters having to do with fabrication, testing and inspection (i.e., operations performed by the vendor or which are directly under the control of the vendor), and (2) items to be addressed by the user.

With regard to the first category of operations, NuPac presented a substantial amount of information, including documentation on required inspections, referenced procedures, and specifications and procurement. All the FL-50/EA-50 HICs will be fabricated and inspected in accordance with NuPac "QA Level 1" criteria. According to NuPac, the Level 1 inspection activity fully meets the requirements of (1) ANSI N 45.2, (2) 10 CFR 50, Appendix B, and (3) 10 CFR 71, Subpart H. This level designation is established after Quality Engineering review of the contract, regulatory, design and fabrication requirements. Specifically required tests, inspections, material controls and data review requirements are then delineated in the inspection planning, drawings, referenced procedures and specifications and related procurement documents. NuPac's program for inspection to assure compliance with material and construction specifications is delineated in a QA manual.

With regard to user QA requirements, the Operating Procedure (Appendix of this report) prescribes procedures to be adhered to by users of the FL-50/EA-50 HIC to assure compliance with handling and material restrictions. HIC users will be required to certify that all required procedures and restrictions have been satisfied. The staff concludes that there is reasonable assurance that quality assurance requirements have been adequately addressed for the FL-50/EA-50 HIC.

3.8 Miscellaneous Requirements

The preceding sections of this Staff Evaluation Report address the technical areas that received the most attention during the course of the review of the FL-50/EA-50 HIC topical report. These items received the most attention because they were deemed to be the most critical with regard to influencing the structural integrity of the HIC. The subjects discussed in the following paragraphs of this subsection, though not trivial, were simpler in scope and in most cases easier to resolve than those addressed earlier.

3.8.1 Free Liquid

The FL-50/EA-50 HIC is designed for containing waste with less than 1% free liquid by volume. Because various types of waste are to be immobilized within these HICs, a variety of dewatering procedures could be used. NuPac has submitted a topical report, No. TP-02, "Dewatering System," dated August 6, 1984 that contains information on the dewatering for these containers.

With regard to the potential effects of dewatering internals on the HIC, NuPac has stated (Ref. 10) that all internal protrusions will be made of a plastic material. All metallic parts of a dewatering system would be restrained from contacting the sides of the HIC by either non-metallic portions of the dewatering structure or by the waste form. Therefore, the dewatering internals should not pose a problem with regard to (a) forming a corrosion couple with the Ferralium 255 HIC or (b) possibly penetrating the HIC during a drop event.

3.8.2 Creep

Design mechanical tests for polymeric material should be conservatively extrapolated from creep test data (Ref. 2). However, inasmuch as the FL-50/EA-50 HICs are to be fabricated from a high strength stainless steel (Ferralium alloy 255), creep of the stainless steel will be negligible under any conceivable condition that the HICs might have to endure. With regard to creep of the gasket, there is metal-to-metal contact between the lid and the body of the HIC when the HIC is closed; therefore, the effects of gasket creep on HIC integrity are expected to be insignificant. The vent also is designed such that the creep load will be relatively low, and any effects of creep would not impact the service of the vent or integrity of the HIC. Hence, creep effects were not considered quantitatively in the review of the design of the FL-50/EA-50 HIC.

3.8.3 Biodegradation

The biodegradation properties of the proposed HIC materials, wastes, and disposal media should be considered in the HIC design (Ref. 2). Certain standardized tests are called for in the NRC Staff Technical Position on Waste Form (Ref. 2).

In the initial version (Ref. 6 and 7) of the FL-50/EA-50 generic topical report, biodegradation is addressed (see Section 2.0, Qualification of Container Material). As noted therein, biodegradation of a metal can be defined as the deterioration of the metal by corrosion processes that occur directly or indirectly as a result of the activity of living organisms. Subsequent discussion then addressed various aspects involving the presence of aerobic versus anaerobic bacteria. For clarification, the NRC Staff requested (Ref. 8) additional information concerning (a) the effects of potential sulfur-bearing compounds in the waste, (b) the magnitude of potential gas generation, and (c) the potential effects of aerobic bacteria in anoxic environments. NuPac's response (Ref. 10), which was quite comprehensive, basically can (along with the information in the original report) be summarized as follows:

(1) Any gas generation that might occur within the container would be relieved by the special vent, or if the vent were plugged by some unforeseen process, by the lid gasket (which under test was detected to leak at about 20 to 75 psig for the lead and silicone rubber gaskets, respectively).

(2) Given the limited amount of oxygen and light within the interior of a HIC, the only possible sustained growth of micro-organisms is through microbes that metabolize fatty acids as a carbon source. The most common fatty acids are rarely used at commercial power plants, and if they were used, they would, in most cases, be in low concentrations.

(3) If sulfate, sulfite, or other sulfur-bearing compounds were present in the waste that is placed in the HIC, and/or should the growth of either aerobic or anaerobic bateria occur, the end products would be low concentrations of sufuric acid and hydrogen sulfide. As described in the report, however, Ferralium 255 has been shown to be very resistant to corrosive attack by such chemicals. Therefore, the effect of their potential presence on the performance of the FL-50/EA-50 HIC is expected to be insignificant.

(4) An explanation of specific microbe metabolism methods, possible

complicating effects of prolonged waste dewatering times, and a list of the most common fatty acids were submitted as an attachment to the response (Ref 10) to Staff questions. The Operating Procedure, to be followed by HIC users, addresses the practical application of limiting organics, the length of dewatering, and other appropriate related concerns.

While staff does not believe that NuPac's contention about the role of fatty acids in the biodegradation process is particularly persuasive, because there is contrary evidence available from experience with operating reactor wastes, the fact is that (a) Ferralium 255 is very resistant to corrosion, (b) operating procedures (Appendix A) will preclude the loading of the most potentially troublesome waste materials, and (c) the passive vent will allow for relief of any internal pressure generated by biodegradation of wastes containing deleterious chemicals such as fatty acids.

Considering these factors, the staff concludes that there is reasonable assurance that (a) biodegradation of the HIC material (Ferralium 255) is so extremely unlikely that biodegradation testing of the alloy in accordance with ASTM or other standardized tests is unnecessary, and (b) significant biodegradation of wastes, leading to a loss of structural integrity of the HIC (resulting from, for example, corrosion of the F255 alloy or extensive gas generation that would not be alleviated by the passive vent) is also unlikely.

3.8.4 Top Surface Water Retention

The HIC should be designed to avoid the collection or retention of water on its top surfaces to minimize the accumulation of trench liquids that could result in corrosive or degrading effects. NuPac has designed the HIC so that the retaining ring at the center of the upper head is slotted such that any water entering the area can drain back out. All areas at the top head are designed to be self draining. The staff concludes that there is reasonable assurance that there will not be a corrosion problem with the FL-50/EA-50 HIC due to collection or retention of water on the top surface.

3.8.5 Cold Weather Testing

The test "criteria" for evaluating the container under normal conditions of transport includes determination of the effect of ambient cold temperatures as low as -40°F on the HIC design. Concerns about cold weather testing were expressed by the State of South Carolina (Ref. 20), and a multi-part question (No. 16c) regarding the impact resistance of Ferralium 255 at low temperatures was generated by the NRC staff (Ref. 8).

In response, NuPac submitted (Refs. 10 and 16b) charpy impact data on welded Ferralium at temperatures as low as -100°F. While the impact strength of F255 weld metal decreases substantially with temperature, the charpy impact values for weldments, at 0°F for example, varied from greater than 10 ft. lbs. to approximately 20 ft. lbs. Even at -40°F, weld metal charpy impact values were equal to or greater than 8 ft. lbs. (Ferralium 255 base metal exhibits much higher toughness values than the welded material at low temperatures). Allowing for (a) the inherent difficulty in performing drop tests on fully-loaded FL-50/EA-50 HICs at temperatures as low as -40°F and (b) the fact that the charpy impact tests on weld material demonstrate significant toughness at low temperatures, the staff conclude that there is reasonable assurance that cold weather will not present an undue hazard with the FL-50/EA-50 HIC and that further testing at low temperatures is not required.

3.9 Surveillance

Generally, demonstration of the adequacy of any HIC design would involve three things: (1) laboratory testing, (2) analytical predictions, and (3) field experience. Because field experience with F255 in soil is sparse, there is some uncertainty regarding the possibility for synergistic effects or environmental degradation phenomena whose magnitude it may not be possible to predict or whose nature it may not even be possible to identify at this time. Final confirmation of the adequacy of a new HIC design such as NuPac's FL-50/EA-50 can, however, be provided over time through inspections of surveillance specimens buried at each licensed disposal site.

NRC is considering a plan for establishment of surveillance protocols involving "archival trench" burials of HIC specimens (and "mini - samples" of HIC materials) at LLW burial sites. NuPac was requested (Ref. 8) to agree in principle to providing F255 surveillance specimens for use in a long-term surveillance program, with the understanding that the details of the program can be established on a schedule independent of and possibly subsequent to, the approval of the FL-50/EA-50 HIC design.

In response (Ref. 16b), NuPac expressed a positive interest in supporting a surveillance program, centering around an "archival trench" concept in which surveillance specimens (for example, corrosion coupons or an actual HIC) could be placed for subsequent periodic retrieval and inspection under an established protocol. Until the specific details of such a program have been established, it is not practicable to mandate particular requirements or to expect vendors, burial site operators, state agencies, etc., to make circumstantial commitments. However, it should be noted that verification of the adequacy of a HIC design and materials of fabrication can only be provided directly through actual surveillance, which would involve periodic inspections over several years.

4.0 REGULATORY POSITION

NRC staff has completed its review of the topical report that is intended to serve as the referential document that describes the design of the NuPac FL-50/EA-50 high integrity container (HIC) for low-level radioactive waste and provides the basis for determining the adequacy of the HIC design. In its evaluation staff primarily focussed on (1) applicable sections of 10 CFR 61, 10 CFR 71, and 49 CFR 173 and (2) additional requirements proposed by state agencies. Based on its evaluation of the information provided in (a) the topical report (original submittal plus revisions), (b) written responses by

NuPac to NRC Staff questions and comments, and (c) meetings and telephone discussions with NuPac representatives and consultants, the staff conclude that there is reasonable assurance that, considering the proposed use of the NuPac FL-50/EA-50 HIC, the HIC meets the structural stability requirements of Part 61 and is consistent with the guidance presented in the NRC staff Technical Position of Waste Form.

This approval of the FL-50/EA-50 HIC and Topical Report is predicated on completion and issuance of the final Topical Report (proprietary and non-proprietary versions) according to review agreements and the following conditions:

(1) That the FL-50/EA-50 HIC shall be used in accordance with the Operating Procedure restrictions outlined in the Appendix to this Technical Evaluation and all additional restrictions and requirements specified by the burial site operators and governing state agencies.

(2) Users of the FL-50/EA-50 HIC shall certify that all restrictions and required procedures have been adhered to and that the HICs do not contain proscribed chemicals or waste materials.

Based on responses (Ref. 16) to questions, staff understands that NuPac will provide appropriate material specimens for a surveillance program where corrosion samples are to be buried in an archival trench at each LLW burial site and retrieved and inspected at periodic intervals.

5.0 REFERENCES:

1. 10 CFR 61, Licensing Requirements for Land Disposal of Radioactive Waste, U.S. Government Printing Office, January 1, 1985.

2. Technical Position on Waste Form, Rev. 0, U.S. Nuclear Regulatory Commission, May 1983.

3. Larry J. Hanson (NuPac), letter to Nancy Kirner (WA), File No. 58436.JCR, November 3, 1983.

4. T.R. Strong (Department of Social and Health Services, WA), letter to Donald A. Nussbaumer (NRC), January 5, 1984.

5. Leo B. Higginbotham (NRC), Memorandum for Donald A. Nussbaumer, "Technical Assistance to Washington State on the NuPac HIC," February 16, 1984.

6. John D. Simchuk (NuPac), letter to Michael Tokar (NRC), Subject: Affidavit to Withhold from Public Disclosure NuPac Proprietary Information on the Model FL50 High Integrity Container," File: FL50-G, February 13, 1984.

7. John D. Simchuk (NuPac), letter to Michael Tokar (NRC), Subject: NuPac Model FL-50 High Integrity Container dated 1/30/84, File: FL50-793, March 1, 1984.

8. Michael Tokar (NRC), letter to Richard T. Haelsig (NuPac), "Request for Additional Information on NuPac's Generic FL50 HIC Report," October 25, 1984.

9. P.L. Piciulo, C.E. Shea, and R.E. Barletta, "Analyses of Soils at Low-Level Radioactive Waste Disposal Sites," Draft Report, Brookhaven National Laboratory, BNL-NUREG-31388, May 1982.

10. Charles J. Temus (NuPac), letter to Michael Tokar (NRC), Subject: "NuPac FL-50/EA-50/EA-50, Response to NRC Questions, dated 2/85," File:680-15, March 1, 1985.

11. FERRALIUM Alloy 255, Cabot Bulletin H-2005.

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15. M. Tokar (NRC), Telecommunications with C. J. Temus and S. D. Goetch (NuPac), April/May 1985.

16(a). C. J. Temus (NuPac), Telecopy to Dan Huang (NRC), "NRC Structural Findings," April 24, 1985.

16(b). C. J. Temus (NuPac), letter to M. Tokar (NRC), May 16, 1985, with Revised Responses to NRC Staff Comments.

17 Heyward G. Shealey (SC), letter to Stephen Goetsch (NuPac), September 27, 1984.

18. Robert Barbarin, "Selecting Elastomer Seals for Nuclear Service," Parker Hannifir Corporation/Seal Group.

19. R. EG. Jaeger, Compendium on Radiation Shielding, Springer-Verlag, 1975.

20. Virgil R. Autry (SC), letter to Donald A. Nussbaumer (NRC), September 17, 1984.

NUCLEAR PACKAGING

OPERATING PROCEDURE

FOR

ENVIRALLOY DISPOSAL CONTAINERS

WITH SERIES A (WEDGE) CLOSURE

OM-32

Rev. 1

AUGUST 29, 1985

Gary L. Clark	29 August 1985
Prepared By	Date
	9/5/85
Engineering	Date
S.E. Hill	9/5/85
Quality Assurance	Date
	9-5-85
Manufacturing/Production	Date
NA	—
Other	Date
	9.5.85
Document Control/Release	Date

TABLE OF CONTENTS

1.0 GENERAL SCOPE

1.1 Purpose

This document delineates several procedures that are required for personnel and property saf_ty and adherence to the applicable regulations for containment and burial of an Enviralloy High Integrity Container (HIC).

1.2 Content

This procedure describes the methods and techniques required to operate any container in the Ferralium family of High Integrity Containers from fabrication through burial. It is an all encompassing generic procedure unless specific site, customer, or application requirements are indicated by the procedure cover page and Section 1.3, Applicability.

Addendums may be attached as necessary. Any addendums are noted in the Table of Contents and Section 1.3, Applicability.

1.3 Applicability

This procedure applies to the related activities of all Nuclear Packaging, Inc. employees, their contract personnel, utility customers and their contract personnel. Any applicable personnel that handle load, procure, store, close and ship the container are bound by this procedure.

2.0 REFERENCES

2.1 United States Code of Federal Regulations Title 10 Part 61

2.2 United States Code of Federal Regulations Title 10 part 71

2.3 Nuclear Packaging Cask handling procedures

2.4 Nuclear Packaging Quality Assurance Program, NRC Approval No. 0192

2.5 Nuclear Packaging, Inc. Enviralloy High Integrity Containers Topical Report

2.6 NuPac Procedure CP-05, Cleaning of Enviralloy Containers

2.7 NuPac Procedure No. LT-17, General Procedure - Soap Bubble (Low Pressure) Test for Enviralloy Containers

2.8 Nupac Procedure NO. FS-01, Sec for Fab/Mach of Steel Parts

2.9 Criteria for High Integrity Containers, Washington State Radiation Control Program, August 25, 1983.

2.10 US NRC Final Waste Classification and Waste Form Technical Position Papers, May 11, 1983

3.0 DEFINITIONS

3.1 HIC: High Integrity Container

3.2 Liquid Free Waste: Dry waste such as dried filters, DAW, hardware etc.

3.3 DAW: Dry Activated Waste

4.0 LIFTING AND HANDLING PROCEDURE

4.1 Empty Container

The empty containers can be lifted by any one of the normal lifting connections (lifting slings, lifting padeye or lifting eye) or by lifting beneath the container with a forklift or other suitable device such as a lifting platform. Care should be taken not to drop or damage the container. The tare weights of the containers are noted in Table 4-1.

4.2 Loaded Container

Lift the loaded container only by the lifting sling assembly or the special lifting lugs designed for remote handling equipment or from beneath the container with a forklift or lifting platform. The maximum gross weight of each container is listed in Table 4-1.

Table 4-1

Model	Tare weight (lbs.)	Gross Weight (lbs.)
EA-210H	3790	20000
EA-210B	3450	20000
EA-190H	3455	20000
EA-190B	3060	20000
EA-142H	2585	10000
EA-142B	2545	10000
EA-140H	2430	15000
EA-140B	2185	15000
EA-7-100H	2640	13000
EA-7-100B	2545	13000
EA-6-100H	2110	12000
EA-6-100B	2060	12000
EA-50H	1435	4200
EA-50B	1435	4200

5.0 STORAGE PROCEDURE

5.1 The containers shall not be stored where they will come in contact with an environment that violates the requirement of 7.4

5.2 Store the closure gasket in a cool dry place out of direct sunlight. Protect the closure gaskets from abrasion, cutting, harsh chemicals and fumes or excessive loaded pressure during storage.

5.3 Take precautions to prevent the container from filling with rain water.

5.4 Store containers in an area where they will not sustain impacts, abrasions, gouging, or other damage.

5.5 Vent must be covered during storage with a ultraviolet (UV) opaque cover (i.e., black polyethylene, black poly vinyl chloride tape, etc.).

6.0 CLOSURE PROCEDURE

6.1 Manual Closure

6.1.1 Clean seal area both on container and on the lid to remove any dirt, grease, oils, or other debris.

6.1.2 Inspect gasket for any cuts or damage. Replace if necessary.

6.1.3 Place lid on gasket and align handles so they are between closure wedge holes on the series A containers.

6.1.4 Place wedges in holes and drive until secure. The wedges should be driven until the lid is metal to metal on the stops under the lid. Note: the wedges do not normally require driving to their full ramp length.

6.1.5 Remove vent UV cover.

6.2 Remote Closure

6.2.1 Perform steps 6.1.1 through 6.1.3

6.2.2 Drive wedges in place using a remote closure tool.

6.2.3 Remove vent UV cover.

7.0 WASTE COMPATIBILITY VERIFICATION PROCEDURE

NOTE: THIS PROCEDURE SECTION APPLIES TO ALL PERSONNEL AS OUTLINED IN SECTION 1.3, APPLICABILITY. THIS SECTION MAY BE PARTICULARLY APPLICABLE TO THE PLANT CHEMICAL MATERIALS COORDINATOR, RADWASTE OPERATIONS SUPERVISOR, RADWASTE TRANSPORTATION SUPERVISOR AND, SECONDARY, TO THOSE WHO USE THE CHEMCIALS SUCH AS THE APPROPRIATE OPERATIONS, CHEMISTRY AND MAINTENANCE GROUPS.

7.1 Scope

7.1.1 Purpose

The waste material placed in the container must be compatible with the operation of the container in addition to the container's material corrosion properties. Verification of the compatibility of the waste and the processes performed on it is required to meet the applicable safety, transportation and burial requirements of a High Integrity Container (HIC).

7.1.2 Content

The waste compatibility procedure is designed to require minimum steps and no plant chemical analysis. Tha procedure requires less than 5 steps.

7.1.3 Applicability

Waste compatibility verification applies to all waste placed in the container regardless of the nature of the material or mixture. It includes, but is not limited to:

7.1.3.1 Ion exchange resins

7.1.3.2 Cartridge filters

7.1.3.3 Cloth material

7.1.3.4 Paper wastes, other small containers and their contents,

7.1.3.5 Hardware and the liquids coating it

7.1.3.6 Stabilization media and the chemicals incorporated in the stabilization media.

7.2 Prerequisites

7.2.1 Utilities and Tools

No utilities or tools are required for this part of the procedure.

7.2.2 Other Procedures and Checklists

No other procedures are required. The checklist that is a duplicate of Figure 1 is required to complete this part of the chemical compatibility section of the container procedure.

The flow diagram, Figure 2, is to be used in conjunction with the chemical compatibility procedure found in Section 7.3.

FIGURE 1 - ENVIRALLOY CONTAINER PROCEDURE CHECK OFF SHEET

A) CONTAINER PREREQUISITES PER THE PROCEDURE

1.0 User__________________ Date________

2.0 Model Number ______________ Serial Number ________________

3.0 Waste Description (cation resin, anion resin, DAW, filters, etc.) ____

____

			Verification
4.0 Containers handled per 4.0 of procedure.			______________
5.0 Container stored per 5.0 of procedure.			______________
6.0 Chemical Compatibility per Section 7.0.			______________
	Yes	No	
The waste is corrosive per section 7.3.1	___	___	______________
Temperature limits met per section 8.0	___	___	______________

B) USAGE VERIFICATION

1.0 Container filled with dry waste or has been dewatered per an approved dewatering procedure. ______________

2.0 Closure

2.1 Seal area clean prior to closing. ______________

2.2 Wedges secured per 6.1.4 of procedure. ______________

NOTE: A COMPLETED COPY OF THIS FORM SHALL BE INCLUDED WITH THE SHIPMENT OF EACH APPLICABLE LOADED CONTAINER. THE ORIGINAL SHALL BE RETAINED BY THE USER IN ACCORDANCE WITH THEIR RECORD KEEPING PROCEDURE.

Signature ____________________ Title__________________

FIGURE 2 - CHEMICAL COMPATIBILITY PROCEDURE FLOW DIAGRAM*

```
        Yes
|<----------Liquid Free Waste(DAW, Dry Filters, Etc.)
|                             |
|                          No |
|      Yes                   \|/
| |<-------------pH Greater Than 3_______________
| |                           |                 /|\
| |                        No |       Neutralize |
| |                          \|/   Yes    Dilute |
| | Greater Than 2 wt.% Cl- Plus F--->WASTE IS CORROSIVE
| |                           |
| |                        No |
|  \|/                       \|/          No
|   |------------->Water Treatment Media------>|
|                             |                |
|                        Yes  |                |
|                            \|/               |
|         Cautionary Phrase on Oxidizers       |
|                             |                |
|                             |<---------------|
|                            \|/
|                             |
|                             |
|                        No   |
|                            \|/
|------>WASTE IS CHEMICALLY O.K. FOR THE CONTAINER
```

*Work the flow diagram with the procedure found in Section 7.3.

7.3 Chemical Compatibility Check Off Procedure

The following check off procedure for chemical compatibility does not require specific chemical analysis or a plant wide chemical inventory. The check off procedure eliminates such analysis and inventories. The check of procedure considers the waste source and the operating function before its chemical composition.

7.3.1 Overall Chemical Compatibility

a). Is the waste completely free of liquids? (dewatered resins and damp cloths are considered wet)

Yes - the waste is not corrosive, note on the check list and go to 7.3.2.

No - continue.

b). Does the waste liquid, or contact water, have a pH greater than 3?

Yes - the waste is not corrosive, note on the check list and go to 7.3.2.

No - continue.

c). Does the waste liquid, or contact water, have greater than 2% by weight chloride plus fluoride ions?

Yes - the waste is corrosive, note on the check list and go to 7.3.4.

No - there are no corrosives, note on the check list and continue.

7.3.2 Water Treatment Media

a). Is the waste media ion exchange resins?

Yes - continue.

No - go to 7.3.4.

7.3.3 Oxidizer Caution

NOTE: OXIDIZERS DO NOT POSE ANY PROBLEMS TO THE CONTAINER ITSELF. AN OPERATIONAL CAUTION IS INCLUDED IN THIS PROCEDURE APPLYING TO THE WASTE HANDLING AND PROCESSING THAT MAY BE PERFORMED IN CONJUNCTION WITH THE CONTAINER.

CAUTION: ION EXCHANGE RESINS WHEN EXPOSED TO SUFFICIENT QUANTITIES OF OXIDIZING CHEMICALS (NITRIC ACID, ALKALINE PERMANGANATES, PEROXIDES, HYPOCHLORITES, ETC.) CAN PRODUCE REACTIONS RANGING FROM INCREASED TEMPERATURES UP TO EXPLOSIONS. SMALL AMOUNTS OF CLEANERS AND DECONTAMINATION SOLUTIONS USED IN NORMAL DAILY OPERATIONS WOULD NOT BE EXPECTED TO BE A PROBLEM. HOWEVER, LARGE HARDWARE DECONTAMINATIONS OR LARGE AREA CLEANINGS COULD POSE A PROBLEM. AN EXAMPLE WOULD BE THE TREATMENT OF THE RINSE WATER FROM A RECIRC PIPE DECONTAMINATION PROCESS. THE ION EXCHANGE RESIN VENDOR SHOULD BE CONSULTED WHEN THERE IS ANY POTENTIAL FOR LAODING OF OXIDIZERS ON ION EXCHANGE RESINS.

7.3.4 If the waste media is too corrosive for the container, the waste may be diluted, neutralized or rinsed to meet the corrosion criteria. Consult with NuPac personnel. Restart the entire procedure when the corrosive nature of the waste is corrected.

7.4 Chemical Corrosion

Chemicals on this list must not be present in the container in sufficient acidic concentrations to corrode the container past acceptable limits for a 300 year life. The use, or evolution of hydrochloric acid above a 2 wt.% chloride concentration and less than a pH of 3 is the situation to avoid.($pH<3$ and $Cl^- + F^-$ >2%wt.)

TABLE 7.1 CORROSIVE CHEMICAL LIST

Chemical Name	Possible Sources
Ammonium Chloride	
Anion Ion Exchange Resins	Treating seawater with the radwaste system
Carbon Tetrachloride	Lab Wastes
Cation Ion Exchange Resins	Unused or partially used hydrogen form resin
Chloroform	Lab Wastes
Degreasers	See Freons, Trichloroethylene, Trichloroethane
Freons R-10, 11, 12, 13, 14, 20, 21, 22, 23, 30, 40, 41, 113, 114, 115, 142, 152, 160, 216, 500's	Refrigerant systems, lab wastes, ultrasonic decon
Halogenated Hydrocarbons	
Hydrochloric Acid (Muriatic Acid)	
Hydrofluoric Acid	
Methylene Chloride	Solvents, degreasing
Muriatic Acid (Hydrochloric Acid)	
Refrigerants - See Freons	
Sea Water and acids	Sump intrusion+acid
Trichloroethylene	Solvents, degreasing
Trichloroethane	Solvents, degreasing
Trifluoroacetic Acid	
Chlorides and Acids	