

External Corrosion Analysis of Model 9975 Packaging Container

by

P. Vormelker

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

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EXTERNAL CORROSION ANALYSIS OF MODEL 9975 PACKAGING CONTAINER (U)

Philip R. Vormelker

Savannah River Technology Center
Strategic Materials Technology Department
Materials Technology Section
Materials Consultation Group

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**Westinghouse Savannah River Company
Savannah River Site
Aiken, SC 29808**

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APPROVALS



Philip R. Vormelker

Date: 1/11/99

Philip R. Vormelker, Author
Materials Consultation Group
MATERIALS TECHNOLOGY SECTION



R. L. Sindelar, Technical Reviewer
Materials Application and Corrosion Technology Group
MATERIALS TECHNOLOGY SECTION

Date: 1/12/99



R. Linnea Bickford, Manager
Materials Consultation Group
MATERIALS TECHNOLOGY SECTION

Date: 1/12/99



Tami L. Capeletti, Manager
MATERIALS TECHNOLOGY SECTION

Date: 1/12/99



R. J. Gromada, Customer
Packaging and Transportation Group
ENGINEERED EQUIPMENT AND SYSTEMS DEPARTMENT

Date: 1/14/99

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LIST OF ABBREVIATIONS

ASTM	American Society for Testing and Materials
ASME	American Society of Mechanical Engineers
RFETS	Rocky Flats Environmental Technology Site
SARP	Safety Analysis Report for Packaging
SRS	Savannah River Site
SRTC	Savannah River Technology Center
SS	Stainless Steel

1.0 SUMMARY

The Materials Consultation Group of SRTC has completed an external corrosion analysis of the Model 9975 packaging container for storage in K Reactor under ambient conditions for a period of 12 years. The 12-year storage period includes two years for shipping and ten years for storage. Based on review of existing literature and stated building storage conditions, corrosion degradation of the 304L Stainless Steel (SS) packaging containers (drum and vessels) should be minimal during the 12 year time period. There may be visible corrosion on the galvanized carbon steel pallet due to initial drum handling. The visible corrosion will not be sufficient to cause significant degradation during the 12-year storage period. The Materials Consultation Group concludes that there are sufficient data to establish the technical basis for safe storage of the Model 9975 container in the 105-K building for up to 10 years following the 2-year shipping period. The data are sufficient to allow the 304L SS containers to be stored for a total period of 15 years.

2.0 BACKGROUND AND ASSUMPTIONS

Pu-bearing materials (metal and oxides) currently stored at RFETS (Rocky Flats Environmental Technology Site) are to be shipped to SRS in Model 9975 packaging assemblies for interim storage prior to future disposition. Multiple units of the Model 9975 packaging assembly will be strapped to a galvanized steel pallet. The outer container in the Model 9975 is composed of a welded SS 35-gallon drum per Figure 1. The welded drum is constructed of 304L SS with 308L SS filler material.^{1,2} The wall, lid, and bottom of the drum will be of 18 gauge (0.048 inches) material. The drum will have a 304L SS identification plate that will be tack welded and then caulked around the top and side edges with a silicone rubber sealant (Dow Corning 732 RTV or equivalent).¹ The SRS total chlorine limit for materials in contact with SS, such as a caulking compound, is 250 ppm.³ The Primary and Secondary Containment Vessels are also constructed of 304L SS.

A maximum of five drums will be strapped together on one galvanized carbon steel pallet similar to Figure 2.⁴ A second pallet will be stacked on top of the first one. The stacking limit is two pallets high.⁴

Upon arrival at SRS, the 9975 packaging assemblies will be stored in Building 105-K process room, crane maintenance area, stack area, and the crane wash area. The building environment will essentially mimic outdoor weather patterns except that the assemblies will be shielded from wind, rain, and storms. Temperatures will range from 0°F to 130°F (-18°C to 54°C) with varying humidity levels up to 100 %.⁵ The building will be heated but not cooled.

3.0 EXTERNAL CORROSION ANALYSIS

3.1 External Corrosion Analysis of Model 9975 Outer Container

Austenitic SS is generally a very corrosion resistant material in most environments. The composition of 304 SS is approximately 18-20 % chromium, 8-12 % nickel, 2 % manganese and 0.08 % carbon with limited amounts of phosphorus, sulfur, silicon, and nitrogen. The chromium

creates an oxide film that protects the material in oxidizing conditions while nickel aids in protecting the material in reducing conditions. Thus, 304 SS shows resistance to both nitric and sulfuric acids. The L-grade reduces the carbon levels to 0.03 % or less to prevent sensitization (precipitation of chromium carbides) during exposure to heating above 800°F. However, the elemental composition of 304L SS does not prevent stress corrosion cracking from occurring due to chloride exposure. The excellent atmospheric corrosion resistance of 304 SS is a very important consideration for use in storage conditions.

While stainless steel's corrosion resistance to building storage conditions has not been found in the literature, exposure to industrial and marine atmospheres is available. Humidity, air temperatures, type of industrial pollution, vicinity to marine exposure, mating of dissimilar materials, and fabrication type influence the behavior of austenitic stainless steel in these atmospheres. The SRS atmosphere tends to be more rural since the site is distant from the more populated and industrial areas. Although the Model 9975 shipping container will be sheltered, data from industrial and/or marine exposure should be a worst case scenario for the 304L SS container. Table 1 contains marine exposure data (250 m from the ocean) for a 15-year exposure of austenitic stainless steel samples.⁶ The 304 SS samples were found to be spotted with a slight rust stain on 15 % of the sample surface with an average pit depth of 1.1 mils (0.028 mm). The maximum average pit depth for all the austenitic stainless steel samples was 1.6 mils (0.04 mm). Data was not available on maximum pit depths. General corrosion of each of the austenitic stainless steels in the marine atmosphere was less than 0.001 mils per year or less than 0.015×10^{-3} inches (3.8×10^{-4} mm) for the 15-year testing period. While the rust stain is probably due to films of soot and dirt containing iron, pitting is due to the presence of chlorides.

In Table 2, the difference in two city atmospheres shows definite effects from chlorides. While samples exposed to the atmosphere in New York City for 26 years showed no rust staining, samples exposed in Niagara Falls near industrial plants producing chlorine and hydrochloric acid were attacked in less than a year.⁷ Assuming that the atmospheric level of chlorides around SRS is more similar to New York, then it is to Niagara Falls, a conservative value of 3.2 mils (0.08 mm) will be used as the maximum expected pit depth for the 105-K storage atmosphere over the 12-year period. This value is double that of the maximum average pit depth in Table 1. This maximum pit depth (0.0032 inches) is approximately 7 % of the thickness (0.048 inches) of the Model 9975 container. The maximum pit depth is also within the permissible variation in sheet thickness of ± 0.005 inches from manufacturing per ASTM standards.⁸ Also, the maximum general corrosion rate of the Model 9975 container is expected to be less than 0.015×10^{-3} inches based on the previously mentioned marine data for a 15-year period. Thus, very little corrosion (general and pitting) is expected on the 9975 outer shipping container during storage conditions in Building 105-K.

Intergranular and transgranular stress corrosion cracking of the welded areas of the Model 9975 container is not expected due to fabrication with annealed, low carbon 304 SS (304L) and the lack of chlorides in the 105-K building environment, respectively. The low carbon content in 304L SS limits precipitation of carbides in the grain boundaries during welding that provides intergranular stress corrosion cracking resistance. Elimination of chloride containing cleaning agents in the drum storage area precludes the potential for transgranular stress corrosion cracking.

3.2 Other Corrosion Concerns

The identification plate will be caulked on sides and top per the 9972-9975 Series Packagings drawing.¹ Caulking is not specified for use on the bottom edge. The caulking is specified as Dow Corning 732 RTV or equivalent. Various 304 SS stress corrosion cracking incidents have occurred in the past at SRS due to chloride bearing labels. To prevent this, a SRS chloride limit of 250 ppm, maximum, is used for any material in contact with SS.³ The Materials Consultation Group maintains a chloride database based on incoming materials being analyzed. Normally, silicones do not contain significant chlorides. One version of Dow Corning's RTV caulking (3145 RTV) was analyzed to have 11 ppm chloride. However, the current Materials Consultation Group chloride database (1993-1998) does not contain test results for Dow Corning's 732 RTV over the last 5 years. It is suggested that the 732 RTV or equivalent be tested for chlorides.

A galvanized carbon steel pallet is normally expected to last a long time, even in exterior applications. However, corrosion of zinc will increase with increasing moisture levels (primarily acid rain). Reference 9 discusses interior applications of hot dip galvanized steel and states that it can be used in wet (high humidity) interior applications for up to 20 years before any maintenance is required. A typical application in this environment is structural steel. One caveat is that this assumes that no penetrations or pinholes exist in the zinc coating. Exposed carbon steel, due to small pinholes in the zinc coating, will not corrode due to cathodic protection. When large through coating penetrations are made, such as a scratch from a drum being scraped against the coating, the exposed area of the carbon steel may be too large to be cathodically protected. This produces surface corrosion in the carbon steel that will be a visual defect. If the visual defects become a housekeeping problem, maintenance may be required. This will not cause significant structural degradation to the carbon steel pallet over the 12-year period.

Galvanized and painted carbon steel strapping is subject to corrosion during service to bind drums on a pallet. Rust stains have been observed (by the author) on D₂O drums (stainless steel) due to corrosion of the galvanized strapping. The drums were stored in the crane maintenance area of 105-K. Condensate will cause corrosion on existing breaks in the strapping coating and will drip on the stainless steel drum. It is very difficult for a coating to survive the tension, twisting, rubbing, and bending of strapping installation without a coating break. This is another visual appearance problem. Stainless steel strapping should behave in the same manner as the 304L SS outer container in the Model 9975 shipping assembly discussed previously. Stainless steel is the recommended material for strapping in this application.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on a review of available data relative to the long-term performance of 304L SS, the Model 9975 outer container is not expected to develop significant corrosion degradation during the total time of 12 years. It is recommended that the specific silicon sealant or equivalent be tested for chloride levels prior to use. Corrosion of the galvanized steel pallet is expected to create a visual appearance problem during the storage period. Stainless steel strapping is also recommended to prevent visual appearance problems on the strapping and the Model 9975 outer container.

5.0 REFERENCES

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- 2) ASME Boiler and Pressure Vessel Code, Section II Materials Part A – Ferrous Material Specifications, SA-240 Type 304L, "Specification for Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels," 1995.
- 3) SRS Engineering Standard No. 05952 Rev. 0, "Practices To Minimize Chloride Induced Stress Corrosion Cracking Of Type 300 Series Austenitic Stainless Steel," (SRS Engineering Standards Manual: WSRC-TM-95-1) August 1, 1995.
- 4) Memo, T. D. Woodsmall to A. J. Cappucci, SRS-RPS-98-0116 Rev. 0, "KAMS Safety Analysis for Container Qualification Inputs and Assumptions (U)," September 13, 1998.
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- 8) ASTM Standards, A-480, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip," (ASTM, Philadelphia, PA, 1994).
- 9) British Standard BS5493, "Protection Systems" (British Standards Institution, London, UK, 1977) per F. C. Porter, 'Corrosion Resistance of Zinc and Zinc Alloys" (Marcel Dekker, 1994) p. 178-179.

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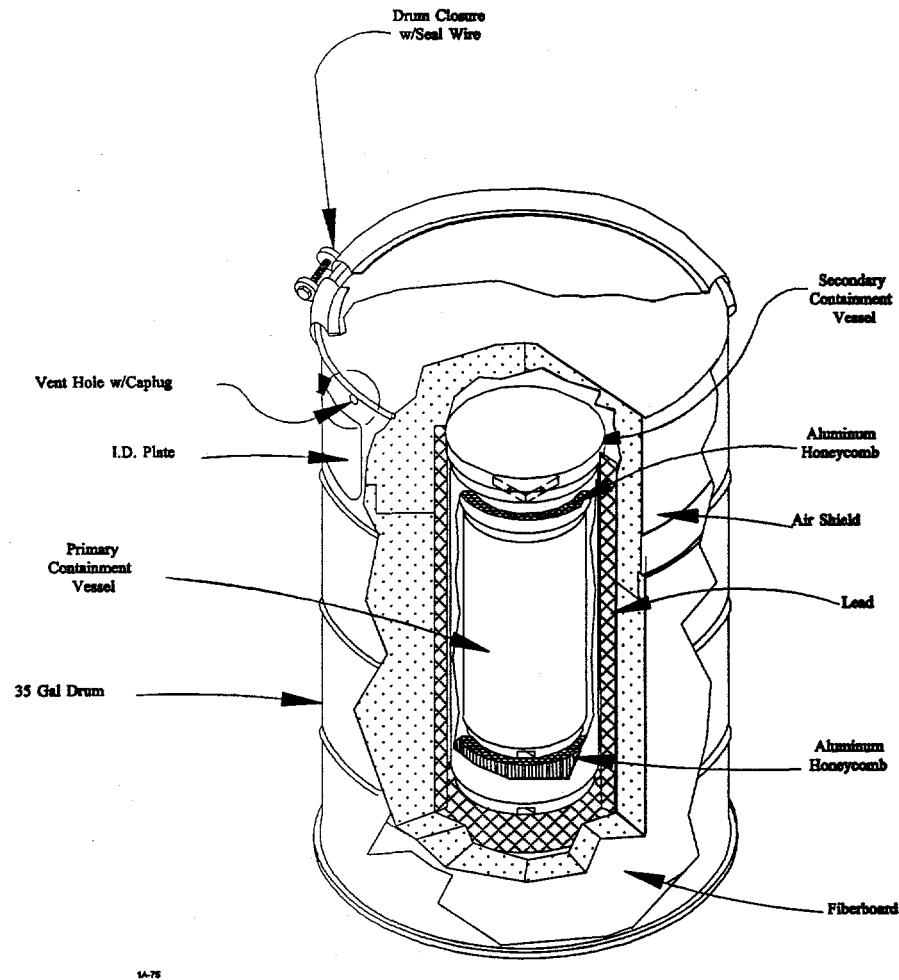


Figure 1. Overall Schematic of the Model 9975 Packaging Assembly [1].

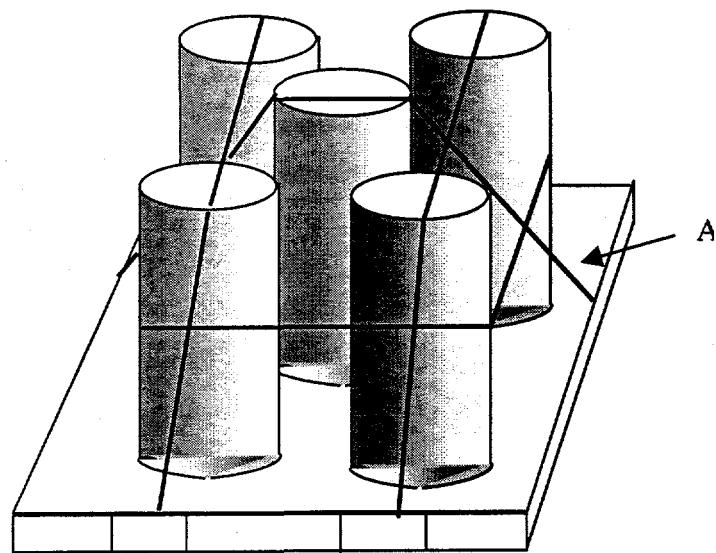


Figure 2 Author's conception of placement of five 9975 drums on galvanized steel pallet. Note strapping (A) securing drums to pallet. Pallet size is 4 feet by 4 feet. Drawing is not to scale.

Table 1. Corrosion of AISI 300-Series Stainless Steels in a marine atmosphere⁶
(Based on 15-year exposures 250 m (800 ft.) from the ocean at Kure Beach, NC)

AISI Type	Average Corrosion Rate mm/yr	Average Corrosion Rate mils/yr	Average Depth of Pits mm	Average Depth of Pits mils	Appearance(a)
301	<2.5 x 10-5	<0.001	0.04	1.6	Light rust and rust stain on 20% of surface
302	<2.5 x 10-5	<0.001	0.03	1.2	Spotted with rust stain on 10 % of surface
304	<2.5 x 10-5	<0.001	0.028	1.1	Spotted with slight rust stain on 15 % of surface
308	<2.5 x 10-5	<0.001	0.04	1.6	Spotted by rust stain on 25 % of surface
316	<2.5 x 10-5	<0.001	0.025	1.0	Extremely slight rust stain on 15 % of surface
317	<2.5 x 10-5	<0.001	0.028	1.1	Extremely slight rust stain on 20 % of surface

(a) All stains easily removed to reveal bright surface

Table 2. Atmospheric Corrosion of Stainless Steels at Two Industrial Sites⁷

Type (a)	New York City (industrial)		Niagara Falls (industrial-chemical)	
	Exposure time, years	Specimen surface evaluation	Exposure time, years	Specimen surface evaluation
302	5	Free from rust stains	<2/3	Rust stains
302	26	Free from rust stains		
304	26	Free from rust stains	<1	Rust stains
304			6	Covered with rust spots and pitted
316	23	Free from rust stains	<2/3	Slight stains
316			6	Slight rust spots, slightly pitted
317			<2/3	Slight stains

(a) Solution-annealed sheet, 1.6 mm (1/16 in.) thick

(b) Pitting depths were not reported

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