DEVELOPMENT OF VISUAL CRITERIA FOR EVALUATION OF CORRODED TRU-WASTE DRUMS AT THE DOE HANFORD SITE

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ABSTRACT

Fluor Hanford, Inc., at the Department of Energy (DOE) Hanford Site, has recently begun retrieving some 37,000 contact-handled, suspect-Transuranic or "Retrievably Stored Waste" (CH-TRU) waste drums from its Low Level Burial Grounds (LLBG). The drums are being retrieved, processed and prepared for eventual shipment to the DOE Waste Isolation Pilot Plant (WIPP). Immediately upon retrieval, the drums are visually inspected against requirements identified in the facility Authorization Basis to ensure they are safe for handling and fit for on-site transfer. A number of the retrieved drums did not meet specified corrosion criteria and as such required structural evaluation by Ultrasonic Test (UT) thickness checking (including mechanical surface prep) or overpacking into a Conex-type container prior to transfer. The additional evaluation and overpacking increases personnel exposure to the radioactive waste and reduces efficiency of the retrieval process.

Based on historic Hanford CH-TRU waste drum corrosion data, showing very low general corrosion rates, there was reason to believe that existing Hanford site-transfer corrosion criteria were more conservative than needed. In an effort to demonstrate this belief, a corrosion investigation was performed.

Eleven CH-TRU waste drums not meeting the corrosion criteria were included in the investigation and from these, 92 separate locations, or areas of corrosion, were evaluated. Each of these locations was visually characterized and evaluated for thickness using the UT method. Visual characterization consisted of ranking photographs for each location on a scale from 1 to 6, representing an increasing level of corrosion attack. UT thickness measurements were then plotted against the visual ratings to identify any significant correlation. Analysis of the data indicated that as the corrosion rating increased, wall thickness decreased. It was concluded that drum surfaces characterized by a corrosion rating of 1-4 could be expected to have wall thickness values exceeding site minimum, calculated structural integrity requirements.

The investigation concluded that existing corrosion criteria were in fact conservative and provided a technical basis for a new corrosion rating system. Application of the new system reduces the amount of evaluation and overpacking needed, while maintaining the transportation safety basis and worker safety.

In addition, Engineering has developed an on-going data sampling program in which UT thickness checking of drums, as they are retrieved from the burial grounds, is performed. Evaluation of this data will determine the impact, if any, on the technical basis established for the rating system and will allow appropriate adjustment, as necessary. Sampling will also allow evaluation of potential surface conditions not observed in the original 11-drum investigation.

It is noted that the safe, on-site transfer of drums is determined by all of the elements in the Hanford CH-TRU waste drum retrieval program, including design analyses, radiological controls, operational procedures, inspection requirements, etc. This paper addresses a single aspect of this process and the conclusions drawn regarding corrosion criteria were considered in the context of the overall program.

INTRODUCTION

Fluor Hanford, Inc. has recently begun retrieving some 37,000 drums containing contact-handled, suspect-Transuranic or "Retrievably Stored Waste" (CH-TRU) waste from the Hanford Site's Low Level Burial Grounds (LLBG). Upon retrieval, the drums are staged in an area at the LLBG where limited processing (nondestructive analysis, venting, labeling, etc.) is performed and are then transferred to the Treatment Storage and Disposal (TSD) facilities. Processing at TSD will prepare and certify the drums for eventual shipment to the Department of Energy's (DOE) Waste Isolation Pilot Plant (WIPP).

The drums considered herein, were fabricated to the Department of Transportation (DOT) 17H or 17C specifications (55-gallon, low-carbon steel with a galvanized or painted coating). These drums, placed into storage from 1970 through 1988, received extensive corrosion evaluation and analysis over the years, to include estimation of corrosion rates, time to loss of structural integrity and recommended future inspection frequencies. A comprehensive compilation of this work was reported in August 2001, reference [1], in which a bare-metal corrosion rate (general corrosion) of 26 microns/y (1 mils/y) was estimated for what is considered to be a "worst-case" storage condition at the LLBG. In addition, the project safety analysis report, reference [2], identified a calculated minimum 0.762 mm (0.030 inch) wall thickness needed to maintain structural integrity when subjected to Normal Transport Conditions (NTC), as defined in the Code of Federal Regulations (CFR).

At completion of limited processing at the LLBG, the drums are transferred to the TSD. Prior to transfer, each drum is visually inspected against criteria addressing attributes such as tears, dents, holes, etc., and attributes dealing with corrosion. Corrosion criteria include the following:

- "Minor corrosion", defined as less than or equal to 5% of the exterior surface
- Corroded surfaces not readily cleaned by steel wool, defined as "major corrosion"
- "No container material degradation that could affect the containment features"
- "No visible major corrosion"
- "If the bottom of the drum is corroded, it shall not be used for transporting payloads"

Drums not meeting one or more of the above corrosion criteria are not approved for on-site transfer. However, based on the estimated corrosion rate reported in reference [1] and the minimum wall criteria in reference [2], there was reason to believe that some of these drums, even though there were "signs" of corrosion, may in fact be suitable for on-site transfer. (It is recognized that the estimated rate is for uniform corrosion and that localized attack, to include pitting, may not have a significant effect on structural integrity but could impact containment integrity.) The above noted criteria provide some qualitative characterization regarding material degradation but do not provide a quantitative assessment of wall thinning, which has a direct impact on structural integrity. In an effort to better understand and quantify the effect of drum corrosion on wall thinning and thus provide a better measure (or criteria) for evaluating fitness for drum transfer, the following investigation was performed.

REPORT

Objective and Scope of Investigation

The primary objective was to obtain data to better understand and quantify the impact of visually observed corrosion on the structural integrity of CH-TRU waste retrieval drums. Structural integrity, for the purpose of this work, is defined as the ability of the drum to withstand catastrophic failure (failure in which the contents could potentially fall or spill out of the drum) under anticipated handling loads.

The scope of the investigation included:

- Eleven retrieved CH-TRU waste drums fabricated to DOT 17H or 17C specifications (55-gallon, low-carbon steel with a galvanized coating), and
- Visual characterization and wall thickness measurements of selected corrosion areas, and analysis to identify correlation between surface features and wall thicknesses and any other significant conclusions with regard to the on-site transfer of drums.

The driver for this effort was two-fold:

- Improve efficiency while ensuring the safe handling of drums during the retrieval process, and
- Reduce the amount of personnel exposure to radioactive waste, resulting from increased handling and processing activities associated with drum surface corrosion.

Corrosion Characterization

The eleven drums investigated are a subset of a group of retrieved and segregated CH-TRU waste drums from the Hanford Sites LLBG not meeting the then-current corrosion criteria for on-site transfer. Selection was subjective with the intent to include a variety of corroded conditions, from “light” to “heavy” attack. The drum shown in Figure 1 is typical of the drums evaluated.

Fig. 1. Typical Drum

A data table for each drum was prepared to include data and information for the each of the corrosion areas (specific locations on the drum) evaluated. The elements of the table are as follows:

- ID**:**
  The identifying number of the corrosion area evaluated.
- Location**:**
  Location of the corrosion area on the drum surface. Specific locations were selected at the discretion of the Design Authority (engineer).
- Wall Thickness**:**
  Thickness of the wall at the corrosion area as determined by UT thickness testing.
- Photographs:
  Photos of the corrosion area.
- Corrosion Rating**:**
  A number from 1 to 6, representing an increasing level of corrosion attack as determined by visual review of photographs taken for each evaluated surface. Ratings 1 and 2 are considered “light”, 3 and 4 - “medium” and, 5 and 6 - “heavy”. The primary attribute in determining the rating was the thickness of the corrosion product or scale, i.e., the heavier the scale the higher the rating. Areas with significant pitting, pocking and/or flaking received a rating of 5 or 6. Areas in which the galvanized coating was not breached, automatically received a rating of 1. The following provides a detailed description for each rating along with corresponding photographs, Figure 2:

  Corrosion Rating Description

  1 Oxidation (white coloration, sometimes powdery) of the galvanized coating in which the coating is not breached. Oxidation can be significant without affecting the base metal.

  2 Galvanized coating breached as evidenced by slight to medium rust coloration (reddish-brown) intermixed with the zinc oxide.

3 Significant breach of galvanized coating in large areas. Iron oxide of medium thickness covers the area, with some flaking.
4 Similar to rating 3 but somewhat heavier scale and greater flaking. Some pocking may be present.
5 Considerably heavier scale with significant pocking and/or flaking. A high potential for pitting under the scale can be expected.
6 The photo showing the corrosion rating of 6 is of the drum where a through-wall pit was exposed during the study. It is expected that drums exhibiting corrosion like that shown in the photo, will have some pitting under the scale.

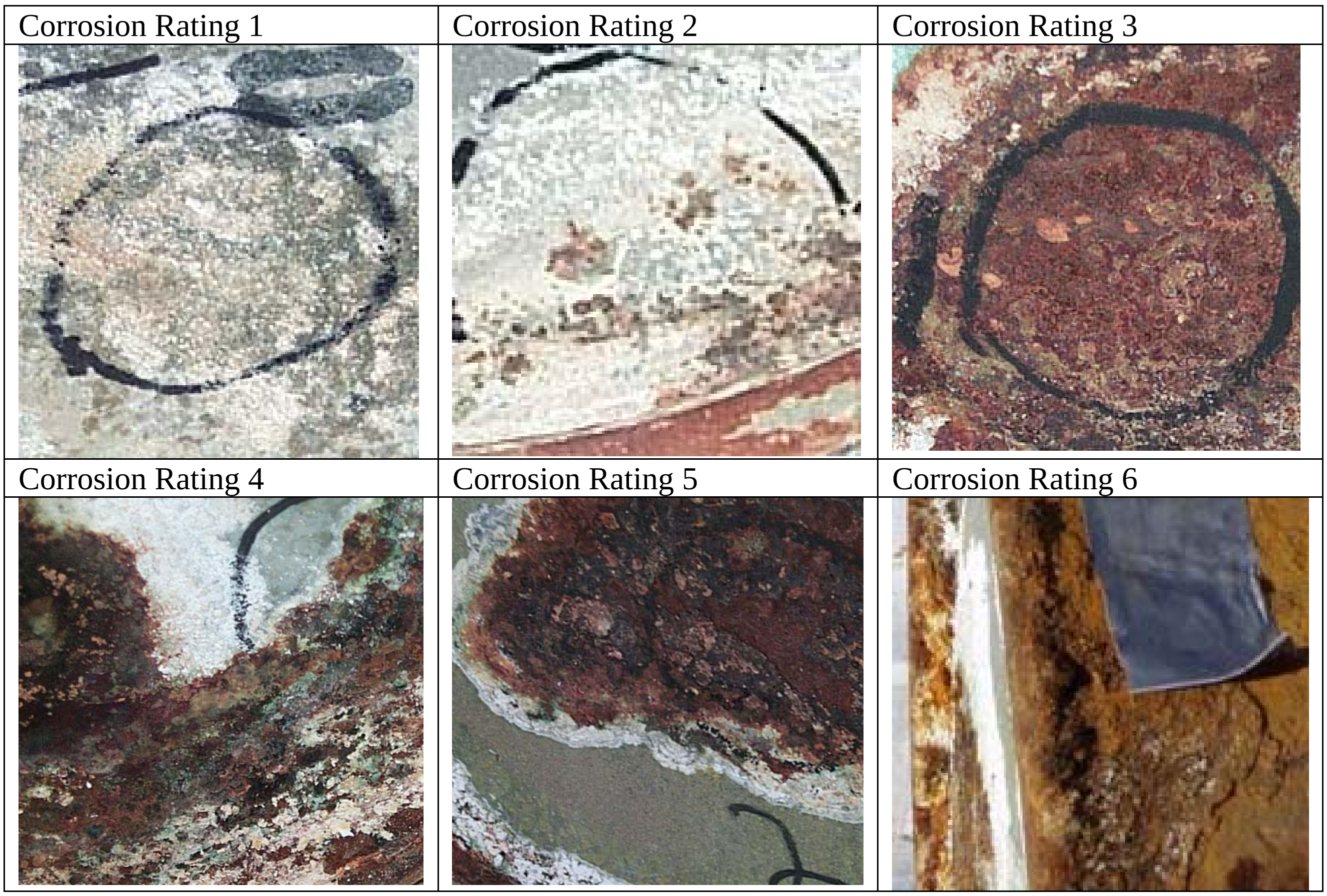

Fig. 2. Representative Photographs for the Six Corrosion Ratings

Characterization Data Analysis

Ninety-two separate corrosion areas from the 11 drums were evaluated for which both photographs and wall thickness measurements were obtained. The nominal wall thickness (at time of manufacture) of all drums evaluated was 1.524 mm (0.060 inch). The maximum wall thickness measured, of the 92 areas, was 1.829 mm (0.072 inch) and the minimum wall thickness, 0.864 mm (0.034 inch).

Figure 3 plots corrosion rating (X axis) against measured wall thickness (Y axis) for 91 areas (The single area rated with a 6 is not plotted.). The data is presented in a "box and whisker" format to help visualize data distribution and identify trends. The data indicates that as the corrosion rating increases, wall thickness decreases. It is acknowledged that additional data points at the higher ratings would provide a greater understanding of specific behavior and trending at those conditions – see box in lower right hand corner of Figure 2 for data point totals. All thickness values for corrosion surfaces characterized with a rating of 5 and less exceeded the Hanford-specified threshold for structural integrity of 0.762 mm (0.030 inch).

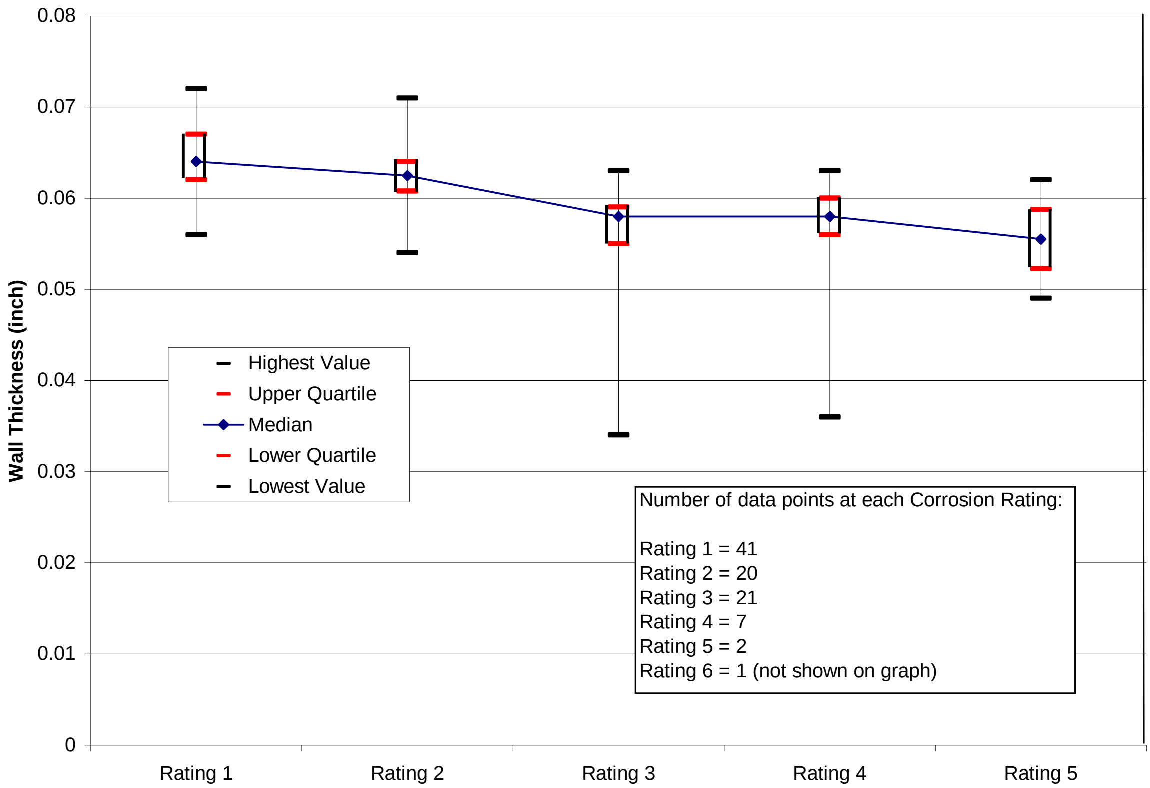

Fig. 3. Wall Thickness vs. Corrosion Rating

During UT testing of one of the drums, a through-wall pit was discovered. The area was being prepared for UT inspection by mechanically removing the corrosion product and scale. Discovery of the through-wall pit, not visible until the corrosion product was removed, caused the UT evaluation to be suspended and the drum subsequently overpacked. The immediate area in which the through-wall pit was discovered received a corrosion rating of 6.

Evaluation and characterization of corroded surfaces are from the drum exterior surface only. There is the potential for Hanford CH-TRU waste drums to experience wall thinning as a result of attack at the drum internal surface. Other DOE sites have reported internal corrosion in some of their CH-TRU waste drums that had become filled with water; due to unique storage and weather conditions, reference [3]. It was observed that pitting was the predominant form of attack and was most likely to occur in the lid. Internal, through-wall pitting, when observed from the drum exterior surface, is evidenced by staining or discoloration (typically dark brown) and a small hole(s) which may or may not be visible to the unaided eye. The surrounding surface appears largely unaffected, see Figure 4. None of the Hanford drums retrieved to date have shown signs of internal pitting corrosion.

Fig. 4. Internal, Through-Wall Pitting

As noted, the primary objective of this effort was to evaluate the impact of corrosion on wall thinning and hence, structural integrity of the drums. The data however, provide some information regarding containment integrity as well. All areas exhibiting general corrosion, evaluated by UT, revealed sound base metal indicating containment properties were not compromised.

It is recognized there are relatively few data points at the higher ratings, thus reducing confidence that these surfaces will be free of near, through-wall corrosion. In addition, disclosure of the through-wall pit, noted above, indicates caution should be applied when drawing conclusions regarding containment integrity at the higher ratings. Measures to detect through-wall pitting of these surfaces, include additional visual review/evaluation and survey for radioactive contamination. When additional review indicates a high potential for through-wall pitting, these drums are immediately overpacked.

Review of CH-TRU Waste Drum Retrieval Efforts at Other DOE Sites

The Savannah River National Laboratory (SRNL) and Idaho National Engineering and Environmental Laboratory (INEEL) were contacted regarding their CH-TRU waste drum retrieval programs. Specific information addressing wall thinning and its impact on structural integrity and visual acceptance criteria were discussed.

Both sites have well-defined programs and have addressed aspects of corrosion-related wall thinning on drum handling activities. Of particular significance are the criteria developed at

INEEL, because these form the basis for the criteria adopted by DOE at WIPP, as documented in DOE/WIPP-02-3122 “Contact-Handled Transuranic Waste Acceptance Criteria for the Waste Isolation Pilot Plant”, reference [4]. These criteria are visual based, i.e., whether or not corroded drums can be safely handled is determined based on evaluation of visually observed features. The visual-based approach for establishing acceptance criteria reported herein, is consistent with the SRNL, INEEL and DOE WIPP approach for accepting CH-TRU waste drums for storage.

The Savannah River National Laboratory concluded that drums can be safely handled even when “containing up to 3 inch to 4 inch long, in line cluster of through-wall corrosion pits”, as determined by “conservative fracture analysis”, reference [3]. INEEL established a similar criterion, in that it limits “significant thinning (almost through the wall)” to no more than 10 inches over the drum circumference, reference [5]. INEEL maintains that drums meeting this corrosion criterion, when used in conjunction with other criteria addressing tears, dents, holes, etc., are considered adequate to preclude catastrophic failure, i.e., failure in which contents could potentially fall or spill out of the drum, during handling activities.

CONCLUSIONS

- The structural integrity of Hanford CH-TRU waste retrieval drums is maintained when wall thickness values are greater than or equal to 0.762 mm (0.030 inch).
- The data reported herein suggests that drum surfaces characterized by a rating of 1-4 can be expected to have wall thickness values greater than or equal to 0.762 mm (0.030 inch) and expected to provide original drum design containment properties.
- The Hanford approach, i.e., a visual based approach, to evaluating drum integrity is consistent with that of other sites throughout the DOE complex.
- Additional characterization and thickness data should be collected as drums are retrieved from the burial grounds and evaluated for impact on the technical basis established in this report. Because of the relative few data points for surfaces rated at 4, additional sampling should begin with these surfaces. The data sampling frequency should be set such that confidence in the technical basis is maintained.
- It is recognized that the DOE has a single, uniform acceptance criteria for the transportation, storage and disposal of CH-TRU waste at the WIPP; however, criteria for the handling of drums at the individual DOE sites varies. There may be benefit in the coordination and establishment of a uniform criteria/evaluation system across the DOE complex for evaluating container corrosion, for on-site handling.

REFERENCES

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