EXPERIENCE WITH ANSI N14.30 FOR IN-SERVICE INSPECTIONS OF SEMI-TRAILER USED FOR SPENT FUEL SHIPMENTS

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ABSTRACT

On July 18, 1996, the Oak Ridge National Laboratory (ORNL) resumed shipping spent fuel in interstate commerce after a 10-year suspension of this activity. This shipment was conducted using a Nuclear Regulatory Commission-licensed spent fuel transport package purchased from General Electric Company by ORNL for the purpose of moving High Flux Isotope Reactor spent fuel to the Savannah River Site. The trailer, fabricated to the ANSI N14.30, "Semi-Trailers Employed in the Highway Transport of Weight-Concentrated Radioactive Loads—Design, Fabrication, and Maintenance," (ANSI, 1992) has recently undergone its first scheduled in-service inspection. This paper presents the experience gained from interpretation and application of the ANSI N14.30 standard focusing on the in-service inspection for the structure of the trailer.

Initially, the term "weight-concentrated" is illustrated giving detail to the location and center of gravity of the 33,500-pound shipping container and forces induced by the tie-down system. Basic information about the design stresses and initial testing provided by the manufacturer are used as a lead-in to the requirements of the standard. The task of examining the trailer structure provided many lessons and required considerable effort. All of the support personnel were provided by ORNL; the garage mechanics and the certified inspection engineers had never been involved in applying ANSI N14.30. Other obstacles were the lack of existing inspection procedures for this particular activity and the lack of a previous experience interpreting the standard with regard to repair work. Some of these questions were resolved by clarification received from the writers of the standard, and others were resolved by the teamwork between the manufacturer and ORNL. This experience illustrated the importance of the trailer manufacturer as a participant in the decisions made concerning in-service inspection and maintenance. Finally, as a result of the effort required, there is also the question of economics related to the option of maintaining or replacing the trailer. This paper presents these and other lessons learned during the in-service inspection.
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INTRODUCTION

The GE-2000 transport package, the third such unit placed into service by General Electric Company (GE) is owned by the Department of Energy (DOE) and operated by Oak Ridge National Laboratory (ORNL). The Research Reactors Division (RRD) of ORNL is the primary user of the transport package, using it for transfer of High Flux Isotope Reactor (HFIR) spent fuel. RRD also accepts the responsibility of maintaining the transport package, which includes the auxiliary equipment and the trailer. During procurement of the trailer, GE specified design requirements including ANSI N14.30-1992. RRD, although not legally required, decided to maintain the trailer based on the in-service requirements of the standard.

The standard identifies the responsibilities of the manufacturer in designing and certifying the trailer for use with a specific loading configuration. For the structural assessment, the key word is "weight-concentrated," as indicated by the standard's title. The GE-2000 transport package has a concentration of weight that is very obvious, as depicted in Figure 1. The cask, which rests upright and centers along the drop deck, produces a static load of 8900 lb per linear foot. As compared to examples of weight-concentrated loads in the standard, the GE-2000 transport package loading is considerable. Appendix A of the standard lists examples of weight-concentrated loads ranging from 1000 to 5486 pounds per linear foot. The tie-down system for the GE-2000 generates an additional 69,700 pounds of force directed downward on the cask, generating a combined total static load of approximately 50 tons on the two inner rails.

Not only does the live load influence the trailer longevity, but the torsional effects on the trailer are considerable. Usually casks used in fuel shipments are long cylinders placed lengthwise on the trailer. The center of gravity for such an arrangement is lower as compared to an upright cask. For instance, consider the design of the General Atomics GA-4/GA-9 transporter (Lyon, 1995), which has a center of gravity of 75 inches above grade and 42.5 inches above trailer deck (Zimmer, 1997). Compared to the GE-2000 transport package, which stands upright and has a center of gravity 82.5 inches above grade and 64.25 inches above the trailer deck, the moment arm for the GE-2000 transport package configuration is 1.5 times greater than that of the horizontally shipped GA series. For roll stability, the ANSI standard suggests that the center of gravity be no greater than 85.75 inches as derived from the wheel base of this particular trailer. It does not indicate a limiting distance for the center of mass of the object with respect to the trailer frame. Because of the noted influences of the high center of gravity and torsional effects, the in-service inspections will also provide invaluable information concerning the design.
INTERPRETATION OF THE STANDARD

The trailer was fabricated and certified and placed it into service in July 1995. The major interval of inspection specified in the ANSI standard is the Level II inspection, which for in-service trailers is required every 2 years or 100,000 miles or before returning to service. The Level II inspection became due in July 1997, based on the schedule criteria; the inspection was performed starting June 9, 1997, and ending August July 25, 1997. The trailer at that time had 24,000 miles of service.

Assessing which structural members to consider for Level II inspection, the standard emphasizes “certain critical structural members or sections in which a failure may potentially cause serious damage or even threaten public safety.” The Level II inspection instruction also includes criteria specific to the more frequently performed Level I inspection. Briefly stated, the components of interest and the attributes identified in the standard are:
• Tie-down attachment points
• Kingpin wear and cracks
• Main load-carrying member uniformity
• Fifth wheel upper coupler assembly and weldments
• Primary structural and primary-structural-to-secondary-member connections
• Suspension-to-trailer structural member weldments

The inspections are accomplished by first removing debris from the trailer structure and paint from the weld areas identified for detailed inspection. The means of paint removal is not specified. The inspection is to be performed by qualified individuals based on the methods employed. Methods used for the inspection include visual inspections for uniformity and structural assessment, dye-penetrant and magnetic-particle inspection of plates and weldments, and ultrasonic inspection of the kingpin.

Deficiencies are required to be brought to the attention of the trailer owner for disposition. The standard indicates that “any repair or modification to a structural member” subsequent to certification of the trailer will then require the owner to have the trailer recertified before placing it in service. The documentation trail for such repairs is also required to be included into all “original” construction documentation, drawings, etc., as needed.

After completion of the inspection and any needed repairs, paint must be returned to all structural surfaces prone to corrosion.

ADDITIONAL GUIDANCE FOR THE INSPECTION OBJECTIVE

To prepare for the inspection, RRD had to identify a basis and a procedure for the inspection. The basis for the procedure was guided by the criteria specified in the standard and from the fabrication documentation provided by the manufacturer. The manufacturer’s design assessment (Kalyn-Siebert, 1994) helped identify the high-stress areas in the trailer. Fabrication drawings allowed a starting point for identifying welds considered for inspection. After the inspection had started, the manufacture-submitted information to RRD categorizing welds in the trailer design (Jordan, 1997). The following information was provided by the manufacturer during the course of the inspection for clarification.

Welds considered critical (primary)

• Longitudinal welds of main beams directly affected by the bending moment between the kingpin and suspension
• Kingpin area welds
• Transition welds of the lower-to-rear deck
• Gooseneck transition welds of the lower and front deck
• Radius weld on gooseneck beam
• Suspension welds
• Rear lower deck crossmember (major connection between inner and outer rails)
• Front lower deck crossmember (major connection between inner and outer rails)

Welds considered noncritical (secondary)

• Crossmember welds at the inner rail and outer rail
• Transverse welds on the crossmember in the suspension area

Lastly, observations and the comments solicited from the conveyance operators is important to the overall scope of inspection. Given the mountainous terrain encountered by this trailer, comments concerning how the trailer handles in curves are important in determining if immediate attention is required. The response from conveyance operators so far has always been positive, indicating no drivability concerns. Our observations indicated early on that the outer rails temporarily twist unless certain steps are taken during off-loading of the package. During the second use of the trailer, it was noted that the upper flanges of the outer rails were tilting inward as a result of the tension in the lower tie-downs. The cantilever action at the tie-down points and increased load transfer along the tie-downs occurred as a result of flexure in the trailer upon removal of the cask load. The deformity was most prevalent within a few feet of the beam nearest the lower tie-down points. These particular tie-downs do not necessarily need to be removed in the process, but given the undesired result of stressing the outer rails, they are now loosened before the cask load is removed from the trailer. At the time of the finding, a detailed dimensional study was initiated and an inspection of the web-to-flange welds was conducted. The dimensional inspection included measuring the distance between the upper to lower flange of the outer beams at specified points close to each rail tie-down attachment. A measurement of the tilt in the upper flange is also recorded for various points along both outer beams. It was determined that no damage resulted from the added stress and that by practicing the release of tension in the lower tie-downs before removal of the package, the upper flange has a uniform “normal” tilt along the entire length of the outer beam. This observation resulted in the identification of a special inspection for beam deformation as indicated for criteria of the monthly Level I inspection. Because of unchanging conditions the detailed dimensional inspections were last performed during the first in-service Level II.
PERFORMING THE INSPECTION

Preparation for the inspection

The majority of inspection points were members beneath the trailer decking. Because the center deck rests low to the ground, easy access was provided by inverting the trailer as opposed to setting the trailer up on blocks. Before the trailer was inverted, a few decking boards were removed from the kingpin area and from between the two inner rails above the rear suspension. Once the trailer was inverted, it was positioned under an awning. The wheels were removed and axles greased for corrosion prevention. The trailer structure was then power-washed to remove road debris. We also had discovered during the deck removal that a bird had previously nested in the boxed area atop the fifth wheel plate. The empty nest was removed. The trailer welds to be stripped were then marked, and paint removal was initiated. The standard had not identified an acceptable paint-removal process, but based on similar practices for weld inspections, it was determined that mechanical means such as sanding should be avoided because this means of stripping paint could obscure defects. Paint removal was performed using a chemical stripper. Industrial Hygiene personnel were required to perform air sampling to confirm that the air quality was acceptable. Because the work was performed outdoors, with adequate ventilation, respiratory protection was not required.

Inspection Personnel and Documentation

The personnel required to prepare for the inspection included two ORNL certified inspection engineers. The inspectors first examined the trailer visually and then by magnetic-particle examination. The inspectors indicated acceptable welds by writing a check mark on the trailer structure, and deficient welds were indicated by marking with the letter C. This was done for both ergonomic reasons and because detailed weld maps with individual weld identification were not available. The engineer recorded the results using trailer drawings to identify the weld types and specific weld location through a method of serializing weld locations. Intersecting parts and associated part numbers identified unique welds such as in the kingpin. For replicated types, like crossmembers, the part numbers were again used combined with a serial number. Unlike the trailer frame, drawing detail for the suspension welds was not available. With the trailer upside down and the wheels removed, a map of the suspension welds was made, serializing all welds using the designation S-##.

Because of the physical obstructions, some of the welds could not be fully inspected. The degree of inspection allowed for these particular welds was indicated in the documentation. None of the obstructed welds were associated with the main load-carrying beams. All weldments inspected were tabulated, and deficient welds were specifically identified with corresponding serial number.
INITIAL INSPECTION RESULTS

Approximately 460 lengths of weld were inspected; less than 3% of these could only be partially inspected because of physical obstructions. Of the welds fully inspected, several indications were discovered. The magnetic-particle inspection of the crossmembers in the center deck identified many instances of crater cracks at the tails of welds, with a few indications appearing to be the result of doubling back over the weld or possibly a result of a touch-up repair during manufacture. Crater cracks were discovered in the support brackets for the landing gear and kingpin box area, again primarily at the weld tail. There were also a few hammer marks on welds of the square-tube supports between the primary beams located in the rear deck.

The most prevalent indications, crater cracks in the secondary crossmember supports, appeared to have a random pattern. There were also no major differences between the percentage of indications in the crossmember connection to the inner rails and outer rails of the center deck, as indicated in Table I.

In two other instances, indications were also identified. One of the transverse welds for the suspension to primary was rejected for porosity based on AWS standards. One other weld at the front corner of the trailer connecting the outer rail to the forward-facing rail had a crack running lengthwise at the intersection.
CORRECTIVE ACTIONS

As the inspection work continued, notification concerning indications in the welds was disseminated to GE, the trailer manufacturer, and the trailer distributor by faxing a copy of the welds list followed by a detailed location map (Hirtz, 1997). Photographs were also taken and video images were downloaded to a computer so that still shots could be sent by Internet to the participating individuals for viewing immediately to support the faxed information. In accordance with ORNL quality assurance procedures, a nonconformance report (NCR) was initiated based on the fact that weld surfaces were not free of cracks or linear indications (ORNL, 1997).

Three different options were determined as feasible for dispositioning the NCR: (1) remove only the flaw, (2) replace the weld, or (3) only document the presence of the defect and monitor during future inspections. Option 3 was applied to the suspension hanger weld, which was found to be porous but had no detrimental effect on the overall strength of the hanger connection. Option 1 was initially selected for the weld at the front of the trailer, but after the weld was excavated, it was determined that the weld needed to be replaced, making it the only repair based on Option 2. Option 1 was applied only to the remainder of nonconforming welds. No further repair was required because it was determined individually for each of these welds. The amount excavated to remove the flaw was not detrimental to the design requirements in each case.

Justification for the different options and closure of the NCR was supported by documentation between RRD engineering and the trailer manufacturer (Jordan, 1997). Agreement was reached with the manufacturer as to the necessary weldment, conditioning of the welds, and the final condition. RRD had not received welding procedure qualification records used by the manufacturer or a specific list of critical weldments before the inspection. Both items became necessary to satisfactorily disposition the NCR. The manufacturer supplied these two key documents for support of Option 2. The manufacturer also supplied input to support the actions prescribed for Options 1 and 3.

The cost of the trailer maintenance was approximately $60K, with 70% of the cost evenly shared between the garage mechanics (includes paint removal and painting), engineering support and management, and quality inspection engineers. Rigging support for turning the trailer, an industrial hygienist, a welder, iron workers, and welding inspectors contributed to the remaining 30%. These labor costs do not include materials such as paint, brake shoes, and bearing seals.
SUMMARY

The inspection of the trailer was expected to require a significant effort based on our interpretation of the standard. The scope of the inspection was very broad. Interpreting "secondary" to be any subsequent member joining into any primary member (i.e., deck mounting crossmembers) meant that more than one-half of the inspection focused on components not considered crucial by the manufacturer. This raises a question of interpreting to the standard's definition of secondary. The manufacturer described noncritical welds as secondary. The use of a generic term like crossmembers in the standard's example of a secondary member should be emphasized with the main goal of examining critical areas. The standard does not identify the criteria in the section on nondestructive inspection but later, in the Level II in-service inspection section, identifies critical as "structural members of sections in which a failure may potentially cause serious damage or even threaten public safety." In the absence of clarification from the manufacturer, and the standard's guidance on inspection areas, RRD's interpretation was to include members connected to primary members as requiring detailed nondestructive inspection. This decision also considers that if an accident unrelated to the structure were to occur, the comprehensive efforts during the inspection would not be subject to criticism.

In addition, interpretation from the ANSI N14 Standards Subcommittee (Best, 1997) was requested to resolve the issue of describing "any" repair to a structural member as requiring recertification. This was necessary because additional tasks may have been required to recertify the trailer. As happens to be the case with the ORNL NCR closure criteria, most of the steps necessary to recertify the trailer were conducted, excluding static and dynamic testing. The subcommittee indicated that recertification was an action required following a major repair or modification of any main load carrying structural member. The manufacturer agreed that the repairs cited were not major because none of the repairs were to components identified as critical. Therefore, it was concluded by RRD that recertification requirements, specifically load tests, were not required. It is believed that with a more focused inspection of critical members, and given a minimal amount of repair, the total cost could be reduced from $60K to less than $10K.

CONCLUSION

There is no economic incentive for inspecting a trailer to the degree described in this paper. The standard is meant for use over a lifetime of 10 years, not 2 years. The experience has taught us that there is an appropriate level of weld inspection that could be applied at a reasonable cost. Reducing the scope of the detailed nondestructive weld inspection to critical structures should result in a reasonable maintenance cost, unless it is necessary to repair numerous critical welds. If such repairs became necessary, a design modification would probably be considered to strengthen this uniquely adapted trailer. For the immediate future our goal is to minimize the cost of inspecting the trailer while at the same time ensuring that adequate safety margins are maintained. This approach will allow us to further our knowledge regarding the durability of such a unique trailer application.
FIGURES

Figure 1: GE-2000 transport package.

TABLES

Table I: Percentage of secondary member (cossmember) weld indications.

REFERENCES


Table I: Percentage of secondary member (crossmember) weld indications

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<th>Front deck</th>
<th>Center deck</th>
<th>Rear deck</th>
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<tbody>
<tr>
<td>Outer rail</td>
<td>2 of 10 = 20%</td>
<td>35 of 104 = 34%</td>
<td>8 of 42 = 19%</td>
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<td>38 of 104 = 37%</td>
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