Appendix A – Design Changes Due to the Addition of the HI-STAR 190 Casks

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Engineering Information Record

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Title: Atlas Railcar CLIN 4 Event 1 White Paper

Summary:
This document provides a white paper detailing required changes to the DOE Atlas railcar conceptual cradle attachment components and Phase 1 conceptual cradle designs due to the addition of the HI-STAR 190 SL and XL casks to the project.

This document is not safety related.

Safety ☐ **Non-Safety** ☒

Contains Unverified Input / Assumptions: **Yes:** ☐ **No:** ☒

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Revision History

Rev.	Changes
000	Initial Release
001	Revised for editorial changes.

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1.0 PURPOSE

This document provides a white paper detailing required changes to the DOE Atlas railcar conceptual cradle attachment components and Phase 1 conceptual cradle designs due to the addition of the HI-STAR 190 SL and XL casks to the project.

1.1 Project Background

The United States Department of Energy (DOE) is laying the groundwork for implementing an integrated nuclear waste management system. This includes preparing for future large-scale transport of spent nuclear fuel (SNF) and high-level radioactive waste (HLW); since transport will be a necessary component of any integrated nuclear waste management system. With this project the DOE will provide for the transportation of SNF and HLW by means of a specific railcar to carry SNF and HLW casks. The scope of work and deliverables for this project are defined through DOE Contract DE-NE0008390, Part 1; Section C titled "Statement of Work" [1]. Per the contract the Atlas railcar project has been divided into three phases. Phase 1 is complete and Phase 2 and 3 are ongoing.

During Phase 1 of the Atlas railcar project, conceptual cradle designs were completed for the 15 casks listed in Attachment A of the SOW [1]. A standardized attachment (cradle attachment components) was also designed which provided a common railcar interface for all 15 cradles. See the Atlas Railcar Phase 1 Final Report [2] for a full description of the Phase 1 work.

1.2 CLIN 0004 Event 1

DOE contract line item number (CLIN) 0004 Event 1 allows for the addition of the HI-STAR 190 SL and HI-STAR 190 XL casks to the Atlas railcar project. This increases the number of possible cask payloads from 15 to 17. CLIN 004 Event 1 will be completed as Phase 1.1 of the project and includes submittal of the following per [1]:

1. HI-STAR 190 SL and HI-STAR 190 XL casks conceptual cradle designs (both drawings and calculations in native SolidWorks and Word files)
2. Revised Phase 1 cradle attachment components conceptual design (both drawings and calculations in native SolidWorks and Word files)
3. White paper detailing required changes to cradle attachment components and Phase 1 conceptual cradle designs due to incorporation of HI-STAR 190 casks

2.0 DESCRIPTION OF CHANGES

The addition of the HI-STAR 190 SL and XL casks and the change to a 12-axle railcar resulted in three new design requirements for the Atlas railcar:

1. New maximum weight - additional load due to the HI-STAR 190 XL weight
2. New maximum cask length
3. New deck height

The new maximum weight from the HI-STAR 190 XL (420,769 pounds per Appendix A of [3]) required an evaluation of the conceptual cradle attachment components design to ensure structural adequacy under new bounding load conditions. The new maximum cask length from the HI-STAR 190 XL (362.06 inches per Attachment A of [1]) required additional clearance for impact limiter installation/removal resulting in movement/redesign of the outer pin attachment blocks. The Atlas railcar was previously revised from an 8-axle design to a 12-axle design, which has now allowed for transportation of the HI-STAR 190 casks. The 12-axle design includes an increased deck height (now 60 inches from the rail [9], was 50.75 inches [8]), and the cask vertical cg and overall height from the rail must be confirmed to be acceptable. The design changes required by

CLIN 0004 Event 1 are described in-depth in the below Section 3.0 "Design Changes" and listed in Section 4.0 "Listing of Design Changes." Additional work required to complete CLIN 0004, Event 1 is listed in Section 5.0 "Additional Design Changes Required."

3.0 DESIGN CHANGES

3.1 New Maximum Weight

To add the Holtec International HI-STAR 190 XL and SL casks to the project, the cradle attachment components drawing (DWG-3015278 [5]) was evaluated. The HI-STAR 190 XL has a larger maximum weight than any of the 15 previously specified casks, 420,769 pounds vs. 312,000 pounds (per Appendix A of [3]).

Through discussions with the cask vendor (Holtec International), it was determined that the HI-STAR 190 XL cask would be restrained in transport in the same manner as the Family 1 casks, with the longitudinal loading being transmitted through the impact limiters to the conceptual cradle ends stops and attachment components outer pin blocks and the vertical and lateral restraint provided by the attachment components center pin blocks.

With the increased load due to the HI-STAR 190 XL weight, there was a concern that the attachment components center pin blocks would not be able to support the vertical and lateral transportation loads. The HI-STAR 190 XL loading configuration and vertical cg location were key in this evaluation. Holtec International confirmed that the cask could be positioned with the impact limiter at the minimum distance of 1 inch from the deck. (A 1 inch minimum clearance is required between the cask impact limiter and the railcar deck per Section 2.2.2.7 of [3]). This provided a vertical cask cg of half the cask impact limiter diameter plus 1 inch. Because of this low cg, even with the increased weight, the HI-STAR 190 XL was not bounding for the vertical load applied to the cradle attachment components. The bounding vertical load comes from the NAC MAGNATRAN cask, which although restrained in the longitudinal direction by the cradle attachment components shear block, applies a vertical load due to the longitudinal transportation load and the cask cg offset above the shear key (See the Figure 3-1 below). The HI-STAR 190 XL is restrained longitudinally by the end stops and the vertical transportation load (2g) is much smaller than the vertical reaction seen by the NAC MAGNATRAN due to the longitudinal transportation load (7.5 g).

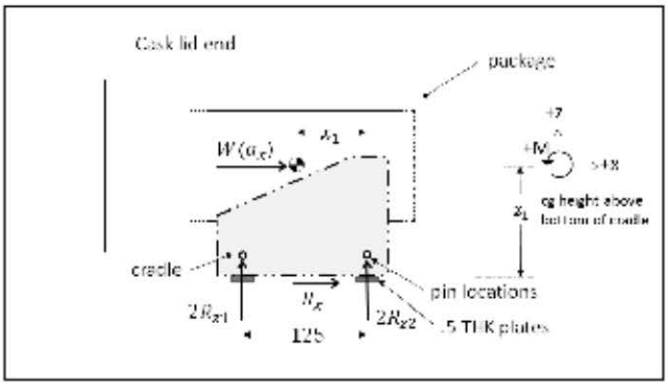

Figure 3-1: Vertical Load from Longitudinal Transportation Loading

The HI-STAR 190 does provide a new bounding lateral load from the lateral transportation loading (which also applies a new bounding simultaneous vertical load). See the Figure 3-2 below.

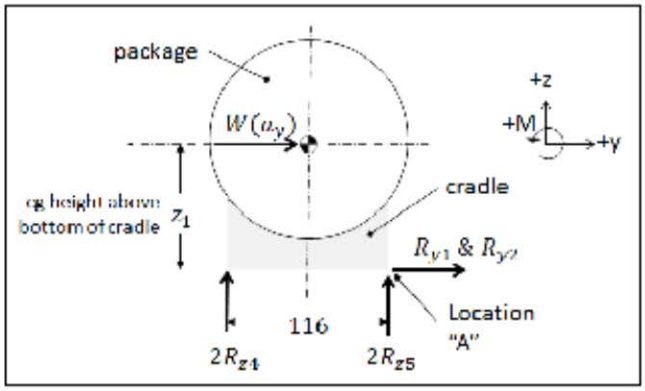

Figure 3-2: Lateral Transportation Loading

The HI-STAR 190 XL also provides an increased bounding load on the attachment components outer pin blocks due to the longitudinal transportation loading applied to the conceptual cradle end stops (see Figure 3-3 below).

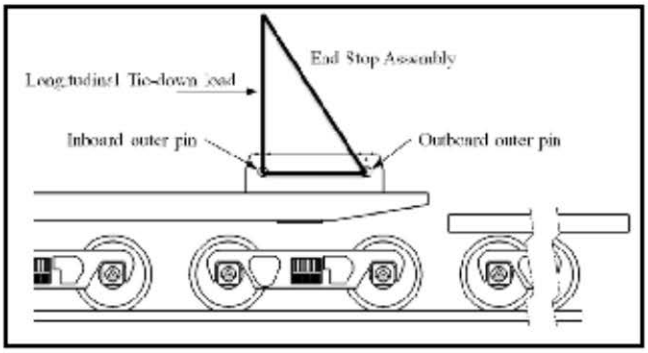

Figure 3-3: Longitudinal Transportation Loading

The increased maximum weight from the HI-STAR 190 XL and revised loadings discussed above resulted in a reevaluation of the conceptual cradle attachment component design. The center four pin blocks were found to be acceptable as designed to support the increased lateral and vertical load. The outer pin blocks were moved outboard (see section "New Maximum Cask Length" below) and redesigned to combine the inboard and outboard outer pin blocks from separate blocks into a single piece as shown in Figure 3-3. This change increases strength and will provide an advantage in fabrication. The attachment pin material strength was also increased to accommodate the increased loadings.

3.2 New Maximum Cask Length

The HI-STAR 190 XL is a long cask design and has a longer overall length than the previous casks. The HI-STAR 190 XL length is 362.06 inches vs 342.4 inches for the previously longest TS125 cask per Attachment A of [1]. After communicating with Holtec International, it was determined that the HI-STAR 190 XL requires a larger clearance to place the cask and remove the impact limiters than is allowed by the current attachment components design. The new maximum cask length required the outer pin blocks to be moved outboard. The pin blocks were also combined into a single piece. Due to the new pin block location required by the addition of the HI-STAR 190 casks, the remaining Phase 1 conceptual cradle designs for Family 1 will be revised to increase the end stop lengths in order to meet the new attachment points on the railcar.

3.3 New Deck Height

The deck height of the unloaded Atlas railcar increased to 60 inches for the 12-axle design [9]. The 8-axle deck height was 50.75 inches [8]. The HI-STAR 190 conceptual cradle designs were evaluated for the new deck height and the bounding conditions for cg and overall weight were updated. The remaining Phase 1 conceptual cradle designs were also evaluated and it was determined that the HI-STAR 100, HI-STAR 100HB and MP187 conceptual cradle designs no longer meet the overall height limit specified by Association of American Railroads (AAR) Plate E. The conceptual designs will be revised to meet the project's AAR Plate E requirement. This is not a bounding cg case and will not change the cg margin listed in Table 7-3 of CALC-3015276 [7].

4.0 LISTING OF DESIGN CHANGES

4.1 Changes to the Family 1 Conceptual Cradle Designs

DWG-3015137 [4]

- The drawing was revised to add the new HI-STAR 190 SL and XL conceptual cradle designs.
- A few other minor drawing changes were made to provide consistency in dimensioning.

CALC-3015133 [6]

- The calculation was revised to add the new HI-STAR 190 SL and XL conceptual cradle designs. This resulted in some new bounding conditions which were applied to the attachment components.
- Additional changes to the Family 1 Calculation NOT due to the addition of the HI-STAR 190 casks:
    1) The center of gravity (cg) for the HI-STAR 60 & 100 conceptual cradle designs was changed due to the cg of the personnel barrier being omitted in the previous calculation revision. The end stop weights were altered to remove some inconstancies.

4.2 Changes to the Cradle Attachment Components

DWG-3015278 [5]

- The drawing was revised to accommodate the new bounding conditions due to the addition of the HI-STAR 190 SL and XL casks:
    1) The position of the outer pin blocks was moved outboard to provide clearance for the HI-STAR 190 XL impact limiter removal;
    2) The pin material was changed to provide adequate strength for the increased loads due to the HI-STAR 190 XL.
- The outer pin attachment blocks were combined into a single unit. This was done after discussions with KASGRO rail for ease of fabrication.
- The welds between the railcar and the attachment components were removed. The welds are to be specified by KASGRO at a later date.

CALC-3015276 [7]

- The calculation was revised to add the HI-STAR 190 SL and XL:
  1. Revised bounding loads from the increased bounding weight of the HI-STAR 190 XL, discussed in Section 3.1, were input and margins of safety were recalculated;
  2. The outer pin attachment block geometry change was incorporated;
  3. The attachment pin material strength was increased to accommodate the increased loadings from the new bounding weight of the HI-STAR 190 XL, see Section 3.1 above;
  4. Weld calculations were removed and replaced with weld connection force requirements.
- The weight of the attachments components was addressed:
  1. A weight calculation for the attachment components hardware was added;
  2. The attachment components weight was added to the cg and total weight calculations.
- Changes to the Family 1 structural calculation, described in Section 4.1 above, were incorporated.

5.0 ADDITIONAL CHANGES REQUIRED

5.1 Changes required to the Family 1 cradles

All Phase 1 Family 1 conceptual cradle designs will be revised to redesign the end stop to meet the new attachment points on the railcar. The family 1 structural calculation will be updated accordingly.

The change to the 12-axle railcar design increased the railcar deck height (see Section 3.3 above). It was determined that the HI-STAR 100 and 100HB conceptual cradle designs no longer meet the overall height limit specified by AAR Plate E. The conceptual design will be revised to meet the project's AAR Plate E requirement. This is not a bounding cg case and will not change the bounding cg margin.

5.2 Changes required to Family 2 cradles

None

5.3 Changes required to Family 3 cradles

None

5.4 Changes required to Family 4 cradle

The change to the 12-axle railcar design increased the railcar deck height (see Section 3.3 above). It was determined that the MP187 conceptual cradle design no longer meets the overall height limit specified by AAR Plate E. The conceptual design will be revised to meet the project's AAR Plate E requirement. This is not a bounding cg case and will not change the bounding cg margin.

6.0 CONCLUSION

The Atlas railcar conceptual cradle attachment components and Phase 1 conceptual cradle designs were evaluated for changes due to incorporation of HI-STAR 190 casks. The addition of the HI-STAR 190 SL and XL casks resulted in design changes for the Atlas railcar cradle attachment components and conceptual cradle designs. Required design changes: A) move attachment components end stops outboard, B) strengthen the attachment pin C) modify all family 1 conceptual cradle end stops for longer length, and D) Modify HI-STAR 100, 100 HB and MP187 conceptual cradle heights to meet AAR Plate E allowing for the 60 inch deck height of the 12-axle railcar.

7.0 REFERENCES

1. Department of Energy Contract DE-NE0008390; Part 1, Section C, Statement of Work.
2. AREVA Federal Services Document, EIR-3016795, *Atlas Railcar Phase 1 Final Report*, Latest Revision
3. AREVA Federal Services Document, EIR-3014611, *Design Basis Requirements Document (DBRD) for the DOE Atlas Railcar*, Latest Revision
4. AREVA Federal Services Drawing, DWG-3015137, *Atlas Railcar, Cradle Family 1, Conceptual Drawing*, Latest Revision
5. AREVA Federal Services Drawing, DWG-3015278, *Atlas Railcar Cradle Attachment Conceptual Drawing*, Latest Revision
6. AREVA Federal Services Calculation, CALC-3015133, *Atlas Railcar Family 1 Conceptual Cradle Structural Calculation*, Latest Revision
7. AREVA Federal Services Calculation, CALC-3015276, *Atlas Railcar Cradle Attachment and Combined Center of Gravity Calculation*, Latest Revision
8. AREVA Federal Services Correspondence, AFS-IN-16-0006, March 10, 2016.
9. AREVA Federal Services Correspondence, AFS-IN-16-0039, August 9, 2016