Design and Prototype Fabrication of Railcars for Transport of High-Level Radioactive Material

Phase 2: Preliminary Design

DE-NE0008390

Prepared by: AREVA Federal Services LLC

REVISION LOG

Rev.	Date	Affected Pages	Revision Description
0	7/14/2017	All	Initial Submission
1	03/06/2018	All	Incorporated all DOE comments. Added Executive Summary, Sections 2.1, 4.2.8 and 5.2.8, but revision bars for these sections were left out in order to reflect changes based on DOE interim comments.

DISCLAIMERS

This is a technical report that does not take into account the contractual limitations under the Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (Standard Contract) (10 CFR Part 961). Under the provisions of the Standard Contract, DOE does not consider spent nuclear fuel in multi-assembly canisters to be an acceptable waste form, absent a mutually agreed to contract amendment. To the extent discussions or recommendations in this report conflict with the provisions of the Standard Contract, the Standard Contract provisions prevail.

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LIST OF ACRONYMS

AAR	Association of American Railroads
AFS	AREVA Federal Services, LLC
ANSI	American National Standards Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
CA	Conditionally Approved
CCG	Combined Center of Gravity
CG	Center of Gravity
CLIN	Contract Line Item Number
CO	Contracting Officer
CoC	Certificate of Compliance
COR	Contracting Officer's Representative
DBRD	Design Basis Requirements Document
DOE	Department of Energy
ECP	Electronically Controlled Pneumatic
EEC	Equipment Engineering Committee
HLRM	High Level Radioactive Material
MMI	Mass Moment of Inertia
MSRP	Manual of Standards and Recommended Practices
NDE	Non-Destructive Examination
NRC	Nuclear Regulatory Commission
ORNL	Oak Ridge National Laboratory
PM	Project Manager
PQAP	Project Quality Assurance Plan
PQR	Procedure Qualification Record
QA	Quality Assurance
QAPD	Quality Assurance Program Description
QASP	Quality Assurance Surveillance Plan
REV	Rail Escort Vehicle
RFI	Request for Information

ROM	Rough Order of Magnitude
SAR	Safety Analysis Report
SME	Subject Matter Expert
SOW	Statement of Work
TTCI	Transportation Technology Center, Inc.
WPS	Welding Procedure Specification

EXECUTIVE SUMMARY

The United States Department of Energy (DOE) is preparing for future large-scale transport of spent nuclear fuel and high-level radioactive waste, which are collectively defined as High-Level Radioactive Material (HLRM) by the Association of American Railroads (AAR). A part of this preparation includes designing railcars to be used for the transport of HLRM.

The DOE Contract DE-NE0008390 titled "Design and Prototype Fabrication of Railcars for Transport of High-Level Radioactive Material" was awarded to AREVA Federal Services, LLC (now known as Orano Federal Services LLC) in August 2015. Prototype railcars are to include both a cask railcar to haul HLRM casks (hereafter, the deliverable cask railcar is specifically referred to as "Atlas") and two buffer railcars used for spacing between the train engine and Atlas railcars, the Atlas and escort railcars, and for weight distribution between Atlas railcars, as deemed necessary.

In addition to the development of design and fabrication requirements, the key contract requirement is for the railcars to be approved by the AAR as compliant with AAR Standard S-2043. This standard prescribes the performance guidelines that must be met by trains carrying HLRM. These guidelines optimize vehicle performance and incorporate the best available technology to minimize the chances of derailment.

The first three phases of this project, governed by DOE Contract Number DE-NE0008390, are summarized below:

1. Phase 1 includes (completed):
    a. The mobilization and conceptual design of an Atlas railcar and its associated buffer railcar;
    b. The conceptual design of cask cradles for securement of HLRM casks on the Atlas railcar;
    c. General Loading Procedures for cask-to-cradle-to-railcar; and
    d. The railcar's functional, design, operational, and maintenance requirements.
2. Phase 2 includes:
    a. The submission of the preliminary design packages of the Atlas and buffer railcars designed to meet the AAR Standard S-2043 guidelines (completed);
    b. The delivery of the preliminary design data package and dynamic modeling input and output data files to DOE (completed), and;
    c. The subsequent receipt from the AAR of a notice to "proceed with the test phase" which allows the prototype railcars to be built in accordance with Section 3.2.1 of S-2043 (completed).
3. Phase 3 includes:
    a. The fabrication and delivery of one Atlas and two buffer prototype railcars; and
    b. The delivery of an as-built design package for upcoming railcar AAR S-2043 approval testing and future fabrication of both the Atlas and buffer railcars.

This report titled "Design and Prototype Fabrication of Railcars for Transport of High-Level

Radioactive Materials, Phase 2: Preliminary Design" compiles the work that was completed during Phase 2. This report includes a summary of the approach and results in meeting Phase 2 contract objectives, including a preliminary design of the prototype railcars, special fabrication process information, test load and necessary ballast load information, dynamic modeling results of the Atlas and buffer railcars, the receipt of the AAR's notice to "proceed with the test phase", and copies of Phase 2 deliverables in the appendices.

1.0 INTRODUCTION

This report presents the preliminary designs of the Atlas and buffer railcars in compliance with the AAR's safety standard S-2043 [3]. The railcars also comply with the recent AAR Standard S-2044, Safety Appliances for Freight Cars, dated 2017 [43].

This section provides background information regarding this report's content and layout, an introduction to the project's team members and their roles, a status summary of Phase 1.1 and Phase 2 deliverables, and a brief chronological outline of Phase 1.1 and Phase 2 activities.

1.1 Report Content and Layout

This report specifically summarizes the efforts and accomplishments of Phase 2 of the High Level Radioactive Material (HLRM) prototype Atlas and buffer railcars project. Sections 2.0 through 6.0 provide introductory and project status information; a description of the HI-STAR 190 conceptual cradle designs, accommodating revisions necessary in other Family 1 and Family 4 conceptual cradle designs, and the railcar-to-cradle interface; a review of the preliminary Atlas and buffer prototype railcar designs and submitted S-2043 data; descriptions of the test load and Atlas ballast load conceptual designs; as well as a summary of estimated cost and schedule estimates for the Phase 4 single-car testing, Phase 5 multi-car testing, and the production of Atlas and buffer railcars. Specifically, the sections include the following:

- Sections 1.2 – 1.4 provide project background, a summary of the project team members, deliverable requirements and status, and a chronological order of the project's Phase 1.1 and Phase 2 major activities.
- Section 2.0 provides a summary of the Association of American Railroads (AAR) Equipment Engineering Committee (EEC) Standard S-2043 approval, supporting regulatory and cask information, and a summary of project challenges.
- Section 3.0 provides information regarding the conceptual cradle designs of the HI-STAR 190 SL and XL casks, impacts to Family 1, Family 4, and railcar-to-cradle interface conceptual designs, and other related changes to Phase 1 documentation including a revision of the general loading procedures.
- Section 4.0 provides an overview of the Atlas railcar preliminary design and deliverables, and a review of its AAR S-2043 submittal package.
- Section 5.0 provides an overview of the buffer railcar preliminary design and deliverables, and a review of its AAR S-2043 submittal package.
- Section 6.0 provides information regarding the conceptual design of the minimum and maximum test loads, the Atlas ballast load conceptual design, and a summary of the report generated to provide cost and schedule estimates for the Phase 4 single-car testing, Phase 5 multi-car testing, and the production phase for Atlas and buffer railcars.
- Section 7.0 provides a listing of references used in this report.
- Appendices for this report include the actual deliverables and conceptual design supporting documents, which were submitted to and approved by the DOE. These will be utilized in the

future detailed design of the Atlas railcar's cask cradles and production railcars. Enclosed appendices include:

- Appendix A – Design Changes Due to the Addition of the HI-STAR 190 Casks
- Appendix B – Revised Railcar-to-Cradle Attachment Interface
- Appendix C – Revised Conceptual Cradle Design Family 1
- Appendix D – Revised Conceptual Cradle Design Family 4
- Appendix E – Revised Preliminary Railcar-to-Cradle Attachment Interface Gap Analysis
- Appendix F – Revised General Loading Procedures
- Appendix G – Prototype Atlas Railcar Deliverables
- Appendix H – Prototype Buffer Railcar Deliverables
- Appendix I – Test Load Conceptual Designs
- Appendix J – Atlas Ballast Load Conceptual Design
- Appendix K – Phase 4, Phase 5, and Production ROM Estimated Cost and Schedule
- Appendix L – Atlas Railcar Cask and Cradle Dynamic Modeling Inputs
- Appendix M – Atlas Railcar Dynamic Modeling Plan

The drawings and calculations included in the appendices are provided as images as they have already been formally issued to the DOE.

1.2 Project Team Members and Their Roles

Federal Services, LLC () has primary responsibility for the project and provides project management and oversight and integration of team members. AFS engineering subject matter experts (SMEs) provided conceptual design of the HI-STAR 190 cask cradles and revision of Phase 1 conceptual cradles for cradle interface impacts from addition of the HI-STAR 190 casks. AFS also performed the preliminary design of the cradle-to-railcar interface system. Kasgro Rail is the designer and fabricator of the prototype test units for the Atlas and buffer railcars. Kasgro Rail is supported by the Transportation Technology Center, Inc. (TTCI) which provides dynamic modeling and preparation of the S-2043 submission package seeking AAR approval to build and test the prototype railcars. TN Americas LLC revised the cask-to-cradle-to-Atlas Railcar General Loading Procedures to include the HI-STAR 190 casks.

Table 1-1 provides a listing of primary project participants performing independently managed tasks along with their defined roles.

TABLE 1-1: PHASE 1.1 AND PHASE 2 PROJECT PARTICIPANTS AND ROLES

Participant	Primary Role
AREVA Federal Services LLC	• Project integrator and manager with overall responsibility for contract execution • HI-STAR 190 cask conceptual cradle designs • Revision of Phase 1 cradle designs impacted by the addition of the HI-STAR 190 casks designs • Preliminary design of Atlas railcar cradle attachment interface • Oversight of engineering and Quality Assurance (QA) processes for entirer project team • Generation of testing and production cost and schedule estimates • Final report generation and publication
Kasgro Rail	• Atlas railcar cradle attachment interface peer review • Atlas and buffer railcars preliminary designs including finite element analysis and modeling • Generation of railcar design, specification, and fabrication documents • Submission of AAR S-2043 approval application and data package to AAR EEC
Transportation Technology Center, Inc (TTCI)	• Assistance in railcar designs by initial modeling of railcar parameters • Dynamic modeling of Atlas and buffer railcars designs • Preparation of AAR S-2043 reports and submission data package • Interface with the AAR EEC
TN Americas LLC	• Revision of cask-to-cradle-to-Atlas railcar general loading procedures for addition of HI-STAR 190 casks

Throughout this report, specific reference to a company name will refer specifically to that company. The use of "Team" refers to all or a portion of the above listed companies based on assignments or as defined in current discussions.

1.3 Deliverable Requirements and Status

All Phase 1.1 and Phase 2 contract deliverables have been submitted to the DOE. A detailed listing by phase follows.

1.3.1 Phase 1.1 Deliverable Requirements and Status

A listing of Phase 1.1 deliverables and their status is included in Table 1-2. All Phase 1.1 deliverables have been approved by the DOE.

TABLE 1-2: PHASE 1.1 DELIVERABLES AND STATUS

Event	Description	Accomplishment Expected	Approval Status
1	Conceptual Design Complete	Submittal of the following: • HI-STAR 190 SL and HI-STAR 190 XL casks conceptual cradle designs (both drawings and calculations in native SolidWorks and Word files) • Revised Phase 1 cradle attachment interface conceptual design (both drawings and calculations in native SolidWorks and Word files) • White paper detailing required changes to cradle attachment interface and Phase 1 conceptual cradle designs due to addition of HI-STAR 190 casks	Approved
2	Phase 1 Deliverable Update	Submittal of the following: • Revised Phase 1 conceptual cradle designs for original 15 casks (both drawings and calculations in native SolidWorks and Word files)	Approved
3	Phase 2 Deliverable Update	Submittal of the following: • Letter from the contractor to DOE providing proof that all the deliverables of Phase 2, including the preliminary design of Atlas railcar cradle attachment interface, the fastener block gap analysis, and the dynamic load models include the HI-STAR 190 casks	Approved

1.3.2 Phase 2 Deliverable Requirements and Status

A listing of Phase 2 deliverables and their status is included in Table 1-3.

TABLE 1-3: PHASE 2 DELIVERABLES AND STATUS

Event	Description	Accomplishment Expected	Approval Status
1	Cask Railcar Finite Modeling Complete	Submission of Modeling Data	Approved
2	Buffer Railcar Finite Modeling Complete	Submission of Modeling Data	Approved
3	Dynamic Modeling Complete	Submission of Modeling Data	Approved
4	Railcar Document Package and Fabrication Estimate Complete	Submission of Design Package and Fabrication Estimates Contracting Officer's Representative (COR) receipt and review of data	Approved
5	AAR Notice to Proceed and Phase 2 Report	AAR Notice to Proceed and Phase 2 Report	AAR Notice to Proceed issued by AAR; Phase 2 Report approved

1.4 Chronological Outline

The following subsections provide a summary-level overview of tasks performed by project phase.

1.4.1 Phase 1.1 Chronological Outline

The following summarizes the major activities performed in completing Phase 1.1 for adding the HI-STAR 190 casks to the Phase 1 conceptual cradle designs and Phase 2 preliminary cradle attachment design.

- Project Phase 1.1 kickoff; October 2016
- Secured HI-STAR 190 SL and XL cask information from Holtec International; October 2016
- Developed HI-STAR 190 casks conceptual cradle designs including drawings and calculations; November – December 2016
- Revision of conceptual cradle attachment interface design including drawing and calculation; late October – December 2016
- Review and whitepaper report of impact of HI-STAR 190 casks and cradle attachment revisions to other 15 Phase 1 conceptual cradle designs; December 2016
- Revision of project's Design Basis Requirements Document and bounding conditions; December 2016
- Revision of original 15 Phase 1 conceptual cradles (with impacts only to Family 1 and Family 4 conceptual cradle designs) including revised drawings and calculations and revision of cradle attachment interface drawing and calculation; January – April 2017
- Revision of the conceptual cradle attachment pin block gap analysis, creation of the HI-STAR dynamic models and revision of the 15 original casks dynamic models as necessary; March – April 2017

- Completion of Phase 1.1; April 2017

1.4.2 Phase 2 Chronological Outline

The following summarizes the major activities performed in completing the Phase 2 preliminary design of the Atlas and buffer prototype railcars, dynamic modeling and preparation, and submission of the AAR EEC submission package.

- Initial preliminary Atlas and buffer railcar design to support initial dynamic modeling; March – April 2016
- Initial dynamic modeling on the conceptual cradles, conceptual cradle attachment interface design, the Atlas and buffer railcar designs; May – June 2016
    - Note: these activities led to the change in the Atlas railcar from 8 to 12 axles and the buffer railcar utilizing the Rail Escort Vehicle (REV) trucks; see the project's Phase 1 report [1] for more detail.
- Official Phase 2 kickoff; September 2016
- Atlas railcar preliminary design; October 2016 – April 2017
    - Development of the Atlas preliminary railcar design; October 2016 – February 2017
    - Redesign of the railcar to lower deck height due to a larger cradle attachment interface as a result of adding the HI-STAR 190 casks; February – April 2017
    - Preliminary design of the cradle attachment interface; December 2016 – April 2017
    - Development of detailed drawings, calculations, finite element analysis, and design specifications; March – May, 2017
- Generation and approval of Atlas railcar Dynamic Modeling Plan; February – April 2017
    - Activity included generation of mass moment of inertia, combined center of gravity and empty/mass payload information for all 17 conceptual cradle designs to support dynamic modeling plan and Atlas railcar dynamic modeling data generation; February – March 2017
- Buffer railcar preliminary design; March – June 2017
    - Development of the buffer preliminary railcar design; January – March; 2017
    - Redesign of the buffer railcar preliminary design to add ballast weight; March – May 2017
    - Second redesign of the buffer railcar preliminary design to redistribute added ballast weight as a result of failing S-2043 performance requirements during dynamic modeling; May 2017
    - Development of detailed drawings, calculations, finite element analysis, and design specifications; May – June, 2017
- Building of Atlas and buffer railcar dynamic models, including revisions for preliminary redesigns; February – April 2017
- Running dynamic modeling regimes for Atlas and buffer railcars; April –June 2017

- Generation of AAR EEC S-2043 dynamic modeling approval request packages; June – July 2017
- Submission of AAR EEC S-2043 review packages and AAR EEC review period; June 2017 – January 2018
- Generation of test loads, test load cradles, and test load end stops; February – April 2017
- Generation of the project's Phase 2 report; May 2017 – January 2018 with update on February 2, 2018 after receipt of AAR Notice to Proceed with the Test Phase.

2.0 GENERAL INFORMATION

This section provides a summary of the AAR EEC approval process and results, background information regarding both external and internal regulatory requirements, a description of utilized cask and Safety Analysis Report (SAR) information data and their sources, and a brief listing of challenges addressed during Phase 1.1 and Phase 2 activities.

2.1 AAR EEC Results

The AAR EEC provided written notices to proceed with test requirements for both the Atlas and buffer railcars on February 2, 2018. The approval to proceed with test phase is based on completion of S-2043 requirements for structural analysis, nonstructural static analysis, dynamic analysis, brake system design, and railcar clearance and weight review. The railcars are not yet approved for the required system safety monitoring requirement of S-2043 as appropriate safety monitoring equipment is not currently needed; therefore, the AAR EEC has postponed review and approval of it until the multi-car testing is underway (see Sections 4.2.8.3 and 5.2.8.3 for additional information).

2.2 Regulatory Requirements

Railroad Transportation Requirements

The Atlas and buffer railcar's fabrication must comply with AAR's Manual of Standards and Recommended Practices [2], including Standard S-2043, *Performance Specification for Trains Used to Carry High-Level Radioactive Material* [3].

The cask and buffer railcar designer and the future prototype railcar fabricator must be approved to AAR *Manual of Standards and Recommended Practices*, Section J – Quality Assurance M-1003 (2014) [4].

During Phase 2, the AAR released standard S-2044, *Safety Appliance Requirements for Freight Cars*. This standard has been incorporated into the design of the Atlas and buffer railcars [43].

Other DOE Requirements

The contract states that the cask and buffer railcars are to comply with other applicable standards as specified in the Oak Ridge National Laboratory (ORNL) report, *Cask Railcar System Requirements Document* [5]. If there is any contradiction between the System Requirements Document and the contract's Statement of Work (SOW), the SOW takes precedence. Note that in AFS' Request for Information (RFI) AFS-RFI-00225-0001-00 [6], Table 3-3 of the ORNL requirements document [5] was questioned regarding the establishment of bounding design requirements specifically for the conceptual cradle designs. The DOE responded to the RFI that the table "simply lists the largest and heaviest cradle characteristics that exist at this time," hence, the word "bounding" is used to describe these characteristics. As a result, AFS has not limited its conceptual cradle designs specifically to the values in this table and has determined bounding conditions necessary to meet AAR S-2043 and AAR Plate E requirements.

As specified by DOE, a total of 17 separate transportation cask designs have had conceptual cradle designs generated for bounding the Atlas railcar's dynamic modeling requirements to AAR S-2043. The cradles are to be tall enough and open-ended so that the impact limiters can be attached to a cask after the cask is secured to the cradle while on the Atlas railcar. Each cask design will need a cradle designed to position the Center-of-Gravity (CG) low for stability during transport (see Appendix B). However, the cradle design will position the impact limiter with a clearance of at least 1 inch above the cask car deck. To understand cask and impact limiter dimension and handling requirements, AFS interfaced with transportation cask vendors identified in SOW Attachment A [7]. AFS obtained and/or verified specific cask information for conceptual cradle designs to meet S-2043 design, operational performance, monitoring, maintenance, and testing requirements (e.g., the height of the cask's CG above the railcar deck, the weight on each axle, etc.). The cask cradle must also be specifically designed to meet the requirements of AAR Rule 88 (which specifies the minimum mechanical requirements for railcars used in interchange commerce service), as included in the AAR 2015 Field Manual of the AAR Interchange Rules [8].

Individual cask vendors will be responsible for the final cradle designs. DOE will provide an interface control document for use by future cask designers/vendors which will include the bounding envelope for the final cask and cradle designs used for the approval of the Atlas railcar.

The Atlas railcar, including a cradle and a cask, and buffer car clearances must fit within AAR Plate E, except when loaded with casks that are more than 128 inches wide with impact limiters attached. Transporting casks that are more than 128 inches wide will require special route analysis that is not a part of this contracted scope of work. The requirements for Plate E are contained within AAR Standards S-2028 [9], S-2029 [10], S-2030 [11], and S-2031 [26]. These standards are referenced in AAR Standard S-2043, Section 4.7.9.1 [12]. Note that there was a contractual change from Plate C to Plate E based on the change in configuration from an 8-axle Atlas railcar to a 12-axle Atlas railcar during Phase 1 [13].

Nuclear Regulatory Commission (NRC) Requirements

For shipments under subtitle A or subtitle C of the NWPA, HLRM must be shipped in transport casks certified by the NRC in accordance with 10 CFR Part 71 [14]. The cask cradle and its attachments are to meet commercial grade requirements.

Code Requirements

The following design codes were used in the development of the conceptual cradle design:

- ANSI N14.6 was used to provide a lifting criteria for the cradles as the cradles are required to lift a loaded cask;
- ASME Boiler and Pressure Vessel Code and ASTM codes were used to provide material properties, primarily material yield, and ultimate strengths.

Project Quality Requirements

In the completion of the Atlas project, AFS is utilizing the AFS QA Program, AFS-QA-PMD-001 [15], which establishes the corporate QA requirements used to implement work activities. The program and its implementing procedures are based on ASME NQA-1-2008/2009a [16] and are organized in the 18 requirements of ASME NQA-1.

The AFS QA program includes the development of a tailored project quality assurance plan (PQAP). AFS developed PQAP QA-3014737 [17], which identifies the project-specific requirements such as safety class, project codes, and procedures to tailor the program to meet the project requirements.

Kasgro Rail activities for the Atlas and buffer railcars are performed in accordance with Kasgro Rail's AAR M-1003-approved QA program [18]. AFS' project management and engineering provides oversight to ensure contract requirements are met.

Also, incorporated into DOE contract DE-NE0008390, Part III, Attachment J-C, is the "AFS Quality Assurance Surveillance Plan" (QASP) [19] – generated during the proposal phase of this project – which is incorporated into the PQAP. This surveillance plan is the basis of the AFS Engineering Oversight Plan in support of the QASP contract requirement.

These requirements apply not only to Phase 2 of the project, but also to Phases 1 and 3.

Specific Project Quality Requirements

A summary of specific project quality requirements includes:

- AAR Standard S-2043, Performance Specification for Trains Used to Carry High-Level Radioactive Material [3]
- AAR Manual of Standards and Recommended Practices (MSRP), Section J – Specification for Quality Assurance, Specification M-1003 [4]
- AFS Quality Assurance Program Description (QAPD), AFS-QA-PMD-001 [15]
- AFS Project Specific QA Plan, QA-3014737, Design and Prototype Fabrication of Atlas Railcars for HLRM [17]
- AFS Quality Assurance Surveillance Plan as incorporated into DOE contract DE-NE0008390, Part III, Attachment J-C [19]
- Kasgro Rail's Quality Assurance Manual for AAR Specification M-1003 [18]

These requirements are incorporated into the single PQAP for the execution of conceptual design, procedural development, report generation, preliminary design, AAR S-2043 modeling, and data submission, detail design, fabrication, and delivery of the Atlas and buffer railcars.

Project Communications

An internal Team project meeting is held weekly with Team members to assess project status, issues and resolutions, schedule progress, and resource needs. This meeting is supplemented by various project status conference calls and a routinely published action item list (internal to the Team).

A monthly project status report is due to the DOE Contracting Officer (CO) and COR by the tenth day of each month, as detailed in contract DE-NE0008390, Part III, Attachment J-A, and as described in contract section 2.5.3. The report includes the following:

- Project Manager's (PM) narrative highlights and status assessment regarding technical progress for each active project phase
- Deliverable status
- Schedule and cost performance indexes
- Issues/concerns (cost, schedule, technical) including forecasted or expected variances, recommended resolution or mitigation, and progress toward resolution or mitigation

- A summary of upcoming activities over the next 90 days
- A listing of project milestone dates and forecast variances

The monthly status report is considered the official record of the project. The monthly project status report is followed by a project review meeting occurring mid-month following the reporting month. The setup of this meeting is coordinated by the AFS PM and the COR.

2.3 Updated Cask Information and Data

Conceptual cask cradle designs must accommodate the 17 cask designs listed in Attachment A of the SOW [7]. For reference, Table 2-1 displays cask data incorporating all changes through Contract Modification #6.

TABLE 2-1: NOMINAL CHARACTERISTICS OF SPENT NUCLEAR FUEL TRANSPORTATION CASKS

Manufacturer and Model	Length without Impact Limiters (in.)	Length with Impact Limiters (in.)	Diameter without Impact Limiters (in.)	Diameter with Impact Limiters (in.)	Empty Weight with Impact Limiters (lb.)	Loaded Weight with Impact Limiters (lb.)
NAC International						
NAC-STC	193.0	273.7	99.0	128.0	188,767-194,560	241,664-254,589
NAC-UMS UTC	209.3	273.3	92.9	124.0	178,798	248,373-255,022
MAGNATRAN	214.0	322.0	110.0	128.0	208,000	312,000
Holtec International						
HI-STAR 100	203.25	307.5	96.0	128.0	179,710	272,622-279,893
HI-STAR HB	128.0	230.8[a]	96.0	128.0[a]	--[b]	187,200
HI-STAR 180	174.37	285.04	106.3	128.0	< 308,647	308,647
HI-STAR 60	158.94	274.37	75.75	128.0[a]	< 164,000	164,000
HI-STAR 190 SL	214.4688	339.5625	106.5[e]	128	282,746	369,049-382,746[f]
HI-STAR 190 XL	236.9688	362.0625	106.5[e]	128	304,369	420,769[f]
AREVA Transnuclear						
MP187	201.5	308.0	92.5	126.75	190,200	265,100-271,300
MP197	208.0	281.25	91.5	122.0	176,710	265,100
MP197HB	210.25	271.25	97.75	126.0	179,000	303,600
TN-32B[c]	184.0	261.0[a]	97.75	144.0[a]	--[d]	263,000[a]
TN-40	183.75	261.0	99.52	144.0	--[d]	271,500
TN-40HT	183.75	260.9	101.0	144.0	--[d]	242,343
TN-68	197.25	271.0	98.0	144.0	< 272,000	272,000
Energy Solutions						
TS125	210.4	342.4	94.2	143.5	196,118	285,000

Source: Contract DE-NE0008390, Modification #6, Part I, Section C, Attachment A - Transport Cask Characteristics [7]

a. Estimated

b. HI-STAR HB transportation casks are already loaded so they would not be shipped empty.

c. This is the TN-32B that DOE plans to use in the High Burnup Dry Storage Cask Research and Development Project, and ship from North Anna Nuclear Power Plant. The TN-32B does not currently have a transport certificate of compliance. The dimensions and weight with impact limiters for the TN-32B are estimated.

d. TN-40 transportation casks are authorized for single use shipments and would not be shipped empty. TN-32B and TN-40HT transportation casks would be authorized for single use shipments and would not be shipped empty on an S-2043 cask car.

e. Diameter is of cask body and does not include trunnions.

f. Weights do not include the weights of any MPC spacers that may be required.

2.4 Use of SAR Designs in Conceptual Cradle Designs

Some certified cask designs provide a cask-specific cradle design in their NRC 10 CFR Part 71-certified SAR general arrangement drawings. In many instances, the general arrangement drawing detailing the cask cradle (including detailed dimensions and CG locations) is part of the NRC Certificate of Compliance (CoC). However, some cask certificate holders have made the drawings proprietary, leaving cradle and support requirements unknown or undefined to the public.

As a result of the inconsistent information regarding SAR provided cradle information and the potential cradle's use (i.e., cradle defined as lifting skid only, nuclear station transport use only, highway transport, use not defined, etc.), AFS chose, with DOE agreement, to neglect constraints (e.g., basic design, detail dimensions, and CG locations) for the cask cradles contained in the SAR General Arrangement Drawings for each of the 17 casks involved in this project [21]. This approach enabled AFS to accommodate the lack of information mentioned above, while not hindering the development of the Atlas railcar or its capability to handle the various transport loads.

Using reasonable engineering judgement, information available that conceptually complies with the requirements of 10 CFR Part 71 for the cask, and requirements from the AAR Field Book Rule 88 [8], AFS designed the original 15 conceptual cradles and the revised 17 Phase 1.1 conceptual cradle designs using the same cask-to-skid/cradle interface locations outlined in publicly available SARs. This provides the DOE with a single Atlas railcar that has the capability to transport all of the casks listed in the contract's SOW, Attachment A – Transport Cask Characteristics [7].

All conceptual cradle designs are to interface with the railcar in the same locations and hence, be interchangeable. Therefore, it is possible that conceptual cradle designs vary from the SAR cradle design to accommodate the required railcar and payload's combined CG. The cask supplier should review and possibly revise their SARs to allow their supplied casks to be transported by the Atlas railcar.

The specific public documents used as references in the conceptual cradle design package include:

- Docket Number 71-9235, NAC-STC Storage and Transport Cask Safety Analysis Report, Non-Proprietary Version, Rev. 15, March 2004.
- Docket Number 71-9356, MAGNATRAN® Submittal, Non-Proprietary Version, Revision 12A, October 2012.
- Docket Number 71-9356, MAGNATRAN® RAI Response Package Submittal, Non-Proprietary Version, Revision 14A, October 2014.
- Docket Number 71-9270, NAC-UMS Universal MPC System, Safety Analysis Report, Non-Proprietary Version, Revision UMST-00A, May 2000.
- Docket Number 71-9270, List of SAR Changes for NAC UMS® Transport SAR Revision 2, Non Proprietary Version, November 2005.
- Certificate Number 9270, Certificate of Compliance, Rev. 4, U.S. Nuclear Regulatory Commission.
- Docket Number 71-9255, Safety Analysis Report for the NUHOMS®-MP187 Multi-Purpose Cask, Non-Proprietary Version, Revision 17, July 2003.

- Docket Number 71-9302, NUHOMS®-MP197 Transportation Package Safety Analysis Report, Non-Proprietary Version, Revision 7, TN Americas LLC.
- Certificate Number 9302, "Certificate of Compliance for Radioactive Material Packages, Package Identification Number USA/9302/B(U)F-96," Revision 7, U.S. Nuclear Regulatory Commission.
- Docket Number 71-9313, TN-40 Transportation Packaging, Safety Analysis Report, Non-Proprietary Version, Revision 16, June 2011.
- Docket Number 71-9293, TN 68 Packaging Safety Analysis Report, Non-Proprietary Version, Revision 4, January 2001.
- Certificate Number 9293, Rev 4, U.S. Nuclear Regulatory Commission.
- Docket Number 71-9276, Fuel SolutionsTM TS125 Transportation Cask Safety Analysis Report, Non-Proprietary Version, Revision 6, BNLF Fuel Solutions Corporation.
- Certificate Number 9276, "Certificate of Compliance for Radioactive Material Packages, Package Identification Number USA/9276/B(U)F-96," Revision 4, U.S. Nuclear Regulatory Commission.
- Certificate Number 9336, "Certificate of Compliance for Radioactive Material Packages, Package Identification Number USA/9336/B(U)F-96," Revision 0, U.S. Nuclear Regulatory Commission.
- Docket Number 71-9336, Safety Analysis Report on the HI-STAR 60 Transport Package, Non-Proprietary Version, Revision 2, May 2009.
- Docket Number 71-9336, Safety Evaluation Report, Rev 0
- Docket Number 71-9261, Safety Analysis Report on the HI-STAR 100 Cask System, Non-Proprietary Version, Revision 15, October 2010.
- Certificate Number 9325, "Certificate of Compliance for Radioactive Material Packages, Package Identification Number USA/9325/B(U)F-96," Revision 2, U.S. Nuclear Regulatory Commission.
- Docket Number 71-9325, Safety Analysis Report on the HI-STAR 180 Package, Non-proprietary Version, Revision 6, April 2014.
- Docket Number 71-9325, Safety Evaluation Report, Revision 2.

The TN-32B and TN-40HT were completed using the TN-40 SAR information, as discussed in Section 3.0 of the calculation enclosed as Appendix C.2. Additional design inputs from proprietary vendor information were used for the HI-STAR 60, HI-STAR 100, HI-STAR 180, HI-STAR 190 SL, HI-STAR 190 XL and HI-STAR HB casks.

Additional Data Sources

In addition to the cask SARs, sources for related cask data included the NRC's ADAMS public searchable database and information requested directly from and provided by the cask suppliers themselves. If used, data acquired from sources other than the SARs is referenced in the applicable cradle or cradle interface calculations

2.5 Challenges

Challenges occurring in Phase 2 of the project related to the increased cradle attachment interface pin block size by the addition of the HI-STAR 190 casks and the necessary weight needed for the Atlas and buffer railcars to meet AAR S-2043 performance requirements. These challenges are summarized below.

- An increase in cradle attachment interface pin block heights due to the necessary deck plate fabrication tolerance requiring the deck height of the Atlas railcar to be lowered. This in turn caused an overall lowering of the railcar deck camber, reduction in railcar deck thickness, and an increase in deck structure. These railcar design changes were made to ensure that the height requirements of AAR Plate E height can be met for any of the 17 payloads.
- Due to the large variance in Atlas railcar payloads as a result of the 17 cask designs in empty and fully loaded configurations, the dynamic modeling simulation approach was revised to ensure that the Atlas railcar's performance would meet S-2043 requirements. This in turn required additional calculations to be performed to generate needed data including mass moment of inertia (MMI), combined center of gravity (CCG), and minimum/maximum railcar payload conditions for each of the 17 cask payloads in addition to the already planned maximum payload and empty condition payload.
- Although considered a minor challenge, dynamic modeling results indicated that the Atlas railcar would need an additional ballast load of approximately 200,000 pounds to meet AAR S-2043 requirements when in an empty condition (no cask or cradle payload). As a result, a conceptual Atlas ballast payload was designed.
- Dynamic modeling results indicated that the buffer railcar would not meet AAR S-2043 performance requirements in high speed stability, yaw and sway, and buff and draft simulations. As a result, the buffer railcar was redesigned to permanently add approximately 196,000 pounds to the railcar (reference AFS RFI #16 [20]).
- An additional redesign of the buffer railcar was required to redistribute the added ballast weight in order to have the railcar meet AAR S-2043 performance requirements.

The above challenges added approximately 2 months to the completion of Phase 2.

3.0 PHASE 1.1 CONCEPTUAL CRADLE DESIGNS REVISIONS

This section provides a description of the added HI-STAR 190 SL and XL casks' conceptual cradle designs and features, required revisions to the original railcar-to-cradle attachment interface to accommodate the HI-STAR 190 conceptual cradle designs, and required changes to the original Phase 1 Family 1 and Family 4 conceptual cradle designs due to required railcar-to-cradle attachment interface changes. Finally, impacts from the addition of the HI-STAR 190 casks to the Atlas preliminary railcar design, the preliminary railcar-to-cradle attachment interface design, planned dynamic modeling activities, and general loading procedures are reviewed.

3.1 HI-STAR 190 Conceptual Cradle Design

During Phase 1of the Atlas railcar project, conceptual cradle designs were completed for the 15 casks listed in Attachment A of the SOW [7]. 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 [13] for a full description of the Phase 1 work.

DOE contract line item number (CLIN) 0004 Event 1 (Phase 1.1) allows for the addition of the HI-STAR 190 SL and HI-STAR 190 XL casks to the Atlas railcar project. This increased the number of possible cask payloads from 15 to 17. 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. Thus, the HI-STAR 190 SL and HI-STAR 190 XL conceptual cradle designs were determined to be part of Family 1.

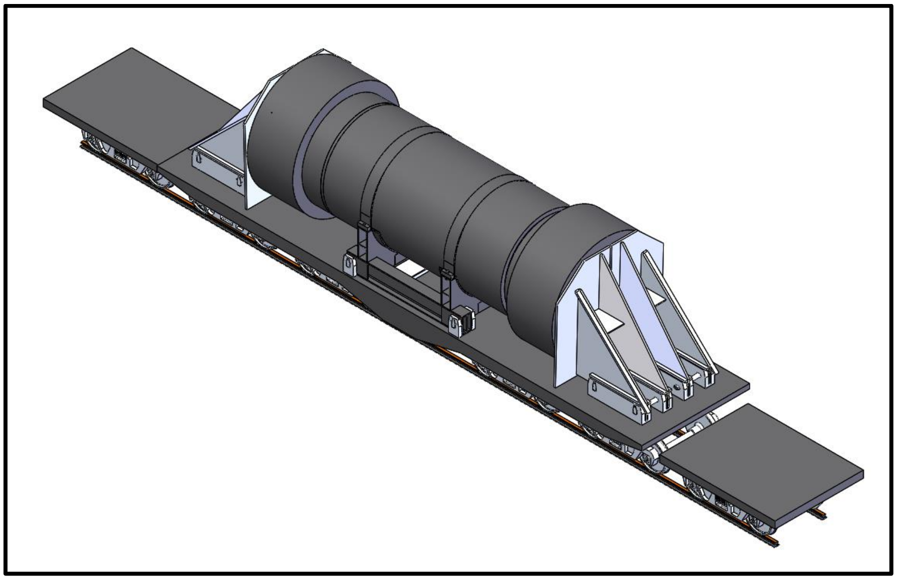
Conceptual cradle designs in Family 1 support the Holtec HI-STAR 60, HI-STAR 100, HI-STAR-100HB, HI-STAR 180, as well as the TN Americas LLC TN-32B, TN-40, TN-40HT casks and were revised to add the HI-STAR 190 SL and HI-STAR 190 XL. Casks in Family 1 do not have shear keys and are restrained axially (longitudinally) by means of end stops touching the ends of the cask impact limiters. The cask rests on multiple saddles, which along with tie-down straps, provide lateral and vertical restraint. Supporting documents generated for the HI-STAR 190 SL and XL conceptual cradle designs are listed below and enclosed in Appendix C:

a) DWG-3015137-001, Atlas Railcar Cradle Family 1 Conceptual Drawing;

b) CALC-3015133-002, Atlas Railcar Family 1 Conceptual Cradle Structural Calculation.

The HI-STAR 190 SL and XL conceptual cradles use the same basic design configuration for each cask/cradle in Family 1. The cask impact limiters interface with cradle end stops, which provide longitudinal restraint at each end of the cask. Casks rest on the central cradle frame, which includes multiple saddles with tie-down straps that provide vertical and lateral restraint.

FIGURE 3-1: FAMILY 1 HI-STAR 190 XL CASK, CONCEPTUAL CRADLE, AND END STOPS



The cradle frame is constructed from two main I-beams, which sandwich the saddle cross members. There is no cask trunnion interface or cask shear key. The central frame is a welded construction with the saddles and cross member weldments welded to the main I-beams. There are four pin locations in the central frame attachment of the cradle to the railcar. These pin locations provide vertical restraint for the cradle. The central frame is not restrained longitudinally, as the end stop assemblies provide this restraint. Lateral restraint for the central frame is provided by the main frame I-beams, both of which interface with the railcar. Longitudinal restraint and lateral connections for end stop assemblies are provided by pinned and blocked connections to the railcar.

The end stop assemblies can be lifted using lifting hardware (shackles or hoist rings) installed above the CG locations specified on the drawing. The cradle and loaded cask can be lifted using a lifting strap located beneath the protruding saddle plates, interior to the end saddles, and combined with a lift beam to provide a vertical lift. A concept of a personnel barrier is included in the conceptual cradle design to meet package SAR requirements and to provide a reasonable cradle weight. This is a temporary barrier to be used when the cask is placed on the cradle to protect personnel from surface or proximity of cask surface due the potential for a high temperature or radiological exposure. The materials specified for this conceptual cradle are primarily carbon steels.

The HI-STAR 190 SL and XL conceptual cradle concepts are approximately 535 inches long (to the outside end of the end stop assemblies which includes the cask length). The end stop assemblies vary from 82 to 93 inches long and are 126 inches tall. The central cradle is approximately 137 inches long and is 119 inches tall. The nominal central cradle weight varies between 13,364 lb. and 13,636 lb., the end stop weight (per railcar end) varies between and 20,000 lb. and 21,272 lb. the total nominal conceptual cradle weight varies between 53,636 lb. and 55,909 lb.

It is assumed that the final HI-STAR 190 SL and 190 XL SAR will not change significantly from the draft version originally used in the conceptual cradle designs.

3.2 Changes Required Due to Addition of HI-STAR 190 Casks

The addition of the HI-STAR 190 SL and XL casks in CLIN 0004, Event 1 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 the DBRD [21]) 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 [7]) 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 [23], was 50.75 inches [24]), 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 a white-paper enclosed as Appendix A and include changes required to the Family 1 and Family 4 conceptual cradle designs; the conceptual cradle designs of Family 2 and Family 3 were not affected and remain as presented in the Phase 1 report [25].

3.2.1 Revised Railcar-to-Cradle Attachment Interface

The Atlas Railcar cradle attachment components conceptual design was revised due to the addition of the HI-STAR 190 casks as described in Section 4.2 of Appendix A. Supporting documents generated for the revised cradle attachment components conceptual design are listed below and enclosed in Appendix B:

- DWG-3015278-002, Atlas Railcar Cradle Attachment Components
- CALC-3015276-002, Atlas Railcar Cradle Attachment and Combined Center of Gravity Calculation

3.2.2 Revised Atlas Railcar Cradle Family 1

The Atlas Railcar Family 1 conceptual cradle designs were revised due to the addition of the HI-STAR 190 casks as described in Section 4.1 and Section 5.1 of Appendix A. Supporting documents generated for the revised Family 1 conceptual cradle designs are listed below and enclosed in Appendix C:

- DWG-3015137-001, Atlas Railcar Cradle Family 1 Conceptual Drawing
- CALC-3015133-002, Atlas Railcar Family 1 Conceptual Cradle Structural Calculation

3.2.3 Revised Atlas Railcar Cradle Family 4

The Atlas Railcar Family 4 conceptual cradle design was revised due to the addition of the HI-STAR 190 casks as described in Section 5.4 of Appendix A. The change to the 12-axle railcar design increased the railcar deck height (see Section 3.2 above). It was determined that the MP187 conceptual cradle design no longer met the overall height limit specified by AAR Plate E. The conceptual design was revised to meet the project's AAR Plate E requirement. Supporting documents generated for the revised Family 4 conceptual cradle design are listed below and enclosed in Appendix D:

- DWG-3015140-001, Atlas Railcar Cradle Family 4 Conceptual Drawing
- CALC-3015136-001, Atlas Railcar Family 4 Conceptual Cradle Structural Calculation

3.3 Other Related Changes

The addition of the HI-STAR 190 XL and SL required additional project changes discussed in the following sections.

3.3.1 Input Into Atlas Railcar Preliminary Design

The railcar attachment design had been previously designed as a conceptual design for the original 15 cask/cradle payloads. The attachment components conceptual design was revised for the addition of the HI-STAR 190 cask as discussed in Section 3.2. The cradle attachment design development continued with the creation of the preliminary cradle attachment interface described in Section 3.3.3. The attachment components conceptual design was used as an input to the dynamic modeling, but the preliminary design was required as the attachments will be fabricated with the prototype Atlas railcar. The attachment components must also be toleranced to provide interchangeability between the railcar and the 17 different final cradle designs.

An additional input to the Atlas preliminary design was the addition of a loaded deck height inspection requirement. The camber and deck height of the railcar can be predicted, but accurate numbers can only be determined through testing. With specific deck height limits required to meet AAR Plate E requirements [26], a testing plan was determined to ensure the loaded deck height of a fabricated railcar will comply with requirements (see Section 3.3.5).

3.3.2 Revised Bounding Conditions

The changes discussed in Section 3.2 revised the railcar attachment and cradle designs requiring a revision of the dynamic modeling inputs. Final cask, cradle and railcar center of gravity, and other revised physical inputs including mass moment of inertia were confirmed and provided to TTCI for inclusion in final dynamic modeling. These inputs are available in Appendix B.1 and Appendix L (Atlas Railcar Cask and Cradle Dynamic Modeling Inputs, Calculation CALC-3015934 Rev 000).

3.3.3 Preliminary Cradle Attachment Interface Revisions

The conceptual design of the cradle attachment to the railcar was designed to handle cradles from 15 different casks. With phase 1.1, two additional casks were added (HI-STAR 190 SL and HI-STAR 190 XL). Both casks used cradles that are similar to the previously designed Family 1 conceptual cradles. As discussed in Section 3.2, due to the length of the HI-STAR 190 casks the attachments for the end stops were moved toward the end of the railcar. With the attachment points further from the centerline of the railcar, all the other Family 1 casks required the end stops to be lengthened and hence increase in weight of the end stops. These changes are discussed in Appendix A.

The earlier design of independent end stop attachment points for each half of the end stop at each pin location was simplified by combining the receivers for each half of the end stop into a single piece. This change simplifies placement of the attachments on the railcar and reduced the required weld size by providing for longer welds. Details can be found in Appendix B.

Appendix B also provides the required positioning of the cradle attachments on the railcar. These are positioned and toleranced to ensure that all 17 cradle designs will mate with the railcar. Also, the positioning allows for fabrication methodologies and the material stock tolerances while ensuring operational clearances for assembly. The positioning and dimensions shown reflect the analyzed loads and load paths required to meet AAR S-2043 and the required AAR Plate E requirements for those casks with impact limiters of 128 inches or less.

Additionally, the cradle attachments and shear blocks have been positioned to ensure that load paths evaluated in the analysis are being met. An example of this is that the slot size in the center attachment pin holes are such that the longitudinal loads are taken by the shear plates rather than the pins as evaluated. Similarly, lateral and vertical load paths were addressed.

3.3.4 Preliminary Cradle Attachment Interface Gap Analysis

As the cradle design progressed, the question of how the mechanical connection to the railcar would affect the dynamic modeling and performance required by AAR S-2043 was evaluated. To answer this question, TTCI took one representative cask (TN-68) and ran 21 different regimes from AAR S-2043. Out of those 21 regimes the lateral movement of the cradle was less than 1/16th inch except for the Hunting regime that was less than 3/8 inch. The hunting condition that caused the movement was a condition of the lowest speed on a track of low curvature and maximum super elevation. Although not even closing the potential gap available, the forces generated by a slow slide of the cradle to the side would be well within the design capacity of the attachment blocks. The report can be found in Appendix E, as AFS Document AFS-IN-17-0013.

Therefore, it can be concluded that the potential gaps created by the mechanical attachment and the positioning of the attachments (Appendix B) will not have any effect on the performance of the railcar.

3.3.5 Dynamic Modeling Loads and Plan

Initial dynamic modeling scoping was performed by TTCI to determine the requirements of the analysis necessary to meet the requirements of S-2043 for the 17 different cask/cradles combinations. Originally it had been proposed to use a minimum load case, a nominal load case, and a maximum load case as bounding conditions. However, based on the initial runs performed by TTCI, it became apparent that bounding runs should be revised to the empty condition case, a maximum load case, and a highest cg case. It was also discovered that the empty Atlas railcar would require ballast weight to meet the requirements of S-2043. Note that when the dynamic plan was presented, there was a possibility that if the weight of the lightest cask was below the required ballast weight, an additional minimum load case would be required (see Appendix M).

The Team documented our dynamic modeling plan and submitted it to the AAR EEC for review and approval (see Appendix M). The Team proposed that the EEC agree that the Atlas cask railcar and its cradle-to railcar interface attachment system be approved and tested to AAR S-2043, and that the successful results of the proposed dynamic modeling test plan including the conceptual cradle designs provided analytical evidence of the entire securement system for approval under AAR S-2043, paragraph 5.4.7 titled “Securement System Test”, approval under AAR S-2043 as a whole, and approval under AAR Rule 88.

Per the submitted plan, dynamic modeling was performed and presented to the EEC in the preliminary design report (reference Appendix G, Section 7 for Atlas railcar and Appendix H, Section 7 for buffer railcar). The preliminary design report shows that the requirements of AAR Standard S-2043, paragraph 4.0, Design, have been met. Dynamic modeling includes consideration of all 17 cask/conceptual cradle designs. Conceptual cradle inputs were used for modeling. The conceptual cradles were designed with large margins to provide a bounding envelope which will be provided to the final cradle designers (cask vendors).

Dynamic modeling of the Atlas railcar includes MSRP Section C Part II, Specification M- 1001, Chapter XI and S-2043 Dynamic Curving for all cask/cradle combinations. Additionally, all S-2043 dynamic modeling requirements were performed on selected cask/conceptual cradle inputs to bound all 17 cask/conceptual cradle cases. These bounding conditions include an empty condition case and a maximum load highest cg case; see the Table 3-1 below. Final dynamic modeling showed that an additional minimum load case, as proposed in the dynamic modeling plan, was not required to bound dynamic modeling response. The selected bounding runs may be used to design the full-scale testing campaign. Final test conditions will be specified by TTCI. The "empty condition" is defined as the railcar and required ballast weight. The ballast was sized based on railcar performance.

TABLE 3-1: ATLAS LOAD CONDITIONS

Empty Condition	Maximum Load Condition(1)	Highest cg(1)
Atlas railcar and load (ballast weight)	Atlas railcar and load (maximum conceptual cradle and cask weight)	Atlas railcar and load at highest cg (conceptual cradle and cask at highest cg)

Notes:

1. The dynamic modeling plan requires a maximum weight condition and a maximum cg condition. For this project the HI-STAR 190 XL cask and conceptual cradle is both the maximum weight and maximum height cg case.
2. Physical single and multi-car testing requirements have not yet been defined. The test loads presented in Section 6.1, "Test Load Conceptual Designs", were based on three load conditions: empty condition, maximum load/highest cg condition and an additional empty cask condition as originally proposed in the dynamic modeling plan. Final test conditions will be specified by TTCI.

3.3.6 General Loading Procedures

Due to the addition of the HI-STAR 190 casks in Phase 1.1, the General Loading Procedures provided in Phase 1 were updated to include these casks [27]. Changes to the General Loading Procedures include: adding procedures related to the HI-STAR 190 SL and HI-STAR 190 XL casks; clarifying what casks can be down-ended on top of the railcar, and; including steps for installing ballast weights onto the railcar when it is shipped empty in an AAR Standard S-2043 compliant consist. The revised general loading procedures, EIR-3016164, "Atlas Railcar General Loading Procedures, Revision 001", can be found in Appendix F.

4.0 PRELIMINARY ATLAS PROTOTYPE RAILCAR DESIGN

This section of the Phase 2 report and its accompanying Appendix G provide preliminary design information for the Atlas cask railcar.

4.1 Atlas Railcar Overview

The Atlas railcar is designed to transport casks containing HLRM on cradles. The railcar design has twelve axles and is symmetrical end-to-end, including its railcar-to-cradle interface and end stop attachment pin blocks. The railcar is designed to meet AAR Standard S-2031 Plate E requirements [26]. The basic railcar design, including its trucks, brakes and their components, and the railcar's monitoring system, is very similar to the Navy's M-290 railcar design, the only other railcar that has received conditional approval to AAR Standard S-2043 from the AAR EEC. The main difference between the two cask railcars is that the Atlas railcar is designed to carry 17 different cask payloads in removable cradles, while the M-290 railcar has a single payload and a permanently mounted cradle.

Of the 17 different cask payloads, the heaviest is the HI-STAR 190 XL. This total payload, including the fully loaded cask, impact limiters, cradle, and end stops, weighs approximately 480,000 pounds. At present, this is the upper limit of payload that the Atlas railcar can carry in compliance with AAR Standard S-2043. If any heavier cask is ever designed, then this new payload would have to be modeled and tested on the Atlas railcar to determine if the payload upper limit could be increased.

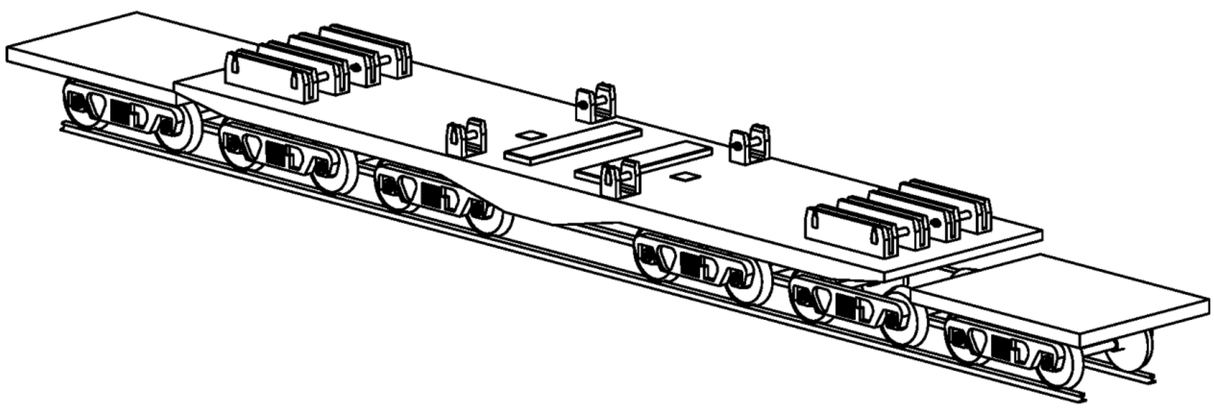
When the Atlas railcar is not carrying a payload, it will weigh only 229,000 pounds (200,000 pounds for the Atlas railcar plus 29,000 pounds for the permanently attached cradle interface and end stop pin blocks). In this configuration, it satisfies the normal freight rail requirements of AAR Standard M-1001. But in this configuration, it does not satisfy the requirements of AAR Standard S-2043. The Atlas railcar only needs to satisfy S-2043 when it is carrying HLRM. The lightest weight HLRM payload is estimated to be 200,000 pounds, so the Atlas railcar has been modeled and will be tested for HLRM payloads in the weight range of 200,000 pounds to 480,000 pounds. As an option, a temporary ballast weight has been conceptually developed to allow the railcar to meet S-2043 performance guidelines when carrying no HLRM; see Section 6.2 and Appendix J for additional information.

Other specific design features of the Atlas railcar are:

- Extreme Width .... 10'-8"
- Loading Deck Length .... 48'-0"
- Coupled Length .... 78'-1 1/4"
- Number of Axles 12
- Wheel Size .... 36"
- Minimum Turning Radius ………………………………………………….. 150 feet
- Design load limits:
    - Design total railcar truck capacity (based on 71,500 lbs/axle limit)…. 858,000 lbs
    - Design railcar empty weight (estimate based on total weight of empty railcar and permanent attachments)…………………………………………… 229,000 lbs
    - Design railcar interchange load limit (based on conservative 65,750 lbs/axle operatinal constraints)………………………………………………………….. 789,000 lbs

- Operational load limits (as will be stenciled on side of railcar):
  - Gross Rail Load (GRL; based on interchange limit of 65,750 lbs/axle; AAR definition as load limit + light weight)….………………………………………….. 789,000 lbs
  - Light Weight Load (LT LD; an estimate based on total weight of empty railcar and permanent attachments)………………………………………………. 229,000 lbs
  - Load Limit (LD LMT; an estimate based on railcar operational payload capacity which is also the largest dynamic modeled weight)………………………… *480,000 lbs
    - Note: Per the Field Manual of the AAR Interchange Rules, Rule 88, B.1.d.(h) [8], when structural limitation of a car is less than truck capacity, a star symbol (*) must be applied to the left of the "LD LMT" stencil. Here, the "LD LMT *480,000 lbs" is used to denote a structual and operational payload limit of the greatest dynamic modeled weight, which is a payload of a loaded HI-STAR 190 XL cask, cradle, and endstops. The railcar will be weighed during fabrication and the actual weight used in railcar markings.

FIGURE 4-1: ATLAS RAILCAR



4.2 Atlas Railcar Deliverables

This section provides explanations of Phase 2 project deliverables for the Atlas railcar. These deliverables include preliminary design and fabrication drawings, fabrication and special process specifications, a bill of material, information regarding the railcar's inspection plan and fabrication traveler, operations and maintenance information, and the AAR EEC submission package.

4.2.1 Preliminary Fabrication Drawings

Fabrication drawings for the Atlas railcar reflect its completed preliminary design and include the railcar's structural analysis and the preliminary design of the cradle-to-railcar attachment interface system. The included drawings are listed in Table 4-1 and are enclosed in Appendix G, Section G-1.

TABLE 4-1: KASGRO ATLAS RAILCAR PRELIMINARY DRAWINGS

Drawing Number	Description	Revision[1]	Reference Appendix Item
1155-1	Car Body Arrangement	"Original"	Appendix G-1.1
1155-2	Brake Arrangement	"Original"	Appendix G-1.2
1155-3	Stencil Arrangement	"Original"	Appendix G-1.3
1155-4	End Platform Arrangement	"Original"	Appendix G-1.4
1155-5	End Platform Details	"Original"	Appendix G-1.5
1155-6	End Platform Details	"Original"	Appendix G-1.6
1155-7	Air Brake Schematic	"Original"	Appendix G-1.7
1155-8	Body Bolster	"Original"	Appendix G-1.8
1155-9	Center Plate	"Original"	Appendix G-1.9
1155-10	Steel Details	"Original"	Appendix G-1.10
1155-11	Steel Details	"Original"	Appendix G-1.11
1155-12	Steel Details	"Original"	Appendix G-1.12
1155-13	Steel Details	"Original"	Appendix G-1.13
1155-14	Steel Details	"Original"	Appendix G-1.14
1155-15	Steel Details	"Original"	Appendix G-1.15
1155-16	Steel Details	"Original"	Appendix G-1.16
1155-17	Steel Details	"Original"	Appendix G-1.17
1155-18	Steel Details	"Original"	Appendix G-1.18
1155-19	Brake Steel Details	"Original"	Appendix G-1.19
1155-20	Brake Steel Details	"Original"	Appendix G-1.20
1155-21	Pipe Details	"Original"	Appendix G-1.21
1155-22	Pipe Details	"Original"	Appendix G-1.22
1155-23	Brake Pipes	"Original"	Appendix G-1.23
1155-24	Steel Details	"Original"	Appendix G-1.24
1155-25	Hand Brake Details	"Original"	Appendix G-1.25
1155-26	Hand Brake Details	"Original"	Appendix G-1.26
1155-27	Hand Brake Details	"Original"	Appendix G-1.27
1155-28	Hand Brake Details	"Original"	AppendixG-1.28
1155-29	Brake Badge Plate	"Original"	Appendix G-1.29
1155-30	Locking Center Pins	"Original"	Appendix G-1.30
1155-31	Hand Brake Details	"Original"	Appendix G-1.31

1155-32	Spring Grouping 290 Ton Straight Deck Flat Car	"Original"	Appendix G-1.32
1155-33	Brake Steel Details	"Original"	Appendix G-1.33
1155-34	Camber Diagram	"Original"	Appendix G-1.34
1155-35	Clearance	"Original"	Appendix G-1.35
1155-36	Steel Details	"Original"	Appendix G-1.36
1155-37	Steel Details	"Original"	Appendix G-1.37
1155-38	Steel Details	"Original"	Appendix G-1.38
1155-39	Center Pin Details	"Original"	Appendix G-1.39
1155-40	Handbrake Arrangement	"Original"	Appendix G-1.40
1155-41	Attachment Arrangement	"Original"	Appendix G-1.41
1155-42	Sheave Brackets	Original	Appendix G-1.42
1155-43	HB (Handbrake) Steel Details	Original	Appendix G-1.43
1155-44	Steps	Original	Appendix G-1.44
N/A	Atlas 12-Axle Flat Car S-2043 4.1 Structural Analysis	May 2017	Appendix G-1.45

Note: 1) The original issue of approved drawing shows no revision levels; first revision will be listed as revision "A".

The enclosed structural analysis in Appendix G-1.45 represents the preliminary Atlas railcar design and supersedes the structural analysis submitted and approved as CLIN 2, Event # 1 [28].

It should be noted that the Atlas railcar's structural analysis uses a conservative live load of 450 kip (Appendix G, page G.1-52). This load was applied at the inboard attachments in the classical analysis to identify the shear and moments about the various cross sections of the railcar. For simplicity, the end stops were not added to the live load because of where they are located on the railcar structure has an insignificant impact on the stress results on each cross section analyzed. However, the end stop weights are applied in the FEA analysis as the classical method is performed to simply back up all FEA stress results. The forces applied are shown on Appendix G, page G.1-67, and include all cask, cradle and end stop weights.

4.2.2 Fabrication Specifications

The Atlas railcar will be fabricated to the following industry specifications:

- AAR MSRP, Section C- Part II, Design, Fabrication and Construction of Freight Cars (M-1001) [2]
- AAR MSRP, Section J, Specification For Quality Assurance, Specification M-1003 [4]
- AAR MSRP, Car Construction Fundamentals and Details, Performance Specification for Trains Used To Carry High-Level Radioactive Material, Standard S-2043 [3]
- Contractual requirement for meeting railcar envelope size Plate E [26]

- Safety appliances are installed per the requirements of the Federal Railroad Administration and the Code of Federal Regulations, 49 CFR, Parts 200-299 [29]
- Association of American Railroads, Manual of Standards and Recommended Practices, Section C, Car Construction Fundamentals and Details, Standard 2044, Safety Appliance Requirements for Freight Cars, 2017 [43]

Major components that are manufactured by others and used in the railcar fabrication process are governed by the following:

- AAR MSRP, Section C – Part II, Design, Fabrication and Construction of Freight Cars (M-1001) [2]:
- AAR MSRP, Section B - Couplers and Freight Car Draft Gear Components [22]
- AAR MSRP, Section D - Trucks and Truck Details [22]
- AAR MSRP, Section E - Brakes and Brake Equipment [22]
- AAR MSRP, Section G - Wheels and Axles [22]
- AAR MSRP, Section H - Journal Bearings and Lubrication [22]

4.2.3 Special Process Specifications

Special process specifications for the Atlas railcar represent fabrication requirements for railcar acceptance industry standards, AAR standards and in-house processes developed for repeatability of railcar fabrication and specific material procurement specifications. Industry designated processes such as welding and Non-Destructive Examination (NDE) processes are utilized to set quality control acceptance requirements while meeting AAR standards. Special air brake tests ensure performance and functionality of the brake system to AAR requirements. Special process specifications also include fabrication and/or testing processes necessary to ensure AAR S-2043 performance guidelines are met such as spring testing and truck weight distribution weighting and shimming. Finally, additional special fabrication processes have been implemented based on experience by the railcar designer and fabricator, Kasgro Rail, with the other S-2043 cask railcar production to ensure repeatability and acceptance of the Atlas railcar. These processes include laser dimension measurements of the railcar deck and tie-down and jacking lug tests, both which will be continued in the fabrication of the Atlas cask railcar. Special processes are to be considered mandatory with no exceptions made in their application to the fabrication, inspection and testing of the Atlas railcar. Appendix G, Section G-2 provides examples and/or forms of the special process specifications described below.

4.2.3.1 Welding Procedure Qualifications Records and Welding Procedure Specifications

A Procedure Qualification Record (PQR) serves as a qualification record regarding the fabricator's compliance in meeting American Welding Society Standard D15.1 for Railroad Welding Specification for Cars and Locomotives [30]. The PQR covers the welding parameters used in the Welding Procedure Specification (WPS) document. In addition, it also includes relevant information, such as the welder's name and the name of the person who did the inspection, and the dates that the weld qualification was performed. The PQR is performed by a qualified individual welder and retained as a record of endorsement of the company and its product to industry standards.

A WPS is a set of welding instructions that aids in planning and ensuring quality control of product welds to its PQR, as well as future reproductions of the weld and its resulting product. In a WPS, required welding parameters referenced in applicable drawings are explained in the context of instructions. The purpose is to allow the welder to reproduce the product and its welds to a particular industry standard and quality.

The use of the PQRs and WPSs provides uniform and consistent instructions for producing welds that meet AAR S-2043 guidelines.

Appendix G-2.1 includes Kasgro's PQRs and WPSs for welds to be used on the Atlas railcar. Appendix G-2.1.1 provides an example of a welding procedure qualification record (PQR F-001 Rev 3) for welding A572 Grade 50 steel in various positions. Appendix G-2.1.2 provides necessary welding procedure specifications for:

- Welding A572 Grade 50 steel in various positions (WPS F-001 Rev 3)
- Welding A572 Grade 60 steel in various positions (WPS F-002 Rev 3)
- Welding dissimilar metals of 656 Grade 80 steel to A572 Grade 60 steel in various positions (WPS F-003 Rev 1)
- Welding A514T steel to A572 Grade 60 steel material (WPS F-004 Rev 1)
- Welding dissimilar metals of A572 Grade 60 steel to A240 Grade 304 stainless in a flat weld position (WPS-08KR-F1097 Rev 2)
- Welding dissimilar metals of A572 Grade 60 steel to A240 Grade 304 stainless only in a horizontal weld position (WPS 15KR-F1087 Rev 2)

4.2.3.2 Atlas Railcar Securement Lugs and Jacking Plate Proof Testing

The Atlas railcar is to be secured against movement during cask loading and unloading by four tie-down securement lugs and jacking plates (see Appendix F, General Loading Procedures [31]). Appendix G-2.2.1 is the current procedure (Kasgro Procedure # 11 Lug Proof Test Procedure, Rev 5) used to test the securement lugs and jacking plates on each individual railcar. Appendix G-2.2.2 (Securing and Jacking Lug Proof Test Certification Form, Form 45 Rev 1) is the data collection form used to collect data and provide for approval of the test. This test duplicates actual loading and unloading operations of the Atlas railcar and is performed to ensure safe operations. A special test rig is used and referenced in the procedure as Drawings D-1128-1, 3, 4, and 5 which can be made available for viewing only at the Kasgro Rail fabrication facility. However, this test rig can be easily duplicated by normal fabrication supports and rigging, and utilizes commonly available jacks capable of meeting the test load pressures.

4.2.3.3 Atlas Railcar Spring Properties Requirements

The specifications of the springs used in the Atlas trucks are very important in meeting AAR S-2043 performance guidelines for the Atlas railcar. Spring tolerance for meeting AAR S-2043 performance requirements for spring load height is narrower than industry standards for non-S-2043 railcars. To ensure that S-2043 performance requirements are consistently met, Kasgro has developed a procedure to test 100% of truck springs utilized in the applicable Atlas trucks. Appendix G-2.3 (Spring Test Requirements and Tolerances Procedure #12, Rev 3) includes the

Kasgro developed procedure and spring load height requirements used to determine acceptable truck springs.

4.2.3.4 Atlas Railcar Weighting

Weighting of the Atlas railcar and the railcar's weight distribution between its trucks is fundamental to ensuring that the Atlas railcar will meet AAR S-2043 modeled and tested performance guidelines. The weighting of the railcars and the trucks provides data with respect to payload capacity, is necessary for properly marking the railcar's stenciled weight markings, but most importantly provides data allowing the proper shimming of the truck center pins before final assembly during the railcar's fabrication process. The Atlas railcar will be weighted by placing dummy weights on the railcar simulating the heaviest payload – a maximum weight HI-STAR 190 XL cask. Note that the procedures and forms referenced in this section are examples as used on the other S-2043 railcar fabrication. Once the Atlas railcar enters fabrication, precise truck weight distributions can be verified to current calculations and specific Atlas railcar weighing procedures and forms generated. Also, a simulated payload of the maximum weight of a HI-STAR 190 XL cask will be compiled to use during weighting. Finally, the fabricator will need to perform pre-use scale calibrations and an annual weight scale calibration of the fabricator facility's weight scale is to be performed by an outside calibration vendor with records maintained to ensure the railcar weight measurements are valid.

Enclosed in Appendix G-2.4.1 is Kasgro Procedure #13, Revision 5, titled "Car Weighting Procedure" which is used to determine the weight distribution of a simulated payload on the S-2043 railcar. Appendix G-2.4.2 (Railcar Weighting Form, Form 46, Rev 3) is the data form that truck weights are recorded on. Prior to railcar weighting, Kasgro records scale calibration events and non-conformances, if occurred, on Form 14, "Measuring and Test Equipment Calibration Record", Rev 2, enclosed as Appendix G-2.4.3. An example of the actual vendor performed scales calibration results that accompany Form 14 is included as Appendix G-2.4.4 (RailScale, Inc. Track Scale – Test and Inspection Report, dated 10/14/2015).

4.2.3.5 Atlas Railcar Air Brake Testing

As this report was nearing completion, in September 2017, the AAR issued a revised version of Standard S-2043, which removed the requirement for electronically controlled pneumatic (ECP) brakes. Therefore, the preliminary design of the Atlas railcar has standard pneumatic brakes instead of ECP brakes. Forms presented in this section are examples only, but portray basic brake testing requirements that will be performed once the testing procedures are completed under Phase 3.

Static air brake testing must follow the AAR's MSRP, Section E, Standard S-486 [32] to demonstrate compliance to AAR S-2043 paragraph 5.3 [33]. In addition, the pneumatic brake system must be functionally tested. Testing must occur for all railcars and includes 100% of the braking system components. Functional system testing of the pneumatic braking system is to the specific equipment's specifications, specifically the New York Air Brake DB-60 system. Additionally, the brake testing must be witnessed by an AAR representative before the railcar can be released by the fabricator. These requirements are included in the AAR Manual of Standards and Recommended Practices, Section E, "Brakes and Brake Equipment" [34]. Finally, fabricator personnel performing static air brake tests must be certified to AAR Standard S-486 [32]. A copy of a written test and supervised practical exam are included for reference. Examples of Kasgro brake test results from the other S-2043 cask railcar are enclosed in Appendix Section G-2.5; the same forms will be used for the Atlas railcar's brake testing.

Appendix G-2.5.1 (Kasgro Rail Static Force Brake Test Data, Form 36-A Rev 1) is an example of an electronically generated form showing results of static force brake test data results. Appendix G-2.5.2 (Kasgro Rail Air Brake Test Report Form 6-A, Rev 1) is an example of the form that records air brake piston travels and any necessary repairs that may be required because of the static air brake test. Appendix G-2.5.3 (EP-60 Single Car Test Results) is an example of the electronically generated results of the brake system functional test; the specific format for a similar functional test will be determined for the DB-60 pneumatic brake system as part of Phase 3. Appendix G-2.5.4 (TTCI letter # CC-209.221 dated January 17, 2017) is an example of the letter provided by a TTCI Field Inspector confirming satisfactory completion of static air brake test per AAR Standards S-486 and S-2043. Finally, Appendix G-2.5.5 includes examples of the written and practical exam required by AAR S-486 to administer static brake tests.

4.2.3.6 Atlas Railcar NDE Examination and Testing

NDE testing is based on industry standard testing protocols from American Welding Society (AWS) standard D15.1 [30]. However, to meet AAR S-2043, Section 4.1.10, Weld Analysis [35], test sample size requirements are 100% for visual inspection identified as full-penetration butt welds or critical structural welds, and 10% nondestructive inspection for all welds not identified as full-penetration butt welds or critical structural welds. The 10% nondestructive inspection shall cover a random sampling of welds chosen by the welding inspector. Finally, all inspections, including visual, must be performed by an AWS-certified inspector. Due to this requirement, Kasgro Rail has contracted all NDE inspection to TUV Rheinland who maintains their own NDE inspection procedures and AWS-certified personnel.

Included examples in Appendix Section G-2.6, Atlas Railcar NDE Examinations and Testing, are from another S-2043 cask railcar program. To meet AAR S-2043 guidelines for welding, and to ensure fabrication consistency, the same work instructions and procedures are to be used on the Atlas railcar's NDE examination and testing activities.

Enclosed in Appendix Section G-2.6 are the following:

- Appendix G-2.6.1 is TUV Rheinland's Non-Destructive Testing Group's work instruction on ultrasonic testing to AWS standard D15.1 (TUV Rheinland Industrial Solutions, Non-Destructive Testing Group Work Instruction No. PA-WI-08-005, Rev No. 1, *Ultrasonic Testing to AWS D15.1 Railroad Welding Specification*) which details the performance of ultrasonic testing and provides forms for recording of the test results.
- Appendix G-2.6.2 is TUV Rheinland's Industrial Solutions procedure and data recording forms for performing visual inspection of welds specifically for Kasgro's production of 12-axle railcars under S-2043 requirements (TUV Rheinland Industrial Solutions Procedure TRIS NDE-VT-4, Rev No. 0, *Visual Inspection NAVSEA Technical Publications T9074-AS-GIB 010/271*).
- Appendix G-2.6.3 is TUV Rheinland's Non-Destructive Testing Group's work instruction for performing liquid penetrant examination to weld specifically for S-2043 requirements (TUV Rheinland Industrial Solutions, Non-Destructive Testing Group Work Instruction No. WI-08-001, Rev No. 1, *Liquid Penetrant Examination*).

- Appendix G-2.6.4 is TUV Rheinland's Non-Destructive Testing Group's work instruction for performing magnetic particle examinations of ferromagnetic materials and is specific to Kasgro Railcars fabricated to AAR S-2043 requirements (TUV Rheinland Industrial Solutions, Non-Destructive Testing Group Work Instruction No. WI-08-002, Rev No. 1, *Magnetic Particle Examination of Ferromagnetic Materials*).

4.2.3.7 Atlas Railcar Laser Measurement

To have repeatable interface of cask cradle payloads while meeting predicted performance requirements of AAR S-2043, precise measurements of the railcar's deck fabrication and placement of the cradle attachment interface pin blocks must occur and reflect that pin block drawing tolerances are being met during fabrication. This is complicated by the size of the railcar and the camber of the railcar deck; therefore, Kasgro Rail utilizes laser measurements of production railcars and will apply this method to the Atlas railcar's fabrication. Repeatability of these measurements is also highly dependent on consistent use of the same portable laser coordinate measure equipment, equipment setup and operation. Kasgro Rail contracts these services while specifically requiring the use of FARO® Laser Tracker Xv2 portable coordinate measurement equipment and trained operators. This equipment is chosen due to its common availability, consistence performance and ease of use. The equipment manufacturer, FARO of Lake Mary, FL [36] also provides detailed user manuals which should be used that includes traceability instructions for the instrument's data, set-up instructions, measurement strategy, and instructions for measurement accuracy due to atmospheric conditions, environmental effects, target materials, and angular checks. FARO also provides operator training and certification for its equipment to ensure consistency and accuracy of dimensional measurements.

Kasgro Rail utilizes laser coordinate measurement services during the placement of a 12-axle railcar's deck and its components and after final welding has occurred. Kasgro has specific forms for the final dimensional measurement records of the railcar's deck, its relationship to the railcar's structure and deck camber measured at multiple positions. Also, positional measurement of the deck's attachments such as pin blocks and other deck structures are checked and recorded. In Appendix G-2.7.3, an example is enclosed of a Kasgro Railcar deck dimensional placement check to its undercarriage structure where actual measurements are recorded and then compared to drawing requirements. Specific forms will be developed for the Atlas railcar during the start-up of the Phase 3 portion of the HLRM Prototype railcar project. Note that each railcar fabricator would develop its own forms dependent on railcar type, deck requirements, fabrication techniques and possible customer requirements. Regardless, the use of a laser coordinate measurement machine is highly encouraged as a very reliable method to ensure long-term production repeatability.

Enclosed in Appendix G-2.7.1 (Example of FARO Laser Tracker and CAM2 Measure Training Certificate of Accomplishment form) is an example of a FARO certificate of training for the FARO Laser Tracker coordinate measure laser machine. Appendix G-2.7.2 (Example of FARO Calibration Certificate) is an example of the coordinate measurement laser equipment's pre-use calibration certificate. Appendix G-2.7.3 (Railcar Deck Measurement Data, Form 73, Date 9/23/14,) is an example of a Kasgro Railcar's dimensional measurement form used to collect data from the measure of a railcar deck placement. Appendix G-2.7.4 is a copy of the FARO® Laser Tracker Xv2 portable coordinate measurement equipment user's manual showing important data traceability, setup, interim tests, accuracy checks and accuracy understanding.

4.2.3.8 Atlas Railcar Amsted Rail Specific Truck Fabrication Processes

The Amsted Rail ASF-K Swing Motion™ Truck for the Atlas railcar is specific to S-2043 12-axle railcar designs. Therefore, specific assembly, run-in and maintenance instructions and requirements are included as a special process. These instructions and requirements are necessary to meet AAR S-2043 performance requirements for the Atlas railcar during testing, operations and maintenance. These instructions encompass the truck's assembly procedure which is utilized by Amsted in manufacture of the trucks and by Kasgro in assembly of the Atlas railcar. Specific break-in instructions have also been developed based on previous single-car testing experience of 12-axle AAR S-2043 railcars and will be utilized in the Atlas railcars. The break-in of the trucks is to be performed before truck placement on the assembled railcar. Specific truck wedges and springs are utilized in the ASF-K Swing Motion™ Truck and drawings are included for reference during assembly and maintenance. Finally, the spring rates and assembly procedures for the middle trucks on an Atlas railcar's tri-span are different from the end trucks on the same tri-span. Therefore, assembly instructions are specific to the truck's location on the tri-span with specific truck drawings and truck assemble checklists to be utilized during truck fabrication or maintenance, and truck inspection and acceptance.

Enclosed in Appendix G, Section G-2.8 are the following:

a) Appendix G-2.8.1 (Amsted Rail ASF-K Swing Motion™ Truck for Kasgro/Bechtel 290 Ton Flat Car Assembly Procedure, Product Bulletin No. N544, Rev C) are the assembly instructions for the Atlas railcar trucks.

b) Appendix G-2.8.2 (Amsted Rail Kasgro/Bechtel Swing Motion Truck Break In Procedure Specification, Spec 459, Rev C) are the break-in instructions for the Atlas railcar trucks.

c) Appendix G-2.8.3 (Amsted Rail ASF Swing Motion Friction Wedge with Composition Friction Material Drawing No. 1-9249, Rev B) is the drawing of the specific friction wedge to be used in the ASF-K Swing Motion™ Truck on the Atlas railcar.

d) Appendix G-2.8.4 (Amsted Rail ASF Swing Motion Truck 6 ½ X 9 Dual Rate Suspension with 12A Adapter Plus Drawing No. AS-517-1, Rev D) is a drawing reflecting specific springs to be utilized in the Atlas railcar end trucks on each tri-span of the Atlas railcar.

e) Appendix G-2.8.5 (Amsted Rail ASF Swing Motion Truck 6 ½ X 9 Low Profile Assembly Dual Rate Suspension, Drawing No. AS-518, Rev D) is a drawing reflecting specific springs to be utilized in the Atlas railcar middle truck on each tri-span of the Atlas railcar.

f) Appendix G-2.8.6 (Amsted Rail Kasgro – End Truck – Assembly Check List, TEC-300, Rev C) is the assembly checklist form to be used on the end trucks of each Atlas railcar tri-span.

g) Appendix G-2.8.7 (Amsted Rail Kasgro – End Truck – Assembly Check List, TEC-301, Rev C) is the assembly checklist form to be used on the middle truck of each Atlas railcar tri-span.

These same documents are utilized during ASF-K Swing Motion™ Truck maintenance and are therefore also included in Appendix G-7, Atlas Maintenance Railcar Supplemental Manual so that it may be used as an independent document.

4.2.3.9 Atlas Railcar Safety Monitoring System

The railcar monitoring system used for the Atlas railcar needs to interface with the planned escort railcar utilized by the DOE, which is the same REV developed for the U.S. Navy's HLRM program. Currently the utilized monitoring is manufactured by Lat-Lon, LLC of Denver, CO [37] and is simply designated as the "AAR Approved S-2043 System". Kasgro has developed a purchasing specification for the procurement of this unique monitoring and tracking system to ensure that applicable system codes and standards are provided. This specification is enclosed as Appendix G.2.9.1 (System Safety Monitoring Procurement Specifications for use with AAR Standard S-2043 HLRW Railcars, Procurement Specification SSM Procurement Spec RF). Also, a Lat-Lon system description is enclosed as Appendix G-2.9.2 (Lat-Lon AAR Approved S-2043 System, Procurement Specification SSM Procurement Spec RF).

4.2.4 Bill of Material

The bill of material for the Atlas cask railcar is included in Appendix G-3. The bill of material contains all materials and parts used in the fabrication of the Atlas railcar. Purchased materials and parts are listed by the specific material number or part number listed on Atlas railcar drawings. A description of each part number is provided and the quantity purchased and utilized in the railcar's fabrication, not including any scrap allowances. AAR approved vendors qualified by specific material or part number and utilized by Kasgro are listed by specific material or part number with the approved vendor listed in the far right column. Items that list as the vendor "AAR Vendor List" are generic items where the supplier is AAR approved, but specific materials or part numbers are not under an approval program; these items are typically common commodities such as nuts, bolts, washers, etc. and available from multiple suppliers. AAR approved suppliers are controlled under the AAR's M-1003 quality assurance program [18]. Additionally, as a result of another S-2043 cask railcar program, Kasgro has specifically qualified multiple vendors to supply common 12-axle railcar materials and parts under the control of the Kasgro Quality Assurance Manual approved under the AAR's M-1003 quality assurance program [18]. These same qualified vendors will be utilized on the Atlas railcar project. Fabrication consumables such as weld wire are not listed on the bill of materials as Kasgro maintains a usable inventory of these items at all times and they are specific to the equipment or fabrication process used by Kasgro Rail; however, these items are still specific to drawing requirements. Finally, as the safety monitoring system is a sole-sourced item, it has no item number and is shown listing its specific vendor, Lat-Lon LLC (reference Section 4.2.3.9).

4.2.5 Fabrication Inspection Plan

The Atlas railcar inspection plan is governed by the Kasgro QA manual which is supported by other specific inspection requirements which are used to collect inspection data for traceability requirements. The Kasgro QA program containing inspection requirements is common to all railcar fabrication programs and fabricators producing railcars under AAR M-1003 [4]. The only significant difference is in the application of how inspection data is collected and acknowledged as accurate. Specific Kasgro inspection data collection forms are provided Appendix G-4 and described below. A Third-Party Inspection Plan is addressed in subsection 4.2.5.8.

4.2.5.1 Kasgro Rail Receiving Inspection Report

This form is used to record the purchase order, drawing number, part number and other received supplier certificates for only acceptable purchased and received materials. This form is used to record only received purchased items that meet purchase order requirements, which also includes drawing and specification requirements. Non-conforming materials are never accepted and therefore, never recorded on this inspection report and fall within the Kasgro QA manual's non-conforming program. The receiving inspection report also has a table of sampling size listed for reference and a location for an inspector approved to the Kasgro QA requirements under AAR M-1003 to sign the form in acceptance of the listed received materials. The Kasgro receiving inspection report is listed in Appendix G-4.1 (Kasgro Rail Receiving Inspection Report, Form 9Z-1).

4.2.5.2 Railcar Dimensional Inspection and Sampling Plan

Enclosed in Appendix G-4.2 (Railcar Dimensional Inspection and Sampling Plan Forms 9B and 9C) are Kasgro's railcar dimensional inspection and sampling plan utilized for purchased and Kasgro fabricated parts and assemblies. This record is made up of two combined forms – Form 9B and Form 9C. Form 9B provides a record of the purchase order, the applicable drawing number and revision level, the specific dimensions to be inspected, and number of samples to be inspected. A chart of sample sizes is also included for reference. Finally, a location for an inspector approved to the Kasgro QA requirements under AAR M-1003 to sign reflecting acceptance of the listed fabricated items is included.

Kasgro's railcar dimension forms provide in Form 9C a reference of specific railcar dimensions by drawing and item number that is to be inspected, the frequency of the inspection, the method and any special tool used, the name of the inspector and date of the inspection. It also records if the results are acceptable or unsatisfactory by piece number. Multiple Form 9C documents may be attached to a single Form 9B.

Non-conforming parts fall within the Kasgro QA manual's non-conforming program and are not included on Form 9B or Form 9C.

4.2.5.3 Kasgro Rail Burning Table Inspection Report

Enclosed as Appendix G-4.3 (Kasgro Rail Burning Table Inspection Report, Form 9Z-A-1) is a form used to record acceptable parts cut on the Kasgro plasma cutting (burn) table used to cut large-scale steel materials. This form is used to record that cut materials meet drawing requirements (which also include specification requirements). Non-conforming materials are never accepted and therefore, never recorded on this inspection report, and fall within the Kasgro QA manual's non-conforming program. The burning table inspection report also has a table of sampling size listed for reference and a location for an inspector approved to the Kasgro QA requirements under AAR M-1003 to sign for acceptance of the listed plasma-cut items.

4.2.5.4 Car Body – Heat Identification Form

Form 44B is used to record approved parts utilized by individual railcar. This form will also be used on the Atlas railcar program to provide traceability of individual welded parts by individual railcar. Included as Appendix G-4.4 (Car Body – Heat Identification Form, Form 44B, Rev 3/12/2010) is an example of a welded part listing for an individual S-2043 cask railcar showing part numbers, drawing number, quantity per car, material the part is made from and any special testing required. This form also breaks out the railcar body from the two bolster boxes used in the railcar. Finally, the form has a place for signature by the Kasgro qualified preparer indicating acceptance. Non-conforming parts are not included as they are not accepted into an in-process railcar fabrication and fall within the Kasgro QA manual's non-conforming program.

4.2.5.5 Span Bolster Heat Identification Form

Form 42 is a Kasgro QA program requirement used to record individual welded parts utilized by individual tri-span bolsters in the Atlas railcar. Included as Appendix G-4.5 (Span Bolster Heat Identification Form, Form 42, Rev 2/11/2010) is an example of an individual span bolster's listing of individual part numbers and weld heat number. Finally, the form has a place for signature by the Kasgro qualified preparer indicating acceptance. Non-conforming parts are not included as they are not accepted into an inspected railcar and fall within the Kasgro QA manual's non-conforming program.

4.2.5.6 Kasgro Rail New Car Inspection Form

The Kasgro New Car Inspection Form is enclosed as Appendix G-4.6 (Kasgro Rail New Car Inspection Form, Form 5-12-B, Rev 2). This form is driven by AAR's Manual of Standards and Recommended Practices, Section C, Part II, *Design, Fabrication and Construction of Freight Cars* [2]. This form is also specific to a 12-axle railcar. The form is completed by qualified Kasgro personnel for each fabricated railcar and is the final Kasgro inspection prior to issuance of a railcar's Certificate of Conformance to the customer. Part numbers are listed and checked to traceability documents for major components. Air brake settings and bearing clearances are measured and recorded for tracking future wear. Overall railcar dimensions are verified and recorded. Results of various functional tests are reviewed and recorded for reference, and final acceptance tests are completed including:

- Single Car Test: review and verification of the railcar's single car air brake test (Appendix G-2.5.2 Kasgro Rail Air Brake Test Form 6-A) as described in Section 4.2.3.5;
- Brake Pipe Restriction Test: a Brake Pipe Restriction Test is performed on the railcar as required in AAR's Manual of Standards and Recommended Practices, Section E, Standard S-471 [38];
- Slack Adjuster Test: specific review and verification of the railcar's slack adjustment test results performed during the single car air brake test (Appendix G-2.5.2 Kasgro Rail Air Brake Test, Form 6-A) as described in Section 4.2.3.5;
- Golden Shoe Test: using a calibrated force measuring brake shoe (Golden Shoe), the railcar's applied brake shoe force is measured to ensure compliance to AAR's Manual of Standards and Recommended Practices, Section E, Standard S-401 [39];
- Truck Curve Test: per the AAR's Manual of Standards and Recommended Practices, a clearance test is performed on the first article railcar only [40]. For every railcar which has a New Car Inspection form completed, verification is made and results are reviewed that the first article railcar traveled a curved section of railroad track having a radius of approximately 150 feet while observers verified there was no interference between the railcar's body, trucks and suspension components, and brake components;
- Load Test: verification and review that the railcar's weight distribution was measured and meets specification per Kasgro Procedure #13, Revision 4, titled Car Weighting Procedure (reference Section 4.2.3.4 and Appendix G-2.4.1).

The new car inspection process also verifies that operational railcar settings for locknuts on brake slack adjuster triggers are properly set, cross key retainer bolts are properly torqued, safety tabs are bent over tri-span-to-center pin bolts, and center pin travel for trucks and car bodies are measured and recorded for proper range and future wear measurements. Railcar stenciling is checked along with the orientation and presence of truck cover plates and pigtail protective covers. Finally, with the railcar is supported by jacks to remove the railcar body's weight from the span bolsters, and the springs and truck wear plates are checked for proper part installation and fit.

4.2.5.7 Certificate of Conformance

A Certificate of Conformance is provided for each railcar by Kasgro upon completion of the railcar's fabrication, all in-process inspections, and the completion of the Kasgro Rail New Car Inspection Form (reference Section 4.2.5.6). An example is included as Appendix G-4.7.

4.2.5.8 Third Party Inspection Plan

A third-party inspection plan is assumed for the receiving acceptance of an individual Atlas railcar. In the case of the Atlas prototype railcar, it is suggested the independent inspection be performed by TTCI under contract to the DOE once the Atlas railcar arrives at the Technology Testing Center in Pueblo, CO as it has the necessary equipment, location and qualified personnel to perform such.

It is suggested that the following inspections and document reviews comprise the third-party inspection plan:

- Perform Kasgro Rail New Car Inspection Form (reference section 4.2.5.6) as it validates that special processes and AAR requirements for brakes and AAR S-2043 predicted dynamic modeling performance requirements will be met by the railcar's suspension;
- Perform Atlas Railcar Weighting (reference section 4.2.3.4) as it will ensure that AAR S-2043 predicted dynamic modeling performance requirements will be met by the railcar's weight distribution;
- Review Kasgro Rail utilizes laser coordinate measurement forms (reference section 4.2.3.7);
- Review that the customer received the fabricator's certificate of conformance.

Since every AAR M-1003 qualified fabricator will approach its fabrication and inspection process differently, a third-party inspection may need to be tailored for each individual fabricator to include the elements of the above bulleted inspection and review processes.

4.2.6 Fabrication Travelers

Kasgro Rail utilizes detailed drawings with specification and fabrication instruction callouts by major railcar assembly operation and/or component. If customer driven inspection and acceptance criteria are to a higher level than AAR standards, these are also references on the drawings. As a result, assembly travelers typically reflect a collection of the applicable drawing(s), part number and material control number lists, and inspection and heat lot records for utilized parts and subassemblies. Therefore, the traveler also serves as a collection of documents for configuration control and as a quality assurance summary document. The traveler also includes a listing of the assembly operators performing the fabrication operations, the operators' supervisor(s) and the applicable inspector(s). The inspector's signature confirms that the fabricated assembly is acceptable to applicable drawing and specification requirements before it is released to the next stage of railcar assembly. This traveler process is acceptable under AAR's quality assurance standard M-1003 [4] which Kasgro Rail maintains certification to, and is indeed the process that

Kasgro Rail utilizes.

Kasgro Rail utilizes a simple traveler process in its 12-axle railcar assembly. Enclosed as Appendix G-5.1 (Kasgro Specialty Railcar Solutions, Form 84, Flat Car Assembly Form, Rev April 11, 2017) is Kasgro's flat car assembly traveler for 12-axle railcar assembly. This form consists of four pages with each page applicable to a major railcar assembly process: body bolster assembly (page 1), railcar body component fit (page 2), railcar bottom cover plate and side sill gussets assembly (page 3), and railcar airbrake piping assembly (page 4). A similar form, Kasgro's Form 85, Span Bolster Assembly, enclosed as Appendix G-5.2 (Kasgro Specialty Railcar Solutions, Span Bolster Assembly Form, QA Form 85, Rev April 11, 2017) serves as the traveler for the 12-axle railcar's span bolster assemblies on each end of the railcar. This form consists of four pages with each page applicable to the assembly of the span bolster: draft sill arrangement assembly (page 1), span bolster fit-up (page 2), end platform assembly (page 3), and assembly of other components such as safety appliances, brake system equipment and couplers (page 4).

4.2.7 Operation and Maintenance Information

Basic railcar maintenance requirements are included in the AAR's Office and Field Manuals of the AAR Interchange Rules. These maintenance activities are completed annually, periodically based on the mileage the railcar has travelled, or before the next routine operation of the Atlas railcar of during routine service. Atlas railcar-specific periodic inspections, maintenance requirements and procedures are included in the Atlas Railcar Supplemental Maintenance Manual enclosed as Appendix G-6 (Atlas Railcar Supplemental Maintenance Manual, Rev 0).

Specific areas of differences in operational and maintenance requirements for the Atlas railcar covered by the supplemental maintenance manual include:

- Pre-use inspections and annual inspections which are supported by detailed checklists included in this manual,
- Brake shoe replacement requirement also detailed by specific instructions in the manual,
- Atlas railcar long-term storage to prevent axle roller bearing seizure,
- Ellcon National truck mounted brake installation and field maintenance instruction,
- New York Air Brake DB-60 Brake System operations, maintenance and repair instruction manuals, and
- Maintenance requirements, assembly procedures and instructional documents for Amsted Rail ASF-Keystone 100 Ton Swing Motion™ Truck with 12A Adapter Plus wedge pads.

Specific operational requirements are included in the general loading procedures enclosed as Appendix F.

4.2.8 AAR EEC Submission and Notice to Proceed

This section provides information regarding the results of the Atlas railcar's dynamic modeling.

4.2.8.1 S-2043 Performance Analysis Summary

Introduction: The purpose of the AAR's Standard S-2043 is to establish performance guidelines so trains carrying HLRM while using the best available technology to minimize the potential for derailments may enter general commerce with others trains in a standard railroad operating environment. This standard sets performance guidelines, which are to be evaluated by the following means:

- A railcar is preliminarily designed and its railroad track performance is predictively analyzed by simulation;
- Prototype railcars are built and tested for extreme and real-world conditions, and;
- Production railcars are real-time monitored and reported against performance guidelines during actual use.

As a result of the first requirement above, analysis must be performed using dynamic simulations of the standard's performance guidelines for both real and extreme test track conditions. The results of the predictive dynamic modeling are not to be interpreted simply as a pass/fail criterion, but as information supporting the utilization of the industry's best available technology in the railcar's design to meet the standard's performance guidelines. Analysis of the dynamic modeling results are to show the simulation conditions in which the railcar does not meet performance guidelines, does not allow for post-test smoothing of individual or combined test results, and must report peak values which occur during dynamic modeling simulations. The dynamic modeling predictions provide insight into the prototype railcar's overall predictive performance as a single railcar and in a consist with other railcars. The results also support the development of specific requirements for the prototype railcar's future single-car and multi-car testing. Dynamic modeling simulation results are reviewed by the AAR's EEC for determination of whether a prototype railcar can be fabricated for future testing.

The performance guidelines set forth in S-2043 are goals representing the highest current and future technology to be used to optimize railcar performance. The AAR EEC's interpretation of the guidelines may reflect trade-offs between various operating regime guidelines in order to achieve optimum overall railcar performance, or reflect limitations of available technologies used to achieve optimum railcar performance.

Dynamic Modeling Results: Results of each simulation regime follow in Table 4-2 and are available in Appendix G-7. Where the Atlas railcar has not met S-2043 performance guidelines, the results are similar to the results of the only other conditionally approved S-2043 railcar, the Navy's M-290 railcar. The simulated performance of both railcars is shown for comparison. Cases to be tested during single car tests are noted with "SC" and cases to be testing during multiple car tests are noted with "MC".

Conclusion and S-2043 Performance Analysis Actions: Although the Atlas railcar did not meet all performance guidelines of S-2043, for those performance guidelines not met, it has performed as well as the other conditionally approved S-2043 cask railcar. As a result, the dynamic modeling simulation regimes are considered complete and were submitted to the AAR EEC for review and application for a notice to proceed with the test phase allowing fabrication of the prototype Atlas railcar. As the Atlas railcar will be single and multi-car tested based on testing parameters influenced by the dynamic modeling simulation results, no further action is considered necessary at this time.

TABLE 4-2: ATLAS RAILCAR PERFORMANCE ANALYSIS RESULTS

Description	S-2043 Paragraph	Subsection	Empty Atlas Railcar		Loaded Atlas Railcar		Worst Example That Does Not Meet Performance Specification Goal	To Be Future Tested
			Meets	Does Not Meet	Meets	Does Not Meet		
Truck Twist Equalization	4.2.1		X		X			SC
Carbody Twist Equalization	4.2.2		X		X			SC
Static Curve Stability	4.2.3	Base Car	X		X			
		Like Car	X		X			
		Long Car	X		X			
		Buffer Car	X		X			
		Long-Base Car Combination	X		X			SC
Curve Negotiation	4.2.4	Uncoupled 150-ft Radius Curve	X		X			
		Coupled 250-ft Radius Curve	X		X			SC
		No. 7 Crossover	X		X			
Twist and Roll	4.3.9.6	39-ft Inputs	X		X			SC
		38-ft Inputs	X		X			
Pitch and Bounce	4.3.9.7	39-ft Inputs	X		X			SC
		38-ft Inputs	X		X			SC
Yaw & Sway	4.3.9.8	39-ft Inputs	X		X			SC
		38-ft Inputs	X		X			

Description	S-2043 Paragraph	Subsection	Empty Atlas Railcar Meets	Empty Atlas Railcar Does Not Meet	Loaded Atlas Railcar Meets	Loaded Atlas Railcar Does Not Meet	Worst Example That Does Not Meet Performance Specification Goal	To Be Future Tested
Dynamic Curving	4.3.9.9	39-foot inputs	X			X	**ATLAS:** Wheel L/V 0.88, Limit=0.8, A-End and B-End lead, Loaded. **CA S-2043 Car[1]:** Wheel L/V 0.98 test, 1.07 simulation, Loaded Cask	SC
		38-foot inputs	X			X	**ATLAS:** Wheel L/V 0.90, Limit=0.8, A-End Lead, Loaded **CA S-2043 Car[1]:** No comparison available, see 39-foot	
Single Bump	4.3.10.1		X		X			
Curving with Single Rail Perturbation	4.3.10.2	1-inch Bump	X		X			
		2-inch Bump	X		X			SC
		3-inch Bump		X		X	**ATLAS:** 5 degree roll angle, Limit=4.0, A and B-End lead, Loaded; Wheel L/V 0.91, Limit=0.80, Empty **CA S-2043 Car[1]:** 5.4 degree roll angle, Empty Cask; Wheel L/V 0.64 Empty Cask	
		1-inch Dip	X		X			
		2-inch Dip		X	X		**ATLAS:** Wheel L/V 0.81, Limit=0.8, Empty. **CA S-2043 Car[1]:** Wheel L/V 0.63, Empty Cask	SC

Description	S-2043 Paragraph	Subsection	Empty Atlas Railcar		Loaded Atlas Railcar		Worst Example That Does Not Meet Performance Specification Goal	To Be Future Tested
			Meets	Does Not Meet	Meets	Does Not Meet		
		3-inch Dip		X		X	**ATLAS:** Roll angle=4.2 degrees, Limit=4.0, Loaded; Wheel L/V=0.96, Limit=0.8, Empty; Truck Side L/V=0.52, Limit=0.5, Empty. **CA S-2043 Car[1]:** Roll angle=4.7 degrees, Loaded Cask; Wheel L/V 0.77, Empty Cask; Truck Side L/V=0.36, Empty Cask.	
Hunting	4.3.11.3		X		X			SC
Constant Curving	4.3.11.4		X		X			SC
Curving with Various Lubrication Conditions	4.3.11.5	Case 1 New	X		X			
		Case 2 New		X	X		**ATLAS:** 95% Wheel L/V Ratio=0.62, Limit = 0.60, Empty **CA S-2043 Car[1]:** 95% Wheel L/V 0.56 simulation. Empty Cask	
		Case 3 New	X		X			
		Case 4 New		X	X		**ATLAS:** 95% Wheel L/V Ratio=0.66, Limit = 0.60, Empty **CA S-2043 Car[1]:** 95% Wheel L/V 0.65, Empty Cask	
		Case 1 Worn		X		X	**ATLAS:** Truck Side L/V 0.56, Limit=0.5, Empty **CA S-2043 Car[1]:** Truck Side L/V 0.52, Empty & Loaded Cask	

Description	S-2043 Paragraph	Subsection	Empty Atlas Railcar		Loaded Atlas Railcar		Worst Example That Does Not Meet Performance Specification Goal	To Be Future Tested
			Meets	Does Not Meet	Meets	Does Not Meet		
		Case 2 Worn		X		X	**ATLAS:** Truck-side L/V Ratio=0.62, Limit=0.5, Loaded; 95% Wheel L/V Ratio =0.68, Limit=0.60, Empty **CA S-2043 Car[1]:** Truck Side L/V 0.54, 95% Wheel L/V 0.67, Empty Cask	
		Case 3 Worn	X		X			
		Case 4 Worn		X		X	**ATLAS:** Truck-side L/V Ratio=0.61, Limit=0.5, Empty, Loaded; 955 Wheel L/V Ratio = .061, Limit = 0.60, Empty **CA S-2043 Car[1]:** Truck Side L/V 0.54, Empty & Loaded Cask	
Limiting Spiral Negotiation	4.3.11.6	Entry A-end	X		X			SC
		Exit A-end	X		X			
Turnouts and Crossovers	4.3.11.7	RH Turnout	X		X			MC
		LH Turnout	X		X			MC
		Crossover	X			X	**ATLAS:** Truck-side L/V Ratio=0.52, Limit=0.5, Loaded **CA S-2043 Car[1]:** Truck Side L/V 0.506, Loaded Cask	MC
Ride Quality	4.3.12	Class 2	X		X			MC

Description	S-2043 Paragraph	Subsection	Empty Atlas Railcar		Loaded Atlas Railcar		Worst Example That Does Not Meet Performance Specification Goal	To Be Future Tested
			Meets	Does Not Meet	Meets	Does Not Meet		
		Class 3	X		X			
		Class 4	X		X			
		Class 5	X		X			
		Class 6	X		X			
Buff and Draft Curving	4.3.13	Base Buff	X		X			
		Long Buff	X		X			
		Like Buff		X	X		**ATLAS:** Truck-side L/V Ratio=0.51, Limit=0.50, Empty **CA S-2043 Car[1]:** Truck Side L/V 0.40, Empty Cask, Draft Condition	
		Buffer Car Buff	X		X			MC
		Base Draft	X		X			
		Long Draft	X		X			
		Like-Draft	X		X			
		Buffer Car Draft	X		X			MC
Braking Effects on Steering	4.3.14		X		X			MC

Notes:
1: CA S-2043 Car = Conditionally Approved S-2043 Cask Railcar (the M-290 Railcar)

4.2.8.2 Worn Component Simulation Summary

Introduction: The purpose of performing worn component simulations under AAR Standard S-2043 is to allow the railcar designer to identify wear limits for railcar truck components. The simulations are based on component performance at the end of its service life with additional simulations to be performed with components beyond their wear limits, broken and missing. In turn, this allows the railcar designer, fabricator and/or user to establish a performance envelope for the truck components and set maintenance requirements for the railcar's truck components to prevent the truck components' performance from exceeding any criterion in S-2043 Table 4.1 by 10%. As the results of the worn component simulations are to establish failure points, there is no pass/fail criteria applied to these simulations.

Worn Component Simulation Results: Results of each simulation regime follow in Table 4-3.

Conclusion and Worn Component Simulation Actions: Preliminary preventative maintenance inspections and component replacement requirements for the Atlas railcar have been established and included in the Phase 2 report as Appendix G-6. The timing and/or frequency of these requirements will be finalized during Phase 3 of the project, and if necessary, revised after single-car and multi-car testing is completed. No further action is considered necessary at this time.

TABLE 4-3: ATLAS RAILCAR WORN COMPONENT SIMULATION RESULTS

Description	S-2043 Paragraph	Subsection	Meets	Does Not Meet	Worst Example That Does Not Meet Performance Specification Goal
Constant Contact Side Bearing	4.3.15	Constant Curving	X		
		Dynamic Curving		X	Maximum Wheel L/V Ratio=1.16, Limit=0.8
		Hunting		X	Minimum Vertical Wheel Load=22%, Limit≥25%
		Twist and Roll	X		
Center Plates	4.3.15	Constant Curving	X		
		Dynamic Curving		X	Maximum Wheel L/V Ratio=0.95, Limit=0.8
		Hunting		X	Minimum Vertical Wheel Load=24%, Limit≥25%
Primary Pad	4.3.15	Constant Curving – Soft	X		
		Dynamic Curving – Soft		X	Maximum Wheel L/V Ratio=0.83, Limit=0.80, but better than baseline of 0.88.
		Hunting – Soft		X	Minimum Vertical Wheel Load=24%, Limit≥25%

Description	S-2043 Paragraph	Subsection	Meets	Does Not Meet	Worst Example That Does Not Meet Performance Specification Goal
		Hunting Empty Car Ballast Load	X		
		Constant Curving – Stiff	X		
		Dynamic Curving – Stiff		X	Maximum Wheel L/V Ratio=0.96, Limit=0.8
		Hunting – Stiff		X	Minimum Vertical Wheel Load=24%, Limit≥25%
Friction Wedges	4.3.15	Limited Spiral	X		
		Dynamic Curving		X	Maximum Wheel L/V Ratio=0.87, Limit=0.80, but better than baseline of 0.88.
		Pitch and Bounce	X		
		Twist and Roll	X		
Broken Springs	4.3.15	Limited Spiral	X		
		Dynamic Curving		X	Maximum Wheel L/V Ratio = 0.97, Limit=0.80 Maximum Truck side L/V Ratio of 0.51, Limit=0.5
		Pitch and Bounce	X		
		Twist and Roll	X		

4.2.8.3 Notice to Proceed with the Test Phase for Atlas Railcar

The Team received a letter from the AAR EEC on February 2, 2018 providing approval of the Atlas railcar's design and dynamic modeling results, and providing a notice to proceed with the test phase of the Atlas railcar design allowing fabrication of the prototype railcar for future single and multi-car testing. A copy of the letter appears in Figure 4.2. The approval to proceed with the test phase for the Atlas railcar is based on the completed S-2043 requirements for structural analysis, nonstructural static analysis, dynamic analysis, brake system design, and railcar clearance and weight review. The Atlas railcar is not yet approved for the system safety monitoring requirement of S-2043. This is due to: a) there not being AAR approved system safety monitoring equipment or a vendor; b) the technology of the currently conditionally approved S-2043 safety monitoring system is becoming outdated in 2018 and a replacement system is starting development, and; c) the presence of the safety monitoring system on the railcar is not needed until multi-car testing occurs. As a result, the AAR EEC has postponed review and approval of the safety monitoring system until the multi-car testing is underway.

FIGURE 4-2: NOTICE TO PROCEED WITH THE TEST PHASE

Ron Hynes
Assistant Vice President
Technical Services

Nichole Fimple
Executive Director
Rules and Standards

ASSOCIATION OF AMERICAN RAILROADS
Transmitted via email

February 2, 2018
File 209.240

Subject: AAR Standard S-2043 Initial Design Approval of the Kasgro/AREVA Department of Energy (DOE) "Atlas" High Level Radioactive Material (HLRM) Cask Car

Mr. Rick Ford
AVP Mechanical & Utilization
Kasgro Rail Corporation
121 Rundle Road
New Castle, PA 16102

Dear Mr. Ford:

The AAR Equipment Engineering Committee (EEC) has completed the S-2043 Initial Review of the DOE Atlas HLRM Cask Car. The initial design is hereby approved, and all parties involved are notified to proceed with the test requirements of S-2043. Approval was based on completion of the following requirements:

Structural Analysis
Nonstructural Static Analysis
Dynamic Analysis
Brake System Design
Railcar Clearance and Weight

There was no mention of System Safety Monitoring in the submission, but EEC understands that this item will be addressed as the Multiple Car Test phase approaches.

If you have any questions or need additional information, please contact Mr. Jon Hannafious of our Transportation Technology Center, Inc., subsidiary at jon_hannafious@aar.com or (719) 584-0682.

Sincerely,

Nichole Fimple

NF/jsh
cc: David Cackovic
Mark Denton, AREVA
Equipment Engineering Committee

Association of American Railroads
425 Third Street, SW, Suite 1000, Washington D. C. 20024, (202) 639-2139 FAX No. (202) 639-2179

5.0 PRELIMINARY BUFFER PROTOTYPE RAILCAR DESIGN

This section of the Phase 2 report and its accompanying Appendix H provide preliminary design information for the buffer railcar.

5.1 Buffer Railcar Overview

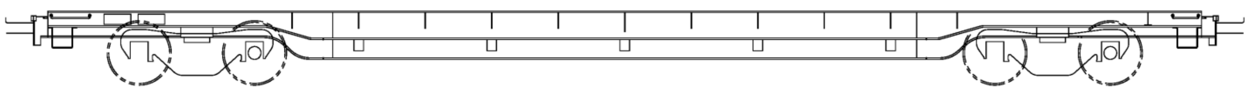
A buffer railcar is designed for use in conjunction with Atlas cask railcars utilized in the shipments of HLRM. The buffer railcar structural design is symmetrical, end-to-end. The buffer railcar is designed to meet AAR Plate E requirements [26] just like the Atlas railcar. Furthermore, because it carries no cargo and has a very low height, it also easily meets AAR Plate C requirements [9]. The basic railcar design utilizes the same trucks as the escort railcar. These trucks will be fully tested in the single-car test phase. For the buffer railcar to meet AAR S-2043 performance guidelines, it must be heavy, so ballast weight was added to the railcar design. To minimize logistics and ensure consistent performance, the ballast weight was permanently built into the buffer railcar's deck and framework.

Other specific design features of the buffer railcar are:

- Extreme Width... 10'-8"
- Loading Deck Length.. 60'-0"
- Coupled Length .... 66'-4 5/8"
- Number of Axles 4
- Wheel Size .... 36"
- Minimum Turning Radius ……………………………………………… 150 feet
- Railcar design load limits:
    - Design total railcar truck capacity (based on 71,500 lbs/axle limit)….. 286,000 lbs
    - Design railcar empty weight (estimate based on total weight of empty railcar and permanent attachments)……………………………………………... 263,000 lbs
    - Design railcar interchange load limit (based on conservative 65,750 lbs/axle operational constraints)………………………………………………………… 263,000 lbs
- Railcar operational load limits (as will be stenciled on side of railcar):
    - Gross Rail Load (GRL; based on interchange limit of 65,750 lbs/axle; AAR definition as load limit + light weight)……………………………………………. 263,000 lbs
    - Light Weight Load (LT LD; an estimate based on total weight of empty railcar and permanent attachments)……..………………………………………. 263,000 lbs
    - Load Limit (LD LMT; an estimate based on railcar operational payload capacity which is also the highest dynamic modeled weight)………..………………… *0 lbs
        - Note: Per the Field Manual of the AAR Interchange Rules, Rule 88, B.1.d.(h) [8], when structural limitation of a car is less than truck capacity, a star symbol (*) must be applied to the left of the "LD LMT" stencil. Here, the "LD LMT *0 lbs" is used to denote a structural and operational payload limit of the greatest dynamic modeled

weight required to meet AAR S-2043 guidelines, and which is also the empty weight of the railcar with its built-in ballast weight and without any additional payload capacity. The railcar will be weighed during fabrication and the actual weight used in railcar markings.

FIGURE 5-1: BUFFER RAILCAR



5.2 Buffer Railcar Deliverables

This section provides explanations of Phase 2 project deliverables for the buffer railcar. These deliverables include preliminary design and fabrication drawings, fabrication and special process specifications, a bill of material, information regarding the railcar's inspection plan and fabrication traveler, operations and maintenance information, and the AAR EEC submission package.

5.2.1 Preliminary Fabrication Drawings

Fabrication drawings for the buffer railcar reflect its completed preliminary design including its permanently attached ballast payload. The included drawings are listed in Table 5-1 and are enclosed in Appendix H, Section H-1.

TABLE 5-1: KASGRO BUFFER RAILCAR PRELIMINARY DRAWINGS

Drawing Number	Description	Revision[1]	Reference Appendix Item
1160-1	General Arrangement 110 Ton Straight Deck Flat	"Original"	Appendix H-1.1
1160-2	Air Brake Arrangement 110 Ton Flat Car	Rev C	Appendix H-1.2
1160-3	Stencil Arrangement	"Original"	Appendix H-1.3
1160-4	Hand Brake Arrangement	"Original"	Appendix H-1.4
1160-5	Draft Sill Details	"Original"	Appendix H-1.5
1160-6	Bolster Assembly and Details	"Original"	Appendix H-1.6
1160-7	Steel Details	"Original"	Appendix H-1.7
1160-8	Steel Details	"Original"	Appendix H-1.8
1160-9	Steel Details	"Original"	Appendix H-1.9
1160-10	Steel Details	"Original"	Appendix H-1.10
1160-11	Steel Details	"Original"	Appendix H-1.11
1160-12	Steel Details	"Original"	Appendix H-1.12
1160-13	Steel Details	"Original"	Appendix H-1.13

1160-14	Steel Details	"Original"	Appendix H-1.14
1160-15	Steel Details	"Original"	Appendix H-1.15
1160-16	Deck Plate	"Original"	Appendix H-1.16
1160-17	Steel Details	"Original"	Appendix H-1.17
1160-18	Steel Details	"Original"	Appendix H-1.18
1160-19	Hand Brake Details	"Original"	Appendix H-1.19
1160-20	Brake Badge Plate	"Original"	Appendix H-1.29
1160-21	Hand Brake Steel Details	"Original"	Appendix H-1.21
1160-22	Hand Brake Details	"Original"	Appendix H-1.22
1160-23	Air Brake Steel Details	"Original"	Appendix H-1.23
1160-24	Air Brake Steel Details	"Original"	Appendix H-1.24
1160-25	Pipe Details	"Original"	Appendix H-1.25
1160-26	Pipe Details	"Original"	Appendix H-1.26
1160-27	Pipe Details	"Original"	Appendix H-1.27
1160-28	Brake Pipe Details	"Original"	Appendix H-1.28
1160-29	Air Brake Details	"Original"	Appendix H-1.29
1160-30	Air Brake Details	"Original"	Appendix H-1.30
1160-31	Air Brake Details	"Original"	Appendix H-1.31
1160-32	Air Brake Steel Details	"Original"	Appendix H-1.32
1160-33	Air Brake Steel Details	"Original"	Appendix H-1.33
1160-34	Pipe Details	"Original"	Appendix H-1.34
1160-35	Camber Diagram	"Original"	Appendix H-1.35
1160-37	Pipe Details	"Original"	Appendix H-1.36
1160-40	Ballast Wt Arrangement	"Original"	Appendix H-1.37
1160-41	Dummy Wt	"Original"	Appendix H-1.38
1160-42	Dummy Wt	"Original"	Appendix H-1.39
1160-43	Dummy Wt	"Original"	Appendix H-1.40
1160-44	Locking Center Pins	"Original"	Appendix H-1.41
1160-45	Steel Details	"Original"	Appendix H-1.42
N/A	Atlas 4-Axle Flat Car, Preliminary Loading Analysis, 60 Ft 110-Ton Flatcar For S-2043 Service	June 2017	Appendix H-1.43

Notes: 1) The original issue of approved drawing shows no revision levels; first revision will be listed as revision "A".

The enclosed structural analysis in Appendix H-1.43 represents the preliminary Buffer railcar design and supersedes the structural analysis submitted and approved as CLIN 2, Event # 2 [41].

5.2.2 Fabrication Specifications

The buffer railcar will be fabricated to the following industry specifications:

- AAR MSRP, Section C, Part II, Design, Fabrication and Construction of Freight Cars (M-1001) [2]
- AAR MSRP, Section J, Specification For Quality Assurance, Specification M-1003 [4]
- AAR MSRP, Car Construction Fundamentals and Details, Performance Specification for Trains Used To Carry High-Level Radioactive Material, Standard S-2043 [3]
- Contractual requirement for meeting railcar envelope size Plate E [26]
- Safety appliances are installed per the requirements of the Federal Railroad Administration and the Code of Federal Regulations, 49 CFR Parts 200-299 [29]
- Association of American Railroads, Manual of Standards and Recommended Practices, Section C, Car Construction Fundamentals and Details, Standard 2044, Safety Appliance Requirements for Freight Cars, 2017 [43]

Other major components, manufactured by others, that are used in the fabrication process are governed by the following:

- AAR MSRP, Section C, Part II, Design, Fabrication and Construction of Freight Cars (M-1001) [2];
- AAR MSRP, Section B - Freight Car Draft Gear Components [22];
- AAR MSRP, Section D - Trucks and Truck Details [22];
- AAR MSRP, Section E - Brakes and Brake Equipment [22];
- AAR MSRP, Section G - Wheels and Axles [22];
- AAR MSRP, Section H - Journal Bearings and Lubrication [22].

5.2.3 Special Process Specifications

Special process specifications for the buffer railcar represent fabrication requirements for railcar acceptance industry standards, AAR standards and in-house processes developed for repeatability of railcar fabrication and specific material procurement specifications. Industry designated processes such as welding and NDE processes are utilized to set quality control acceptance requirements while meeting AAR standards. Special air brake tests ensure performance and functionality of the brake system to AAR requirements.

Not all special processes utilized on the Atlas railcar are used on the buffer railcar; however, the process methodologies are the same. To prevent confusion, buffer railcar special processes are discussed in the following subsections. Special processes are to be considered mandatory with no exceptions made in their application to the fabrication, inspection and testing of the buffer railcar. Appendix H, Section H-2 provides examples and/or forms of the special process specifications described below.

5.2.3.1 Welding Procedure Qualifications Records and Welding Procedure Specifications

A PQR serves as a qualification record regarding the fabricator's compliance in meeting American Welding Society Standard D15.1 for Railroad Welding Specification for Cars and Locomotives [30]. The PQR covers the welding parameters used in the WPS document. In addition, it also includes relevant information, such as the welder's name and the name of the person who did the inspection, and the dates that the weld qualification was performed. The PQR is performed by a qualified individual welder and retained as a record of endorsement of the company and its product to industry standards.

A WPS is a set of welding instructions that aids in planning and ensuring quality control of product welds to its PQR, as well as future reproductions of the weld and its resulting product. In a WPS, required welding parameters referenced in applicable drawings are explained in the context of instructions. The purpose is to allow the welder to reproduce the product and its welds to a particular industry standard and quality.

The use of the PQRs and WPSs provides uniform and consistence instructions for producing welds that meet AAR S-2043 requirements.

Appendix H-2.1 includes Kasgro's PQRs and WPSs for welds to be used on the Buffer railcar. Appendix H.2.1.1 provides an example of a welding procedure qualification record (PQR F-001 Rev 3) for welding A572 Grade 50 steel in various positions. Appendix H-2.1.2 provides necessary welding procedure specifications for:

- Welding A572 Grade 50 steel in various positions (WPS F-001 Rev 3)
- Welding of A572 Grade 60 steel in various positions(WPS F-002 Rev 3)
- Welding dissimilar metals of 656 Grade 80 steel to A572 Grade 60 steel in various positions (WPS F-003 Rev 1)
- Welding A514T steel to A572 Grade 60 steel material (WPS F-004 Rev 1)
- Welding dissimilar metals of A572 Grade 60 steel to A240 Grade 304 stainless in a flat weld position (WPS-08KR-F1097 Rev 2)
- Welding dissimilar metals of A572 Grade 60 steel to A240 Grade 304 stainless only in a horizontal weld position (WPS 15KR-F1087 Rev 2)

5.2.3.2 Buffer Railcar Spring Properties Requirements

The specifications of the springs used in the buffer railcar's trucks are very important in meeting AAR S-2043 performance requirements for the buffer railcar. Spring tolerance for meeting AAR S-2043 performance requirements for spring load height is narrower than industry standards for non-S-2043 railcars. To ensure that S-2043 performance requirements are consistently met, Kasgro will develop a procedure similar to its 12-axle spring testing procedure to test 100% of the truck springs utilized in the applicable buffer railcar trucks. Appendix G-2.3 (Spring Test Requirements and Tolerances Procedure #12, Rev 3) is an example of the testing procedure and spring load height requirements that Kasgro will develop developed procedure to determine acceptable buffer railcar truck springs.

5.2.3.3 Buffer Railcar Air Brake Testing

As this report was nearing completion, in September 2017, the AAR issued a revised version of Standard S-2043, which removed the requirement for ECP brakes. Therefore, the preliminary design of the buffer railcar has standard pneumatic brakes instead of ECP brakes. Forms presented in this section are examples only, but portray basic brake testing requirements that will be performed once the testing procedures are completed under Phase 3.

Static air brake testing must follow the AAR's Manual of Standards and Recommended Practices, Section E, Standard S-486 [32] to demonstrate compliance to AAR S-2043 paragraph 5.3 [33]. In addition, the pneumatic brake system must be functionally tested. Testing must occur for all railcars and includes 100% of the braking system components. Functional system testing of the pneumatic braking system is to the specific equipment's specifications, specifically the New York Air Brake DB-60 system. Additionally, the brake testing must be witnessed by an AAR representative before the railcar can be released by the fabricator. These requirements are included in the AAR Manual of Standards and Recommended Practices, Section E, Brakes and Brake Equipment [34]. Finally, fabricator personnel performing static air brake tests must be certified to AAR Standard S-486 [32]. A copy of a written test and supervised practical exam are included for reference. Examples of Kasgro brake test results from another S-2043 railcar program are enclosed in Appendix Section H-2.3; similar forms will be developed for the buffer railcar's brake testing.

Appendix H-2.2.1 (Static Force Brake Test Data, Form 36-A Rev 1) is an example of an electronically generated form showing results of static force brake test data results. Appendix H-2.2.2 (Air Brake Test Form 6-A, Rev 1) is an example of the form that records air brake piston travels and any necessary repairs that may be required because of the static air brake test. Appendix H-2.3.3 (EP-60 Single Car Test Results) is an example of the electronically generated results of the brake system functional test; the specific format will be determined for the DB-60 pneumatic brake system as part of Phase 3. Appendix H-2.2.4 (TTCI letter # CC-209.221 dated January 17, 2017) is an example of the letter provided by a TTCI Field Inspector confirming satisfactory completion of static air brake test per AAR Standards S-486 and S-2043. Finally, Appendix H-2.2.5 includes examples of the written and practical exam required by AAR S-486 to administer static brake tests.

5.2.3.4 Buffer Railcar NDE Examination and Testing

NDE testing is based on industry standard testing protocols from AWS standard D15.1 [30]. However, to meet AAR S-2043, Section 4.1.10, Weld Analysis [35], test sample size requirements are 100% for visual inspection identified as full-penetration butt welds or critical structural welds, and 10% nondestructive inspection for all welds not identified as full-penetration butt welds or critical structural welds. The 10% nondestructive inspection shall cover a random sampling of welds chosen by the welding inspector. Finally, all inspections, including visual, must be performed by an AWS-certified inspector. Due to this requirement, Kasgro Rail has contracted all NDE inspection to TUV Rheinland who maintains their own NDE inspection procedures and AWS-certified personnel.

Included examples in Appendix H-2.3, Atlas Railcar NDE Examinations and Testing, are from another S-2043 cask railcar program. To meet AAR S-2043 requirements for welding, and to ensure fabrication consistency, similar work instructions and procedures are to be developed and used on the buffer railcar's NDE examination and testing activities. Examples of the work instructions and procedures from Kasgro's 12-axle to be developed for the buffer railcar are included in Appendix H-2.3.

Enclosed in Appendix H-2.4 are the following:

- Appendix H-2.3.1 is TUV Rheinland's Non-Destructive Testing Group's work instruction on ultrasonic testing to AWS standard D15.1 (TUV Rheinland Industrial Solutions, Non-Destructive Testing Group Work Instruction No. PA-WI-08-005, Rev No. 1, Ultrasonic Testing to AWS D15.1 Railroad Welding Specification) which details the performance of ultrasonic testing and provides forms for recording of the test results.
- Appendix H-2.3.2 is TUV Rheinland's Industrial Solutions procedure and data recording forms for performing visual inspection of welds specifically for Kasgro's production of 12-axle railcars under S-2043 requirements (TUV Rheinland Industrial Solutions Procedure TRIS NDE-VT-4, Rev No. 0, Visual Inspection NAVSEA Technical Publications T9074-AS-GIB 010/271).
- Appendix H-2.3.3 is TUV Rheinland's Non-Destructive Testing Group's work instruction for performing liquid penetrant examination to weld specifically for S-2043 requirements (TUV Rheinland Industrial Solutions, Non-Destructive Testing Group Work Instruction No. WI-08-001, Rev No. 1, Liquid Penetrant Examination).
- Appendix H-2.3.4 is TUV Rheinland's Non-Destructive Testing Group's work instruction for performing magnetic particle examinations of ferromagnetic materials and is specific to Kasgro Railcars fabricated to AAR S-2043 requirements (TUV Rheinland Industrial Solutions, Non-Destructive Testing Group Work Instruction No. WI-08-002, Rev No. 1, Magnetic Particle Examination of Ferromagnetic Materials).

5.2.3.5 Buffer Railcar Safety Monitoring System

The railcar monitoring system used for the buffer railcar needs to interface with the planned escort railcar utilized by the DOE, which is the same REV developed for the U.S. Navy's HLRM program. Currently the utilized monitoring is manufactured by Lat-Lon, LLC of Denver, CO [37] and is simply designated as the "AAR Approved S-2043 System". Kasgro has developed a purchasing specification for the procurement of this unique monitoring and tracking system to ensure that applicable system codes and standards are provided. This specification is enclosed as Appendix H.2.3.1 (System Safety Monitoring Procurement Specifications for use with AAR Standard S-2043 HLRW Railcars, Procurement Specification SSM Procurement Spec RF). Also, a Lat-Lon system description is enclosed as Appendix H-2.3.2 (Lat-Lon AAR Approved S-2043 System, Procurement Specification SSM Procurement Spec RF).

5.2.4 Bill of Material

The bill of material for the buffer railcar is included in Appendix H-3. The bill of material contains all materials and parts used in the fabrication of the buffer railcar. Purchased materials and parts are listed by the specific material number or part number listed on the buffer railcar drawings. A description of each part number is provided and the quantity purchased and utilized in the railcar's fabrication, not including any scrap allowances. AAR approved vendors qualified by specific material or part number and utilized by Kasgro are listed by specific material or part number with the approved vendor listed in the far right column. Items that list as the vendor "AAR Vendor List" are generic items where the supplier is AAR approved, but specific materials or part numbers are not under an approval program; these items are typically common commodities such as nuts, bolts, washers, etc. and available from multiple suppliers. AAR approved suppliers are controlled under the AAR's M-1003 quality assurance program [18]. Fabrication consumables such as weld wire are not listed on the bill of materials as Kasgro maintains a usable inventory of these items at all times and they are specific to the equipment or fabrication process used by Kasgro Rail; however, these items are still specific to drawing requirements. Finally, as the safety monitoring system is a sole-sourced item, it has no item number and is shown as the last item on the bill of material and listing its specific vendor, Lat-Lon LLC (reference Section 5.2.3.5).

5.2.5 Fabrication Inspection Plan

The buffer railcar inspection plan is governed by the Kasgro QA manual which is supported by other specific inspection requirements which are used to collect inspection data for traceability requirements. The Kasgro QA program containing inspection requirements is common to all railcar fabrication programs and fabricators producing railcars under AAR M-1003 [4]. The only significate difference is in the application of how inspection data is collected and acknowledged as accurate. Specific Kasgro inspection data collection forms are provided Appendix H-4 and described below. A Third-Party Inspection Plan is addressed in subsection 5.2.5.7.

5.2.5.1 Kasgro Rail Receiving Inspection Report

This form is used to record the purchase order, drawing number, part number and other received supplier certificates for only acceptable purchased and received materials. This form is used to record only received purchased items that meet purchase order requirements, which also includes drawing and specification requirements. Non-conforming materials are never accepted and therefore, never recorded on this inspection report and fall within the Kasgro QA manual's non-conforming program. The receiving inspection report also has a table of sampling size listed for reference and a location for an inspector approved to the Kasgro QA requirements under AAR M-1003 to sign the form in acceptance of the listed received materials. The Kasgro receiving inspection report is listed in Appendix H-4.1 (Kasgro Rail Receiving Inspection Report, Form 9Z-1).

5.2.5.2 Railcar Dimensional Inspection and Sampling Plan

Enclosed in Appendix H-4.2 (Railcar Dimensional Inspection and Sampling Plan Forms 9B and 9C) are Kasgro's railcar dimensional inspection and sampling plan utilized for purchased and Kasgro fabricated parts and assemblies. This record is made up of two combined forms – Form 9B and Form 9C. Form 9B provides a record of the purchase order, the applicable drawing number and revision level, the specific dimensions to be inspected, and number of samples to be inspected. A chart of sample sizes is also included for reference. Finally, a location for an inspector approved to the Kasgro QA requirements under AAR M-1003 to sign reflecting acceptance of the listed fabricated items is included.

Kasgro's railcar dimension forms provide in Form 9C a reference of specific railcar dimensions by drawing and item number that is to be inspected, the frequency of the inspection, the method and any special tool used, the name of the inspector and date of the inspection. It also records if the results are acceptable or unsatisfactory by piece number. Multiple Form 9C documents may be attached to a single Form 9B.

Non-conforming parts fall within the Kasgro QA manual's non-conforming program and are not included on Form 9B or Form 9C.

5.2.5.3 Kasgro Rail Burning Table Inspection Report

Enclosed as Appendix H-4.3 (Kasgro Rail Burning Table Inspection Report, Form 9Z-A-1) is a form used to record acceptable parts cut on the Kasgro plasma cutting (burn) table used to cut large-scale steel materials. This form is used to record that cut materials meet drawing requirements (which also include specification requirements). Non-conforming materials are never accepted and therefore, never recorded on this inspection report, and fall within the Kasgro QA manual's non-conforming program. The burning table inspection report also has a table of sampling size listed for reference and a location for an inspector approved to the Kasgro QA requirements under AAR M-1003 to sign for acceptance of the listed plasma-cut items.

5.2.5.4 Car Body – Heat Identification Form

Form 44B is used to record approved parts utilized by each individual railcar. A revised version of this form will be used on the buffer railcar program to provide traceability of individual welded parts by individual railcar. Included as Appendix H-4.4 (Car Body – Heat Identification Form, Form 44B, Rev 3/12/2010) is an example of a welded part listing for an individual S-2043 cask railcar showing part numbers, drawing number, quantity per car, material the part is made from and any special testing required. This form also breaks out the railcar body from the two bolster boxes used in the railcar. Finally, the form has a place for signature by the Kasgro qualified preparer indicating acceptance. Non-conforming parts are not included as they are not accepted into an in-process railcar fabrication and fall within the Kasgro QA manual's non-conforming program.

5.2.5.5 Kasgro Rail New Car Inspection Form

The Kasgro New Car Inspection Form is enclosed as Appendix G-4.6 (*Kasgro Rail New Car Inspection Form*, Form 5-12-B, Rev 2). This form is specifically for a 12-axle railcar; the form will be modified during the start-up Phase 3 of the HLRM railcar project to specifically match the buffer railcar's configuration. This form is driven by AAR's Manual of Standards and Recommended Practices, Section C, Part II, Design, Fabrication and Construction of Freight Cars [2]. The form is completed by qualified Kasgro personnel for each fabricated railcar and is the final Kasgro inspection prior to issuance of a railcar's Certificate of Conformance to the customer. Part numbers are listed and checked to traceability documents for major components. Air brake settings and bearing clearances are measured and recorded for tracking future wear. Overall railcar dimensions are verified and recorded. Results of various functional tests are reviewed and recorded for reference, and final acceptance tests are completed including:

- Single Car Test: review and verification of the railcar's single car air brake test (Appendix H-2.3.2 Kasgro Rail Air Brake Test Form 6-A) as described in Section 5.2.3.3;
- Brake Pipe Restriction Test: a Brake Pipe Restriction Test is performed on the railcar as required in AAR's Manual of Standards and Recommended Practices, Section E, Standard S-471 [38];
- Slack Adjuster Test: specific review and verification of the railcar's slack adjustment test results performed during the single car air brake test (Appendix H-2.3.2 Kasgro Rail Air Brake Test, Form 6-A) as described in Section 5.2.3.3;

- Golden Shoe Test: using a calibrated force measuring brake shoe (Golden Shoe), the railcar's applied brake shoe force is measured to ensure compliance to AAR's Manual of Standards and Recommended Practices, Section E, Standard S-401 [39];
- Truck Curve Test: per the AAR's Manual of Standards and Recommended Practices, a clearance test is performed on the first article railcar only [40]. For every railcar which has a New Car Inspection form completed, verification is made and results are reviewed that the first article railcar traveled a curved section of railroad track having a radius of approximately 150 feet while observers verified there was no interference between the railcar's body, trucks and suspension components, and brake components;
- Load Test: Due to the trucks utilized on the buffer railcar, this test will not be needed on the buffer railcar and the form modified to remove or modify it a simple weighting of the buffer railcar.

The new car inspection process also verifies that operational railcar settings for locknuts on brake slack adjuster triggers are properly set, cross key retainer bolts are properly torqued, safety tabs are bent over tri-span-to-center pin bolts, and center pin travel for trucks and car bodies are measured and recorded for proper range and future wear measurements. Railcar stenciling is checked along with the orientation and presence of truck cover plates and pigtail protective covers.

5.2.5.6 Certificate of Conformance

A Certificate of Conformance is provided for each railcar by Kasgro upon completion of the railcar's fabrication, all in-process inspections, and the completion of the Kasgro Rail New Car Inspection Form (reference Section 5.2.5.5). An example is included as Appendix H-4.6.

5.2.5.7 Third Party Inspection Plan

A third-party inspection plan is assumed for the receiving acceptance of an individual buffer railcar. In the case of the buffer prototype railcar, it is suggested the independent inspection be performed by TTCI under contract to the DOE once the buffer railcar arrives at the Technology Testing Center in Pueblo, CO as it has the necessary equipment, location and qualified personnel to perform such.

It is suggested that the following inspections and document reviews comprise the third-party inspection plan:

- Perform Kasgro Rail New Car Inspection Form (reference section 5.2.5.5) as it validates that special processes and AAR requirements for brakes and AAR S-2043 predicted dynamic modeling performance requirements will be met by the railcar's suspension
- Review that the customer received the fabricator's certificate of conformance

Since every AAR M-1003 qualified fabricator will approach its fabrication and inspection process differently, a third-party inspection will need to be tailored for each individual fabricator. For potential fabricators of the buffer railcar other than Kasgro Rail, the third-party inspection process will need to include the elements of the above bulleted inspection and review processes.

5.2.6 Fabrication Travelers

Kasgro Rail utilizes detailed drawings with specification and fabrication instruction callouts by major railcar assembly operation and/or component. If customer driven inspection and acceptance criteria are to a higher level than AAR standards, these are also references on the drawings. As a result, assembly travelers typically reflect a collection of the applicable drawing(s), part number and material control number lists, and inspection and heat lot records for utilized parts and subassemblies. Therefore, the traveler also serves as a collection of documents for configuration control and as a quality assurance summary document. The traveler also includes a listing of the assembly operators performing the fabrication operations, the operators' supervisor(s) and the applicable inspector(s). The inspector's signature confirms that the fabricated assembly is acceptable to applicable drawing and specification requirements before it is released to the next stage of railcar assembly. This traveler process is acceptable under AAR' quality assurance standard M-1003 [4] which Kasgro Rail maintains certification to, and is indeed the process that Kasgro Rail utilizes.

Kasgro Rail utilizes a simple traveler process in its flatcar railcar assembly. Enclosed as Appendix H-5 (Kasgro Specialty Railcar Solutions, Form 84, Flat Car Assembly Form, Rev April 11, 2017) is Kasgro's flat car assembly traveler for 12-axle railcar assembly; a very similar form exists for a 4-axle flatcar which will be modified during the startup of Phase 3 for the buffer railcar. The buffer railcar traveler will follow the same format as the example 12-axle railcar travel in that it will also consists of four pages with each page applicable to a major railcar assembly process: body bolster assembly (page 1), railcar body component fit (page 2), railcar bottom cover plate and side sill gussets assembly (page 3), and railcar airbrake piping assembly (page 4). As a 4-axle railcar does not have a span bolster, Kasgro's Form 85, Span Bolster Assembly, will not be used in the fabrication of the buffer railcar.

5.2.7 Operation and Maintenance Information

Basic railcar maintenance requirements are included in the AAR's Office and Field Manuals of the AAR Interchange Rules. These maintenance activities are completed annually, periodically based on the mileage the railcar has travelled, or before the next routine operation of the Atlas railcar of during routine service. Specific periodic buffer railcar inspections, maintenance requirements and procedures are included in the Buffer Railcar Supplemental Maintenance Manual enclosed as Appendix H-6 (Buffer Railcar Supplemental Maintenance Manual, Rev 0).

Specific areas of differences in operational and maintenance requirements for the buffer railcar covered by the supplemental maintenance manual include:

- Pre-use inspections and annual inspections which are supported by detailed checklists included in this manual
- Brake shoe replacement requirement also detailed by specific instructions in the manual
- Buffer railcar long-term storage to prevent axle roller bearing seizure
- Ellcon National truck mounted brake installation and field maintenance instruction
- New York Air Brake DB-60 Brake System operations, maintenance and repair instruction manuals, and
- Maintenance requirements, assembly procedures and instructional documents for MeridianRail AMTRACK Swing Motion Trucks.

5.2.8 AAR EEC Submission and Notice to Proceed

This section provides information regarding the results of the Atlas railcar's dynamic modeling.

5.2.8.1 S-2043 Performance Analysis Summary

Introduction: The purpose of AAR Standard S-2043 is to establish performance guidelines so trains carrying HLRM, while using the best available technology to minimize the potential for derailments, may enter general commerce with others trains in a standard railroad operating environment. This standard sets performance guidelines, which are to be evaluated by the following means:

- A railcar is preliminary designed and its track performance is predictively analyzed by simulation;
- Prototype railcars are built and tested for extreme and real-world conditions, and;
- Production railcars are real-time monitored and reported against performance guidelines during actual use.

As a result of the first requirement above, analysis must be performed using dynamic simulations of the standard's performance guidelines for both real and extreme test track conditions. The results of the predictive dynamic modeling are not to be interpreted simply as a pass/fail criterion, but as information supporting the utilization of the industry's best available technology in the railcar's design to meet the standard's performance guidelines. Analysis of the dynamic modeling results are to show the simulation conditions in which the railcar does not meet performance guidelines, does not allow for post-test smoothing of individual or combines test results, and must report peak values which occur during dynamic modeling simulations. The dynamic modeling predictions provide insight into the prototype railcar's overall predictive performance as a single railcar and in a consist with other railcars. The results also support the development of specific requirements for the prototype railcar's future single-car and multi-car testing. Dynamic modeling simulation results are reviewed by the AAR's EEC for determination of whether a prototype railcar can be fabricated for future testing.

The performance guidelines set forth in S-2043 are goals representing the highest current and future technology to be used to optimize railcar performance. The AAR EEC's interpretation of the guidelines may reflect trade-offs between various operating regime guidelines in order to achieve optimum overall railcar performance, or reflect limitations of available technologies used to achieve optimum railcar performance.

Dynamic Modeling Results: Results of each simulation regime follow in Table 5-2 and available in Appendix H-7. No similar buffer car has been submitted for evaluation to S-2043 performance guidelines; therefore, no comparison data for such railcars exists. The buffer railcar's empty weight and load limit are the same due to built-in ballast weight needed to meet S-2043 performance guidelines; therefore, dynamic modeling of an empty and loaded buffer railcar is the same. Cases to be tested during single car tests are noted with SC and cases to be testing during multiple car tests are noted with MC.

Conclusion and S-2043 Performance Analysis Actions: Although the buffer railcar did not meet all performance guidelines of S-2043, its performance is extremely close to the guidelines and as close as achievable. As a result, the dynamic modeling simulation regimes are considered complete and are submitted to the AAR EEC for review and application for a notice to proceed with the test phase allowing fabrication of the prototype buffer railcars.

TABLE 5-2: BUFFER RAILCAR PERFORMANCE ANALYSIS RESULTS

Description	S-2043 Paragraph	Subsection	Meets	Does Not Meet	Worst Example That Does Not Meet Performance Specification Goal	To Be Future Tested
Truck Twist Equalization	4.2.1		X			SC
Carbody Twist Equalization	4.2.2		X			SC
Static Curve Stability	4.2.3	Base Car	X			
		Like Car	X			
		Long Car	X			
		Cask Car	X			
		Long-Short Car Combination	X			SC
Curve Negotiation	4.2.4	Uncoupled 150-ft Radius Curve	X			
		Coupled 250-ft Radius Curve	X			SC
		No. 7 Crossover	X			
Twist and Roll	4.3.9.6	39-ft Inputs	X			SC
		44-ft 6-inch Inputs	X			
Pitch and Bounce	4.3.9.7	39-ft Inputs	X			SC
		44-ft 6-inch Inputs	X			SC
Yaw & Sway	4.3.9.8	39-ft Inputs	X			SC
		44-ft 6-inch Inputs	X			
Dynamic Curving	4.3.9.9	39-foot inputs	X			SC

Description	S-2043 Paragraph	Subsection	Meets	Does Not Meet	Worst Example That Does Not Meet Performance Specification Goal	To Be Future Tested
		44-ft 6-inch Inputs	X			
Single Bump	4.3.10.1		X			
Curving with Single Rail Perturbation	4.3.10.2	1-inch Bump	X			
		2-inch Bump	X			SC
		3-inch Bump	X			
		1-inch Dip	X			
		2-inch Dip	X			SC
		3-inch Dip	X			
Hunting	4.3.11.3		X			SC
Constant Curving	4.3.11.4		X			SC
Curving with Various Lubrication Conditions	4.3.11.5	Case 1 New	X			
		Case 2 New	X			
		Case 3 New	X			
		Case 4 New	X			
		Case 1 Worn	X			
		Case 2 Worn	X			
		Case 3 Worn	X			
		Case 4 Worn	X			
Limiting Spiral Negotiation	4.3.11.6	Entry A-end	X			SC
		Exit A-end	X			SC
		Entry B-end	X			SC

Description	S-2043 Paragraph	Subsection	Meets	Does Not Meet	Worst Example That Does Not Meet Performance Specification Goal	To Be Future Tested
		Exit B-end	X			SC
Turnouts and Crossovers	4.3.11.7	RH Turnout	X			MC
		LH Turnout	X			MC
		Crossover	X			MC
Ride Quality	4.3.12	Class 2	X			MC
		Class 3	X			
		Class 4	X			
		Class 5	X			
		Class 6	X			
Buff and Draft Curving	4.3.13	Base Buff	X			
		Long Buff	X			
		Like Buff	X			
		Cask Car Buff	X			
		Cask Car-Escort Car Buff	X			MC
		4-Axle Locomotive-Cask Car Buff	X			
		6-Axle Locomotive-Cask Car Buff	X			MC
		Base Draft		X	Truck-side L/V = 0.51, Limit = 0.50	
		Long Draft	X			
		Like Draft	X			
		Cask Car Draft	X			

Description	S-2043 Paragraph	Subsection	Meets	Does Not Meet	Worst Example That Does Not Meet Performance Specification Goal	To Be Future Tested
		Cask Car-Escort Car Draft		X	Truck-side L/V = 0.51, Limit = 0.50	MC
		4-Axle Locomotive-Cask Car Draft	X			
		6-Axle Locomotive-Cask Car Draft	X			MC
Braking Effects on Steering	4.3.14		X			MC

5.2.8.2 Worn Component Simulation Summary

Introduction: The purpose of performing worn component simulations under AAR Standard S-2043 is to allow the railcar designer to identify wear limits for railcar truck components. The simulations are based on component performance at the end of its service life with additional simulations to be performed with components beyond their wear limits, broken and missing. In turn, this allows the railcar designer, fabricator and/or user to establish a performance envelope for the truck components and set maintenance requirements for the railcar's truck components to prevent the truck components' performance from exceeding any criterion in S-2043 Table 4.1 by 10%. As the results of the worn component simulations are to establish failure points, there is no pass/fail criteria applied to these simulations.

Worn Component Simulation Results: Results of each simulation regime follow in Table 5-3.

Conclusions and Worn Component Simulation Actions: Preliminary preventative maintenance inspections and component replacement requirements for the buffer railcar have been established and included in the Phase 2 report in Appendix H-6. The timing and/or frequency of these requirements will be finalized during Phase 3 of the project, and if necessary, after single-car and multi-car testing is completed.

TABLE 5-3: WORN COMPONENT SIMULATION RESULTS

Description	S-2043 Paragraph	Subsection	Meets	Does Not Meet	Worst Example That Does Not Meet Performance Specification Goal
Constant Contact Side Bearing	4.3.15	Constant Curving	X		
		Dynamic Curving	X		
		Hunting	X		
		Twist and Roll	X		
Center Plates	4.3.15	Constant Curving	X		
		Dynamic Curving	X		
		Hunting	X		
Primary Pad	4.3.15	Constant Curving – Soft	X		
		Dynamic Curving – Soft	X		
		Hunting – Soft	X		
		Constant Curving – Stiff	X		
		Dynamic Curving – Stiff	X		
		Hunting – Stiff	X		
	4.3.15	Dynamic Curving	X		

Description	S-2043 Paragraph	Subsection	Meets	Does Not Meet	Worst Example That Does Not Meet Performance Specification Goal
Friction Wedges		Pitch and Bounce	X		
		Twist and Roll	X		
Broken Springs	4.3.15	Dynamic Curving	X		
		Pitch and Bounce	X		
		Twist and Roll	X		
Vertical Damper	4.3.15	Dynamic Curving	X		
		Pitch and Bounce	X		
		Twist and Roll	X		

5.2.8.3 Notice to Proceed with the Test Phase for Buffer Railcar

The Team received a letter from the AAR EEC on February 2, 2018 providing approval of the buffer railcar's design and dynamic modeling results, and providing a notice to proceed with the test phase of the buffer railcar design allowing fabrication of the prototype railcar for future single and multi-car testing. A copy of the letter appears in Figure 5-2. The approval to proceed with the test phase for the buffer railcar is based on the completed S-2043 requirements for structural analysis, nonstructural static analysis, dynamic analysis, brake system design, and railcar clearance and weight review. The buffer railcar is not yet approved for the system safety monitoring requirement of S-2043. This is due to: a) there not being AAR approved system safety monitoring equipment or a vendor; b) the technology of the currently conditionally approved S-2043 safety monitoring system is becoming outdated in 2018 and a replacement system is starting development, and; c) the presence of the safety monitoring system on the railcar is not needed until multi-car testing occurs. As a result, the AAR EEC has postponed review and approval of the safety monitoring system until the multi-car testing is underway.

FIGURE 5-2: NOTICE TO PROCEED WITH THE TEST PHASE

Ron Hynes
Assistant Vice President
Technical Services

Nichole Fimple
Executive Director
Rules and Standards

ASSOCIATION OF AMERICAN RAILROADS
Transmitted via email

February 2, 2018
File 209.240

Subject: AAR Standard S-2043 Initial Design Approval of the Kasgro/AREVA Department of Energy (DOE) High Level Radioactive Material (HLRM) Buffer Car

Mr. Rick Ford
AVP Mechanical & Utilization
Kasgro Rail Corporation
121 Rundle Road
New Castle, PA 16102

Dear Mr. Ford:

The AAR Equipment Engineering Committee (EEC) has completed the S-2043 Initial Review of the DOE HLRM Buffer Car. The initial design is hereby approved, and all parties involved are notified to proceed with the test requirements of S-2043. Approval was based on completion of the following requirements:

Structural Analysis
Nonstructural Static Analysis
Dynamic Analysis
Brake System Design
Railcar Clearance and Weight

There was no mention of System Safety Monitoring in the submission, but EEC understands that this item will be addressed as the Multiple Car Test phase approaches.

If you have any questions or need additional information, please contact Mr. Jon Hannafious of our Transportation Technology Center, Inc., subsidiary at jon_hannafious@aar.com or (719) 584-0682.

Sincerely,

Nichole Fimple

NF/jsh
cc: David Cackovic
Mark Denton, AREVA
Equipment Engineering Committee

Association of American Railroads
425 Third Street, SW, Suite 1000, Washington D. C. 20024, (202) 639-2139 FAX No. (202) 639-2179

6.0 OTHER DELIVERABLES

The section provides information regarding other deliverables; specifically, a test load to simulate loaded cask and cradles placed on the Atlas railcar during single and multi-car testing, a ballast load necessary to maintain S-2043 requirements on an empty Atlas railcar, and the report on cost and schedule estimates for the S-2043 required single-car testing, the S-2043 required multi-car testing and the production phase of 120 Atlas and 60 buffer railcars.

6.1 Test Load Conceptual Designs

A test load to simulate cask/cradle payloads will be required for single-car and multi-car testing of the Atlas cask railcar. Currently, test load configurations are adopted to simulate bounding condition loads, including the HI-STAR 190 XL cask. Test loads were selected based on the guidance of the dynamic modeling plan as described in Section 3.3.5. Basic information concerning the selected test loads, test load configurations and conceptual designs of the test loads, cradles and end stops was developed and a description is included in Appendix I.

To align with the dynamic modeling plan (Section 3.3.5) and based on preliminary dynamic modeling results and previous experience with another S-2043 cask railcar, three test load configurations may be required. These conditions are adopted to simulate the two minimum load conditions, the maximum load condition and the highest cg condition. By coincidence, the maximum load and highest cg condition represent the same load case, which is the loaded HI-STAR 190 XL cask (See Table 5-2 and Table 5-5 of Appendix B.2). The final required test loads and conditions will not be fully defined until the Atlas Railcar S-2043 Phase 4 Single-Car Testing's actual test plan is developed by TTCI. As discussed in Section 3.3.5, final dynamic modeling showed that an additional minimum load case, as proposed in the dynamic modeling plan, was not required to bound the car dynamic modeling response. However, all three load cases were still considered for the test loads to bound future, currently undefined, testing requirements. The test load conditions are shown in Table 6-1 below and discussed in the following sections.

TABLE 6-1: TEST LOAD CONDITIONS

Minimum Condition 1	Minimum Condition 2	Maximum Condition
Atlas Railcar + Ballast Load	Atlas Railcar + Lightest Cask Weight / Conceptual Cradle	Atlas Railcar + Maximum Cask Weight / Conceptual Cradle (Also Maximum cg case)

6.1.1 Minimum Conditions 1 & 2 Test Load

The minimum condition 1 test load condition is the "empty condition" defined here as the Atlas railcar loaded with the required ballast weight. See Section 6.2 for a description of the ballast load.

Based on the Atlas Railcar S-2043 Phase 4 Single-Car Testing's actual test plan, a second minimum load case may be required. The lightest cask and conceptual cradle load may need to be tested separately from the "empty condition" The empty MP197 cask and conceptual cradle is the lightest combined load and was used as a basis for the minimum condition test load (see Table 4-3 and Table 4-4 of Appendix B.2). The minimum condition test load conceptual design is described in Section 2.2 of Appendix I.

6.1.2 Maximum Condition Test Load

The maximum condition test load was designed to match the weight of the heaviest cask payload and the maximum combined center of gravity height. The loaded HI-STAR 190 XL cask and conceptual cradle and end stop design was used as a basis for the maximum condition test load. The HI-STAR 190 XL cask and conceptual cradle payload is both the heaviest cask and also has the highest combined payload center of gravity (Appendix B.2). The maximum condition test load conceptual design is described in Section 2.2 of Appendix I.

6.2 Atlas Ballast Load Conceptual Design

During the development of the preliminary design of the Atlas railcar, it has been determined that a ballast load of approximately 200,000 pounds is required in order for the railcar to meet AAR S-2043 guidelines when in an empty condition. The ballast load is conceptual in design and consists of four modular weights of approximately 40,000 pounds each and two modular weights of approximately 20,000 pounds each; this is so the ballast weights can individually be transported to a location where needed. Based on the results of the dynamic modeling the ballast load may be used as a test load in the minimum condition 1 (see Section 6.1). Supporting documents generated for the ballast load conceptual design are listed below and enclosed in Appendix J:

- DWG-3018955, Atlas Railcar Ballast Load Conceptual Drawing
- CALC-3018954, Atlas Railcar Conceptual Ballast Load Structural Calculation

6.3 Phase 4, Phase 5, and Production ROM Estimated Cost and Schedule (EIR-3018318)

EIR-3018318 in Appendix K provides Rough Order of Magnitude (ROM) cost and schedule estimates for the:

- Single-car testing to AAR Standard S-2043 [3] (Phase 4 of the project)
- Multi-car testing to AAR Standard S-2043 [3] (Phase 5 of the project)
- The railcar production phase of 120 Atlas cask railcars and 60 buffer railcars

These estimates are a requirement of DOE contract DE-NE0008390, Design and Prototype Fabrication of Railcars for Transport of High-Level Radioactive Material (HLRM) project [42] and are to be used for future DOE planning and budgeting purposes.

7.0 REFERENCES

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