Update on Development of a U.S. Rail Transport Capability for Spent Nuclear Fuel and High-Level Waste – 21353

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ABSTRACT

This paper[a] provides an overview of the progress to date, and discussion of the path forward, related to designing, fabricating and testing prototype railcars that will comply with the standard developed by the Association of American Railroads (AAR) specifically for railcars used to transport High-Level Radioactive Material (HLRM): *Performance Specification for Trains Used to Carry High-Level Radioactive Material, Standard S-2043*. AAR defines the term HLRM to include both spent nuclear fuel (SNF) and high-level radioactive waste (HLW). DOE is in the process of developing and testing prototype railcars that will satisfy Standard S-2043.

The Atlas Railcar Project continues to make steady progress. One Atlas and two buffer prototype railcars are now being tested at the Transportation Technology Center (TTC) near Pueblo, CO. The required testing for the railcars includes extensive full-scale testing of the individual railcars and of the complete rail consist. This testing is required to obtain AAR conditional approval of the railcar designs. A rail consist for a train carrying HLRM in accordance with S-2043 would include two locomotives, followed by one buffer railcar, followed by one or more Atlas railcars carrying one cask each, followed by another buffer railcar, and finally one Rail Escort Vehicle (REV). The REV is scheduled for delivery to the TTC in March 2021, just before the start of multiple-car testing.

There were some engineering challenges revealed during single-car testing this year, which is not unexpected for a new railcar design. For example, a dynamic instability in which the railcar's wheels oscillate between left and right was observed during higher speed runs on tangent track with minimum test loads. The engineering team researched the causes of this dynamic instability and was able to implement design changes to resolve the issue. Other engineering challenges revealed during testing are discussed in

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[a] This technical paper does not take into account contractual limitations or obligations under the Standard Contract for Disposal of Spent Nuclear Fuel and/or High-Level Radioactive Waste (Standard Contract) (10 CFR Part 961). For example, under the provisions of the Standard Contract, spent nuclear fuel in multi-assembly canisters is not an acceptable waste form, absent a mutually-agreed-to contract amendment.

To the extent discussions or recommendations in this paper conflict with the provisions of the Standard Contract, the Standard Contract governs the obligations of the parties, and this paper in no manner supersedes, overrides, or amends the Standard Contract.

This paper reflects technical work which could support future decision-making by the U.S. Department of Energy (DOE or Department). No inferences should be drawn from this paper regarding future actions by DOE, which are limited both by the terms of the Standard Contract and Congressional appropriations for the Department to fulfill its obligations under the Nuclear Waste Policy Act including licensing and construction of a spent nuclear fuel repository.

The total project to design and develop railcar prototypes, conduct the necessary testing, and secure AAR approval of S-2043–compliant railcars is scheduled to be finished in early 2023.

INTRODUCTION

The Association of American Railroads (AAR) has published a technical standard developed specifically for railcars used to transport High-Level Radioactive Material (HLRM): *Performance Specification for Trains Used to Carry High-Level Radioactive Material, Standard S-2043*. [1] AAR defines the term HLRM to include spent nuclear fuel (SNF) and high-level waste (HLW). DOE is in the process of developing prototype railcars that will be compliant with S-2043.

Moving HLRM from its current locations will require both a receiving site or multiple sites and a transportation capability. The U.S. currently has the capability to move large casks of HLRM; however, improved railcars will be needed to move the HLRM in compliance with S-2043.

The total project to design and develop railcar prototypes, conduct the necessary testing, and secure approval of S-2043–compliant railcars is scheduled to be finished in early 2023. Approval by the AAR will require extensive full-scale testing of the individual railcars and the complete rail consist.

HLRM will need to be shipped in transport casks certified in accordance with 10 CFR Part 71 by the Nuclear Regulatory Commission (NRC). The NRC has certified numerous rail transport cask designs supplied by various manufacturers. These rail transportation casks will weigh between approximately 82 and 210 tons when loaded; additionally, each cask, if transported by rail, would need to be attached to the railcar by a cradle (often called a “skid”) that is expected to weigh between 10 and 20 tons. No existing railcars have been approved as AAR S-2043 compliant for shipping these NRC-certified casks. Therefore, transport of HLRM over the railroad infrastructure in the U.S. in railcars that meet S-2043 will require new railcars to be designed, tested, and approved by the AAR for use.

DOE’s Office of Nuclear Energy (DOE-NE) has funded efforts to have industry design, develop, fabricate, and test S-2043 compliant cask, buffer, and escort railcars. The results of this effort are fabricated prototype railcars that are being tested to obtain approval from the AAR for transport of HLRM.

DOE is pursuing the design and development of S-2043 compliant railcars to help ensure that a capable transportation system will be available for the safe, secure, and efficient movement of HLRM from commercial nuclear power reactor sites and/or DOE sites in a timely manner when a receiving site becomes operational.

ATLAS RAILCAR DESIGN PROJECT OVERVIEW

The DOE awarded a contract on August 21, 2015, for the design, associated analysis, and prototype fabrication of cask and buffer railcars to transport HLRM. This contract was awarded to Orano Federal Services (OFS), with primary subcontractors Kasgro Rail and the Transportation Technology Center, Inc. (TTCI).

DOE awarded a second contract on June 27, 2018, for the single-car and multiple-car testing of the Atlas and buffer railcars. The railcar testing contract was awarded to the TTCI, with primary subcontractors Kasgro Rail and OFS. So, the primary membership of the contractor team is unchanged from the first contract to the second one.

The new cask railcar design is named *Atlas*. The project's five phases are being implemented via two multi-year contracts. The Orano contract was for Phase 1—Mobilization and Conceptual Design, Phase 2—Preliminary Design, and Phase 3—Prototype Fabrication and Delivery. The TTCI contract is for Phase 4—Single-Car Testing and Phase 5—Multiple-Car Testing. A description of the major activities in each of the five project phases is provided in this paper. The summary-level project schedule is shown in Fig. 1.

Phases 1 through 3 of the Atlas Railcar Project are now complete. One Atlas and two buffer prototype railcars were delivered in the spring of 2019 to the TTCI near Pueblo, CO, for testing. TTCI is a transportation research and testing organization that tests locomotives, freight and passenger rolling stock, vehicle and track components, and safety devices for the railway industry.

Phase 4 activities started in June 2018 and include the acquisition of test loads; fabrication of instrumented wheel sets (IWSs) to support railcar dynamic testing; and various static, structural, and dynamic tests of the individual railcars. Completion of the testing and receipt of AAR approval to proceed with multiple-car testing is expected in March 2021.

Phase 5 began in April 2020, to include testing of the complete rail consist, testing of the safety monitoring system, and a demonstration run. The full consist will include a cask railcar, two buffer railcars, and a rail escort vehicle (REV). The REV is where the armed security personnel will ride and watch over the whole train.

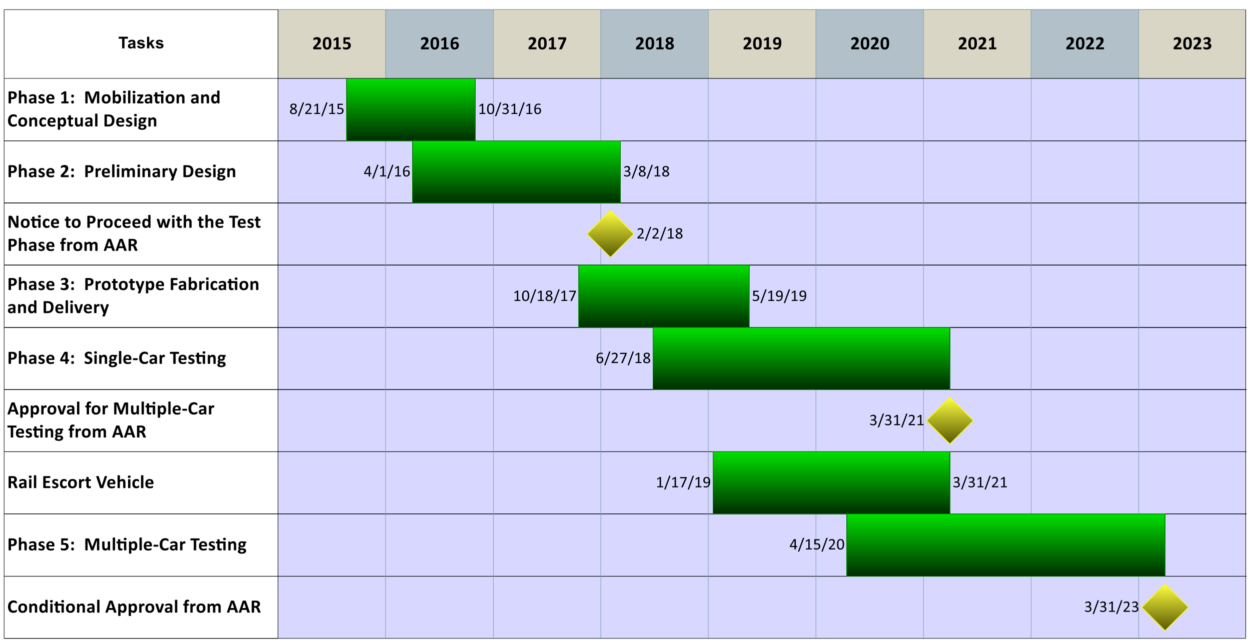


Fig. 1. Schedule for Atlas Railcar Design Project

Fortunately, the U.S. Naval Nuclear Propulsion Program (NNPP) began designing a new REV in 2015, and the two federal agencies have now agreed to use the same REV design. This agreement was formalized in a Memorandum of Understanding [2] in May 2017, and the NNPP is responsible for single-car testing of this REV design. DOE is fabricating one REV unit for the purpose of testing the full consist during Phase 5. Delivery of the DOE REV is expected in March 2021.

PHASE 1: MOBILIZATION AND CONCEPTUAL DESIGN

The Phase 1 conceptual design was completed in October 2016 as reported by OFS in the *Atlas Railcar Phase 1 Final Report* [3], which has been posted by DOE on the www.energy.gov website. The mobilization part of Phase 1 included typical project management planning activities such as development of a project management plan and other associated plans. Conceptual designs were developed for the cask cradles, cask railcars, and buffer railcars. General loading procedures were developed for each cask and cradle combination.

The Atlas railcar was designed to carry 17 different HLRM cask types. During transport, a transportation cask must rest on a cradle, often called a skid, on top of the cask railcar deck. The cask railcar was designed to transport one cask at a time along with one cradle. The cask railcar design includes all needed attachment points and the methods to attach each of the cradles to the deck.

OFS was responsible for interfacing with all the transportation cask vendors to obtain the transportation cask information necessary to design the cask railcar. One result of this collaboration has been the development of conceptual designs for cradles that accommodate each of the 17 cask types. These conceptual cradle designs were used to determine the height of the cask's center of gravity above the railcar deck, the weight on each axle, etc., as necessary to perform the analysis and provide simulated cradle test weights and supporting information needed for testing of the railcar. These conceptual cradle designs, however, were not carried through to preliminary designs or final designs. DOE is using simulated casks and cradles during the testing phases of this project.

Cask Railcar Conceptual Design

The Atlas Railcar design shown in Fig. 2 is similar to the Navy's M-290 cask railcar design, the only other railcar to have achieved approval from the AAR to transport HLRM in compliance with S-2043. Both of these railcars have twelve axles. The major components under the railcars' decks, including the trucks and tri-span bolsters, are virtually identical. The decision to use the design experience from the Navy's program greatly increases the probability of success in the Atlas Railcar Design Project.

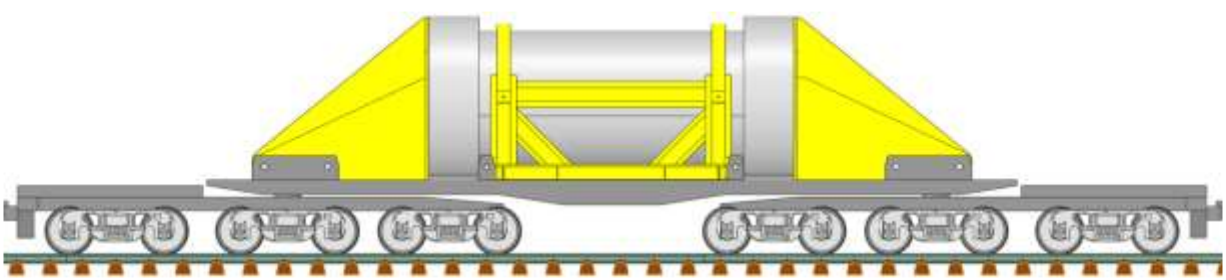


Fig. 2. Atlas Railcar Conceptual Design

Buffer Railcar Conceptual Design

Buffer railcars are flatbed cars that are required to separate HLRM cask cars from the cars carrying people (locomotives and REVs). The buffer railcar conceptual design is a four-axle freight railcar as shown in Fig. 3. The process of developing a conceptual design called for generating basic design information such as dimensions, deck layout, and number and type of trucks and then providing that information to the simulation team for the initial design analysis and modeling that occurred in Phase 2.

Fig. 3. Buffer Railcar Conceptual Design

This buffer railcar design uses the same trucks as the REV, which was also designed to satisfy AAR Standard S-2043. This reduced the number of issues that could have occurred during the design analysis and preliminary design development.

Atlas Railcar Heaviest Load

The Atlas railcar carrying the Holtec HI-STAR 190XL cask is shown in Fig. 4. This is the largest cask payload that the Atlas railcar is designed to carry.

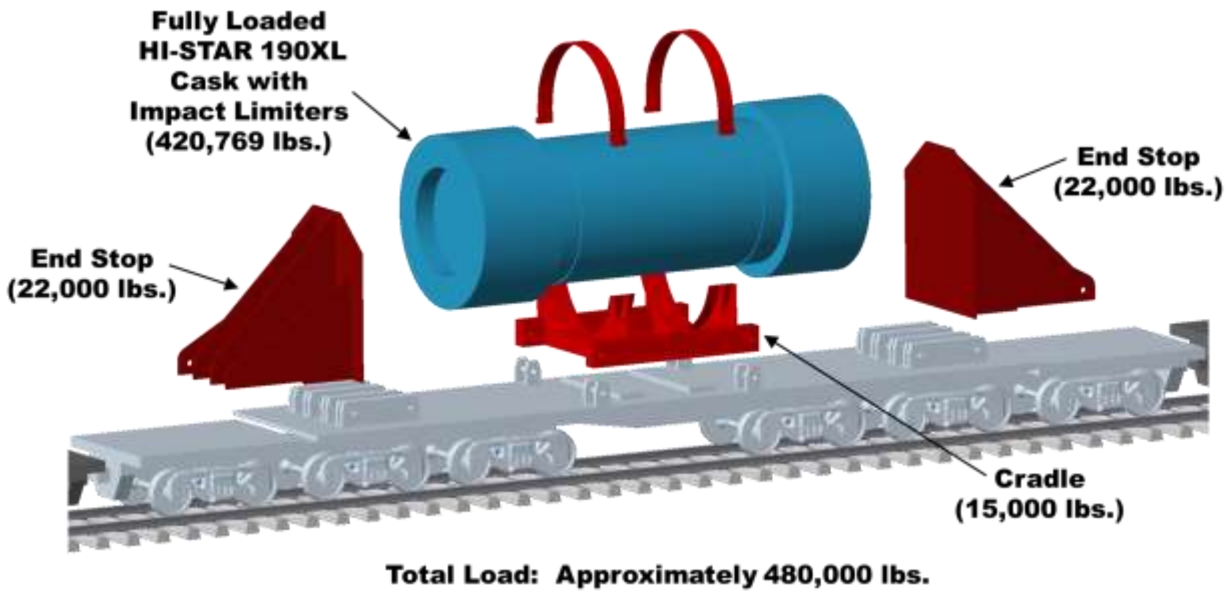


Fig. 4. Atlas Railcar with HI-STAR 190XL cask

PHASE 2: PRELIMINARY DESIGN

The Phase 2 preliminary design has been completed as reported by OFS in the *Atlas Railcar Phase 2 Final Report* [4] that has been posted by DOE on the www.energy.gov website. This included performing the required design analysis, modeling and simulation of the railcar designs, preparing preliminary designs of the Atlas and buffer railcars, and submitting a preliminary S-2043 design package to the AAR for review and approval.

The conceptual designs from Phase 1 were developed further in Phase 2 to include detailed technical descriptions of the railcars, general design drawings, parts lists, and detailed documentation of the design analysis, modeling, and simulation. Phase 2 resulted in a detailed preliminary design package with sufficient information to support fabrication of prototype Atlas and buffer railcars in Phase 3.

Design Development, Analysis, Modeling, and Simulation

The railcars were designed to meet AAR Standard S-2043 design requirements which covers six areas: (1) structural analysis, (2) nonstructural static analysis, (3) dynamic analysis, (4) brake system design, (5) system safety monitoring, and (6) railcar clearance and weight.

Structural analysis of the railcar designs was performed using commercial finite-element analysis (FEA) software that considers a number of load and force combinations, including dead load, live load, coupler load, compressive end load, and impact load as specified in S-2043. The analysis included an assessment of whether the cask cradles and securement points could withstand specific static, cyclic, and dynamic loads. There were also crashworthiness requirements to ensure that railcar coupling systems, trucks, and wheel sets would not separate from one another in the event of a derailment.

Nonstructural static analysis included an assessment of truck twist equalization to ensure adequate truck load distribution under statically applied track twist conditions, car body twist equalization to document the amount of wheel unloading during car body twist, like that encountered during negotiation of a spiral, and static curve stability analysis to calculate the amount of wheel unloading in adverse curving scenarios.

Dynamic analysis simulations of the railcars are modeled for 14 areas of track performance. The purpose of the simulations was to provide a realistic basis for evaluation of railcar dynamic performance under less-than-ideal conditions. This demonstrates that the railcar designs provide an adequate margin of safety from structural damage and from any tendency to derail. Each simulation must meet nine performance criteria related to lateral and vertical wheel forces, car body roll angle, and various car body accelerations.

The brake monitoring system transmits vital safety-related information (e.g., brake pressure, roller bearing temperature, vibration level, etc.) to the locomotive, which will allow the train crew to stop the consist in the event of equipment malfunction or failure. The brake design is modeled during the dynamic simulations.

The railcar design includes a reliable and robust safety monitoring system designed to prevent derailments caused by equipment degradation or failure. The system is designed to provide the train crew with real-time monitoring of 10 performance parameters, including railcar location, speed, truck hunting, rocking, wheel flats, bearing condition, ride quality, vertical acceleration, lateral acceleration, and longitudinal acceleration.

The railcar designers provided railcar clearance diagrams for each railcar design and determined bridge loadings for each railcar.

Preliminary S-2043 Design Package Submittal to AAR

The railcar designer submitted a preliminary S-2043 design package to the AAR Equipment Engineering Committee (EEC) in July 2017. The AAR EEC performed an in-depth technical review of the railcar designs which was required prior to Phase 3 prototype fabrication.

DOE received the AAR EEC’s notification to proceed with the railcar test phase on February 2, 2018, which allowed the railcar designer to proceed with the Phase 3 fabrication of the railcar prototypes.

PHASE 3: PROTOTYPE RAILCAR FABRICATION

The Phase 3 prototype fabrication has been completed as reported by OFS in the *Atlas Railcar Phase 3 Final Report* [5] that has been posted by DOE on the www.energy.gov website. Phase 3 included the prototype fabrication of one Atlas railcar and two buffer railcars. These prototype railcars are now being used in the Phases 4 and 5 testing activities.

One of the completed buffer railcars is shown in Fig. 5. The Atlas cask railcar is shown in Figs. 6, 7 and 8.

Fig. 5. Buffer Railcar (February 2019)

Fig. 6. Inspecting Atlas Railcar End Stop Pin Blocks (February 2019)

Fig. 7. Atlas Railcar with Heavy Test Load at TTC (October 2019)

Fig. 8. Atlas Railcar with Minimum Test Load at TTC (October 2019)

One prototype Atlas railcar and two prototype buffer railcars were delivered to TTC near Pueblo, Colorado, in April 2019. TTCI is now nearing completion the single-car testing phase. OFS delivered the as-built Atlas Railcar Design Project documentation package to DOE. This represents the closeout deliverable package for the first contract.

ACQUISITION OF RAIL ESCORT VEHICLE

The REV is a passenger railcar that will provide conveyance for armed escorts as required in 10 CFR 73.37 for rail shipments of irradiated reactor fuel. The REV must be included in the consist during the multiple-car testing to meet all S-2043 requirements. DOE considered the options available to acquire an REV and decided to use the design already being developed for the NNPP. The NNPP REV design will likely meet all AAR and DOE requirements to provide effective physical protection for rail shipments of HLRM.

DOE and the NNPP negotiated and signed a memorandum of understanding (MOU) on May 15, 2017 that describes DOE's intent to adopt the NNPP REV design. DOE and the NNPP signed an Agreement and Project Plan for Rail Escort Vehicle Procurements on June 13, 2018. The NNPP is responsible for single-car testing of the REV design; then DOE will use its REV in the multiple-car testing program. The NNPP plans to use the DOE buffer car design.

The NNPP plans to procure a series of REVs. The NNPP will acquire the first REV manufactured, and DOE will acquire the second REV. The contract to fabricate DOE's REV was signed in January 2019, materials were procured, and the fabrication began in May 2019. The completed DOE REV will be used for the Phase 5 testing at TTC starting in April 2021. The NNPP will then acquire the remainder of the ordered REVs. The DOE REV during fabrication is shown in Fig. 9. The first REV is currently undergoing single car testing at TTC to meet S-2043 requirements.

Fig. 9. Rail Escort Vehicle

PHASE 4: SINGLE-CAR TESTING

AAR Standard S-2043 requires completion of a comprehensive set of single-car tests to confirm the results of the design simulations and to ensure that the railcars meet the stringent safety requirements of the standard. The single-car testing is conducted in five major categories: (1) vehicle characterization, (2) nonstructural static tests, (3) static brake tests, (4) structural tests, and (5) dynamic tests. Phase 4 activities started in June 2018 and included the acquisition of test loads, fabrication of instrumented wheel sets to support railcar dynamic testing, and various static, structural, and dynamic tests of the individual railcars.

Vehicle characterization is performed to verify that the components and vehicle as a whole are built as designed. This involves characterizing properties of the railcar body and its suspension using off-track testing methods. Characterization results will aid the railcar designers in estimating performance under conditions that cannot easily be tested. Tests include system-level and component-level stiffness, damping and resonances, twist and roll, pitch and bounce, yaw and sway, and hunting performance. Other tests in this category include truck rotation stiffness and break-away moment, inter-axle longitudinal stiffness, and axle yaw stiffness.

Nonstructural static tests are performed to demonstrate the ability of the railcar to maintain adequate vertical wheel loads in extreme load conditions and poor track geometry environments. Tests include truck twist equalization, car body twist equalization, static curve stability, and horizontal curve negotiation.

Static brake tests include measurement of braking ratios of the braking systems on the railcar consist. Braking ratio is the braking force of a full brake application of a railcar divided by the total weight of the railcar.

Structural tests are conducted to demonstrate the railcar’s ability to withstand the rigorous railroad load environment and to verify the accuracy of the structural analysis modeling. Tests include compressive end loading, coupler vertical loads, jacking, twisting, and impact tests. A minimum of 50 strain gages on the railcar underframe must be monitored and compared to the Finite Element Analysis (FEA) predictions.

Dynamic tests are conducted and the results compared to the dynamic analysis simulations previously performed. Instrumented wheel sets are required and are used to measure dynamic performance in 14 areas of track performance under less-than-ideal conditions. This demonstrates that the railcar designs provide an adequate margin of safety from structural damage and from any tendency to derail. Instrumented wheel sets are railway wheel sets that have been instrumented and calibrated so that they are capable of accurately measuring the dynamic contact forces between the wheel and rail. In addition, for one dynamic test, high-speed stability (hunting) is also performed with wheel sets having AAR KR wheel profiles on all wheels. These KR wheel sets simulate a 100,000-mile average worn wheel profile.

There were some engineering challenges revealed during single-car testing this year, which is not unexpected for a new railcar design. During the S-2043 dynamic tests, many of which are performed to more difficult standards than required of other freight cars, some tests did not fully meet all S-2043 requirements. For example, a dynamic instability in which the railcar’s wheels oscillate between left and right was observed during higher speed runs on tangent track with minimum test loads. The engineering team researched the causes of this dynamic instability and was able to implement design changes recommended by the truck manufacturer, Amsted Rail. These changes were made to the railcar trucks to allow the testing to be completed satisfactorily to S-2043 standards. As of the drafting of this paper, single-car testing is not yet complete. The testing status will be updated in the presentation.

Design and Fabrication of Modular Test Loads

OFS designed test loads that support the Phase 4 and 5 testing. A modular test load design was developed to allow TTCI to use its existing cranes to lift and place the various test loads on the Atlas railcar for testing. The modular design allows the test loads to simulate the weights of various sizes of SNF casks, various sizes of cask cradles, and cask end stops. The test loads simulate the components' (casks, cradles, and end stops) weight, center of gravity, combined center of gravity, and mass moment of inertia.

Two test load configurations will be used during the railcar testing:

1. **Minimum load configuration:** Atlas railcar + empty small cask + cradle
2. **Maximum load configuration:** Atlas railcar + loaded large cask + cradle + end stops

The minimum test load configuration simulates the Atlas railcar loaded with an empty small cask and cradle, as shown in Fig. 10. This figure depicts what an actual empty small cask would look like loaded on the Atlas railcar (upper left in figure), and it also shows the modular test load that simulates this configuration.

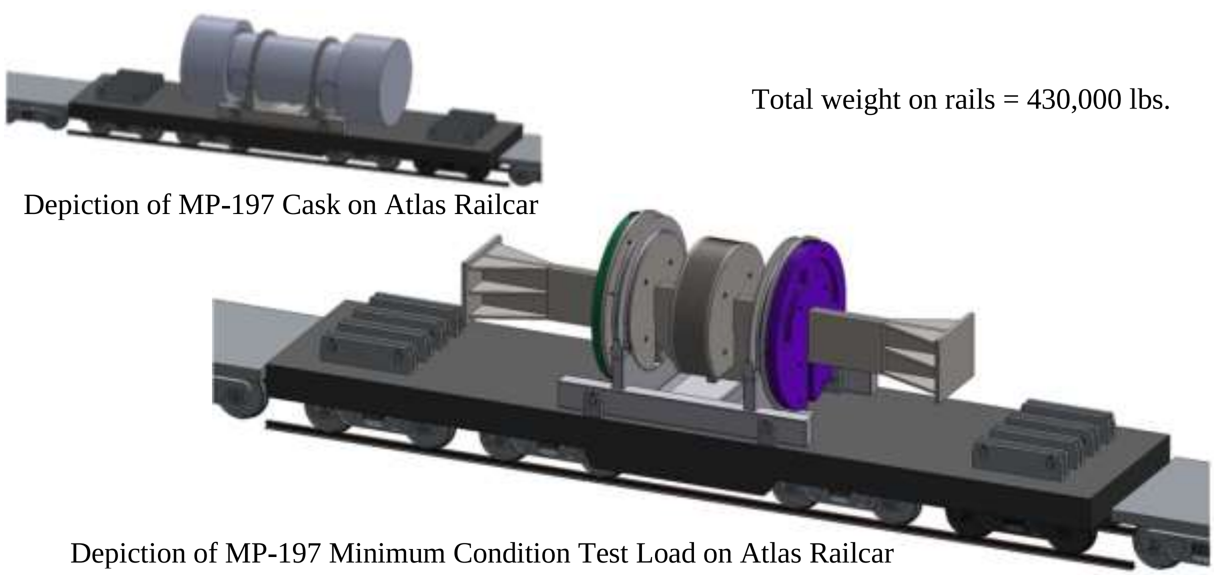
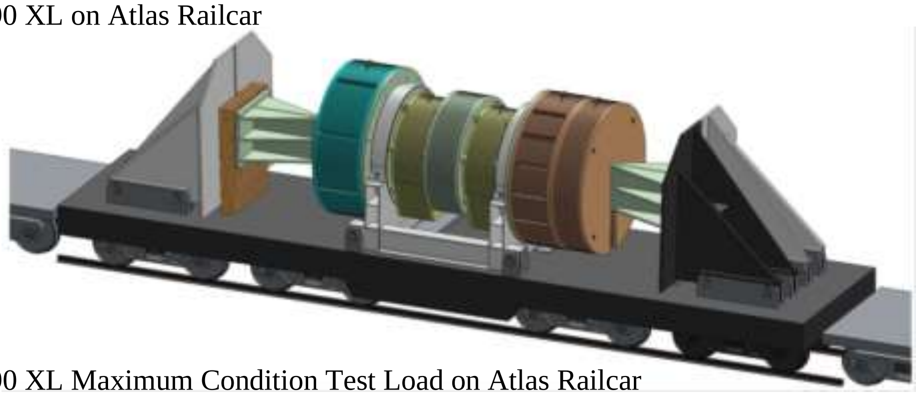


Fig. 10. Minimum Railcar Test Load

The maximum test load configuration simulates the Atlas railcar loaded with a large cask full of HLRM, a cask cradle, and end stops as shown in Fig. 11. The figure depicts what an actual loaded large cask would look like when placed on the Atlas railcar (upper left in figure) and shows the modular test load that simulates this configuration.

Total weight on rails = 703,000 lbs.

Depiction of HI-Star 190 XL on Atlas Railcar



Depiction of HI-Star 190 XL Maximum Condition Test Load on Atlas Railcar

Fig. 11. Maximum Railcar Test Load

PHASE 5: MULTIPLE-CAR TESTING

The Phase 5 detailed preparations for multiple-car track tests began in April 2020 to include testing of the complete rail consist, testing of the safety monitoring system, and a demonstration run. The multiple-car test train consist must match the anticipated DOE HLRM train as closely as possible with a minimum of one of each type of car. It is anticipated that a DOE consist will include two locomotives, followed by one buffer car, then one or more Atlas railcars, another buffer railcar, and finally one REV as shown in Fig. 12.

Fig. 12. Complete HLRM Rail Consist

The multiple-car tests are designed to verify that the individual cars do not adversely affect the performance of adjacent cars. There are three categories of multiple-car tests, including dynamic, system monitoring, and revenue service tests.

Dynamic tests are performed to measure braking stop distance under various loads and rail conditions, braking performance in curves, ability of the hand brakes to hold the train on a grade, and buff and draft loads in curves.

System monitoring tests are conducted on all the train's communications and monitoring systems under normal service conditions and during failure simulations of various components.

Revenue service tests are performed to demonstrate acceptable performance under revenue service conditions such as turnouts, crossovers, and on poorly maintained spur tracks.

The final activity required by S-2043 is a demonstration run, as specified in paragraph 6.3.4 of the standard. The demonstration run must be performed over an actual rail service route. No special instrumentation or measurements are required during the demonstration. An operator's log must be kept throughout the trip to document train operation and any problems that occur. The log, combined with a route map and photo documentation, must be submitted as part of the final testing report described in the following paragraph.

The Atlas railcar final testing report will be completed in Phase 5 of this project and submitted to the AAR EEC for a final review with a successful outcome resulting in approval to operate the railcars. After satisfactory operation of the railcars for approximately 100,000 service miles, the railcar designer will submit a follow-up test report to the AAR EEC for final review. A successful outcome would result in the AAR EEC granting full approval of the Atlas railcar design to DOE.

DOE is also developing an integrated security and safety monitoring system (ISSMS) for the railcars that will meet S-2043 safety requirements and DOE security requirements for rail transport of SNF and HLW. The ISSMS will be integrated into and monitored by the existing DOE Transportation Tracking and Communications System (TRANSCOM). The ISSMS will be needed to conduct any long-term transportation operation with dozens of shipments per year. This system prototype is planned to be completed in time for testing during the revenue service tests and for use during the demonstration run.

OPERATIONAL CONSIDERATIONS

After AAR approval of the Atlas railcar design, the railcars will be used during transportation operations for HLRM. Standard rail industry operating practices will be followed, as detailed in Federal Railroad Administration and AAR standards, guides, and field manuals. However, there are also special operating standards and requirements for the Atlas consist, as specified in AAR Standard S-2043, Appendix B: "Operating Standard for Trains Used to Carry High-Level Radioactive Material." This appendix establishes special operating standards for these railcars, including the requirement to follow the latest revision of AAR Circular Letter OT-55: "Recommended Railroad Operating Practices for Transportation of Hazardous Materials." The appendix states that all pre- and post-loading inspections must be completed and that all system safety monitoring equipment must be functioning correctly before train movement. The appendix also includes special crew training requirements specific to railcars used to ship HLRM.

DOE will have several options to choose from (e.g., lease, purchase) to establish and maintain the necessary railcar fleet for HLRM shipments. DOE does not plan to develop any new locomotives but will instead expect private railroad companies to provide locomotives compatible with the S-2043–compliant railcars.

CONCLUSIONS

Significant progress has been achieved on the Atlas Railcar Project over the last year. The prototype railcars have completed much of the single-car testing necessary to receive AAR EEC approval to proceed with multiple-car testing, which is expected in the spring of 2021. Completion of the multiple-car testing is expected in early 2023.

Over the last seven years, DOE has been pursuing the design and development of S-2043 compliant railcars to help ensure that a capable transportation system will be available for the safe, secure, efficient, and timely movement of HLRM from commercial nuclear power reactor sites and/or DOE sites when a receiving site becomes available.

REFERENCES

[1] Association of American Railroads, "Performance Specification for Trains Used to Carry High-Level Radioactive Material," *Car Construction Fundamentals and Details, AAR Manual of Standards and Recommended Practices,* Standard S-2043 (effective 2003, revised most recently in 2017).

[2] Department of Energy, "Memorandum of Understanding Between the US Department of Energy, Office of Nuclear Energy, and the US Department of the Navy, Naval Nuclear Propulsion Program," May 2017.

[3] Orano Federal Services LLC, "Atlas Railcar Phase 1 Final Report," EIR-3016795 Rev. 1, October 28, 2016. https://www.energy.gov/ne/downloads/atlas-railcar-phase-1-final-report.

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