Appendix M – Atlas Railcar Dynamic Modeling Plan

APPENDIX M-1 ATLAS PROJECT: PROPOSED DYNAMIC MODELING PLAN

Document # AFS-17-0031
Delivery via email

Jon Hannafious
Association of American Railroads
Equipment Engineering Committee
c/o TTCI
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Pueblo, CO 81001

February 27, 2017

Subject: Atlas Project: Proposed Dynamic Modeling Plan

Dear Jon;

The Atlas project team is quickly approaching the official start of dynamic modeling in preparation of a submittal request to the Association of American Railroads (AAR) Equipment Engineering Committee (EEC) for a notice to proceed to the test phase for the Atlas railcar and its associated buffer railcar. Since our last discussions, the DOE has requested that the project team add two additional casks for load consideration – the Holtec HI-STAR 190 SL and XL casks. The addition of these two cask loads is based on the increased capacity of the 12-axle Atlas cask railcar now being able to carry new maximum weights of the HI-STAR 190 SL cask at ~382,700 pounds and the HI-STAR 190 XL cask at ~414,200 pounds, plus cradle and attachment weights. (Enclosed for reference is a listing of the current 17 cask loads and their characteristics from DOE contract DE-NE0008390, Modification 00005, and titled *Attachment A – Transport Cask Characteristics, Nominal Characteristics of Spent Fuel Transportation Casks.*)

In order to satisfy AAR S-2043 requirements, the project team proposes the following:

1. That the AAR EEC agree with the project team's proposed dynamic modeling plan (enclosed as document *Atlas Design Team Proposal to EEC – Dynamic Modeling Bounding Case*) for the Atlas cask railcar and its cradle-to-railcar interface attachment system for approval and testing to AAR S-2043, and;
2. That the successful results of the proposed dynamic modeling test plan including the conceptual cradle designs (as described in the enclosed *Atlas Design Team Proposal to EEC – Dynamic Modeling Bounding Case*) will provide 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.

The project team requests a response by March 31, 2017.

Feel free to contact Slade Klein (253-552-1338 or slade.klein@areva.com) or myself (704-805-2876 or mark.denton@areva.com) with any questions or comments. Thank you for your assistance with this matter.

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AFS-17-0032
Jon Hannafious
February 27, 2017

Best Regards,

Mark A. Denton
Sr. Project Manager
Used Fuel and Waste Management

Copies (delivery via email):
- Rick Ford, Kasgro Rail
- Slade Klein, AFS Federal Way
- Charles Temus, AFS Federal Way
- Russell Walker, TTCI

Enclosures:
a) Atlas Design Team Proposal to EEC – Dynamic Modeling Bounding Case
b) DOE contract DE-NE0008390, Modification 00005, and titled Attachment A – Transport Cask Characteristics, Nominal Characteristics of Spent Fuel Transport Casks

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Atlas Design Team Proposal to EEC – Dynamic Modeling Bounding Case

The US Department of Energy (DOE) has contracted with AREVA Federal Services (AFS) and its subcontractors Kasgro Rail and TTCI, to design a cask railcar (named by DOE the "Atlas" railcar) including standardized attachment components (cradle-to-railcar tie-down interface), and transport package conceptual cradle designs for 17 SNF transportation casks. (Note: there have been 2 cask/conceptual cradle combinations added to the original 15 cask/cradle combinations presented to the EEC in August 2016.) Cradles are used to restrain the cask during transport. The Atlas cask railcar must be designed and built to satisfy the requirements of the Association of American Railroads (AAR) Standard S-2043. The railcar's securement system must be fabricated and tested and to meet the requirements of AAR Rule 88. The cask cradle designs are considered conceptual designs. The DOE's vision is that the individual cask vendors will design the final cask cradles at an unspecified later date. The Atlas project team will provide guidelines for the final cradle design such that the cradle designs comply with S-2043 paragraph 4.1.8 (AAR Rule 88) and the dynamic modeling performed and presented to the EEC.

The Atlas project team proposes 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 (as detailed below) will provide 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.

The Atlas railcar design is based on M-290 railcar design which was designed for S-2043. See "Railcar Design Precedent" below.

Conceptual Cradle Dynamic Modeling Plan

Dynamic modeling will be performed and presented to the EEC in the preliminary design report. The preliminary design report will show that the requirements of AAR Standard S-2043, paragraph 4.0, *Design*, have been met. Dynamic modeling will include consideration of all 17 cask/conceptual cradle designs. Conceptual cradle inputs will be 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). See "Vendor Interface Document" below.

Dynamic modeling of the Atlas railcar will include MSRP Section C Part II, Specification M-1001, Chapter XI and S-2043 Dynamic Curving for all cask/cradle combinations. Additionally, complete S-2043 dynamic modeling will be performed on selected cask/conceptual cradle inputs to bound all 17 cask/conceptual cradle cases; see Table 3. These bounding conditions will include an empty condition case, a maximum load case, and a highest cg case; see the Table 1 below. The selected bounding runs will be used to design the full scale testing campaign. The "empty condition" is defined as the railcar and required ballast weight. The ballast will be sized based on railcar performance. Based on the weight of the lightest empty cask, an additional

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minimum load case may be required. Planned Atlas railcar dynamic modeling regimes are shown in Table 3.

Table 1 – Atlas Load Conditions

Empty Condition[(1)]	Maximum Load Condition	Highest cg
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) If the weight of the lightest empty cask is below the required ballast weight, an additional minimum load case may be required.

Securement System

The Atlas railcar securement system consists of all components/features that connect the load (cask) to the railcar. The securement system is comprised of the attachment components (lugs welded to the railcar deck that interface with the cask cradles using inserted pins) and the cask cradles. The attachment component lugs and pins will be shown to meet the requirements of S-2043 paragraph 4.1.8 using analysis as allowed by S-2043 paragraph 5.4.7. The cask cradles have been designed as conceptual designs and shown to meet S-2043 paragraph 4.1.8 using analysis. The final cradles will be required to be designed to meet the requirements of S-2043 paragraph 4.1.8 and to meet the envelope requirements provided by the results of the dynamic modeling, and as provided in the Vendor Interface Document described below.

Vendor Interface Document

Individual cask vendors will be responsible for the final cradle designs. AFS will provide in the vendor interface document to the DOE and for use by future cask designer/vendors, the bounding envelope for the final cradle designs used for the certification of the Atlas railcar. The vendor interface document will include:

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- Final cradle design requirements per S-2043 (including fatigue, welding, and securement system loading)
- Final cradle fabrication requirements per S-2043
- Final cradle design requirements per Atlas dynamic modeling
    - Cradle mass limits
    - Cradle center of gravity limits
    - Cradle mass moment of inertia limits
- Cradle to Atlas railcar interface requirements

Railcar Design Precedent

The M-290 railcar was designed for AAR S-2043 and presented to the EEC for a similar payload. The M-290 empty and loaded conditions were as follows:

Table 2 – M-290 Load Conditions

Empty Condition	Loaded Condition
Railcar and load (empty cask) 623,000 pounds cg height = 90 inches from rails	Railcar and load (loaded cask) 780,000 pounds cg height = 98 inches from rails

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The following table shows the planned dynamic modeling test cases.

Table 3 – Atlas Railcar Dynamic Modeling Regimes

Cask	Twist and Roll (4.3.9.6)	Pitch and Bounce (4.3.9.7)	Yaw and Sway (4.3.9.8)	Dynamic Curving (4.3.9.9)	Single Bump Test (4.3.10.1)	Curving with Single Rail Perturbation (4.3.10.2)	Hunting (4.3.11.3)	Constant Curving (4.3.11.4)	Curving with Carious Lubrication Conditions (4.3.11.5)	Limiting Spiral Negotiation (4.3.11.6)	Turnouts and Crossovers (4.3.11.7)	Ride Quality (4.3.12)	Buff and Draft Curving (4.3.13)	Braking Effects on Steering (4.3.14)
NAC-STC				x										
NAC-UMS UTC				x										
MAGNATRAN				x										
HI-STAR 100				x										
HI-STAR 100HB				x										
HI-STAR 180				x										
HI-STAR 60				x										
Ballast Load or Lightest Cask(1)	x	x	x	x	x	x	x	x	x	x	x	x	x	x
HI-STAR 190 SL				x										
HI-STAR 190 XL(2)	x	x	x	x	x	x	x	x	x	x	x	x	x	x
MP187				x										
MP197				x										
MP197HB				x										
TN-32B				x										
TN-40				x										
TN40HT				x										
TN-68				x										
TS125				x										

Notes:

1) The lightest empty cask and cradle may need to be run separately from the required ballast weight.
2) The maximum load and highest cg are both provided by the HI-STAR 190 XL conceptual cradle and loaded cask.

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Attachment A – Transport Cask Characteristics

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	106.30	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	412,169-414,269[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
TN40HT	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: Greene, S.R., J.S. Medford, and S.A. Macy, Storage and Transport Cask Data for Used Commercial Nuclear Fuel, 2013 U.S. Edition, Report ATI-TR-13047, August 2013
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 TN40HT transportation casks are also assumed to 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.

APPENDIX M-2 ATLAS PROJECT: PROPOSED DYNAMIC MODELING PLAN RESPONSE FROM AAR EEC

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Subject: Atlas Project: Proposed Dynamic Modeling Plan, Document 3 AFS-17-0031

Mark A. Denton
Sr. Project Manager
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Dear Mr. Denton,

On April 20 during their monthly teleconference, the AAR Equipment Engineering Committee discussed the subject dynamic modeling plan for the Atlas railcar and the various cask/cradle configurations that the car will be used to transport.

EEC reached a consensus that the approach was reasonable and modeling can proceed as planned. There was a bit of concern regarding the extreme difference in Gross Rail Load between the heaviest and lightest scenarios. EEC asks that thought be given to how the system responds to the intermediate loads for each regime. Providing that an understanding is in place for each regime, the intermediate loads do not need to be modeled.

EEC reserves the right to request additional modeling upon reviewing the results from the pending effort.

Sincerely,

Jon Hannafious

cc: David Cackovic, TTCI

TTCI is a subsidiary of the Association of American Railroads