Atlas Railcar Interface Control Document

Spent Fuel & Waste Disposition

Prepared for
US Department of Energy
Integrated Waste Management System

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EXECUTIVE SUMMARY

This report satisfies the requirements of the US Department of Energy (DOE) Office of Integrated Waste Management Level-4 milestone M4SF-19OR020303022, “Atlas Railcar Interface Control Document.” This interface control document (ICD) identifies, manages and controls the transportation system interactions between the Atlas railcar transportation equipment and external activities including vendor-supplied high-level radioactive material (HLRM) transportation casks and cradles. The term *HLRM* was established by Association of American Railroads (AAR). HLRM includes both spent nuclear fuel and high-level waste.

DOE is developing the Atlas cask car and buffer car designs to meet the requirements of AAR Standard S-2043, *Performance Specification for Trains Used to Carry High-Level Radioactive Material*. These car designs will be made available to the public to facilitate their use in the transportation of HLRM.

Commercial vendors develop and supply transportation casks certified by the US Nuclear Regulatory Commission for use in transporting spent nuclear fuel. These cask vendors or other transportation equipment vendors also provide the cradles used to attach the casks to transportation vehicles. This ICD provides the information necessary to control the interfaces to the railcar so that the cask and cradle vendors can ensure that their cradle designs and the transport casks can be transported on the Atlas cask car.

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ACRONYMS AND ABBREVIATIONS

AAR	Association of American Railroads
AFS	AREVA Federal Services, LLC (now Orano 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
CoC	certificate of compliance
DBRD	design basis requirements document
DOE	US Department of Energy
EEC	Equipment Engineering Committee (of the AAR)
FS	Orano Federal Services LLC (formerly AFS)
HLRM	high-level radioactive material
ICD	interface control document
in	inches
kips	thousand pounds
lb	pound
MoM	mass moment of inertia
MSRP	Manual of Standards and Recommended Practices (AAR)
NAC	NAC International
NDE	non-destructive examination
NRC	US Nuclear Regulatory Commission
QA	quality assurance
REV	rail escort vehicle
ROM	rough order of magnitude
SAR	safety analysis report
TTCI	Transportation Technology Center, Inc.
WPS	welding procedure specification

ATLAS RAILCAR INTERFACE CONTROL DOCUMENT

1. PURPOSE

The purpose of this interface control document (ICD) is to identify, manage, and control the transportation system interactions between the Atlas railcar transportation equipment and vendor-supplied high-level radioactive material (HLRM) transportation casks and cradles. The term *HLRM* was established by the Association of American Railroads (AAR). HLRM it includes both spent nuclear fuel and high-level waste.

DOE is developing the Atlas cask car and buffer car designs to meet the requirements of AAR Standard S-2043, *Performance Specification for Trains Used to Carry High-Level Radioactive Material*. These car designs will be made available to the public to facilitate their use in the transportation of HLRM. This document provides the interface information necessary for this use.

2. SCOPE

This ICD provides details on the mechanical, dimensional, and analytical interfaces for transportation systems used in the Atlas railcar design, including bounding weights, centers of gravity (CGs), and structural limits. Transportation systems are expected to use commercial railways to move the HLRM from current locations to operating facilities. Heavy-haul transporters are also expected to use public roadways to move HLRM from current locations to railhead transfer locations, and barge and rigging companies are expected to use inland or intracoastal waterways to move HLRM to rail-connected ports. To ensure the safety of these moves, the HRLM transportation casks and cradles must interface appropriately with the Atlas railcar. Unless otherwise stated herein, the term *payload* refers to the cradle with the associated cask, impact limiters, and any other attachments added to the Atlas railcar (e.g., end stops).

Railcars must be designed, modeled, and tested to carry specific payloads in compliance with AAR Standard S-2043. For the Atlas railcar, these payloads include the 17 specific HLRM casks listed in Appendix D, Table D-1, along with their associated cradles. DOE has not performed any analysis of the railcar carrying any other HLRM transportation cask-and-cradle combinations. Therefore, it is not clear if the Atlas railcar could be used to transport any other cask-and-cradle combinations in compliance with AAR Standard S-2043. Of particular concern would be any new cask-and-cradle combination that presented more weight and/or a higher CG than any of the 17 existing HLRM cask-and-cradle combinations.

3. ASSUMPTIONS

1. Vendor-supplied transportation payloads mounted on the Atlas cask railcar are used to transport commercial spent nuclear fuel.
2. Transportation casks certified by the US Nuclear Regulatory Commission (NRC) are used for transportation on the Atlas railcar.
3. Heavy-haul transporters may be used to move payloads to the railhead for transportation.
4. Barge transport may also be used from some sites and may use the same payload combinations identified in this ICD.

> Note: Transportation payload attachments to heavy-hauls transporter or barges must be implemented in a manner that does not void the certification of the payload for use on the railcar, e.g., use of mechanical connections without welding.

4. ATLAS RAILCAR-TO-TRANSPORTATION CASK AND CRADLE INTERFACES

Individual cask vendors or other transportation system suppliers/vendors are responsible for the final cradle designs. This ICD provides information for use by vendors, including the cask and cradle design information used by the design team when establishing the loading conditions and physical interfaces for the Atlas railcar's certification. This ICD does not provide all the design parameters needed for a vendor to design their equipment; it does provide the designer with details regarding the interfaces to the as-built railcar. The vendor is responsible for meeting all applicable requirements. The physical design loading information provided herein was used to certify the Atlas railcar. See the Note in Section 3 above.

4.1 Design Requirements

4.1.1 Railcar Interface Design Requirements.

1. The Atlas railcar must not be loaded in such a way that it exceeds the performance criteria of S-2043, Section 4.3.8. The Atlas railcar was designed for the loads applied by 17 specific payloads. See Appendix A for the parameters used in the Atlas railcar design.
2. Appendix B provides the attachment component drawings of the Atlas railcar. Attachment points are shown, as well as the attachment details. This drawing is the interface control drawing.
3. Appendix C shows the Atlas railcar dimensions for information only.

4.1.2 Cradle, Cask, and Other Attachments (Payload) Design Requirements

This section provides interface design requirements for the loads applied to the Atlas railcar.

1. The payload must be designed to interface with the Atlas railcar using the standardized attachments. See Section 4.3, "Dimensional Requirements," below.
2. The payload must be designed to meet the applicable design requirements of AAR S-2043, including fatigue, welding, and securement system loading.
3. The payload must be designed to provide tie-down loading inputs (generated from the payload) to the standardized attachments that do not exceed the bounds of the values in Appendix B, Table B-1. In addition, the cradle itself must meet the structural requirements specified in Section 4.1.2(5).
4. The final payload design must meet the limits analyzed by dynamic modeling:
   a. Cask weight limits, CG limits, and mass moment of inertia (MoM) limits are shown in Appendix A, Tables A-1 through A-3.
   b. Cradle weight limits are shown in Appendix A, Tables A-4 through A-6.
   c. Cradle CG limits are shown in Appendix A, Tables A-4 through A-6.
   d. Cradle MoM limits and modeling inputs are shown in Appendix A, Tables A-7 through A-10
5. Cradle (or Other Attachments to Railcar) Structural Requirements are as follows:
   a. The cradle must be designed to meet the requirements of AAR S-2043, paragraph 4.1.8, including the transportation loading listed in *Field Manual of the AAR Interchange Rules,*

Rule 88 A.16.c(3), "Securement system specification loads for irradiated fuel casks shipped on flat or gondola cars," and 10 CFR 71.45.

b. The cradle welds must meet the requirements of S-2043, paragraph 4.1.10.2.
c. The cradle must be designed to meet the fatigue requirements of AAR S-2043, paragraph 4.1.9, which refers to the AAR *Manual of Standards and Recommended Practices* (MSRP) M-1001, Chapter 7.

Note: Materials specified in the appendices (Orano Federal Services, LLC [FS] published reports and calculations, as well as Atlas dimensional drawings) are available on the DOE website.

4.2 Bounding Center of Gravity and Maximum and Minimum Loads for Railcar Analysis

The Atlas railcar was analyzed for bounding center of gravity (CG) and weight combinations for the various cask/cradle loads listed in Appendix D, Table D-1. The maximum vertical CG (design limit) for a fully loaded railcar is 98 inches measured from the top of rails per AAR, MSRP, M-1001, Section 2.1.3. However, the maximum CG used for dynamic modeling of the Atlas railcar was 96.08 inches from the top of the rails. The minimum and maximum total load dynamic modeling input for the cradle and cask with impact limiters is shown below:

- Minimum payload (cask and cradle) load = 200,500 pounds
- Maximum payload (cask and cradle) load = 474,405 pounds

To calculate the combined weight and CG location of a specific payload, the cask weight and vertical CG location, minimum cradle weight, cradle vertical CG location, railcar weight, deck height (when loaded), and railcar vertical CG location are required. The minimum analyzed Atlas railcar weight of 195,000 pounds is used for CG calculations. The unloaded Atlas railcar deck height is 59.25 inches, and the unloaded Atlas railcar CG is 35.3 inches from the top of the rails. These values are lower when under load but can be used for conservative calculations.

Appendix A provides the modeling parameters for the actual analyses performed for each cask type. Appendix D, Table D-1 lists the casks used for the railcar analyses and the cask dimensions and weights.

Railcars must be designed, modeled, and tested to carry specific payloads to demonstrate compliance with AAR Standard S-2043. For the Atlas railcar, these payloads include the 17 specific HLRM casks listed in Appendix D, Table D-1, along with their associated cradles. DOE has also defined the bounding conditions in Appendix A. DOE has not performed analysis of the railcar carrying a payload outside of these bounding conditions. Therefore, it is not clear if the Atlas railcar could be used to transport any payload outside of these bounding conditions in compliance with AAR Standard S-2043. Of particular concern would be any new cask-and-cradle combination with a greater weight and/or a higher CG.

For further information on these dynamic analyses, contact:

Vice President, Engineering Services
Transportation Technology Center, Inc.
55500 DOT Road
PO Box 11130
Pueblo, Colorado 81001-0130
719-584-0750

If the planned approach is different than what was modeled and tested, contact:

Equipment Engineering Committee
Technical Services
The Association of American Railroads
425 3rd ST. SW #1000
Washington, DC 20024

4.3 Dimensional Requirements

The Atlas railcar's clearances, including the payload, must fit within AAR Plate E except when loaded with casks (including impact limiters) that are more than 128 inches wide, which requires special route clearances. The requirements for Plate E are contained within AAR Standard S-2056. These standards are referenced in AAR Standard S-2043, Section 4.7.9.1.

The final payload design must interface with the Atlas railcar using the standardized attachment points shown schematically in Figure 1 and detailed as follows:

- Atlas cask railcar attachments interface drawing and tie-down attachment loading limits (Appendix B)
- Atlas cask railcar dimensions (Appendix C), for information only

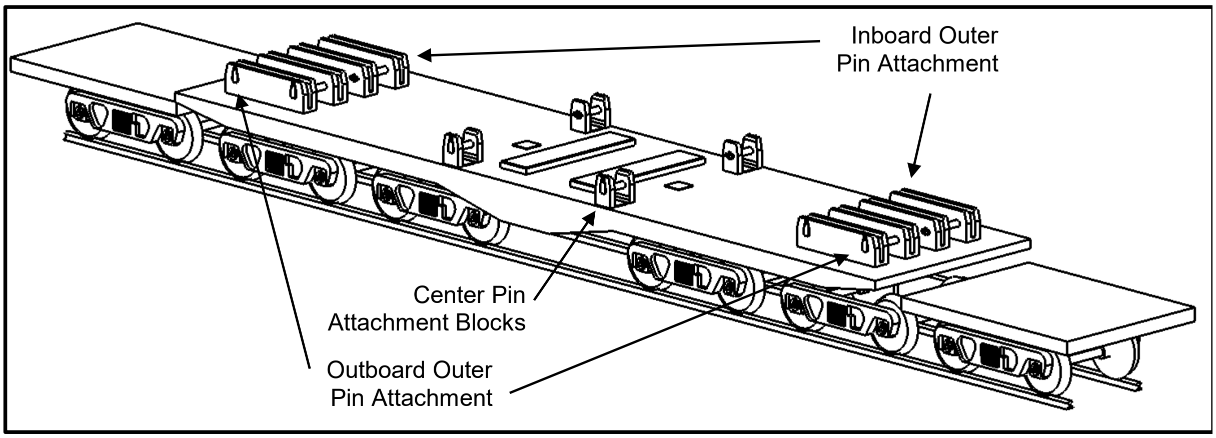

Figure 1. Atlas Railcar Standardized Attachment Components.

4.4 Cradle Conceptual Designs

The final payload designs are the responsibility of the transportation cask vendor or other transportation system vendor. However, to ensure that the designs would meet the Atlas car requirements and allow for railcar testing, the Atlas design team prepared conceptual cradle designs, and in some cases, end stop designs were prepared which were used in the railcar development process. These conceptual designs can be found in Appendix D and are provided for informational purposes only. However, if significant differences affecting overall weights and CG are planned, then the design requirement cautions noted in this ICD should be followed.

4.5 Loading and Unloading Considerations

As part of the Atlas railcar design, the design team developed general procedures for loading and unloading casks onto the railcar. These procedures are included in the DOE Atlas Phase 3 report, Appendix K (See References). Most casks with cradles will be loaded horizontally onto the railcar. For cases in which the cask-cradle assembly is designed to allow transfer to the horizontal position in the cradle (i.e., up/down-ending), the Atlas railcar was designed to permit this operation with the cradle attached to the railcar as long as jacks are deployed to unload the railcar suspension. Due to their weight, the HI-STAR 190SL/XL casks cannot be up/down-ended while on top of the railcar deck.

Table 1 provides the loading configuration by cask model and cradle family. Information highlighted in yellow indicates the casks designed to allow up/down-ending and are compatible with the Atlas railcar. These configurations may be up/down-ended on the Atlas railcar if appropriate jacking procedures are followed.

Table 1. Cask Loading Configuration

Cradle Family	Cask Model	Starting Configuration	Source / Basis
Family 1	TN-32B	Loaded cask is horizontal in a site-provided up-/down-ending device	The safety analysis report (SAR) discusses an up-ending/down-ending frame that is separate from the cradle
	TN-40		
	TN-40HT		
	HI-STAR 60	Loaded cask is vertical on a concrete pad	Information received suggests that the cask is to be down-ended on the cradle[a]
	HI-STAR HB	Loaded cask is horizontal in a site-provided up/down-ending device	Previous experience with the HI-STAR 100 included using a up/down-ending frame that was separate from the cradle.
	HI-STAR 100		
	HI-STAR 180	Loaded cask is vertical on a concrete pad	Information received suggests that the cask is to be down-ended on the cradle[a]
	HI-STAR 190SL	Loaded cask is horizontal in a site-provided up/down-ending device	The SAR indicates that the cask can be down-ended prior to being placed on the transport vehicle[b]
	HI-STAR 190XL		
Family 2	TN-68	Loaded cask is vertical on a concrete pad	The SARs state that the cask is down-ended on the cradle[a]
	NAC-STC		
	NAC-UMS		
	MAGNATRAN		
Family 3	MP197	Loaded cask is horizontal on a site-provided transfer trailer	The SAR states that the cask is down-ended on the on-site transfer trailer and is then to be lifted horizontally and placed onto the transport cradle
	MP197HB		
	TS125	1) Loaded cask is horizontal on a site-provided transfer trailer, OR 2) Loaded cask is vertical on a concrete pad	The SAR presents the 2 options shown for how the cask is oriented prior to loading the cradle[a]
Family 4	MP187	Loaded cask is horizontal on a site-provided transfer trailer	The SAR states that the cask is horizontal on the on-site transfer trailer

DOE Atlas Phase 3 Report, Appendix K, Table 4-1 (see References).

The casks that can be down-ended onto their cradles include HI-STAR 60, HI-STAR 180, TN-68, NAC-STC, NAC-UMS, MAGNATRAN, and TS125. In all of these cases, there is no restriction as to where the down-ending is performed, although when down-ending activities are performed on top of the railcar, the railcar deck must be supported by jacks, stabilized by tie-downs, and not supported by the railcar's suspension system (trucks and span bolsters).

[a] The railcar has been designed to permit up/down-ending of these casks while on top of the railcar deck, as long as jacks and tie-downs are deployed to unload the railcar suspension.

[b] Due to their weight, the HI-STAR 190SL/XL casks cannot be up/down-ended while on top of the railcar deck.

Jacks and tie-down devices must also be used to stabilize and secure the railcar deck during loading/unloading operations. Jacking points and tie-down brackets are provided on the railcar. Site tie-downs must be loaded in line with the railcar's tie-down bracket. A specific site tie-down design, including analysis, must be performed to ensure that the provided railcar tie-down bracket meets the site loading requirements. Wheel chocks must be used to prevent railcar movement when loading.

5. REFERENCES

US DOE, *Design and Prototype Fabrication of Railcars for Transport of High-Level Radioactive Material, Phase 2: Preliminary Design*, DE-NE0008390, Rev 1, March 6, 2018. https://www.energy.gov/ne/downloads/atlas-railcar-phase-2-final-report.

US DOE, *Design and Prototype Fabrication of Railcars for Transport of High-Level Radioactive Material; Phase 3 – Prototype Fabrication and Delivery*, DE-NE0008390, EIR-3021970-000, May 13, 2019, https://www.energy.gov/ne/downloads/atlas-railcar-phase-3-final-report.

US DOE, *Atlas Railcar General Loading Procedures*, DE-NE0008390, EIR-3016164, Rev 002, Appendix K to Phase 3 report.

Association of American Railroads, *Manual of Standards and Recommended Practices*, Section C Part II, Design, Fabrication and Construction of Freight Cars (M-1001), 2015.

Association of American Railroads, *Manual of Standards and Recommended Practices*, Section C, Car Construction Fundamentals and Details, Standard 2043, Performance Specification for Trains Used to Carry High-Level Radioactive Material, 2017.

Association of American Railroads, *Manual of Standards and Recommended Practices*, Section J, Quality Assurance Standard M-1003, 2014.

Association of American Railroads, 2015 *Field Manual of the AAR Interchange Rules*, Section C Requirements for Acceptance, Rule 88, 2015.

Association of American Railroads, *Manual of Standards and Recommended Practices*, Section C, Car Construction Fundamentals and Details, Standard 2031, Plate E – Equipment Diagram for Limited Interchange Service, 2007.

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APPENDIX A
TABLE OF CONTROLLED INTERFACE PARAMETERS FOR MODELING

Table A-1. Cask Modeling Inputs – Weight and Center of Gravity

Cask	Maximum (Loaded) Cask Weight (lb)[a]	Minimum (Empty) Cask Weight (lb)[b]	Cask Vertical CG from Railcar Deck (in)[c]	Cask Longitudinal CG from Railcar Center (in)	Cask Lateral CG from Railcar Center (in)
NAC-STC	254,589	188,767	68.00	2.25[h]	0
NAC-UMS UTC	255,022	178,798	68.00	1.65[h]	0
MAGNATRAN	312,000	208,000	68.00	6.90[h]	0
HI-STAR 100	279,893	179,710	66.50	0.40[i]	0
HI-STAR 100HB	187,200	-[d]	66.50	2.60[i]	0
HI-STAR 180	308,647	-[e]	65.00	18.10[i]	0
HI-STAR 60	164,000	142,530[f]	60.13	11.60[i]	0
HI-STAR 190SL	382,746	282,746	65.00	17.90[i]	0
HI-STAR 190XL	420,769[12]	304,369	65.00	17.70[i]	0
MP187	271,300	190,200	65.00	0[j]	0
MP197	265,100	176,710	62.50	1.15[k]	0
MP197HB	303,600	179,000	64.50	1.63[k]	0
TN-32B	263,000	-[g]	73.00	0.50 [i]	0
TN-40	271,500	-[g]	73.00	0[i]	0
TN-40HT	242,343	-[g]	73.00	0[i]	0
TN-68	272,000	-[e]	78.00	6.10[h]	0
TS125	285,000	196,118	73.30	5.00[k]	0

Table 5-1 [A.7]

Notes:

a. The loaded cask weight is from Appendix D, Table D-1.
b. The empty cask weights are from Appendix D, Table D-1, except where noted. Some empty weights are not available.
c. The cask vertical CG is from Calculation CALC-315276-004. Revised values are from calculation reference A.1 and A.5 for families 1 and 4 (see Appendix D for information on families). Values from A.1 and A.5 are increased 0.5 inches due to standardized attachment components' shim plate.
d. The HI-STAR 100HB cask is already loaded and will not be shipped empty.
e. Table D-1 lists an empty weight of less than the loaded weight. However, this is not a bounding empty condition weight and will not be listed here.
f. Table D-1 lists an empty weight of <164,000 pounds. An empty weight of 142,530 pounds is listed in Section 1.2.1.3 of the HI-STAR 60 Safety Analysis Report (SAR), Rev 2 (Docket 71-9336).
g. Per Table D-1, TN-40 is authorized for a single-use shipment and would not be shipped empty. Per Table D–1, this is also assumed to be the case for TN-32B and TN40HT.

h. This value was calculated using values derived from "Minimum/Maximum Combined CG Distance from Rear Cradle Pins, X (in)" in Tables B-2 and B-4 of CALC-3015134 (A.3) and the distance between attachment pins of 125 inches per A.1. Cask CG is the bounding value farthest from railcar's center.
i. This value was calculated using "Cask CG from Pin near Cask Bottom (P1) (in) (dc hcg)" from CALC-3015133 Table 5.1 [A.2] and the distance between attachment pins of 125 inches per [A.1].
j. The MP187 cask's CG is at the center of the attachment points [A.5].
k. This value was calculated using "Cask Length (in)" and "Cask Longitudinal CG (in)" from Table 4.1-1 of CALC-3015135 [A.4]. Where available, bounding values were used. Casks are geometrically centered on their respective cradles.
l. This is the loaded cask weight adjusted from Table D-1 per AFS-RFI-00225-0015-00, November 2016.

Calculation References for all Tables in Appendix A:

A.1 - AREVA Federal Services Drawing, DWG-3015278, *Atlas Railcar Cradle Attachment Components Drawing,* Rev. 2.

A.2 - Orano Federal Services Calculation, CALC-3015133, *Atlas Railcar Family 1 Conceptual Cradle Structural Calculation*, Rev. 4

A.3 - AREVA Federal Services Calculation, CALC-3015134, *Atlas Railcar Family 2 Conceptual Cradle Structural Calculation*, Rev. 0

A.4 - AREVA Federal Services Calculation, CALC-3015135, Atlas Railcar Family 3 Conceptual Cradle Structural Calculation, Rev. 0

A.5 - AREVA Federal Services Calculation, CALC-3015136, Atlas Railcar Family 4 Conceptual Cradle Structural Calculation, Rev. 1

A.6 - Orano Federal Services Calculation, CALC-3015276, Atlas Railcar Cradle Attachment and Combined Center of Gravity Calculation, Rev. 4

A.7 Orano Federal Services Calculation CALC-3015934, Atlas Railcar Cask and Cradle Dynamic Modeling Inputs, Rev. 2

Table A-2. Cask Modeling Inputs – Loaded Mass Moment of Inertia

Cask	Maximum (Loaded) Cask Weight (lb)	Cask Length (in)[(a)]	Cask Radius (in)[(b)]	Rotational Mass Moment of Inertia (lb×in^2), Loaded Cask around CG		
				Longitudinal Axis (x)	Lateral Axis (y)	Vertical Axis (z)
NAC-STC	254,589	193.0	49.50	311903349	947506003	947506003
NAC-UMS UTC	255,022	209.3	46.45	275118052	1069221548	1069221548
MAGNATRAN	312,000	214.0	55.00	471900000	1441500320	1441500320
HI-STAR 100	279,893	203.3	48.00	322436736	1125282050	1125282050
HI-STAR 100HB	187,200	128.0	48.00	215654400	364683072	364683072
HI-STAR 180	308,647	174.4	53.15	435951927	1101392609	1101392609
HI-STAR 60	164,000	158.9	37.88	117661341	425971047	425971047
HI-STAR 190SL	382,746	214.5	53.25	542650102	1861480626	1861480626
HI-STAR-190XL	420,769	237.0	53.25	596558399	2399616416	2399616416
MP187	271,300	201.5	46.25	290163828	1063031116	1063031116
MP197	265,100	208.0	45.75	277435434	1094842179	1094842179
MP197HB	303,600	210.3	48.88	362688818	1301071121	1301071121
TN-32B	263,000	184.0	48.88	314186954	899169893	899169893
TN-40	271,500	183.8	49.76	336124819	932390115	932390115
TN-40HT	242,343	183.8	50.50	309017618	836753630	836753630
TN-68	272,000	197.3	49.00	326536000	1055741027	1055741027
TS125	285,000	210.4	47.10	316123425	1216555513	1216555513

Reference: Table 5-2 [A.7].

Notes:

a. The cask length is taken as the "Length without Impact Limiters" from Table D-1.

b. The cask radius is taken as half of the "Diameter without Impact Limiters" from Table D-1.

Table A-3. Cask Modeling Inputs – Empty Mass Moment of Inertia

Cask	Minimum (Empty) Cask Weight (lb)	Cask Length (in)[(a)]	Cask Radius (in)[(b)]	Rotational Mass Moment of Inertia (lb×in^2), Empty Cask around CG		
				Longitudinal Axis (x)	Lateral Axis (y)	Vertical Axis (z)
NAC-STC	188,767	193.0	49.50	231263171	702535717	702535717
NAC-UMS UTC	178,798	209.3	46.45	192887506	749639930	749639930
MAGNATRAN	208,000	214.0	55.00	314600000	961000213	961000213
HI-STAR 100	179,710	203.3	48.00	207025920	722506234	722506234
HI-STAR 100HB	-	128.0	48.00	-	-	-
HI-STAR 180	-	174.4	53.15	-	-	-
HI-STAR 60	142,530	158.9	37.88	102257749	370205203	370205203
HI-STAR 190SL	282,746	214.5	53.25	400871977	1375131813	1375131813
HI-STAR 190XL	304,369	237.0	53.25	431528661	1735795291	1735795291
MP187	190,200	201.5	46.25	203424844	745258084	745258084
MP197	176,710	208.0	45.75	184932537	729798421	729798421
MP197HB	179,000	210.3	48.88	213838269	767100562	767100562
TN-32B	-	184.0	48.88	-	-	-
TN-40	-	183.8	49.76	-	-	-
TN-40HT	-	183.8	50.50	-	-	-
TN-68	-	197.3	49.00	-	-	-
TS125	196,118	210.4	47.10	217535066	837152400	837152400

Reference: Table 5-3 [A.7].

Notes:

a. The cask length is taken as the “Length without Impact Limiters” from Table D-1.

b. The cask radius is taken as half of the “Diameter without Impact Limiters” from Table D-1.

Table A-4. Cradle Modeling Inputs – Weight and CG – Families 2-4

Cask	Nominal Cradle Weight (lb)(a)	Cradle Vertical CG from Railcar Deck (in)(b)	Cradle Longitudinal CG from Railcar Center (in)(c)	Cradle Lateral CG from Railcar Center (in)
NAC-STC	42,000	27.5	7.5	0
NAC-UMS UTC	42,000	27.5	7.5	0
MAGNATRAN	42,000	27.5	7.5	0
MP187	32,500	29.0	0	0
MP197	26,000	17.5	0	0
MP197HB	26,000	18.0	0	0
TN-68	27,000	26.5	8.5	0
TS125	30,000	25.0	0	0

Reference: Table 5-4 [A.7].

Notes:

a. Nominal weight values rather than maximum or minimum weight values are used in each calculation.

b. The CG is taken from Table 4-1 [A.7] and increased by 0.5 inches due to the standardized attachment components.

c. The cradle longitudinal CG is adjusted to the center of the railcar by taking the value from Table 4-1 [A.7] and adjusting using the distance between the pins (125 inches per [A.1]), x = abs(125/2-d).

Table A-5. Cradle Modeling Inputs – Weight and CG – Family 1 Central Cradle

Cask	Nominal Central Cradle Weight (lb)(a)	Central Cradle Vertical CG from Railcar Deck (in)(b)	Central Cradle Longitudinal CG from Railcar Center (in)(c)	Central Cradle Lateral CG from Railcar Center (in)
HI-STAR 100	20,545	25.7	4.3	0
HI-STAR 100HB	15,000	27.6	2.3	0
HI-STAR 180	9,182	27.8	0.1	0
HI-STAR 60	16,091	27.1	2.6	0
TN-32B	13,272	35.6	5.6	0
TN-40	12,909	32.5	5.8	0
TN-40HT	12,909	32.5	5.8	0
HI-STAR 190SL	13,364	22.3	0.1	0
HI-STAR 190XL	13,636	22.3	0.1	0

Reference: Table 5-5 [A.7].

Notes:

a. Each calculation uses nominal weight values rather than maximum or minimum weight values.

b. The CG is taken from Table 4-2 [A.7] and is increased by 0.5 inches due to the standardized attachment components.

c. The CG is adjusted to the center of the railcar by taking the value from Table 4-2 [A.7] and adjusting it using the distance between the pins: 125 inches per [4], x = abs(125/2-d).

Table A-6. Cradle Modeling Inputs – Weight and CG – Family 1 End Stops

Cask	Nominal End Stop Weight per End (lb)[(a)]	End Stop Vertical CG from Railcar Deck (in)	End Stop Longitudinal CG from Railcar Center (in)[(b)]	End Stop Lateral CG from Railcar Center (in)
HI-STAR 100	23,273	52.7	197.8	0
HI-STAR 100HB	29,091	65.5	190.0	0
HI-STAR 180	24,545	60.0	175.9	0
HI-STAR 60	24,000	47.1	195.8	0
TN-32B	30,364	52.3	168.3	0
TN-40	31,091	50.7	172.1	0
TN40HT	31,091	50.7	172.1	0
HI-STAR 190SL	21,273	61.9	197.5	0
HI-STAR 190XL	20,000	62.2	201.5	0

Reference: Table 5-6 [A.7]

Notes:

a. Each calculation uses nominal weight values rather than maximum or minimum weight values.

b. The CG is adjusted to the center of the railcar by taking the value from Table 4-3 [A.7] and adjusting using the distance between the outer pins:
125+148.5+148.5+48+48 inches per [4], x = abs[(125+148.5+148.5+48+48)/2-d].

Table A-7. Cradle Modeling Results – Families 2–4

Cask	Nominal Cradle Weight (lb)	Calculated Rotational Mass Moment of Inertia ($lb*in^2$)		
		Longitudinal Axis (x)	Lateral Axis (y)	Vertical Axis (z)
NAC-STC	42,000	107420031	177507865	245802070
NAC-UMS UTC	42,000	108344606	215505187	283962578
MAGNATRAN	42,000	107996979	214855254	284549589
MP187	32,500	76512209	102544674	129466464
MP197	26,000	53452254	53944950	83293680
MP197HB	26,000	57567432	90162852	119270004
TN-68	27,000	70617158	73796861	112935016
TS125	30,000	63572366	130481182	160163420

Reference: Table 5-7 [A.7].

Table A-8. Cradle Modeling Results – Family 1 Central Cradle

Cask	Nominal Central Cradle Weight (lb)	Calculated Rotational Mass Moment of Inertia, (lb×in^2)		
		Longitudinal Axis (x)	Lateral Axis (y)	Vertical Axis (z)
HI-STAR 100	20,545	43074602	50542232	67971425
HI-STAR 100HB	15,000	36189820	27793388	44375308
HI-STAR 180	9,182	25366782	28726632	37587666
HI-STAR 60	16,091	36195191	30279548	49192035
TN-32B	13,272	36398191	41030969	53446863
TN-40	12,909	33491643	36922579	48700012
TN-40HT	12,909	33491643	36922579	48700012
HI-STAR 190SL	13,364	31907634	40984186	51573243
HI-STAR 190XL	13,636	32560720	41818848	52626918

Reference: Table 5-8 [A.7].

Table A-9. Cradle Modeling Results – Family 1 End Stops

Cask	Nominal End Stop Weight per End(lb)	Calculated Rotational Mass Moment of Inertia, (lb×in^2)		
		Longitudinal Axis (x)	Lateral Axis (y)	Vertical Axis (z)
HI-STAR 100	23,273	31791742	41822972	40285039
HI-STAR 100HB	29,091	37918666	78764969	78321041
HI-STAR 180	24,545	42279179	51551205	52133252
HI-STAR 60	24,000	27014338	50559633	49547744
TN-32B	30,364	56558696	78818952	69306526
TN-40	31,091	57912871	80706101	70965920
TN-40HT	31,091	57912871	80706101	70965920
HI-STAR 190SL	21,273	38400939	34801023	35530098
HI-STAR 190XL	20,000	36701031	29459126	29937032

Reference: Table 5-9 [A.7]

Table A-10. Combined Cask and Cradle Dynamic Modeling Inputs, Loaded Cask

Cask	Mass (lb)	CG relative to Railcar Deck Center (in)			Calculated Rotational Mass Moment of Inertia (lb×in^2)		
		Longitudinal Axis (x)	Lateral Axis (y)	Vertical Axis (z)	Longitudinal Axis (x)	Lateral Axis (y)	Vertical Axis (z)
NAC-STC	296,589	3.0	0.0	62.3	478458289	1185142470	1194301767
NAC-UMS UTC	297,022	2.5	0.0	62.3	442611789	1345109965	1354418225
MAGNATRAN	354,000	7.0	0.0	63.2	640614030	1717085951	1726063235
HI-STAR 100	300,438	0.7	0.0	63.7	397372649	1207976714	1193544596
HI-STAR 100HB	202,200	2.6	0.0	63.6	272858531	413492021	409059629
HI-STAR 180	317,829	17.6	0.0	63.9	473658043	1145347597	1141869297
HI-STAR 60	180,091	10.8	0.0	57.2	169842899	473423872	476349992
HI-STAR 190SL	396,110	17.3	0.0	63.6	598102106	1930100576	1917145263
HI-STAR-190XL	434,405	17.1	0.0	63.7	653201069	2469608514	2456334633
MP187	303,800	0.0	0.0	61.1	404290112	1203189865	1192497580
MP197	291,100	1.0	0.0	58.5	378835181	1196765935	1178167173
MP197HB	329,600	1.5	0.0	60.8	472040039	1443081392	1420404755
TN-32B	276,272	0.7	0.0	71.2	368257664	958202003	952945378
TN-40	284,409	0.3	0.0	71.2	389829387	989940166	981504675
TN-40HT	255,252	0.3	0.0	71.0	362612405	894191649	885865939
TN-68	299,000	6.3	0.0	73.3	462297386	1194823592	1168817519
TS125	315,000	4.5	0.0	68.7	443017091	1411036566	1377397504

Reference: Table 5-10 [A.7]

Table A-11. Combined Cask and Cradle Dynamic Modeling Inputs, Empty Cask

Cask	Mass (lb)	CG relative to Railcar Deck Center (in)			Calculated Rotational Mass Moment of Inertia ($lb \times in^2$)		
		Longitudinal Axis (x)	Lateral Axis (y)	Vertical Axis (z)	Longitudinal Axis (x)	Lateral Axis (y)	Vertical Axis (z)
NAC-STC	230,767	3.2	0.0	60.6	395035510	937342825	949284722
NAC-UMS UTC	220,798	2.8	0.0	60.3	357018322	1022095262	1034766443
MAGNATRAN	250,000	7.0	0.0	61.2	479913875	1233184943	1245562383
HI-STAR 100	200,255	0.8	0.0	62.3	280791826	804020200	790758089
HI-STAR 100HB	-	-	-	-	-	-	-
HI-STAR 180	-	-	-	-	-	-	-
HI-STAR 60	158,621	10.7	0.0	56.8	154227003	417429962	420568385
HI-STAR 190SL	296,110	17.1	0.0	63.1	456046355	1443425893	1430748206
HI-STAR-190XL	318,005	16.9	0.0	63.2	487885669	1805453195	1792464977
MP187	222,700	0.0	0.0	59.7	315910218	883775924	874724549
MP197	202,710	1.0	0.0	56.7	284281794	829670349	813122076
MP197HB	205,000	1.4	0.0	58.6	320494050	906412081	886430884
TN-32B	-	-	-	-	-	-	-
TN-40	-	-	-	-	-	-	-
TN-40HT	-	-	-	-	-	-	-
TN-68	-	-	-	-	-	-	-
TS125	226,118	4.3	0.0	66.9	341808710	1028985354	997966315

Reference: Table 5-11 [A7]

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APPENDIX B
ATLAS RAILCAR TO CASK/CRADLE INTERFACE DRAWING AND TIE-DOWN LOADING INPUTS

Atlas tie-down loading inputs are shown in Table B-1.

Table B-1. Tie-Down Loading Inputs (kips)

	Pin Location 1	**Pin Location 2**	**Pin Location 3**	**Pin Location 4**
Vertical (+z)	730	730	730	730
Vertical (-z)	730	730	730	730
Lateral (y) (3)	611	611	611	611
	Shear Block			
Axial (x)	2,921			
	Pin Location 5-8	**Pin Location 9-12**	**Pin Location 13-16**	**Pin Location 17-20**
Axial (+x)	0	944	228	0
Axial (-x)	0	228	944	0
Vertical (+z)	118	1,077	1,077	118
Vertical (-z)	1,077	118	118	1,077
Lateral (y)	145	145	145	145

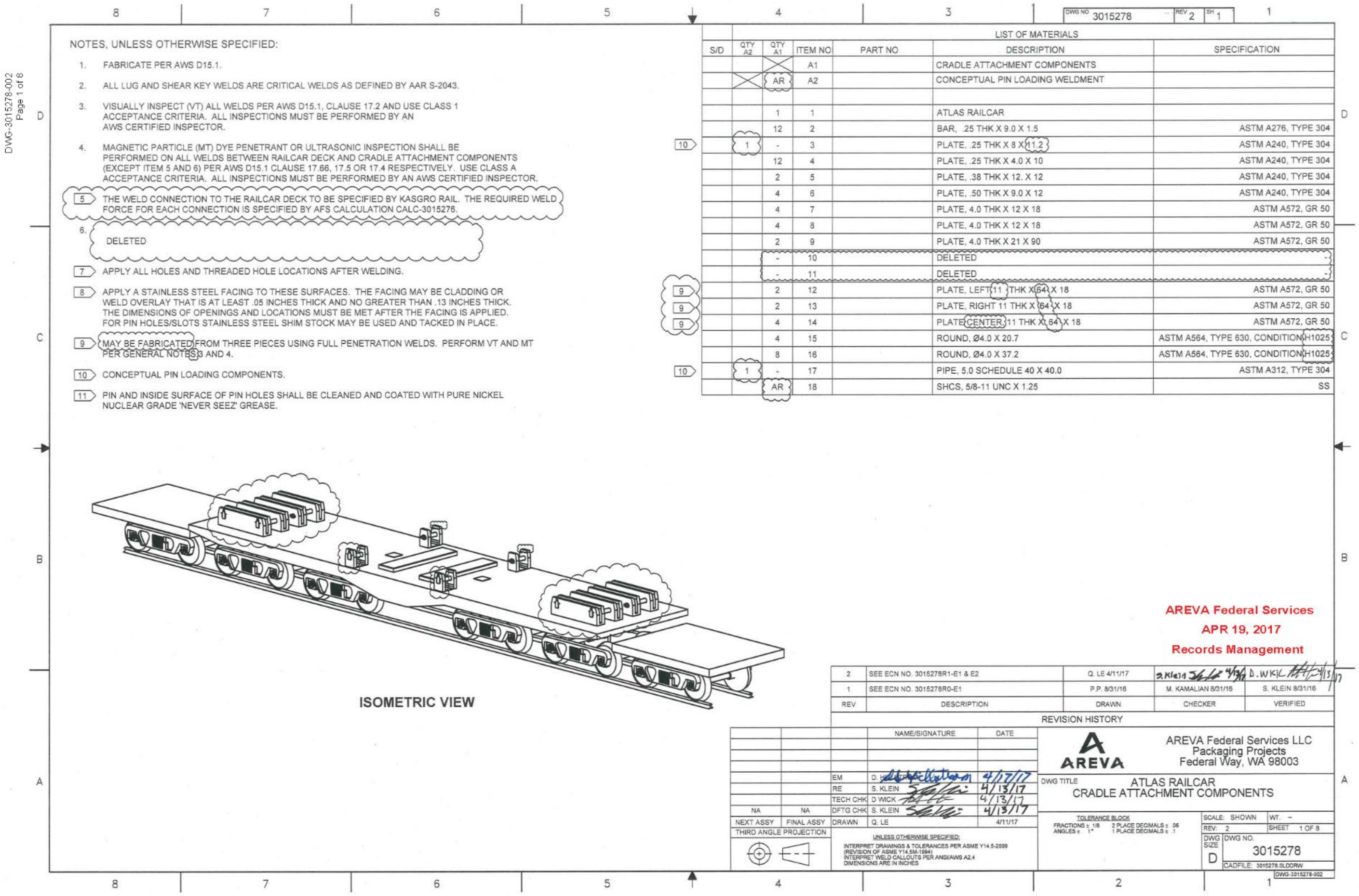
Notes:

1. Refer to AFS CALC-3015276, Table 4-2, for further information.
2. The Atlas railcar payloads are divided into 4 groups based on the cask tie-down methods. The values calculated above are based on the listed tie-down configuration. These four groups are referred to as *families* herein (see Appendix D for more information) and are briefly described below:
   - Family 1 Casks that need end stops to restrain axial (longitudinal) movement. The casks rest on single or multiple saddles with straps restraining lateral and vertical movement. Casks included in this family are TN-32, TN-40, TN-40HT, HISTAR 60, HI-STAR 100, HI-STAR-100HB, HI-STAR 180, HI-STAR 190SL and HI-STAR 190XL.
   - Family 2 Casks that are restrained axially and vertically by their lower trunnions (or pocket trunnions in some cases). Casks included in this family are MAGNATRAN, NAC-STC, NAC-UMS, and TN-68.
   - Family 3 Casks with an integral shear key. Casks included in this family are MP197, MP197HB, and TS-125.
   - Family 4 Casks with an integral shear key where the cask rests on multiple saddles, with a frame restraining vertical movement. The only cask in this family is the MP-187.
3. The bounding vertical load is calculated based on the following assumptions:
   a. Family 1 casks are assumed to be restrained without motion by the end stop assemblies, and if impact limiter and shims are required, they are assumed to be rigid under the securement tie-down loads (7.5 g).
   b. If the impact limiter could be crushed under load, then the cask vendor must add a shear key and address other features of the cradle that may be affected by the new load path. The vendor must also ensure that all SAR requirements are met.
   c. Shims (if required) are assumed to be rigid and captured.

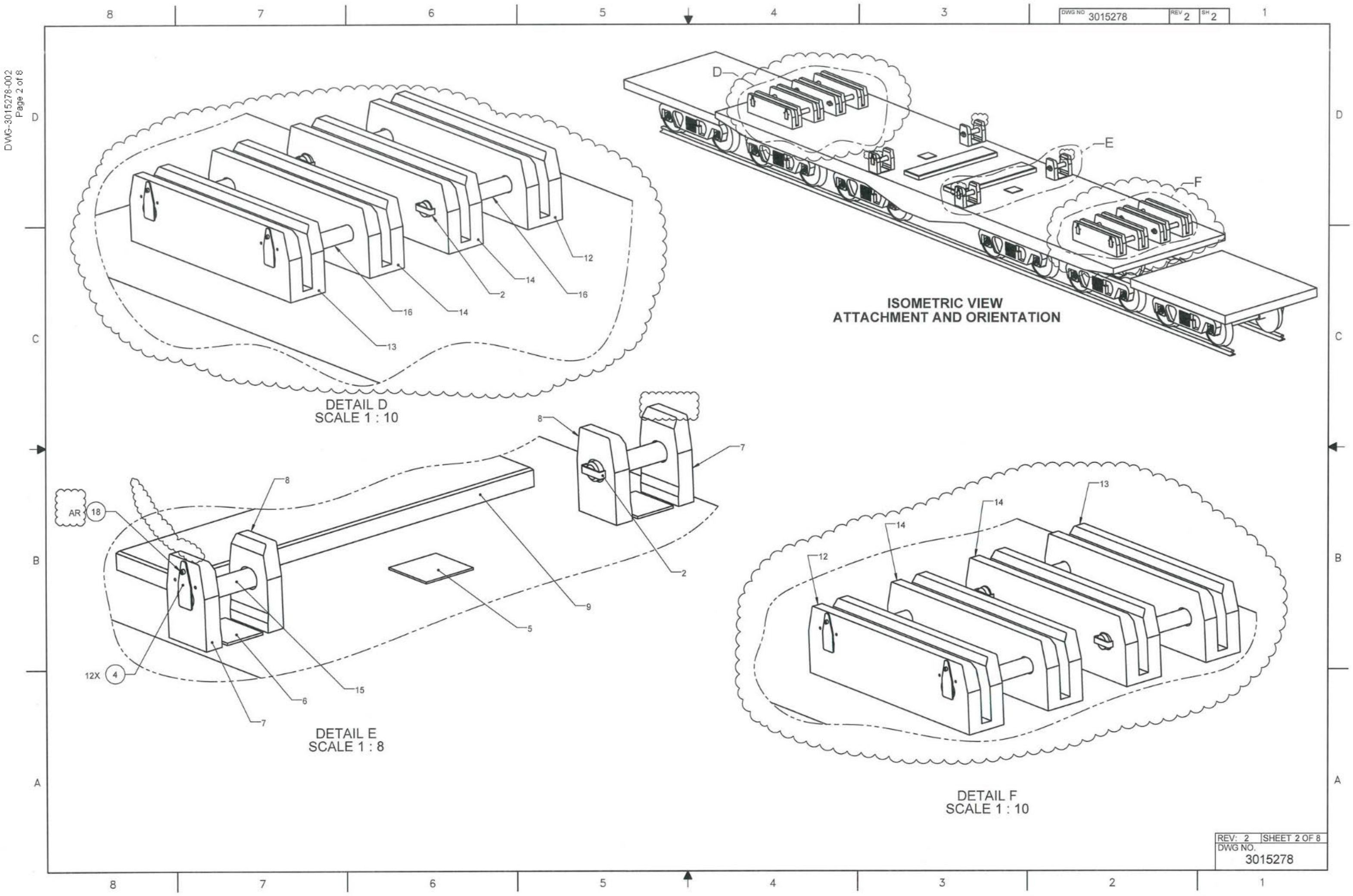
4. Conservatively, the lateral loading is assumed to result in a combined loading at one pin location. The maximum vertical load to be combined with the lateral load in the lateral load case is 312 kips.
5. AAR Rule 88 A.16.C(3) requires the following tie-down loads (g force to yield):
    a. 7.5g longitudinal
    b. 2g vertical
    c. 2g lateral

These loads shall be evaluated as static loads with no dynamic load factors applied. Loads are applied individually, not combined.

Figure B-1. Atlas Railcar Cradle Attachment Components.



Reference: Appendix B of the FS Atlas Railcar Phase 2 Report [Reference 1] (AFS CALC-3015276).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DWG-3015278-002
Page 2 of 8
D
E
F
ISOMETRIC VIEW
ATTACHMENT AND ORIENTATION
DETAIL D
SCALE 1 : 10
DETAIL E
SCALE 1 : 8
DETAIL F
SCALE 1 : 10
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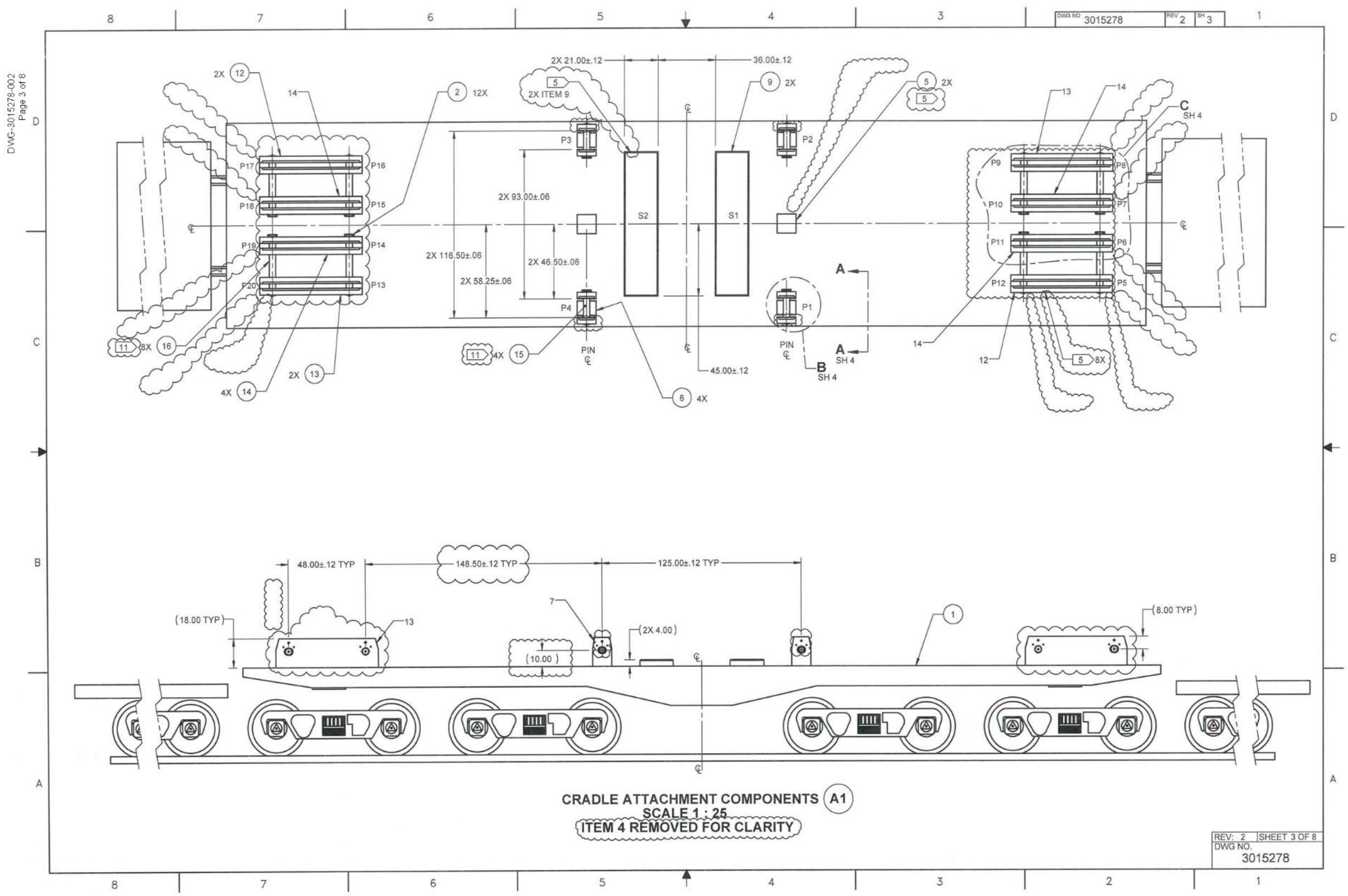
12X 4
REV: 2 SHEET 2 OF 8
DWG NO.
3015278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DWG-3015278-002
Page 3 of 8
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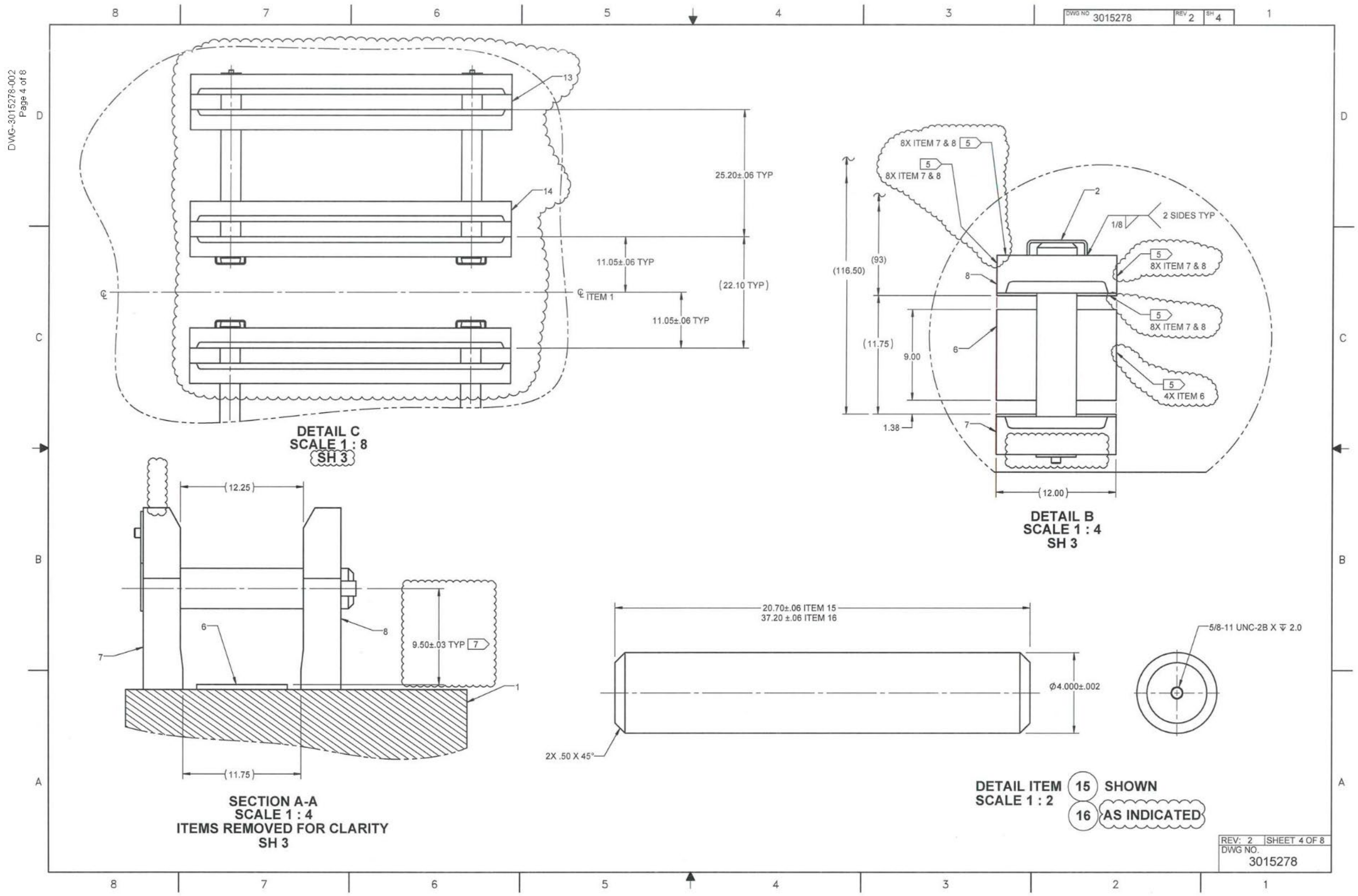
DWG NO.
3015278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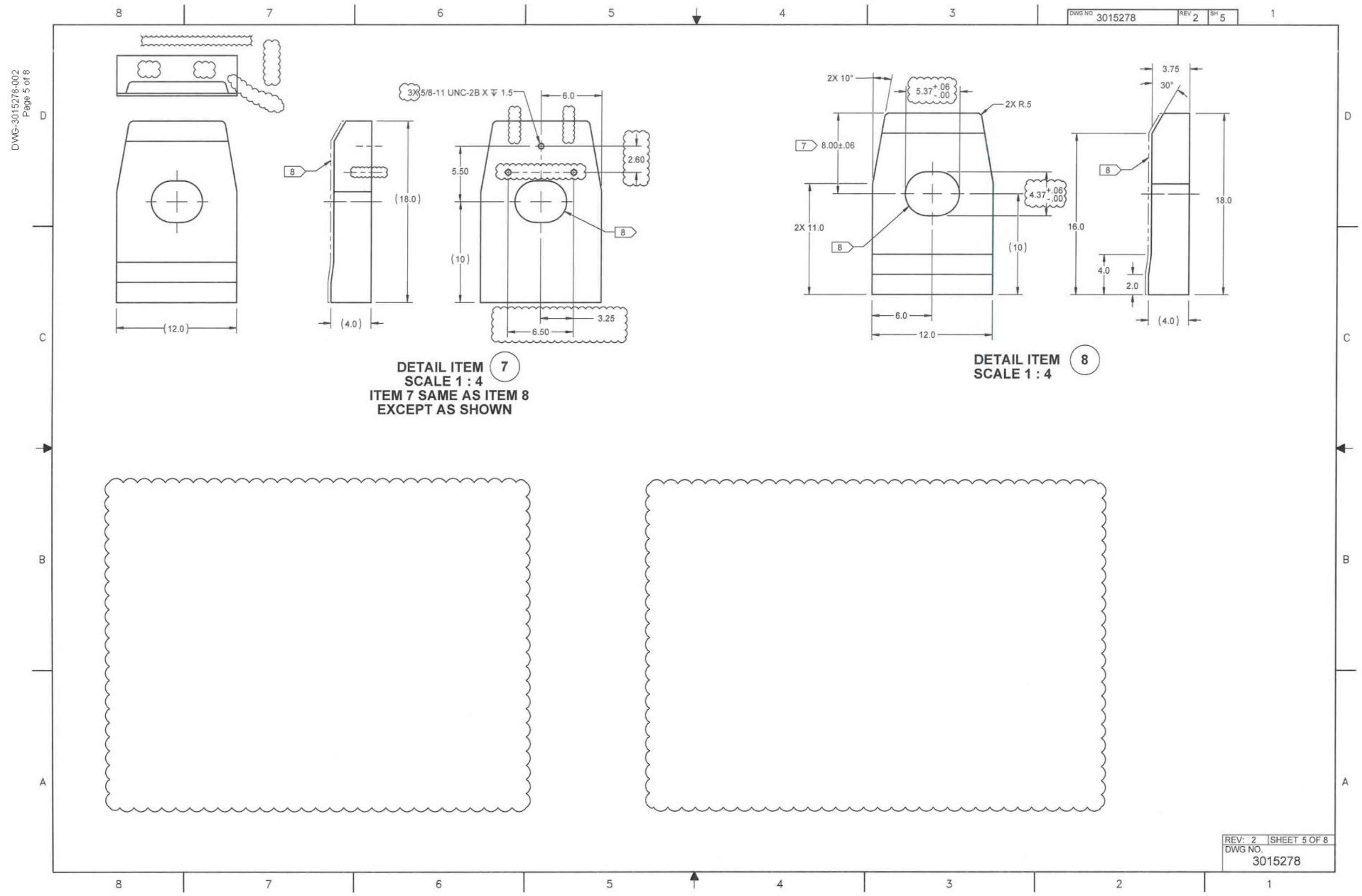
DWG-3015278-002
Page 4 of 8
25.20±.06 TYP
11.05±.06 TYP
(22.10 TYP)
℄ ITEM 1
11.05±.06 TYP
DETAIL C
SCALE 1 : 8
SH 3
8X ITEM 7 & 8
5
2 SIDES TYP
1/8
(116.50)
(93)
(11.75)
9.00
1.38
(12.00)
4X ITEM 6
DETAIL B
SCALE 1 : 4
SH 3
(12.25)
9.50±.03 TYP
(11.75)
SECTION A-A
SCALE 1 : 4
ITEMS REMOVED FOR CLARITY
SH 3
20.70±.06 ITEM 15
37.20 ±.06 ITEM 16
Ø4.000±.002
2X .50 X 45°
5/8-11 UNC-2B X ⊽ 2.0
DETAIL ITEM 15 SHOWN
SCALE 1 : 2
16 AS INDICATED
REV: 2 SHEET 4 OF 8
DWG NO.
3015278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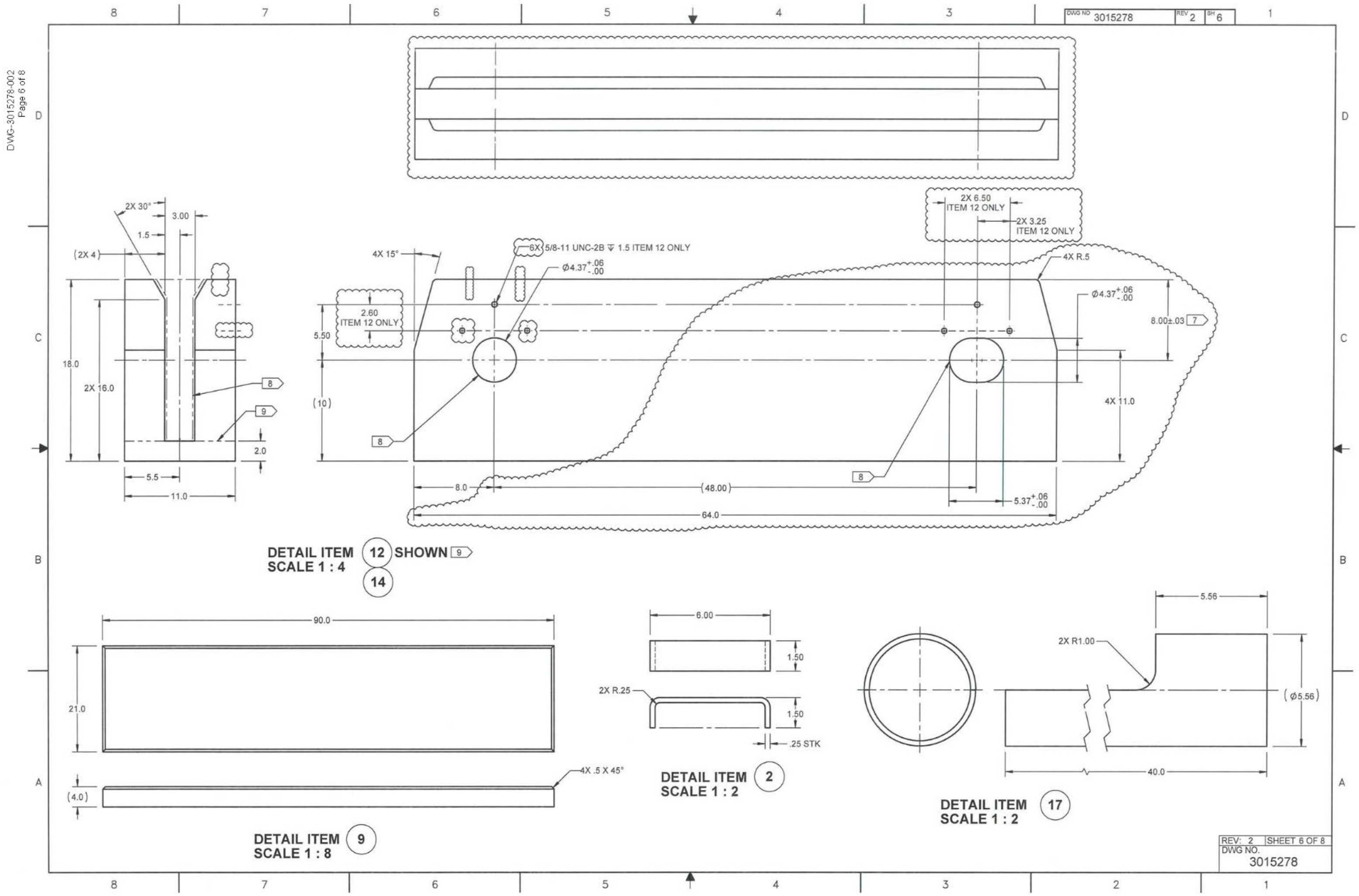
DWG-3015278-002
Page 5 of 8
3X 5/8-11 UNC-2B X ↧ 1.5
6.0
5.50
2.60
(18.0)
(10)
(12.0)
(4.0)
3.25
6.50
DETAIL ITEM 7
SCALE 1 : 4
ITEM 7 SAME AS ITEM 8
EXCEPT AS SHOWN
2X 10°
5.37 +.06 -.00
2X R.5
8.00±.06
4.37 +.06 -.00
2X 11.0
16.0
4.0
2.0
18.0
3.75
30°
12.0
DETAIL ITEM 8
SCALE 1 : 4
REV: 2 SHEET 5 OF 8
DWG NO.
3015278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Page 6 of 8
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SCALE 1 : 4
14
DETAIL ITEM 9
SCALE 1 : 8
DETAIL ITEM 2
SCALE 1 : 2
DETAIL ITEM 17
SCALE 1 : 2
2X 6.50
ITEM 12 ONLY
2X 3.25
ITEM 12 ONLY
6X 5/8-11 UNC-2B ↧ 1.5 ITEM 12 ONLY
2.60
ITEM 12 ONLY
4X R.5
8.00±.03
4X 11.0
64.0
(48.00)
90.0
21.0
4X .5 X 45°
6.00
2X R.25
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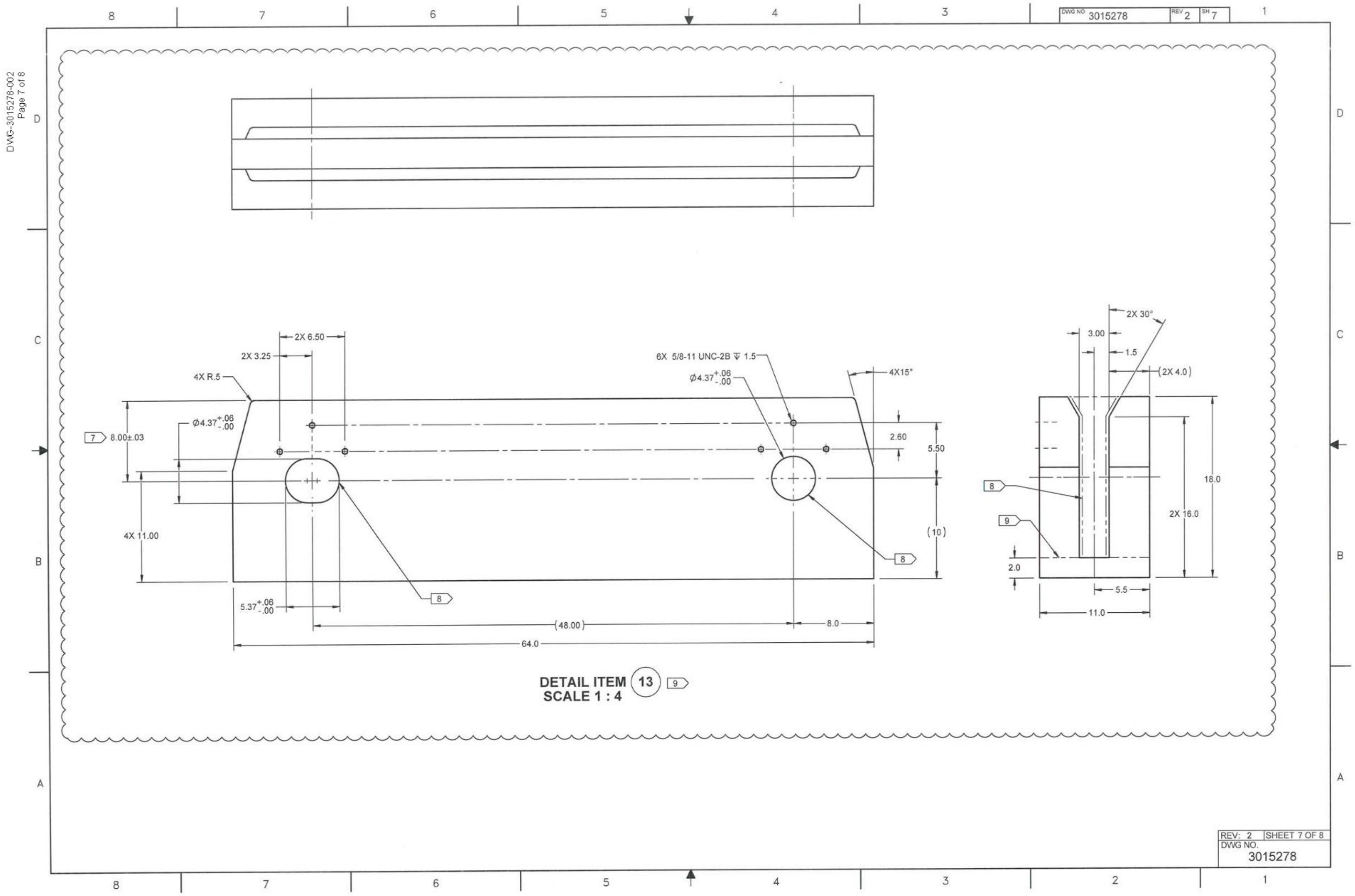
5.56
2X R1.00
(Ø5.56)
40.0
REV: 2 SHEET 6 OF 8
DWG NO.
3015278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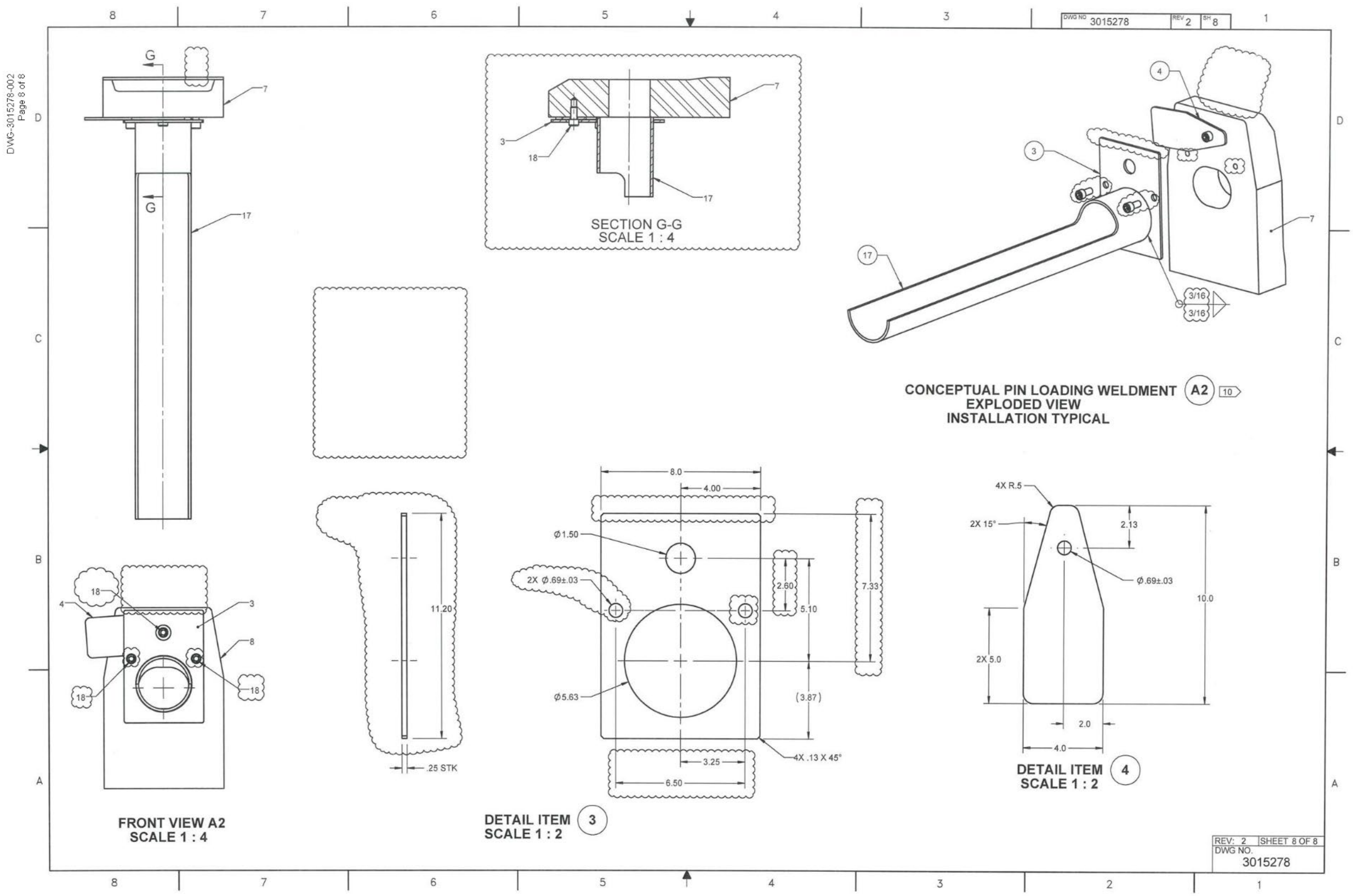
DWG-3015278-002
Page 7 of 8
2X 6.50
2X 3.25
4X R.5
Ø4.37 +.06 -.00
8.00±.03
4X 11.00
5.37 +.06 -.00
(48.00)
8.0
64.0
6X 5/8-11 UNC-2B ↧ 1.5
4X15°
2.60
5.50
(10)
2X 30°
3.00
1.5
(2X 4.0)
18.0
2X 16.0
2.0
5.5
11.0
DETAIL ITEM 13
SCALE 1 : 4
REV: 2 SHEET 7 OF 8
DWG NO.
3015278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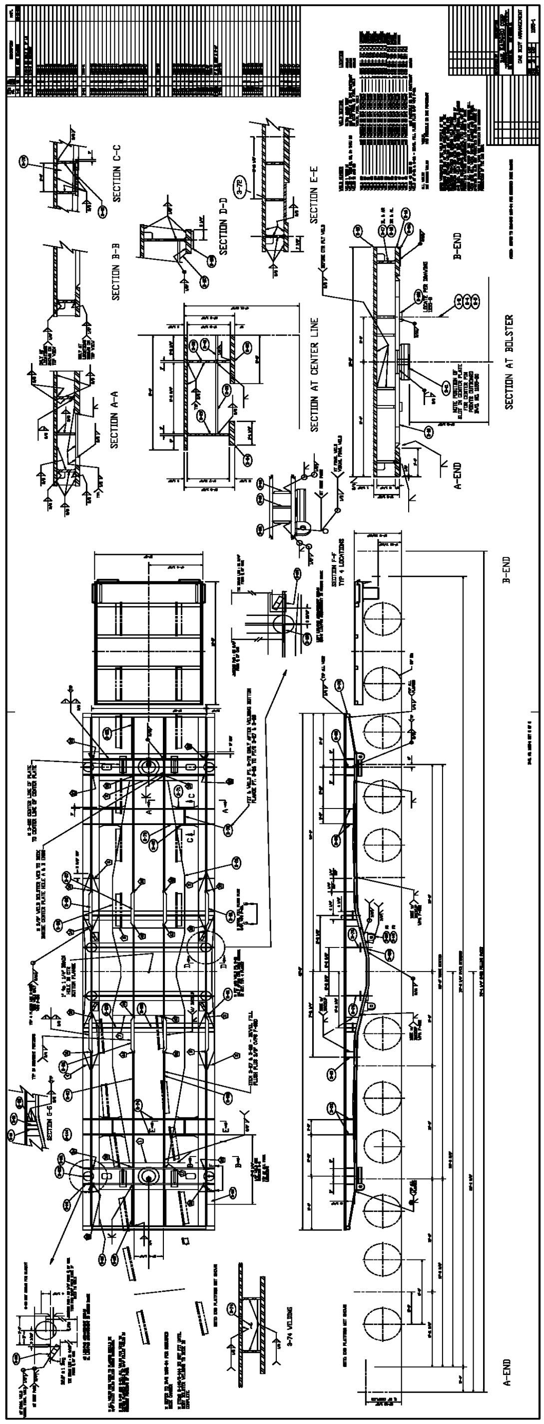
DWG-3015278-002 Page 8 of 8
SECTION G-G
SCALE 1 : 4
CONCEPTUAL PIN LOADING WELDMENT A2
EXPLODED VIEW
INSTALLATION TYPICAL
FRONT VIEW A2
SCALE 1 : 4
DETAIL ITEM 3
SCALE 1 : 2
DETAIL ITEM 4
SCALE 1 : 2
REV: 2 SHEET 8 OF 8
DWG NO.
3015278

APPENDIX C
ATLAS RAILCAR ARRANGEMENT DRAWING



Drawing provided for information only. (The Appendix B drawing is the interface control drawing.)

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APPENDIX D
CASK CRADLE CONCEPTUAL DESIGN

FS developed transport package cradle concepts for the 17 spent nuclear fuel transport casks using the information listed in Table D-1.

Table D-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	106.30	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	Up to 420,769
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 US 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 to ship from North Anna Nuclear Power Plant. The TN-32B does not currently have a transport certificate of compliance (CoC). 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. This is the diameter is of cask body, and it does not include trunnions.
f. These weights do not include the weights of any multi-purpose canister spacers that may be required.

Reference: FS Phase 1 report for Cradle Families 2 & 3, and Phase 2 report for Cradle Families 1 & 4.

The conceptual cradle designs were necessary to determine the height of the cask's CG above the railcar deck, the weight on each axle, etc., as required to perform analysis and provide the supporting information needed to design the Atlas railcar.

The 17 casks were divided into 4 groups based on the cask tie-down methods. This allowed a minimized number of required cradle designs, with each cradle grouping containing configurations for each cask. These four groups are referred to as *families*, and are described below, with full description in the following sections of this appendix:

Family 1 Casks with no shear keys that are supported axially on the ends of the impact limiters. The casks rest on single or multiple saddles, with straps restraining vertical movement. Casks included in this family are TN-32, TN-40, TN-40HT, HI-STAR 60, HI-STAR 100, HI-STAR-100HB, HI-STAR 180, HI-STAR 190SL and HI-STAR 190XL.

Family 2 Casks that are restrained axially and vertically by their lower trunnions (or pocket trunnions in some cases). Casks included in this family are MAGNATRAN, NAC-STC, NAC-UMS, and TN-68.

Family 3 Casks with an integral shear key. Casks included in this family are MP197, MP197HB, and TS-125.

Family 4 Casks with an integral shear key. The cask rests on multiple saddles, with a frame restraining vertical movement. The only cask in this family is MP-187.

The cradle–to–Atlas railcar connection was designed using common (standardized) attachment points that accommodate all cradle designs. All conceptual cradle designs were designed to attach to the railcar using the standardized attachment points. The standardized attachments are shown in Appendix B.

The conceptual cradle designs were developed using scoping hand calculations. Cradle weight and CG calculations were performed using hand calculations or spreadsheets. The stress criteria for sizing the conceptual cradle components was based on the 7.5g/2g/2g loading, with the resulting loads compared to material yield stress. Each cradle family is supported by a structural calculation and drawing. The individual cradle family structural calculations use first principle manual calculations to evaluate/size the primary structural members on the cradle concepts. Bounding or conservative component evaluations are used where appropriate to reduce the number of required evaluations. The lifting criteria applied to the conceptual cradles were conservative, in accordance with ANSI N14.6.

The conceptual design of each cradle was evaluated to provide good assurance that a design could be made to support the applied loads. Each cradle must support the 7.5g/2g/2g transportation loads taken individually. In addition, it was demonstrated that lifting load path components in the cradle can support the combined load of the cradle and package to support transfer between modes of transportation. The AAR Field Book Rule 88 was used to define the load cases for evaluation.

D.1 Atlas Railcar Cradle Family 1

Conceptual cradle designs in Family 1 support Holtec HI-STAR 100, HI-STAR-100HB, HI-STAR 180 HI-STAR 190SL and HI-STAR 190XL casks (Figure D-1), as well as Transnuclear TN-32B, TN-40, TN-40HT casks. Casks in Family 1 do not have shear keys and are restrained axially (longitudinally) on the ends of the cask impact limiters. The cask rests on multiple saddles which, along with tie-down straps, provide lateral and vertical restraint. The drawings for the Family 1 cradle are provided later in this appendix.

The Family 1 cradles use the same basic design configuration for each cask. The cask impact limiters interface with cradle end stops, which provide longitudinal support on each end of the cask. Casks rest on the central cradle frame, which includes multiple saddles with tie-down straps providing vertical restraint.

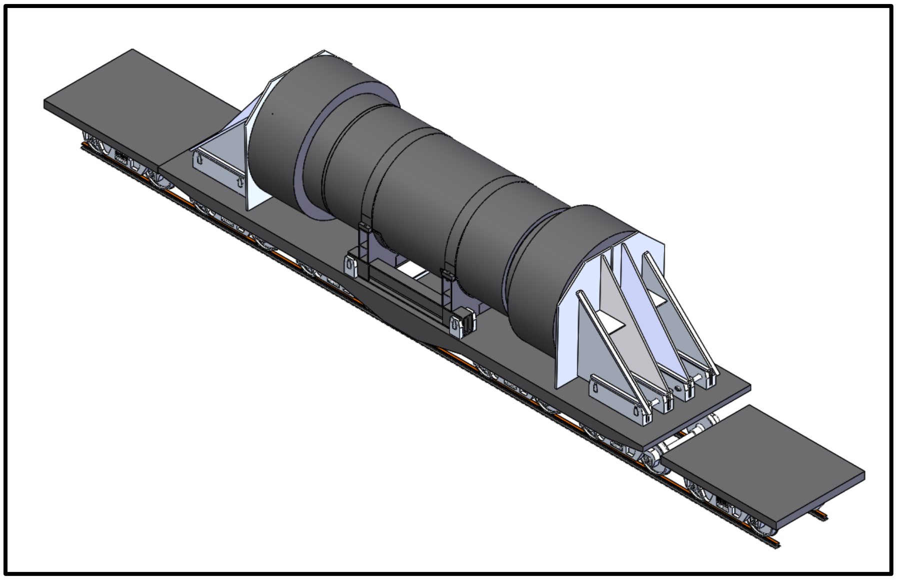

Figure D-1. Family 1 HI-STAR 190XL Cask, Conceptual Cradle, and End Stops.

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, combined with a lift beam to provide a vertical lift. A concept design 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 the surface or the proximity of the cask surface, where there is the potential for a high-temperature or radiological exposure. The material specified for this conceptual cradle is primarily carbon steel.

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 dimensions of 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 119 inches tall. The nominal central cradle weight varies between 13,364 and 13,636 lb, the end stop weight (per railcar end) varies between and 20,000 and 21,272 lb, and the total nominal conceptual cradle weight varies between 53,636and 55,909 lb.

It is assumed that the final HI-STAR 190 SL and 190 XL SAR will not change significantly from the current draft version. These casks are not yet certified under 10 CFR Part 71.

The TN-40, TN-40HT and TN-32 central cradles have three cut-outs in the cradle weldment that allow clearance for cask tie-rod installation. Package tie-rods are used to attach the impact limiters to the package.

All Family 1 cradle concepts are approximately 505 to 535 inches long (to the outside end of the end stop assemblies which includes the cask length). The dimensions of the end stop assemblies vary from 82 to 132 inches long and 100 to 142 inches tall. The central cradle is approximately 137 inches long and varies from 82 to 132 inches tall. The nominal central cradle weight varies between 9,000 and 21,272 lb, the end stop weight (per railcar end) varies between and 22,600 and 28,600 lb and the total cradle weight varies between 53,686 and 70,200 lb.

There are small variations in the Family 1 cradle designs compared to the designs depicted in the SARs. These differences are due to variations in the Atlas railcar cradle requirements and omission of information in the publicly available SARs. Some cask centerline heights depicted in SAR cradle drawings may not match SAR (figure or cradle drawing) locations. If dimensions were included in the SAR text, then they were met. For example, the SAR cradle drawing for TN-40 shows the cask centerline (radial CG) much higher than the centerline in the final design. Additionally, the HI-STAR 60 has an option to be axially supported at the trunnions instead of the end stops. However, as documented in FS-RFI-00225-010-00, FS chose to support HI-STAR 60 with end stops. Even with these differences, the conceptual cradle designs accommodate loads that should bound the final design railcar loads for each of these casks.

D.2 Atlas Railcar Cradle Family 2

Conceptual cradle designs in Family 2 support NAC International NAC MAGNATRAN®, NAC-STC™, and NAC-UMS™ casks, Transnuclear TN-68 (Figure D-2). Casks in Family 2 are restrained axially and vertically by their lower trunnions (or pocket trunnions in some cases). DWG-3015138, “Atlas Railcar Cradle Family 2 (NAC International [NAC]) Conceptual Drawing,” is included later in this appendix.

The NAC cradles use the same basic design configuration for each cask. The cask trunnions or trunnion pockets interface with the cradle trunnion interface, which provides axial and vertical restraint for the cask. The opposite end of the cask rests on a front saddle and is constrained vertically with a front strap tie-down. Axial cask support is also provided by the fastened front saddle, which interfaces with the cask’s upper forging. The cradle frame is constructed from two main I-beams which sandwich the center cradle shear block and other cross members. The trunnion interface is tied into the bottom and front saddle with plates running down the length of the cradle side. The front saddle is fastened to the cradle frame using bolts. There are four pin locations for attachment of the cradle to the railcar. These pin locations provide vertical cradle restraint. Longitudinal cradle restraint is provided by the cradle shear block, and lateral restraint is provided by the main frame I-beams, both of which interface with the railcar.

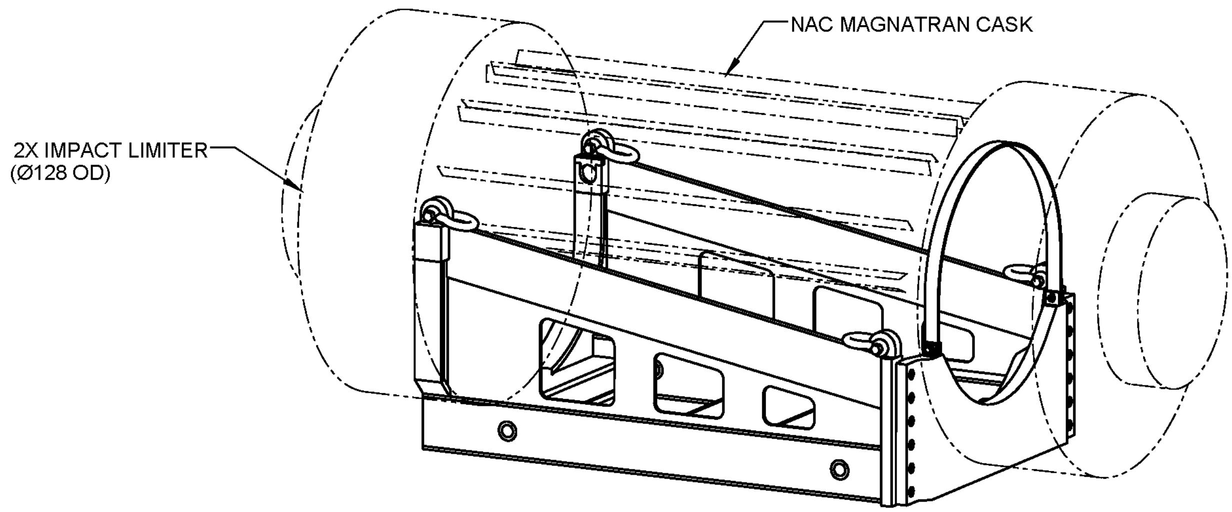

Figure D-2. Family 2 NAC MAGNATRAN Conceptual Cradle Design.

The TN-68 has a similar design to the NAC cradles, but with a different trunnion tower and front saddle design. These features were changed to accommodate the slightly different tie-down methodology. The front saddle and front strap provide vertical restraint, and the saddle includes cutouts that provide clearance for package tie-rods, which are used to attach the impact limiters to the package. The trunnion interface is a trunnion tower and cap for axial and vertical cask restraint.

The NAC conceptual cradles and loaded package can be lifted using hoist rings installed in the four lifting lugs on the corners of the cradle frame and combined with a lift beam. The TN-68 conceptual cradle and loaded package can be lifted using four bolted or welded lift lugs attached to the side main cradle frame inboard of the railcar pin attachment points. A lift beam should be used to provide a vertical lift. A concept design of a personnel barrier is included in the conceptual cradle design to meet package SAR requirements and to provide a reasonable cradle weight. The material specified for the Family 2 conceptual cradle is primarily carbon steel, with bronze specified for the cask trunnion interface, and aluminum specified for the personnel barrier.

All of the Family 2 cradle concept designs are approximately 150 to 190 inches long and 80 to 90 inches tall. The nominal cradle weight varies between 27,000 and 42,000 lb.

The cradle designs in this family have small variations when compared to the designs depicted in the SARs. These differences are due to variations in the Atlas railcar cradle requirements and omission of information in the publicly available SARs. Specifically, the NAC cradle drawings are listed in the NRC Certificate of Compliance (CoC) but are not available to the public. Even with these differences, the conceptual cradle designs accommodate loads that should bound the final design railcar loads for each of these casks.

D.3 Atlas Railcar Cradle Family 3

Conceptual cradle designs in Family 3 support AREVA TN MP197 and MP197HB casks, as well as the Energy Solutions TS125 cask (Figure D-3). Casks in Family 3 are restrained axially by an integral shear key and vertically by saddles and tie-down straps. DWG-3015139, "Atlas Railcar Cradle Family 3 Conceptual Drawing," is included later in this appendix.

The Family 3 cradles use the same basic design configuration for each cask. The cask rests on front and rear saddles which, along with the tie-down straps, provide vertical cask restraint. Axial cask support is provided by a shear key that protrudes into the cask. The cradle frame is constructed from two main I-beams which sandwich the center cradle shear block and saddle cross members. There are four pin locations for attachment to the cradle railcar. These pin locations provide vertical cradle restraint. Longitudinal cradle restraint is provided by the cradle shear block, and lateral restraint is provided by the main frame I-beams, both of which interface with the railcar.

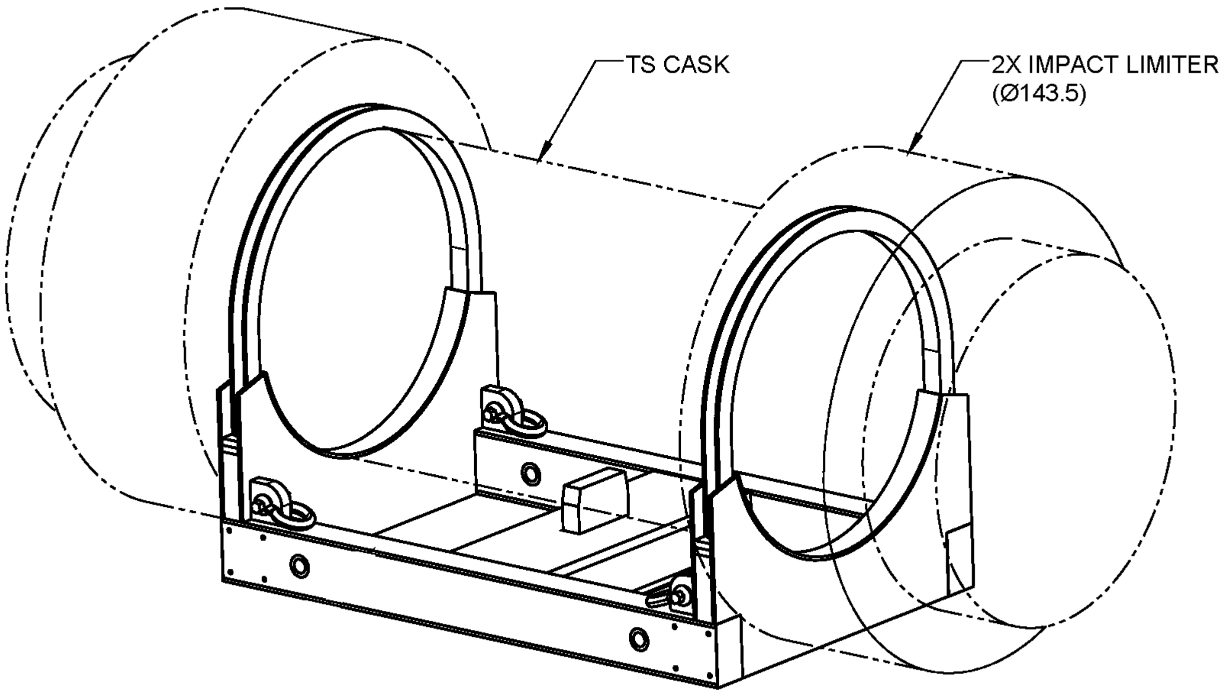

Figure D-3. Family 3 EnergySolutions TS125 Conceptual Cradle Design.

The Family 3 conceptual cradles and loaded package can be lifted using shackles installed in the four lifting lugs on the top of the cradle frame I-beams combined with a lift beam to provide a vertical lift. Detailed cradle designers should note that the four lifting lugs may not be accessible when the personnel barrier is in place, so considerations should be made during the cradle's detailed design. Optionally, bolt-on lift lugs may be used as attachment points instead of the gusset attachment points. However, the bolt-on lift lugs must be removed for transport. A concept design of a personnel barrier is included for each cask in the conceptual cradle design to meet package SAR requirements and to provide a reasonable cradle weight for supporting cask railcar bounding load calculations. The Family 3 conceptual cradle is primarily carbon steel, with stainless steel specified for the personnel barrier.

All of the Family 3 cradle concept designs are approximately 180 inches long and 114–126 inches tall. The nominal cradle weight varies between 26,000 and 30,000 lb.

The cradle designs in this family have small variations in the conceptual cradle designs when compared to the designs depicted in the SARs. These differences are due to variations in the Atlas railcar cradle requirements and omission of information in the publicly available SARs. Lifting provisions were not included in the original AREVA TN MP197 and 197HB public SARs, which drove adjustments in the saddle gusset design to allow for a lifting lug provision. A similar provision was provided in the TS125 cradle, while maintaining bolt-on lifting lugs.

Details of the cradle side rail size and design for each cradle were developed to support Atlas railcar loads based on a shared connection point design. Sizing of the personnel barriers was based on the nominal 1-inch impact limiter–to–deck height requirement and the height of the side rails. Even with these differences, the cradle designs accommodate loads that should bound the final design rail car loads for each of these casks.

D.4 Atlas Railcar Cradle Family 4

The conceptual cradle design in Family 4 supports the AREVA TN MP-187 package. The cask has an integral shear key, rests on multiple saddles, and has a structural frame resisting vertical movement. DWG-3015140-001, "Atlas Railcar Cradle Family 4 Conceptual Drawing," is included later in this appendix.

For the Family 4 cradle (Figure D-4), the cask rests on front and rear saddles which, along with the installed structural fame, provides vertical and lateral cask restraint. Axial cask restraint is provided by a shear key that protrudes into the cask. The cradle frame is constructed from two main I-beams which sandwich the center cradle shear interface and saddle cross members. There are four pin locations for attachment of the cradle to the railcar. These pin locations provide vertical cradle restraint. Longitudinal cradle restraint is provided by the cradle shear interface, and lateral restraint is provided by the main frame I-beams, both of which interface with the railcar.

The Family 4 conceptual cradle and loaded package can be lifted using hoist rings installed in the four threaded lift point holes located on the top of the cradle structural frame and combined with a lift beam to provide a vertical lift. A concept design of a personnel barrier is included in the conceptual cradle design to meet package SAR requirements and to provide a reasonable cradle weight. The material specified for the Family 4 conceptual cradle is primarily carbon steel, with stainless steel specified for the personnel barrier.

The Family 4 cradle concept is approximately 138 inches long and 124 inches tall. The nominal cradle weight is 36,800 lb.

The cradle design in this family has small variations when compared to the design depicted in the SARs. These differences are due to the Atlas railcar cradle requirements and the cradle depicted in the SAR. Even with these differences, the conceptual cradle designs accommodate loads that should bound the final design railcar loads for this cask.

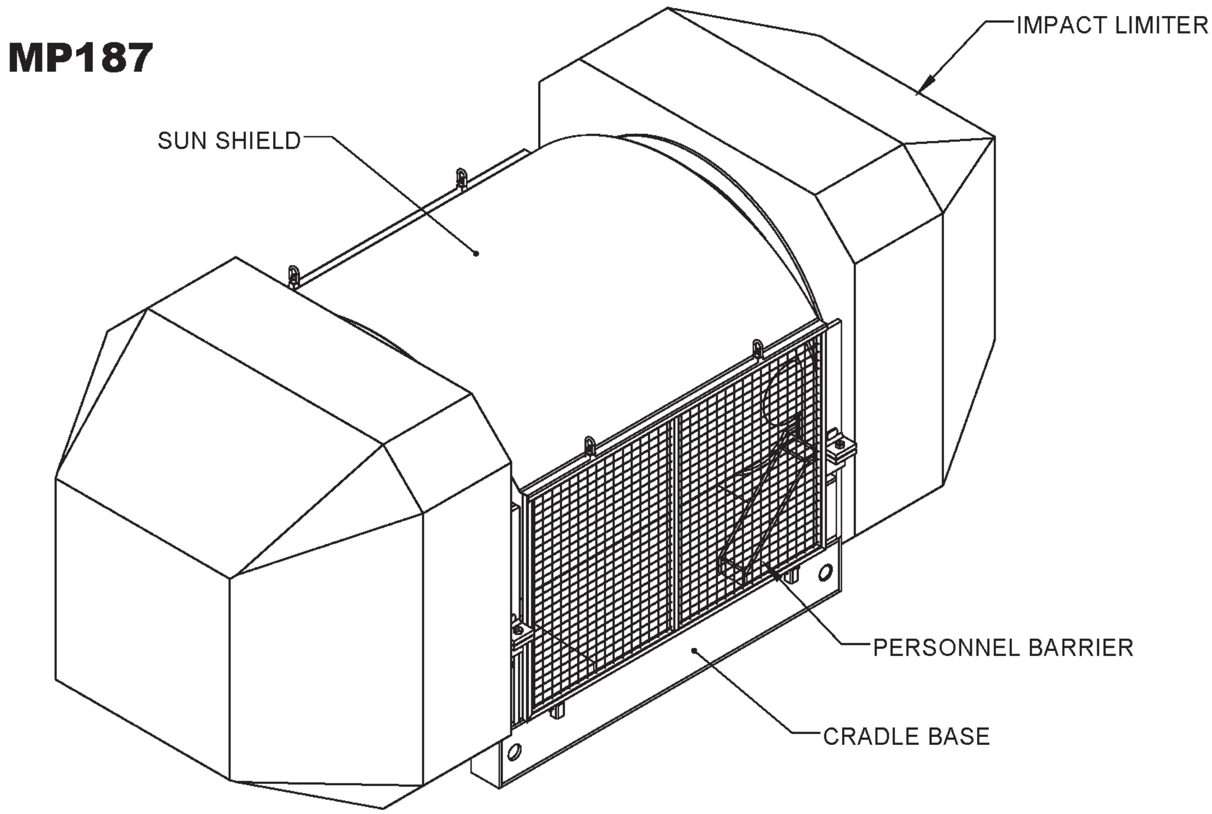

Figure D-4. Family 4 Areva TN MP187 Cask and Conceptual Cradle.

Family 1 Conceptual Cradle Drawings

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DWG NO 3015137 REV 2 SH 1

NOTES, UNLESS OTHERWISE SPECIFIED:

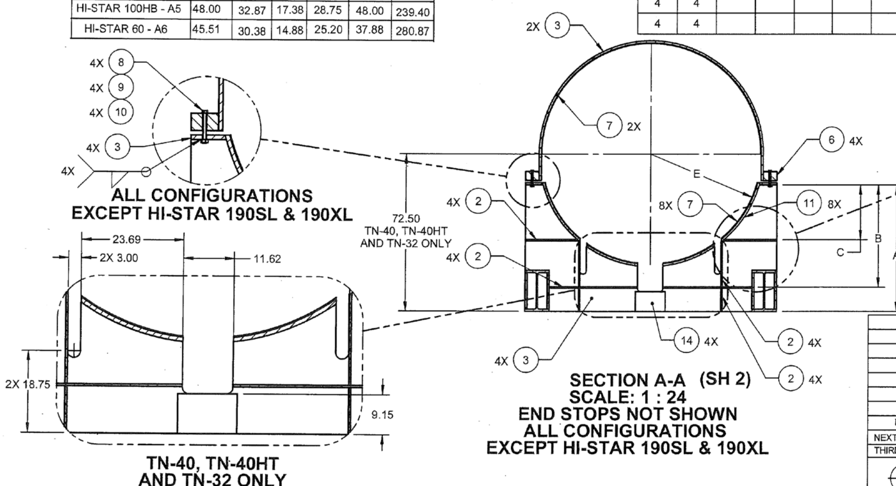
1. CONCEPTUAL DESIGN ASSUMES ALL WELDS ARE FULL PENETRATION UNLESS OTHERWISE NOTED. ALL WELDS WILL BE FURTHER SPECIFIED IN A FINAL DESIGN.
2. FABRICATION SHALL BE PERFORMED IN ACCORDANCE WITH AWS D1.1.
3. DIMENSIONS WITH TOLERANCES SPECIFIED ARE RAILCAR INTERFACE DIMENSIONS AND SHOULD BE CONSIDERED DURING FINAL CRADLE DESIGN.
4. ALL SURFACES OF THE CRADLE WELDMENT, EXCEPT FOR THREADED HOLES AND THE 4.13 DIAMETER HOLES, SHALL BE BLAST CLEANED PER SSP-SP-10 AND COATED WITH SELF-PRIMING ENAMEL, 2 COATS. THE NON-PAINTED CRADLE WELDMENT SURFACES SHALL BE LIGHTLY COATED WITH NUCLEAR GRADE "NEVER-SEEZ" GREASE.
5. ATTACHMENTS FOR PERSONNEL BARRIER TO THE CRADLE ARE TO BE DEFINED DURING THE FINAL DESIGN.
6. THE ADDITION OF ALIGNMENT MARKS BETWEEN THE CRADLE AND RAILCAR INTERFACE SHOULD BE CONSIDERED IN THE DETAILED DESIGN TO SUPPORT LOADING OPERATIONS.
7. CASK AND ATTACHED CRADLE ARE LIFTED USING A LIFTING STRAP LOCATED BENEATH THE PROTRUDING CRADLE PLATES (ITEM 11) LOCATED INTERIOR TO THE END SADDLES AND COMBINED WITH A LIFTING BEAM.
8. FOLLOWING INSTALLATION OF CENTRAL CRADLE, CASK WITH IMPACT LIMITERS AND END STOPS ON RAILCAR, INSTALL SHIMS BETWEEN END STOPS AND IMPACT LIMITERS TO CLOSE GAP.
9. END STOPS FOR ASSEMBLIES A1 AND A2 EXCEED AAR PLATE E DIMENSIONS WHEN INSTALLED IN TRANSPORTATION CONFIGURATION.
10. LOCATE 2 SHACKLES OR HOIST RINGS FOR LIFTING END STOPS ABOVE CENTER OF GRAVITY LOCATIONS IDENTIFIED IN TABLE 1 MINIMUM WORKING LOAD TO BE AS SHOWN IN TABLE 1. ALTERNATIVELY, USE SLOTTED HOLES AT OR ABOVE THE LOCATIONS SHOWN AND INSTALL ENDLESS STRAPS FOR LIFTING.

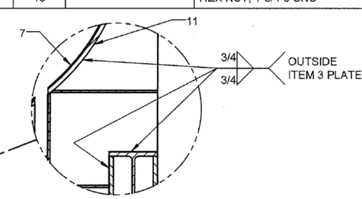
LIST OF MATERIALS

QTY A8	QTY A7	QTY A6	QTY A5	QTY A4	QTY A3	QTY A2	QTY A1	ITEM NO	PART NO	DESCRIPTION	SPECIFICATION
							X	A1		TN-40 AND TN-40HT CRADLE ASSEMBLY	
						X		A2		TN-32 CRADLE ASSEMBLY	
					X			A3		HI-STAR 180 CRADLE ASSEMBLY	
				X				A4		HI-STAR 100 CRADLE ASSEMBLY	
			X					A5		HI-STAR 100HB CRADLE ASSEMBLY	
		X						A6		HI-STAR 60 CRADLE ASSEMBLY	
	X							A7		HI-STAR 190SL CRADLE ASSEMBLY	
X								A8		HI-STAR 190XL CRADLE ASSEMBLY	
2	2	2	2	2	2	2	2	1		W18X119	ASTM A992
12	12	16	16	24	14	16	16	2		PLATE, 1/2 THK	ASTM A572, GR 50
18	18	18	18	23	14	26	26	3		PLATE, 1 THK	ASTM A572, GR 50
		16	16	16	16	16	16	4		PLATE, 1/4 THK	ASTM A572, GR 50
28	28	24	24	24	24	24	24	5		PLATE, 2 THK	ASTM A572, GR 50
4	4	4	4	6	4	4	4	6		PLATE, 4 THK	ASTM A572, GR 50
4	4	4	3	4	4	10	10	7		RUBBER, 1/4 THK	80 DURO
		4	4	6	4	4	4	8		HEX BOLT, 1 1/2-6 UNC X 7 LG	ASTM A490, TYPE 1
		4	4	6	4	4	4	9		WASHER, Ø1 1/2 NOM	ASTM F436
		4	4	6	4	4	4	10		HEX NUT, 1 1/2-6 UNC	ASTM A563, GR DH PLAIN
2	2	2	1	1	2	8	8	11		CRADLE PLATE, 1 THK	ASTM A572, GR 50
10	10	10	10	10	10	10	10	12		ANGLE, 3 X 3 X 1/4	ASTM A36
4	4	4	4	4	4	4	4	13		EXPANDED METAL	RYTEX 1-1/2 NO. 6 OR EQUIV
		4	4	6	4	4	4	14		BAR, 3.25 X 9.15 X 13.63	ASTM A572, GR 50
4	4							15		PLATE OR BAR, 5 X 11 1/2 X 50.7	ASTM A572, GR 42
16	16							16		PLATE, 1 1/4 THK	ASTM A572. GR 65
4	4							17		SHCS, 1-3/4-5 UNC X 7.25 LG	ASTM A574
4	4							18		WASHER, Ø1 3/4 NOM	ASTM F436
4	4							19		HEX NUT, 1-3/4-5 UNC	ASTM A563, GR DH PLAIN

CRADLE DIMENSIONS TABLE:

CONFIGURATIONS	DIMENSIONS					
	A	B	C	D	E	F
TN-40 - TN-40HT - A1	58.36	47.11	25.28	32.51	50.50	262.75
TN-32B - A2	58.79	47.54	23.52	32.51	48.88	259.75
HI-STAR 180 - A3	49.68	39.58	16.48	23.13	53.15	294.50
HI-STAR 100 - A4	48.00	32.87	17.38	28.75	48.00	315.71
HI-STAR 100HB - A5	48.00	32.87	17.38	28.75	48.00	239.40
HI-STAR 60 - A6	45.51	30.38	14.88	25.20	37.88	280.87





Orano Federal Services
OCT 23 2018
Records Management

REV	DESCRIPTION
2	ECN NO. 3015137R1-E1 & E2
1	ECN NO. 3015137R0-E1

REVISION HISTORY

	NAME/SIGNATURE	DATE
EM	DJH [signature]	10/22/18
RE	S. Klein [signature]	10/15/18
TECH CHK	E. Conley [signature]	10/16/18
DFTG CHK	[signature]	10/12/18
DRAWN	T. MARTIN	10/09/18

NEXT ASSY: NA | FINAL ASSY: NA

THIRD ANGLE PROJECTION

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5-2009 (REVISION OF ASME Y14.5M-1994)
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

orano
Orano Federal Services LLC
Packaging Projects
Federal Way, WA 98003

DWG TITLE: ATLAS RAILCAR CRADLE FAMILY 1 CONCEPTUAL DRAWING

SCALE: SHOWN | WT. ~ LBS
REV: 2 | SHEET 1 OF 8
DWG SIZE: D | DWG NO. 3015137
CADFILE: 3015137-2.SLDDRW

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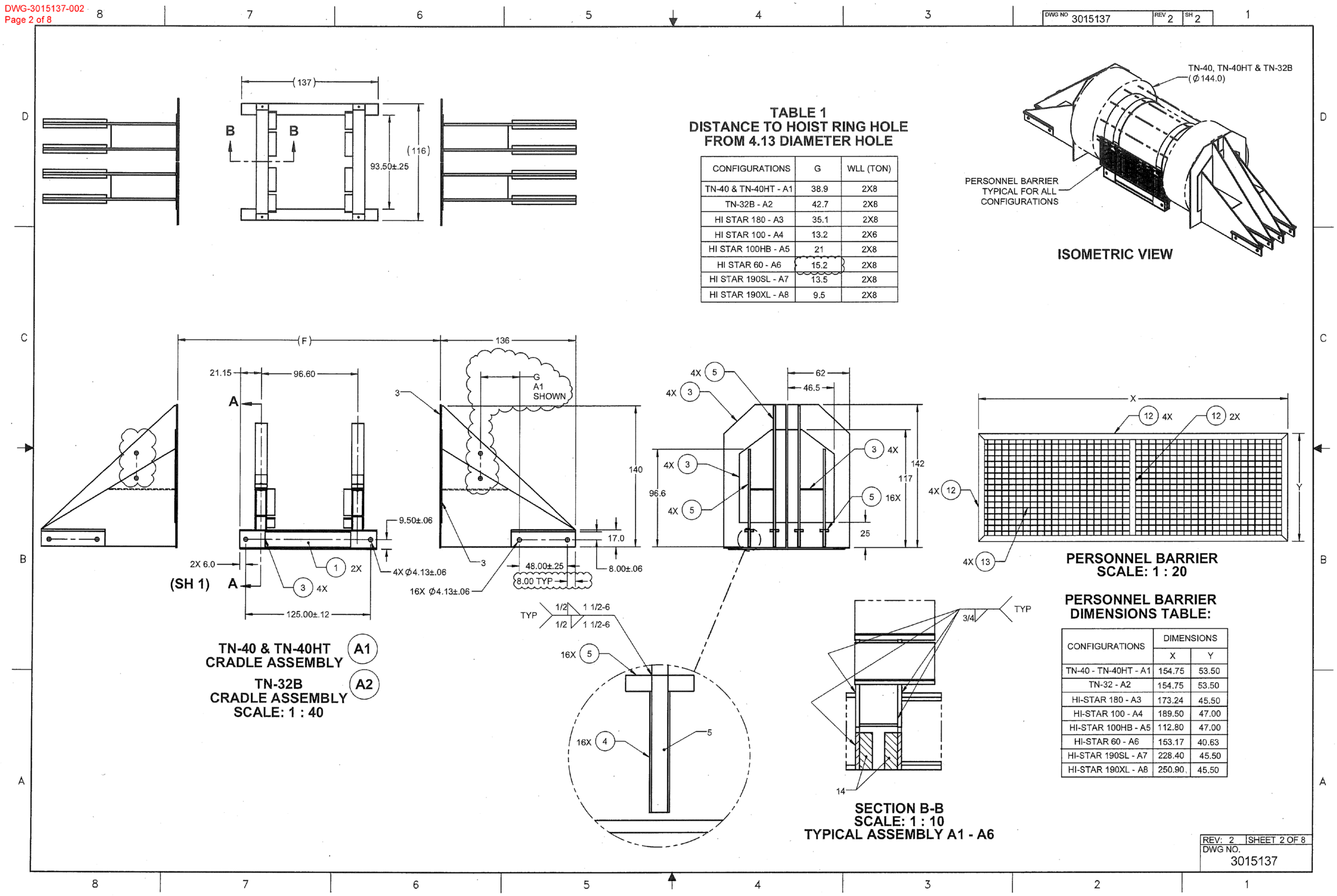

TABLE 1
DISTANCE TO HOIST RING HOLE FROM 4.13 DIAMETER HOLE

CONFIGURATIONS	G	WLL (TON)
TN-40 & TN-40HT - A1	38.9	2X8
TN-32B - A2	42.7	2X8
HI STAR 180 - A3	35.1	2X8
HI STAR 100 - A4	13.2	2X6
HI STAR 100HB - A5	21	2X8
HI STAR 60 - A6	15.2	2X8
HI STAR 190SL - A7	13.5	2X8
HI STAR 190XL - A8	9.5	2X8

PERSONNEL BARRIER DIMENSIONS TABLE:

CONFIGURATIONS	DIMENSIONS X	DIMENSIONS Y
TN-40 - TN-40HT - A1	154.75	53.50
TN-32 - A2	154.75	53.50
HI-STAR 180 - A3	173.24	45.50
HI-STAR 100 - A4	189.50	47.00
HI-STAR 100HB - A5	112.80	47.00
HI-STAR 60 - A6	153.17	40.63
HI-STAR 190SL - A7	228.40	45.50
HI-STAR 190XL - A8	250.90	45.50

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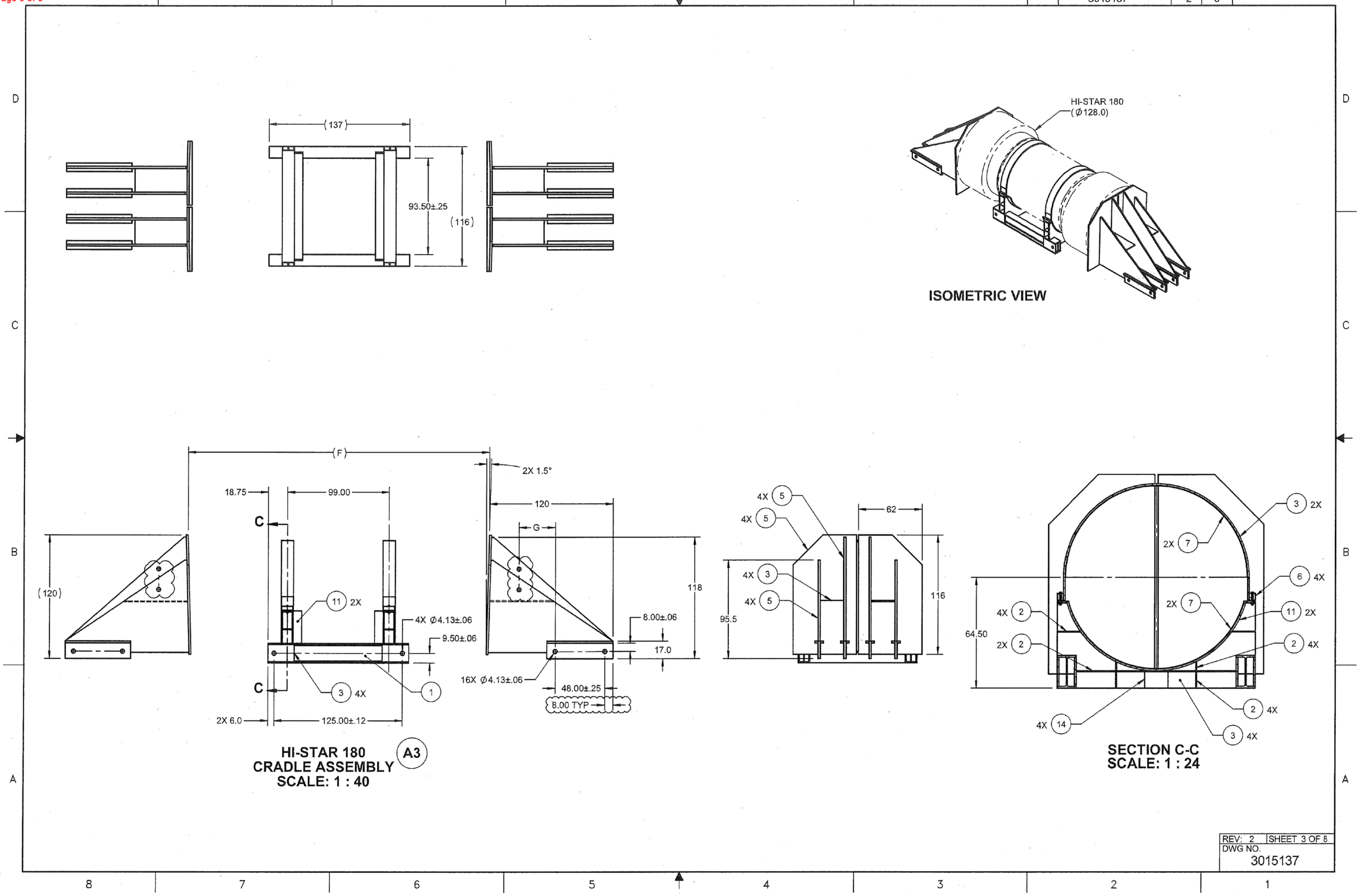

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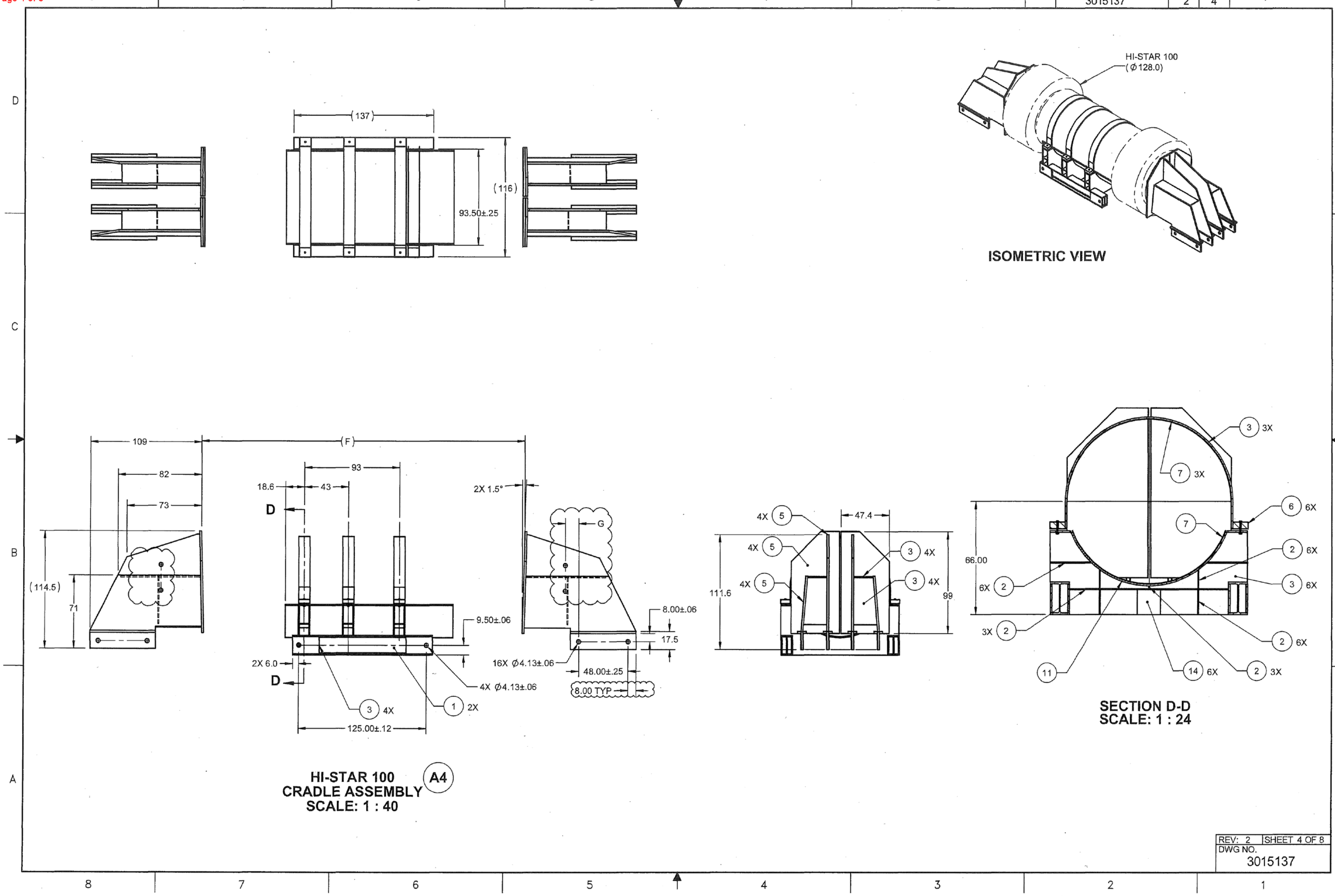

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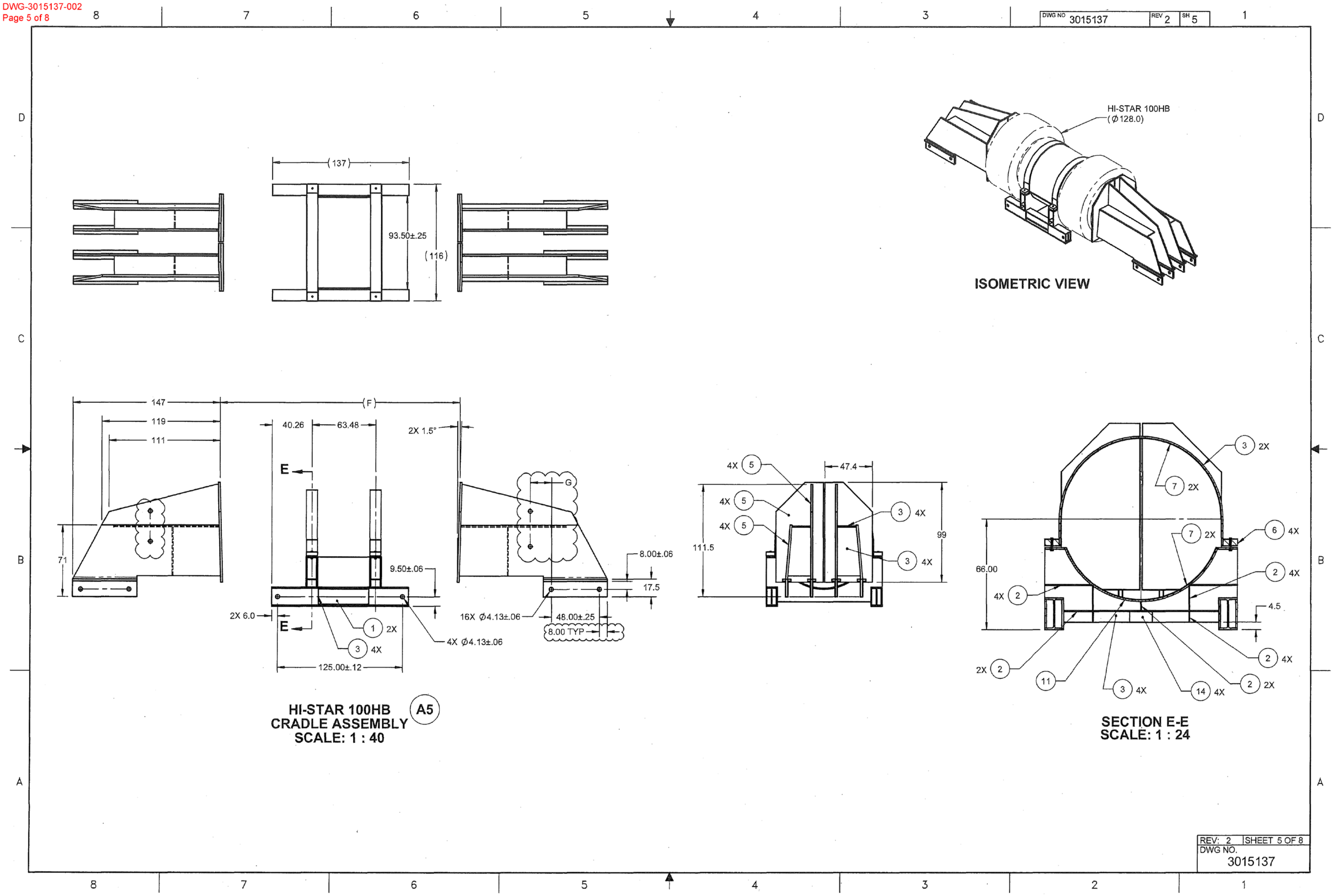

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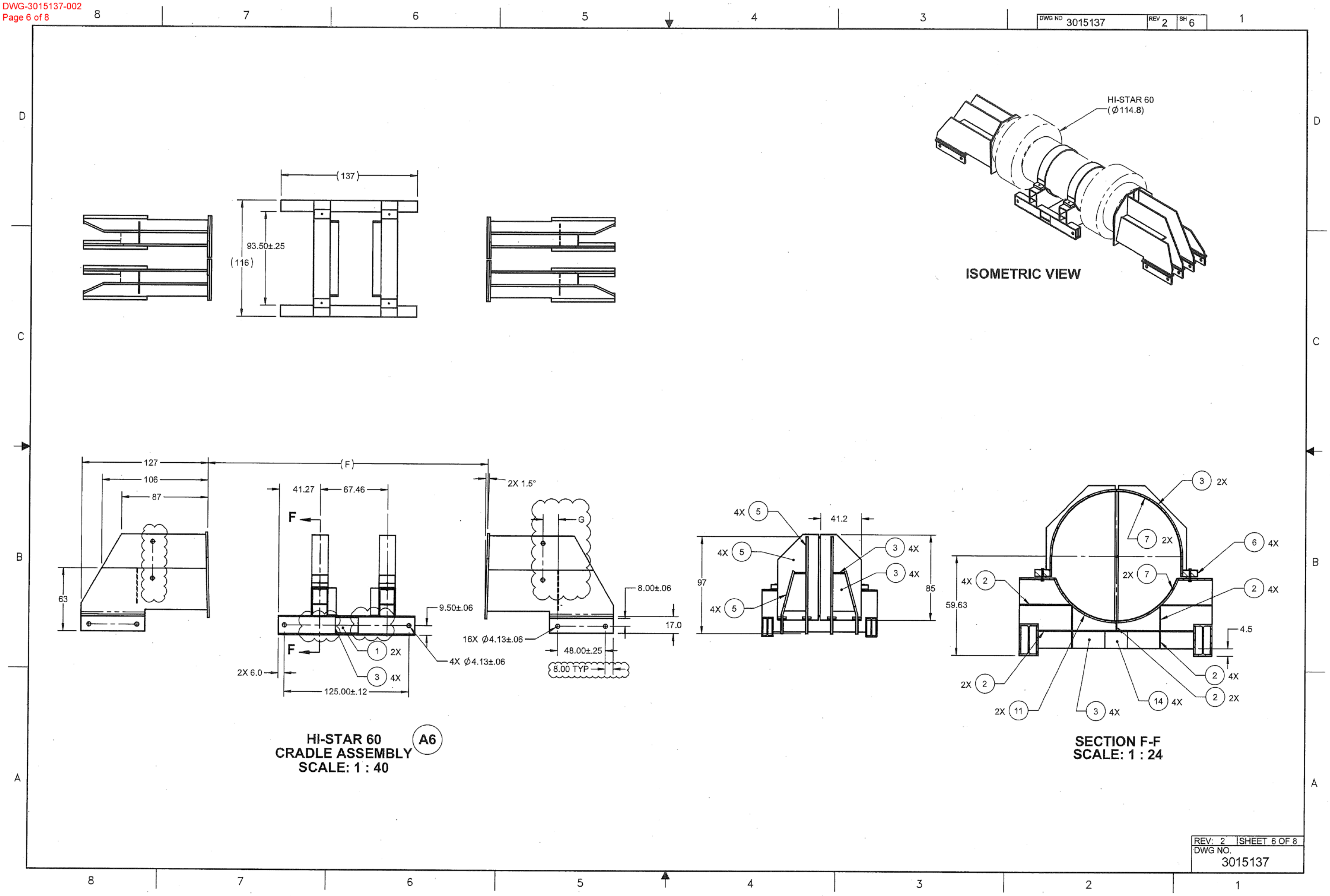

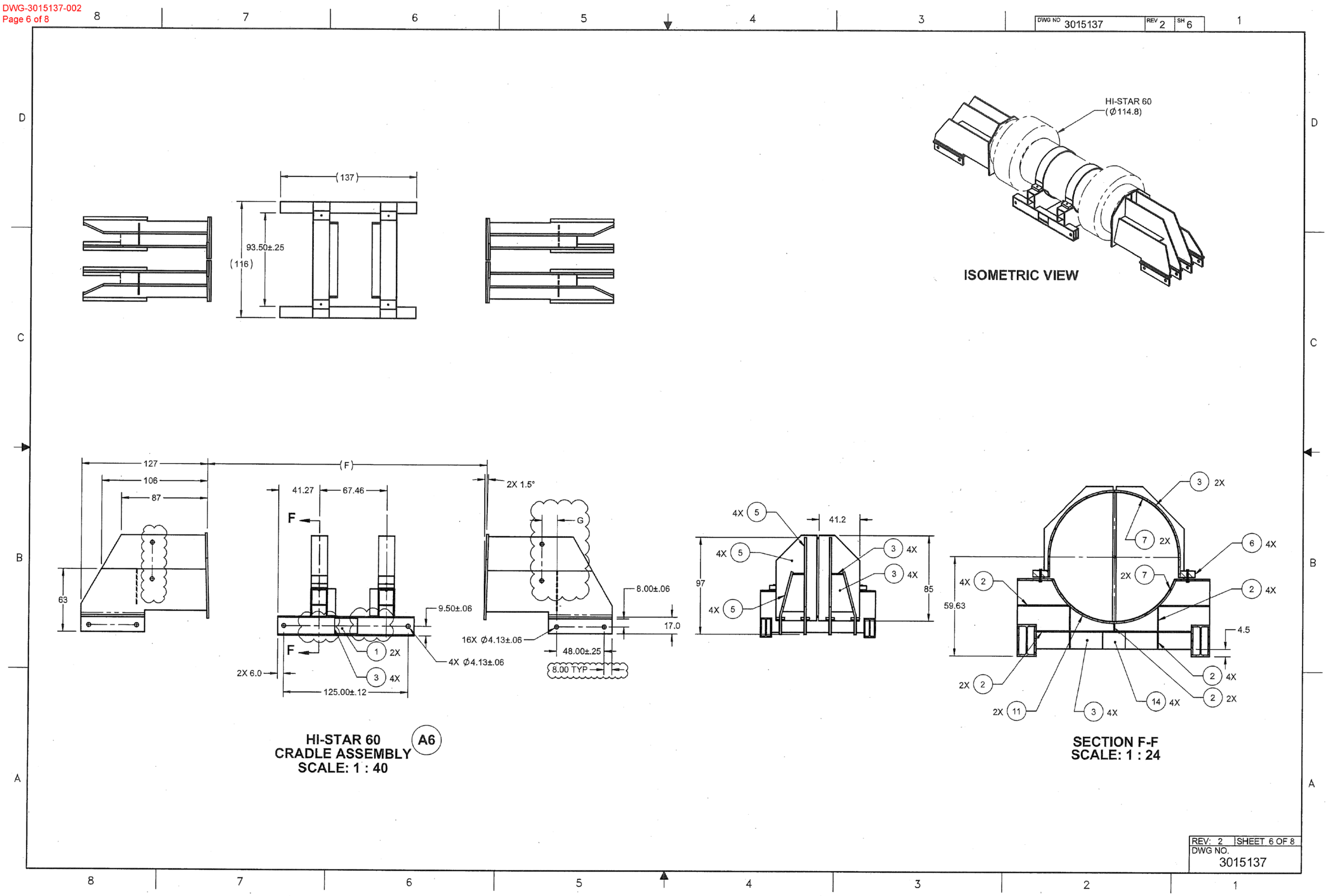
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HI-STAR 60
(Ø114.8)
ISOMETRIC VIEW
(137)
93.50±.25
(116)
127
106
87
(F)
63
41.27
67.46
F
F
9.50±.06
2X 6.0
125.00±.12
1 2X
3 4X
4X Ø4.13±.06
16X Ø4.13±.06
2X 1.5°
G
8.00±.06
17.0
48.00±.25
8.00 TYP
41.2
97
85
59.63
4.5
HI-STAR 60
CRADLE ASSEMBLY
SCALE: 1 : 40
A6
SECTION F-F
SCALE: 1 : 24
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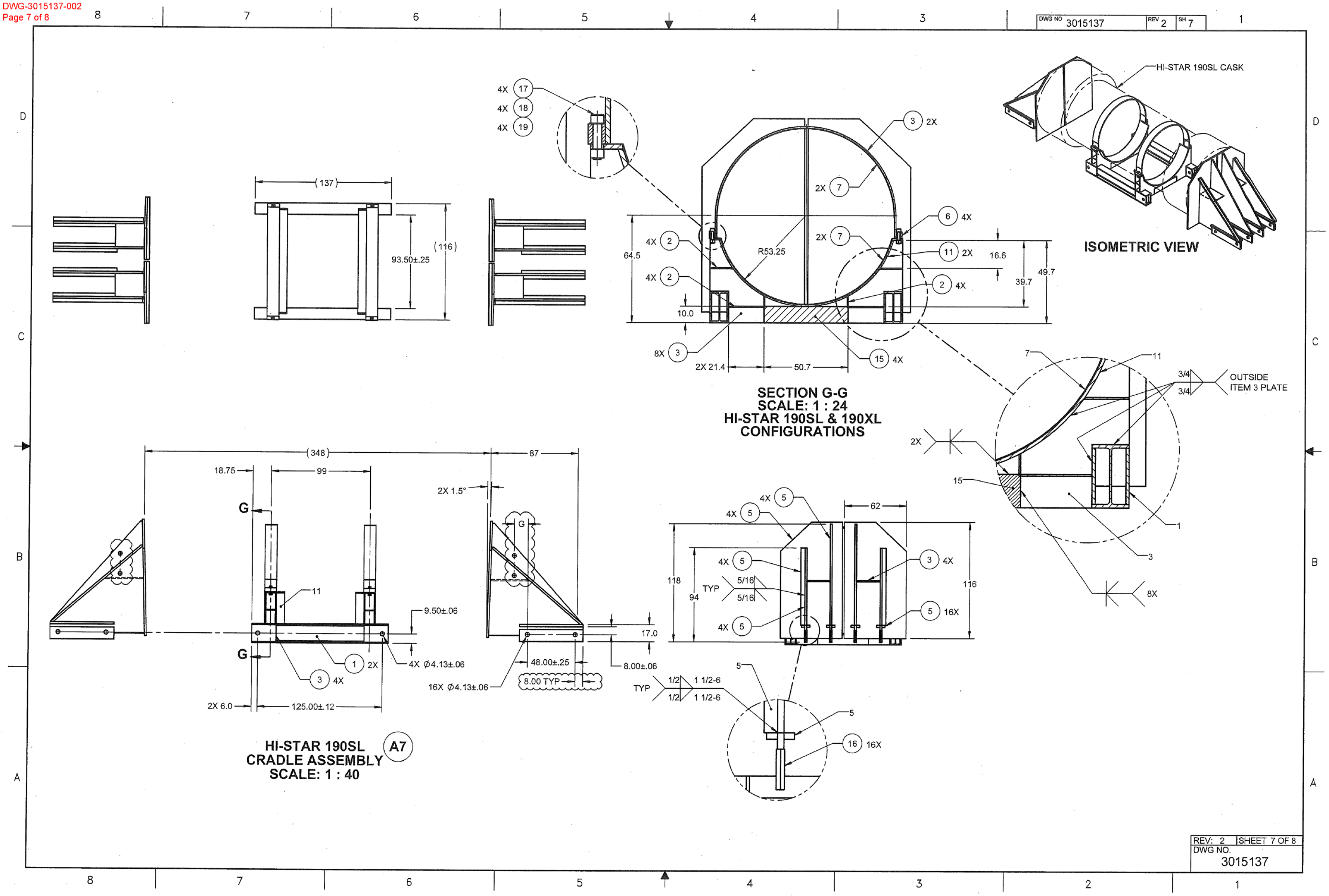

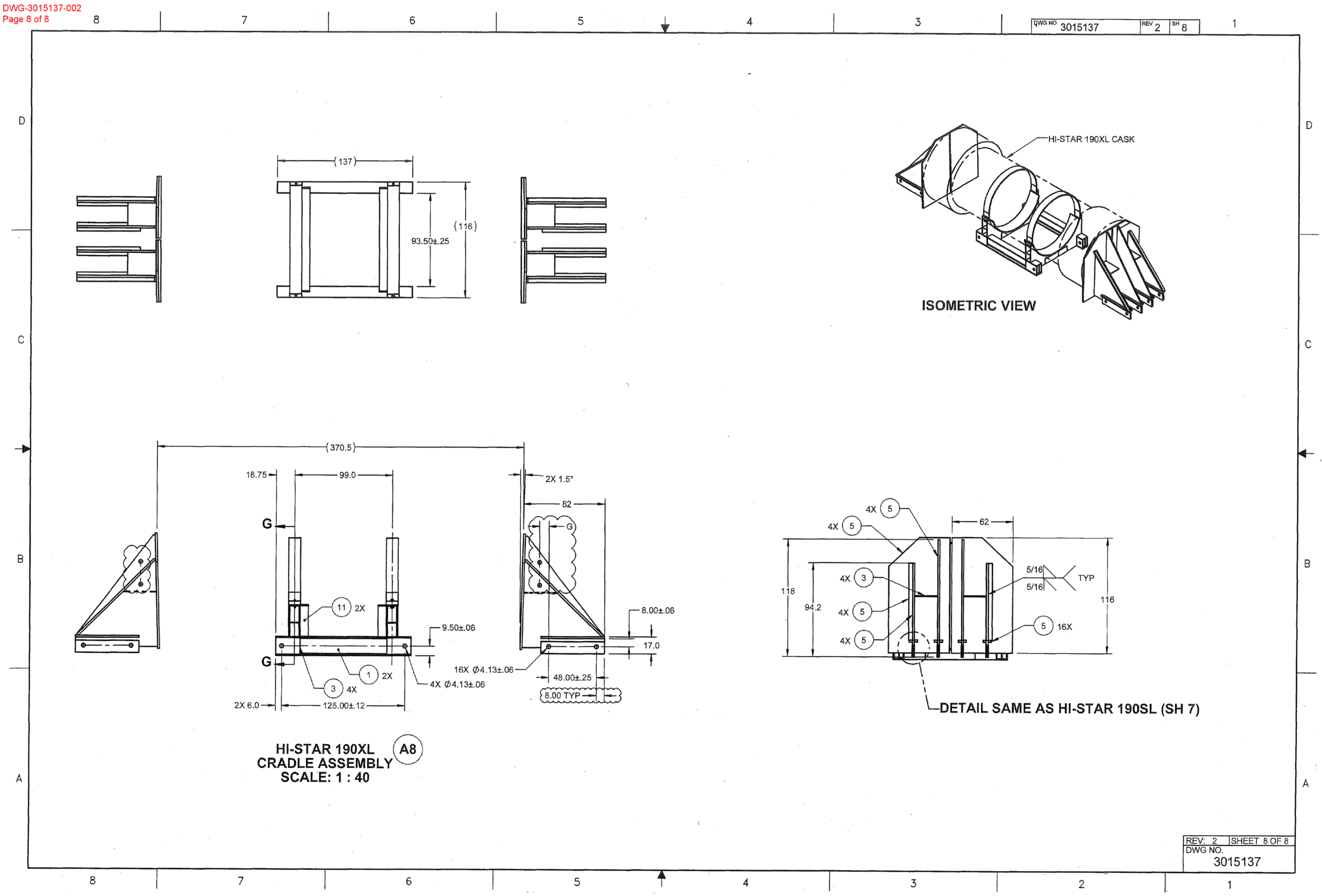
DWG-3015137-002
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DWG NO 3015137 REV 2 SH 8
HI-STAR 190XL CASK
ISOMETRIC VIEW
(137)
93.50±.25
(116)
(370.5)
18.75
99.0
2X 1.5°
82
G
11 2X
9.50±.06
8.00±.06
17.0
1 2X
3 4X
16X Ø4.13±.06
4X Ø4.13±.06
48.00±.25
8.00 TYP
2X 6.0
125.00±.12
62
4X 5
4X 3
5/16
TYP
116
118
94.2
5 16X
DETAIL SAME AS HI-STAR 190SL (SH 7)
HI-STAR 190XL CRADLE ASSEMBLY
SCALE: 1 : 40
A8
REV: 2 SHEET 8 OF 8
DWG NO.
3015137

Family 2 Conceptual Cradle Drawings (NAC)

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NOTES, UNLESS OTHERWISE SPECIFIED:

1. CONCEPTUAL DESIGN ASSUMES ALL WELDS ARE FULL PENETRATION WELDS UNLESS OTHERWISE NOTED. ALL WELDS WILL BE FURTHER SPECIFIED IN A FINAL DESIGN.
2. FABRICATION SHALL BE PERFORMED IN ACCORDANCE WITH AWS D1.1.
3. DIMENSIONS WITH TOLERANCES SPECIFIED ARE RAILCAR INTERFACE DIMENSIONS AND SHOULD BE CONSIDERED DURING FINAL CRADLE DESIGN.
4. ALL SURFACES OF THE CRADLE WELDMENT, EXCEPT FOR SHACKLE HOLES, PIN HOLES, AND ALL FASTENER SURFACES, SHALL BE BLAST CLEANED PER SSP-SP-10 AND COATED WITH SELF-PRIMING ENAMEL, 2 COATS. THE NON-PAINTED CRADLE SURFACES SHALL BE LIGHTLY COATED WITH NUCLEAR GRADE NICKEL 'NEVER-SEEZ' GREASE.
5. ATTACHMENTS FOR PERSONNEL BARRIER TO THE CRADLE, AND PERSONNEL BARRIER LIFT POINTS, ARE NOT INCLUDED IN THE CONCEPTUAL DESIGN. ADDITIONAL COMPONENTS MAY BE ADDED AS NECESSARY.
6. THE ADDITION OF ALIGNMENT MARKS BETWEEN THE CRADLE AND RAILCAR INTERFACE SHOULD BE CONSIDERED IN THE DETAILED DESIGN TO SUPPORT LOADING OPERATIONS.

7 COVER INDICATED SURFACES WITH 1/8" FIBER REINFORCED ELASTOMER BEARING PAD MATERIAL OR EQUIVALENT.

8 ITEMS 11 AND 13 ON ASSEMBLY A2, AND ITEMS 11 AND 14 ON ASSEMBLY A3, MAY BE DESIGNED AS A SINGLE HIGH STRENGTH FORGING WITH A MINIMUM YIELD STRENGTH OF 135 KSI.

9 HEAT TREAT MATERIAL FOR MINIMUM YIELD OF 135 KSI.

10 LIFT LUGS MAY BE ADDED AS REQUIRED FOR HANDLING.

11 GUSSET HOLES SHOWN ARE REPRESENTATIVE ONLY. FINAL SIZING OF THE GUSSET HOLES IS NOT INCLUDED IN THE CONCEPTUAL DESIGN.

12 PERSONNEL BARRIER PANELS REMOVED PRIOR TO LIFTING LOADED CRADLE, AND RE-INSTALLED PRIOR TO TRANSPORT.

DWG NO 3015138 REV 0 SH 1

LIST OF MATERIALS

QTY A3	QTY A2	QTY A1	ITEM NO	PART NO	DESCRIPTION	SPECIFICATION
		X	A1		NAC-MAGNATRAN CRADLE ASSEMBLY	
	X		A2		NAC-STC CRADLE ASSEMBLY	
X			A3		NAC-UMS CRADLE ASSEMBLY	
2	2	2	1		W18 X 119	ASTM A992 OR A572, GR 50
2	2	2	2		PLATE, .19 THK	ASTM A572, GR 50
2	2	2	3		PLATE, .75 THK	BRONZE
1	1	1	4		PLATE, .75 THK	ASTM A572, GR 50
7	7	7	5		PLATE, 1.0 THK	ASTM A572, GR 50
8	8	8	6		PLATE, 1.5 THK	ASTM A572, GR 50
2	2	2	7		PLATE, 1.75 THK	ASTM A572, GR 50
11	14	16	8		PLATE, 2.0 THK	ASTM A527, GR50
3	3	3	9		PLATE, 3.0 THK	ASTM A572, GR 50
6	6	6	10		PLATE 4.0 THK	ASTM A572, GR 50
2	2	2	11		FORGING, 12.0 THK	ASTM A350, GRADE LF 6
1	1	1	12		CASTING, 16 THK	ASTM A732 GR 10Q
9 -	2	-	13		BAR, Ø6.0	ASTM A434, CLASS BD
9 2	-	-	14		BAR, Ø8.0	ASTM A434, CLASS BD
-	-	4	15		SHCS, 1-8 UNC	ASTM A574
2	2	2	16		HEX BOLT, 1-1/2-6 UNC	ASTM A490
2	2	2	17		HEX NUT, 1-1/2-6 UNC	ASTM A563
12	12	12	18		SHCS, 2-1/4- 4.5 UNC	ASTM A574
4	4	4	19	G-2130	SHACKLE, 2.5-IN, 55 TONNE WLL	CROSBY OR EQUIVALENT
4	4	4	20		BAR, Ø6.5	ASTM A276, TYPE 304
AR	AR	AR	21		SHEET, EXPANDED/PERFORATED, .12 THK, 65% OPENING	ALUMINUM
AR	AR	AR	22		PLATE, .19 THK	ALUMINUM

AREVA
July 6, 2016
Records Management

REV	DESCRIPTION	DRAWN	CHECKER	VERIFIED

REVISION HISTORY

	NAME/SIGNATURE	DATE
EM	[signature]	6/21/16
RE	G. Johnson [signature]	6/16/2016
TECH CHK	[signature]	6-16-16
DFTG CHK	[signature]	6-16-16
DRAWN	P. PIKULIN	6-16-16

NA	NA
NEXT ASSY	FINAL ASSY

THIRD ANGLE PROJECTION

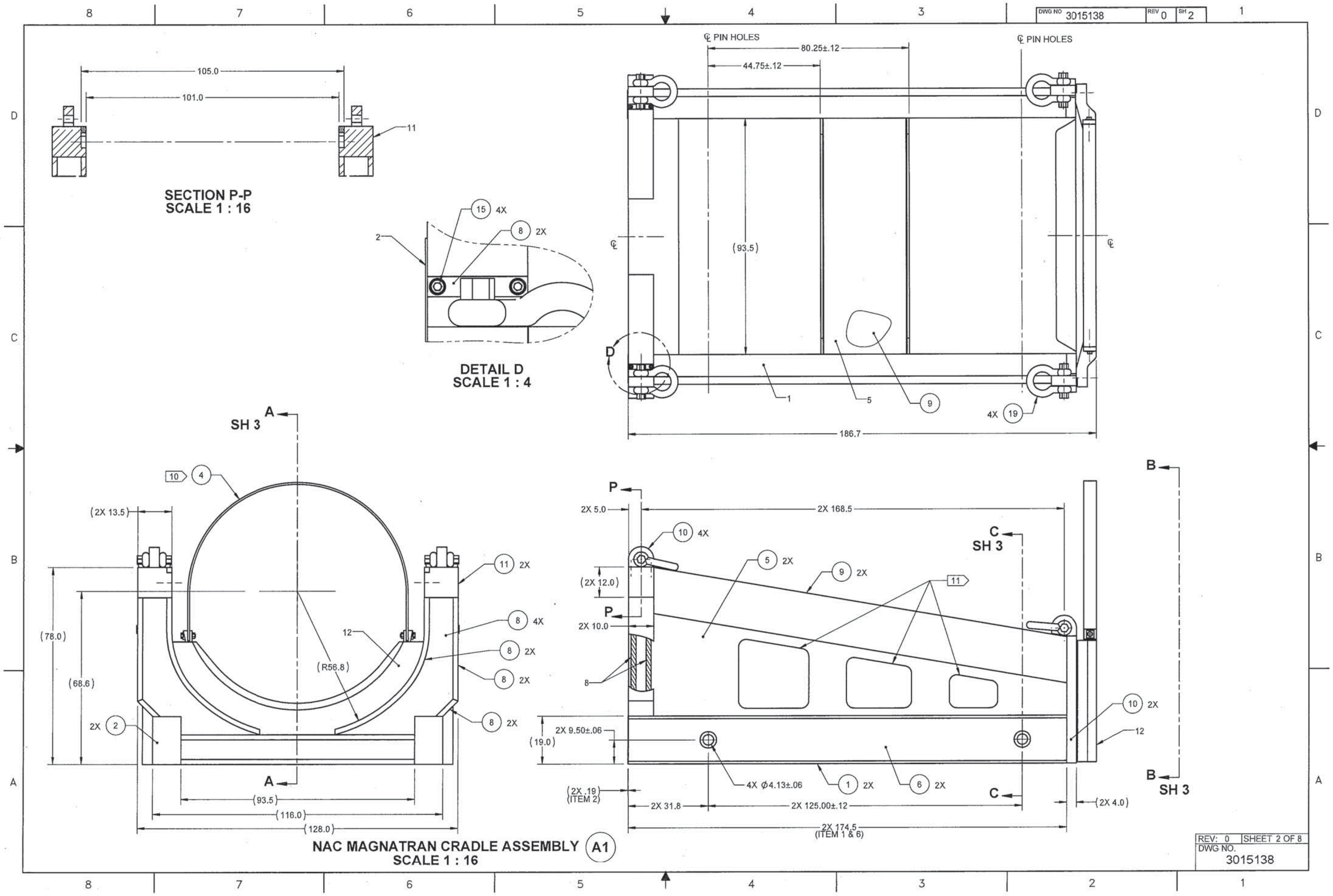
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5-2009 (REVISION OF ASME Y14.5M-1994)
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

AREVA
AREVA Federal Services LLC
Packaging Projects
Federal Way, WA 98003

DWG TITLE: ATLAS RAILCAR CRADLE FAMILY 2, (NAC) CONCEPTUAL DRAWING

SCALE: SHOWN | WT. ~
REV: 0 | SHEET 1 OF 8
DWG SIZE: D | DWG NO. 3015138
CADFILE: 3015138.SLDDRW
DWG-3015138-000

DWG-3015138-000
Page 2 of 8



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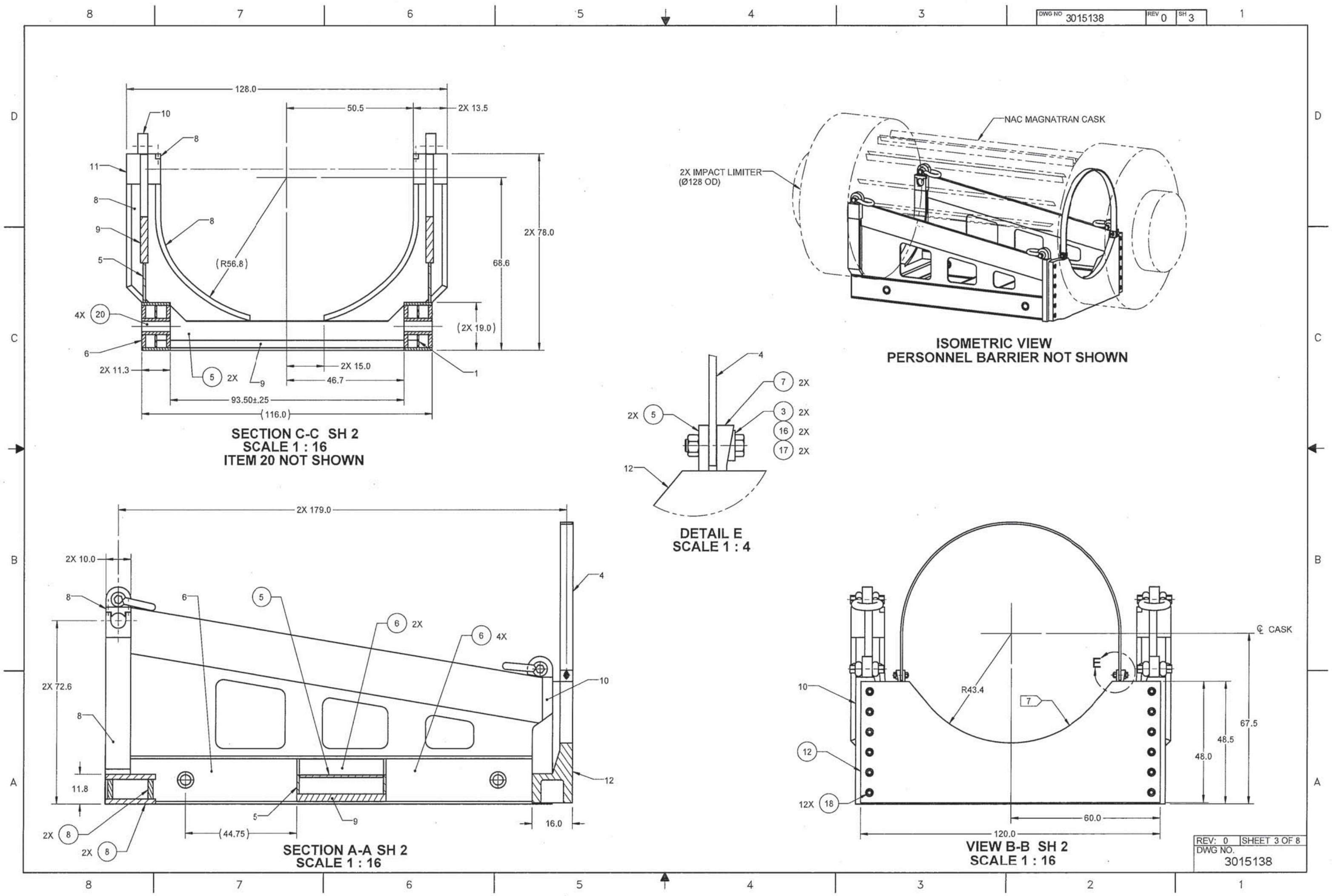

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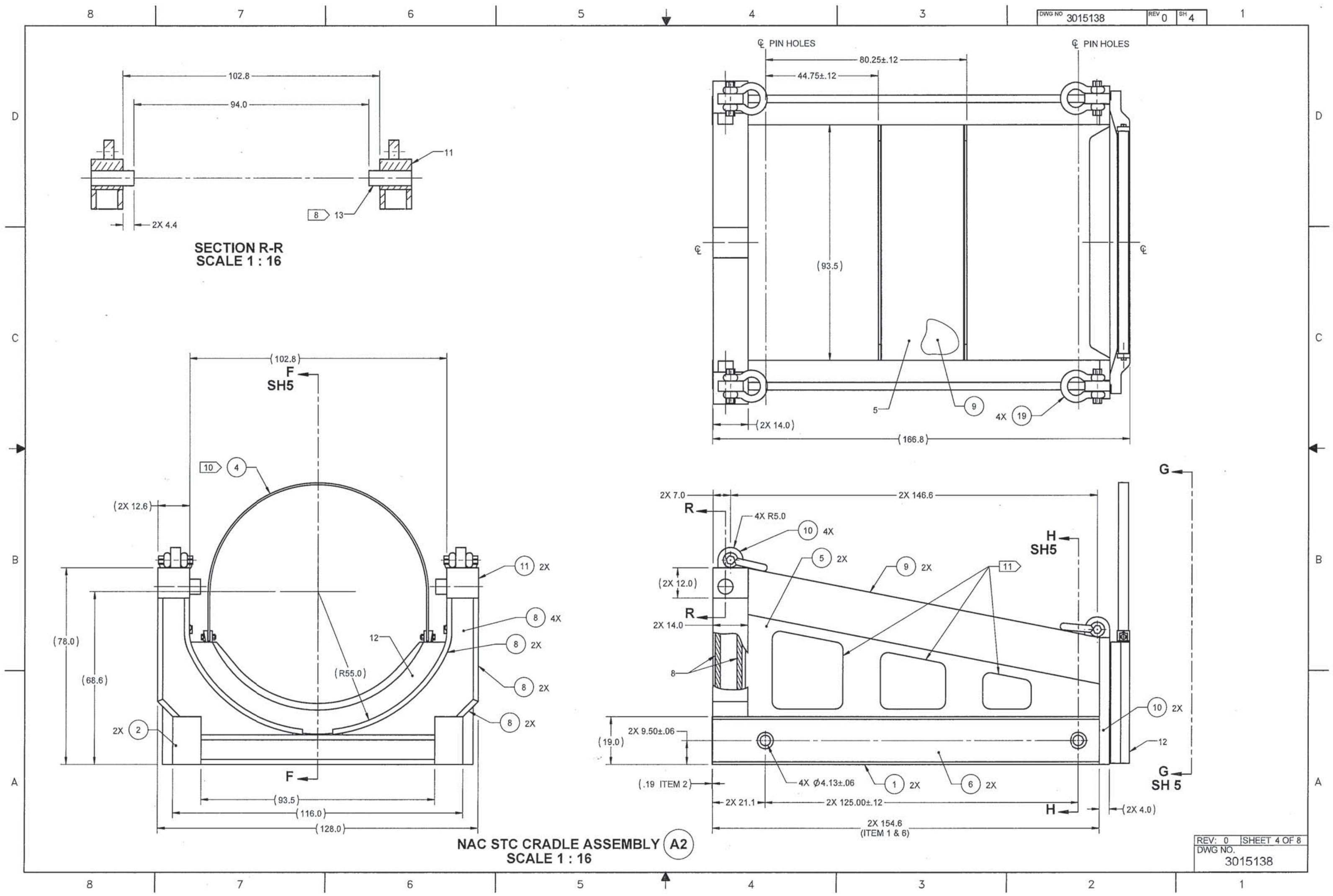

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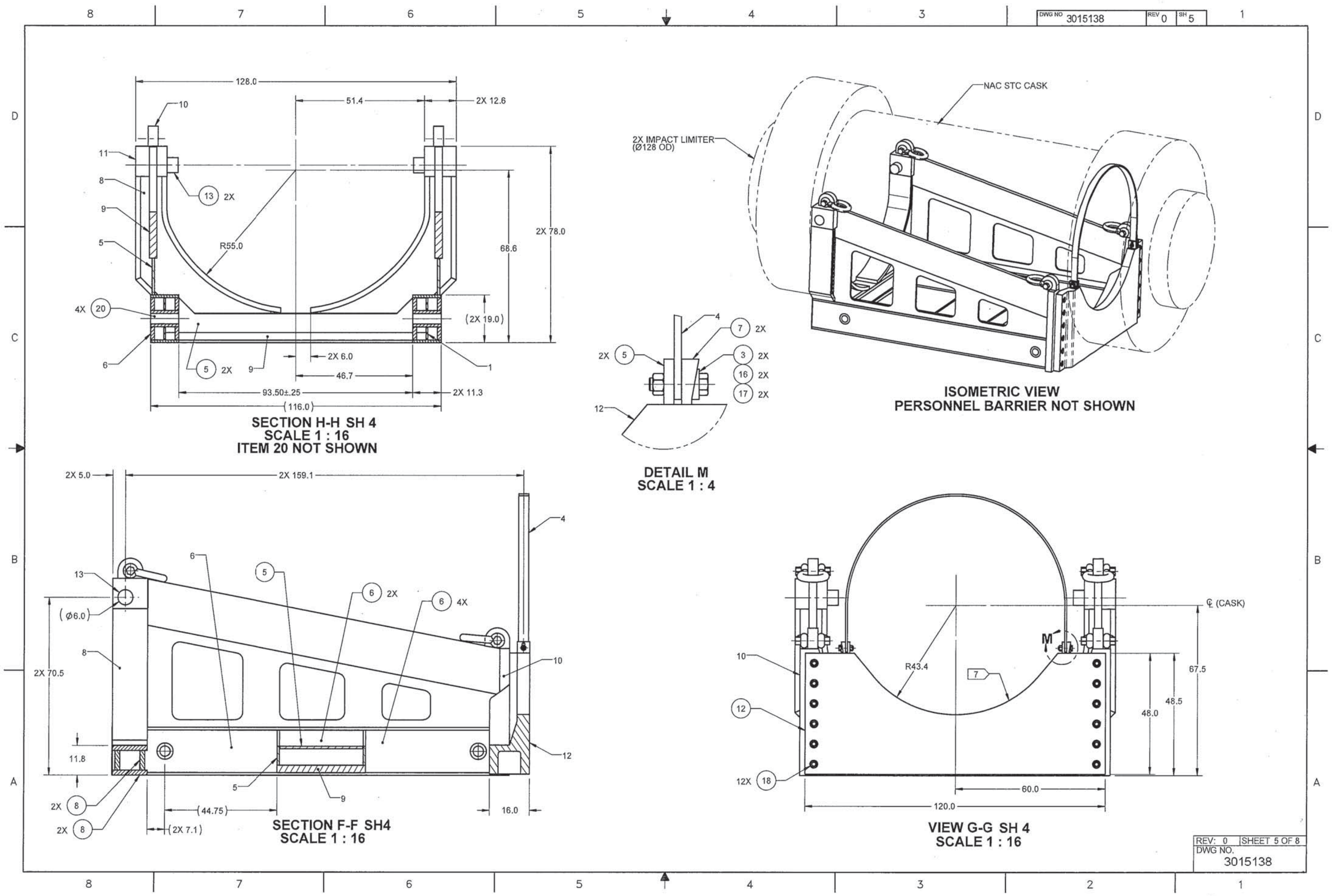

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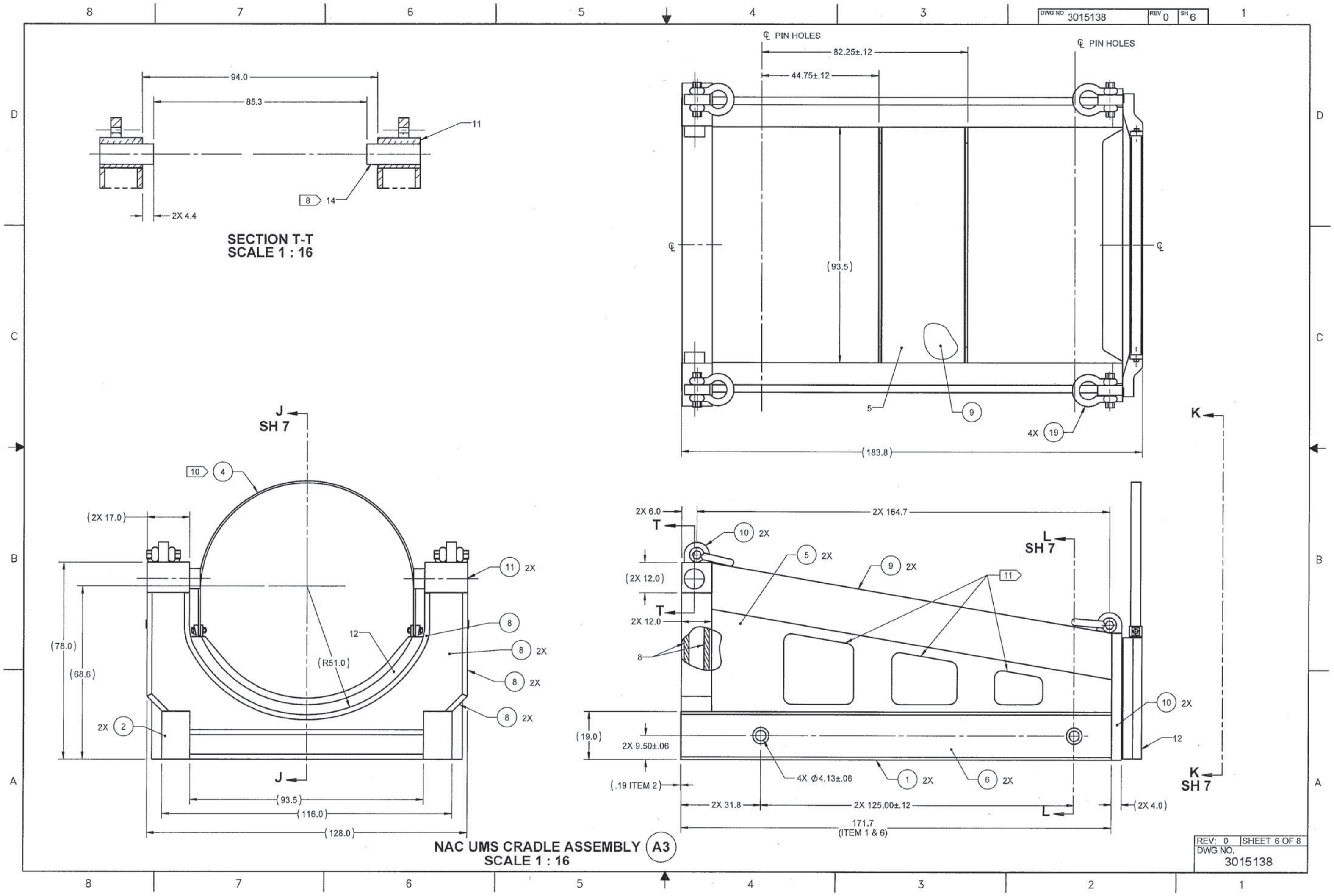
Page 6 of 8



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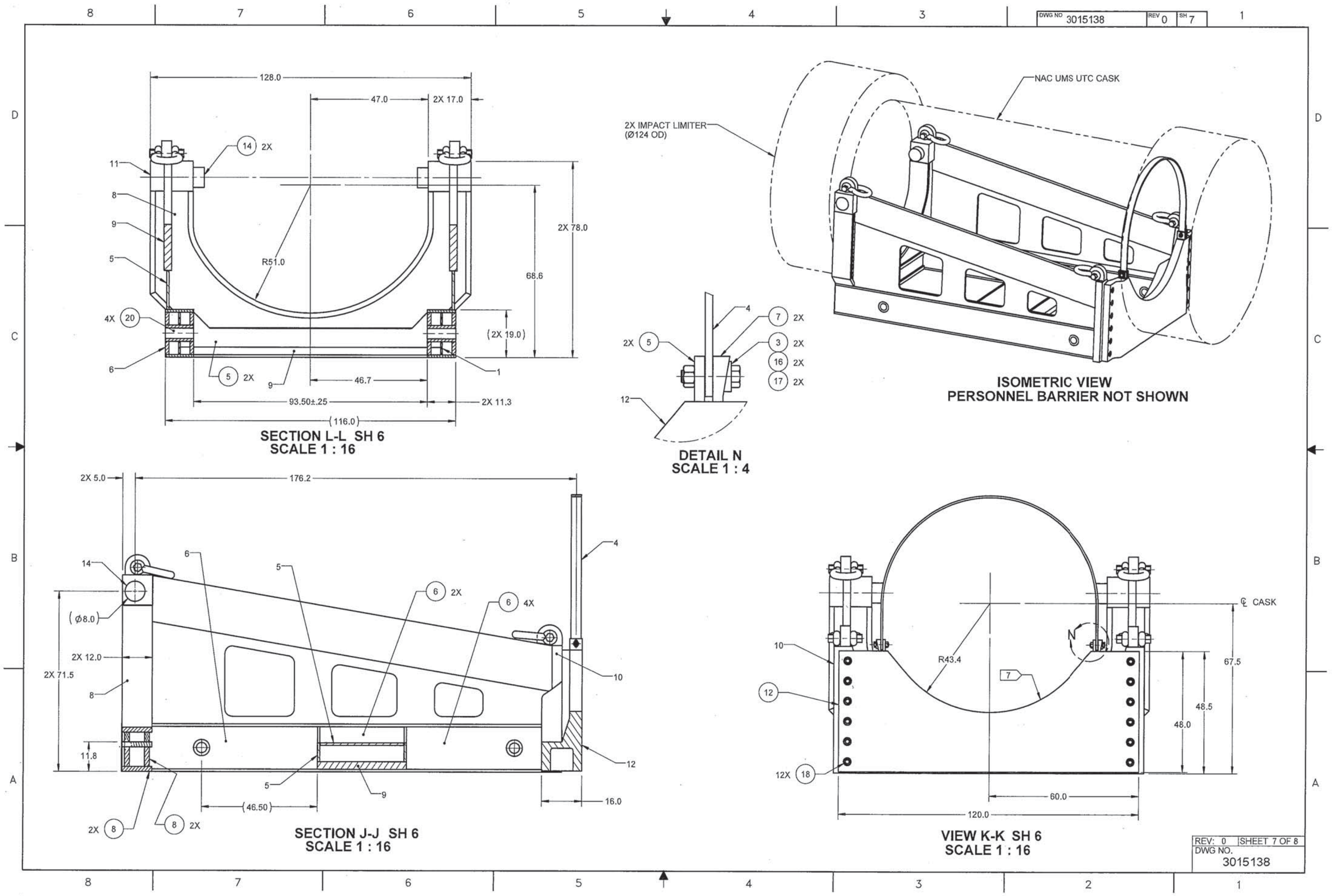

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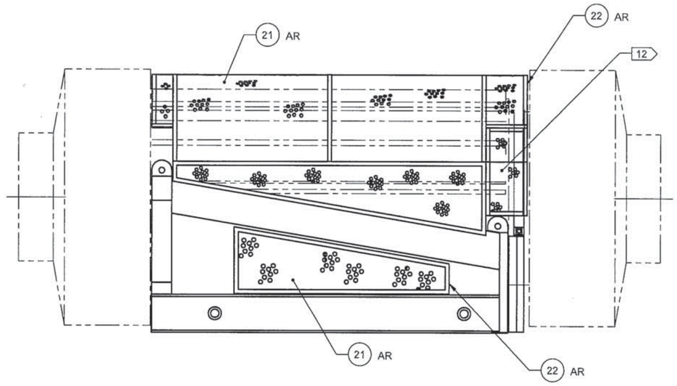
Page 8 of 8



NAC-MAGNATRAN CRADLE ASSEMBLY
TYPICAL PERSONNEL BARRIER CONCEPT
SCALE 1 : 24

REV: 0 SHEET 8 OF 8
DWG NO. 3015138

Family 2 Conceptual Cradle Drawings (TN-68)

DWG-3015277-000
Page 1 of 4

DWG NO 3015277 REV 0 SH 1

NOTES, UNLESS OTHERWISE SPECIFIED:

1. CONCEPTUAL DESIGN ASSUMES ALL WELDS ARE FULL PENETRATION WELDS UNLESS OTHERWISE NOTED. ALL WELDS WILL BE FURTHER SPECIFIED IN A FINAL DESIGN.
2. FABRICATION SHALL BE PERFORMED IN ACCORDANCE WITH AWS D1.1.
3. DIMENSIONS WITH TOLERANCES SPECIFIED ARE RAILCAR INTERFACE DIMENSIONS AND SHOULD BE CONSIDERED DURING FINAL CRADLE DESIGN.
4. ALL SURFACES OF THE CRADLE, EXCEPT FOR SHACKLE HOLES, PIN HOLES, AND ALL FASTENER SURFACES, SHALL BE BLAST CLEANED PER SSP-SP-10 AND COATED WITH SELF-PRIMING ENAMEL, 2 COATS. THE NON-PAINTED CRADLE SURFACES SHALL BE LIGHTLY COATED WITH NUCLEAR GRADE NICKEL 'NEVER-SEEZ' GREASE.
5. ATTACHMENTS FOR PERSONNEL BARRIER TO THE CRADLE, AND PERSONNEL BARRIER LIFT POINTS, ARE NOT INCLUDED IN THE CONCEPT DESIGN. ADDITIONAL COMPONENTS MAY BE ADDED AS NECESSARY.
6. THE ADDITION OF ALIGNMENT MARKS BETWEEN THE CRADLE AND RAILCAR INTERFACE SHOULD BE CONSIDERED IN THE DETAILED DESIGN TO SUPPORT LOADING OPERATIONS.

7 COVER INDICATED SURFACES WITH 1/8" FIBER REINFORCED ELASTOMER BEARING PAD MATERIAL OR EQUIVALENT.

8 FRONT SADDLE NOTCHED TO CLEAR TN-68 IMPACT LIMITER TIE RODS.

9 LIFT FEATURE MAY BE DESIGNED TO BE ATTACHED USING FASTENERS TO ENABLE REMOVAL FOR EMPTY CRADLE TRANSPORT UNDER AAR-S2028 PLATE C.

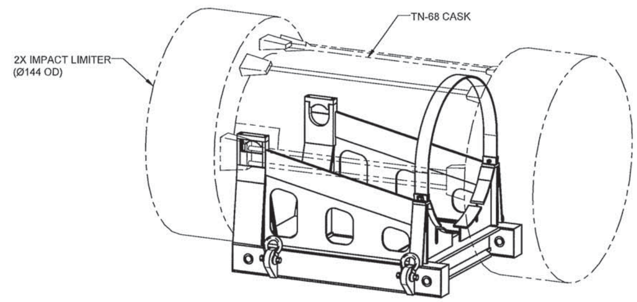
10 GUSSETS CENTERED BEHIND LIFT POINTS.

11 LIFT LUGS MAY BE ADDED AS REQUIRED FOR HANDLING.

12 GUSSET HOLES SHOWN ARE REPRESENTATIVE ONLY. FINAL SIZING OF THE GUSSET HOLES IS NOT INCLUDED IN THE CONCEPTUAL DESIGN.

LIST OF MATERIALS

QTY A1	ITEM NO	PART NO	DESCRIPTION	SPECIFICATION
	A1		TN-68 CRADLE ASSEMBLY	
1	1		W14 X 233	ASTM A992 OR A572, GR 50
2	2		W18 X 119	ASTM A992 OR A572, GR 50
4	3		PLATE, .19 THK	ASTM A572, GR 50
3	4		PLATE, .75 THK	ASTM A572, GR 50
2	5		PLATE, .75 THK	BRONZE
21	6		PLATE, 1.0 THK	ASTM A572, GR 50
8	7		PLATE, 1.5 THK	ASTM A572, GR 50
2	8		PLATE, 1.63 THK	ASTM A572, GR 50
2	9		PLATE, 1.75 THK	ASTM A572, GR 50
10	10		PLATE, 2.0 THK	ASTM A572, GR 50
1	11		PLATE, 3.0 THK	ASTM A572, GR 50
4	12		PLATE, 4.0 THK	ASTM A572, GR 50
4	13		FORGING, 6.5 THK	ASTM A350, LF6
2	14		HEX BOLT, 1-1/2-6 UNC	ASTM A490, TYPE 1
2	15		HEX NUT, 1-1/2-6 UNC	ASTM A563
4	16		SHCS, 1-8 UNC X 4.0	ASTM A490, TYPE 1
4	17		BAR, Ø6.5	ASTM A276, TYPE 304
4	18	G-2130	SHACKLE, 2.5-IN, 55 TONNE WLL	CROSBY OR EQUIVALENT
AR	19		SHEET, EXPANDED/PERFORATED, .12 THK, 65% OPENING	ALUMINUM
AR	20		PLATE .19 THK	ALUMINUM



ISOMETRIC VIEW
PERSONNEL BARRIER NOT SHOWN

AREVA
July 6, 2016
Records Management

REV		DRAWN	CHECKER	VERIFIED

REVISION HISTORY

	NAME/SIGNATURE	DATE
EM	[signature]	6/21/16
RE	[signature]	6/16/2016
TECH CHK	[signature]	6.16.16
DFTG CHK	[signature]	6.16.16
DRAWN	P. PIKULIN	6-16-16

NA	NA
NEXT ASSY	FINAL ASSY

THIRD ANGLE PROJECTION

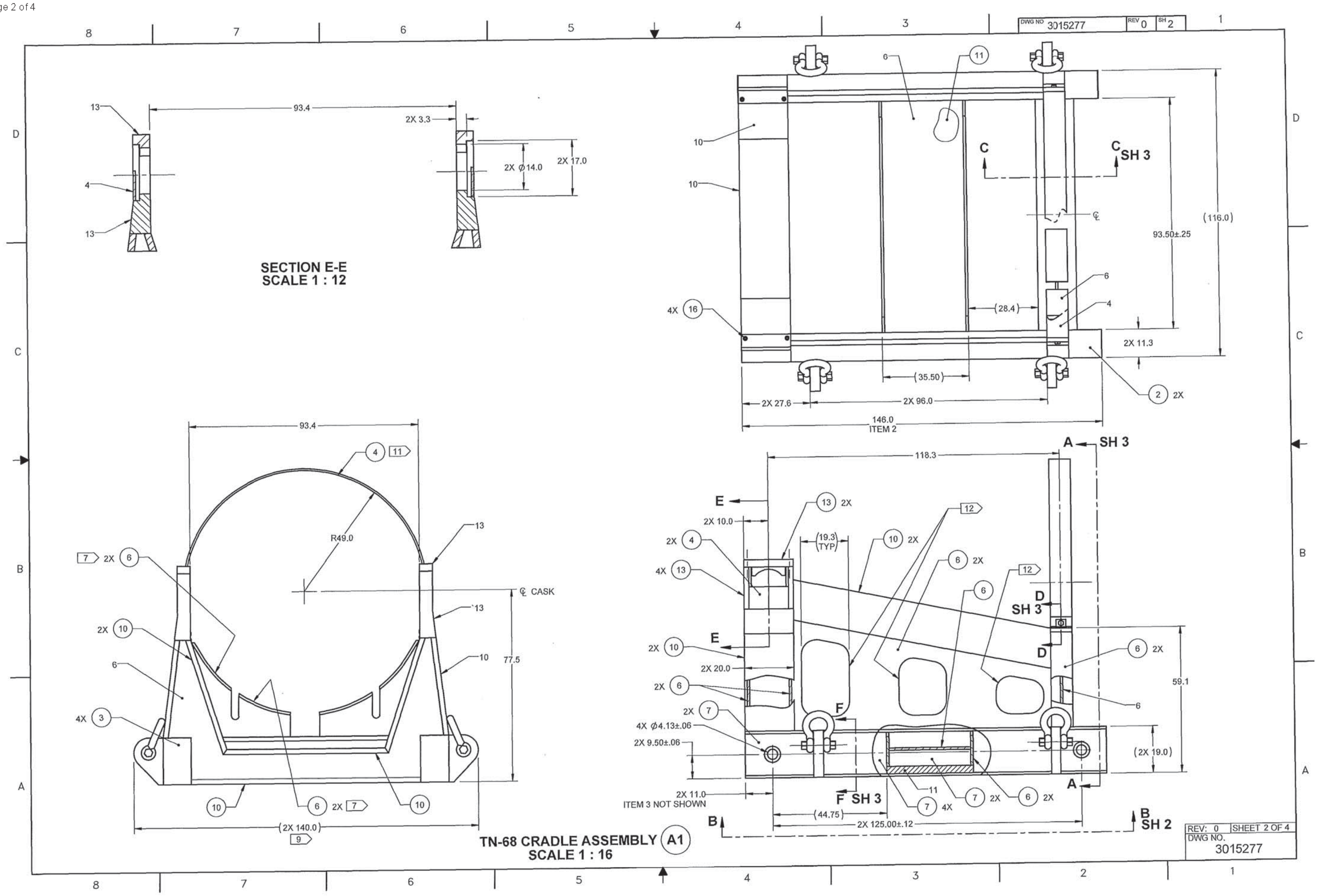
UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5-2009 (REVISION OF ASME Y14.5M-1994)
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

AREVA
AREVA Federal Services LLC
Packaging Projects
Federal Way, WA 98003

DWG TITLE ATLAS RAILCAR
CRADLE FAMILY 2 (TN-68)
CONCEPTUAL DRAWING

SCALE: SHOWN | WT. ~
REV: 0 | SHEET 1 OF 4
DWG SIZE D | DWG NO. 3015277
CADFILE: 3015277.SLDDRW
DWG-3015277-000

DWG-3015277-000
Page 2 of 4



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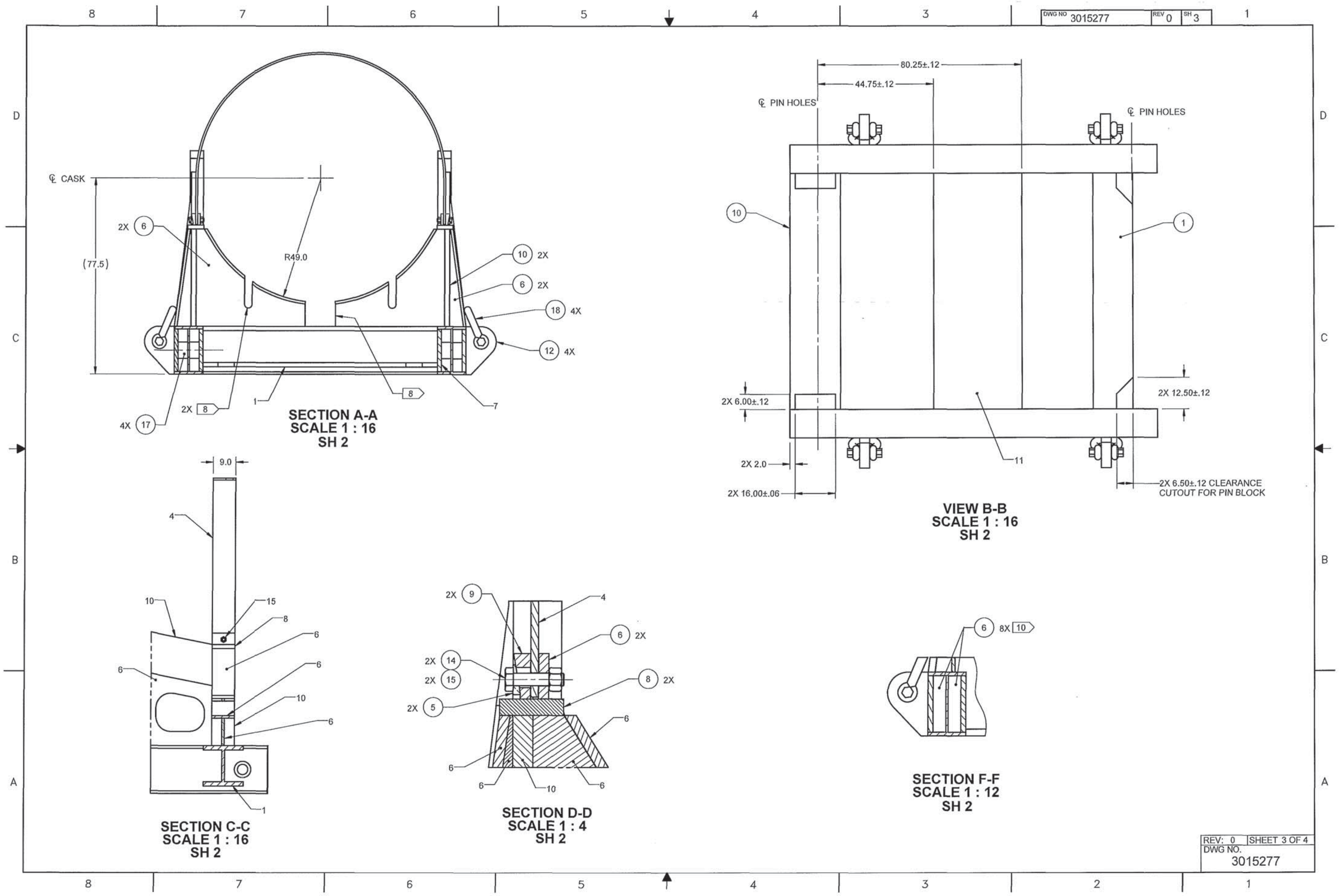
Page 3 of 4



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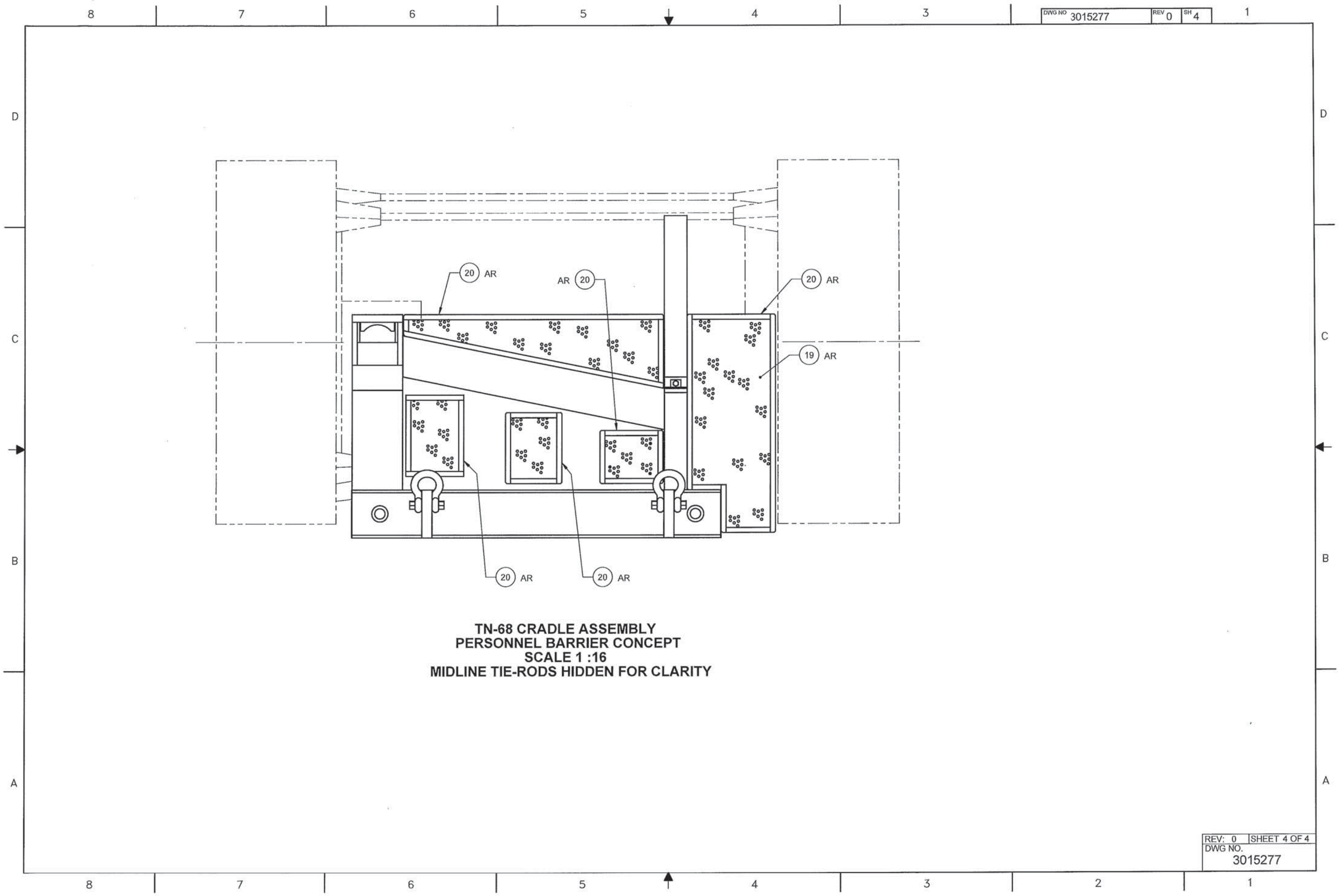


TN-68 CRADLE ASSEMBLY
PERSONNEL BARRIER CONCEPT
SCALE 1 :16
MIDLINE TIE-RODS HIDDEN FOR CLARITY

Family 3 Conceptual Cradle Drawings

DWG-3015139-000
Page 1 of 6

DWG NO 3015139 REV 0 SH 1

NOTES, UNLESS OTHERWISE SPECIFIED:

1. CONCEPTUAL DESIGN ASSUMES ALL WELDS ARE FULL PENETRATION WELDS UNLESS OTHERWISE NOTED. ALL WELDS WILL BE FURTHER SPECIFIED IN A FINAL DESIGN.
2. FABRICATION SHALL BE PERFORMED IN ACCORDANCE WITH AWS D1.1.
3. DIMENSIONS WITH TOLERANCES SPECIFIED ARE RAILCAR INTERFACE DIMENSIONS AND SHOULD BE CONSIDERED DURING FINAL CRADLE DESIGN.
4. ALL SURFACES OF THE CRADLE, EXCEPT FOR THE SHACKLE, PIN HOLES, AND PERSONNEL BARRIER SHALL BE BLAST CLEANED PER SSP-SP-10 AND COATED WITH SELF-PRIMING ENAMEL, 2 COATS. THE NON-PAINTED SHACKLE AND PIN HOLES ON THE WELDMENT SHALL BE LIGHTLY COATED WITH NUCLEAR GRADE 'NEVER SEEZ' GREASE.
5. ATTACHMENTS FOR PERSONNEL BARRIER TO THE CRADLE ARE TO BE DEFINED DURING THE FINAL DESIGN.
6. THE ADDITION OF ALIGNMENT MARKS BETWEEN THE CRADLE AND RAILCAR INTERFACE SHOULD BE CONSIDERED IN THE DETAILED DESIGN TO SUPPORT LOADING OPERATIONS.
7. PURCHASE ASTM A992 MATERIALS WITH SUPPLEMENTAL REQUIREMENT S30 AND ASTM A514 MATERIALS WITH SUPPLEMENTAL REQUIREMENT S5.

8 COVER INDICATED SURFACES WITH 1/8-INCH FABREEKA FIBER REINFORCED BEARING PAD MATERIAL OR EQUIVALENT.

9 OPTIONAL LIFTING LUG AND MOUNTING HOLE PATTERN.

10 DIMENSION SHOWN INCLUDES 1/8" FABREEKA, SEE FLAG NOTE 8.

11 PERSONNEL BARRIER NOT SHOWN.

12 DIMENSION SHOWN IS TO A 3-INCH WIDE RAISED BOSS. POSITION AND HEIGHT OF BOSS TO BE DETERMINED DURING DETAILD DESIGN.

LIST OF MATERIALS

QTY A3	QTY A2	QTY A1	ITEM NO	PART NO	DESCRIPTION	SPECIFICATION
		X	A1		MP197 CRADLE ASSEMBLY	
	X		A2		MP197HB CRADLE ASSEMBLY	
X			A3		TS125 CRADLE ASSEMBLY	
2	2	2	1		W 18 X 119	ASTM A992
4	4	4	2		PLATE, .13 THK	ASTM A514
20	20	20	3		PLATE, 1.0 THK	ASTM A514
18	18	18	4		PLATE, 2.0 THK	ASTM A514
8	8	8	5		PLATE, 3.0 THK	ASTM A514
8	8	8	6		PLATE, 4.0 THK	ASTM A514
1	1	1	7		PLATE, 6.0 THK	ASTM A705 OR A564 XM-16 H900
4	4	4	8		HSHCS, Ø2.5 X 6.0	ASTM A540, B24 CL1
4	4	4	9		WASHER, FLAT, 2.5-IN ID	CS
4	4	4	10	G-2140	SHACKLE, 2-IN, 85 TONNE WLL	CROSBY OR EQUIVALENT
4	4	4	11		BAR, Ø6.5	ASTM A276, TYPE 304
AR	AR	AR	12		SHEET, EXPANDED/PERFORATED, .12 THK, 80% OPENING	SS
2	2	2	13		PLATE, .38 THK	SS
AR	AR	AR	14		SQ. TUBE, 2 X 2 X .12 WALL	SS
2	-	-	15		PLATE, .50 THK	SS

AREVA
July 6, 2016
Records Management

REV	DESCRIPTION	DRAWN	CHECKER	VERIFIED

REVISION HISTORY

	NAME/SIGNATURE	DATE
EM	D. Hillstrom	6-24-16
RE	D. WICK	6-21-16
TECH CHK	S. BEAR SLB	6-21-16
DFTG CHK	S. BEAR SLB	6-21-16
DRAWN	P. PIKULIN	6-21-16

NA	NA
NEXT ASSY	FINAL ASSY

THIRD ANGLE PROJECTION

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5-2009 (REVISION OF ASME Y14.5M-1994)
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

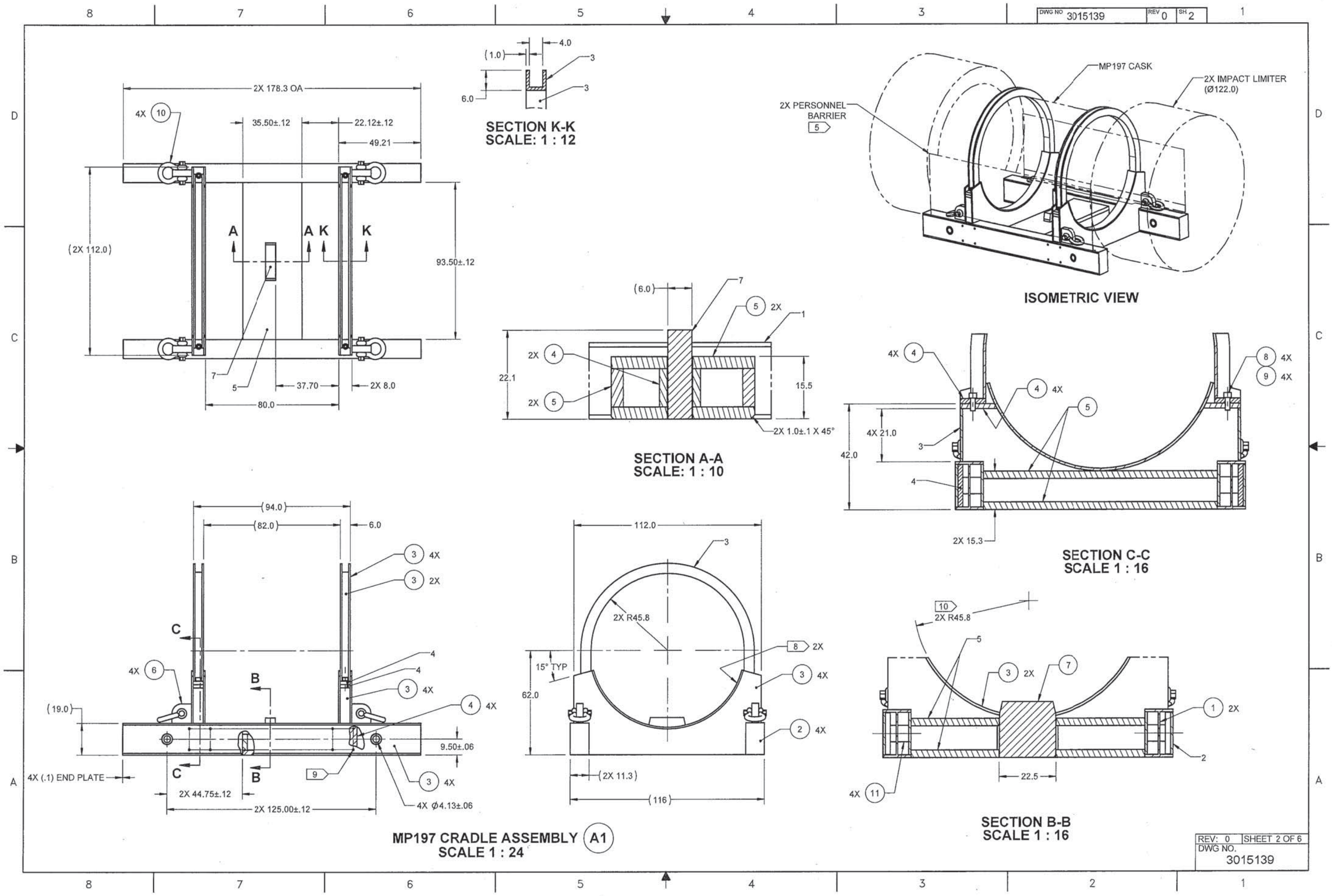
AREVA

AREVA Federal Services LLC
Packaging Projects
Federal Way, WA 98003

DWG TITLE: ATLAS RAILCAR CRADLE FAMILY 3 CONCEPTUAL DRAWING

SCALE: SHOWN | WT. ~ LBS
REV: 0 | SHEET 1 OF 6
DWG SIZE D | DWG NO. 3015139
CADFILE: 3015139.SLDDRW
DWG-3015139-000

DWG-3015139-000
Page 2 of 6



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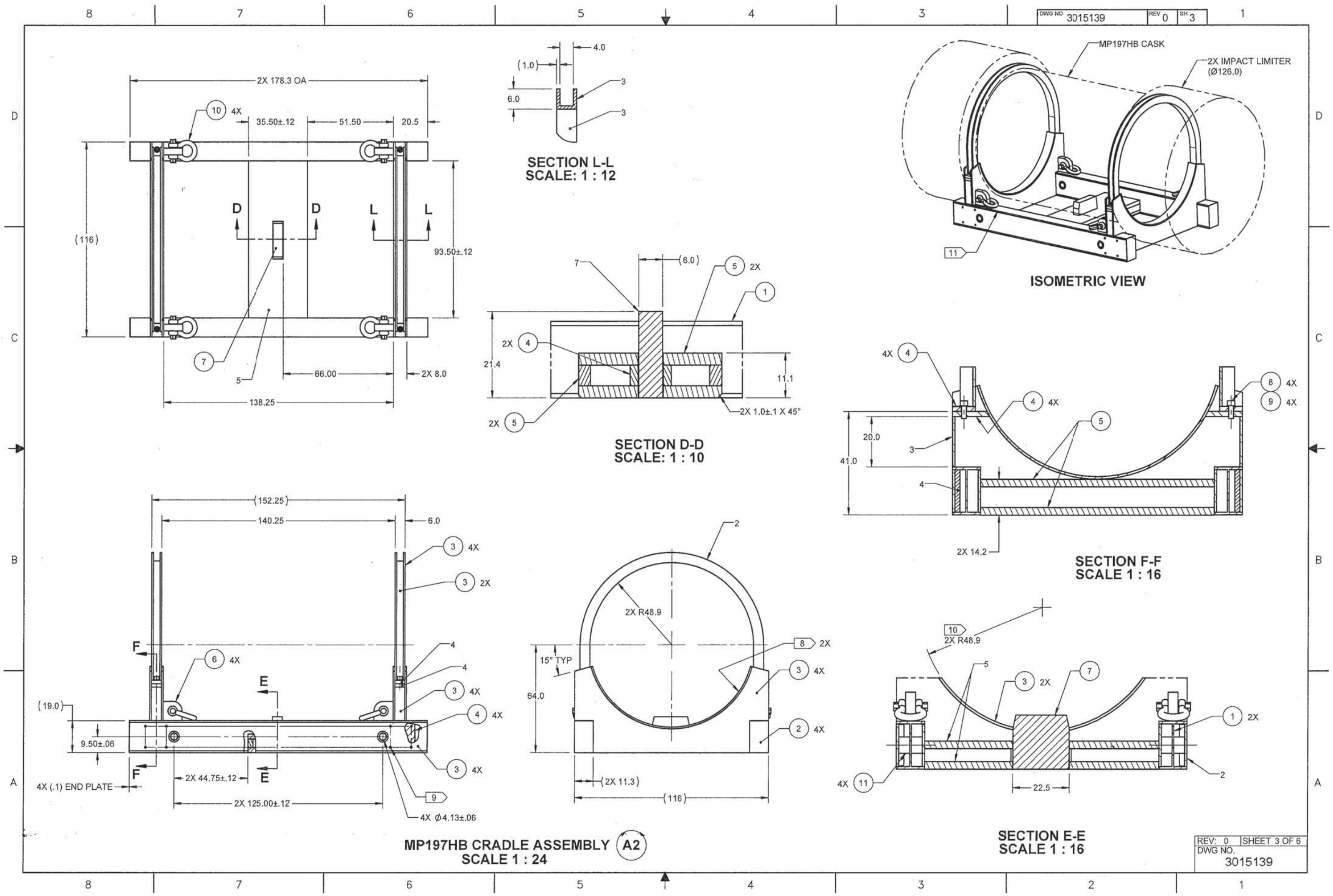
Page 3 of 6



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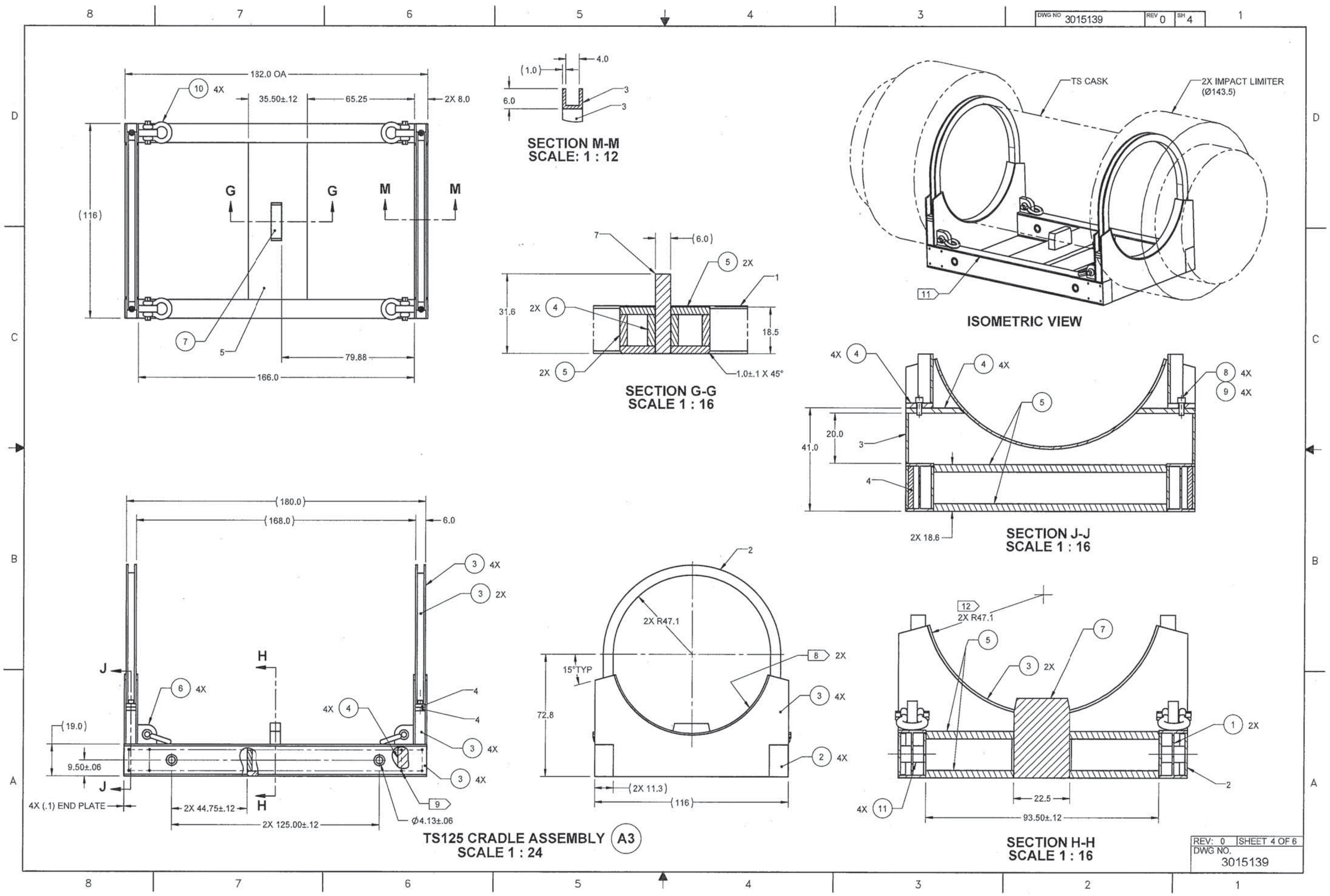

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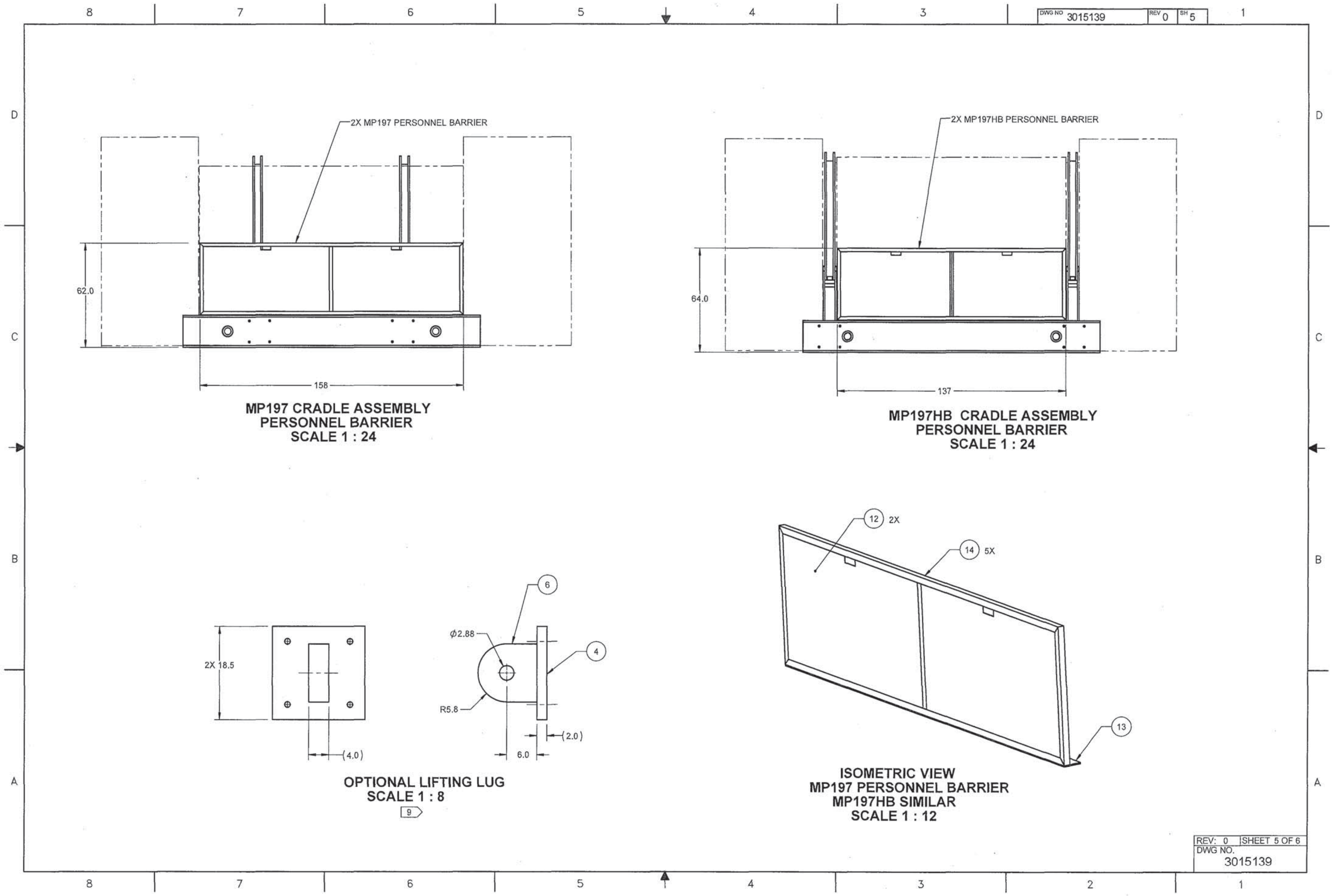

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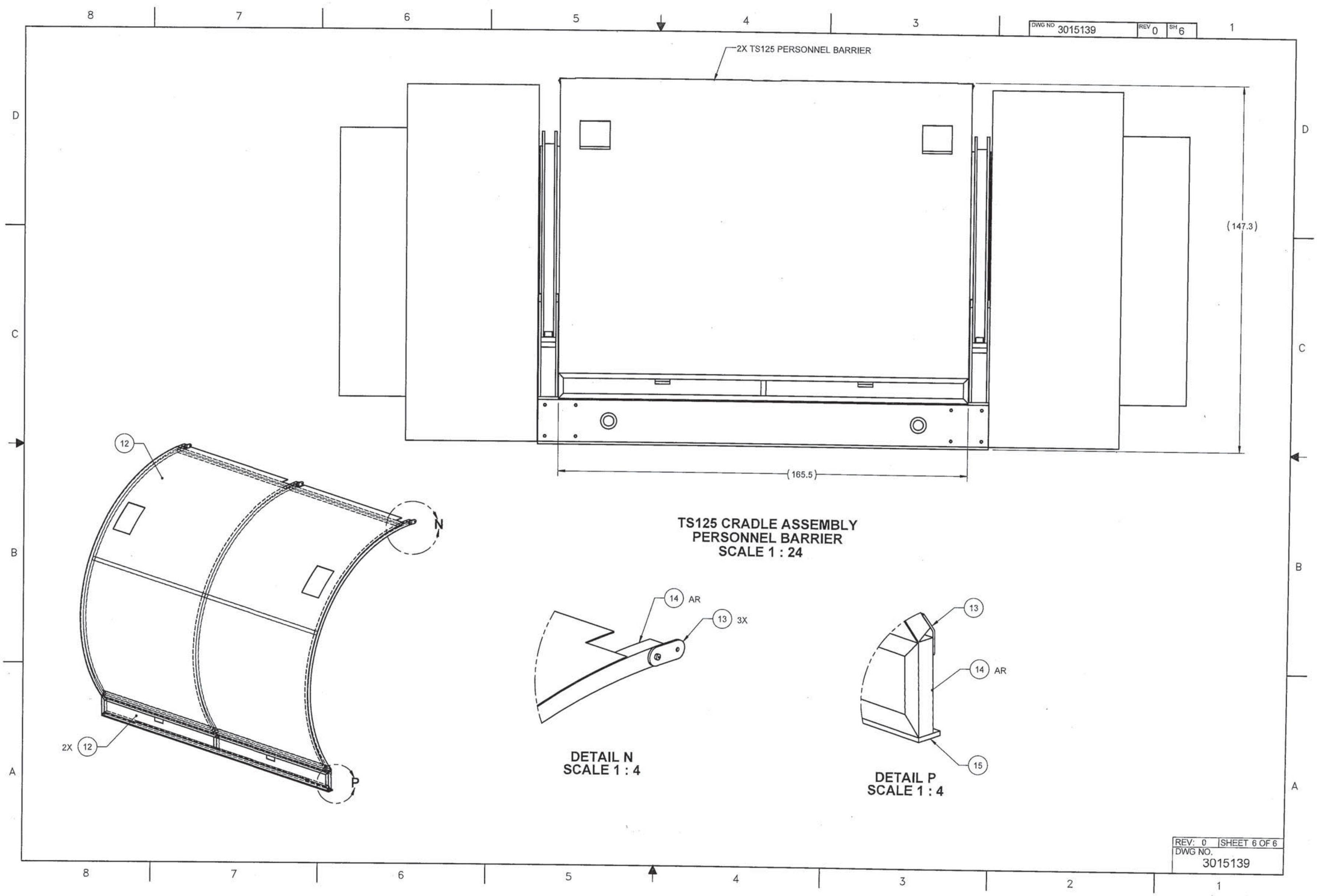

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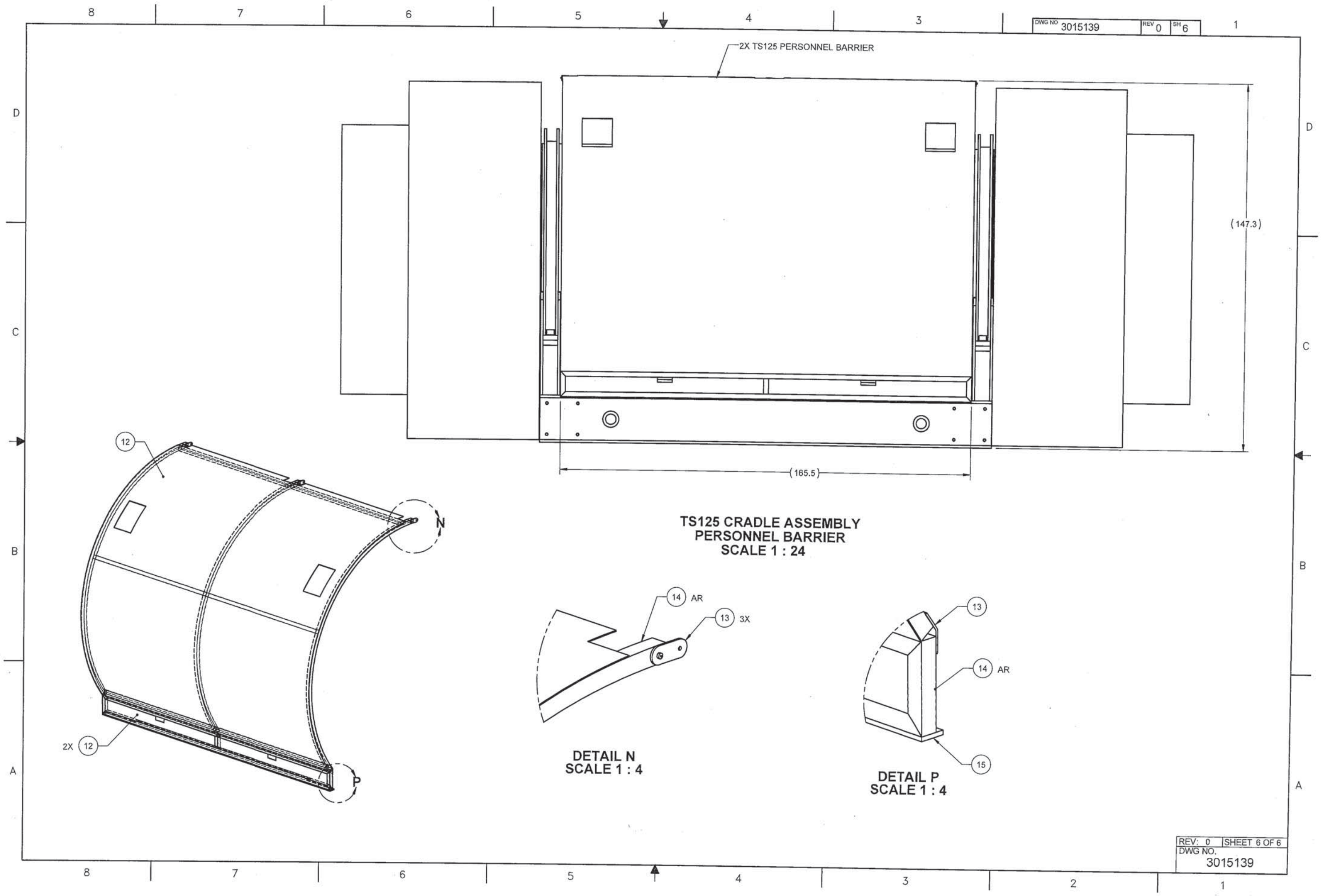
Page 6 of 6



Family 4 Conceptual Cradle Drawings

DWG NO 3015140 REV 1 SH 1

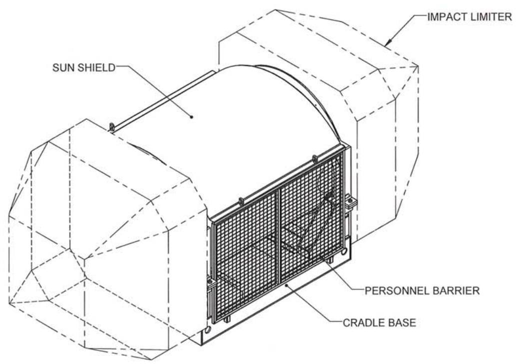
DWG-3015140-001 Page 1 of 3

NOTES, UNLESS OTHERWISE SPECIFIED:

1. CONCEPTUAL DESIGN ASSUMES ALL WELDS ARE FULL PENETRATION UNLESS OTHERWISE NOTED. ALL WELDS WILL BE FURTHER SPECIFIED IN A FINAL DESIGN.
2. WELDING SHALL BE PERFORMED IN ACCORDANCE WITH AWS D1.1.
3. DIMENSIONS WITH TOLERANCES SPECIFIED ARE RAILCAR INTERFACE DIMENSIONS AND SHOULD BE CONSIDERED DURING FINAL CRADLE DESIGN.
4. ALL SURFACES OF THE CRADLE WELDMENT, EXCEPT FOR PIN HOLES, PINS AND THREADED HOLES, SHALL BE BLAST CLEANED PER SSP-SP-10 AND COATED WITH SELF-PRIMING ENAMEL, 2 COATS WITH A DRY FILM THICKNESS OF 4 TO 8 MILS PER COAT. THE NON-PAINTED CRADLE WELDMENT SURFACES SHALL BE LIGHTLY COATED WITH NUCLEAR GRADE "NEVER-SEEZ" GREASE.
5. ATTACHMENTS FOR PERSONNEL BARRIER TO THE CRADLE ARE TO BE DEFINED DURING THE FINAL DESIGN.
6. THE ADDITION OF ALIGNMENT MARKS BETWEEN THE CRADLE AND RAILCAR INTERFACE SHOULD BE CONSIDERED IN THE DETAILED DESIGN TO SUPPORT LOADING OPERATIONS.
7. ALTERNATE MATERIAL (PLATE, BAR, OR FORGING) HAVING THE SAME CHEMICAL COMPOSITION WITH MECHANICAL PROPERTIES EQUAL TO OR GREATER THAN THOSE SPECIFIED MAY BE USED WITH THE APPROVAL OF THE DESIGN AUTHORITY.
8. ALL FILLETS OR INTERNAL RADII AND OUTSIDE CORNERS SHALL BE NO GREATER THAN 0.12 IN. UNLESS OTHERWISE SPECIFIED.
9. A SET OF LIFTING LINKAGE SHALL BE USED FOR VERTICAL LIFTING AT THE FOUR LIFTING POINTS PROVIDED.

LIST OF MATERIALS

QTY A1	ITEM NO	PART NO	DESCRIPTION	SPECIFICATION
	A1		MP187 CRADLE ASSEMBLY	
44	1		PLATE, 1 THK	ASTM A572, GR 50 OR EQUIV
2	2		W18X119	ASTM A992
4	3		PLATE, 6.0 THK	ASTM A514
1	4		PLATE, 6.0 X 23.3 X 22.4	ASTM A514
4	5		PLATE, 3 1/2 THK	ASTM A572, GR 50
16	6		PLATE, 1 1/2 THK	ASTM A572, GR 50
4	7		PLATE, 2 THK	ASTM A572, GR 50
4	8		PLATE, 1/2 THK	ASTM A572, GR 50
2	9		RUBBER, 1 THK	80 DURO
4	10		SQ BAR, 6 X 6 X 8	ASTM A514
6	11		RUBBER, 1/2 THK	80 DURO
3	12		PLATE, 1/4 THK	ASTM A572, GR 50
4	13		SIDE SCREEN MESH, 50% OPEN AREA	STAINLESS STEEL
4	14	2994T69	HOIST RING, 3/4-10 UNC, 5000 WLL	McMASTER-CARR OR EQUIV
	15		DELETED	
4	16		BUILD-UP ANGLE, 6 X 8 X 1.5	ASTM A572, GR 50
6	17		PLATE, 1 THK	ASTM A514
12	18	98404A515	BALL LOCK PIN, Ø.50 X 3.5 LG	McMASTER-CARR OR EQUIV
4	19		BAR, Ø2.5 X 10.5 LG	ASTM A311, GR 1144 CLASS B
4	20	91268A958	HEX BOLT, 1 1/2-6 UNC X 5 LG	McMASTER-CARR OR EQUIV
4	21	94895A041	HEX NUT, 1 1/2-6 UNC	McMASTER-CARR OR EQUIV
AR	22		TUBE, 2 X 2 X .125 WALL	STAINLESS STEEL
4	23		BAR, Ø6.5	ASTM A276, TYPE 304
2	24		W16X57	ASTM A992
4	25		PLATE OR SQ BAR, 1 1/2 X 1 1/2 X 2 LG	ASTM A572, GR 50
4	26		PLATE OR SQ BAR, 2 X 2 X 3.8 LG	ASTM A572, GR 50
4	27		TUBE, 3 X 3 X 1/4 WALL	ASTM A500



ISOMETRIC VIEW

AREVA Federal Services
APR 13, 2017
Records Management

REVISION HISTORY

REV	DESCRIPTION	DRAWN	CHECKER	VERIFIED
1	SEE ECN NO. 3015140R0-E1	R. LE 4/04/17	4/12/17	4/12/17

NEXT ASSY	FINAL ASSY		NAME/SIGNATURE	DATE
		EM	D. HILLSTROM	4/12/17
		RE	D. WICK	4/6/2017
		TECH CHK	S. KLEIN	4/6/2017
NA	NA	DFTG CHK	T. LE	4/6/2017
		DRAWN	R. LE	4/04/17

THIRD ANGLE PROJECTION

UNLESS OTHERWISE SPECIFIED:
INTERPRET DRAWINGS & TOLERANCES PER ASME Y14.5-2009 (REVISION OF ASME Y14.5M-1994)
INTERPRET WELD CALLOUTS PER ANSI/AWS A2.4
DIMENSIONS ARE IN INCHES

AREVA

AREVA Federal Services LLC
Packaging Projects
Federal Way, WA 98003

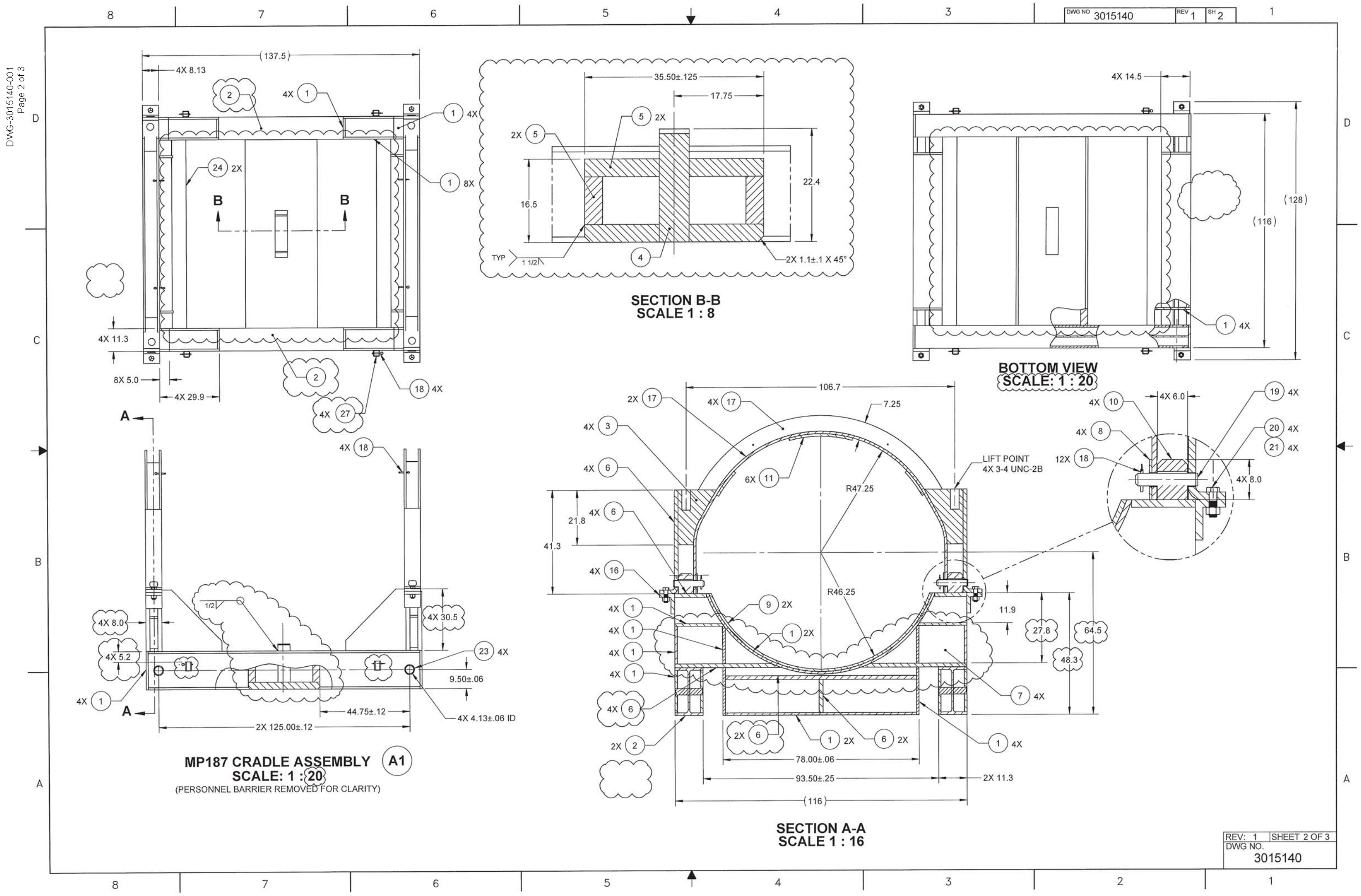
DWG TITLE: ATLAS RAILCAR CRADLE FAMILY 4 CONCEPTUAL DRAWING

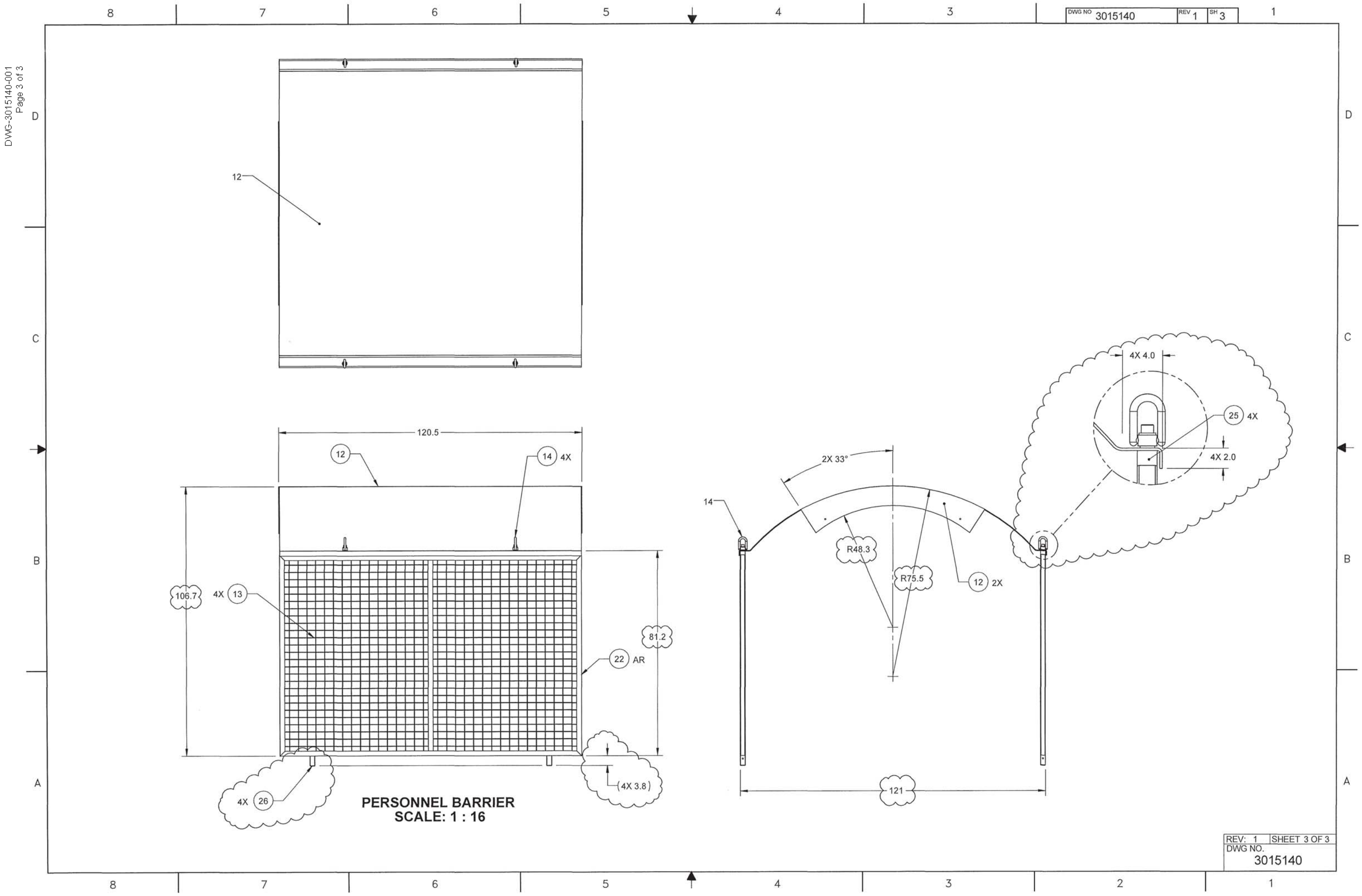
SCALE: SHOWN | WT. ~ LBS | REV: 1 | SHEET 1 OF 3

DWG SIZE D | DWG NO. 3015140

CADFILE: 3015140-1.SLDDRW

DWG-3015140-001


DWG-3015140-001
Page 2 of 3
DWG NO 3015140 REV 1 SH 2
SECTION B-B
SCALE 1 : 8
BOTTOM VIEW
SCALE: 1 : 20
MP187 CRADLE ASSEMBLY A1
SCALE: 1 : 20
(PERSONNEL BARRIER REMOVED FOR CLARITY)
SECTION A-A
SCALE 1 : 16
LIFT POINT
4X 3-4 UNC-2B
REV: 1 SHEET 2 OF 3
DWG NO.
3015140


DWG NO 3015140 REV 1 SH 3
DWG-3015140-001
Page 3 of 3
12
120.5
14 4X
106.7
4X 13
81.2
22 AR
4X 26
4X 3.8
PERSONNEL BARRIER
SCALE: 1 : 16
2X 33°
R48.3
R75.5
12 2X
121
4X 4.0
25 4X
4X 2.0
REV: 1 SHEET 3 OF 3
DWG NO.
3015140