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MD 6/28/05

COGEMA DOCUMENT TITLE: Trunnion Collar Removal Machine – Gap Analysis Table

COGEMA DOCUMENT ID: COGEMA-C0115-EN-CLC-0023

REFERENCE: YMPC-C0115-00367/DE-L-SC-PA005391-00705

COGEMA, INC.

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COVER SHEET
(PRELIMINARY)**

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Design Analysis/Calculation No: COGEMA-C0115-EN-CLC-0023 Revision: 2

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Project No. & Title: C0115, COGEMA Operational Design Services

The assigned engineers are qualified to perform the attached calculations in accordance with COGEMA-C0115-EN-PRC-005, "Design Analysis/Calculations."

P. Kerrien / 6/10/05

Engineering Manager/Date

CALCULATION/ANALYSIS APPROVAL

	Name/Signature/Date
Originator:	E. Faillace / 10 JUNE 2005
Checked By:	N. Labrecque / 6/10/2005
Approved By:	P. Kerrien / 6/10/2005
Other:	

RECORD OF REVISION

Rev.	Reason for Revision
0	Initial Issue
1	Continued on next page

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RECORD OF REVISION (Continued)

1 This is a complete revision.

Safety functions were developed and used to determine proper application of codes and standards.

Two of the nuclear design bases requirements used in Rev. 0 were dropped. The nuclear safety design bases requirement "The WP turntable shall be designed to not prematurely actuate (while holding the WP on an emplacement pallet) before the disengagement of the Trunnion Collar Removal Machine" was removed. This safety requirement will be addressed in a future WP turntable gap analysis. The nuclear safety design bases requirement "The trunnion collars shall employ a no-drop safety function during and after a DBGM-2 seismic event" was dropped. This safety requirement is applicable to trunnion collars installed on waste packages, but is not applicable to the trunnion collar removal machine.

The Nuclear Safety Design Bases for License Application [Ref. 10] was updated since the last issue of this analysis. Three nuclear safety design bases requirements are now listed for the Trunnion Collar Removal Machine. These requirements are listed in Appendix A, and addressed in this analysis.

Modification on instrumentation and controls section to upgrade code & standard to IEEE 603 [Ref. 9] instead of ANSI/ISA S84.01 [Ref. 3] as applicable per the PDC (reference [11]).

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Incorporation of Bechtel SAIC Company, LLC. comments provided in transmittal DE-XMTL-SDR-PA005391-00216.

Section 1 revised to reflect current design development plan.

Section 2 added BSC document numbers and updated reference list.

Section 3 (Design Inputs) inserted to comply with revised procedure and renumbered following sections.

Sections 6, 7, 8, 9, and 10 revised to state that there are no design development requirements identified.

Appendix A, Table 1, revised to clarify supplemental requirements.

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1 PURPOSE

The purpose of this document is to review the existing the trunnion collar removal machine against the *Nuclear Safety Design Bases for License Application* (NSDB) [Ref. 10] requirements and to identify codes and standards and supplemental requirements to meet these requirements. If these codes and standards can not fully meet these requirements then a "gap" is identified. These gaps will be identified here and addressed using the *Trunnion Collar Removal Machine Design Development Plan* [Ref. 15].

The codes and standards, supplemental requirements, and design development requirements for the trunnion collar removal machine are provided in the gap analysis table (Appendix A, Table 1). Because the trunnion collar removal machine is credited with performing functions important to safety (ITS) in the NSDB [Ref. 10], design basis requirements are applicable to ensure equipment is available and performs required safety functions when needed.

The gap analysis table is used to identify design objectives and provide a means to satisfy safety requirements. To ensure that the trunnion collar removal machine performs required safety functions and meets performance criteria, this portion of the gap analysis tables supplies codes and standards sections and the supplemental requirements and identifies design development requirements, if needed.

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2 REFERENCES

The following documents were used in the preparation of this analysis:

2.1 DOCUMENTS

- [1] AISC (American Institute of Steel Construction) 1997. *Manual of Steel Construction, Allowable Stress Design*, 9th ed. Chicago, Illinois: American Institute of Steel Construction.
- [2] ASCE (American Society of Civil Engineers) 4-98, 2000. *Seismic Analysis of Safety-Related Nuclear Structures and Commentary*. Reston, Virginia: American Society of Civil Engineers.
- [3] ANSI/ISA 84.01 -1996, *Application of Safety Instrumented Systems for the Process Industries*.
- [4] ASME (American Society of Mechanical Engineers) NOG-1-2002, *Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)*.
- [5] ASME NQA-1-2000, 2001. *Quality Assurance Requirements for Nuclear Facility Applications*. New York, New York: American Society of Mechanical Engineers.
- [6] AWS (American Welding Society) D1.1/D1.1M:2002, 2002. *Structural Welding Code—Steel*, 18th ed. Miami, Florida: American Welding Society.
- [7] *Canister Handling Facility Collar Removal Machine Control Functional Description*, COGEMA-C0115-EN-FD-1265, Rev. B. (BSC Standard Document No. V0-M00Z-QPA0-05391-00304-001)
- [8] COGEMA 2005a. *Design Bases Requirements Document*, COGEMA-C0115-RP-03-018, Revision 2. (BSC Standard Document No. V0-M00Z-QPA0-05391-00356-001-1)
- [9] IEEE (Institute of Electrical and Electronics Engineers) 603-1998, *Standard Criteria for Safety Systems for Nuclear Power Generating Stations*.

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- [10] BSC (Bechtel SAIC Company) 2005. *Nuclear Safety Design Bases for License Application*, BSC 000-30R-MGR0-00400-000-001, March 2005.
- [11] BSC (Bechtel SAIC Company) 2004a. *Project Design Criteria Document*. 000-3DR-MGR0-00100-000-003. Las Vegas, Nevada: Bechtel SAIC Company.
- [12] BSC (Bechtel SAIC Company) 2004b. *SNF/HLW Transfer System Description Document*. 110-3YD-HT00-00100-000-000. Las Vegas, Nevada: Bechtel SAIC Company.
- [13] AAR (Association of American Railroads) 2002. *Manual of Standards and Recommended Practices*.
- [14] ANSI (American National Standards Institute)/AISC N690-1994. *Specification for the Design, Fabrication, and Erection of Steel Safety-Related Structures for Nuclear Facilities*. Chicago, Illinois: American Institute of Steel Construction.
- [15] COGEMA 2005b. *Trunnion Collar Removal Machine Design Development Plan*. COGEMA-C0115-DDP-05-005, Rev. 1. Las Vegas, Nevada: COGEMA Inc. (BSC Standard Document No. V0-M00Z-QPA0-05391-00364-001-2)
- [16] BSC (Bechtel SAIC Company) 2004c. *Preclosure Seismic Design Methodology for a Geologic Repository at Yucca Mountain*. BSCTDR-WHS-MD-000004, Rev. 1. Las Vegas, Nevada: Bechtel SAIC Company.
- [17] ASTM (American Society for Testing and Materials) A759-00, 2001. *Standard Specification for Carbon Steel Rails*. West Conshocken, Pennsylvania: American Society for Testing and Materials.

2.2 DRAWINGS

The following drawings were used in the preparation of this analysis:

- [A] *Canister Handling Facility, Collar Removal Machine, Mechanical Equipment Envelope*, YMP-C0115-0806, Sheet 1, Rev. D (BSC Standard Document No. V0-M00Z-QPA0-05391-00129-001)

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- [B] *Dry Transfer Facility #1/Remediation Facility, General Arrangement, Ground Floor Plan C, 110-P10-WHS0-00110-000-00A.*
- [C] *Canister Handling Facility, General Arrangement, Ground Floor Plan, 190-P10-CH00-00103-000-00B.*
- [D] *Fuel Handling Facility General Arrangement, Ground Floor Plan, 210-P10-FH00-00102-000-00B.*
- [E] *Canister Handling Facility Collar Removal Machine, Process & Instrument Diagram, YMP-C0115-1265, Sheets 1 and 2, Rev. A. (BSC Standard Document No. V0-M00Z-QPA0-05391-00256-001 and -002)*
- [F] *Fuel Handling Facility, Collar Removal Machine, Mechanical Equipment Envelope, YMP-C0115-0913, Sheets 1 and 2, Rev. A. (BSC Standard Document No. V0-M00Z-QPA0-05391-00339-001 and -002)*
- [G] *SNF/HLW Transfer System, Trunnion Collar Removal Machine, Mechanical Equipment Envelope, YMP-C0115-0760, Sheet 1, Rev. A. (BSC Standard Document No. V0-M00Z-QPA0-05391-00218-001)*

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All other editions obsolete

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3 DESIGN INPUTS

- *Nuclear Safety Design Bases for License Application* [Ref. 10]. This document is used to identify the ITS requirements for each piece of equipment.
- *Canister Handling Facility, Collar Removal Machine, Mechanical Equipment Envelope* [Ref. A].
- *Fuel Handling Facility, Collar Removal Machine, Mechanical Equipment Envelope* [Ref. F].
- *SNF/HLW Transfer System, Trunnion Collar Removal Machine, Mechanical Equipment Envelope* [Ref. G].

The above three mechanical equipment envelopes are used to provide a preliminary design to which we can apply solutions to the ITS requirements.

- *SNF/HLW Transfer System Description Document* [Ref. 12]. This document is used as input to the Functional Description, section 5 of this calculation.
- *Project Design Criteria Document* [Ref. 11]. This document provides input to potentially applicable codes and standards that are referenced in this calculation.

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4 ASSUMPTIONS

The following assumptions were used in the development of this analysis:

- [1] The trunnion collar removal machine is not required to hold the waste package during a seismic event [TBV-N-1-42].

Rationale: The NSDB [Ref. 10] states that, "The trunnion collar removal machine system shall be designed for loading conditions associated with a DBGM-2 seismic event to prevent slapdown of the WP." This is interpreted to mean the trunnion collar removal machine will not cause a slapdown of the waste package during a DBGM-2 seismic event. It is not interpreted that the trunnion collar removal machine will hold the waste package on the WP turntable in a DBGM-2 seismic event. A design capable of holding a waste package during a seismic event would be too cumbersome and may interfere with the operation of the machine. Also, the waste package is not supported by the trunnion collar removal machine while the turntable is rotating.

- [2] A rail-based trunnion collar removal machine design [Ref. G] is considered to be representative for purposes of this analysis.

Rationale: A rail-based design is currently envisioned for the Dry Transfer Facility (DTF) [Ref. G]. While the current designs for the Canister Handling Facility (CHF) [Ref. A] and the Fuel Handling Facility (FHF) [Ref. F] are frame-based, these frames contain internal tracks so that the equipment in both cases moves along tracks to accommodate different waste package dimensions. The major difference is whether the rails/tracks are structurally attached to a base frame, or to the building floor.

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5 FUNCTIONAL DESCRIPTION

The function of the trunnion collar removal machine (equipment number: 110-MX-HTLO-CRM00001 [DTF], 190-MJ-HTLO-CRM00001 [CHF], 210-MX-HTLO-CRM00001 [FHF]) is to remove trunnion collars from waste packages before they are sent to the waste package emplacement and retrieval system. The waste package turntable positions the waste packages before trunnion collars are removed.

The trunnion collar removal machine is designed to remove collars from the following waste package types:

- 21-PWR (Absorber Plate and Control Rod)
- 12-PWR Long
- 44-BWR
- 24-BWR
- 5-DHLW/DOE SNF Long
- 5-DHLW/DOE SNF Short
- Naval SNF Long
- Naval SNF Short
- 2-MCO/2-DHLW

The trunnion collar removal machine is used by the waste package loadout subsystem, part of the SNF/HLW transfer system. The machine is located in the canister transfer cell [Ref. C, room 1033] in the CHF, in the WP loadout cell [Ref. B, room 1091] in the DTF, and in the main transfer room [Ref. D, room 1003] in the FHF.

The Trunnion Collar Removal Machine includes the following subcomponents:

- A base frame
- A trolley with a motorized drive train
- A trolley locking device
- Trunnion locking devices
- A trunnion collar rotating device

See Figure 1 in section 8.2.4 for the CHF and FHF trunnion collar removal machine. The base frame is fixed to the floor for the CHF and FHF trunnion collar removal machine. The trolley with a motorized drive train travels horizontally on this base frame. The DTF base

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frame rolls on rails, is motorized, and is used as a reference design for this analysis [Assumption 2].

The trolley locking device locks the trolley at its operating locations. The trunnion locking devices lock onto the trunnions of the waste package. The trunnion collar rotating device rotates the trunnion collar to remove it from the waste package.

After the waste package closure and survey, the waste package is placed on an emplacement pallet in a horizontal orientation. The emplacement pallet is supported by the WP turntable. By rotating and adjusting the height of the waste package, the turntable moves the waste package into correct position for collar removal. Once the waste package is correctly positioned for collar removal, the trunnion collar removal machine extends to engage and lock onto the trunnion collar. The machine then rotates the collar off and backs away from the waste package. Then a crane removes the trunnion collar from the trunnion collar removal machine and places the collar in a stand. The waste package turntable rotates the waste package 180 degrees for the second collar removal and the collar removal process is repeated.

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6 METHODOLOGY

This analysis began with the statement of applicable gap analysis table requirements for the trunnion collar removal machine as set forth in NSDB [Ref. 10] and inserted in this document in Table 1 of Appendix A. Then, safety functions are identified so that a design feature or proposed structures, systems or components (SSCs) could be applied.

Generic SSCs are intended to be major assemblies of the trunnion collar removal machine. Proposed SSCs and design features are defined as specific components of the trunnion collar removal machine needed to satisfy the safety functions. Examples of proposed SSCs or design features include trunnion locks, wheels, structural frame supports, and mechanical devices.

For the development of the proposed SSC, a code and standard is determined and applicable sections are listed to guide its development. Any calculations, modeling, or testing required by the code or standard is also noted. Section 8 provides a basis for selecting the codes and standards, and notes the extent of any applicability.

When a single code and standard does not adequately address the safety requirement then a supplemental requirement may be specified. These are requirements which supplement areas of the code or standard for additional criteria, calculations, modeling, and/or testing. If a safety function is still not adequately addressed then a "gap" is identified and a design development requirement is determined for the safety function. The process is repeated until all safety functions for a given requirement are determined and met. The design development requirements, if needed, are discussed in the *Trunnion Collar Removal Machine Design Development Plan* [Ref.15].

This document only addresses safety function performed by proposed SSCs associated with the trunnion collar removal machine. A code and standard not specifically supporting an item's identified safety function is not included.

The *Nuclear Safety Design Bases for License Application* (Appendix A, Table A-II) lists safety requirements for specific components. Tables A-I and A-II were reviewed for all safety requirements pertaining to the trunnion collar removal machine.

The trunnion collar removal machine is a unique component and many of the detailed design aspects are not determined at this time. As such, no single code or standard was found that is specifically intended for this type of equipment. By specifying codes and standards

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particular to a certain industry to parts of this machine, such as ASME NOG-1 [Ref. 4], it is not intended to drive the design towards that industry. Rather, the intent is to show that the required safety functions can be satisfied by following relevant portions of selected codes and standards. As the design progresses, the codes and standards may need to be reviewed for applicability. In addition, the list may need to be updated to reflect applied design solutions.

The *Project Design Criteria Document* [Ref. 11] provides support for the development of preliminary and detailed design for SSCs. Applicable sections of this document were reviewed for codes and standards. For those items which may seem relevant but were not selected, brief justification is provided in Section 8.

Consistent with Section 1.5 of the *Project Design Criteria Document*, the codes and standards referenced provide a technical basis for design features. These codes and standards chosen for the structural design and mechanical components will enable acceptable seismic evaluation methodology and design criteria.

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7 COMPUTER SOFTWARE

No computer calculations were performed as part of this analysis. Standard office software was used to produce this document.

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8 DISCUSSION

8.1 BACKGROUND

Chosen design codes and standards are based on the assumption that the trunnion collar removal machine is similar to a crane trolley and a trunnion collar removal device [Assumption 2]. More flexibility and design options are available for this customized trunnion collar removal machine using codes and standards for a trolley rather than a railcar. Railcar codes and standards are not written to comply with the nuclear industry standards whereas ASME NOG-1 is. In this comparison, ASME NOG-1 [Ref. 4] provides more flexibility over the Association of American Railroads (AAR) [Ref. 13] for a rail-based vehicle. For example, the AAR uses predetermined standards and specifications for various parts of the railcar that may restrict the optimum design of specialized aspects of the trunnion collar removal machine. Furthermore, ASME NOG-1 addresses seismic analysis whereas the AAR does not.

8.2 SAFETY FUNCTIONS

From the NSDB, there are three ITS requirement identified in Table A-II [Ref. 10]. These requirements specify that:

- The trunnion collar removal machine system shall be designed for loading conditions associated with a DBGM-2 (Design Basis Ground Motion - 2) seismic event to prevent slapdown of the WP. In addition, an analysis shall demonstrate that the trunnion collar removal machine system has sufficient seismic design margin to ensure that "no slapdown" and "no breach" safety functions are maintained for loading conditions associated with a BDBGM (Beyond Design Basis Ground Motion) seismic event.
- The premature actuation of the WP turntable (while holding the WP on an emplacement pallet) before the disengagement of the trunnion collar removal machine shall be precluded.
- An impact or collision between the trunnion collar removal machine and a WP shall not breach the WP or cause it to fall off the emplacement pallet.

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These nuclear safety design bases are evaluated for all payloads where safety functions apply. There are five safety functions identified in the ITS requirements above. These safety functions are listed below:

1. No slapdown of the waste package caused by the trunnion collar removal machine resulting from a DBGM-2 or a BDBGM seismic event.
2. No breach of the waste package caused by the trunnion collar removal machine resulting from a BDBGM seismic event.
3. No premature actuation of the WP turntable when the trunnion collar removal machine is engaged to the waste package.
4. No slapdown of the waste package resulting from a collision with the trunnion collar removal machine.
5. No breach of the waste package resulting from a collision between the trunnion collar removal machine and the waste package.

The design features identified for each safety function are either mechanical devices or instrumented controls. As such, a review of potentially applicable consensus codes and standards was performed to identify applicability. The codes and standards reviewed include American Institute of Steel Construction (AISC) 1997 [Ref. 1], American National Standards Institute (ANSI)/AISC N690-1994 [Ref. 14], American Society of Civil Engineers (ASCE) 4-98 [Ref. 2], ASME NOG-1 [Ref. 4], and Institute of Electrical and Electronics Engineers (IEEE) 603-1998 [Ref. 9].

ASME NOG-1 [Ref. 4] is chosen for all structural and mechanical design features as it directly applies to rail-based vehicles (crane components) used at nuclear facilities. ASME NOG-1 references common standards such as AISC 1997 and AWS D1.1 [Ref. 6] for applicability at the point of reference. As with AISC 1997, ASME NOG-1 specifies allowable stresses for structural components and also addresses crane rail requirements. ASME NOG-1 includes increased conservatism (for nuclear facilities) and also addresses features not covered by AISC, such as wheels, axles, bearings, brakes, deflections, and component alignments tailored for rail-based vehicles [Assumption 2].

ASME NOG-1 satisfies safety functions and mechanical and structural design features without the need for multiple codes and standards. This standard contains requirements relevant to the design and specification of structural and mechanical components used in nuclear facilities. ASME NOG-1 also invokes and conforms to ASME NQA-1 [Ref. 5], a standard quality assurance requirement for nuclear facilities where mechanical-handling

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equipment is used. ASME NOG-1 also contains seismic requirements and analytical techniques accepted by the nuclear industry. When practicable, the trunnion collar removal machine will be designed and specified in accordance with ASME NOG-1.

ANSI/AISC N690-1994 [Ref. 14] was reviewed as it applies to seismic analysis design, fabrication, and erection of steel safety-related structures for nuclear facilities. This standard was not chosen as it does not lend assistance in the design of a rail-based vehicle beyond what is covered in ASME NOG-1. This standard does discuss the erection of crane rails, and ANSI/AISC N690-1994 meets the minimum NOG-1 requirements. This standard also discusses anchor bolts and embedments that could be utilized by the facilities.

IEEE 603-1998 [Ref. 9] is identified in the *Project Design Criteria Document* [Ref. 11] as applicable to ITS control systems. This standard provides broad-reaching guidance for implementing principle safety features and invokes many other instrumentation industry standards.

ASCE 4-98 [Ref. 2] was reviewed as it applied to seismic analysis of safety-related structures. This standard was not chosen as it does not include detailed design requirements and tends to apply more to building structures (not rail-based vehicles – Assumption 2).

AISC 1997 [Ref. 1] was reviewed as it is widely used for steel construction, including crane runway rail. This standard could be used for the steel design features, but lends no assistance in the design of a rail-based vehicle. Without a more encompassing code or standard such as ASME NOG-1 for the design of the trunnion collar removal machine structural (not mechanical) components, AISC 1997 is a strong candidate to satisfy the allowable stress design considerations, particularly for any non-rail-based portions of the design such as the trunnion gripping arm.

8.2.1 Safety Function: No slapdown of the waste package caused by the trunnion collar removal machine resulting from a DBGM-2 or a BDBGM seismic event.

Table 1 in Appendix A states the following ITS requirement:

The trunnion collar removal machine system shall be designed for loading conditions associated with a DBGM-2 (Design Basis Ground Motion - 2) seismic event to prevent

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slapdown of the WP. In addition, an analysis shall demonstrate that the trunnion collar removal machine system has sufficient seismic design margin to ensure that “no slapdown” and “no breach” safety functions are maintained for loading conditions associated with a BDBGM (Beyond Design Basis Ground Motion) seismic event.

The no slapdown safety function is interpreted such that the trunnion collar removal machine will not cause a slapdown in a DBGGM-2 or a BDBGM seismic event. The trunnion collar removal machine is not intended to hold the waste package on the WP turntable during a DBGGM-2 or BDBGM seismic event [Assumption 1]. A slapdown is defined in the NSDB [Ref. 10] as a slapdown or rapid drop of a cask or WP in transit (i.e., the fall of a cask or WP, a vertical distance and subsequent impact on the floor, ground or onto another object).

The trunnion collar removal machine satisfies the no slapdown safety function by mechanically decoupling from the waste package in the event of a DBGGM-2 or BDBGM seismic event.

A design feature that could meet this safety function would be to use shear pins or mechanical links that will break during a seismic event and decouple the collar removal machine from the waste package. To adequately meet this safety function, a calculation will be required to adequately size shear pins or mechanical links. For this reason, no consensus codes and standards were selected. A supplemental requirement is added requiring a calculation demonstrating that this safety function can be met, but no design development requirements are identified for satisfying the seismically-initiated “no breach” safety requirements.

8.2.2 Safety Function: No breach of the waste package caused by the trunnion collar removal machine resulting from a BDBGM seismic event.

Table 1 in Appendix A states the following ITS requirement:

The trunnion collar removal machine system shall be designed for loading conditions associated with a DBGGM-2 (Design Basis Ground Motion - 2) seismic event to prevent slapdown of the WP. In addition, an analysis shall demonstrate that the trunnion collar removal machine system has sufficient seismic design margin to ensure that “no slapdown” and “no breach” safety functions are maintained for loading conditions associated with a BDBGM (Beyond Design Basis Ground Motion) seismic event.

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A postulated scenario is the collar removal machine could collapse during a BDBGM seismic event creating a spike that the waste package could fall on and breach. The corresponding safety function is the collar removal machine shall not collapse during a BDBGM seismic event. The design features that will be used to meet this safety function are the support structure, the moving structure, and the mechanical components used to support, extend and rotate the collar removal arms.

Applying the no collapse safety function to the trunnion collar removal machine for a BDBGM seismic event should leave sufficient design margin to ensure that the no collapse safety function is also met following a DBGM-2 seismic event.

To ensure the trunnion collar removal machine will meet this safety function, specific components will be designed and evaluated using applicable sections of ASME NOG-1 [Ref. 4]. Applicable sections include NOG-4100, Structural General; NOG-4200, Materials and Connections; NOG-4300, Design Criteria; NOG-4460, Rails; NOG-5200, Materials; NOG-5300, Design and Performance Criteria; NOG-5453, Axles – Bridge and Trolley; NOG-5456, Fasteners; NOG-5470, Analytical Procedures; NOG-5480, Seismic Analysis; NOG-6120, Seismic Considerations (Types I, II, and III Cranes); NOG-6210, General; NOG-6460, Auxiliary Equipment (Types I, II, and III Cranes); and NOG-6461, General. Further sections may also apply, depending on the detailed design. ASME NOG-1 includes seismic loading and normal operating condition loading. The rail system will also be designed and evaluated using ASTM A759 [Ref. 17], in addition to the applicable NOG-1 sections.

Inspections and acceptance testing performed by the manufacturer and at the site are identified as a general supplemental requirement applicable to all safety requirements. NOG-7000 covers inspection and testing; however, the applicability of this section must be reviewed against the WP tilting machine design to determine inspection and testing requirements needed to ensure that safety requirements are met. Inspection and testing candidates include material certifications, weld examinations and tests, assembly inspections, mechanical tests, and load tests.

Supplemental requirements are necessary to determine additional acceptance criteria for NOG-5470, Analytical Procedures; and permissible analytical methods for NOG-5481, Seismic Analysis, in association with the BDBGM seismic event. The seismic related calculations and/or analyses will be performed for BDBGM and for high confidence of low probability of failure seismic margin analysis. These will be performed to the methodologies identified in *Preclosure Seismic Design Methodology for a Geologic Repository Yucca Mountain* [Ref. 16]. A supplemental test requirement is identified to determine the seismic

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load capacity of the rail, especially horizontal loads. Crane rail standards [Ref. 17] do not provide material yield or ultimate strengths for standard evaluation. Supplemental testing for the rail may be performed under other equipment, such as the cask trolley, and applied for all rail at the facilities including the trunnion collar machine rails.

It can be seen from the table in Appendix A that this nuclear safety design requirement can be satisfied through ASME NOG-1 and the supplemental requirements covering inspection, testing, and BDBGM seismic analyses criteria and methods. No design development requirements are identified for satisfying the seismically-initiated "no breach" safety requirements.

8.2.3 Safety Function: No premature actuation of the WP turntable when the trunnion collar removal machine is engaged to the waste package.

Table 1 in Appendix A states the following ITS requirement:

The premature actuation of the WP turntable (while holding the WP on an emplacement pallet) before the disengagement of the trunnion collar removal machine shall be precluded.

This requirement is applicable to the WP Turntable. Safety functions, design features, and applicable consensus codes and standards will be developed separately for the WP turntable.

8.2.4 Safety Function: No slapdown of the waste package resulting from a collision with the trunnion collar removal machine.

Table 1 in Appendix A states the following ITS requirement:

An impact or collision between the trunnion collar removal machine and a WP shall not breach the WP or cause it to fall off the emplacement pallet.

A slapdown is defined in the Nuclear Safety Design Bases [Ref. 10] as a slapdown or rapid drop of a cask or WP in transit (i.e., the fall of a cask or WP, a vertical distance and subsequent impact on the floor, ground or onto another object). The term "fall off the

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emplacement pallet" used in the requirement text is assumed to mean no slapdown as a result of a collision or impact.

Two postulated scenarios are identified that will cause a slapdown as a result of a collision between the trunnion collar removal machine and the waste package.

1. One scenario is that the trunnion collar removal machine may push or pull the WP off the emplacement pallet.
2. The other scenario is that the trunnion collar removal machine is in its extended position while the WP turntable is rotating.

Scenario 1

The first scenario that may result in the WP being dropped from the emplacement pallet would be if the trunnion collar removal machine were to push or pull the WP from the emplacement pallet. The trunnion collar removal machine extensions and retractions are based on the various waste package sizes. The longest WP is the Naval SNF long (length: 236 inches) and the shortest WP is the 5-DHLW/DOE SNF short (length: 143 inches) [Ref. 8]. The 5-DHLW/DOE SNF short WP emplacement pallet is 98 inches long while the length for the Naval- SNF-long WP emplacement pallet is 163 inches long [Ref. 8].

The difference in the stroke to engage the longest and the shortest waste package

$$\text{Stroke} = \frac{L_{\text{NavalLong}} - L_{\text{DHLWShort}}}{2} + L_{\text{clearance}}$$

$$\text{Stroke} = \frac{236\text{in} - 143\text{in}}{2} + 12\text{in}$$

$$\text{Stroke} = 58.5\text{in}$$

Distance from the center to the edge of the emplacement pallet

$$\text{dist} = \frac{L_{\text{palletShort}}}{2}$$

$$\text{dist} = \frac{98\text{in}}{2}$$

$$\text{dist} = 49\text{in}$$

This shows that the trunnion collar removal machine must be designed with enough stroke that it is capable of pulling the center of gravity of a 5-DHLW/DOE SNF short waste package off the short emplacement pallet. Figure 1 below illustrates this configuration.

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- Figure 1. Hypothetical illustration of the end of stroke for the collar removal machine and the 5-DHLW/DOE SNF short waste package.

For the trunnion collar removal machine to be capable of pulling or pushing a waste package, the drive train that extends and retracts the trolley of the collar removal machine would have to be designed with the capability of producing sufficient force to cause a waste package to slide on the emplacement pallet. The design feature is the trunnion collar removal machine shall have force limiting protection so that it will not have the capacity to overcome the static friction forces holding the waste package on the emplacement pallet. This may be solved by a number of simple mechanical design features. The drive motor could be sized so that it is not capable of pulling or pushing a waste package from the emplacement pallet, a torque limiter could be installed in the power drive train, or shear pins could be included in the design of the drive train. To adequately meet this safety function, an analysis will be required to adequately size a motor, torque limiter, or shear pin. For this reason, no consensus codes and standards were selected, and a supplemental requirement was added requiring a sizing calculation of the mechanical design feature that meets this safety function.

Scenario 2

The second scenario that could cause a waste package to fall from the emplacement pallet would be if the trunnion collar removal machine is extended while a waste package is being rotated. The resulting impact may cause the waste package fall off the emplacement pallet. The design feature is an interlock to prevent the trunnion collar removal machine from extending if the turntable is not in proper alignment.

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To ensure the trunnion collar removal machine will meet the safety function and associated design features stated above, the consensus code IEEE 603-1998, "*Standard Criteria for Safety Systems for Nuclear Power Generating Stations*" [Ref. 9] was selected. This standard provides broad reaching guidance for implementing safety features and invokes many other industry standards.

Other non-safety process control functions and associated components for the collar removal machine are not subject to the derived safety function. The safety-related SSCs and non safety-related SSC shall be independent.

No supplemental requirements are identified for the interlock that satisfies the safety function discussed in this scenario.

No design development requirements are identified for satisfying the "no slapdown" safety requirement.

8.2.5 Safety Function: No breach of the waste package resulting from a collision with the trunnion collar removal machine.

Table 1 in Appendix A states the following ITS requirement:

An impact or collision between the trunnion collar removal machine and a WP shall not breach the WP or cause it to fall off the emplacement pallet.

The safety function is the collar removal machine shall not be capable of breaching a waste package upon collision with a waste package. The postulated scenario that could result in a breach would be if the collar removal machine arms were design with sharp protruding objects capable of breaching a waste package when traveling at its operational speed. A calculation is required to determine acceptable protruding trunnion collar gripping mechanisms and acceptable maximum trolley frame speeds. To ensure that the trunnion collar removal machine meets this safety function the results of the calculation shall be incorporated into the design. For this reason, no consensus codes and standards were selected, and a supplemental requirement was added requiring a sizing calculation of the mechanical design features that meet this safety function. No design development requirements are identified for satisfying the "no breach" safety requirement.

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8.3 APPLICABLE ENVIRONMENTAL AND OPERATIONAL REQUIREMENTS

The *SNF/HLW Transfer System Description Document* [Ref. 12] currently identifies no environmental or operational requirements for the trunnion collar removal machine that may affect the chosen codes and standards at this stage of the design.

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9 RESULTS

Section 8 discusses codes and standards and supplemental requirements (when identified) for each generic SSC for each design feature to meet the safety functions for the trunnion collar removal machine set forth in the NSDB [Ref. 10]. Table 1 in Appendix A summarizes these codes/standards and supplemental requirements. No design development requirements are identified.

The list of the codes and standards identified in Table 1 includes ASME NOG-1 [Ref. 4], ASTM A759 [Ref. 17], and IEEE 603-1998 [Ref. 9]. Table 1 lists the applicable sections of the above codes and standards identified to meet the requirements of the NSDB.

Supplemental requirements include:

- Inspection and testing applying NOG-7000 [Ref. 4] as applicable
- Analytical methods and acceptance criteria for the BDBGM seismic event
- A calculation to qualify the trunnion collar removal machine breakaway (decoupling) interface
- A calculation to properly size motor, drive train, torque limiter, and/or shear pin
- A calculation to determine acceptable collision speeds
- Tests to determine seismic load capacity of the rails.

Table 1 identifies which SSCs the supplemental requirements are associated with to meet the requirements of the NSDB.

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10 CONCLUSION

By scrutinizing design basis requirements and implementing codes and standards and their related sections,, the gap analysis table shows that the trunnion collar removal machine can be designed to meet the nuclear safety design basis requirements. The ITS SSCs identified are based upon the current preliminary design and may change based on future design developments and configurations.

There is one primary mechanical standard that applies to the trunnion collar removal machine. ASME NOG-1, *Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)* [Ref. 4] is used as it applies to rail-based vehicles and structural and mechanical components in nuclear facilities. ASTM A759 [Ref. 17] also applies to the rails. Specific sections as they apply to the safety requirements are identified in Section 8 and Table 1 in Appendix A.

There is one primary power, instrumentation and control standard identified that applies to the trunnion collar removal machine; IEEE 603-1998 [Ref. 9] provides broad-reaching guidance for implementing principle safety features.

The additional supplemental requirements are included to show how the design fully satisfies the safety requirements address inspections and testing, analytical methods and acceptance criteria for the BDBGM seismic event (including the breakaway interface) qualification, to limit the torque of trolley frame drive train, and to ensure that the trolley frame travel speed is below the maximum calculated to avoid a waste package breach.

No design development requirements are identified. Design development requirements may be identified as the design progresses. The *Trunnion Collar Removal Machine Design Development Plan* [Ref. 15] provides a progressive approach and framework for developing design development activities addressing standard engineering design, procurement, and testing methods.

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11 APPENDIX A

Table 1. Trunnion Collar Removal Machine GAP Analysis

Design Analysis/Calculation Title: Trunnion Collar Removal Machine – Gap Analysis Table

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Table 1. Trunnion Collar Removal Machine Gap Analysis

ITS Requirements and Engineering Solutions				Code and Standard Applicability							Supplemental Requirements				Design Developments						
Req. Number	Requirement Text	Generic SSCs	Proposed SSCs	Code or Standard	Applicable Section	Section Description	Required Calculation	Required Modeling	Required Testing	Additional Criteria	Required Calculation	Required Modeling	Required Testing	Required Calculation	Required Drawings	Required Modeling	Required Testing				
1	The trunnion collar removal machine system shall be designed for loading conditions associated with a DBGM-2 seismic event to prevent slapdown of the WP. In addition, an analysis shall demonstrate that the trunnion collar removal machine system has sufficient seismic design margin to ensure that "no slapdown" and "no breach" safety functions are maintained for loading conditions associated with a BDBGM seismic event.	Trunnion collar removal machine	Mechanical Devices: breakaway interface between trunnion collar and trunnion collar removal machine				N/A	N/A	N/A	Supplemental requirement to qualify the trunnion collar removal machine breakaway interface											
				ASME NOG-1	NOG-4100	Structural General	Yes	No	No												
					NOG-4200	Materials and Connections	Yes	No	No												
					NOG-4300	Design Criteria	Yes	No	No												
					NOG-4430	Trolley Frames	Yes	No	No												
					NOG-4460	Rails	Yes	No	No					Seismic Load Capacity	No	No	Yes				
					NOG-5200	Materials	Yes	No	No												
					NOG-5300	Design Performance Criteria	Yes	No	No												
					NOG-5453	Axles – Bridge and Trolley	Yes	No	No												
					NOG-5456	Fasteners	Yes	No	No												
					NOG-5470	Analytical Procedures								Analytical Method and Acceptance criteria for a BDBGM seismic event	Yes	No	No				
	NOG-5480	Seismic Analysis	Yes	Yes	No				Acceptance criteria to be defined	Yes	No	No									
	NOG-6120	Seismic Considerations	Yes	No	No																
	NOG-6210	General	Yes	No	Yes																
	NOG-6460	Auxiliary Equipment	Yes	No	Yes																

Design Analysis/Calculation Title: Turnunion Collar Removal Machine – Gap Analysis Table

Orig: SF Date: 6/10/05

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ITS Requirements and Engineering Solutions				Code and Standard Applicability										Supplemental Requirements				Design Development Requirements			
Req. Number	Requirement Text	Generic SSCs	Proposed SSCs	Code or Standard	Applicable Section	Section Description	Required Calculation	Required Modeling	Required Testing	Additional Criteria	Required Calculation	Required Modeling	Required Testing	Required Calculation	Required Drawings	Required Modeling	Required Testing				
1 (Cont'd)	The trunnion collar removal machine system shall be designed for loading conditions associated with a DBGM-2 seismic event to prevent slapdown of the WP. In addition, an analysis shall demonstrate that the trunnion collar removal machine system has sufficient seismic design margin to ensure that "no slapdown" and "no breach" safety functions are maintained for loading conditions associated with a BDBGM seismic event.	Trunnion collar removal machine	Mechanical devices: steel devices including the trolley frame support structure and a device on the trolley frame preventing the wheels from disengaging from the rail.	ASME NOG-1	NOG-7000	Inspection and Testing	No	No	No	Determine applicable requirement	No	No	Yes								
				ASTM A759	All	Carbon steel crane rails	No	No	No												
2	The premature actuation of the WP turntable (while holding the WP on the emplacement pallet) before the disengagement of the trunnion collar removal machine shall be precluded.	WP Turntable	N/A	N/A	N/A	N/A	N/A	N/A	N/A												
3	An impact or collision between the trunnion collar removal machine and the WP shall not breach the WP or cause it to fall off the emplacement pallet.	Trunnion collar removal machine	Mechanical devices: trolley frame drive train	N/A	N/A	N/A	N/A	N/A	N/A	Supplemental requirement on the trolley frame drive train are required to limit the maximum torque capable by the drive train	Yes	No	No								
				Instrumentation and control devices	IEEE-603-1998	All	As applicable	Yes	No		Yes										
			Mechanical devices: trolley frame drive train and mechanical interface with trunnion collar	N/A	N/A	N/A	N/A	N/A	N/A	Supplemental requirement on the trolley frame speed and mechanical interface with the trunnion collar to ensure no breach of the waste package	Yes	No	No								

NOTES: The requirement text (second column) is derived from Nuclear Safety Design Bases for License Application [Ref. 10].
Generic SSCs are intended to be major assemblies of the turnunion collar removal machine.
Proposed SSCs are intended to be design features and subassemblies of the Generic SSC.