KN

21

Page 1 of 1

609378

Design Package Lazy Susan For The Fuel Retrieval System

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Abstract: This is a design package that contains the details for a Lazy Susan style small tool for the Fuel Retrieval System. The Lazy Susan tool is used to help rotate an MCO Fuel Basket when loading it. This document contains requirements, development design information, tests and test reports that pertain to the production of Lazy Susan small tool.

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Karen L. Noland 11/9/98
Release Approval Date

Release Stamp

Approved for Public Release

Design Package

Lazy Susan for the Fuel Retrieval System

HNF-3525 Rev. 0

November 6, 1998

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Fuel Retrieval System Small Tools Design Package

Lazy Susan

HNF-3525 Rev. 0

November 6, 1998

Page 2

1.0 Introduction

The Fuel Retrieval System (FRS) Subproject at Hanford's 100 K basins Spent Nuclear Fuel Project has employed robotic arms (named Konans) to load fuel elements into long term storage baskets.

This robotic arm has been tested and continues to be used for training. The testing and training has shown that a method is required to help turn the MCO fuel basket while loading. Use of a manual style "Lazy Susan" platform worked well in testing but needed refined to meet the conditions of operation. This design package documents the development of a "Lazy Susan" style device that will be capable of meeting all the design requirements FRS requires for operation.

2.0 Scope

2.1 Objectives

The scope of this design package is to document the design, fabrication, and testing of a "Lazy Susan" style platform for holding the fuel baskets during FRS loading operations.

2.2 Products Delivered

This package will deliver the following:

Documents

- 1) This document, which includes product requirements, analysis, graphical depictions, tests and reports.
- 2) Hanford formatted drawings
- 3) Vendor information
- 4) Procurement documentation

Hardware

- 1) Four "Lazy Susan" style platforms

3.0 Products Requirements and Constraints

The general design requirements/criteria for the Spent Nuclear Fuel Project Fuel Retrieval subproject is in HNF-S-0461, *Specification For Design Of The SNF Project Fuel Retrieval Subproject*. The following requirements are additional or clarify it for the Lazy Susan.

Fuel Retrieval System Small Tools Design Package

Lazy Susan

HNF-3525 Rev. 0

November 9, 1998

Page 3

3.1 Dimensional/Physical Constraints

- a) Platform must fit within the fuel basket loading station (24 inches in diameter) as defined by Westinghouse supplied drawing DAG-327.
- b) Platform must keep the height of the fuel basket to no greater than 3 to 4 inches above the process table for Mark I A (23.125 inches tall) and Mark IV (27.8 inches tall) MCO Fuel Baskets. MCO Fuel Baskets dimensions taken from drawing H-2-828060.
- c) Platform needs to be round with a diameter of no greater than 22 inches (consistent with the Mark IV) and no less than 14 inches.
- d) Platform shall not interfere with light tube as described by Westinghouse supplied drawing DAG-327.

3.2 Environmental Constraints

- a) Platform material must be able to withstand the effects of high radiation field of 40 rem / hr. This value is a conservative interpretation of BNFL Inc. Report L/B-SD-SNF-RPT-04, Radiological Shielding Design Plan for the SNF Fuel Retrieval Project.
- b) Platform must be able to be submersed in deionized water at a temperature of 50 °F for a period of its design life.
- c) Platform must be able to handle a semi-abrasive environment, suspended metal particulates without deterioration for the period of its design life.
- d) No grease or petroleum based material lubricant can be used.

3.3 Operational Requirements

- a) Platform shall have a 3 year operating life, assuming the bearing is rotated ¼ turn every 15 minutes during those 3 years.
- b) Platform shall be capable of rotating 360° using the Konan robotic arm with a fully loaded Mark IV fuel basket on it.
- c) Platform will operate under 16-20 feet of water.

Fuel Retrieval System Small Tools Design Package

Lazy Susan

HNF-3525 Rev. 0

November 9, 1998

Page 4

- d) Platform shall not restrict light from shining up through the bottom of a MCO Fuel Basket.
- e) Platform shall be capable of supporting a fully loaded Mark IV fuel basket (3500 lbs.) but be designed for 5000 lbs.
- f) Platform shall be capable of withstanding an impact load from a fuel element dropping 36 inches with the basket nearly loaded.

3.4 Maintenance Requirements

- a) Platform shall be remotely replaceable with manipulators and/or long pole tools and overhead cranes.
- b) Platform will be replaced rather than repaired if a premature failure were to occur.

3.5 Applicable Laws, Regulations, and Standards

Applicable Fluor Daniel Hanford Engineering procedures shall be used for documenting development stages of design, reviews, and approvals of engineering documents.

4.0 Development of Product

4.1 Management of Task

4.1.1 Engineering

Engineering will be done using Fluor Daniel Northwest. Documents will be reviewed and approved by Duke Engineering & Services Hanford.

4.1.2 Procurement

Developmental materials will be procured using credit cards from Numatec. Final parts will be ordered based on who is awarded the final fabrication.

4.1.3 Fabrication / Construction

Fluor Daniel Northwest will be responsible for fabrication and construction of prototype and the final design.

Fuel Retrieval System Small Tools Design Package

Lazy Susan

HNF-3525 Rev. 0

November 6, 1998

Page 5

4.1.4 Prototype

Fluor Daniel Northwest will control prototype equipment. The Engineer in charge will redline control of prototype fabrication drawings/sketches. Prototype testing and test results will be documented. The prototype information will be incorporated into this document.

4.2 Discussion of Development

A Lazy Susan style concept utilizes a rotating platform. Usually a bearing type device is utilized to allow for the rotation. In all the concepts considered, a bearing was used.

To develop these concepts, several bearing manufacturers were contacted. Each manufacturer suggested that a ceramic bearing rolling device should be based on the environmental requirements. They all suggested also that a single radial ball type bearing should be used.

The problem lies in that a ceramic ball is harder than the race material and thus a harder race material is required. Standard race material is hardened steel which contains a higher carbon content. This type of steel tends to corrode in water. Use of other materials is too expensive for developing a bearing and manufacturers are not willing to build something that would meet the requirements.

A specialized bearing manufacturer (Champion) was contacted who builds bearing for outer space. Champion applies a dry lubricant to the bearing races through a sputtering technique. A 14 inch diameter steel (AISI 52100) bearing sputtered with silver and loaded with 122 ceramic balls was purchased from Champion at a real low cost for testing. The sputtering is expected to keep the corrosion from taking place.

4.2.1 Sketches/Drawings

All graphical depictions can be found in Appendix A

Sketch 1

This is a concept that would use a large diameter ring that contained several small radial bearings. The platform that would hold the basket would ride on the outer race of the radial bearings.

Fuel Retrieval System Small Tools Design Package

Lazy Susan

HNF-3525 Rev. 0

November 9, 1998

Page 6

Sketch 2

This is a concept that placed several balls in a large radial ring and the platform (the MCO Fuel Basket rests on) would rotate on top of the balls.

Drawing 1

This is a drawing showing how a radial bearing from Champion would be used. A holding block secures the outer race of the bearing and the inner race holds the platform that the basket can ride on.

4.3 Verification of Product Design

All equipment developed will be verified by either having an independent review, test specification, or calculations. This document will be changed via an ECN to incorporate verification documentation.

4.3.1 Analysis

Calculations can be found in Appendix B. An analysis of the loading was done to verify the use of 122 balls and that the bearing won't fail when fully loaded.

A structural analysis of the tables support beams and its welds on the table were done to verify the weight of the Lazy Susan and loaded basket.

Fuel Retrieval System Small Tools Design Package

Lazy Susan

HNF-3525 Rev. 0

November 3, 1998

Page 7

Appendix A

Graphical Depictions of Product

MK IV BASKBT - 22.625" O.D.

FUEL BASKBT GUAGE - 22.85" I.D.

A-A

CERAMIC
G301 BEARING
PROPOSE
(TYP. 8 PL)

FLUOR DANIEL NORTHWEST, INC.

September 9, 1998

SKETCHES OF LAZY SUSAN OPTION SECTIONS

Option 1

Option 2

1 ASSEMBLY BEARING HOLDER

SCALE: 1/1

- GENERAL NOTES (UNLESS OTHERWISE SPECIFIED)**
1. ALL MATERIAL SHALL BE AS SPECIFIED OR AN APPROVED EQUAL.
 2. ABBREVIATIONS ARE IN ACCORDANCE WITH AWS T1.1-1989.
 3. DIMENSIONS AND TOLERANCES ARE PER ASME Y14.5M-1994.
 4. ALL DIMENSIONS ARE IN INCHES.
 5. TOLERANCES: DECIMAL .X $\pm$.1, .XX $\pm$.03, .XXX $\pm$.010, ANGLES $\pm$.1°.
 6. BREAK ALL SHARP EDGES AND REMOVE ALL BURRS.
 7. ALL MACHINED SURFACES SHALL BE 125 OR BETTER.

PARTS/MATERIAL LIST				MATERIAL/REFERENCE	
QTY REQ.	PART/POSH NUMBER	DESCRIPTION	QTY REQ.	QTY REQ.	QTY REQ.
1	-010	ASSEMBLY, BEARING HOLDER	1	1	1
1	-000	SUBASSEMBLY, INNER BEARING HOLDER	1	1	1
1	-030	SUBASSEMBLY, OUTER BEARING HOLDER	1	1	1
1	-001	OUTER BEARING HOLDER BLOCK	1	1	1
1	-002	INNER BEARING HOLDER BLOCK	1	1	1
4	-003	OUTER BEARING HOLDER PLATE	4	4	4
4	-004	INNER BEARING HOLDER PLATE	4	4	4
2	-005	BUSH CHANNEL, 1/8" THK.	2	2	2
1	-006	BUSH PLATE, 1/8" THK.	1	1	1
1	-007	PLATE, 1/25 THK.	1	1	1
1	-008	PLATE, 1/3 THK.	1	1	1
1	-009	PLATE, 25 THK.	1	1	1
1	-010	SILVER COATED BEARING WITH CERAMIC BALLS	1	1	1
1	-011	SOC. HD. CAP. SCREW 1/4"-20 UNC-2A X 1/2 L	1	1	1
1	-012	SOC. HD. CAP. SCREW 1/4"-20 UNC-2A X 3/8 L	1	1	1
1	-013	WASHER/SPACER	1	1	1
1	-014	ASTM A-36	1	1	1
1	-015	ASTM A-36	1	1	1
1	-016	ASTM A-36	1	1	1
1	-017	ASTM A-36	1	1	1
1	-018	ASTM A-36	1	1	1
1	-019	ASTM A-36	1	1	1

QTY REQ.	PART/POSH NUMBER	DESCRIPTION	QTY REQ.	QTY REQ.	QTY REQ.
1	-010	ASSEMBLY, BEARING HOLDER	1	1	1
1	-000	SUBASSEMBLY, INNER BEARING HOLDER	1	1	1
1	-030	SUBASSEMBLY, OUTER BEARING HOLDER	1	1	1
1	-001	OUTER BEARING HOLDER BLOCK	1	1	1
1	-002	INNER BEARING HOLDER BLOCK	1	1	1
4	-003	OUTER BEARING HOLDER PLATE	4	4	4
4	-004	INNER BEARING HOLDER PLATE	4	4	4
2	-005	BUSH CHANNEL, 1/8" THK.	2	2	2
1	-006	BUSH PLATE, 1/8" THK.	1	1	1
1	-007	PLATE, 1/25 THK.	1	1	1
1	-008	PLATE, 1/3 THK.	1	1	1
1	-009	PLATE, 25 THK.	1	1	1
1	-010	SILVER COATED BEARING WITH CERAMIC BALLS	1	1	1
1	-011	SOC. HD. CAP. SCREW 1/4"-20 UNC-2A X 1/2 L	1	1	1
1	-012	SOC. HD. CAP. SCREW 1/4"-20 UNC-2A X 3/8 L	1	1	1
1	-013	WASHER/SPACER	1	1	1
1	-014	ASTM A-36	1	1	1
1	-015	ASTM A-36	1	1	1
1	-016	ASTM A-36	1	1	1
1	-017	ASTM A-36	1	1	1
1	-018	ASTM A-36	1	1	1
1	-019	ASTM A-36	1	1	1

U.S. DEPARTMENT OF ENERGY
K BASIN (FRS)
LAZY SUSAN
FUEL BASKET HOLDER

Page 7-3
NF-3525 Rev 0

2 INNER BEARING HOLDER ASSEMBLY
SCALE: 2/1

3 OUTER BEARING HOLDER ASSEMBLY
SCALE: 2/1

SECTION A-A
SCALE: 2/1

6 OUTER BEARING HOLDER BLOCK
SCALE: 2/1

10 BASE CHANNEL
SCALE: 2/1

7 INNER BEARING HOLDER BLOCK
SCALE: 2/1
NOTED 187 SHOWN AS INSTALLED

9 INNER BEARING HOLDER PLATE
SCALE: 2/1

8 OUTER BEARING HOLDER PLATE
SCALE: 2/1

17 BEARING
SCALE: 1/1

DWG. NO.	TITLE	REV. NO.	REV. DESCRIPTION	DATE	BY	CHECKED	APPROVED
1	INNER BEARING HOLDER ASSEMBLY	1	ISSUED FOR FABRICATION	10/1/74	J. L. HARRIS	J. L. HARRIS	J. L. HARRIS
2	OUTER BEARING HOLDER ASSEMBLY	1	ISSUED FOR FABRICATION	10/1/74	J. L. HARRIS	J. L. HARRIS	J. L. HARRIS
3	INNER BEARING HOLDER BLOCK	1	ISSUED FOR FABRICATION	10/1/74	J. L. HARRIS	J. L. HARRIS	J. L. HARRIS
4	OUTER BEARING HOLDER BLOCK	1	ISSUED FOR FABRICATION	10/1/74	J. L. HARRIS	J. L. HARRIS	J. L. HARRIS
5	INNER BEARING HOLDER PLATE	1	ISSUED FOR FABRICATION	10/1/74	J. L. HARRIS	J. L. HARRIS	J. L. HARRIS
6	OUTER BEARING HOLDER PLATE	1	ISSUED FOR FABRICATION	10/1/74	J. L. HARRIS	J. L. HARRIS	J. L. HARRIS
7	BEARING	1	ISSUED FOR FABRICATION	10/1/74	J. L. HARRIS	J. L. HARRIS	J. L. HARRIS
8	BASE CHANNEL	1	ISSUED FOR FABRICATION	10/1/74	J. L. HARRIS	J. L. HARRIS	J. L. HARRIS

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LAZY SUSAN
FUEL BASKET HOLDER

HNF-3525 Rev 0
Page 7-4

Fuel Retrieval System Small Tools Design Package

Lazy Susan

HNF-3525 Rev. 0

November 3, 1998

Page 8

Appendix B

Calculations

Fluor Daniel Northwest

Calc. No
Revision 0
Page 1 of 5

DESIGN CALCULATION

Client : Duke

Subject : Weld Verification for Lazy Susan Table

Location : 100K Basin

WO/Job No 65100101

Date 9/17/98

Checked 10/23/98

Revised

By D.J.Tedeschi

By *Stang/10*

By

Problem: Verify tubing and its welding can support the weight of the lazy Susan and the basket filled with fuel rods.

Given:

Material is Carbon Steel Assume ASTM A36

Ultimate Strength: US: 58 ksi (tension)

US := 58000

Yield Strength: YS: 36 ksi (tension)

YS := 36000

YSs: 21 ksi (shear)

YS_{shear} := 21000Mod of Elasticity: E: 29×10^6 psiSketches of structure being analyzedWeld Dimensions Sketch

P1 = 833 lbs

P2 = 833 lbs

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Calc. No
Revision 0
Page 2 of 5

DESIGN CALCULATION

Client : Duke
Subject : Weld Verification for Lazy Susan Table
Location : 100K Basin

WO/Job No 65100101
Date 9/17/98 By D.J. Tedeschi
Checked 10/23/98 By [Signature]
Revised By

Solution: Verify tubing material and it's welds can support a 5000 lbs weight distributed by bending and shear stress. Results should contain a factor of safety greater than 1.

Assumptions:

- Loading will be in bending
- Overall load is 5000 lbs, supported by 3 members, the middle beam is really supported by the other two members.
- To simplify the problem, the analysis will be on half of the long beam as shown in the sketch, thus the loading is as shown.
- The allowable stress in tension is 60% of the Yield strength (21.6 ksi) and 40% for Shear strength (14.4 ksi)

Check for failure in the tubing:

For bending about the x or y axis:

tube dimensions $b_{outer} := 3$ $h_{outer} := 3$ $b_{inner} := 2.5$ $h_{inner} := 2.5$ $c := \frac{1}{2} \cdot h_{outer}$

moment of inertia $I_{xy} := \left[\frac{1}{12} \cdot (b_{outer})^3 \cdot h_{outer} \right] - \frac{1}{12} \cdot (b_{inner})^3 \cdot h_{inner}$

$$I_{xy} = 3.495 \text{ in}^4$$

area $A_{tube} := (b_{outer} \cdot h_{outer}) - (b_{inner} \cdot h_{inner})$

$$A_{tube} = 2.75 \text{ in}^2$$

Free Body Diagram

Forces P1 and P2 are in the negative z axis.

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 Calc. No
 Revision 0
 Page 3 of 5

DESIGN CALCULATION

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 Date 9/17/98 By D.J.Tedeschi
 Checked K/23/98 By *SK*
 Revised By

Determining loading:

Overall load is 5000 lbs, each member supports 1/3 of the weight. Therefore each member supports about 1667 lbs. Loads are reduced by 1/2 when calculating since the beams are supported at both ends (833.5 lbs). The 3rd member will cause torque about the other two.

Forces $P_1 = 833.5$ $P_2 = 833.5$

Sum Loads about point A as shown on the free body diagram.

$$\Sigma P_z = P_1 + P_2$$

$$\Sigma P_z = 1.667 \cdot 10^3 \text{ lbf}$$

Moments about A

x axis $M_x = (P_1 \cdot 12.13) + (P_2 \cdot 18.5)$

$$M_x = 2.553 \cdot 10^4 \text{ lbs in}$$

y axis $M_y = (P_1 \cdot 17.26) + (P_2 \cdot 4.5)$

$$M_y = 1.814 \cdot 10^4 \text{ lbs in}$$

Loading in shear

$$\lambda_{\text{tube}} = \frac{\Sigma P_z}{A_{\text{tube}}}$$

$$\lambda_{\text{tube}} = 606.182 \text{ psi}$$

Loading due to bending

x axis $\sigma_x = \frac{M_x \cdot c}{I_{xy}}$

$$\sigma_x = 1.096 \cdot 10^4 \text{ psi}$$

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Calc. No
Revision 0
Page 4 of 5

DESIGN CALCULATION

Client : Duke
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Date 9/17/98 By D.J. Tedeschi
Checked 10/23/98 By *[Signature]*
Revised By

y axis

$$\sigma_y = \frac{M_y \cdot c}{I_{xy}}$$

$$\sigma_y = 7.785 \cdot 10^3 \quad \text{psi}$$

Summation of stress at point A

$$\Sigma \sigma = \left(\sigma_x^2 + \sigma_y^2 + \lambda_{\text{tube}}^2 \right)^{\frac{1}{2}}$$

$$\Sigma \sigma = 1.346 \cdot 10^4 \quad \text{psi}$$

Solve for the factor of safety:

$$n_{\text{tube}} = \frac{YS}{\Sigma \sigma}$$

$$n_{\text{tube}} = 2.676$$

The overall stress when compared to the yield stress of the tubing results in a factor of safety of 2.6 which is acceptable and therefore tube will not fail.

Check stress for welds at point A as shown in the sketches and freebody diagram:

Assume weld pattern as shown in the previous sketch.

This is a similar pattern for calculations but is not much different.

Welds are 1/4 fillets.

thickness of weld

$$h = .25 \quad d_{\text{outer}} = 3$$

Welds in shear

weld area

$$A_w = 1.414 \cdot h \cdot (b_{\text{outer}} + d_{\text{outer}})$$

$$A_w = 2.121 \quad \text{in}^2$$

Shear

$$\lambda_{\text{shear}} = \frac{\Sigma P \cdot z}{A_w}$$

$$\lambda_{\text{shear}} = 785.95 \quad \text{psi}$$

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Calc. No
Revision 0
Page 4 of 5

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Revised By

Stress due to bending:

$$I_{xyweld} = 0.707 \cdot h \cdot \frac{d_{outer}^2}{6} \cdot (3 \cdot b_{outer} + d_{outer})$$

$$I_{xyweld} = 3.181$$

$$\text{x axis } \sigma_{xweld} = \frac{M_x \cdot \frac{d_{outer}}{2}}{I_{xyweld}}$$

$$\sigma_{xweld} = 1.204 \cdot 10^4$$

$$\text{y axis } \sigma_{yweld} = \frac{M_y \cdot \frac{d_{outer}}{2}}{I_{xyweld}}$$

$$\sigma_{yweld} = 8.551 \cdot 10^3 \text{ psi}$$

Summation of overall stress:

$$\Sigma \sigma_{weld} = \left(\sigma_{xweld}^2 + \sigma_{yweld}^2 + 1 \cdot \text{shear}^2 \right)^{\frac{1}{2}}$$

$$\Sigma \sigma_{weld} = 1.479 \cdot 10^4 \text{ psi}$$

$$n = \frac{YS}{\Sigma \sigma_{weld}}$$

$$n = 2.435$$

The overall stress when compared to the yield stress of the weld results in a factor of safety of 2.4 which is acceptable and therefore welds will not fail.

Fuel Retrieval System Small Tools Design Package

Lazy Susan

HNF-3525 Rev. 0

November 3, 1998

Page 9

Appendix C

Test Specifications

Fuel Retrieval System Small Tools Design Package

Lazy Susan

HNF-3525 Rev. 0

November 3, 1998

Page 10

Appendix D

Test Report

Fuel Retrieval System Small Tools Design Package

Lazy Susan

HNF-3525 Rev. 0

November 3, 1998

Page 11