NOV 09 1998 21 ENGINEERING DATA TRANSMITTAL Page 1 of 1
1. EDT 609377

2. To: (Receiving Organization)		3. From: (Originating Organization)		4. Related EDT No.:	
DESH		FDNWN		7. Purchase Order No.:	
5. Proj./Prog./Dept./Div.:		6. Design Authority/Design Agent/Cog. Engr.:		N/A	
SNF/Fuel Retrieval System		Eric Shen		9. Equip./Component No.:	
8. Originator Remarks:		This is a design Package for the Stinger Tool Modification		Fuel Retrieval	
				10. System/Bldg./Facility:	
				100 K Basin	
				12. Major Assm. Dwg. No.:	
				None	
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Approval Designator (F)	Reason for Transmittal (G)			Disposition (H) & (I)	
E, S, Q, D OR N/A (See WHC-CM-3-5, Sec. 12.7)	1. Approval	4. Review		1. Approved	4. Reviewed no/comment
	2. Release	5. Post-Review		2. Approved w/comment	5. Reviewed w/comment
	3. Information	6. Dist. (Receipt Acknow. Required)		3. Disapproved w/comment	6. Receipt acknowledged

SIGNATURE/DISTRIBUTION (See Approval Designator for required signatures)				
(G) Reason	(H) Disp.	(J) Name	(K) Signature	(L) Date (M) MSIN
1		Design Authority	<i>[Signature]</i>	11/5/98 X3-76
1	1	Design Agent	David Tedeschi <i>[Signature]</i>	11/5/98 54-15
		Cog. Eng.		
		Cog. Mgr.		
		QA		
		Safety		
		Env.		

18. <u><i>[Signature]</i></u> <u>11/5/18</u> Signature of EDT Date Originator	19. _____ Authorized Representative Date for Receiving Organization	20. <u><i>[Signature]</i></u> <u>11/5/18</u> Design Authority/ Date Cognizant Manager	21. DOE APPROVAL (if required) Ctrl No. <u>N/A</u> ☐ Approved ☐ Approved w/comments ☐ Disapproved w/comments
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Design Package For Fuel Retrieval System Fuel Handling Tool Modification

David Tedeschi

for Duke Engineering and Services Hanford, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-96RL13200

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Key Words: Spent Nuclear Fuel, Stinger, Fuel Handling Tool, Fuel Retrieval System, Elastomer

Abstract: This is a design package that contains the details for a modification to a tool used for moving fuel elements during loading of MCO Fuel Baskets for the Fuel Retrieval System. The tool is called the fuel handling tool (or stinger). This document contains requirements, development design information, tests, and test reports.

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Karen A. Nolan
Release Approval

11/9/98
Date

Release Stamp

Approved for Public Release

**Design Package
for
Fuel Retrieval System Fuel Handling Tool Modification**

HNF-3526 Rev O

November 3, 1998

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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.

The robotic arms use a fuel handling tool (also known as the "stinger tool") to relocate an inner and or outer fuel element. The stinger moves an element by being inserted inside of the element and opening the robotic arm's jaw. Opening of the jaw causes an elastomer spring on the stinger to expand past the inside diameter of the element. The spring exerts enough force against the inner diameter of the element's wall that it can be lifted.

The robotic arms are being tested and being used for training. Testing and training has shown that the current stinger design is failing to meet its usage requirements. The elastomer springs are failing prematurely and adjustments are required after operating it for a short period. This design package will modify the current design of the stinger and bring it up to the expected requirements.

2.0 Scope

2.1 Objectives

The scope of this design package is to document the design, fabrication, and testing of stinger tool modification.

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 or information for upgrades to the vendor drawings.
- 3) Vendor information
- 4) Procurement documentation

Hardware

- 1) Modified stinger tool.

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3.0 Brief Description of Problem

The stinger functions by using a wire rope attached to Konan's robotic hand via a holding block mechanism. As the robotic jaw opens, the wire rope is pulled. Pulling on the wire rope results in the elastomer springs being compressed and expanding. The stinger is placed into either an inner or outer fuel element. When the elastomer spring expands, it applies a force against the inner wall of the fuel element. A fuel element can be lifted by using the stinger tool, as long as the frictional forces between the wall of the rod and the elastomer spring are not overcome by the weight of the fuel element. A sketch of the stinger is shown in Appendix A.

4.0 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 to this and apply to the stinger tool.

4.1 Dimensional/Physical Constraints

- a) Large and small elastomer springs must be able to accommodate the following dimensions:

Fuel Elements

The largest diameters will be the worst case and will therefore be listed

Outer fuel element inside diameter: 1.779 in.

Inner fuel element inside diameter: 0.492 in

(Taken from drawing number H-1-39775)

Assume both inner and outer fuel element weighs approximately 55 lbs. where the outer is 38 and the inner is 17.

Reference HNF-SD-SNF-TI-009, rev. 2, *105-K Basin Material Design Basis Feed Description for Spent Nuclear Fuel Project Facilities*.

4.2 Environmental Constraints

- a) Stinger 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) Stinger must be able to be submersed in deionized water at a temperature of 50 °F for a period of its design life.

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4.3 Operational Requirements

- a) Stinger should be able to operate for a period of 3 months assuming 3 shifts per day, 7 days a week, and process about 140 fuel assemblies per day. Cold validation testing (report not yet available) has shown that there will only be 140 outer fuel elements processed per day and inner elements will not require the use of a stinger tool for processing.
- b) Stinger shall overcome weight of a fuel element and not slip when being lifted. Required force that stinger's elastomer spring must exert on the outer fuel elements inner diameter is 278 lbf assuming a reliability factor of 2. See Appendix B for calculations.
- b) Stinger shall be able to operate under 16-20 feet of water.
- c) Springs must be able to be fully compressed in the elastic region at 700 lbs. (± 100 lbs.)
- d) Elastomer springs shall maintain diameter dimensions shown in the figure. Length to be determined.
- e) Elastomer spring housings shall not touch when either the small or large springs are compressed. If the two pieces of the house do touch, this will place a high stress on the wire rope and thus produce a failure.

4.4 Maintenance Requirements

- a) Stinger tools will be thrown away unless there is an inexpensive method for replacing failed parts.

4.5 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.

5.0 Development of Product

5.1 Management of Task

5.1.1 Engineering

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

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5.1.2 Procurement

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

5.1.3 Fabrication / Construction

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

5.1.4 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.

5.2 Discussion of Development

The stinger tool has undergone several tests and has shown under dry conditions that the current design requires periodic tightening adjustments to continue its use. This will be an unacceptable practice in that it will not be accessible and that it could be highly radioactively contaminated.

It was then determined by Duke/PNNL to just fix the large spring then work on the small one once good results were achieved. It was also decided to maintain the current design but change the spring's material property.

Extensive research was done on finding manufactures that made the springs. Finally, a manufacture of urethane was chosen (PSI Urethanes Inc.) because they actually formulated the material and cast it as well. A purchase order was given to them and we procured the following springs:

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Procured Springs by PSI Urethane	
Spring Shore Hardness (Durometer A)	Spring Length (inches) (± 0.005)
30	1.00
30	1.125
30	1.25
30	1.375
40	1.00
40	1.125
40	1.25
40	1.375

Springs have an outside diameter of 1.63 inches (± 0.005) and an inside diameter of 0.87 inches (± 0.005).

These springs will undergo testing to evaluate which ones will last the longest and thus meet the requirements set forth in this document.

5.2.1 Sketches/Drawings

All graphical depiction can be found in Appendix A.

Drawing 1

This is a drawing of the stinger tool and its associated Bill of Material. GEC Alsthom has provided the drawing. The drawing number is 101-3737.

5.3 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.

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5.3.1 Analysis

Developmental calculations can be found in Appendix B.

In addition to the research for the spring material, a finite element model of the spring was developed using ANSYS®. Good results were not attainable because it was too difficult to get actual physical properties of the urethane. This calculation was not included in the document.

Another calculation was performed that solved for the minimum required force/pressure the spring must exert on the inner diameter of an element in order for the element to be lifted. This calculation was conservative in that it used a reliability factor of 2 and assumed an outer element weighed 50 lbs.. This calculation along with its results can be found in Appendix B.

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Appendix A

Graphical Depictions of Product

RELEASED FOR	COPIES	STANDARD NUMBER	NO.	MARK	REV.
PRODUCTION	2-1	101-3737	C	2	D

Software, Inc.

Schilling Robotic Systems, Inc.

H4

MANUFACTURING BOM WITH LABOR AND PROCESS

Assembly	Description	Group	PFC	Commodity	Class	Planner	Buyer	Drawing	Rev	LT
3737	TOOL,FUEL HANDLING		KB	7062	A	PW	01	S3737C2D	D	4

Package Factor: 0.00

ITEM	LEVEL	SEQ.	DESCRIPTION	REV	CL	LT	QUANTITY	U/M	REFERENCE	MLT	BEGIN	END
2-1750	*1	1	CABLE, FLEX	D	R	20	1.00	EA	-	Yes		
11-4882	*1	2	CABLE END, FUEL SIDE	A	R	30	1.00	EA	-	Yes		
12-1727	*1	3	SPRING,URETHANE,SPEC P087 5-1000-60A		R	15	1.00	EA	-	Yes		
12-0110	*1	4	SCREW,SET,10-32 X 1/4,316 SS,HEX DRIVE		R	15	1.00	EA	-	Yes		
11-5036	*1	5	BODY,FUEL HANDLING	B	R	30	1.00	EA	-	Yes		
13-0240	*1	6	BUSHING,SLEEVE,23/32 OD X 5/8 ID X 1, IGLIDE TS00		R	30	1.00	EA	-	Yes		
13-0244	*1	7	BUSHING,SLEEVE,23/32 OD X 5/8ID X 3/8,IGLIDE		R	30	1.00	EA	-	Yes		
2-1775	*1	8	STOP SLEEVE, 3/32,COPPER		R	20	1.00	EA	-	Yes		
11-4900	*1	10	GRIPPER,URETHANE,INNER EL EMENT	B	R	45	1.00	EA	-	Yes		
11-5037	*1	11	GUIDE,INSERTION	B	R	30	1.00	EA	-	Yes		
11-4888	*1	12	CABLE END,MOUNTING SIDE	B	R	30	1.00	EA	-	Yes		
11-4889	*1	13	PIN,ARM,ACTUATOR	B	R	30	1.00	EA	-	Yes		
17-0367	*1	14	ARM,ACTUATOR	A	R	30	1.00	EA	-	Yes		
11-4891	*1	15	LOCKNUT,CABLE	A	R	30	1.00	EA	-	Yes		
11-4892	*1	16	PIN,SWIVEL,CABLE	A	R	30	1.00	EA	-	Yes		
11-4893	*1	17	BODY,TOOL MOUNTING	D	R	30	1.00	EA	-	Yes		
11-4894	*1	18	PLATE,LOCK,TOOL MOUNTING	C	R	30	1.00	EA	-	Yes		
12-1729	*1	19	SPRING,.500D X 1.44L,SS,C ENTURY S-1292		R	15	1.00	EA	-	Yes		
11-4895	*1	20	PLATE,COVER,TOOL MOUNTING	A	R	30	1.00	EA	-	Yes		
12-0186	*1	21	SHCS,1/4-28 X 3/4,SS		R	15	10.00	EA	-	Yes		
12-1728	*1	22	SCREW,SHOULDER,1/4 X 1 LG SS		R	15	1.00	EA	-	Yes		
13-0223	*1	23	BUSHING,SLEEVE,5/16 OD X 1/4 ID X 3/8 LG		R	20	1.00	EA	-	Yes		
12-1163	*1	24	WASHER,FLAT,#10,.438 OD,S S		R	5	1.00	EA	-	Yes		

Software, Inc.

Schilling Robotic Systems, Inc.

05/11/98

MANUFACTURING BOM WITH LABOR AND PROCESS

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only Description Group PFC Commodity Class Planner Buyer Drawing Rev LT
 1737 TOOL, FUEL HANDLING KB 7062 A PW 01 S3737C2D D 4
 Exchange Factor: 0.00

ITEM	LEVEL	SEQ.	DESCRIPTION	REV	CL	L/T	QUANTITY	U/M	REFERENCE	MLT	BEGIN	END
1-1747	*1	25	WASHER, LOCK, #10, SS	R		15	1.00	EA	-	Yes		
1-0222	*1	26	NUT, 10-32	R		20	1.00	EA	-	Yes		
1-1771	*1	27	NUT, JAM, 3/8-24 UNF SS	R		15	1.00	EA	-	Yes		
1-1530	*1	28	HOSE, PARKER, -6, 421 HT	R		15	1.40	FT	-	Yes		
1-5211	*1	29	CRIMP, NOSE, FUEL TOOL	B	R	30	1.00	EA	-	Yes		
1-1772	*1	40	LUBRICANT, ANTISEIZE, NICKEL, NEVER-SEEZ, 1LB	R		15	0.00	EA	-	Yes		
1-0873	*1	41	LOCTITE, RC620, 50ML BOTTLE	R		10	0.00	EA	-	Yes		
1-0795	*1	42	ADHESIVE, #271 RED LOCTITE 50ML	R		15	0.00	EA	-	Yes		
1-0610	*1	43	CRIMP TOOL, 3/32 - 7/32 CA BLE	R		20	0.00	EA	-	Yes		
1-3737-WI	*1	50	WORK INSTRUCTIONS	A	R	0	0.00	EA	-	Yes		
1-1	*1	54	MECHANICAL ASSEMBLY	L		0	6.00	HR	-	Yes		
1-0R-NO	*1	55	NO LABOR REQUIRED	L		0	0.00	HR	-	Yes		

Relative Lead Time for 101-3737 = 49

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Appendix B

Calculations

Fluor Daniel Northwest

Calc. No 65100301-001
Revision 0
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DESIGN CALCULATION

Client : Duke
Subject : Lifting Fuel Rods With CONAN Stinger
Location : 100 K Basin

WO/Job No 65100301
Date By David J. Tedeschi
Checked By
Revised By

GIVEN:

Inside radii for outer and inner fuel rods Weight of fuel rod length of spring rod
 $r_{outer} = 0.889$ in $w_{rod} = 50$ lbf $H = 1, 1.125, 1.375$ H in

1
1.125
1.25
1.375

PROBLEM: An elastomer spring is inserted into fuel rod and expanded. Once expanded, the rod can be lifted. Solve for the required pressure the elastomer spring must exert on the inner surface wall of the fuel rod in order to lift an outer fuel rod.

SOLUTION: The weight of a fuel rod is equivalent to what the required force is to lift the fuel rod. The coefficient of resistance which keeps the spring from slipping when the rod is lifted is unknown as well as the resistant force due to moving the rod through the water. Therefore a factor of reliability of 2 will be applied.

The following diagrams illustrate the problem:

FREE BODY DIAGRAM

ORDER POINT NO.	
ORDER	<i>Henry J. Noack</i>
DATE	10/26/98

Fluor Daniel Northwest

Calc. No 65100301-001
Revision 0
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DESIGN CALCULATION

Client : Duke
Subject : Lifting Fuel Rods With CONAN Stinger
Location : 100 K Basin

WO/Job No 65100301
Date By David J.Tedeschi
Checked By
Revised By

Solve for the minimal normal force N that the spring needs to apply in order to keep the spring from slipping when a lifting force of 50 lbs or greater is applied.

N = the normal force applied from the spring to the wall

Assume μ (coefficient of friction) based on rubber against steel: $\mu = 0.36$

Ref. Engineering Mechanics Vol 1 Statics, J.L. Meriam, pub. John Wiley and Sons

Frictional force is equal to the weight of the fuel rod.

$$F_{\text{friction}} = W_{\text{rod}}$$

$$N = \frac{F_{\text{friction}}}{\mu}$$

$$N = 138.889$$

Apply a Factor of Reliability: $R = 2$

The required force for the elastomer spring to exert against the wall is:

$$F_{\text{required}} = N \cdot R$$

$$F_{\text{required}} = 277.778 \text{ lbf}$$

Solve for the pressure needed to be applied:

Assume the elastomer spring surface area contacts the wall of the rod by the following dimensions:

Although the outside radii of the spring is .407, the inside radii of the tube will be used since it is the dimension the spring must be to apply pressure.

$$C_{\text{outer}} = 2 \cdot \pi \cdot r_{\text{outer}}$$

Henry 2 Noval
10/26/98

Fluor Daniel Northwest

Calc. No 65100301-001
Revision 0
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DESIGN CALCULATION

Client : Duke
Subject : Lifting Fuel Rods With CONAN Stinger
Location : 100 K Basin

WO/Job No 65100301
Date By David J. Tedeschi
Checked By
Revised By

Surface area of spring $A(H) := H \cdot C_{outer}$

$A(H)$ in²

5.586
6.284
6.982
7.68

Percentage of actual area applied to wall due to bulge is 10-30%.

P10% := .1 P20% := .2 P30% := .3

Applied area $A_{ap10}(P\%, H) := P10\% \cdot A(H)$ $A_{ap20}(P\%, H) := P20\% \cdot A(H)$

$A_{ap30}(P\%, H) := P30\% \cdot A(H)$

$A_{ap10}(P10\%, H)$ in²

0.559
0.628
0.698
0.768

$A_{ap20}(P20\%, H)$ in²

1.117
1.257
1.396
1.536

$A_{ap30}(P30\%, H)$ in²

1.676
1.885
2.095
2.304

Required pressure spring needs to apply for to prevent slipping at spring lengths of H 10 to 30 % surface contact:

$$P_{10}(H) := \frac{F_{required}}{A_{ap10}(P10\%, H)}$$

$$P_{20}(H) := \frac{F_{required}}{A_{ap20}(P20\%, H)}$$

$$P_{30}(H) := \frac{F_{required}}{A_{ap30}(P30\%, H)}$$

$P_{10}(H)$ psi

497.297
442.042
397.838
361.671

$P_{20}(H)$ psi

248.649
221.021
198.919
180.835

$P_{30}(H)$ psi

165.766
147.347
132.613
120.557

Henry J. Walsh
10/26/98

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**Appendix C
Test Specifications**

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Appendix D

Test Report