START

DOCUMENT CLEARANCE REQUEST

Part 1 – Issuing Manager's Approval

SECTION 1 – Clearance Information

1. Date Clearance Required: November 2, 1988
2. Document Identification: WHC- SA-0331-FP
2B. Previous Document Identification: WHC-SA-0331-S
3. Title (Include UC Category): FFTF/IEM CELL FUEL DUCT CUTTERS - REMOTE OPERATIONS DESIGN CONSIDERATIONS
4. Author's Name(s): P. W. Gibbons
5. Phone: 6-5760
6. MSIN: N2-02
7. Desired Clearance/Release: Public Clearance [X] Open Literature [ ] Oral Public; Limited Clearance [ ] Applied Technology [ ] Foreign Exchange; DOE Directed Release [ ] FOIA [ ] Media [ ] Other
8. Document Type: (Choose One) [ ] Speech/Article [ ] Abs. [ ] Sum. [X] Full Paper [ ] Speakers Bureau (WHC-SA-XXXX) Complete Sections 1, 2, 3, 4, submit with four copies of S/A to Doc. Clearance; [ ] Report (WHC-EP-XXXX) Complete Sections 1, 2, 3, 4, submit with two copies of doc. to Doc. Clearance
9. Meeting Name, Location, Date: ANS Robotics & REmote systems, Topical Meeting; Charleston, S.C.; March 13-16, 1989
10. [X] To Be Published in Journal [X] Handouts for Attendees; Official Publishing Month: March 1989

SECTION 2 – Program Office Information

11. WHC Program: LMR/FFTF
12. Does this document contain Liquid Metal Reactor (LMR) information? [X] No [ ] Yes
(If "Yes" and public clearance or limited clearance for foreign exchange is desired, answer questions 12A and 12B.)
12A. When was the information generated? 1983 to Present
12B. What prior dissemination of the information has been made to LMR contractors? (Cite report number, page, date of issuance, and distribution, and/or meeting handouts, date and distribution.) WHC-SA-0081-FP, Sept. 87 ANS Winter Meeting - Handouts, Proceedings of 55th Conference on Remote system Technology
13. Does this document or its source document contain applied technology information [ ] No [X] Yes
(If "Yes" and public clearance or limited clearance for foreign exchange is desired, answer questions 13A, 13B, 13C.)
13A. What prior dissemination of the information has been made under international exchange agreements? Identify country, document, and date of release.
None
13B. Does the information have substantive value for international exchange? (Explain)
No - does not supply specific details
13C. What is the justification for the proposed release of this information? (Be specific)
Supports transfer of Technology to U.S. Industry
14. Does the document contain Nuclear Waste Policy Act information? (Explain)
No

SECTION 3 – Patent Legal Info.

Does this document contain or disclose any of the following? If "Yes" identify information and location in document.

15. New or novel (patentable) subject matter? [X] No [ ] Yes
If "Yes", has disclosure been submitted by WHC or other company? [ ] No [ ] Yes Disclosure No(s)
16. Information received from a foreign country under an exchange agreement? [X] No [ ] Yes (Identify)
17. Information received from others in confidence, such as proprietary data, trade secrets, and/or inventions? [X] No [ ] Yes (Identify)
18. Copyrighted material? [X] No [ ] Yes
If "Yes", has written permission been granted? [ ] No [ ] Yes (Attach Permission)
19. Trademarks? [X] No [ ] Yes (Identify)

SECTION 4 – Remarks and Approvals

20. Sponsoring Agency (if not U.S. Department of Energy):
21. DOE/HQ Assistant Secretary For: Nuclear Energy
22. Remarks

Document is approved as conforming to all applicable requirements. The above information is certified to be correct.

	23. Author	Immediate Manager	Issuing Manager (Level III)	24. Date
Type Name	P. W. Gibbons	J. L. Marshall	D. J. Newland	
Signature	[signature]	[signature]	[signature]	10-12-88

Attach additional sheet if more space is needed.

BD-7600-062 (04/88)

9 1 1 2 5 6 7 0 3 0 4

DOCUMENT CLEARANCE REQUEST
Part 2 – Clearance Reviews and Approvals

Document Identification: WHC- SA-0331-FP

Legends	Remove	Affix	Reviewer
UCNI	☐	☐	
Proprietary Information	☐	☐	
Limited Disclosure	☐	☐	
Applied Technology	☐	☐	
Copyright License Notice	☐	☐	
Patent Status	☐	☐	
	☐	☐	

Disclaimers	Remove	Affix	Reviewer
Legal	☐	☐	
	☐	☐	
	☐	☐	
	☐	☐	
	☐	☐	
	☐	☐	
	☐	☐	

Reviewer	Required (✓ if yes)	Approve No	Approve Yes	Mandatory Changes No	Mandatory Changes Yes	See Remarks (✓ if yes)	Signature	Date
Publications Services 11/3/88	✓						Carolyn Wheelwright	11/9/88
WHC Classification								
WHC Patent/Legal								
DOE Patent/Legal								
Westinghouse Corporate								
WHC Public Relations								
References	✓						Chris Willingham	10/31/88
WHC Int. Prog. Coord.	✓		✓	✓			[illegible]	10/31/88
C Prog. Office/or Working Group Rep.	✓		✓	✓			DJ Newland per telecon Mgr Signature	
DOE Program Sponsor	✓	✓					[illegible]	
DOE Working Group Chairman	✓	✓					[illegible]	

Working Group Name: Plant Experience

Remarks

For Information Services Use Only

Released subject to reviewer requirements and dissemination guidelines.

	Released By	Date
☐ Public Clearance		
☐ Limited Clearance		
☐ DOE Directed Release		

Date Request Received 10/17/88 DOE F 1332.15 Form Date

BD-7600-062R (04/88)

DOCUMENT CLEARANCE REQUEST

Part 1 – Issuing Manager's Approval

SECTION 1 – Clearance Information

1. Date Clearance Required: November 2, 1988
2. Document Identification: WHC- SA-0331-FP
2B. Previous Document Identification: WHC-SA-0331-S
3. Title (Include UC Category): FFTF/IEM CELL FUEL DUCT CUTTERS - REMOTE OPERATIONS DESIGN CONSIDERATIONS
4. Author's Name(s): P. W. Gibbons
5. Phone: 6-5760
6. MSIN: N2-02
7. Desired Clearance/Release: Public Clearance [X] Open Literature [ ] Oral Public; Limited Clearance [ ] Applied Technology [ ] Foreign Exchange; DOE Directed Release [ ] FOIA [ ] Media [ ] Other
8. Document Type: (Choose One) [ ] Speech/Article [ ] Abs. [ ] Sum. [X] Full Paper [ ] Speakers Bureau (WHC-SA-XXXX) Complete Sections 1, 2, 3, 4, submit with four copies of SIA to Doc. Clearance; [ ] Report (WHC-EP-XXXX) Complete Sections 1, 2, 3, 4, submit with two copies of doc. to Doc. Clearance
9. Meeting Name, Location, Date: ANS Robotics & REmote systems, Topical Meeting; Charleston, S.C.; March 13-16, 1989
10. [X] To Be Published in Journal [X] Handouts for Attendees Official Publishing Month: March 1989

SECTION 2 – Program Office Information

11. WHC Program: LMR/FFTF
12. Does this document contain Liquid Metal Reactor (LMR) information? [X] No [ ] Yes
(If "Yes" and public clearance or limited clearance for foreign exchange is desired, answer questions 12A and 12B.)
12A. When was the information generated? 1983 to Present
12B. What prior dissemination of the information has been made to LMR contractors? (Cite report number, page, date of issuance, and distribution, and/or meeting handouts, date and distribution.) WHC-SA-0081-FP, Sept. 87 ANS Winter Meeting - Handouts, Proceedings of 55th Conference on Remote system Technology
13. Does this document or its source document contain applied technology information [ ] No [X] Yes
(If "Yes" and public clearance or limited clearance for foreign exchange is desired, answer questions 13A, 13B, 13C.)
13A. What prior dissemination of the information has been made under international exchange agreements? Identify country, document, and date of release.
None
13B. Does the information have substantive value for international exchange? (Explain)
No - does not supply specific details
13C. What is the justification for the proposed release of this information? (Be specific)
Supports transfer of Technology to U.S. Industry
14. Does the document contain Nuclear Waste Policy Act information? (Explain)
No

SECTION 3 – Patent Legal Info.

Does this document contain or disclose any of the following? If "Yes" identify information and location in document.

15. New or novel (patentable) subject matter? [X] No [ ] Yes
If "Yes", has disclosure been submitted by WHC or other company? [ ] No [ ] Yes Disclosure No(s).
16. Information received from a foreign country under an exchange agreement? [X] No [ ] Yes (Identify)
17. Information received from others in confidence, such as proprietary data, trade secrets, and/or inventions? [X] No [ ] Yes (Identify)
18. Copyrighted material? [X] No [ ] Yes
If "Yes", has written permission been granted? [ ] No [ ] Yes (Attach Permission)
19. Trademarks? [X] No [ ] Yes (Identify)

SECTION 4 – Remarks and Approvals

20. Sponsoring Agency (if not U.S. Department of Energy):
21. DOE/HQ Assistant Secretary For: Nuclear Energy
22. Remarks

Document is approved as conforming to all applicable requirements. The above information is certified to be correct.

	23. Author	Immediate Manager	Issuing Manager (Level III)	24. Date
Type Name	P. W. Gibbons	J. L. Marshall	D. J. Newland	
Signature	[signature]	[signature]	D J Newland	10-12-88

Attach additional sheet if more space is needed.

BD-7600-062 (04/88)

DOCUMENT CLEARANCE REQUEST
Part 2 – Clearance Reviews and Approvals

Document Identification: WHC- SA-0331-FP

Legends	Remove	Affix	Reviewer
UCNI	☐	☐	
Proprietary Information	☐	☐	
Limited Disclosure	☐	☐	
Applied Technology	☐	☐	
Copyright License Notice	☐	☒	J.W. Berglin 10/28/88
Patent Status	☐	☐	
	☐	☐	

Disclaimers	Remove	Affix	Reviewer
Legal	☐	☒	J.W. Berglin 10/28/88
	☐	☐	
	☐	☐	
	☐	☐	
	☐	☐	
	☐	☐	
	☐	☐	

Reviewer	Required (✓ if yes)	Approve No	Approve Yes	Mandatory Changes No	Mandatory Changes Yes	See Remarks (✓ if yes)	Signature	Date
Publications Services								
WHC Classification	✓		✓	✓			M. Williams	10/18/88
WHC Patent/Legal	✓		✓		✓	(1)	J.W. Berglin	10/28/88
DOE Patent/Legal	✓		✓	✓			J.W. Berglin	10/28/88
Westinghouse Corporate	No						J.W. Berglin	10/28/88
WHC Public Relations							V.P. Treadway BMB	10/27/88
References								
WHC Int. Prog. Coord.								
WHC Prog. Office/or Working Group Rep.								
DOE Program Sponsor								
DOE Working Group Chairman								

Working Group Name:

Remarks: (1) Trademarks if any must be noted the first time mentioned including company's name e.g. "(1) Trademark of XYZ Company". J.W. Berglin (6-2788) 10/28/88

For Information Services Use Only

Released subject to reviewer requirements and dissemination guidelines	Released By	Date
☒ Public Clearance	C.A. Forbes	11/10/88
☐ Limited Clearance		
☐ DOE Directed Release		

Date Request Received 10/17/88 DOE F 1332.15 Form Date ________

BD-7400-062R (04/88)

SPEECH ARTICLE

DOE F 1332.15 (2-88)

U.S. DEPARTMENT OF ENERGY

OMB Control No. 1910-1400

DOE AND MAJOR CONTRACTOR RECOMMENDATIONS FOR ANNOUNCEMENT AND DISTRIBUTION OF DOCUMENTS

1. DOE Report No.	2. DOE Contract No.	3. DOE B and R codes	4. OSTI UC or C Category No.
WHC-SA-0331FP	DE-AC06-87RL-10930		

5. Title FFTF INTERIM EXAMINATION AND MAINTENANCE CELL FUEL DUCT CUTTERS: REMOTE OPERATIONS DESIGN CONSIDERATIONS

6. Type of Document ("x" one)

a. Scientific and technical report: ☐ monthly ☐ quarterly ☐ annual ☒ final ☐ topical ☐ other

b. Conference paper: Name of conference (no abbreviations) ANS ROBOTICS AND REMOTE SYSTEMS, TOPICAL MEETING

Location (city/st/ctry) CHARLESTON, SOUTH CAROLINA

Date (mo/day/yr) 03/13-16/88 Sponsor

Contents: ☐ proceedings ☐ viewgraphs ☐ paper ☐ poster sessions

c. Computer Media:

Document is accompanied by ☐ magnetic tape(s) ☐ diskette(s) ☐ other (specify)

d. Other (e.g., journal article, manuscript, manual, etc.) (specify)

7. Copies Transmitted to OSTI ("x" one or more)

☐ a. Copies transmitted for unclassified distribution.
☐ b. Copies transmitted for special distribution.
☒ c. Two reproducible copies transmitted.
☐ d. Ten copies transmitted for OSTI processing and NTIS sales.
☐ e. Copies transmitted for classified distribution as defined in M-3679.
☐ f. One copy transmitted for OSTI classified processing.

8. Document contains information pertaining to any of the following:

☐ Yes ("x" one or more) ☒ No (if no, unlimited distribution may be made within the U.S. In addition, copies may be made available to Foreign requestors through exchange agreements or NTIS sales.)

☐ a. Classified (Announce to addresses in M-3679)
☐ b. Official Use Only (OUO)
☐ c. Export Control/ITAR/EAR
☐ d. Proprietary Information
☐ e. Small Business Innovation Research (SBIR)
☐ f. Unclassified Controlled Nuclear Information (UCNI)
☐ g. Patent Sensitivity
☐ h. Translations of copyrighted material
(Boxes b–h will be announced to Government agencies and their contractors)
☐ i. Other (explain)
(This designation must be in accordance with written DOE Program Office guidance)

Upon demand, OSTI will make distribution of these documents in accordance with existing laws, regulations, and/or written program office guidance.

9. Patent and Copyrighted Information

a. ("x" one) ☒ 1. DOE patent clearance has been granted by responsible DOE patent group.
☐ 2. Document has been sent to responsible DOE patent group for clearance.
☐ 3. Patent clearance not required.

b. Does this material contain copyrighted information? ☐ No ☐ Yes
If yes, has release been obtained for DOE reproduction? ☐ No ☐ Yes
(attach release)

10. Additional information, remarks, and special handling instructions. (*Do not* identify Sigma categories for Nuclear Weapon Data reports, and *do not* provide additional instructions which are inconsistent with item 8 above.) (Continue on separate sheet, if necessary)

11. Submitted by (Name and Position) (Please print or type)	Phone
CHRISTINE WILLINGHAM, CLERK	509-376-5194 FTS 88-444-5194
Organization: INFORMATION RESOURCE MANAGEMENT — Signature: Christine Willingham	Date: 12-7-88

0 3 1 1 2 5 0 3 3 8

WHC-SA-0331-FP

Fast Flux Test Facility Interim Examination and Maintenance Cell Fuel Duct Cutters: Remote Operations Design Considerations

P. W. Gibbons

Date Published
November 1988

To be presented at the
Third Topical Meeting on
Robotics and Remote Systems
Charleston, South Carolina
March 13-16, 1989

Prepared for the U.S. Department of Energy
Assistant Secretary for Nuclear Energy

Westinghouse
Hanford Company
P.O. Box 1970
Richland, Washington 99352

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

Printed in the United States of America

FAST FLUX TEST FACILITY INTERIM EXAMINATION AND MAINTENANCE CELL FUEL DUCT CUTTERS: REMOTE OPERATIONS DESIGN CONSIDERATIONS

P. W. Gibbons, Westinghouse Hanford Company
P.O. Box 1970
Richland, WA 99352
509-376-9221

ABSTRACT Two remotely operated mill-type slitting cutters, specifically designed for remote, hot-cell use have been in service in the Fast Flux Test Facility (FFTF) Interim Examination and Maintenance (IEM) Cell for 3 and 4 yr, respectively, without the benefit of hands-on maintenance. These cutters are used to sever the outer duct of Driver Fuel Assemblies DFA being dismantled for further examination elsewhere. During this period, twelve DFAs requiring duct cutting were dismantled in the IEM Cell. A discussion of the remote design features of those cutters is presented that highlights features that were successful and addresses areas that needed improvement.

INTRODUCTION

The Fast Flux Test Facility (FFTF) is a U.S. Government-owned 400 MW sodium-cooled fast reactor plant designed specifically for irradiation testing of nuclear reactor fuels and materials, inherent safety research and development, and equipment demonstration for liquid metal fast reactors. The FFTF is located on the Department of Energy's Hanford Site near Richland, Washington, and is operated by Westinghouse Hanford Company, a wholly owned subsidiary of the Westinghouse Electric Corporation.

The Interim Examination and Maintenance (IEM) Cell (Fig. 1), located inside the FFTF, is used for the remote disassembly and examination of irradiated fuel and material experiments and limited maintenance activities. All in-cell equipment is designed to operate in a dry argon atmosphere and a high [100 Gy/h (10,000 rad/h)] gamma radiation environment.

After irradiation in the FFTF, certain Driver Fuel Assemblies (DFA) are selected for disassembly in the IEM Cell for further examination elsewhere. The first step in the removal of the DFAs outer duct is to separate it from the lower nozzle and shield-orifice block assembly (Fig. 2). Two fuel duct cutters are used in the dismantling operation. The Vertical Duct Cutter (Fig. 3) is used for slitting the duct along its axis to allow the duct to be withdrawn over swollen fuel pins. The Horizontal Duct Cutter (Fig. 4) is used for slitting the duct across its axis, severing it from the nozzle assembly. The two cutters have been in the IEM Cell for 3 and 4 yr, respectively. They were both recently removed from the IEM Cell for the first time since they were placed in service. Because the duct cutters are essential for examining irradiated fuel assemblies, they have to be fully functional for continued IEM Cell operation. Removal from the IEM Cell for maintenance had not been possible because chips from fuel duct cutting that were adhering to the cutters made radiation levels too high for manual bagging procedures. Manual bagging was the only available method of equipment transfer to and from the IEM Cell until the recent development of a shielded transfer cask. The cutters can now be transported in the cask to a remote, wet, spray-down area for gross decontamination. This reduces radiation levels so that manual decontamination can be performed to ready the equipment for hands-on maintenance.

Because the cutters could not be removed from the IEM Cell, tedious and innovative methods were often used for remote repairs or to work around problem areas. While most design features performed satisfactorily throughout this operational period, when hands-on maintenance became possible, several changes were made to improve remote operability and mitigate future maintenance problems.

DESIGN GOALS

The two primary goals of remote design, in addition to meeting functional criteria, are damage

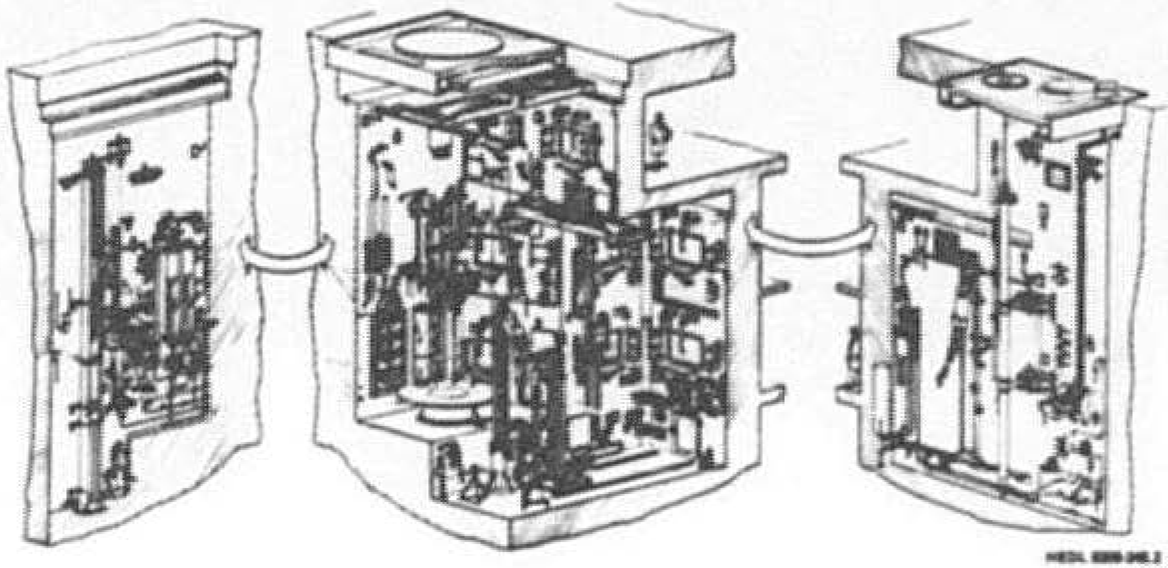

Fig. 1. Interim Examination and Maintenance Cell.

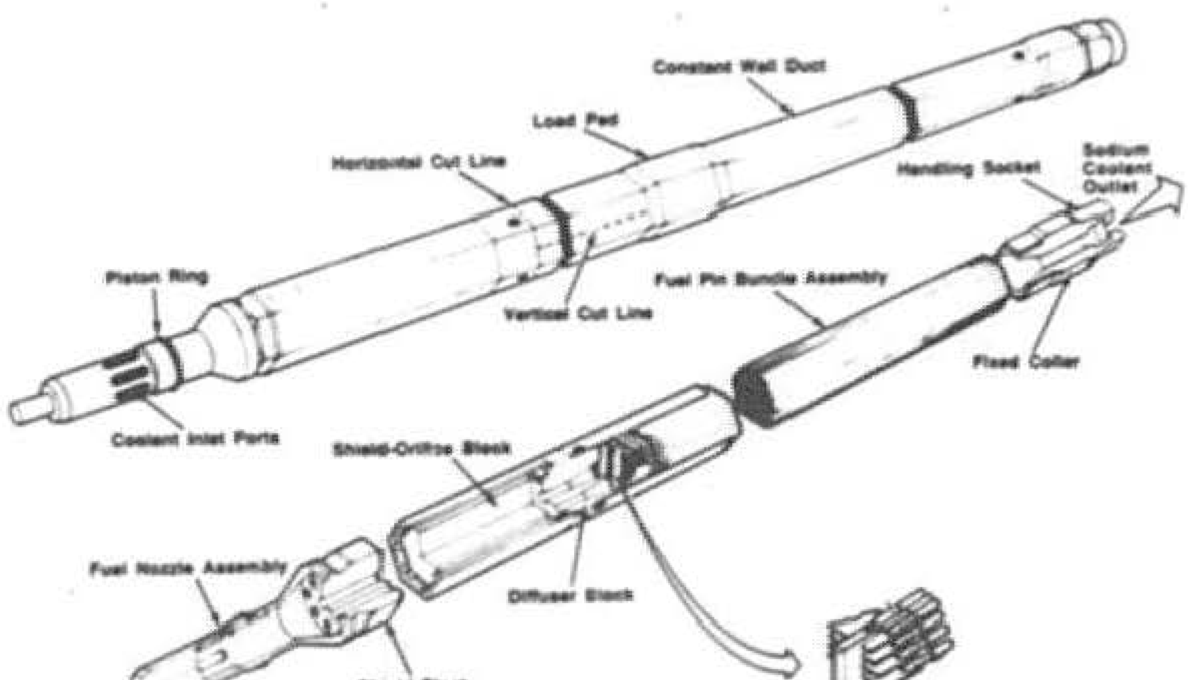

Fig. 2. Driver Fuel Assembly.

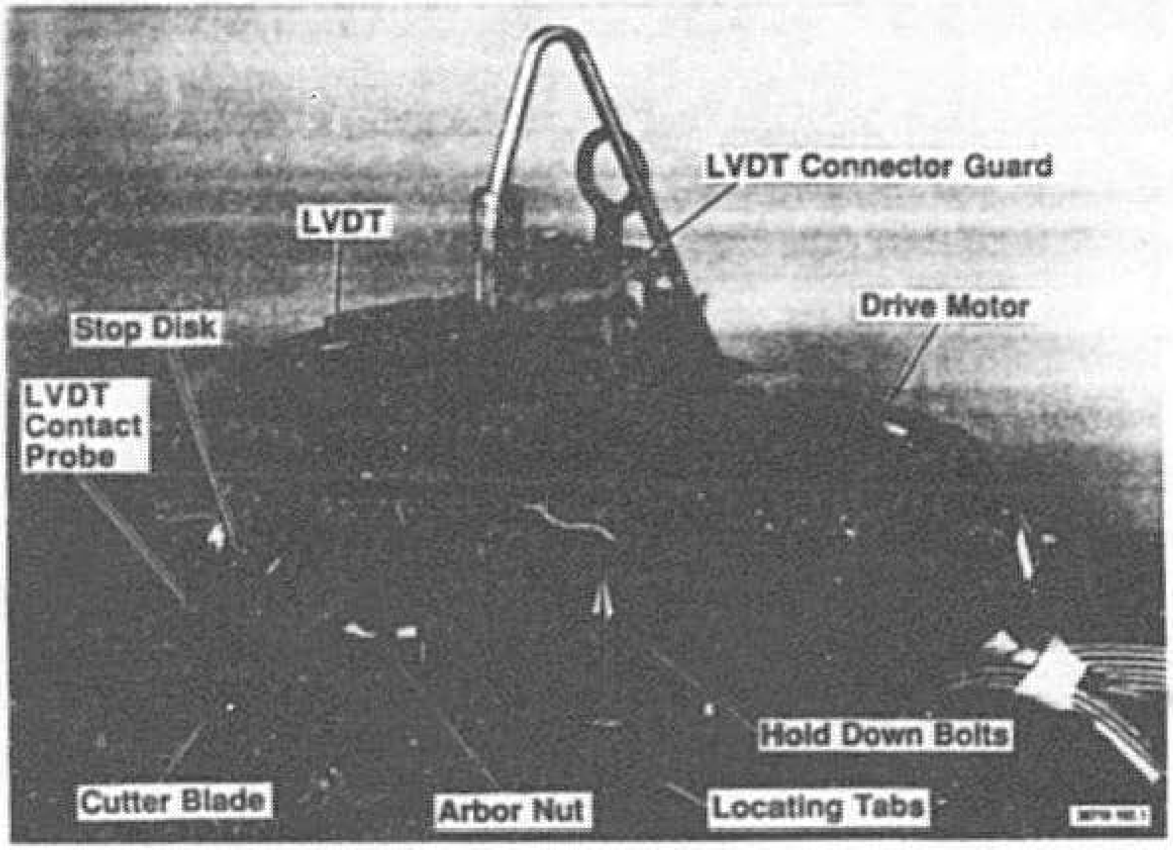

Fig. 3. Vertical Duct Cutter with Chip Collector and Linear Variable Differential Transformer (LVDT) Guard Removed.

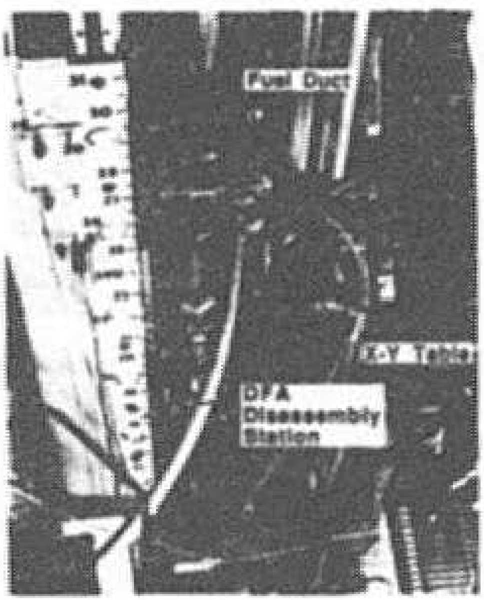

Fig. 4. Horizontal Duct Cutter.

avoidance and ease of remote operation. Damage avoidance lengthens the time before the equipment must be removed from service for maintenance. Simplifying remote operation not only reduces task time but also contributes to damage avoidance. Components that are difficult to operate are more likely to be damaged in use.

Damage avoidance has several strategies. Equipment should be sufficiently rugged to function for the desired time period without requiring repair due to worn parts or foreseeable external abuse. Moving parts such as gear boxes should be over-designed so they run lightly loaded. Delicate parts should be protected by guards or recessed so they cannot be impacted. Threaded fasteners should be permanently engaged or provisions made for precise alignment before thread engagement. If practical, clearances should be loose enough to allow continued operation after some mechanical deformation. Components that are subject to early failure should be readily removable for repair or replacement.

For ease of remote operation, equipment should be designed for remote manipulation skill. Parts installed remotely should be self aligning with a minimum of precision required to engage fasteners. Handling points should have grips that allow a firm hold. Levers should operate easily to a stop. Mechanisms that can be operated by a closed manipulator hand are preferable to those requiring precise location and manual orientation.

CUTTER REMOTE HANDLING/ MANIPULATION

The cutters are handled by master-slave manipulators (MSM) at window stations, two remotely controlled electromechanical manipulators (EMM), and either of two overhead bridge cranes. The cutters normally undergo the following remote operations during one DFA disassembly cycle:

- Retrieval from and return to the in-cell storage location
- Installation on and removal from the x-y-z motion table on the DFA Disassembly Station
- Electrical connection and disconnection of motor power and position and vibration sensor cables
- Installation and removal of cutter blades, arbor nuts, blade spacers, hard-depth stops, and a position sensor arm
- Installation and removal of a vacuum chip collector shroud.

FEATURES THAT PERFORMED WELL

One remote feature that performed well was the cutter's remote hold-down bolts (Fig. 3) that fasten it to the x-y motion table. Success in remotely engaging threaded fasteners such as these depends on the precise alignment of the fastener directly over the threaded hole. Otherwise, the use of a standard or even a pointed bolt will eventually result in cross-threading and a ruined, if not a jammed, fastener and threaded hole. The cutters are placed on a x-y motion table with the overhead crane and then fastened with captive, spring-loaded bolts. The bolts are operated by MSMs using socket wrenches with reversible ratchets. Tabs on the corners of the cutter base and two guide pins on the table align the cutters and position each bolt precisely over its threaded hole in the table. When the bolts are loosened, the springs lift the bolts up about 1 in. after the threads clear the tapped hole. This provides the operator positive indication of thread disengagement. The crane can then be used to lift the cutter without the possibility of damage to the fasteners or the table.

Another successful remote fastener type is the wing-headed clamping screw used to position the Linear Variable Differential Transformer (LVDT) position sensor body (Fig. 5). The large, flat head is easily operated by the MSMs while the threads remain permanently engaged.

Both the Horizontal and Vertical Duct Cutters proved successful in performing their basic function of cutting DFA ducts. Inspection during hands-on maintenance revealed that the gear boxes were sufficiently rugged to require no attention during service. In addition, delicate parts such as the Vertical Cutter LVDT sensing arm and the LVDT connector were adequately protected by installed guards (Fig. 3).

AREAS REQUIRING UPGRADE

One problem area was the damage to the electrical cables that occurred as the cutters were placed in their storage location. The designated storage area for the cutters is on the IEM Cell floor under the edge of an overhanging table. They are moved to that location by the crane, placed on the floor, and pushed under the overhang by an EMM. A problem occurred when the electrical cables slipped between the cutter base plate and the floor. As the 150-lb cutter was skidded the few inches across the floor, the cables were occasionally damaged. Extra effort to neatly place the cables on top of the cutters before storage was only partially successful.

Electrical cable damage was the primary source of down-time for the in-cell cutter equipment. The cutters have three electrical components, each of which originally had a separate cable. Two of the three cables had local connectors, while the third was hard-wired. With some difficulty, the locally connected cables have been replaced remotely. Failure of the hard-wired motor cable would place the cutter out of service. These concerns were eliminated by mounting a rugged Gulton Industries remote connector on the cutter base plates (Fig. 6) and using a remotely detachable cable. The cable is now removed and stored separately. This separates the cable from its primary source of damage and, if the cable is damaged, allows it to be replaced with a spare without having to remove the cutters from the IEM Cell.

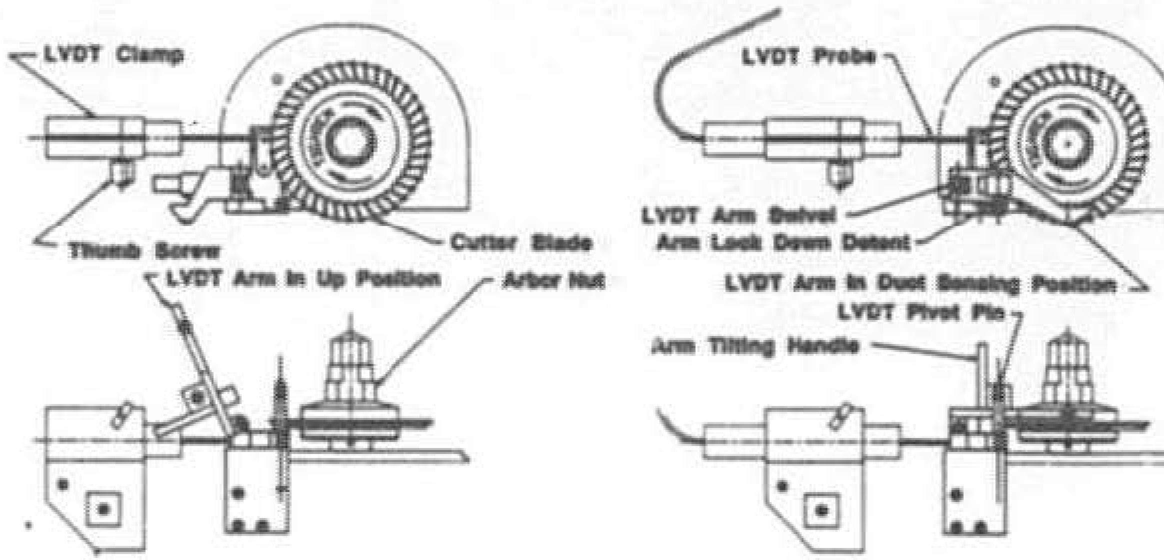

Fig. 5. Tilt-Back Linear Variable Differential Transformer (LVDT) Sensing Alarm for Blade Replacement.

The following additional changes were made to facilitate remote repair or replacement of easily damaged parts.

- Local connectors were installed on all three electrical components (Fig. 6). This makes remote replacement of cutter wiring between the individual components and the single Gulton Industries connector possible.
- The fixed guard over the Vertical Cutter LVDT body (Fig. 3) was altered so that it can be moved out of the way. This allows local disconnection of the LVDT wiring connector and greatly simplifies remote replacement of the LVDT itself.

DAMAGE AVOIDANCE

The following changes were made to repair damaged components and reduce the likelihood of damage during future remote operations.

- The key on the cutter arbor that engages the cutter blade was fabricated as an integral part of the hardened arbor. The original key was made as a separate part and tack welded in place. The severe service of the Vertical Cutter broke the weld allowing the key to be lost. A new, loose key had to be installed almost every time a blade was replaced. This proved to be a very difficult and time-consuming remote manipulation task.
- The accelerometer on the Horizontal Cutter was repositioned to move it out of the way of incidental blows during handling and operations. It has been located along the chip collector base plate rather than extending perpendicular from it (Fig. 7). The electrical connector had been broken several times as the cutter was moved to its storage location.
- An aerobic thread adhesive was applied to all fixed threaded fasteners. Some of these joints, notably in the position-sensing linkage, had vibrated apart in service without the adhesive.

EASE OF REMOTE OPERATION

The following changes were made to facilitate remote operations.

- Flats were added to the cylindrical barrel of the arbor nut (Fig. 7). This provides a more secure grip point for handling by the MSM. The arbor nut is a frequently handled part and has been dropped. The configuration of the IEM Cell makes retrieval of dropped items very difficult.

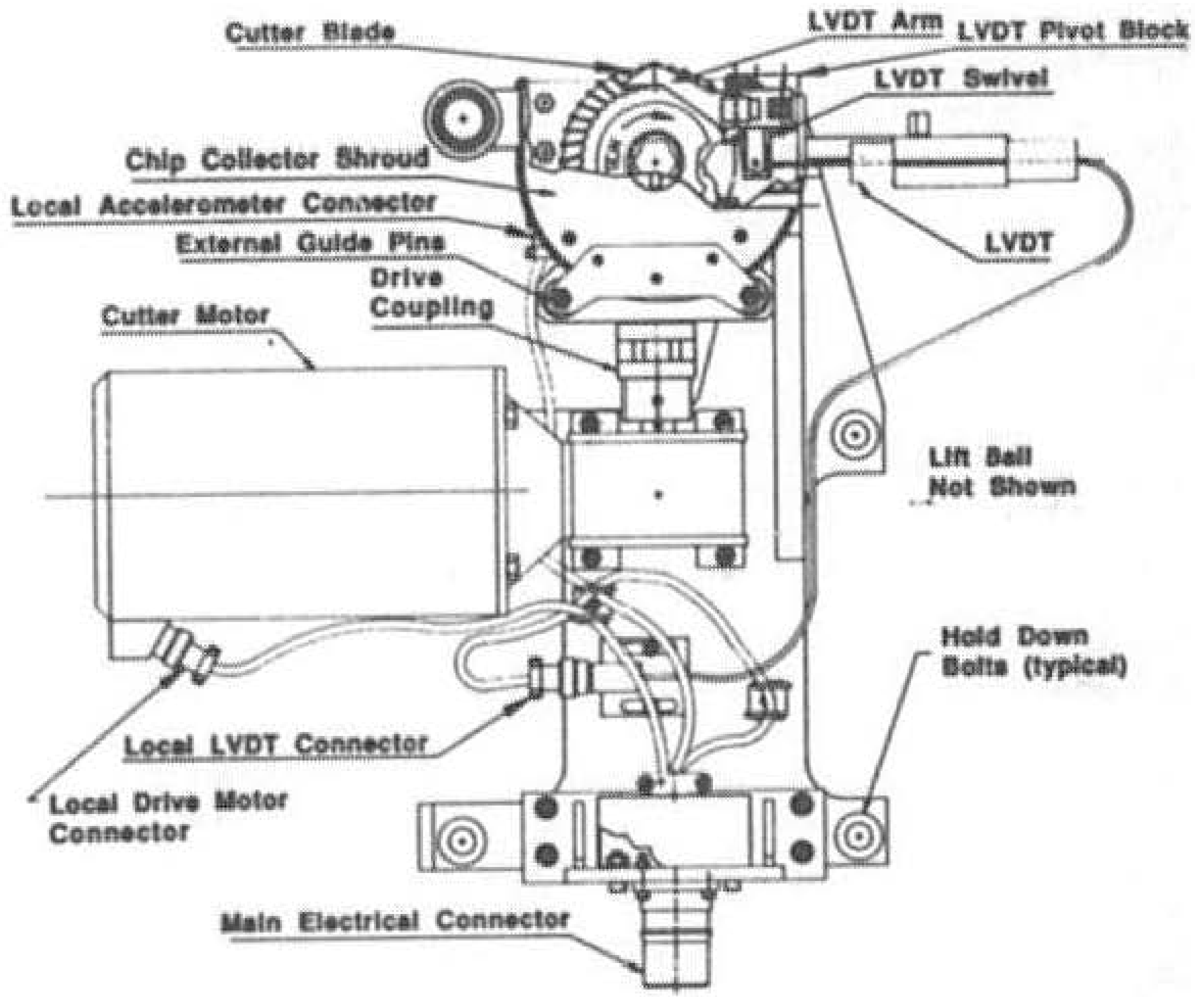

Fig. 6. Interim Examination and Maintenance Cell Horizontal Duct Cutter.

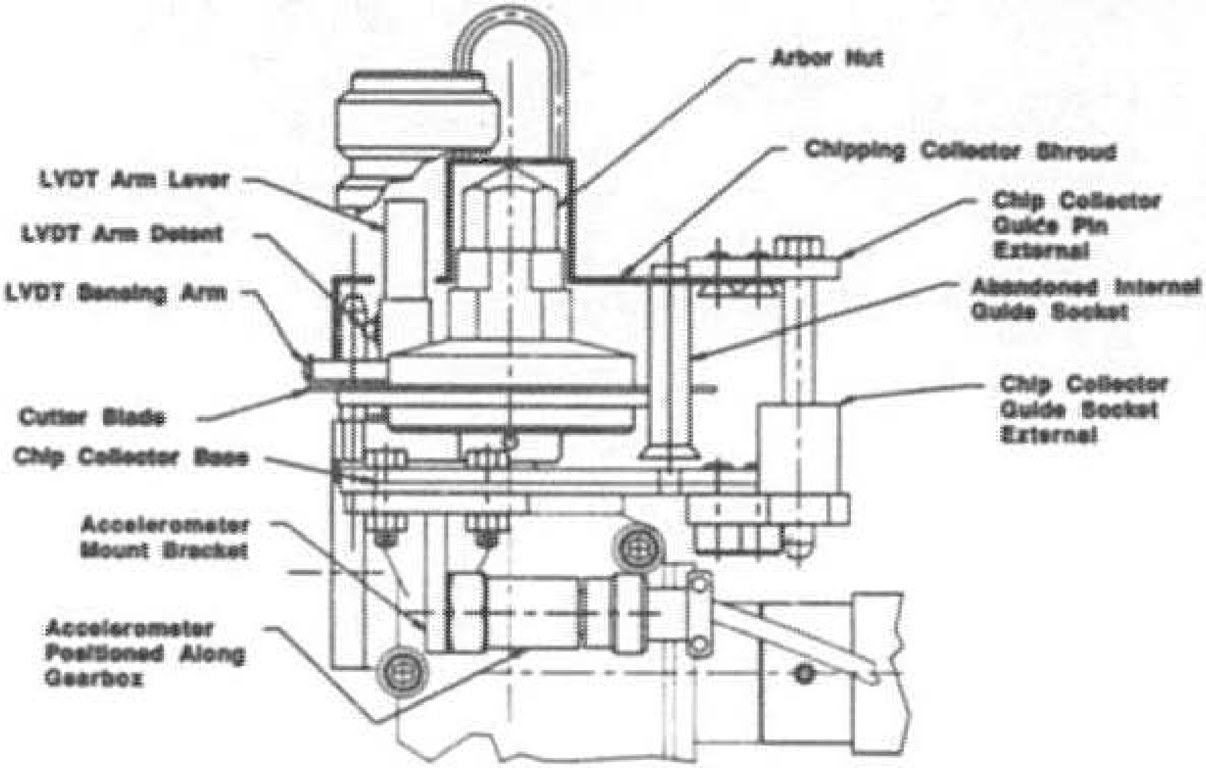

Fig. 7. Horizontal Duct Cutter Detail.

- Flats were added to the shaft coupling between the two gear boxes so a second wrench could be used behind the arbor nut for loosening the arbor nuts. The back-drive resistance in the worm reduction gears was designed to hold the arbor when loosening and tightening the arbor nut. On occasion, after a cutting sequence, the resistance was not sufficient to allow loosening the arbor nut.

- The chip collector for the Horizontal Cutter is placed vertically over two guide pins (Fig. 6 and 7). These pins locate the collector and hold it in place during operation. The original configuration had the sockets for the pins and the pins themselves inside the collector. This made a compact package, but due to the location of the cutter in the IEM Cell, the pins could not be seen and had to be engaged blindly in the sockets. This resulted in a time-consuming, trial-and-error operation. The guide pins and sockets were enlarged and placed on the outside of the chip collector where they are easily visible. The pins engage easily, and the collector then drops into place. Large, external guide rails have been successfully used during this operating period to position the Vertical Cutter chip collector shroud.

- The Horizontal Cutter has a mechanical, cut-depth sensor arm located just above the cutter blade (Fig. 5). This arm must be moved out of the way each time the cutter blade is replaced. The original configuration required that this arm [0.6 x 0.6 x 5 cm (0.25 x 0.25 x 2 in.)] be removed and replaced on two small pins by a MSM each time the cutter blade was changed. This was a delicate task with a high risk of dropping the arm. A new arm assembly was designed that pivots out of the way like the arm of a phonograph. A delicate procedure has been replaced with a simple one.

CONCLUSION

The FFTF IEM Cell Horizontal and Vertical Cutters have proved to be effective tools in the adverse environment of severe service and remote operation. Operating experience has revealed the strengths and weaknesses of the equipment. The opportunity to retrieve the cutters and modify them based on experience has resulted in more trouble-free, easy-to-operate equipment that will result in a significant savings in future repair costs and schedule delays.

REFERENCES

1. D. M. Romrell, "Remote Cutting of Irradiated Fuel Ducts at FFTF," ANS Proc. 32nd Conf. on Remote Syst. Technol., 55 (1984).

2. P. W. Gibbons, "Fuel Assembly Duct Cutting in the FFTF/IEM Cell," ANS Proc. 33rd Conf. on Remote Syst. Technol., 55 (1985).

3. P. W. Gibbons, "HT9 Duct Cutting--IEM Cell and Mock-up Testing Experience at FFTF," ANS Transact. 1987 Winter Meeting, 650 (1987).